

# **TDA2Px ADAS Applications Processor**

## **23mm Package (ABZ Package)**

### **Silicon Revision 1.0**

## **1 Device Overview**

### **1.1 Features**

- Architecture Designed for ADAS Applications
- Video, Image, and Graphics Processing Support
  - Full-HD Video (1920 × 1080p, 60 fps)
  - Multiple Video Input and Video Output
- Dual Arm® Cortex®-A15 Microprocessor Subsystem
- Up to Two C66x Floating-Point VLIW DSP
  - Fully Object-Code Compatible with C67x and C64x+
  - Up to Thirty-Two 16 × 16-Bit Fixed-Point Multiplies per Cycle
- Up to 2.5MB of On-Chip L3 RAM
- Level 3 (L3) and Level 4 (L4) Interconnects
- Two DDR2/DDR3/DDR3L Memory Interface (EMIF) Modules
  - Supports up to DDR2-800 and DDR3-1333
  - Up to 2GB Supported per EMIF
- Dual Arm® Cortex®-M4 Image Processing Units (IPU)
- Vision AccelerationPac
  - Up to Two Embedded Vision Engines (EVEs)
- Imaging Subsystem (ISS)
  - Image Signal Processor (ISP)
  - Wide Dynamic Range and Lens Distortion Correction (WDR and Mesh LDC)
  - One Camera Adaptation Layer (CAL\_B)
- IVA-HD Subsystem
- Display Subsystem
  - Display Controller with DMA Engine and up to Three Pipelines
  - HDMI™ Encoder: HDMI 1.4a and DVI 1.0 Compliant
- 2D-Graphics Accelerator (BB2D) Subsystem
  - Vivante® GC320 Core
- Video Processing Engine (VPE)
- Dual-Core PowerVR® SGX544 3D GPU
- Two Video Input Port (VIP) Modules
  - Support for up to Eight Multiplexed Input Ports
- General-Purpose Memory Controller (GPMC)
- Enhanced Direct Memory Access (EDMA)
- Controller
  - 2-Port Gigabit Ethernet (GMAC)
  - Up to Two Controller Area Network (DCAN) Modules
    - CAN 2.0B Protocol
  - Modular Controller Area Network (MCAN) Module
    - CAN 2.0B Protocol with Available FD (Flexible Data Rate) Functionality
  - PCI Express® 3.0 Port with Integrated PHY
    - One 2-Lane Gen2-Compliant Port
    - or Two 1-Lane Gen2-Compliant Ports
  - Sixteen 32-Bit General-Purpose Timers
  - 32-Bit MPU Watchdog Timer
  - Ten Configurable UART/IrDA/CIR Modules
  - Four Multichannel Serial Peripheral Interfaces (McSPI)
  - Quad SPI Interface
  - Five Inter-Integrated Circuit (I²C) Ports
  - SATA Interface
  - Eight Multichannel Audio Serial Port (McASP) Modules
  - SuperSpeed USB 3.0 Dual-Role Device
  - Three High-Speed USB 2.0 Dual-Role Devices
  - Four MultiMedia Card/Secure Digital/Secure Digital Input Output Interfaces (MMC™/ SD®/SDIO)
  - Up to 247 General-Purpose I/O (GPIO) Pins
  - Real-Time Clock Subsystem (RTCSS)
  - Device Security Features
    - Hardware Crypto Accelerators and DMA
    - Firewalls
    - JTAG® Lock
    - Secure Keys
    - Secure ROM and Boot
    - Customer Programmable Keys and OTP Data
  - Power, Reset, and Clock Management
  - On-Chip Debug With CTools Technology
  - Automotive AEC-Q100 Qualified
  - 28-nm CMOS Technology
  - 23 mm × 23 mm, 0.8-mm Pitch, 760-Pin BGA (ABZ)



## 1.2 Applications

- Mono, Stereo or Tri-Optic Front Camera
  - Object Detection
  - Pedestrian Detection
  - Traffic Sign Recognition
  - Lane Detection and Departure Warning
  - Automatic Emergency Braking
  - Adaptive Cruise Control
  - Forward Collision Warning
  - High Beam Assist
- LVDS or Ethernet Surround View
  - 2D surround view
  - 3D surround view
  - Rear object detection
  - Parking assist
  - Pedestrian Detection
  - Lane tracking
  - Drive Recording
- Sensor Fusion – Vision, Radar, Ultrasonic, Lidar sensors
  - Object data fusion
  - Raw data fusion

## 1.3 Description

TI's new TDA2Px System-on-Chip (SoC) is a highly optimized and scalable family of devices designed to meet the requirements of leading Advanced Driver Assistance Systems (ADAS). The TDA2Px family enables broad ADAS applications in automobiles by integrating an optimal mix of performance, low power and ADAS vision analytics processing that aims to facilitate a more autonomous and collision-free driving experience.

The TDA2Px SoC enables sophisticated embedded vision technology in automobiles by broadest range of ADAS applications including front camera, park assist, surround view and sensor fusion on a single architecture.

The TDA2Px SoC incorporates a heterogeneous, scalable architecture that includes a mix of TI's fixed and floating-point TMS320C66x digital signal processor (DSP) generation cores, Vision AccelerationPac, Arm Cortex-A15 MPCore™ and dual-Cortex-M4 processors. The integration of a video accelerator for decoding multiple video streams over an Ethernet AVB network, along with graphics accelerators for rendering virtual views, enable a 3D viewing experience. And the TDA2Px SoC also integrates a host of peripherals including multi-camera interfaces (both parallel and serial) for LVDS-based surround view systems, displays, CAN and GigB Ethernet AVB.

The Vision AccelerationPac for this family of products includes multiple embedded vision engines (EVEs) offloading the vision analytics functionality from the application processor while also reducing the power footprint. The Vision AccelerationPac is optimized for vision processing with a 32-bit RISC core for efficient program execution and a vector coprocessor for specialized vision processing.

Additionally, TI provides a complete set of development tools for the Arm, DSP, and EVE coprocessor, including C compilers, a DSP assembly optimizer to simplify programming and scheduling, and a debugging interface for visibility into source code execution.

Cryptographic acceleration is available in all devices. All other supported security features, including support for secure boot, debug security and support for trusted execution environment are available on High-Security (HS) devices. For more information about HS devices, contact your TI representative.

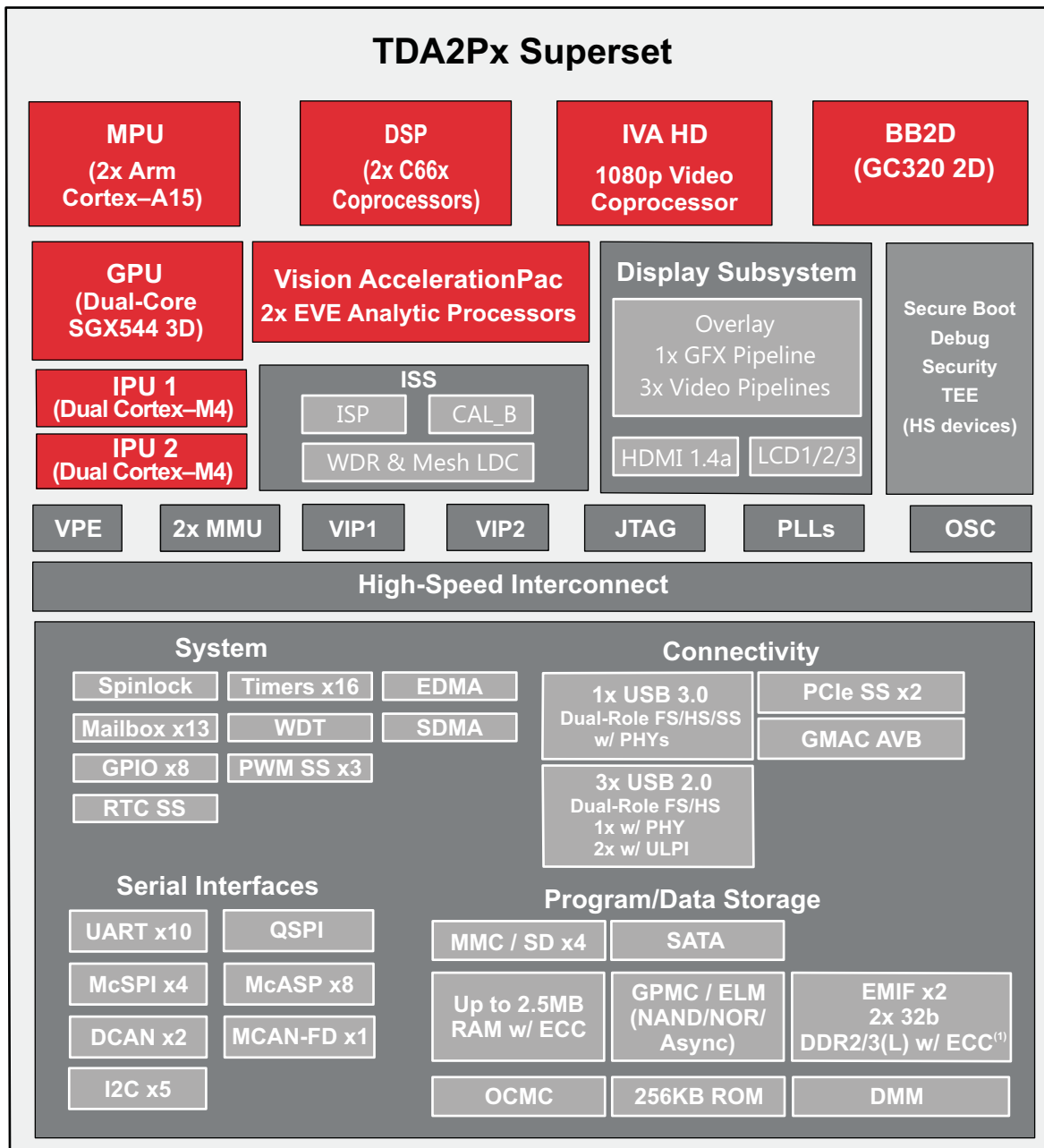
The TDA2Px ADAS processor is qualified according to the AEC-Q100 standard.

### Device Information

| PART NUMBER | PACKAGE     | BODY SIZE         |
|-------------|-------------|-------------------|
| TDA2Px      | FCBGA (760) | 23.0 mm × 23.0 mm |

## 1.4 Functional Block Diagram

Figure 1-1 is functional block diagram of the superset.



intro-001

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**Figure 1-1. TDA2Px Block Diagram**

(1) ECC is only available on EMIF1.

## Table of Contents

|          |                                                           |                            |          |                                                 |                            |
|----------|-----------------------------------------------------------|----------------------------|----------|-------------------------------------------------|----------------------------|
| <b>1</b> | <b>Device Overview</b>                                    | <b><a href="#">1</a></b>   | 6.5      | ISS                                             | <a href="#">340</a>        |
| 1.1      | Features                                                  | <a href="#">1</a>          | 6.6      | IVA                                             | <a href="#">340</a>        |
| 1.2      | Applications                                              | <a href="#">2</a>          | 6.7      | EVE                                             | <a href="#">341</a>        |
| 1.3      | Description                                               | <a href="#">2</a>          | 6.8      | IPU                                             | <a href="#">342</a>        |
| 1.4      | Functional Block Diagram                                  | <a href="#">3</a>          | 6.9      | VPE                                             | <a href="#">343</a>        |
| <b>2</b> | <b>Revision History</b>                                   | <b><a href="#">5</a></b>   | 6.10     | GPU                                             | <a href="#">345</a>        |
| <b>3</b> | <b>Device Comparison</b>                                  | <b><a href="#">6</a></b>   | 6.11     | Memory Subsystem                                | <a href="#">346</a>        |
| 3.1      | Device Comparison Table                                   | <a href="#">6</a>          | 6.12     | Interprocessor Communication                    | <a href="#">349</a>        |
| 3.2      | Related Products                                          | <a href="#">8</a>          | 6.13     | Interrupt Controller                            | <a href="#">350</a>        |
| <b>4</b> | <b>Terminal Configuration and Functions</b>               | <b><a href="#">9</a></b>   | 6.14     | EDMA                                            | <a href="#">351</a>        |
| 4.1      | Pin Diagram                                               | <a href="#">9</a>          | 6.15     | Peripherals                                     | <a href="#">352</a>        |
| 4.2      | Pin Attributes                                            | <a href="#">9</a>          | 6.16     | On-Chip Debug                                   | <a href="#">367</a>        |
| 4.3      | Signal Descriptions                                       | <a href="#">77</a>         | <b>7</b> | <b>Applications, Implementation, and Layout</b> | <b><a href="#">370</a></b> |
| 4.4      | Pin Multiplexing                                          | <a href="#">118</a>        | 7.1      | Introduction                                    | <a href="#">370</a>        |
| 4.5      | Connections for Unused Pins                               | <a href="#">134</a>        | 7.2      | Power Optimizations                             | <a href="#">371</a>        |
| <b>5</b> | <b>Specifications</b>                                     | <b><a href="#">135</a></b> | 7.3      | Core Power Domains                              | <a href="#">385</a>        |
| 5.1      | Absolute Maximum Ratings <sup>(1)</sup>                   | <a href="#">136</a>        | 7.4      | Single-Ended Interfaces                         | <a href="#">397</a>        |
| 5.2      | ESD Ratings                                               | <a href="#">137</a>        | 7.5      | Differential Interfaces                         | <a href="#">399</a>        |
| 5.3      | Power-On Hours (POH) Limits                               | <a href="#">137</a>        | 7.6      | Clock Routing Guidelines                        | <a href="#">420</a>        |
| 5.4      | Recommended Operating Conditions <sup>(5)</sup>           | <a href="#">137</a>        | 7.7      | DDR2/DDR3 Board Design and Layout Guidelines    | <a href="#">422</a>        |
| 5.5      | Operating Performance Points                              | <a href="#">141</a>        | <b>8</b> | <b>Device and Documentation Support</b>         | <b><a href="#">457</a></b> |
| 5.6      | Power Consumption Summary                                 | <a href="#">162</a>        | 8.1      | Device Nomenclature and Orderable Information   | <a href="#">457</a>        |
| 5.7      | Electrical Characteristics                                | <a href="#">162</a>        | 8.2      | Tools and Software                              | <a href="#">459</a>        |
| 5.8      | VPP Specifications for One-Time Programmable (OTP) eFuses | <a href="#">169</a>        | 8.3      | Documentation Support                           | <a href="#">460</a>        |
| 5.9      | Thermal Resistance Characteristics                        | <a href="#">170</a>        | 8.4      | Receiving Notification of Documentation Updates | <a href="#">460</a>        |
| 5.10     | Timing Requirements and Switching Characteristics         | <a href="#">172</a>        | 8.5      | Community Resources                             | <a href="#">461</a>        |
| <b>6</b> | <b>Detailed Description</b>                               | <b><a href="#">331</a></b> | 8.6      | Trademarks                                      | <a href="#">461</a>        |
| 6.1      | Description                                               | <a href="#">331</a>        | 8.7      | Electrostatic Discharge Caution                 | <a href="#">461</a>        |
| 6.2      | Functional Block Diagram                                  | <a href="#">331</a>        | 8.8      | Export Control Notice                           | <a href="#">461</a>        |
| 6.3      | MPU                                                       | <a href="#">333</a>        | 8.9      | Glossary                                        | <a href="#">461</a>        |
| 6.4      | DSP Subsystem                                             | <a href="#">336</a>        | <b>9</b> | <b>Mechanical Packaging Information</b>         | <b><a href="#">462</a></b> |
|          |                                                           |                            | 9.1      | Mechanical Data                                 | <a href="#">462</a>        |

## 2 Revision History

| Changes from March 17, 2018 to December 15, 2018 (from E Revision (March 2018) to F Revision)                                                                 | Page                |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| • Added TDA2PHF device and speed grade U to <a href="#">Table 3-1, Device Comparison</a> .....                                                                | <a href="#">6</a>   |
| • Added clarification notes regarding X5777x part number to <a href="#">Table 3-1, Device Comparison</a> .....                                                | <a href="#">6</a>   |
| • Added TDA2PHFx device in Pin Attributes section .....                                                                                                       | <a href="#">9</a>   |
| • Removed wrong placed balls in <a href="#">Table 4-19, GPIOs Signal Descriptions</a> .....                                                                   | <a href="#">102</a> |
| • Updated porz, resetn and rstoutn signal descriptions in <a href="#">Table 4-22 PRCM Signal Descriptions</a> . ....                                          | <a href="#">110</a> |
| • Added table note for maximum valid input voltage on an IO pin to <a href="#">Section 5.1, Absolute Maximum Rating Over Junction Temperature Range</a> ..... | <a href="#">136</a> |
| • Added clarification note regarding TSHUT feature. ....                                                                                                      | <a href="#">141</a> |
| • Added TDA2PxxU speed grade to <a href="#">Table 5-1, Speed Grade Maximum Frequency</a> . ....                                                               | <a href="#">141</a> |
| • Added definition for MPU OPP_LOW in Voltage Domains Operating Performance Points and Supported OPP vs Max Frequency tables .....                            | <a href="#">142</a> |
| • Updated SYS_32K to FUNC_32K_CLK in <a href="#">Table 5-5, Maximum Supported Frequency</a> .....                                                             | <a href="#">144</a> |
| • Added Ivpp specification in <a href="#">Table 5-14, Recommended Operating Conditions for OTP eFuse Programming</a> .....                                    | <a href="#">169</a> |
| • Updated <a href="#">Section 5.8.3, Impact to Your Hardware Warranty</a> .....                                                                               | <a href="#">170</a> |
| • Updated Power Supply Sequences section .....                                                                                                                | <a href="#">174</a> |
| • Updated system clock names in <a href="#">Section 5.10.4, Clock Specifications</a> .....                                                                    | <a href="#">183</a> |
| • Updated manual mode and timing tables for DSS, GMAC-RGMII, and MMC2 .....                                                                                   | <a href="#">221</a> |
| • Added missing balls in <a href="#">Table 5-70, McSPI3/4 IOSETs</a> .....                                                                                    | <a href="#">261</a> |
| • Updated phase polarity in all QSPI timing figures .....                                                                                                     | <a href="#">264</a> |
| • Removed references to OpenGL in <a href="#">Section 6.10, GPU</a> .....                                                                                     | <a href="#">345</a> |
| • Updated <a href="#">Section 7.3.5, Power Supply Mapping</a> .....                                                                                           | <a href="#">389</a> |
| • Added new <a href="#">Section 7.3.7, Loss of Input Power Event</a> .....                                                                                    | <a href="#">390</a> |
| • Added speed grade "U" to <a href="#">Table 8-1, Nomenclature Description</a> .....                                                                          | <a href="#">458</a> |
| • Added clarification notes regarding X5777x part number in , <a href="#">Nomenclature Description</a> .....                                                  | <a href="#">458</a> |

### 3 Device Comparison

#### 3.1 Device Comparison Table

Table 3-1 shows a comparison between devices, highlighting the differences.

**Table 3-1. Device Comparison<sup>(6)</sup>**

| Features                                                                             |                               | Device             |                    |                    |                    |                    |
|--------------------------------------------------------------------------------------|-------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                                                                                      |                               | TDA2PSxx           | TDA2PHxx           |                    |                    |                    |
|                                                                                      |                               | TDA2PSXx           | TDA2PHGx           | TDA2PHFx           | TDA2PHVx           | TDA2PHAx           |
| <b>Features</b>                                                                      |                               |                    |                    |                    |                    |                    |
| CTRL_WKUP_STD_FUSE_DIE_ID_2[31:24] Base PN register bitfield value <sup>(5)(6)</sup> |                               | 51 (0x33)          | 42 (0x2A)          | 41 (0x29)          | 38 (0x26)          | 37 (0x25)          |
| <b>Processors/ Accelerators</b>                                                      |                               |                    |                    |                    |                    |                    |
| Speed Grades                                                                         |                               | T                  | R, D               | U                  | R, D               | R, D               |
| Arm Dual Cortex-A15 Microprocessor Subsystem                                         | MPU core 0                    | Yes                | Yes                | Yes                | Yes                | Yes                |
|                                                                                      | MPU core 1                    | Yes                | No                 | Yes                | No                 | No                 |
| C66x VLIW DSP                                                                        | DSP1 (with L1D ECC)           | Yes                | Yes                | Yes                | Yes                | Yes                |
|                                                                                      | DSP2 (with L1D ECC)           | Yes                | Yes                | Yes                | Yes                | Yes                |
| BitBLT 2D Hardware Acceleration Engine                                               | BB2D                          | Yes                | Yes                | No                 | No                 | No                 |
| Display Subsystem                                                                    | VOUT1                         | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> |
|                                                                                      | VOUT2                         | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> |
|                                                                                      | VOUT3                         | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> | Yes <sup>(1)</sup> |
|                                                                                      | HDMI                          | Yes                | Yes                | Yes                | Yes                | Yes                |
| Embedded Vision Engine                                                               | EVE1                          | Yes                | Yes                | Yes                | Yes                | Yes                |
|                                                                                      | EVE2                          | Yes                | Yes                | Yes                | Yes                | Yes                |
| Arm Dual Cortex-M4 Image Processing Unit                                             | IPU1                          | Yes                | Yes                | Yes                | Yes                | Yes                |
|                                                                                      | IPU2                          | Yes                | Yes                | Yes                | Yes                | Yes                |
| Image Video Accelerator                                                              | IVA                           | Yes                | Yes                | Yes                | Yes                | No                 |
| SGX544 Dual-Core 3D Graphics Processing Unit                                         | GPU                           | Yes                | Yes                | No                 | No                 | No                 |
| Imaging Subsystem with WDR & LDC (ISS)                                               | ISP                           | Yes                | Yes                | Yes                | Yes                | No                 |
|                                                                                      | WDR & Mesh LDC <sup>(4)</sup> | Yes                | Yes                | Yes                | Yes                | No                 |
|                                                                                      | CAL_B                         | Yes                | Yes                | Yes                | Yes                | No                 |
| Video Input Port                                                                     | VIP1                          | vin1a              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      |                               | vin1b              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      |                               | vin2a              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      |                               | vin2b              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      | VIP2                          | vin3a              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      |                               | vin3b              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      |                               | vin4a              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      |                               | vin4b              | Yes                | Yes                | Yes                | Yes                |
|                                                                                      | VIP3                          | vin5a              | No                 | No                 | No                 | No                 |
|                                                                                      |                               | vin6a              | No                 | No                 | No                 | No                 |
| Video Processing Engine                                                              | VPE                           | Yes                | Yes                | Yes                | Yes                | Yes                |
| Camera Adaptation Layer (CAL) Camera Serial Interface 2 (CSI2)                       | CSI2_0 (CLK + 4 Data)         | No                 | No                 | No                 | No                 | No                 |
|                                                                                      | CSI2_1 (CLK + 2 Data)         | No                 | No                 | No                 | No                 | No                 |

**Table 3-1. Device Comparison<sup>(6)</sup> (continued)**

| Features                                                                           |                             | Device         |                |                |                |                |
|------------------------------------------------------------------------------------|-----------------------------|----------------|----------------|----------------|----------------|----------------|
|                                                                                    |                             | TDA2PSxx       | TDA2PHxx       |                |                |                |
|                                                                                    |                             | TDA2PSXx       | TDA2PHGx       | TDA2PHFx       | TDA2PHVx       | TDA2PHAx       |
| <b>Program/Data Storage</b>                                                        |                             |                |                |                |                |                |
| On-Chip Shared Memory (RAM)                                                        | OCMC_RAM1                   | 512 KB         | 512 KB         | 512 KB         | 512 KB         | 512 KB         |
|                                                                                    | OCMC_RAM2                   | 1 MB           | 1 MB           | 1 MB           | 1 MB           | 1 MB           |
|                                                                                    | OCMC_RAM3                   | 1 MB           | 1 MB           | 1 MB           | 1 MB           | 1 MB           |
| General-Purpose Memory Controller                                                  | GPMP                        | Yes            | Yes            | Yes            | Yes            | Yes            |
| DDR2/DDR3/DDR3L Memory Controller <sup>(2)</sup>                                   | EMIF1 (with R-mod-W ECC)    | up to 2 GB     | up to 2 GB     | up to 2 GB     | up to 2 GB     | up to 2 GB     |
|                                                                                    | EMIF2                       | up to 2 GB     | up to 2 GB     | up to 2 GB     | up to 2 GB     | up to 2 GB     |
| Dynamic Memory Manager                                                             | DMM                         | Yes            | Yes            | Yes            | Yes            | Yes            |
| <b>Radio Support</b>                                                               |                             |                |                |                |                |                |
| Audio Tracking Logic                                                               | ATL                         | No             | No             | No             | No             | No             |
| Viterbi Coprocessor                                                                | VCP1                        | No             | No             | No             | No             | No             |
|                                                                                    | VCP2                        | No             | No             | No             | No             | No             |
| <b>Peripherals</b>                                                                 |                             |                |                |                |                |                |
| Controller Area Network Interface (CAN)                                            | DCAN1 <sup>(3)</sup>        | Yes            | Yes            | Yes            | Yes            | Yes            |
|                                                                                    | DCAN2 <sup>(3)</sup>        | Yes            | Yes            | Yes            | Yes            | Yes            |
|                                                                                    | MCAN with FD <sup>(3)</sup> | Yes            | Yes            | Yes            | Yes            | Yes            |
| Enhanced DMA                                                                       | EDMA                        | Yes            | Yes            | Yes            | Yes            | Yes            |
| System DMA                                                                         | SDMA                        | Yes            | Yes            | Yes            | Yes            | Yes            |
| Ethernet Subsystem (Ethernet SS)                                                   | GMAC_SW[0]                  | Yes            | Yes            | Yes            | Yes            | Yes            |
|                                                                                    | GMAC_SW[1]                  | Yes            | Yes            | Yes            | Yes            | Yes            |
| General-Purpose IO                                                                 | GPIO                        | up to 247      | up to 247      | up to 247      | up to 247      | up to 247      |
| Inter-Integrated Circuit Interface                                                 | I2C                         | 5              | 5              | 5              | 5              | 5              |
| System Mailbox Module                                                              | MAILBOX                     | 13             | 13             | 13             | 13             | 13             |
| Media Local Bus                                                                    | MLB                         | No             | No             | No             | No             | No             |
| Multi-Channel Audio Serial Port                                                    | McASP1                      | 16 serializers | 16 serializers | 16 serializers | 16 serializers | 16 serializers |
|                                                                                    | McASP2                      | 16 serializers | 16 serializers | 16 serializers | 16 serializers | 16 serializers |
|                                                                                    | McASP3                      | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  |
|                                                                                    | McASP4                      | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  |
|                                                                                    | McASP5                      | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  |
|                                                                                    | McASP6                      | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  |
|                                                                                    | McASP7                      | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  |
|                                                                                    | McASP8                      | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  | 4 serializers  |
| MultiMedia Card/Secure Digital/Secure Digital Input Output Interface (MMC/SD/SDIO) | MMC1                        | Yes            | Yes            | Yes            | Yes            | Yes            |
|                                                                                    | MMC2                        | Yes            | Yes            | Yes            | Yes            | Yes            |
|                                                                                    | MMC3                        | Yes            | Yes            | Yes            | Yes            | Yes            |
|                                                                                    | MMC4                        | Yes            | Yes            | Yes            | Yes            | Yes            |
| PCI Express 3.0 Port with Integrated PHY                                           | PCIe_SS1                    | Yes            | Yes            | Yes            | Yes            | Yes            |
|                                                                                    | PCIe_SS2                    | Yes            | Yes            | Yes            | Yes            | Yes            |
| SATA Gen2 Interface                                                                | SATA                        | Yes            | Yes            | Yes            | Yes            | Yes            |
| Real-Time Clock Subsystem                                                          | RTCSS                       | Yes            | Yes            | Yes            | Yes            | Yes            |
| Programmable Real-Time Unit Subsystem and Industrial Communication Subsystem       | PRU-ICSS                    | No             | No             | No             | No             | No             |
| Multichannel Serial Peripheral Interface                                           | McSPI                       | 4              | 4              | 4              | 4              | 4              |

**Table 3-1. Device Comparison<sup>(6)</sup> (continued)**

| Features                                    |                                                                | Device   |          |          |          |          |
|---------------------------------------------|----------------------------------------------------------------|----------|----------|----------|----------|----------|
|                                             |                                                                | TDA2PSxx | TDA2PHxx |          |          |          |
|                                             |                                                                | TDA2PSxx | TDA2PHGx | TDA2PHFx | TDA2PHVx | TDA2PHAx |
| HDQ1W                                       | HDQ1W                                                          | No       | No       | No       | No       | No       |
| Quad SPI                                    | QSPI                                                           | Yes      | Yes      | Yes      | Yes      | Yes      |
| Spinlock Module                             | SPINLOCK                                                       | Yes      | Yes      | Yes      | Yes      | Yes      |
| Keyboard Controller                         | KBD                                                            | No       | No       | No       | No       | No       |
| Timers, General-Purpose                     | TIMER                                                          | 16       | 16       | 16       | 16       | 16       |
| Timer, Watchdog                             | WATCHDOG TIMER                                                 | Yes      | Yes      | Yes      | Yes      | Yes      |
| Pulse-Width Modulation Subsystem            | PWMSS1                                                         | Yes      | Yes      | Yes      | Yes      | Yes      |
|                                             | PWMSS2                                                         | Yes      | Yes      | Yes      | Yes      | Yes      |
|                                             | PWMSS3                                                         | Yes      | Yes      | Yes      | Yes      | Yes      |
| Universal Asynchronous Receiver/Transmitter | UART                                                           | 10       | 10       | 10       | 10       | 10       |
| Universal Serial Bus (USB3.0)               | USB1 (SuperSpeed, Dual-Role-Device [DRD])                      | Yes      | Yes      | Yes      | Yes      | Yes      |
| Universal Serial Bus (USB2.0)               | USB2 (HighSpeed, Dual-Role-Device [DRD], with embedded HS PHY) | Yes      | Yes      | Yes      | Yes      | Yes      |
|                                             | USB3 (HighSpeed, OTG2.0, with ULPI)                            | Yes      | Yes      | Yes      | Yes      | Yes      |
|                                             | USB4 (HighSpeed, OTG2.0, with ULPI)                            | Yes      | Yes      | Yes      | Yes      | Yes      |

- (1) DSS clock jitter can be improved by providing an external clock source (via inputs vin1a\_clk, vin1b\_clk, wakeup0, wakeup1) or from internal SATA or PCIe PLLs.
- (2) In the Unified L3 memory map, there is maximum of 2 GB of SDRAM space which is available to all L3 initiators including MPU (MPU, GPU, DSP, IVA, DMA, etc). Typically this space is interleaved across both EMIFs to optimize memory performance. If a system populates > 2 GB of physical memory, that additional addressable space can be accessed only by the MPU via the Arm V7 Large Physical Address Extensions (LPAE).
- (3) DCAN1 has one pin mux option that can optionally be used for MCAN functionality. DCAN2 has two pin mux options, one of which can be optionally used for MCAN functionality.
- (4) Wide Dynamic Range and Lens Distortion Correction.
- (5) For more details about the CTRL\_WKUP\_STD\_FUSE\_DIE\_ID\_2 register and Base PN bitfield, see the *TDA2Px Technical Reference Manual*.
- (6) X577Px is the base part number for the superset device. Software should constrain the features used to match the intended production device. The Base PN register bitfield value is 0x69.

## 3.2 Related Products

### Automotive Processors

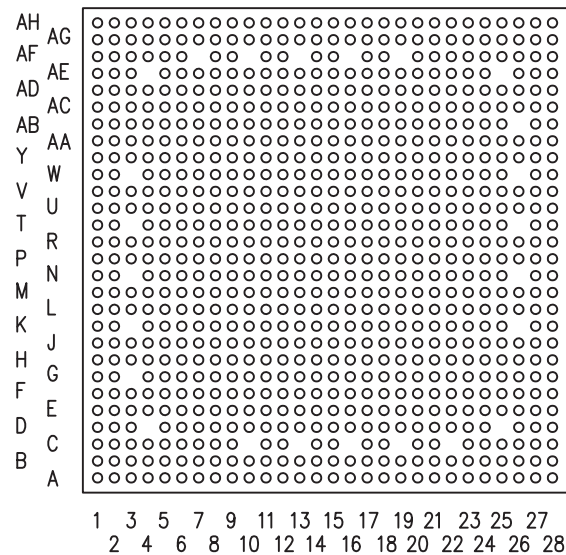
**TDAX ADAS SoCs** TI's TDAx Driver Assistance System-on-Chip (SoC) family offers scalable and open solutions and a common hardware and software architecture for Advanced Driver Assistance Systems (ADAS) applications including camera-based front (mono and stereo), rear, surround view and night vision systems, and mid- and long-range radar and sensor fusion systems.

**Companion Products for TDA2** Review products that are frequently purchased or used in conjunction with this product.

## 4 Terminal Configuration and Functions

### 4.1 Pin Diagram

Figure 4-1 shows the ball locations for the 760 plastic ball grid array (PBGA) package and are used in conjunction with Table 4-1 through Table 4-27 to locate signal names and ball grid numbers.



**Figure 4-1. ABZ S-PBGA-N760 Package (Bottom View)**

#### NOTE

The following bottom balls are not connected: AF7 / AF10 / AF13 / AF16 / AF19 / AE4 / AE25 / AB26 / W3 / W26 / T3 / T26 / N3 / N26 / K3 / K26 / G3 / D4 / D25 / C10 / C13 / C16 / C19 / C22.

These balls do not exist on the package.

### 4.2 Pin Attributes

Table 4-1 describes the terminal characteristics and the signals multiplexed on each ball. The following list describes the table column headers:

1. **BALL NUMBER:** Ball number(s) on the bottom side associated with each signal on the bottom.
2. **BALL NAME:** Mechanical name from package device (name is taken from muxmode 0).
3. **SIGNAL NAME:** Names of signals multiplexed on each ball (also notice that the name of the ball is the signal name in muxmode 0).

#### NOTE

Table 4-1 does not take into account the subsystem multiplexing signals. The subsystem multiplexing signals are described in Section 4.3, *Signal Descriptions*.

#### NOTE

In the Driver off mode, the buffer is configured in high-impedance.

4. **PHxx:** This column shows if the functionality is applicable for TDA2PHxx devices. Note that the Pin Attributes table presents the functionality of TDA2PSxx device.  
**PHxx - TDA2PHGx; TDA2PHFx; TDA2PHVx; TDA2PHAx;**

5. **MUXMODE:** Multiplexing mode number:

- a. MUXMODE 0 is the primary mode; this means that when MUXMODE = 0, the function mapped on the pin corresponds to the name of the pin. The primary muxmode is not necessarily the default muxmode.

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**NOTE**

The default muxmode is the mode at the release of the reset; also see the RESET REL. MUXMODE column.

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- b. MUXMODE 1 through 15 are possible muxmodes for alternate functions. On each pin, some muxmodes are effectively used for alternate functions, while some muxmodes are not used. Only MUXMODE values which correspond to defined functions should be used.
- c. An empty box means Not Applicable

6. **TYPE:** Signal type and direction:

- I = Input
- O = Output
- IO = Input or Output
- D = Open drain
- DS = Differential Signaling
- A = Analog
- PWR = Power
- GND = Ground
- CAP = LDO Capacitor

7. **BALL RESET STATE:** The state of the terminal at power-on reset:

- drive 0 (OFF): The buffer drives  $V_{OL}$  (pulldown or pullup resistor not activated)
- drive 1 (OFF): The buffer drives  $V_{OH}$  (pulldown or pullup resistor not activated)
- OFF: High-impedance
- PD: High-impedance with an active pulldown resistor
- PU: High-impedance with an active pullup resistor
- An empty box means Not Applicable

8. **BALL RESET REL. STATE:** The state of the terminal at the deactivation of the rstoutn signal (also mapped to the PRCM SYS\_WARM\_OUT\_RST signal)

- drive 0 (OFF): The buffer drives  $V_{OL}$  (pulldown or pullup resistor not activated)
  - drive clk (OFF): The buffer drives a toggling clock (pulldown or pullup resistor not activated)
  - drive 1 (OFF): The buffer drives  $V_{OH}$  (pulldown or pullup resistor not activated)
  - OFF: High-impedance
  - PD: High-impedance with an active pulldown resistor
  - PU: High-impedance with an active pullup resistor
  - An empty box means Not Applicable
- 

**NOTE**

For more information on the CORE\_PWRON\_RET\_RST reset signal and its reset sources, see the Power Reset and Clock Management / PRCM Reset Management Functional Description section of the Device TRM.

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9. **RESET REL. MUXMODE:** This muxmode is automatically configured at the release of the rstoutn signal (also mapped to the PRCM SYS\_WARM\_OUT\_RST signal).

An empty box means Not Applicable.

10. **IO VOLTAGE VALUE:** This column describes the IO voltage value (the corresponding power supply).

An empty box means Not Applicable.

11. **POWER:** The voltage supply that powers the terminal IO buffers.

An empty box means Not Applicable.

12. **HYS:** Indicates if the input buffer is with hysteresis:

- Yes: With hysteresis
- No: Without hysteresis
- An empty box: Not Applicable

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**NOTE**

For more information, see the hysteresis values in [Section 5.7, Electrical Characteristics](#).

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13. **BUFFER TYPE:** Drive strength of the associated output buffer.

An empty box means Not Applicable.

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**NOTE**

For programmable buffer strength:

- The default value is given in [Table 4-1](#).
  - A note describes all possible values according to the selected muxmode.
- 

14. **PULLUP / PULLDOWN TYPE:** Denotes the presence of an internal pullup or pulldown resistor.

Pullup and pulldown resistors can be enabled or disabled via software.

- PU: Internal pullup
- PD: Internal pulldown
- PU/PD: Internal pullup and pulldown
- PUx/PDy: Programmable internal pullup and pulldown
- PDy: Programmable internal pulldown
- An empty box means No pull

15. **DSIS:** The deselected input state (DSIS) indicates the state driven on the peripheral input (logic "0" or logic "1") when the peripheral pin function is not selected by any of the PINCNLTx registers.

- 0: Logic 0 driven on the peripheral's input signal port.
- 1: Logic 1 driven on the peripheral's input signal port.
- blank: Pin state driven on the peripheral's input signal port.

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**NOTE**

Configuring two pins to the same input signal is not supported as it can yield unexpected results. This can be easily prevented with the proper software configuration (Hi-Z mode is not an input signal).

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**NOTE**

When a pad is set into a multiplexing mode which is not defined by pin multiplexing, that pad's behavior is undefined. This should be avoided.

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**CAUTION**

Peripherals exposed in Ball Characteristics Table and Pin Multiplexing Table represent functionality of a superset device. Not all exposed peripherals are supported on ADAS devices. For peripherals supported on ADAS family of products please refer to [Table 3-1, Device Comparison](#).

**NOTE**

Some of the DDR1 and DDR2 signals have an additional state change at the release of porz. The state that the signals change to at the release of porz is as follows:

drive 0 (OFF) for: ddr1\_csn0, ddr1\_ck, ddr1\_nck, ddr1\_casn, ddr1\_rasn, ddr1\_wen, ddr1\_ba[2:0], ddr1\_a[15:0], ddr2\_csn0, ddr2\_ck, ddr2\_nck, ddr2\_casn, ddr2\_rasn, ddr2\_wen, ddr2\_ba[2:0], ddr2\_a[15:0].

OFF for: ddr1\_ecc\_d[7:0], ddr1\_dqm[3:0], ddr1\_dqm\_ecc, ddr1\_dqs[3:0], ddr1\_dqsn[3:0], ddr1\_dqs\_ecc, ddr1\_dqsn\_ecc, ddr1\_d[31:0], ddr2\_dqm[3:0], ddr2\_dqs[3:0], ddr2\_dqsn[3:0], ddr2\_d[31:0].

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Table 4-1. Pin Attributes<sup>(1)</sup>

| BALL NUMBER [1] | BALL NAME [2]      | SIGNAL NAME [3]    | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|--------------------|--------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| K9              | cap_vbbldo_dspeve  | cap_vbbldo_dspeve  |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| Y14             | cap_vbbldo_gpu     | cap_vbbldo_gpu     |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| R20             | cap_vbbldo_iva     | cap_vbbldo_iva     |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| J16             | cap_vbbldo_mpu     | cap_vbbldo_mpu     |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| L9              | cap_vddram_core1   | cap_vddram_core1   |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| J19             | cap_vddram_core2   | cap_vddram_core2   |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| Y15             | cap_vddram_core3   | cap_vddram_core3   |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| P19             | cap_vddram_core4   | cap_vddram_core4   |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| Y16             | cap_vddram_core5   | cap_vddram_core5   |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| J10             | cap_vddram_dspeve1 | cap_vddram_dspeve1 |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| J9              | cap_vddram_dspeve2 | cap_vddram_dspeve2 |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| Y13             | cap_vddram_gpu     | cap_vddram_gpu     |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| T20             | cap_vddram_iva     | cap_vddram_iva     |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| K16             | cap_vddram_mpu1    | cap_vddram_mpu1    |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| K19             | cap_vddram_mpu2    | cap_vddram_mpu2    |          |             | CAP      |                      |                           |                             |                        |            |          |                     |                        |           |
| G19             | dcan1_rx           | dcan1_rx           |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |                    | mcan_tx            |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | uart8_txd          |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | mmc2_sdwp          |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | sata1_led          |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | hdmi1_cec          |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | gpio1_15           |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | Driver off         |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| G20             | dcan1_tx           | dcan1_tx           |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |                    | mcan_tx            |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | uart8_rxd          |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | mmc2_sdcd          |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | hdmi1_hpd          |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | gpio1_14           |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | Driver off         |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AD20            | ddr1_a0            | ddr1_a0            |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVCMOS DDR          | Pux/PDy                |           |
| AC19            | ddr1_a1            | ddr1_a1            |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVCMOS DDR          | Pux/PDy                |           |
| AC20            | ddr1_a2            | ddr1_a2            |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVCMOS DDR          | Pux/PDy                |           |
| AB19            | ddr1_a3            | ddr1_a3            |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVCMOS DDR          | Pux/PDy                |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| AF21            | ddr1_a4       | ddr1_a4         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AH22            | ddr1_a5       | ddr1_a5         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AG23            | ddr1_a6       | ddr1_a6         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE21            | ddr1_a7       | ddr1_a7         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF22            | ddr1_a8       | ddr1_a8         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE22            | ddr1_a9       | ddr1_a9         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AD21            | ddr1_a10      | ddr1_a10        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AD22            | ddr1_a11      | ddr1_a11        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC21            | ddr1_a12      | ddr1_a12        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF18            | ddr1_a13      | ddr1_a13        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE17            | ddr1_a14      | ddr1_a14        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AD18            | ddr1_a15      | ddr1_a15        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF17            | ddr1_ba0      | ddr1_ba0        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE18            | ddr1_ba1      | ddr1_ba1        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AB18            | ddr1_ba2      | ddr1_ba2        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC18            | ddr1_casn     | ddr1_casn       |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AG24            | ddr1_ck       | ddr1_ck         |          | 0           | O        | PD                   | drive clk (OFF)           |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AG22            | ddr1_cke      | ddr1_cke        |          | 0           | O        | PD                   | drive 0 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AH23            | ddr1_csn0     | ddr1_csn0       |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF25            | ddr1_d0       | ddr1_d0         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF26            | ddr1_d1       | ddr1_d1         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AG26            | ddr1_d2       | ddr1_d2         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AH26            | ddr1_d3       | ddr1_d3         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| AF24            | ddr1_d4       | ddr1_d4         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE24            | ddr1_d5       | ddr1_d5         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF23            | ddr1_d6       | ddr1_d6         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE23            | ddr1_d7       | ddr1_d7         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC23            | ddr1_d8       | ddr1_d8         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF27            | ddr1_d9       | ddr1_d9         |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AG27            | ddr1_d10      | ddr1_d10        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF28            | ddr1_d11      | ddr1_d11        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE26            | ddr1_d12      | ddr1_d12        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC25            | ddr1_d13      | ddr1_d13        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC24            | ddr1_d14      | ddr1_d14        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AD25            | ddr1_d15      | ddr1_d15        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| V20             | ddr1_d16      | ddr1_d16        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| W20             | ddr1_d17      | ddr1_d17        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AB28            | ddr1_d18      | ddr1_d18        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC28            | ddr1_d19      | ddr1_d19        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC27            | ddr1_d20      | ddr1_d20        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y19             | ddr1_d21      | ddr1_d21        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AB27            | ddr1_d22      | ddr1_d22        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y20             | ddr1_d23      | ddr1_d23        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AA23            | ddr1_d24      | ddr1_d24        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y22             | ddr1_d25      | ddr1_d25        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y23             | ddr1_d26      | ddr1_d26        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| AA24            | ddr1_d27      | ddr1_d27        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y24             | ddr1_d28      | ddr1_d28        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AA26            | ddr1_d29      | ddr1_d29        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AA25            | ddr1_d30      | ddr1_d30        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AA28            | ddr1_d31      | ddr1_d31        |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AD23            | ddr1_dqm0     | ddr1_dqm0       |          | 0           | O        | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AB23            | ddr1_dqm1     | ddr1_dqm1       |          | 0           | O        | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AC26            | ddr1_dqm2     | ddr1_dqm2       |          | 0           | O        | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AA27            | ddr1_dqm3     | ddr1_dqm3       |          | 0           | O        | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| V26             | ddr1_dqm_ecc  | ddr1_dqm_ecc    | No       | 0           | O        | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AH25            | ddr1_dqs0     | ddr1_dqs0       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| AE27            | ddr1_dqs1     | ddr1_dqs1       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| AD27            | ddr1_dqs2     | ddr1_dqs2       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| Y28             | ddr1_dqs3     | ddr1_dqs3       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| AG25            | ddr1_dqsn0    | ddr1_dqsn0      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| AE28            | ddr1_dqsn1    | ddr1_dqsn1      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| AD28            | ddr1_dqsn2    | ddr1_dqsn2      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| Y27             | ddr1_dqsn3    | ddr1_dqsn3      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| V28             | ddr1_dqsn_ecc | ddr1_dqsn_ecc   | No       | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| V27             | ddr1_dqs_ecc  | ddr1_dqs_ecc    | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  |          | LVC MOS DDR      | Pux/PDy                |           |
| W22             | ddr1_ecc_d0   | ddr1_ecc_d0     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| V23             | ddr1_ecc_d1   | ddr1_ecc_d1     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| W19             | ddr1_ecc_d2   | ddr1_ecc_d2     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| W23             | ddr1_ecc_d3   | ddr1_ecc_d3     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y25             | ddr1_ecc_d4   | ddr1_ecc_d4     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| V24             | ddr1_ecc_d5   | ddr1_ecc_d5     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| V25             | ddr1_ecc_d6   | ddr1_ecc_d6     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y26             | ddr1_ecc_d7   | ddr1_ecc_d7     | No       | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AH24            | ddr1_nck      | ddr1_nck        |          | 0           | O        | PD                   | drive clk (OFF)           |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AE20            | ddr1_odt0     | ddr1_odt0       |          | 0           | O        | PD                   | drive 0 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AF20            | ddr1_rasn     | ddr1_rasn       |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| AG21            | ddr1_rst      | ddr1_rst        |          | 0           | O        | PD                   | drive 0 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| Y18             | ddr1_vref0    | ddr1_vref0      |          | 0           | PWR      | OFF                  | OFF                       |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      |                        |           |
| AH21            | ddr1_wen      | ddr1_wen        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr1  | No       | LVC MOS DDR      | Pux/PDy                |           |
| R25             | ddr2_a0       | ddr2_a0         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| R26             | ddr2_a1       | ddr2_a1         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| R28             | ddr2_a2       | ddr2_a2         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| R27             | ddr2_a3       | ddr2_a3         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| P23             | ddr2_a4       | ddr2_a4         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| P22             | ddr2_a5       | ddr2_a5         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| P25             | ddr2_a6       | ddr2_a6         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| N20             | ddr2_a7       | ddr2_a7         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| P27             | ddr2_a8       | ddr2_a8         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| N27             | ddr2_a9       | ddr2_a9         |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| N23             | ddr2_a10      | ddr2_a10        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| P26             | ddr2_a11      | ddr2_a11        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| N28             | ddr2_a12      | ddr2_a12        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| T22             | ddr2_a13      | ddr2_a13        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| R22             | ddr2_a14      | ddr2_a14        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| U22             | ddr2_a15      | ddr2_a15        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| U23             | ddr2_ba0      | ddr2_ba0        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| U27             | ddr2_ba1      | ddr2_ba1        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| U26             | ddr2_ba2      | ddr2_ba2        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| U28             | ddr2_casn     | ddr2_casn       |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| T28             | ddr2_ck       | ddr2_ck         |          | 0           | O        | PD                   | drive clk (OFF)           |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| U24             | ddr2_cke      | ddr2_cke        |          | 0           | O        | PD                   | drive 0 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| P24             | ddr2_csn0     | ddr2_csn0       |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| E26             | ddr2_d0       | ddr2_d0         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| G25             | ddr2_d1       | ddr2_d1         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| F25             | ddr2_d2       | ddr2_d2         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| F24             | ddr2_d3       | ddr2_d3         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| F26             | ddr2_d4       | ddr2_d4         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| F27             | ddr2_d5       | ddr2_d5         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| E27             | ddr2_d6       | ddr2_d6         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| E28             | ddr2_d7       | ddr2_d7         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| H23             | ddr2_d8       | ddr2_d8         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| H25             | ddr2_d9       | ddr2_d9         |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| H24             | ddr2_d10      | ddr2_d10        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| H26             | ddr2_d11      | ddr2_d11        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| G26             | ddr2_d12      | ddr2_d12        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| J25             | ddr2_d13      | ddr2_d13        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| J26             | ddr2_d14      | ddr2_d14        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| J24             | ddr2_d15      | ddr2_d15        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| L22             | ddr2_d16      | ddr2_d16        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| K20             | ddr2_d17      | ddr2_d17        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| K21             | ddr2_d18      | ddr2_d18        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| L23             | ddr2_d19      | ddr2_d19        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| L24             | ddr2_d20      | ddr2_d20        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| J23             | ddr2_d21      | ddr2_d21        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| K22             | ddr2_d22      | ddr2_d22        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| J20             | ddr2_d23      | ddr2_d23        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| L27             | ddr2_d24      | ddr2_d24        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| L26             | ddr2_d25      | ddr2_d25        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| L25             | ddr2_d26      | ddr2_d26        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| L28             | ddr2_d27      | ddr2_d27        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| M23             | ddr2_d28      | ddr2_d28        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| M24             | ddr2_d29      | ddr2_d29        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| M25             | ddr2_d30      | ddr2_d30        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| M26             | ddr2_d31      | ddr2_d31        |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| F28             | ddr2_dqm0     | ddr2_dqm0       |          | 0           | O        | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| G24             | ddr2_dqm1     | ddr2_dqm1       |          | 0           | O        | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |
| K23             | ddr2_dqm2     | ddr2_dqm2       |          | 0           | O        | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR      | Pux/PDy                |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]     | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|----------------------|------------------------|-----------|
| M22             | ddr2_dqm3     | ddr2_dqm3       |          | 0           | O        | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR          | Pux/PDy                |           |
| G28             | ddr2_dqs0     | ddr2_dqs0       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| H27             | ddr2_dqs1     | ddr2_dqs1       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| K27             | ddr2_dqs2     | ddr2_dqs2       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| M28             | ddr2_dqs3     | ddr2_dqs3       |          | 0           | IO       | PD                   | PD                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| G27             | ddr2_dqsn0    | ddr2_dqsn0      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| H28             | ddr2_dqsn1    | ddr2_dqsn1      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| K28             | ddr2_dqsn2    | ddr2_dqsn2      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| M27             | ddr2_dqsn3    | ddr2_dqsn3      |          | 0           | IO       | PU                   | PU                        |                             | 1.35/1.5/1.8           | vdds_ddr2  |          | LVC MOS DDR          | Pux/PDy                |           |
| T27             | ddr2_nck      | ddr2_nck        |          | 0           | O        | PD                   | drive clk (OFF)           |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR          | Pux/PDy                |           |
| R23             | ddr2_odt0     | ddr2_odt0       |          | 0           | O        | PD                   | drive 0 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR          | Pux/PDy                |           |
| T23             | ddr2_rasn     | ddr2_rasn       |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR          | Pux/PDy                |           |
| R24             | ddr2_rst      | ddr2_rst        |          | 0           | O        | PD                   | drive 0 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR          | Pux/PDy                |           |
| N22             | ddr2_vref0    | ddr2_vref0      |          | 0           | PWR      | OFF                  | OFF                       |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR          |                        |           |
| U25             | ddr2_wen      | ddr2_wen        |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.35/1.5/1.8           | vdds_ddr2  | No       | LVC MOS DDR          | Pux/PDy                |           |
| G21             | emu0          | emu0            |          | 0           | IO       | PU                   | PU                        | 0                           | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVC MOS | PU/PD                  |           |
|                 |               | gpio8_30        |          | 14          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
| D24             | emu1          | emu1            |          | 0           | IO       | PU                   | PU                        | 0                           | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVC MOS | PU/PD                  |           |
|                 |               | gpio8_31        |          | 14          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
| AC5             | gpio6_10      | gpio6_10        |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVC MOS | PU/PD                  |           |
|                 |               | mdio_mclk       |          | 1           | O        |                      |                           |                             |                        |            |          |                      |                        | 1         |
|                 |               | i2c3_sda        |          | 2           | IO       |                      |                           |                             |                        |            |          |                      |                        | 1         |
|                 |               | usb3_ulpi_d7    |          | 3           | IO       |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | vin2b_hsync1    |          | 4           | I        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | ehrpwm2A        |          | 10          | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | gpio6_10        |          | 14          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                      |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]     | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|---------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AB4             | gpio6_11      | gpio6_11            |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mdio_d              |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | i2c3_scl            |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | usb3_ulpi_d6        |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_vsync1        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm2B            |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_11            |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off          |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E21             | gpio6_14      | gpio6_14            |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mcasp1_axr8         |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | dcan2_tx<br>mcan_tx |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart10_rxd          |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_hsync         |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_hsync0        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c3_sda            |          | 9           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | timer1              |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_14            |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off          |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F20             | gpio6_15      | gpio6_15            |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mcasp1_axr9         |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | dcan2_rx<br>mcan_rx |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart10_txd          |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_vsync         |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_vsync0        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c3_scl            |          | 9           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | timer2              |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_15            |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off          |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F21             | gpio6_16      | gpio6_16            |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mcasp1_axr10        |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_fld           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_fld0          |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | clkout1             |          | 9           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | timer3              |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_16            |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off          |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]                 | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|---------------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| R6              | gpmc_a0       | gpmc_a0                         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_d16                       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d16                       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d0                        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d0                        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c4_scl                        |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart5_rxd                       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_3<br>gpmc_a26<br>gpmc_a16 |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| T9              | gpmc_a1       | gpmc_a1                         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_d17                       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d17                       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d1                        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d1                        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c4_sda                        |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart5_txd                       |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_4                         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| T6              | gpmc_a2       | gpmc_a2                         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_d18                       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d18                       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d2                        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d2                        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart7_rxd                       |          | 7           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart5_ctsn                      |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_5                         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| T7              | gpmc_a3       | gpmc_a3         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_cs2       |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin3a_d19       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d19       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d3        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d3        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart7_txd       |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart5_rtsn      |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_6         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| P6              | gpmc_a4       | gpmc_a4         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_cs3       |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin3a_d20       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d20       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d4        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d4        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c5_scl        |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart6_rxd       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio1_26        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| R9              | gpmc_a5       | gpmc_a5         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_d21       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d21       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d5        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d5        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c5_sda        |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart6_txd       |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_27        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| R5              | gpmc_a6       | gpmc_a6         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_d22       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d22       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d6        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d6        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart8_rxd       |          | 7           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart6_ctsn      |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio1_28        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| P5              | gpmc_a7       | gpmc_a7         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_d23       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d23       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d7        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d7        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart8_txd       |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart6_rtsn      |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_29        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| N7              | gpmc_a8       | gpmc_a8         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_hsync0    |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_hsync     |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_hsync1    |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer12         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_sclk       |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio1_30        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| R4              | gpmc_a9       | gpmc_a9         |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_vsync0    |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_vsync     |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_vsync1    |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer11         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_d1         |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio1_31        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| N9              | gpmc_a10      | gpmc_a10        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_de0       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_de        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_clk1      |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer10         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_d0         |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_0         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| P9              | gpmc_a11      | gpmc_a11        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin3a_fld0      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_fld       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_fld0      |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_de1       |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer9          |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_cs0        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio2_1         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| P4              | gpmc_a12      | gpmc_a12        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin4a_clk0      |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpmc_a0         |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_fld1      |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer8          |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_cs1        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | dma_evt1        |          | 9           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_2         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| R3              | gpmc_a13      | gpmc_a13        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_rtclk     |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4a_hsync0    |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer7          |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_cs2        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | dma_evt2        |          | 9           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_3         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| T2              | gpmc_a14      | gpmc_a14        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_d3        |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4a_vsync0    |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer6          |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_cs3        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio2_4         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| U2              | gpmc_a15      | gpmc_a15        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_d2        |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4a_d8        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer5          |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio2_5         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| U1              | gpmc_a16      | gpmc_a16        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_d0        |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4a_d9        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_6         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| P3              | gpmc_a17      | gpmc_a17        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_d1        |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4a_d10       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_7         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| R2              | gpmc_a18      | gpmc_a18        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_sclk      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d11       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_8         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| K7              | gpmc_a19      | gpmc_a19        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat4       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a13        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d12       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_d0        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| M7              | gpmc_a20      | gpmc_a20        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat5       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a14        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d13       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_d1        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_10        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| J5              | gpmc_a21      | gpmc_a21        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat6       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a15        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d14       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_d2        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_11        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| K6              | gpmc_a22      | gpmc_a22        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat7       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a16        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d15       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_d3        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_12        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| J7              | gpmc_a23      | gpmc_a23        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_clk        |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a17        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_fld0      |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_d4        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_13        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| J4              | gpmc_a24      | gpmc_a24        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat0       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a18        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3b_d5        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_14        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| J6              | gpmc_a25      | gpmc_a25        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat1       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a19        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3b_d6        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_15        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| H4              | gpmc_a26      | gpmc_a26        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat2       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a20        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3b_d7        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_16        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| H5              | gpmc_a27      | gpmc_a27        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_dat3       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a21        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3b_hsync1    |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_17        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| M6              | gpmc_ad0      | gpmc_ad0        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d0        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d0        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_6         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot0        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| M2              | gpmc_ad1      | gpmc_ad1        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d1        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d1        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_7         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot1        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| L5              | gpmc_ad2      | gpmc_ad2        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d2        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d2        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_8         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot2        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| M1              | gpmc_ad3      | gpmc_ad3        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d3        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d3        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot3        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| L6              | gpmc_ad4      | gpmc_ad4        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d4        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d4        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_10        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot4        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| L4              | gpmc_ad5      | gpmc_ad5        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d5        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d5        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_11        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot5        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| L3              | gpmc_ad6      | gpmc_ad6        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d6        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d6        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_12        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot6        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| L2              | gpmc_ad7      | gpmc_ad7        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d7        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d7        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_13        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot7        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| L1              | gpmc_ad8      | gpmc_ad8        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d8        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d8        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_18        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot8        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| K2              | gpmc_ad9      | gpmc_ad9        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d9        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d9        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_19        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot9        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| J1              | gpmc_ad10     | gpmc_ad10       |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d10       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d10       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_28        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot10       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| J2              | gpmc_ad11     | gpmc_ad11       |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d11       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d11       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_29        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot11       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| H1              | gpmc_ad12     | gpmc_ad12       |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d12       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d12       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_18        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot12       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| J3              | gpmc_ad13     | gpmc_ad13       |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d13       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d13       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_19        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot13       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| H2              | gpmc_ad14     | gpmc_ad14       |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d14       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d14       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_20        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot14       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| H3              | gpmc_ad15     | gpmc_ad15       |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_d15       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d15       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_21        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | sysboot15       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]      | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|----------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| N1              | gpmc_advn_ale | gpmc_advn_ale        |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpmc_cs6             |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | clkout2              |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_wait1           |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin4a_vsync0         |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpmc_a2              |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a23             |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | timer3               |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | i2c3_sda             |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | dma_evt2             |          | 9           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_23<br>gpmc_a19 |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off           |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| N6              | gpmc_ben0     | gpmc_ben0            |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpmc_cs4             |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin1b_hsync1         | No       | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_de1            |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer2               |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | dma_evt3             |          | 9           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_26<br>gpmc_a21 |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off           |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| M4              | gpmc_ben1     | gpmc_ben1            |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpmc_cs5             |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin1b_de1            | No       | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_clk1           |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpmc_a3              |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3b_fld1           |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer1               |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | dma_evt4             |          | 9           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_27<br>gpmc_a22 |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off           |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]                  | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|----------------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| P7              | gpmc_clk      | gpmc_clk                         |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | gpmc_cs7                         |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | clkout1                          |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_wait1                       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin4a_hsync0                     |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4a_de0                        |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_clk1                       |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer4                           |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | i2c3_scl                         |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | dma_evt1                         |          | 9           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_22<br>gpmc_a20             |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| T1              | gpmc_cs0      | gpmc_cs0                         |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpio2_19                         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                                  |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| H6              | gpmc_cs1      | gpmc_cs1                         |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv11   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc2_cmd                         |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpmc_a22                         |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_de0                        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3b_vsync1                     |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_18                         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| P2              | gpmc_cs2      | gpmc_cs2                         |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_cs0                        |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio2_20<br>gpmc_a23<br>gpmc_a13 |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                                  |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| P1              | gpmc_cs3      | gpmc_cs3                         |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | qspi1_cs1                        |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin3a_clk0                       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_clk                        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a1                          |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio2_21<br>gpmc_a24<br>gpmc_a14 |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off                       |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                                  |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                                  |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]        | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|-------------------------|------------------------|-----------|
| M5              | gpmc_oen_ren  | gpmc_oen_ren    |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS     | PU/PD                  |           |
|                 |               | gpio2_24        |          | 14          | IO       |                      |                           |                             |                        |            |          |                         |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                         |                        |           |
| N2              | gpmc_wait0    | gpmc_wait0      |          | 0           | I        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS     | PU/PD                  | 1         |
|                 |               | gpio2_28        |          | 14          | IO       |                      |                           |                             |                        |            |          |                         |                        |           |
|                 |               | gpmc_a25        |          | 14          | IO       |                      |                           |                             |                        |            |          |                         |                        |           |
| M3              | gpmc_wen      | gpmc_wen        |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv10   | Yes      | Dual Voltage LVCMOS     | PU/PD                  |           |
|                 |               | gpio2_25        |          | 14          | IO       |                      |                           |                             |                        |            |          |                         |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                         |                        |           |
| AG16            | hdmi1_clockx  | hdmi1_clockx    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| AH16            | hdmi1_clocky  | hdmi1_clocky    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| AG17            | hdmi1_data0x  | hdmi1_data0x    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| AH17            | hdmi1_data0y  | hdmi1_data0y    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| AG18            | hdmi1_data1x  | hdmi1_data1x    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| AH18            | hdmi1_data1y  | hdmi1_data1y    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| AG19            | hdmi1_data2x  | hdmi1_data2x    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| AH19            | hdmi1_data2y  | hdmi1_data2y    |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_hdmi  |          | HDMIPHY                 | PDy                    |           |
| C20             | i2c1_scl      | i2c1_scl        |          | 0           | IO       | OFF                  | OFF                       |                             | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS I2C | PU/PD                  |           |
| C21             | i2c1_sda      | i2c1_sda        |          | 0           | IO       | OFF                  | OFF                       |                             | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS I2C | PU/PD                  |           |
| F17             | i2c2_scl      | i2c2_scl        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS I2C | PU/PD                  | 1         |
|                 |               | hdmi1_ddc_sda   |          | 1           | IO       |                      |                           |                             |                        |            |          |                         |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                         |                        |           |
| C25             | i2c2_sda      | i2c2_sda        |          | 0           | IO       | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS I2C | PU/PD                  | 1         |
|                 |               | hdmi1_ddc_scl   |          | 1           | IO       |                      |                           |                             |                        |            |          |                         |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                         |                        |           |
| AH15            | ljcb_clkn     | ljcb_clkn       |          | 0           | IO       |                      |                           |                             | 1.8                    | vdda_pcie  |          | LJCB                    |                        |           |
| AG15            | ljcb_clkp     | ljcb_clkp       |          | 0           | IO       |                      |                           |                             | 1.8                    | vdda_pcie  |          | LJCB                    |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| B14             | mcasep1_aclkr | mcasep1_aclkr   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep7_axr2    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d0        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d0        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c4_sda        |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_0         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C14             | mcasep1_aclkx | mcasep1_aclkx   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | i2c3_sda        |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_31        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| G12             | mcasep1_axr0  | mcasep1_axr0    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | uart6_rxd       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | i2c5_sda        |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_2         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F12             | mcasep1_axr1  | mcasep1_axr1    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | uart6_txd       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | i2c5_scl        |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_3         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| G13             | mcasep1_axr2  | mcasep1_axr2    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep6_axr2    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart6_ctsn      |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d2        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d2        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_4         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| J11             | mcasep1_axr3  | mcasep1_axr3    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep6_axr3    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart6_rtsn      |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d3        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d3        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_5         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| E12             | mcasep1_axr4  | mcasep1_axr4    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep4_axr2    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d4        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d4        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_6         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F13             | mcasep1_axr5  | mcasep1_axr5    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep4_axr3    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d5        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d5        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_7         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C12             | mcasep1_axr6  | mcasep1_axr6    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep5_axr2    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d6        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d6        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_8         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| D12             | mcasep1_axr7  | mcasep1_axr7    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep5_axr3    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d7        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d7        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer4          |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio5_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| B12             | mcasep1_axr8  | mcasep1_axr8    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep6_axr0    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_sclk       |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer5          |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio5_10        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A11             | mcasep1_axr9  | mcasep1_axr9    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep6_axr1    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_d1         |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer6          |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio5_11        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| B13             | mcasep1_axr10 | mcasep1_axr10   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep6_acllx   |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasep6_aclkr   |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_d0         |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer7          |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio5_12        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A12             | mcasep1_axr11 | mcasep1_axr11   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep6_fsx     |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasep6_fsr     |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_cs0        |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | timer8          |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_17        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E14             | mcasep1_axr12 | mcasep1_axr12   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep7_axr0    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_cs1        |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | timer9          |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_18        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A13             | mcasep1_axr13 | mcasep1_axr13   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep7_axr1    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | timer10         |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_4         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| G14             | mcasep1_axr14 | mcasep1_axr14   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep7_acllx   |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasep7_aclkr   |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | timer11         |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_5         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F14             | mcasep1_axr15 | mcasep1_axr15   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep7_fsx     |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasep7_fsr     |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | timer12         |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_6         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| J14             | mcasep1_fsr   | mcasep1_fsr     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep7_axr3    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d1        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d1        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | i2c4_scl        |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_1         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| D14             | mcasep1_fsx   | mcasep1_fsx     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | i2c3_scl        |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_30        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E15             | mcasep2_aclkr | mcasep2_aclkr   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep8_axr2    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d8        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d8        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A19             | mcasep2_aclkx | mcasep2_aclkx   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B15             | mcasep2_axr0  | mcasep2_axr0    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d10       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d10       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A15             | mcasep2_axr1  | mcasep2_axr1    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d11       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d11       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C15             | mcasep2_axr2  | mcasep2_axr2    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep3_axr2    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio6_8         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A16             | mcasep2_axr3  | mcasep2_axr3    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep3_axr3    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio6_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| D15             | mcasep2_axr4  | mcasep2_axr4    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep8_axr0    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d12       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d12       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio1_4         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B16             | mcasep2_axr5  | mcasep2_axr5    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep8_axr1    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d13       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d13       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio6_7         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B17             | mcasep2_axr6  | mcasep2_axr6    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep8_acllx   |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasep8_aclkr   |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d14       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d14       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_29        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| A17             | mcasep2_axr7  | mcasep2_axr7    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep8_fsx     |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasep8_fsr     |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d15       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d15       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio1_5         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| A20             | mcasep2_fsr   | mcasep2_fsr     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep8_axr3    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d9        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d9        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A18             | mcasep2_fsx   | mcasep2_fsx     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| B18             | mcasep3_aclkx | mcasep3_aclkx   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep3_aclkx   |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mcasep2_axr12   |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart7_rxd       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_13        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B19             | mcasep3_axr0  | mcasep3_axr0    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep2_axr14   |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart7_ctsn      |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart5_rxd       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| C17             | mcasep3_axr1  | mcasep3_axr1    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep2_axr15   |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart7_rtsn      |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart5_txd       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| F15             | mcasep3_fsx   | mcasep3_fsx     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep3_fsr     |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mcasep2_axr13   |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart7_txd       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio5_14        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C18             | mcasep4_aclkx | mcasep4_aclkx   |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep4_aclkx   |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_sclk       |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart8_rxd       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | i2c4_sda        |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d16       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d16       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| G16             | mcasep4_axr0  | mcasep4_axr0    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | spi3_d0         |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart8_ctsn      |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart4_rxd       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d18       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d18       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| D17             | mcas4_axr1    | mcasp4_axr1     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | spi3_cs0        |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart8_rtsn      |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart4_bxd       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d19       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d19       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A21             | mcas4_fsx     | mcasp4_fsx      |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasp4_fsr      |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_d1         |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart8_bxd       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | i2c4_scl        |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d17       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d17       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
| AA3             | mcas5_aclkx   | mcasp5_aclkx    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasp5_aclkr    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_sclk       |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart9_rxd       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | i2c5_sda        |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d20       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d20       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
| AB3             | mcas5_axr0    | mcasp5_axr0     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | spi4_d0         |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart9_ctsn      |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart3_rxd       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d22       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d22       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AA4             | mcas5_axr1    | mcasp5_axr1     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | spi4_cs0        |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart9_rtsn      |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart3_bxd       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d23       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d23       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AB9             | mcasep5_fsx   | mcasep5_fsx     |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mcasep5_fsr     |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_d1         |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart9_bxd       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | i2c5_scl        |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d21       |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d21       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| U4              | mdio_d        | mdio_d          |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart3_ctsn      |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | mii0_txer       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_d0        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d0        |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_16        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| V1              | mdio_mclk     | mdio_mclk       |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart3_rtsn      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii0_col        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_clk0      |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_clk1      |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_15        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| W6              | mmc1_clk      | mmc1_clk        |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | SDIO1833            | PU/PD                  | 1         |
|                 |               | gpio6_21        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| Y6              | mmc1_cmd      | mmc1_cmd        |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | SDIO1833            | PU/PD                  | 1         |
|                 |               | gpio6_22        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AA6             | mmc1_dat0     | mmc1_dat0       |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | SDIO1833            | PU/PD                  | 1         |
|                 |               | gpio6_23        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| Y4              | mmc1_dat1     | mmc1_dat1       |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | SDIO1833            | PU/PD                  | 1         |
|                 |               | gpio6_24        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AA5             | mmc1_dat2     | mmc1_dat2       |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | SDIO1833            | PU/PD                  | 1         |
|                 |               | gpio6_25        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]        | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| Y3              | mmc1_dat3     | mmc1_dat3              |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | SDIO1833            | PU/PD                  | 1         |
|                 |               | gpio6_26               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| W7              | mmc1_sdcd     | mmc1_sdcd              |          | 0           | I        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart6_rxd              |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | i2c4_sda               |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio6_27               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| Y9              | mmc1_sdwp     | mmc1_sdwp              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv8    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | uart6_txd              |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | i2c4_scl               |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio6_28               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AD4             | mmc3_clk      | mmc3_clk               |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | usb3_ulpi_d5           |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d7               |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | ehrpwm2_tripzone_input |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio6_29               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AC4             | mmc3_cmd      | mmc3_cmd               |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi3_sclk              |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d4           |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d6               |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eCAP2_in_PWM2_out      |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio6_30               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AC7             | mmc3_dat0     | mmc3_dat0              |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi3_d1                |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart5_rxd              |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | usb3_ulpi_d3           |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d5               |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP3A_in              |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio6_31               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AC6             | mmc3_dat1     | mmc3_dat1       |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi3_d0         |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart5_txd       |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | usb3_ulpi_d2    |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d4        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP3B_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio7_0         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AC9             | mmc3_dat2     | mmc3_dat2       |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi3_cs0        |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart5_ctsn      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | usb3_ulpi_d1    |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d3        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP3_index     |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio7_1         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AC3             | mmc3_dat3     | mmc3_dat3       |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi3_cs1        |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart5_rtsn      |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | usb3_ulpi_d0    |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d2        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP3_strobe    |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio7_2         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AC8             | mmc3_dat4     | mmc3_dat4       |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi4_sclk       |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart10_rxd      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | usb3_ulpi_nxt   |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d1        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | ehrpwm3A        |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_22        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]        | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AD6             | mmc3_dat5     | mmc3_dat5              |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi4_d1                |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart10_txd             |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | usb3_ulpi_dir          |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_d0               |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | ehrpwm3B               |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_23               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AB8             | mmc3_dat6     | mmc3_dat6              |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi4_d0                |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart10_ctsn            |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | usb3_ulpi_stp          |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2b_de1              |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm3_tripzone_input |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio1_24               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AB5             | mmc3_dat7     | mmc3_dat7              |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv7    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | spi4_cs0               |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart10_rtsn            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | usb3_ulpi_clk          |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2b_clk1             |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eCAP3_in_PWM3_out      |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio1_25               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| D21             | nmin_dsp      | nmin_dsp               |          | 0           | I        | PD                   | PD                        |                             | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
| Y11             | on_off        | on_off                 |          | 0           | O        | PU                   | drive 1 (OFF)             |                             | 1.8/3.3                | vddshv5    | Yes      | BC1833IHH V         | PU/PD                  |           |
| AG13            | pcie_rxn0     | pcie_rxn0              |          | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_pcie0 |          | SERDES              |                        |           |
| AG11            | pcie_rxn1     | pcie_rxn1              | No       | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_pcie1 |          | SERDES              |                        |           |
| AH13            | pcie_rxp0     | pcie_rxp0              |          | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_pcie0 |          | SERDES              |                        |           |
| AH11            | pcie_rxp1     | pcie_rxp1              | No       | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_pcie1 |          | SERDES              |                        |           |
| AG14            | pcie_txn0     | pcie_txn0              |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_pcie0 |          | SERDES              |                        |           |
| AG12            | pcie_txn1     | pcie_txn1              | No       | 0           | O        |                      |                           |                             | 1.8                    | vdda_pcie1 |          | SERDES              |                        |           |
| AH14            | pcie_txp0     | pcie_txp0              |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_pcie0 |          | SERDES              |                        |           |
| AH12            | pcie_txp1     | pcie_txp1              | No       | 0           | O        |                      |                           |                             | 1.8                    | vdda_pcie1 |          | SERDES              |                        |           |
| F22             | porz          | porz                   |          | 0           | I        |                      |                           |                             | 1.8/3.3                | vddshv3    | Yes      | IHHV1833            | PU/PD                  |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| E23             | resetrn       | resetrn         |          | 0           | I        | PU                   | PU                        |                             | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
| U5              | rgmii0_rxc    | rgmii0_rxc      |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rmii1_txen      |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii0_txclk      |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_d5        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d5        |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d2    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_26        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| V5              | rgmii0_rxctl  | rgmii0_rxctl    |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rmii1_txd1      |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii0_txd3       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2a_d6        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d6        |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d3    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_27        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| W2              | rgmii0_rxd0   | rgmii0_rxd0     |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rmii0_txd0      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii0_txd0       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2a_fld0      |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_fld1      |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d7    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_31        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| Y2              | rgmii0_rxd1   | rgmii0_rxd1     |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rmii0_txd1      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii0_txd1       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2a_d9        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d6    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_30        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| V3              | rgmii0_rxd2   | rgmii0_rxd2     |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rmii0_txen      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii0_txen       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2a_d8        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d5    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_29        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| V4              | rgmii0_rxd3   | rgmii0_rxd3     |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rmii1_txd0      |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii0_txd2       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2a_d7        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d7        |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d4    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio5_28        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| W9              | rgmii0_txc    | rgmii0_txc      |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart3_ctsn      |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | rmii1_rxd1      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii0_rxd3       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_d3        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d3        |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_clk   |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_d0         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi4_cs2        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_20        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| V9              | rgmii0_txcctl | rgmii0_txcctl   |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart3_rtsn      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | rmii1_rxd0      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii0_rxd2       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_d4        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin4b_d4        |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_stp   |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_cs0        |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | spi4_cs3        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_21        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| V9              | rgmii0_txcctl | Driver off      |          | 15          | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| U6              | rgmii0_txd0   | rgmii0_txd0     |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | rmii0_rxd0      |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii0_rxd0       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_d10       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d1    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi4_cs0        |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart4_rtsn      |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio5_25        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| V6              | rgmii0_txd1   | rgmii0_txd1     |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | rmii0_rxd1      |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii0_rxd1       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_vsync0    |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_vsync1    |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_d0    |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi4_d0         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart4_ctsn      |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio5_24        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| U7              | rgmii0_txd2   | rgmii0_txd2     |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | rmii0_rxer      |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii0_rxer       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_hsync0    |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4b_hsync1    |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb4_ulpi_nxt   |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi4_d1         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart4_txd       |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio5_23        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1] | BALL NAME [2]      | SIGNAL NAME [3]    | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|--------------------|--------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| V7              | rgmii0_txd3        | rgmii0_txd3        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |                    | rmii0_crs          |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |                    | mii0_crs           |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |                    | vin2a_de0          |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |                    | vin4b_de1          |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |                    | usb4_ulpi_dir      |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |                    | spi4_sclk          |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |                    | uart4_rxd          |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |                    | gpio5_22           |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | Driver off         |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| U3              | RMII_MHZ_50_CLK    | RMII_MHZ_50_CLK    |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |                    | vin2a_d11          |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |                    | gpio5_17           |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | Driver off         |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F23             | rstoutn            | rstoutn            |          | 0           | O        | PD                   | drive 1 (OFF)             |                             | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
| E18             | rtck               | rtck               |          | 0           | O        | PU                   | drive clk (OFF)           | 0                           | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |                    | gpio8_29           |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| AF14            | rtc_iso            | rtc_iso            |          | 0           | I        |                      |                           |                             | 1.8/3.3                | vddshv5    | Yes      | IHHV1833            | PU/PD                  |           |
| AE14            | rtc_osc_xi_clkin32 | rtc_osc_xi_clkin32 |          | 0           | I        |                      |                           |                             | 1.8                    | vdda_rtc   | No       | LVCMOS OSC          |                        |           |
| AD14            | rtc_osc_xo         | rtc_osc_xo         |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_rtc   | No       | LVCMOS OSC          |                        |           |
| AB17            | rtc_porz           | rtc_porz           |          | 0           | I        |                      |                           |                             | 1.8/3.3                | vddshv5    | Yes      | IHHV1833            | PU/PD                  |           |
| AH9             | sata1_rxn0         | sata1_rxn0         |          | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_sata  |          | SATAPHY             |                        |           |
| AG9             | sata1_rxp0         | sata1_rxp0         |          | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_sata  |          | SATAPHY             |                        |           |
| AG10            | sata1_txn0         | sata1_txn0         |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_sata  |          | SATAPHY             |                        |           |
| AH10            | sata1_txp0         | sata1_txp0         |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_sata  |          | SATAPHY             |                        |           |
| A24             | spi1_cs0           | spi1_cs0           |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |                    | gpio7_10           |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | Driver off         |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A22             | spi1_cs1           | spi1_cs1           |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |                    | sata1_led          |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | spi2_cs1           |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |                    | gpio7_11           |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |                    | Driver off         |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| B21             | spi1_cs2      | spi1_cs2        |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart4_rxd       |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | mmc3_sdcd       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | spi2_cs2        |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | dcan2_tx        |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | mdio_mclk       |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | hdmi1_hpd       |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_12        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B20             | spi1_cs3      | spi1_cs3        |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart4_bxd       |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mmc3_sdwpi      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi2_cs3        |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | dcan2_rx        |          | 4           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | mdio_d          |          | 5           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | hdmi1_cec       |          | 6           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_13        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B25             | spi1_d0       | spi1_d0         |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | gpio7_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F16             | spi1_d1       | spi1_d1         |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | gpio7_8         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A25             | spi1_sclk     | spi1_sclk       |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | gpio7_7         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B24             | spi2_cs0      | spi2_cs0        |          | 0           | IO       | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart3_rtsn      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart5_txd       |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_17        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| G17             | spi2_d0       | spi2_d0         |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | uart3_ctsn      |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart5_rxd       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_16        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| B22             | spi2_d1       | spi2_d1         |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | uart3_txd       |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio7_15        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A26             | spi2_sclk     | spi2_sclk       |          | 0           | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | uart3_rxd       |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_14        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E20             | tclk          | tclk            |          | 0           | I        | PU                   | PU                        | 0                           | 1.8/3.3                | vddshv3    | Yes      | IQ1833              | PU/PD                  |           |
| D23             | tdi           | tdi             |          | 0           | I        | PU                   | PU                        | 0                           | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpio8_27        |          | 14          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F19             | tdo           | tdo             |          | 0           | O        | PU                   | PU                        | 0                           | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpio8_28        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| F18             | tms           | tms             |          | 0           | IO       | OFF                  | OFF                       | 0                           | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
| D20             | trstn         | trstn           |          | 0           | I        | PD                   | PD                        |                             | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
| E25             | uart1_ctsn    | uart1_ctsn      |          | 0           | I        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart9_rxd       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | mmc4_clk        |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_24        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C27             | uart1_rtsn    | uart1_rtsn      |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart9_txd       |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mmc4_cmd        |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_25        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B27             | uart1_rxd     | uart1_rxd       |          | 0           | I        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | mmc4_sdcd       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_22        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C26             | uart1_txd     | uart1_txd       |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mmc4_sdw        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio7_23        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| D27             | uart2_ctsn    | uart2_ctsn      |          | 0           | I        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart3_rxd       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | mmc4_dat2       |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart10_rxd      |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart1_dtrn      |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio1_16        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C28             | uart2_rtsn    | uart2_rtsn      |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart3_txd       |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart3_irtx      |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mmc4_dat3       |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart10_txd      |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart1_rin       |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio1_17        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| D28             | uart2_rxd     | uart3_ctsn      |          | 1           | I        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | uart3_rctx      |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mmc4_dat0       |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart2_rxd       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart1_dcdn      |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio7_26        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| D26             | uart2_txd     | uart2_txd       |          | 0           | O        | PU                   | PU                        | 15                          | 1.8/3.3                | vddshv4    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart3_rtsn      |          | 1           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart3_sd        |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mmc4_dat1       |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | uart2_txd       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart1_dsrn      |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio7_27        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11]   | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|--------------|----------|---------------------|------------------------|-----------|
| V2              | uart3_rxd     | uart3_rxd       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9      | Yes      | Dual Voltage LVCMOS | PU/PD                  | 1         |
|                 |               | rmii1_crs       |          | 2           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | mii0_rxdv       |          | 3           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | vin2a_d1        |          | 4           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | vin4b_d1        |          | 5           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | spi3_sclk       |          | 7           | IO       |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | gpio5_18        |          | 14          | IO       |                      |                           |                             |                        |              |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |              |          |                     |                        |           |
| Y1              | uart3_txd     | uart3_txd       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv9      | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | rmii1_rxr       |          | 2           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | mii0_rxcclk     |          | 3           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | vin2a_d2        |          | 4           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | vin4b_d2        |          | 5           | I        |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | spi3_d1         |          | 7           | IO       |                      |                           |                             |                        |              |          |                     |                        | 0         |
|                 |               | spi4_cs1        |          | 8           | IO       |                      |                           |                             |                        |              |          |                     |                        | 1         |
|                 |               | gpio5_19        |          | 14          | IO       |                      |                           |                             |                        |              |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |              |          |                     |                        |           |
| AC12            | usb1_dm       | usb1_dm         |          | 0           | IO       | OFF                  | OFF                       |                             | 3.3                    | vdda33v_usb1 |          | USBPHY              |                        |           |
| AD12            | usb1_dp       | usb1_dp         |          | 0           | IO       | OFF                  | OFF                       |                             | 3.3                    | vdda33v_usb1 |          | USBPHY              |                        |           |
| AB10            | usb1_drvvbus  | usb1_drvvbus    |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6      | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | timer16         |          | 7           | IO       |                      |                           |                             |                        |              |          |                     |                        |           |
|                 |               | gpio6_12        |          | 14          | IO       |                      |                           |                             |                        |              |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |              |          |                     |                        |           |
| AF11            | usb2_dm       | usb2_dm         |          | 0           | IO       |                      |                           |                             | 3.3                    | vdda33v_usb2 | No       | USBPHY              |                        |           |
| AE11            | usb2_dp       | usb2_dp         |          | 0           | IO       |                      |                           |                             | 3.3                    | vdda33v_usb2 | No       | USBPHY              |                        |           |
| AC10            | usb2_drvvbus  | usb2_drvvbus    |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6      | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | timer15         |          | 7           | IO       |                      |                           |                             |                        |              |          |                     |                        |           |
|                 |               | gpio6_13        |          | 14          | IO       |                      |                           |                             |                        |              |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |              |          |                     |                        |           |
| AF12            | usb_rxn0      | usb_rxn0        |          | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_usb1    |          | SERDES              |                        |           |
| AE12            | usb_rxp0      | usb_rxp0        |          | 0           | I        | OFF                  | OFF                       |                             | 1.8                    | vdda_usb1    |          | SERDES              |                        |           |
| AC11            | usb_txn0      | usb_txn0        |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_usb1    |          | SERDES              |                        |           |
| AD11            | usb_txp0      | usb_txp0        |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_usb1    |          | SERDES              |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1]                                                                                              | BALL NAME [2]  | SIGNAL NAME [3]    | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|--------------------------------------------------------------------------------------------------------------|----------------|--------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| H13, H14, J17, J18, L7, L8, N10, N13, P11, P12, P13, R11, R16, R19, T13, T16, T19, U13, U16, U8, U9, V16, V8 | vdd            | vdd                |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| K14                                                                                                          | vpp            | vpp <sup>(6)</sup> |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AA12                                                                                                         | vdda33v_usb1   | vdda33v_usb1       |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| Y12                                                                                                          | vdda33v_usb2   | vdda33v_usb2       |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| M14                                                                                                          | vdda_abe_per   | vdda_abe_per       |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| P16                                                                                                          | vdda_ddr       | vdda_ddr           |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| N11                                                                                                          | vdda_debug     | vdda_debug         |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| N12                                                                                                          | vdda_dsp_eve   | vdda_dsp_eve       |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| P15                                                                                                          | vdda_gmac_core | vdda_gmac_core     |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| R14                                                                                                          | vdda_gpu       | vdda_gpu           |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| Y17                                                                                                          | vdda_hdmi      | vdda_hdmi          |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| R17                                                                                                          | vdda_iva       | vdda_iva           |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| N16                                                                                                          | vdda_mpu       | vdda_mpu           |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AD16, AE16                                                                                                   | vdda_osc       | vdda_osc           |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| W14                                                                                                          | vdda_pcie      | vdda_pcie          |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AA17                                                                                                         | vdda_pcie0     | vdda_pcie0         |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AA16                                                                                                         | vdda_pcie1     | vdda_pcie1         |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AB13                                                                                                         | vdda_rtc       | vdda_rtc           |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| V13                                                                                                          | vdda_sata      | vdda_sata          |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AA13                                                                                                         | vdda_usb1      | vdda_usb1          |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AB12                                                                                                         | vdda_usb2      | vdda_usb2          |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| W12                                                                                                          | vdda_usb3      | vdda_usb3          |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| P14                                                                                                          | vdda_video     | vdda_video         |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| G18, H17, M8, M9, N8, P8, R8, T8, V21, V22, W17, W18                                                         | vdds18v        | vdds18v            |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| AA18, AA19, W21, Y21                                                                                         | vdds18v_ddr1   | vdds18v_ddr1       |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| J21, J22, N21, P20, P21                                                                                      | vdds18v_ddr2   | vdds18v_ddr2       |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| E3, E5, G4, G5, H8, H9                                                                                       | vddshv1        | vddshv1            |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |
| B6, D10, E10, H10, H11                                                                                       | vddshv2        | vddshv2            |          |             | PWR      |                      |                           |                             |                        |            |          |                  |                        |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1]                                                                | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|--------------------------------------------------------------------------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| B23, D16, D22, E16, E22, G15, H15, H16, H18, H19                               | vddshv3       | vddshv3         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| C24                                                                            | vddshv4       | vddshv4         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| V12                                                                            | vddshv5       | vddshv5         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| AD5, AD7, AE7, AF5                                                             | vddshv6       | vddshv6         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| AB6, AB7                                                                       | vddshv7       | vddshv7         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| W8, Y8                                                                         | vddshv8       | vddshv8         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| U10, W4, W5                                                                    | vddshv9       | vddshv9         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| N4, N5, P10, R10, R7, T4, T5                                                   | vddshv10      | vddshv10        |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| J8, K8                                                                         | vddshv11      | vddshv11        |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| AA21, AA22, AB21, AB22, AB24, AB25, AC22, AD26, AG20, AG28, AH27, W16, W27     | vdds_ddr1     | vdds_ddr1       |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| E24, G22, G23, H20, H21, H22, J27, L20, L21, M20, M21, T24, T25                | vdds_ddr2     | vdds_ddr2       |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| AA7, Y7                                                                        | vdds_milbp    | vdds_milbp      |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| J13, K10, K11, K12, K13, L10, L11, L12, M10, M11, M12, M13                     | vdd_dspeve    | vdd_dspeve      |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| U11, U12, V10, V11, V14, W10, W11, W13                                         | vdd_gpu       | vdd_gpu         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| U18, U19, V18, V19                                                             | vdd_iva       | vdd_iva         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| K17, K18, L15, L16, L17, L18, L19, M15, M16, M17, M18, N17, N18, P17, P18, R18 | vdd_mpu       | vdd_mpu         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| AB15                                                                           | vdd_rtc       | vdd_rtc         |          |             | PWR      |                      |                           |                             |                        |            |          |                     |                        |           |
| AG8                                                                            | vin1a_clk0    | vin1a_clk0      | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                                                                                |               | vout3_d16       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                                                                                |               | vout3_fld       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                                                                                |               | gpio2_30        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                                                                                |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]        | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AE8             | vin1a_d0      | vin1a_d0               | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d7               |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d23              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart8_rxd              |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | ehrpwm1A               |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_4                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AD8             | vin1a_d1      | vin1a_d1               | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d6               |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d22              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart8_bxd              |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm1B               |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_5                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AG7             | vin1a_d2      | vin1a_d2               | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d5               |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d21              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart8_ctsn             |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | ehrpwm1_tripzone_input |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_6                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AH6             | vin1a_d3      | vin1a_d3               | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d4               |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d20              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart8_rtsn             |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eCAP1_in_PWM1_out      |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_7                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AH3             | vin1a_d4      | vin1a_d4               | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d3               |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d19              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm1_synci          |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_8                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AH5             | vin1a_d5      | vin1a_d5        | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d2        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d18       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm1_synco   |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AG6             | vin1a_d6      | vin1a_d6        | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d1        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d17       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP2A_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_10        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AH4             | vin1a_d7      | vin1a_d7        | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout3_d0        |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout3_d16       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP2B_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_11        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AG4             | vin1a_d8      | vin1a_d8        | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d7        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d15       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP2_index     |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_12        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AG2             | vin1a_d9      | vin1a_d9        | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d6        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d14       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP2_strobe    |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_13        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AG3             | vin1a_d10     | vin1a_d10       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d5        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d13       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_14        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AG5             | vin1a_d11     | vin1a_d11       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d4        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d12       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a23        |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_15        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AF2             | vin1a_d12     | vin1a_d12       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d3        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d7    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d11       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a24        |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_16        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AF6             | vin1a_d13     | vin1a_d13       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d2        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d6    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d10       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a25        |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_17        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AF3             | vin1a_d14     | vin1a_d14       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d1        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d5    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d9        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a26        |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_18        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AF4             | vin1a_d15     | vin1a_d15       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d0        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d4    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d8        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a27        |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio3_19        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AF1             | vin1a_d16     | vin1a_d16       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d7        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d3    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d7        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d0        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_20        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AE3             | vin1a_d17     | vin1a_d17       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d6        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d2    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d6        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d1        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_21        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AE5             | vin1a_d18     | vin1a_d18       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d5        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d1    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d5        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d2        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_22        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AE1             | vin1a_d19     | vin1a_d19       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d4        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_d0    |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d4        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d3        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_23        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AE2             | vin1a_d20     | vin1a_d20       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d3        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_nxt   |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d3        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d4        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_24        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AE6             | vin1a_d21     | vin1a_d21       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d2        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_dir   |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d2        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d5        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_25        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
| AD2             | vin1a_d22     | vin1a_d22       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d1        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_stp   |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d1        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d6        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_26        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
| AD3             | vin1a_d23     | vin1a_d23       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_d0        | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | usb3_ulpi_clk   |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d0        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d7        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_27        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
| AD9             | vin1a_de0     | vin1a_de0       | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_hsync1    | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_d17       |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_de        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | uart7_rxd       |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | timer16         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_sclk       |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP1A_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_0         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| AF9             | vin1a_fld0    | vin1a_fld0      | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_vsync1    | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_clk       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart7_bxd       |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | timer15         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_d1         |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP1B_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_1         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AE9             | vin1a_hsync0  | vin1a_hsync0    | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_fld1      | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_hsync     |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart7_ctsn      |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | timer14         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_d0         |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP1_index     |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_2         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AF8             | vin1a_vsync0  | vin1a_vsync0    | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin1b_de1       | No       | 1           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout3_vsync     |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart7_rtsn      |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | timer13         |          | 7           | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi3_cs0        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | eQEP1_strobe    |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_3         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| AH7             | vin1b_clk1    | vin1b_clk1      | No       | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv6    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin3a_clk0      |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio2_31        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]        | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| E1              | vin2a_clk0    | vin2a_clk0             |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vout2_fld              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu5                   |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP1A_in              |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_28               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a27               |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a17               |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| F2              | vin2a_d0      | Driver off             |          | 15          | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin2a_d0               |          | 0           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d23              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu10                  |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart9_ctsn             |          | 7           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | spi4_d0                |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | ehrpwm1B               |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
| F3              | vin2a_d1      | gpio4_1                |          | 14          | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin2a_d1               |          | 0           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d22              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu11                  |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart9_rtsn             |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spi4_cs0               |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
| D1              | vin2a_d2      | ehrpwm1_tripzone_input |          | 10          | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpio4_2                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2a_d2               |          | 0           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d21              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu12                  |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart10_rxd             |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
| E2              | vin2a_d3      | eCAP1_in_PWM1_out      |          | 10          | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | gpio4_3                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2a_d3               |          | 0           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d20              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu13                  |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart10_txd             |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
| E2              | vin2a_d3      | ehrpwm1_synci          |          | 10          | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | gpio4_4                |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                        |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| D2              | vin2a_d4      | vin2a_d4        |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d19       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu14           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart10_ctsn     |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | ehrpwm1_synco   |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_5         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F4              | vin2a_d5      | vin2a_d5        |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d18       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu15           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart10_rtsn     |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP2A_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_6         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C1              | vin2a_d6      | vin2a_d6        |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d17       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu16           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_rxd1       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP2B_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_7         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E4              | vin2a_d7      | vin2a_d7        |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d16       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu17           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_rxd2       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP2_index     |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_8         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F5              | vin2a_d8      | vin2a_d8        |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d15       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu18           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_rxd3       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP2_strobe    |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a26        |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]        | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| E6              | vin2a_d9      | vin2a_d9               |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vout2_d14              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu19                  |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_rxd0              |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | ehrpwm2A               |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_10<br>gpmc_a25   |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| D3              | vin2a_d10     | vin2a_d10              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mdio_mclk              |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d13              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm2B               |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_11<br>gpmc_a24   |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                        |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| F6              | vin2a_d11     | vin2a_d11              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | mdio_d                 |          | 3           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vout2_d12              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm2_tripzone_input |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_12<br>gpmc_a23   |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                        |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| D5              | vin2a_d12     | vin2a_d12              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rgmii1_txc             |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d11              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_rxclk             |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eCAP2_in_PWM2_out      |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_13               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C2              | vin2a_d13     | vin2a_d13              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rgmii1_txc             |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d10              |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_rxdv              |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP3A_in              |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_14               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| C3              | vin2a_d14     | vin2a_d14       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rgmii1_txd3     |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d9        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_txclk      |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP3B_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_15        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C4              | vin2a_d15     | vin2a_d15       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | rgmii1_txd2     |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d8        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mii1_txd0       |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP3_index     |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_16        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B2              | vin2a_d16     | vin2a_d16       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d7        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_txd1     |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d7        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d8        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_txd1       |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP3_strobe    |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_24        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| D6              | vin2a_d17     | vin2a_d17       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d6        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_txd0     |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_d6        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d9        |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_txd2       |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm3A        |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_25        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]        | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|------------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| C5              | vin2a_d18     | vin2a_d18              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d5               |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_rxc             |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d5               |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d10              |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_txd3              |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | ehrpwm3B               |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_26               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A3              | vin2a_d19     | vin2a_d19              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d4               |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_rxctl           |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d4               |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_d11              |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_txer              |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | ehrpwm3_tripzone_input |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_27               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B3              | vin2a_d20     | vin2a_d20              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d3               |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_rxd3            |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d3               |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_de0              |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d12              |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_rxer              |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eCAP3_in_PWM3_out      |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_28               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B4              | vin2a_d21     | vin2a_d21              |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d2               |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_rxd2            |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d2               |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_fld0             |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d13              |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_col               |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_29               |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off             |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| B5              | vin2a_d22     | vin2a_d22       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d1        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_rxd1     |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d1        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_hsync0    |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d14       |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_crs        |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_30        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A4              | vin2a_d23     | vin2a_d23       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  | 0         |
|                 |               | vin2b_d0        |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | rgmii1_rxd0     |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vout2_d0        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin3a_vsync0    |          | 5           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d15       |          | 6           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mii1_txen       |          | 8           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio4_31        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| G2              | vin2a_de0     | vin2a_de0       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin2a_fld0      |          | 1           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2b_fld1      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2b_de1       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_de        |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu6            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP1B_in       |          | 10          | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_29        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| H7              | vin2a_fld0    | vin2a_fld0      |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin2b_clk1      |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_clk       |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu7            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | eQEP1_index     |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_30        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a27        |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpmc_a18        |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3]      | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|----------------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| G1              | vin2a_hsync0  | vin2a_hsync0         |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin2b_hsync1         |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_hsync          |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu8                 |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart9_rxd            |          | 7           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | spl4_sclk            |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | eQEP1_strobe         |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio3_31<br>gpmc_a27 |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| G6              | vin2a_vsync0  | Driver off           |          | 15          | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv1    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin2a_vsync0         |          | 0           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin2b_vsync1         |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_vsync          |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu9                 |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart9_txd            |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | spl4_d1              |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | ehrpwm1A             |          | 10          | O        |                      |                           |                             |                        |            |          |                     |                        |           |
| D11             | vout1_clk     | gpio4_0              |          | 14          | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | Driver off           |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout1_clk            |          | 0           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_fld0           |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_fld0           |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spl3_cs0             |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
| F11             | vout1_d0      | gpio4_19             |          | 14          | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | Driver off           |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout1_d0             |          | 0           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | uart5_rxd            |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin4a_d16            |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d16            |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spl3_cs2             |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio8_0              |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off           |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| G10             | vout1_d1      | vout1_d1        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart5_txd       |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d17       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d17       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio8_1         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F10             | vout1_d2      | vout1_d2        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu2            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d18       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d18       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs0            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs16           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs_irq1        |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_2         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| G11             | vout1_d3      | vout1_d3        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu5            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d19       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d19       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs1            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs17           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs_dmarq1      |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_3         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E9              | vout1_d4      | vout1_d4        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu6            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d20       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d20       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs2            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs18           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_4         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| F9              | vout1_d5      | vout1_d5        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu7            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d21       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d21       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs3            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs19           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_5         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| F8              | vout1_d6      | vout1_d6        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu8            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d22       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d22       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs4            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs20           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_6         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E7              | vout1_d7      | vout1_d7        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu9            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d23       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d23       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio8_7         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| E8              | vout1_d8      | vout1_d8        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart6_rxd       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin4a_d8        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d8        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio8_8         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| D9              | vout1_d9      | vout1_d9        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart6_txd       |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d9        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d9        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio8_9         |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| D7              | vout1_d10     | vout1_d10       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu3            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d10       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d10       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs5            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs21           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs_irq2        |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_10        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
| D8              | vout1_d11     | Driver off      |          | 15          | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vout1_d11       |          | 0           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu10           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d11       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d11       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs6            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs22           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs_dmarq2      |          | 7           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
| A5              | vout1_d12     | gpio8_11        |          | 14          | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout1_d12       |          | 0           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu11           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d12       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d12       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs7            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs23           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
| C6              | vout1_d13     | gpio8_12        |          | 14          | IO       | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout1_d13       |          | 0           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | emu12           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d13       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d13       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs8            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs24           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_13        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| C8              | vout1_d14     | vout1_d14       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu13           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d14       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d14       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs9            |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs25           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_14        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C7              | vout1_d15     | vout1_d15       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu14           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d15       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d15       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs10           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs26           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_15        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B7              | vout1_d16     | vout1_d16       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart7_rxd       |          | 2           | I        |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | vin4a_d0        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d0        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio8_16        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| B8              | vout1_d17     | vout1_d17       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | uart7_txd       |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d1        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d1        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio8_17        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| A7              | vout1_d18     | vout1_d18       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu4            |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d2        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d2        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs11           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs27           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_18        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| A8              | vout1_d19     | vout1_d19       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu15           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d3        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d3        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs12           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs28           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_19        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| C9              | vout1_d20     | vout1_d20       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu16           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d4        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d4        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs13           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs29           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_20        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| A9              | vout1_d21     | vout1_d21       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu17           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d5        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d5        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs14           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs30           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_21        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B9              | vout1_d22     | vout1_d22       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu18           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d6        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d6        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | obs15           |          | 5           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | obs31           |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio8_22        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| A10             | vout1_d23     | vout1_d23       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | emu19           |          | 2           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_d7        |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_d7        |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_cs3        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio8_23        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
| B10             | vout1_de      | vout1_de        |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin4a_de0       |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_de0       |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_d1         |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_20        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| B11             | vout1_fld     | vout1_fld       |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin4a_clk0      |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_clk0      |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_cs1        |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 1         |
|                 |               | gpio4_21        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| C11             | vout1_hsync   | vout1_hsync     |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin4a_hsync0    |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_hsync0    |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_d0         |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_22        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |
| E11             | vout1_vsync   | vout1_vsync     |          | 0           | O        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv2    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | vin4a_vsync0    |          | 3           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | vin3a_vsync0    |          | 4           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | spi3_sclk       |          | 8           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | gpio4_23        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               |                 |          |             |          |                      |                           |                             |                        |            |          |                     |                        |           |

**Table 4-1. Pin Attributes<sup>(1)</sup> (continued)**

| BALL NUMBER [1]                                                                                                                                                                                                                                                                                                                                                                                                                       | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13] | PULL UP/DOWN TYPE [14] | DSIS [15] |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|------------------|------------------------|-----------|
| A1, A14, A2, A23, A28, A6, AA10, AA14, AA15, AA20, AA8, AA9, AB14, AB20, AD1, AD24, AG1, AH1, AH2, AH20, AH28, AH8, B1, D13, D19, E13, E19, F1, F7, G7, G8, G9, H12, J12, J15, J28, K1, K15, K24, K25, K4, K5, L13, L14, M19, N14, N15, N19, N24, N25, P28, R1, R12, R13, R15, R21, T10, T11, T12, T14, T15, T17, T18, T21, U15, U17, U20, U21, V15, V17, W1, W15, W24, W25, W28, AD19, AE19, AD13, AE13, AE10, AA11, AB11, AD10, U14 | vss           | vss             |          |             | GND      |                      |                           |                             |                        |            |          |                  |                        |           |
| AF15                                                                                                                                                                                                                                                                                                                                                                                                                                  | vssa_osc0     | vssa_osc0       |          |             | GND      |                      |                           |                             |                        |            |          |                  |                        |           |
| AC14                                                                                                                                                                                                                                                                                                                                                                                                                                  | vssa_osc1     | vssa_osc1       |          |             | GND      |                      |                           |                             |                        |            |          |                  |                        |           |
| AD17                                                                                                                                                                                                                                                                                                                                                                                                                                  | Wakeup0       | Wakeup0         |          | 0           | I        | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv5    | Yes      | IHV1833          | PU/PD                  | 1         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | dcan1_rx        |          | 1           | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | gpio1_0         |          | 14          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
| AC17                                                                                                                                                                                                                                                                                                                                                                                                                                  | Wakeup1       | Wakeup1         |          | 0           | I        | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv5    | Yes      | IHV1833          | PU/PD                  | 1         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | dcan2_rx        |          | 1           | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | gpio1_1         |          | 14          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
| AB16                                                                                                                                                                                                                                                                                                                                                                                                                                  | Wakeup2       | Wakeup2         |          | 0           | I        | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv5    | Yes      | IHV1833          | PU/PD                  |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | sys_nirq2       |          | 1           | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | gpio1_2         |          | 14          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
| AC16                                                                                                                                                                                                                                                                                                                                                                                                                                  | Wakeup3       | Wakeup3         |          | 0           | I        | OFF                  | OFF                       | 15                          | 1.8/3.3                | vddshv5    | Yes      | IHV1833          | PU/PD                  |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | sys_nirq1       |          | 1           | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | gpio1_3         |          | 14          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                  |                        |           |
| AE15                                                                                                                                                                                                                                                                                                                                                                                                                                  | xi_osc0       | xi_osc0         |          | 0           | I        |                      |                           |                             | 1.8                    | vdda_osc   | No       | LVCNOS Analog    |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]     | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|----------------------|------------------------|-----------|
| AC15            | xi_osc1       | xi_osc1         |          | 0           | I        |                      |                           |                             | 1.8                    | vdda_osc   | No       | LVC MOS Analog       |                        |           |
| AD15            | xo_osc0       | xo_osc0         |          | 0           | O        |                      |                           |                             | 1.8                    | vdda_osc   | No       | LVC MOS Analog       |                        |           |
| AC13            | xo_osc1       | xo_osc1         |          | 0           | A        |                      |                           |                             | 1.8                    | vdda_osc   | No       | LVC MOS Analog       |                        |           |
| D18             | xref_clk0     | xref_clk0       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVC MOS | PU/PD                  |           |
|                 |               | mcasp2_axr8     |          | 1           | IO       |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | mcasp1_axr4     |          | 2           | IO       |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | mcasp1_ahclkx   |          | 3           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | mcasp5_ahclkx   |          | 4           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | clkout2         |          | 9           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | timer13         |          | 10          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | gpio6_17        |          | 14          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                      |                        |           |
| E17             | xref_clk1     | xref_clk1       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVC MOS | PU/PD                  |           |
|                 |               | mcasp2_axr9     |          | 1           | IO       |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | mcasp1_axr5     |          | 2           | IO       |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | mcasp2_ahclkx   |          | 3           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | mcasp6_ahclkx   |          | 4           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | timer14         |          | 10          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | gpio6_18        |          | 14          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                      |                        |           |
| B26             | xref_clk2     | xref_clk2       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVC MOS | PU/PD                  |           |
|                 |               | mcasp2_axr10    |          | 1           | IO       |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | mcasp1_axr6     |          | 2           | IO       |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | mcasp3_ahclkx   |          | 3           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | mcasp7_ahclkx   |          | 4           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | vout2_clk       |          | 6           | O        |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | vin4a_clk0      |          | 8           | I        |                      |                           |                             |                        |            |          |                      |                        | 0         |
|                 |               | timer15         |          | 10          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | gpio6_19        |          | 14          | IO       |                      |                           |                             |                        |            |          |                      |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                      |                        |           |

Table 4-1. Pin Attributes<sup>(1)</sup> (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | PHxx [4] | MUXMODE [5] | TYPE [6] | BALL RESET STATE [7] | BALL RESET REL. STATE [8] | BALL RESET REL. MUXMODE [9] | I/O VOLTAGE VALUE [10] | POWER [11] | HYS [12] | BUFFER TYPE [13]    | PULL UP/DOWN TYPE [14] | DSIS [15] |
|-----------------|---------------|-----------------|----------|-------------|----------|----------------------|---------------------------|-----------------------------|------------------------|------------|----------|---------------------|------------------------|-----------|
| C23             | xref_clk3     | xref_clk3       |          | 0           | I        | PD                   | PD                        | 15                          | 1.8/3.3                | vddshv3    | Yes      | Dual Voltage LVCMOS | PU/PD                  |           |
|                 |               | mcasp2_axr11    |          | 1           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasp1_axr7     |          | 2           | IO       |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | mcasp4_ahclkx   |          | 3           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | mcasp8_ahclkx   |          | 4           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vout2_de        |          | 6           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | vin4a_de0       |          | 8           | I        |                      |                           |                             |                        |            |          |                     |                        | 0         |
|                 |               | clkout3         |          | 9           | O        |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | timer16         |          | 10          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | gpio6_20        |          | 14          | IO       |                      |                           |                             |                        |            |          |                     |                        |           |
|                 |               | Driver off      |          | 15          | I        |                      |                           |                             |                        |            |          |                     |                        |           |

(1) NA in this table stands for Not Applicable.

(2) For more information on recommended operating conditions, see [Section 5.4, Recommended Operating Conditions](#).

(3) The pullup or pulldown block strength is equal to: minimum = 50  $\mu$ A, typical = 100  $\mu$ A, maximum = 250  $\mu$ A.

(4) The output impedance settings of this IO cell are programmable; by default, the value is DS[1:0] = 10, this means 40  $\Omega$ . For more information on DS[1:0] register configuration, see the Device TRM.

(5) IO drive strength for usb1\_dp, usb1\_dm, usb2\_dp and usb2\_dm: minimum 18.3 mA, maximum 89 mA (for a power supply vdda33v\_usb1 and vdda33v\_usb2 = 3.46 V).

(6) Minimum PU = 900  $\Omega$ , maximum PU = 3.090 k $\Omega$  and minimum PD = 14.25 k $\Omega$ , maximum PD = 24.8 k $\Omega$ .  
For more information, see chapter 7 of the USB2.0 specification, in particular section Signaling / Device Speed Identification.

(7) In PUx / PDy, x and y = 60  $\mu$ A to 200  $\mu$ A.  
The output impedance settings (or drive strengths) of this IO are programmable (34  $\Omega$ , 40  $\Omega$ , 48  $\Omega$ , 60  $\Omega$ , 80  $\Omega$ ) depending on the values of the I[2:0] registers.

(8) This signal is valid only for High-Security devices. For more details, see [Section 5.8, VPP Specification for One-Time Programmable \(OTP\) eFUSES](#). For General Purpose devices do not connect any signal, test point, or board trace to this signal.

### 4.3 Signal Descriptions

Many signals are available on multiple pins, according to the software configuration of the pin multiplexing options.

1. **SIGNAL NAME:** The name of the signal passing through the pin.

#### NOTE

The subsystem multiplexing signals are not described in [Table 4-1](#) and [Table 4-29](#).

2. **DESCRIPTION:** Description of the signal

3. **TYPE:** Signal direction and type:

- I = Input
- O = Output
- IO = Input or output
- D = Open Drain
- DS = Differential Signaling
- A = Analog
- PWR = Power
- GND = Ground

4. **BALL:** Associated ball(s) number

#### NOTE

For more information, see the Control Module / Control Module Register Manual section of the Device TRM.

#### 4.3.1 VIP

#### NOTE

For more information, see the Video Input Port (VIP) section of the Device TRM.

#### CAUTION

The I/O timings provided in [Section 5.10, Timing Requirements and Switching Characteristics](#) are applicable for all combinations of signals for vin1. However, the timings are valid only for vin2, vin3, and vin4 if signals within a single IOSET are used. The IOSETs are defined in the [Table 5-34](#), [Table 5-35](#) and [Table 5-36](#).

**Table 4-2. VIP Signal Descriptions**

| SIGNAL NAME          | DESCRIPTION                                                                                                                            | TYPE | BALL                |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------|------|---------------------|
| <b>Video Input 1</b> |                                                                                                                                        |      |                     |
| vin1a_clk0           | Video Input 1 Port A Clock input. Input clock for 8-bit 16-bit or 24-bit Port A video capture. Input data is sampled on the CLK0 edge. | I    | <a href="#">AG8</a> |
| vin1a_de0            | Video Input 1 Port A Data Enable input                                                                                                 | I    | <a href="#">AD9</a> |
| vin1a_fld0           | Video Input 1 Port A Field ID input                                                                                                    | I    | <a href="#">AF9</a> |
| vin1a_hsync0         | Video Input 1 Port A Horizontal Sync input                                                                                             | I    | <a href="#">AE9</a> |
| vin1a_vsync0         | Video Input 1 Port A Vertical Sync input                                                                                               | I    | <a href="#">AF8</a> |
| vin1a_d0             | Video Input 1 Port A Data input                                                                                                        | I    | <a href="#">AE8</a> |
| vin1a_d1             | Video Input 1 Port A Data input                                                                                                        | I    | <a href="#">AD8</a> |

**Table 4-2. VIP Signal Descriptions (continued)**

| SIGNAL NAME          | DESCRIPTION                                | TYPE | BALL         |
|----------------------|--------------------------------------------|------|--------------|
| vin1a_d2             | Video Input 1 Port A Data input            | I    | AG7          |
| vin1a_d3             | Video Input 1 Port A Data input            | I    | AH6          |
| vin1a_d4             | Video Input 1 Port A Data input            | I    | AH3          |
| vin1a_d5             | Video Input 1 Port A Data input            | I    | AH5          |
| vin1a_d6             | Video Input 1 Port A Data input            | I    | AG6          |
| vin1a_d7             | Video Input 1 Port A Data input            | I    | AH4          |
| vin1a_d8             | Video Input 1 Port A Data input            | I    | AG4          |
| vin1a_d9             | Video Input 1 Port A Data input            | I    | AG2          |
| vin1a_d10            | Video Input 1 Port A Data input            | I    | AG3          |
| vin1a_d11            | Video Input 1 Port A Data input            | I    | AG5          |
| vin1a_d12            | Video Input 1 Port A Data input            | I    | AF2          |
| vin1a_d13            | Video Input 1 Port A Data input            | I    | AF6          |
| vin1a_d14            | Video Input 1 Port A Data input            | I    | AF3          |
| vin1a_d15            | Video Input 1 Port A Data input            | I    | AF4          |
| vin1a_d16            | Video Input 1 Port A Data input            | I    | AF1          |
| vin1a_d17            | Video Input 1 Port A Data input            | I    | AE3          |
| vin1a_d18            | Video Input 1 Port A Data input            | I    | AE5          |
| vin1a_d19            | Video Input 1 Port A Data input            | I    | AE1          |
| vin1a_d20            | Video Input 1 Port A Data input            | I    | AE2          |
| vin1a_d21            | Video Input 1 Port A Data input            | I    | AE6          |
| vin1a_d22            | Video Input 1 Port A Data input            | I    | AD2          |
| vin1a_d23            | Video Input 1 Port A Data input            | I    | AD3          |
| vin1b_hsync1         | Video Input 1 Port B Horizontal Sync input | I    | N6/ AD9      |
| vin1b_vsync1         | Video Input 1 Port B Vertical Sync input   | I    | AF9          |
| vin1b_fld1           | Video Input 1 Port B Field ID input        | I    | AE9          |
| vin1b_de1            | Video Input 1 Port B Data Enable input     | I    | AF8/ M4      |
| vin1b_clk1           | Video Input 1 Port B Clock input           | I    | AH7          |
| vin1b_d0             | Video Input 1 Port B Data input            | I    | AF4/ AD3     |
| vin1b_d1             | Video Input 1 Port B Data input            | I    | AF3/ AD2     |
| vin1b_d2             | Video Input 1 Port B Data input            | I    | AF6/ AE6     |
| vin1b_d3             | Video Input 1 Port B Data input            | I    | AF2/ AE2     |
| vin1b_d4             | Video Input 1 Port B Data input            | I    | AG5/ AE1     |
| vin1b_d5             | Video Input 1 Port B Data input            | I    | AG3/ AE5     |
| vin1b_d6             | Video Input 1 Port B Data input            | I    | AG2/ AE3     |
| vin1b_d7             | Video Input 1 Port B Data input            | I    | AG4/ AF1     |
| <b>Video Input 2</b> |                                            |      |              |
| vin2a_clk0           | Video Input 2 Port A Clock input           | I    | E1 / V1      |
| vin2a_de0            | Video Input 2 Port A Data Enable input     | I    | G2 / V7      |
| vin2a_fld0           | Video Input 2 Port A Field ID input        | I    | G2 / H7 / W2 |
| vin2a_hsync0         | Video Input 2 Port A Horizontal Sync input | I    | G1 / U7      |
| vin2a_vsync0         | Video Input 2 Port A Vertical Sync input   | I    | G6 / V6      |
| vin2a_d0             | Video Input 2 Port A Data input            | I    | F2 / U4      |
| vin2a_d1             | Video Input 2 Port A Data input            | I    | F3 / V2      |
| vin2a_d2             | Video Input 2 Port A Data input            | I    | D1 / Y1      |
| vin2a_d3             | Video Input 2 Port A Data input            | I    | E2 / W9      |
| vin2a_d4             | Video Input 2 Port A Data input            | I    | D2 / V9      |
| vin2a_d5             | Video Input 2 Port A Data input            | I    | F4 / U5      |

**Table 4-2. VIP Signal Descriptions (continued)**

| SIGNAL NAME          | DESCRIPTION                                | TYPE | BALL         |
|----------------------|--------------------------------------------|------|--------------|
| vin2a_d6             | Video Input 2 Port A Data input            | I    | C1 / V5      |
| vin2a_d7             | Video Input 2 Port A Data input            | I    | E4 / V4      |
| vin2a_d8             | Video Input 2 Port A Data input            | I    | F5 / V3      |
| vin2a_d9             | Video Input 2 Port A Data input            | I    | E6 / Y2      |
| vin2a_d10            | Video Input 2 Port A Data input            | I    | D3 / U6      |
| vin2a_d11            | Video Input 2 Port A Data input            | I    | F6 / U3      |
| vin2a_d12            | Video Input 2 Port A Data input            | I    | D5           |
| vin2a_d13            | Video Input 2 Port A Data input            | I    | C2           |
| vin2a_d14            | Video Input 2 Port A Data input            | I    | C3           |
| vin2a_d15            | Video Input 2 Port A Data input            | I    | C4           |
| vin2a_d16            | Video Input 2 Port A Data input            | I    | B2           |
| vin2a_d17            | Video Input 2 Port A Data input            | I    | D6           |
| vin2a_d18            | Video Input 2 Port A Data input            | I    | C5           |
| vin2a_d19            | Video Input 2 Port A Data input            | I    | A3           |
| vin2a_d20            | Video Input 2 Port A Data input            | I    | B3           |
| vin2a_d21            | Video Input 2 Port A Data input            | I    | B4           |
| vin2a_d22            | Video Input 2 Port A Data input            | I    | B5           |
| vin2a_d23            | Video Input 2 Port A Data input            | I    | A4           |
| vin2b_clk1           | Video Input 2 Port B Clock input           | I    | AB5/ H7      |
| vin2b_de1            | Video Input 2 Port B Data Enable input     | I    | AB8/ G2      |
| vin2b_fld1           | Video Input 2 Port B Field ID input        | I    | G2           |
| vin2b_hsync1         | Video Input 2 Port B Horizontal Sync input | I    | AC5/ G1      |
| vin2b_vsync1         | Video Input 2 Port B Vertical Sync input   | I    | AB4/ G6      |
| vin2b_d0             | Video Input 2 Port B Data input            | I    | AD6/ A4      |
| vin2b_d1             | Video Input 2 Port B Data input            | I    | AC8/ B5      |
| vin2b_d2             | Video Input 2 Port B Data input            | I    | AC3/ B4      |
| vin2b_d3             | Video Input 2 Port B Data input            | I    | AC9/ B3      |
| vin2b_d4             | Video Input 2 Port B Data input            | I    | AC6/ A3      |
| vin2b_d5             | Video Input 2 Port B Data input            | I    | AC7/ C5      |
| vin2b_d6             | Video Input 2 Port B Data input            | I    | AC4/ D6      |
| vin2b_d7             | Video Input 2 Port B Data input            | I    | AD4/ B2      |
| <b>Video Input 3</b> |                                            |      |              |
| vin3a_clk0           | Video Input 3 Port A Clock input           | I    | B11/ AH7/ P1 |
| vin3a_de0            | Video Input 3 Port A Data Enable input     | I    | N9/ B3/ B10  |
| vin3a_fld0           | Video Input 3 Port A Field ID input        | I    | P9/ B4/ D11  |
| vin3a_hsync0         | Video Input 3 Port A Horizontal Sync input | I    | N7/ B5/ C11  |
| vin3a_vsync0         | Video Input 3 Port A Vertical Sync input   | I    | R4/ A4/ E11  |
| vin3a_d0             | Video Input 3 Port A Data input            | I    | M6/ AF1/ B7  |
| vin3a_d1             | Video Input 3 Port A Data input            | I    | M2/ AE3/ B8  |
| vin3a_d2             | Video Input 3 Port A Data input            | I    | L5/ AE5/ A7  |
| vin3a_d3             | Video Input 3 Port A Data input            | I    | M1/ AE1/ A8  |
| vin3a_d4             | Video Input 3 Port A Data input            | I    | L6/ AE2/ C9  |
| vin3a_d5             | Video Input 3 Port A Data input            | I    | L4/ AE6/ A9  |
| vin3a_d6             | Video Input 3 Port A Data input            | I    | L3/ AD2/ B9  |
| vin3a_d7             | Video Input 3 Port A Data input            | I    | L2/ AD3/ A10 |
| vin3a_d8             | Video Input 3 Port A Data input            | I    | L1/ B2/ E8   |
| vin3a_d9             | Video Input 3 Port A Data input            | I    | K2/ D6/ D9   |

**Table 4-2. VIP Signal Descriptions (continued)**

| SIGNAL NAME          | DESCRIPTION                                | TYPE | BALL             |
|----------------------|--------------------------------------------|------|------------------|
| vin3a_d10            | Video Input 3 Port A Data input            | I    | J1/ C5/ D7       |
| vin3a_d11            | Video Input 3 Port A Data input            | I    | J2/ A3/ D8       |
| vin3a_d12            | Video Input 3 Port A Data input            | I    | H1/ B3/ A5       |
| vin3a_d13            | Video Input 3 Port A Data input            | I    | J3/ B4/ C6       |
| vin3a_d14            | Video Input 3 Port A Data input            | I    | H2/ B5/ C8       |
| vin3a_d15            | Video Input 3 Port A Data input            | I    | H3/ A4/ C7       |
| vin3a_d16            | Video Input 3 Port A Data input            | I    | R6/ F11          |
| vin3a_d17            | Video Input 3 Port A Data input            | I    | T9/ G10          |
| vin3a_d18            | Video Input 3 Port A Data input            | I    | T6/ F10          |
| vin3a_d19            | Video Input 3 Port A Data input            | I    | T7/ G11          |
| vin3a_d20            | Video Input 3 Port A Data input            | I    | P6/ E9           |
| vin3a_d21            | Video Input 3 Port A Data input            | I    | R9/ F9           |
| vin3a_d22            | Video Input 3 Port A Data input            | I    | R5/ F8           |
| vin3a_d23            | Video Input 3 Port A Data input            | I    | P5/ E7           |
| vin3b_clk1           | Video Input 3 Port B Clock input           | I    | P7/ M4           |
| vin3b_de1            | Video Input 3 Port B Data Enable input     | I    | N6               |
| vin3b_fld1           | Video Input 3 Port A Field ID input        | I    | M4               |
| vin3b_hsync1         | Video Input 3 Port A Horizontal Sync input | I    | H5               |
| vin3b_vsync1         | Video Input 3 Port A Vertical Sync input   | I    | H6               |
| vin3b_d0             | Video Input 3 Port B Data input            | I    | K7               |
| vin3b_d1             | Video Input 3 Port B Data input            | I    | M7               |
| vin3b_d2             | Video Input 3 Port B Data input            | I    | J5               |
| vin3b_d3             | Video Input 3 Port B Data input            | I    | K6               |
| vin3b_d4             | Video Input 3 Port B Data input            | I    | J7               |
| vin3b_d5             | Video Input 3 Port B Data input            | I    | J4               |
| vin3b_d6             | Video Input 3 Port B Data input            | I    | J6               |
| vin3b_d7             | Video Input 3 Port B Data input            | I    | H4               |
| <b>Video Input 4</b> |                                            |      |                  |
| vin4a_clk0           | Video Input 4 Port A Clock input           | I    | P4/ B26/ B11     |
| vin4a_de0            | Video Input 4 Port A Data Enable input     | I    | H6/ C23/ B10/ P7 |
| vin4a_fld0           | Video Input 4 Port A Field ID input        | I    | J7/ F21/ P9/ D11 |
| vin4a_hsync0         | Video Input 4 Port A Horizontal Sync input | I    | R3/ E21/ C11/ P7 |
| vin4a_vsync0         | Video Input 4 Port A Vertical Sync input   | I    | T2/ F20/ E11/ N1 |
| vin4a_d0             | Video Input 4 Port A Data input            | I    | R6/ B7/ B14      |
| vin4a_d1             | Video Input 4 Port A Data input            | I    | T9/ B8/ J14      |
| vin4a_d2             | Video Input 4 Port A Data input            | I    | T6/ A7/ G13      |
| vin4a_d3             | Video Input 4 Port A Data input            | I    | T7/ A8/ J11      |
| vin4a_d4             | Video Input 4 Port A Data input            | I    | P6/ C9/ E12      |
| vin4a_d5             | Video Input 4 Port A Data input            | I    | R9/ A9/ F13      |
| vin4a_d6             | Video Input 4 Port A Data input            | I    | R5/ B9/ C12      |
| vin4a_d7             | Video Input 4 Port A Data input            | I    | P5/ A10/ D12     |
| vin4a_d8             | Video Input 4 Port A Data input            | I    | E8/ U2/ E15      |
| vin4a_d9             | Video Input 4 Port A Data input            | I    | D9/ U1/ A20      |
| vin4a_d10            | Video Input 4 Port A Data input            | I    | D7/ P3/ B15      |
| vin4a_d11            | Video Input 4 Port A Data input            | I    | D8/ R2/ A15      |
| vin4a_d12            | Video Input 4 Port A Data input            | I    | A5/ K7/ D15      |
| vin4a_d13            | Video Input 4 Port A Data input            | I    | C6/ M7/ B16      |

**Table 4-2. VIP Signal Descriptions (continued)**

| SIGNAL NAME  | DESCRIPTION                                | TYPE | BALL        |
|--------------|--------------------------------------------|------|-------------|
| vin4a_d14    | Video Input 4 Port A Data input            | I    | C8/ J5/ B17 |
| vin4a_d15    | Video Input 4 Port A Data input            | I    | C7/ K6/ A17 |
| vin4a_d16    | Video Input 4 Port A Data input            | I    | C18/ F11    |
| vin4a_d17    | Video Input 4 Port A Data input            | I    | A21/ G10    |
| vin4a_d18    | Video Input 4 Port A Data input            | I    | G16/ F10    |
| vin4a_d19    | Video Input 4 Port A Data input            | I    | D17/ G11    |
| vin4a_d20    | Video Input 4 Port A Data input            | I    | AA3/ E9     |
| vin4a_d21    | Video Input 4 Port A Data input            | I    | AB9/ F9     |
| vin4a_d22    | Video Input 4 Port A Data input            | I    | AB3/ F8     |
| vin4a_d23    | Video Input 4 Port A Data input            | I    | AA4/ E7     |
| vin4b_clk1   | Video Input 4 Port B Clock input           | I    | N9/ V1      |
| vin4b_de1    | Video Input 4 Port B Data Enable input     | I    | P9/ V7      |
| vin4b fld1   | Video Input 4 Port B Field ID input        | I    | P4/ W2      |
| vin4b_hsync1 | Video Input 4 Port B Horizontal Sync input | I    | N7/ U7      |
| vin4b_vsync1 | Video Input 4 Port B Vertical Sync input   | I    | R4/ V6      |
| vin4b_d0     | Video Input 4 Port B Data input            | I    | R6/ U4      |
| vin4b_d1     | Video Input 4 Port B Data input            | I    | T9/ V2      |
| vin4b_d2     | Video Input 4 Port B Data input            | I    | T6/ Y1      |
| vin4b_d3     | Video Input 4 Port B Data input            | I    | T7/ W9      |
| vin4b_d4     | Video Input 4 Port B Data input            | I    | P6/ V9      |
| vin4b_d5     | Video Input 4 Port B Data input            | I    | R9/ U5      |
| vin4b_d6     | Video Input 4 Port B Data input            | I    | R5/ V5      |
| vin4b_d7     | Video Input 4 Port B Data input            | I    | P5/ V4      |

### 4.3.2 DSS

#### CAUTION

The I/O timings provided in [Section 5.10, Timing Requirements and Switching Characteristics](#) are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 5-48](#) and [Table 5-49](#).

**Table 4-3. DSS Signal Descriptions**

| SIGNAL NAME               | DESCRIPTION                                                                             | TYPE | BALL |
|---------------------------|-----------------------------------------------------------------------------------------|------|------|
| <b>DPI Video Output 1</b> |                                                                                         |      |      |
| vout1_clk                 | Video Output 1 Clock output                                                             | O    | D11  |
| vout1_de                  | Video Output 1 Data Enable output                                                       | O    | B10  |
| vout1 fld                 | Video Output 1 Field ID output. This signal is not used for embedded sync modes.        | O    | B11  |
| vout1_hsync               | Video Output 1 Horizontal Sync output. This signal is not used for embedded sync modes. | O    | C11  |
| vout1_vsync               | Video Output 1 Vertical Sync output. This signal is not used for embedded sync modes.   | O    | E11  |
| vout1_d0                  | Video Output 1 Data output                                                              | O    | F11  |
| vout1_d1                  | Video Output 1 Data output                                                              | O    | G10  |
| vout1_d2                  | Video Output 1 Data output                                                              | O    | F10  |
| vout1_d3                  | Video Output 1 Data output                                                              | O    | G11  |
| vout1_d4                  | Video Output 1 Data output                                                              | O    | E9   |
| vout1_d5                  | Video Output 1 Data output                                                              | O    | F9   |

**Table 4-3. DSS Signal Descriptions (continued)**

| SIGNAL NAME               | DESCRIPTION                                                                             | TYPE | BALL    |
|---------------------------|-----------------------------------------------------------------------------------------|------|---------|
| vout1_d6                  | Video Output 1 Data output                                                              | O    | F8      |
| vout1_d7                  | Video Output 1 Data output                                                              | O    | E7      |
| vout1_d8                  | Video Output 1 Data output                                                              | O    | E8      |
| vout1_d9                  | Video Output 1 Data output                                                              | O    | D9      |
| vout1_d10                 | Video Output 1 Data output                                                              | O    | D7      |
| vout1_d11                 | Video Output 1 Data output                                                              | O    | D8      |
| vout1_d12                 | Video Output 1 Data output                                                              | O    | A5      |
| vout1_d13                 | Video Output 1 Data output                                                              | O    | C6      |
| vout1_d14                 | Video Output 1 Data output                                                              | O    | C8      |
| vout1_d15                 | Video Output 1 Data output                                                              | O    | C7      |
| vout1_d16                 | Video Output 1 Data output                                                              | O    | B7      |
| vout1_d17                 | Video Output 1 Data output                                                              | O    | B8      |
| vout1_d18                 | Video Output 1 Data output                                                              | O    | A7      |
| vout1_d19                 | Video Output 1 Data output                                                              | O    | A8      |
| vout1_d20                 | Video Output 1 Data output                                                              | O    | C9      |
| vout1_d21                 | Video Output 1 Data output                                                              | O    | A9      |
| vout1_d22                 | Video Output 1 Data output                                                              | O    | B9      |
| vout1_d23                 | Video Output 1 Data output                                                              | O    | A10     |
| <b>DPI Video Output 2</b> |                                                                                         |      |         |
| vout2_clk                 | Video Output 2 Clock output                                                             | O    | H7/ B26 |
| vout2_de                  | Video Output 2 Data Enable output                                                       | O    | G2/ C23 |
| vout2_fld                 | Video Output 2 Field ID output. This signal is not used for embedded sync modes.        | O    | E1/ F21 |
| vout2_hsync               | Video Output 2 Horizontal Sync output. This signal is not used for embedded sync modes. | O    | G1/ E21 |
| vout2_vsync               | Video Output 2 Vertical Sync output. This signal is not used for embedded sync modes.   | O    | G6/ F20 |
| vout2_d0                  | Video Output 2 Data output                                                              | O    | A4/ B14 |
| vout2_d1                  | Video Output 2 Data output                                                              | O    | B5/ J14 |
| vout2_d2                  | Video Output 2 Data output                                                              | O    | B4/ G13 |
| vout2_d3                  | Video Output 2 Data output                                                              | O    | B3/ J11 |
| vout2_d4                  | Video Output 2 Data output                                                              | O    | A3/ E12 |
| vout2_d5                  | Video Output 2 Data output                                                              | O    | C5/ F13 |
| vout2_d6                  | Video Output 2 Data output                                                              | O    | D6/ C12 |
| vout2_d7                  | Video Output 2 Data output                                                              | O    | B2/ D12 |
| vout2_d8                  | Video Output 2 Data output                                                              | O    | C4/ E15 |
| vout2_d9                  | Video Output 2 Data output                                                              | O    | C3/ A20 |
| vout2_d10                 | Video Output 2 Data output                                                              | O    | C2/ B15 |
| vout2_d11                 | Video Output 2 Data output                                                              | O    | D5/ A15 |
| vout2_d12                 | Video Output 2 Data output                                                              | O    | F6/ D15 |
| vout2_d13                 | Video Output 2 Data output                                                              | O    | D3/ B16 |
| vout2_d14                 | Video Output 2 Data output                                                              | O    | E6/ B17 |
| vout2_d15                 | Video Output 2 Data output                                                              | O    | F5/ A17 |
| vout2_d16                 | Video Output 2 Data output                                                              | O    | E4/ C18 |
| vout2_d17                 | Video Output 2 Data output                                                              | O    | C1/ A21 |
| vout2_d18                 | Video Output 2 Data output                                                              | O    | F4/ G16 |
| vout2_d19                 | Video Output 2 Data output                                                              | O    | D2/ D17 |
| vout2_d20                 | Video Output 2 Data output                                                              | O    | E2/ AA3 |
| vout2_d21                 | Video Output 2 Data output                                                              | O    | D1/ AB9 |
| vout2_d22                 | Video Output 2 Data output                                                              | O    | F3/ AB3 |

**Table 4-3. DSS Signal Descriptions (continued)**

| SIGNAL NAME               | DESCRIPTION                                                                             | TYPE | BALL          |
|---------------------------|-----------------------------------------------------------------------------------------|------|---------------|
| vout2_d23                 | Video Output 2 Data output                                                              | O    | F2/ AA4       |
| <b>DPI Video Output 3</b> |                                                                                         |      |               |
| vout3_clk                 | Video Output 3 Clock output                                                             | O    | P1/ AF9       |
| vout3_de                  | Video Output 3 Data Enable output                                                       | O    | N9/ AD9       |
| vout3_fid                 | Video Output 3 Field ID output. This signal is not used for embedded sync modes.        | O    | P9/ AG8       |
| vout3_hsync               | Video Output 3 Horizontal Sync output. This signal is not used for embedded sync modes. | O    | N7/ AE9       |
| vout3_vsync               | Video Output 3 Vertical Sync output. This signal is not used for embedded sync modes.   | O    | R4/ AF8       |
| vout3_d0                  | Video Output 3 Data output                                                              | O    | M6/ AH4 / AD3 |
| vout3_d1                  | Video Output 3 Data output                                                              | O    | M2/ AG6 / AD2 |
| vout3_d2                  | Video Output 3 Data output                                                              | O    | L5/ AH5 / AE6 |
| vout3_d3                  | Video Output 3 Data output                                                              | O    | M1/ AH3 / AE2 |
| vout3_d4                  | Video Output 3 Data output                                                              | O    | L6/ AH6 / AE1 |
| vout3_d5                  | Video Output 3 Data output                                                              | O    | L4/ AG7 / AE5 |
| vout3_d6                  | Video Output 3 Data output                                                              | O    | L3/ AD8 / AE3 |
| vout3_d7                  | Video Output 3 Data output                                                              | O    | L2/ AE8 / AF1 |
| vout3_d8                  | Video Output 3 Data output                                                              | O    | L1/ AF4       |
| vout3_d9                  | Video Output 3 Data output                                                              | O    | K2/ AF3       |
| vout3_d10                 | Video Output 3 Data output                                                              | O    | J1/ AF6       |
| vout3_d11                 | Video Output 3 Data output                                                              | O    | J2/ AF2       |
| vout3_d12                 | Video Output 3 Data output                                                              | O    | H1/ AG5       |
| vout3_d13                 | Video Output 3 Data output                                                              | O    | J3/ AG3       |
| vout3_d14                 | Video Output 3 Data output                                                              | O    | H2/ AG2       |
| vout3_d15                 | Video Output 3 Data output                                                              | O    | H3/ AG4       |
| vout3_d16                 | Video Output 3 Data output                                                              | O    | R6/ AG8 / AH4 |
| vout3_d17                 | Video Output 3 Data output                                                              | O    | T9/ AD9 / AG6 |
| vout3_d18                 | Video Output 3 Data output                                                              | O    | T6/ AH5       |
| vout3_d19                 | Video Output 3 Data output                                                              | O    | T7/ AH3       |
| vout3_d20                 | Video Output 3 Data output                                                              | O    | P6/ AH6       |
| vout3_d21                 | Video Output 3 Data output                                                              | O    | R9/ AG7       |
| vout3_d22                 | Video Output 3 Data output                                                              | O    | R5/ AD8       |
| vout3_d23                 | Video Output 3 Data output                                                              | O    | P5/ AE8       |

### 4.3.3 HDMI

#### NOTE

For more information, see the Display Subsystem section of the Device TRM.

**Table 4-4. HDMI Signal Descriptions**

| SIGNAL NAME   | DESCRIPTION                                   | TYPE | BALL     |
|---------------|-----------------------------------------------|------|----------|
| hdmi1_cec     | HDMI consumer electronic control              | IOD  | B20/ G19 |
| hdmi1_hpd     | HDMI display hot plug detect                  | IO   | B21/ G20 |
| hdmi1_ddc_scl | HDMI display data channel clock               | IOD  | C25      |
| hdmi1_ddc_sda | HDMI display data channel data                | IOD  | F17      |
| hdmi1_clockx  | HDMI clock differential positive or negative  | ODS  | AG16     |
| hdmi1_clocky  | HDMI clock differential positive or negative  | ODS  | AH16     |
| hdmi1_data2x  | HDMI data 2 differential positive or negative | ODS  | AG19     |

**Table 4-4. HDMI Signal Descriptions (continued)**

| SIGNAL NAME  | DESCRIPTION                                   | TYPE | BALL                 |
|--------------|-----------------------------------------------|------|----------------------|
| hdmi1_data2y | HDMI data 2 differential positive or negative | ODS  | <a href="#">AH19</a> |
| hdmi1_data1x | HDMI data 1 differential positive or negative | ODS  | <a href="#">AG18</a> |
| hdmi1_data1y | HDMI data 1 differential positive or negative | ODS  | <a href="#">AH18</a> |
| hdmi1_data0x | HDMI data 0 differential positive or negative | ODS  | <a href="#">AG17</a> |
| hdmi1_data0y | HDMI data 0 differential positive or negative | ODS  | <a href="#">AH17</a> |

**4.3.4 EMIF****NOTE**

For more information, see the Memory Subsystem / EMIF Controller section of the Device TRM.

**Table 4-5. EMIF Signal Descriptions**

| SIGNAL NAME           | DESCRIPTION                                | TYPE | BALL                 |
|-----------------------|--------------------------------------------|------|----------------------|
| <b>EMIF Channel 1</b> |                                            |      |                      |
| ddr1_csn0             | EMIF1 Chip Select 0                        | O    | <a href="#">AH23</a> |
| ddr1_cke              | EMIF1 Clock Enable                         | O    | <a href="#">AG22</a> |
| ddr1_ck               | EMIF1 Clock                                | O    | <a href="#">AG24</a> |
| ddr1_nck              | EMIF1 Negative Clock                       | O    | <a href="#">AH24</a> |
| ddr1_odt0             | EMIF1 On-Die Termination for Chip Select 0 | O    | <a href="#">AE20</a> |
| ddr1_casn             | EMIF1 Column Address Strobe                | O    | <a href="#">AC18</a> |
| ddr1_rasn             | EMIF1 Row Address Strobe                   | O    | <a href="#">AF20</a> |
| ddr1_wen              | EMIF1 Write Enable                         | O    | <a href="#">AH21</a> |
| ddr1_rst              | EMIF1 Reset output (DDR3-SDRAM only)       | O    | <a href="#">AG21</a> |
| ddr1_ba0              | EMIF1 Bank Address                         | O    | <a href="#">AF17</a> |
| ddr1_ba1              | EMIF1 Bank Address                         | O    | <a href="#">AE18</a> |
| ddr1_ba2              | EMIF1 Bank Address                         | O    | <a href="#">AB18</a> |
| ddr1_a0               | EMIF1 Address Bus                          | O    | <a href="#">AD20</a> |
| ddr1_a1               | EMIF1 Address Bus                          | O    | <a href="#">AC19</a> |
| ddr1_a2               | EMIF1 Address Bus                          | O    | <a href="#">AC20</a> |
| ddr1_a3               | EMIF1 Address Bus                          | O    | <a href="#">AB19</a> |
| ddr1_a4               | EMIF1 Address Bus                          | O    | <a href="#">AF21</a> |
| ddr1_a5               | EMIF1 Address Bus                          | O    | <a href="#">AH22</a> |
| ddr1_a6               | EMIF1 Address Bus                          | O    | <a href="#">AG23</a> |
| ddr1_a7               | EMIF1 Address Bus                          | O    | <a href="#">AE21</a> |
| ddr1_a8               | EMIF1 Address Bus                          | O    | <a href="#">AF22</a> |
| ddr1_a9               | EMIF1 Address Bus                          | O    | <a href="#">AE22</a> |
| ddr1_a10              | EMIF1 Address Bus                          | O    | <a href="#">AD21</a> |
| ddr1_a11              | EMIF1 Address Bus                          | O    | <a href="#">AD22</a> |
| ddr1_a12              | EMIF1 Address Bus                          | O    | <a href="#">AC21</a> |
| ddr1_a13              | EMIF1 Address Bus                          | O    | <a href="#">AF18</a> |
| ddr1_a14              | EMIF1 Address Bus                          | O    | <a href="#">AE17</a> |
| ddr1_a15              | EMIF1 Address Bus                          | O    | <a href="#">AD18</a> |
| ddr1_d0               | EMIF1 Data Bus                             | IO   | <a href="#">AF25</a> |
| ddr1_d1               | EMIF1 Data Bus                             | IO   | <a href="#">AF26</a> |
| ddr1_d2               | EMIF1 Data Bus                             | IO   | <a href="#">AG26</a> |
| ddr1_d3               | EMIF1 Data Bus                             | IO   | <a href="#">AH26</a> |

**Table 4-5. EMIF Signal Descriptions (continued)**

| SIGNAL NAME  | DESCRIPTION                                                                                                                                  | TYPE | BALL |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------|------|------|
| ddr1_d4      | EMIF1 Data Bus                                                                                                                               | IO   | AF24 |
| ddr1_d5      | EMIF1 Data Bus                                                                                                                               | IO   | AE24 |
| ddr1_d6      | EMIF1 Data Bus                                                                                                                               | IO   | AF23 |
| ddr1_d7      | EMIF1 Data Bus                                                                                                                               | IO   | AE23 |
| ddr1_d8      | EMIF1 Data Bus                                                                                                                               | IO   | AC23 |
| ddr1_d9      | EMIF1 Data Bus                                                                                                                               | IO   | AF27 |
| ddr1_d10     | EMIF1 Data Bus                                                                                                                               | IO   | AG27 |
| ddr1_d11     | EMIF1 Data Bus                                                                                                                               | IO   | AF28 |
| ddr1_d12     | EMIF1 Data Bus                                                                                                                               | IO   | AE26 |
| ddr1_d13     | EMIF1 Data Bus                                                                                                                               | IO   | AC25 |
| ddr1_d14     | EMIF1 Data Bus                                                                                                                               | IO   | AC24 |
| ddr1_d15     | EMIF1 Data Bus                                                                                                                               | IO   | AD25 |
| ddr1_d16     | EMIF1 Data Bus                                                                                                                               | IO   | V20  |
| ddr1_d17     | EMIF1 Data Bus                                                                                                                               | IO   | W20  |
| ddr1_d18     | EMIF1 Data Bus                                                                                                                               | IO   | AB28 |
| ddr1_d19     | EMIF1 Data Bus                                                                                                                               | IO   | AC28 |
| ddr1_d20     | EMIF1 Data Bus                                                                                                                               | IO   | AC27 |
| ddr1_d21     | EMIF1 Data Bus                                                                                                                               | IO   | Y19  |
| ddr1_d22     | EMIF1 Data Bus                                                                                                                               | IO   | AB27 |
| ddr1_d23     | EMIF1 Data Bus                                                                                                                               | IO   | Y20  |
| ddr1_d24     | EMIF1 Data Bus                                                                                                                               | IO   | AA23 |
| ddr1_d25     | EMIF1 Data Bus                                                                                                                               | IO   | Y22  |
| ddr1_d26     | EMIF1 Data Bus                                                                                                                               | IO   | Y23  |
| ddr1_d27     | EMIF1 Data Bus                                                                                                                               | IO   | AA24 |
| ddr1_d28     | EMIF1 Data Bus                                                                                                                               | IO   | Y24  |
| ddr1_d29     | EMIF1 Data Bus                                                                                                                               | IO   | AA26 |
| ddr1_d30     | EMIF1 Data Bus                                                                                                                               | IO   | AA25 |
| ddr1_d31     | EMIF1 Data Bus                                                                                                                               | IO   | AA28 |
| ddr1_ecc_d0  | EMIF1 ECC Data Bus                                                                                                                           | IO   | W22  |
| ddr1_ecc_d1  | EMIF1 ECC Data Bus                                                                                                                           | IO   | V23  |
| ddr1_ecc_d2  | EMIF1 ECC Data Bus                                                                                                                           | IO   | W19  |
| ddr1_ecc_d3  | EMIF1 ECC Data Bus                                                                                                                           | IO   | W23  |
| ddr1_ecc_d4  | EMIF1 ECC Data Bus                                                                                                                           | IO   | Y25  |
| ddr1_ecc_d5  | EMIF1 ECC Data Bus                                                                                                                           | IO   | V24  |
| ddr1_ecc_d6  | EMIF1 ECC Data Bus                                                                                                                           | IO   | V25  |
| ddr1_ecc_d7  | EMIF1 ECC Data Bus                                                                                                                           | IO   | Y26  |
| ddr1_dqm0    | EMIF1 Data Mask                                                                                                                              | O    | AD23 |
| ddr1_dqm1    | EMIF1 Data Mask                                                                                                                              | O    | AB23 |
| ddr1_dqm2    | EMIF1 Data Mask                                                                                                                              | O    | AC26 |
| ddr1_dqm3    | EMIF1 Data Mask                                                                                                                              | O    | AA27 |
| ddr1_dqm_ecc | EMIF1 ECC Data Mask                                                                                                                          | O    | V26  |
| ddr1_dqs0    | Data strobe 0 input/output for byte 0 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO   | AH25 |
| ddr1_dqsn0   | Data strobe 0 invert                                                                                                                         | IO   | AG25 |
| ddr1_dqs1    | Data strobe 1 input/output for byte 1 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO   | AE27 |
| ddr1_dqsn1   | Data strobe 1 invert                                                                                                                         | IO   | AE28 |

**Table 4-5. EMIF Signal Descriptions (continued)**

| SIGNAL NAME           | DESCRIPTION                                                                                                                                  | TYPE | BALL |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------|------|------|
| ddr1_dqs2             | Data strobe 2 input/output for byte 2 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO   | AD27 |
| ddr1_dqsn2            | Data strobe 2 invert                                                                                                                         | IO   | AD28 |
| ddr1_dqs3             | Data strobe 3 input/output for byte 3 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO   | Y28  |
| ddr1_dqsn3            | Data strobe 3 invert                                                                                                                         | IO   | Y27  |
| ddr1_dqs_ecc          | EMIF1 ECC Data strobe input/output. This signal is output to the EMIF1 memory when writing and input when reading.                           | IO   | V27  |
| ddr1_dqsn_ecc         | EMIF1 ECC Complementary Data strobe                                                                                                          | IO   | V28  |
| ddr1_vref0            | Reference Power Supply EMIF1                                                                                                                 | A    | Y18  |
| <b>EMIF Channel 2</b> |                                                                                                                                              |      |      |
| ddr2_csn0             | EMIF2 Chip Select 0                                                                                                                          | O    | P24  |
| ddr2_cke              | EMIF2 Clock Enable                                                                                                                           | O    | U24  |
| ddr2_ck               | EMIF2 Clock                                                                                                                                  | O    | T28  |
| ddr2_nck              | EMIF2 Negative Clock                                                                                                                         | O    | T27  |
| ddr2_odt0             | EMIF2 On-Die Termination for Chip Select 0                                                                                                   | O    | R23  |
| ddr2_casn             | EMIF2 Column Address Strobe                                                                                                                  | O    | U28  |
| ddr2_rasn             | EMIF2 Row Address Strobe                                                                                                                     | O    | T23  |
| ddr2_wen              | EMIF2 Write Enable                                                                                                                           | O    | U25  |
| ddr2_rst              | EMIF2 Reset output (DDR3-SDRAM only)                                                                                                         | O    | R24  |
| ddr2_ba0              | EMIF2 Bank Address                                                                                                                           | O    | U23  |
| ddr2_ba1              | EMIF2 Bank Address                                                                                                                           | O    | U27  |
| ddr2_ba2              | EMIF2 Bank Address                                                                                                                           | O    | U26  |
| ddr2_a0               | EMIF2 Address Bus                                                                                                                            | O    | R25  |
| ddr2_a1               | EMIF2 Address Bus                                                                                                                            | O    | R26  |
| ddr2_a2               | EMIF2 Address Bus                                                                                                                            | O    | R28  |
| ddr2_a3               | EMIF2 Address Bus                                                                                                                            | O    | R27  |
| ddr2_a4               | EMIF2 Address Bus                                                                                                                            | O    | P23  |
| ddr2_a5               | EMIF2 Address Bus                                                                                                                            | O    | P22  |
| ddr2_a6               | EMIF2 Address Bus                                                                                                                            | O    | P25  |
| ddr2_a7               | EMIF2 Address Bus                                                                                                                            | O    | N20  |
| ddr2_a8               | EMIF2 Address Bus                                                                                                                            | O    | P27  |
| ddr2_a9               | EMIF2 Address Bus                                                                                                                            | O    | N27  |
| ddr2_a10              | EMIF2 Address Bus                                                                                                                            | O    | N23  |
| ddr2_a11              | EMIF2 Address Bus                                                                                                                            | O    | P26  |
| ddr2_a12              | EMIF2 Address Bus                                                                                                                            | O    | N28  |
| ddr2_a13              | EMIF2 Address Bus                                                                                                                            | O    | T22  |
| ddr2_a14              | EMIF2 Address Bus                                                                                                                            | O    | R22  |
| ddr2_a15              | EMIF2 Address Bus                                                                                                                            | O    | U22  |
| ddr2_d0               | EMIF2 Data Bus                                                                                                                               | IO   | E26  |
| ddr2_d1               | EMIF2 Data Bus                                                                                                                               | IO   | G25  |
| ddr2_d2               | EMIF2 Data Bus                                                                                                                               | IO   | F25  |
| ddr2_d3               | EMIF2 Data Bus                                                                                                                               | IO   | F24  |
| ddr2_d4               | EMIF2 Data Bus                                                                                                                               | IO   | F26  |
| ddr2_d5               | EMIF2 Data Bus                                                                                                                               | IO   | F27  |
| ddr2_d6               | EMIF2 Data Bus                                                                                                                               | IO   | E27  |
| ddr2_d7               | EMIF2 Data Bus                                                                                                                               | IO   | E28  |
| ddr2_d8               | EMIF2 Data Bus                                                                                                                               | IO   | H23  |

**Table 4-5. EMIF Signal Descriptions (continued)**

| SIGNAL NAME | DESCRIPTION                                                                                                                                  | TYPE | BALL |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------|------|------|
| ddr2_d9     | EMIF2 Data Bus                                                                                                                               | IO   | H25  |
| ddr2_d10    | EMIF2 Data Bus                                                                                                                               | IO   | H24  |
| ddr2_d11    | EMIF2 Data Bus                                                                                                                               | IO   | H26  |
| ddr2_d12    | EMIF2 Data Bus                                                                                                                               | IO   | G26  |
| ddr2_d13    | EMIF2 Data Bus                                                                                                                               | IO   | J25  |
| ddr2_d14    | EMIF2 Data Bus                                                                                                                               | IO   | J26  |
| ddr2_d15    | EMIF2 Data Bus                                                                                                                               | IO   | J24  |
| ddr2_d16    | EMIF2 Data Bus                                                                                                                               | IO   | L22  |
| ddr2_d17    | EMIF2 Data Bus                                                                                                                               | IO   | K20  |
| ddr2_d18    | EMIF2 Data Bus                                                                                                                               | IO   | K21  |
| ddr2_d19    | EMIF2 Data Bus                                                                                                                               | IO   | L23  |
| ddr2_d20    | EMIF2 Data Bus                                                                                                                               | IO   | L24  |
| ddr2_d21    | EMIF2 Data Bus                                                                                                                               | IO   | J23  |
| ddr2_d22    | EMIF2 Data Bus                                                                                                                               | IO   | K22  |
| ddr2_d23    | EMIF2 Data Bus                                                                                                                               | IO   | J20  |
| ddr2_d24    | EMIF2 Data Bus                                                                                                                               | IO   | L27  |
| ddr2_d25    | EMIF2 Data Bus                                                                                                                               | IO   | L26  |
| ddr2_d26    | EMIF2 Data Bus                                                                                                                               | IO   | L25  |
| ddr2_d27    | EMIF2 Data Bus                                                                                                                               | IO   | L28  |
| ddr2_d28    | EMIF2 Data Bus                                                                                                                               | IO   | M23  |
| ddr2_d29    | EMIF2 Data Bus                                                                                                                               | IO   | M24  |
| ddr2_d30    | EMIF2 Data Bus                                                                                                                               | IO   | M25  |
| ddr2_d31    | EMIF2 Data Bus                                                                                                                               | IO   | M26  |
| ddr2_dqm0   | EMIF2 Data Mask                                                                                                                              | O    | F28  |
| ddr2_dqm1   | EMIF2 Data Mask                                                                                                                              | O    | G24  |
| ddr2_dqm2   | EMIF2 Data Mask                                                                                                                              | O    | K23  |
| ddr2_dqm3   | EMIF2 Data Mask                                                                                                                              | O    | M22  |
| ddr2_dqs0   | Data strobe 0 input/output for byte 0 of the 32-bit data bus. This signal is output to the EMIF2 memory when writing and input when reading. | IO   | G28  |
| ddr2_dqsn0  | Data strobe 0 invert                                                                                                                         | IO   | G27  |
| ddr2_dqs1   | Data strobe 1 input/output for byte 1 of the 32-bit data bus. This signal is output to the EMIF2 memory when writing and input when reading. | IO   | H27  |
| ddr2_dqsn1  | Data strobe 1 invert                                                                                                                         | IO   | H28  |
| ddr2_dqs2   | Data strobe 2 input/output for byte 2 of the 32-bit data bus. This signal is output to the EMIF2 memory when writing and input when reading. | IO   | K27  |
| ddr2_dqsn2  | Data strobe 2 invert                                                                                                                         | IO   | K28  |
| ddr2_dqs3   | Data strobe 3 input/output for byte 3 of the 32-bit data bus. This signal is output to the EMIF2 memory when writing and input when reading. | IO   | M28  |
| ddr2_dqsn3  | Data strobe 3 invert                                                                                                                         | IO   | M27  |
| ddr2_vref0  | Reference Power Supply EMIF2                                                                                                                 | A    | N22  |

#### NOTE

DDR SDRAM Channel 2 is not supported by Vision High Surround, Vision High and Vision Mid devices.

For more details on the device differentiation, refer to [Table 3-1, Device Comparison](#).

**NOTE**

The index numbers 1 and 2 which is part of the EMIF1 and EMIF2 signal prefixes (ddr1\_\* and ddr2\_\*) listed in [Table 4-5](#), DDR2/DDR3/DDR3L SDRAM Signal Descriptions, column "SIGNAL NAME" not to be confused with DDR1 and DDR2 types of SDRAM memories.

**4.3.5 GPMC****NOTE**

For more information, see the Memory Subsystem / General-Purpose Memory Controller section of the Device TRM.

**Table 4-6. GPMC Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                                                                                 | TYPE | BALL    |
|-------------|---------------------------------------------------------------------------------------------|------|---------|
| gpmc_ad0    | GPMC Data 0 in A/D nonmultiplexed mode and additionally Address 1 in A/D multiplexed mode   | IO   | M6      |
| gpmc_ad1    | GPMC Data 1 in A/D nonmultiplexed mode and additionally Address 2 in A/D multiplexed mode   | IO   | M2      |
| gpmc_ad2    | GPMC Data 2 in A/D nonmultiplexed mode and additionally Address 3 in A/D multiplexed mode   | IO   | L5      |
| gpmc_ad3    | GPMC Data 3 in A/D nonmultiplexed mode and additionally Address 4 in A/D multiplexed mode   | IO   | M1      |
| gpmc_ad4    | GPMC Data 4 in A/D nonmultiplexed mode and additionally Address 5 in A/D multiplexed mode   | IO   | L6      |
| gpmc_ad5    | GPMC Data 5 in A/D nonmultiplexed mode and additionally Address 6 in A/D multiplexed mode   | IO   | L4      |
| gpmc_ad6    | GPMC Data 6 in A/D nonmultiplexed mode and additionally Address 7 in A/D multiplexed mode   | IO   | L3      |
| gpmc_ad7    | GPMC Data 7 in A/D nonmultiplexed mode and additionally Address 8 in A/D multiplexed mode   | IO   | L2      |
| gpmc_ad8    | GPMC Data 8 in A/D nonmultiplexed mode and additionally Address 9 in A/D multiplexed mode   | IO   | L1      |
| gpmc_ad9    | GPMC Data 9 in A/D nonmultiplexed mode and additionally Address 10 in A/D multiplexed mode  | IO   | K2      |
| gpmc_ad10   | GPMC Data 10 in A/D nonmultiplexed mode and additionally Address 11 in A/D multiplexed mode | IO   | J1      |
| gpmc_ad11   | GPMC Data 11 in A/D nonmultiplexed mode and additionally Address 12 in A/D multiplexed mode | IO   | J2      |
| gpmc_ad12   | GPMC Data 12 in A/D nonmultiplexed mode and additionally Address 13 in A/D multiplexed mode | IO   | H1      |
| gpmc_ad13   | GPMC Data 13 in A/D nonmultiplexed mode and additionally Address 14 in A/D multiplexed mode | IO   | J3      |
| gpmc_ad14   | GPMC Data 14 in A/D nonmultiplexed mode and additionally Address 15 in A/D multiplexed mode | IO   | H2      |
| gpmc_ad15   | GPMC Data 15 in A/D nonmultiplexed mode and additionally Address 16 in A/D multiplexed mode | IO   | H3      |
| gpmc_a0     | GPMC Address 0. Only used to effectively address 8-bit data nonmultiplexed memories         | O    | R6 / P4 |
| gpmc_a1     | GPMC address 1 in A/D nonmultiplexed mode and Address 17 in A/D multiplexed mode            | O    | T9 / P1 |
| gpmc_a2     | GPMC address 2 in A/D nonmultiplexed mode and Address 18 in A/D multiplexed mode            | O    | T6 / N1 |
| gpmc_a3     | GPMC address 3 in A/D nonmultiplexed mode and Address 19 in A/D multiplexed mode            | O    | T7 / M4 |
| gpmc_a4     | GPMC address 4 in A/D nonmultiplexed mode and Address 20 in A/D multiplexed mode            | O    | P6      |

**Table 4-6. GPMC Signal Descriptions (continued)**

| SIGNAL NAME                | DESCRIPTION                                                                       | TYPE | BALL                                   |
|----------------------------|-----------------------------------------------------------------------------------|------|----------------------------------------|
| gpmc_a5                    | GPMC address 5 in A/D nonmultiplexed mode and Address 21 in A/D multiplexed mode  | O    | R9                                     |
| gpmc_a6                    | GPMC address 6 in A/D nonmultiplexed mode and Address 22 in A/D multiplexed mode  | O    | R5                                     |
| gpmc_a7                    | GPMC address 7 in A/D nonmultiplexed mode and Address 23 in A/D multiplexed mode  | O    | P5                                     |
| gpmc_a8                    | GPMC address 8 in A/D nonmultiplexed mode and Address 24 in A/D multiplexed mode  | O    | N7                                     |
| gpmc_a9                    | GPMC address 9 in A/D nonmultiplexed mode and Address 25 in A/D multiplexed mode  | O    | R4                                     |
| gpmc_a10                   | GPMC address 10 in A/D nonmultiplexed mode and Address 26 in A/D multiplexed mode | O    | N9                                     |
| gpmc_a11                   | GPMC address 11 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | P9                                     |
| gpmc_a12                   | GPMC address 12 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | P4                                     |
| gpmc_a13                   | GPMC address 13 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | R3 / K7 / P2                           |
| gpmc_a14                   | GPMC address 14 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | T2 / M7 / P1                           |
| gpmc_a15                   | GPMC address 15 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | U2 / J5 / N2                           |
| gpmc_a16                   | GPMC address 16 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | U1 / K6 / R6                           |
| gpmc_a17                   | GPMC address 17 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | P3 / J7 / E1                           |
| gpmc_a18                   | GPMC address 18 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | R2 / J4 / H7                           |
| gpmc_a19                   | GPMC address 19 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | K7 <sup>(3)</sup> / J6 / N1            |
| gpmc_a20                   | GPMC address 20 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | M7 <sup>(3)</sup> / H4 / P7            |
| gpmc_a21                   | GPMC address 21 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | J5 <sup>(3)</sup> / H5 / N6            |
| gpmc_a22                   | GPMC address 22 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | K6 <sup>(3)</sup> / H6 / M4            |
| gpmc_a23                   | GPMC address 23 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | J7 / AG5 / N1 / P2 / F6                |
| gpmc_a24                   | GPMC address 24 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | J4 <sup>(3)</sup> / AF2 / P1 / D3      |
| gpmc_a25                   | GPMC address 25 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | J6 <sup>(3)</sup> / AF6 / N2 / E6      |
| gpmc_a26                   | GPMC address 26 in A/D nonmultiplexed mode and unused in A/D multiplexed mode     | O    | H4 <sup>(3)</sup> / AF3 / R6 / F5      |
| gpmc_a27                   | GPMC address 27 in A/D nonmultiplexed mode and Address 27 in A/D multiplexed mode | O    | H5 <sup>(3)</sup> / AF4 / E1 / H7 / G1 |
| gpmc_cs0                   | GPMC Chip Select 0 (active low)                                                   | O    | T1                                     |
| gpmc_cs1                   | GPMC Chip Select 1 (active low)                                                   | O    | H6                                     |
| gpmc_cs2                   | GPMC Chip Select 2 (active low)                                                   | O    | P2                                     |
| gpmc_cs3                   | GPMC Chip Select 3 (active low)                                                   | O    | P1                                     |
| gpmc_cs4                   | GPMC Chip Select 4 (active low)                                                   | O    | N6                                     |
| gpmc_cs5                   | GPMC Chip Select 5 (active low)                                                   | O    | M4                                     |
| gpmc_cs6                   | GPMC Chip Select 6 (active low)                                                   | O    | N1                                     |
| gpmc_cs7                   | GPMC Chip Select 7 (active low)                                                   | O    | P7                                     |
| gpmc_clk <sup>(1)(2)</sup> | GPMC Clock output                                                                 | IO   | P7                                     |

**Table 4-6. GPMC Signal Descriptions (continued)**

| SIGNAL NAME   | DESCRIPTION                                           | TYPE | BALL    |
|---------------|-------------------------------------------------------|------|---------|
| gpmc_advn_ale | GPMC address valid active low or address latch enable | O    | N1      |
| gpmc_oen_ren  | GPMC output enable active low or read enable          | O    | M5      |
| gpmc_wen      | GPMC write enable active low                          | O    | M3      |
| gpmc_ben0     | GPMC lower-byte enable active low                     | O    | N6      |
| gpmc_ben1     | GPMC upper-byte enable active low                     | O    | M4      |
| gpmc_wait0    | GPMC external indication of wait 0                    | I    | N2      |
| gpmc_wait1    | GPMC external indication of wait 1                    | I    | P7 / N1 |

- (1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any non-monotonicity in voltage that occurs at the pad loopback clock pin between  $V_{IH}$  and  $V_{IL}$  must be less than  $V_{HYS}$ .
- (2) The gpio6\_16.clkout1 signal can be used as an "always-on" alternative to gpmc\_clk provided that the external device can support the associated timing. See [Table 5-55, GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Default](#) and [Table 5-57, GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Alternate](#) for timing information.
- (3) The internal pull resistors for balls K7, M7, J5, K6, J4, J6, H4, H5 are permanently disabled when sysboot15 is set to 1 as described in the section Sysboot Configuration of the Device TRM. If internal pull-up/down resistors are desired on these balls then sysboot15 should be set to 0. If gpmc boot mode is used with SYSBOOT15 = 1 (not recommended) then external pull-downs should be implemented to keep the address bus at logic-0 value during boot since the gpmc ms-address bits are Hi-Z during boot.

### 4.3.6 Timers

#### NOTE

For more information, see the Timers section of the Device TRM.

**Table 4-7. Timers Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                    | TYPE | BALL           |
|-------------|--------------------------------|------|----------------|
| timer1      | PWM output/event trigger input | IO   | M4/ E21        |
| timer2      | PWM output/event trigger input | IO   | N6/ F20        |
| timer3      | PWM output/event trigger input | IO   | N1/ F21        |
| timer4      | PWM output/event trigger input | IO   | P7/ D12        |
| timer5      | PWM output/event trigger input | IO   | U2/ B12        |
| timer6      | PWM output/event trigger input | IO   | T2/ A11        |
| timer7      | PWM output/event trigger input | IO   | R3/ B13        |
| timer8      | PWM output/event trigger input | IO   | P4/ A12        |
| timer9      | PWM output/event trigger input | IO   | P9/ E14        |
| timer10     | PWM output/event trigger input | IO   | N9/ A13        |
| timer11     | PWM output/event trigger input | IO   | R4/ G14        |
| timer12     | PWM output/event trigger input | IO   | N7/ F14        |
| timer13     | PWM output/event trigger input | IO   | D18/ AF8       |
| timer14     | PWM output/event trigger input | IO   | E17/ AE9       |
| timer15     | PWM output/event trigger input | IO   | B26/ AF9/ AC10 |
| timer16     | PWM output/event trigger input | IO   | C23/ AD9/ AB10 |

### 4.3.7 I2C

#### NOTE

For more information, see the Serial Communication Interface / I2C section of the Device TRM.

### NOTE

I2C1 and I2C2 do not support HS mode.

**Table 4-8. I2C Signal Descriptions**

| SIGNAL NAME                                      | DESCRIPTION | TYPE | BALL              |
|--------------------------------------------------|-------------|------|-------------------|
| <b>Inter-Integrated Circuit Interface (I2C1)</b> |             |      |                   |
| i2c1_scl                                         | I2C1 Clock  | IOD  | C20               |
| i2c1_sda                                         | I2C1 Data   | IOD  | C21               |
| <b>Inter-Integrated Circuit Interface (I2C2)</b> |             |      |                   |
| i2c2_scl                                         | I2C2 Clock  | IOD  | F17               |
| i2c2_sda                                         | I2C2 Data   | IOD  | C25               |
| <b>Inter-Integrated Circuit Interface (I2C3)</b> |             |      |                   |
| i2c3_scl                                         | I2C3 Clock  | IOD  | P7/ D14/ AB4/ F20 |
| i2c3_sda                                         | I2C3 Data   | IOD  | N1/ C14/ AC5/ E21 |
| <b>Inter-Integrated Circuit Interface (I2C4)</b> |             |      |                   |
| i2c4_scl                                         | I2C4 Clock  | IOD  | R6/ J14/ A21/ Y9  |
| i2c4_sda                                         | I2C4 Data   | IOD  | T9/ B14/ C18/ W7  |
| <b>Inter-Integrated Circuit Interface (I2C5)</b> |             |      |                   |
| i2c5_scl                                         | I2C5 Clock  | IOD  | AB9/ P6/ F12      |
| i2c5_sda                                         | I2C5 Data   | IOD  | AA3/ R9/ G12      |

## 4.3.8 UART

### NOTE

For more information, see the Serial Communication Interface /UART/IrDA/CIR section of the Device TRM.

**Table 4-9. UART Signal Descriptions**

| SIGNAL NAME                                                     | DESCRIPTION                                                | TYPE | BALL                |
|-----------------------------------------------------------------|------------------------------------------------------------|------|---------------------|
| <b>Universal Asynchronous Receiver/Transmitter (UART1)</b>      |                                                            |      |                     |
| uart1_dcdn                                                      | UART1 Data Carrier Detect active low                       | I    | D28                 |
| uart1_dsrn                                                      | UART1 Data Set Ready active Low                            | I    | D26                 |
| uart1_dtrn                                                      | UART1 Data Terminal Ready active Low                       | O    | D27                 |
| uart1_rin                                                       | UART1 Ring Indicator                                       | I    | C28                 |
| uart1_rxd                                                       | UART1 Receive Data                                         | I    | B27                 |
| uart1_txd                                                       | UART1 Transmit Data                                        | O    | C26                 |
| uart1_ctsn                                                      | UART1 Clear to Send active low                             | I    | E25                 |
| uart1_rtsn                                                      | UART1 Request to Send active low                           | O    | C27                 |
| <b>Universal Asynchronous Receiver/Transmitter (UART2)</b>      |                                                            |      |                     |
| uart2_rxd                                                       | UART2 Receive Data                                         | I    | D28                 |
| uart2_txd                                                       | UART2 Transmit Data                                        | O    | D26                 |
| uart2_ctsn                                                      | UART2 Clear to Send active low                             | I    | D27                 |
| uart2_rtsn                                                      | UART2 Request to Send active low                           | O    | C28                 |
| <b>Universal Asynchronous Receiver/Transmitter (UART3)/IrDA</b> |                                                            |      |                     |
| uart3_rxd                                                       | UART3 Receive Data for both normal UART mode and IrDA mode | I    | V2 / AB3 / A26/ D27 |
| uart3_txd                                                       | UART3 Transmit Data                                        | O    | Y1/ B22/ C28/ AA4   |
| uart3_ctsn                                                      | UART3 Clear to Send active low                             | I    | U4/ W9/ G17/ D28    |
| uart3_rtsn                                                      | UART3 Request to Send active low                           | O    | V1/ V9/ D26/ B24    |

**Table 4-9. UART Signal Descriptions (continued)**

| SIGNAL NAME                                                 | DESCRIPTION                             | TYPE | BALL                   |
|-------------------------------------------------------------|-----------------------------------------|------|------------------------|
| uart3_rctx                                                  | Remote control data                     | O    | D28                    |
| uart3_sd                                                    | Infrared transceiver configure/shutdown | O    | D26                    |
| uart3_irtx                                                  | Infrared data output                    | O    | C28                    |
| <b>Universal Asynchronous Receiver/Transmitter (UART4)</b>  |                                         |      |                        |
| uart4_rxd                                                   | UART4 Receive Data                      | I    | V7/ G16/ B21           |
| uart4_txd                                                   | UART4 Transmit Data                     | O    | U7/ D17/ B20           |
| uart4_ctsn                                                  | UART4 Clear to Send active low          | I    | V6                     |
| uart4_rtsn                                                  | UART4 Request to Send active low        | O    | U6                     |
| <b>Universal Asynchronous Receiver/Transmitter (UART5)</b>  |                                         |      |                        |
| uart5_rxd                                                   | UART5 Receive Data                      | I    | R6/ F11/ B19/ AC7/ G17 |
| uart5_txd                                                   | UART5 Transmit Data                     | O    | T9/ G10/ C17/ AC6/ B24 |
| uart5_ctsn                                                  | UART5 Clear to Send active low          | I    | T6/ AC9                |
| uart5_rtsn                                                  | UART5 Request to Send active low        | O    | T7/ AC3                |
| <b>Universal Asynchronous Receiver/Transmitter (UART6)</b>  |                                         |      |                        |
| uart6_rxd                                                   | UART6 Receive Data                      | I    | P6/ E8/ G12/ W7        |
| uart6_txd                                                   | UART6 Transmit Data                     | O    | R9/ D9/ F12/ Y9        |
| uart6_ctsn                                                  | UART6 Clear to Send active low          | I    | R5/ G13                |
| uart6_rtsn                                                  | UART6 Request to Send active low        | O    | P5/ J11                |
| <b>Universal Asynchronous Receiver/Transmitter (UART7)</b>  |                                         |      |                        |
| uart7_rxd                                                   | UART7 Receive Data                      | I    | T6/ AD9/ B7/ B18       |
| uart7_txd                                                   | UART7 Transmit Data                     | O    | T7/ AF9/ B8/ F15       |
| uart7_ctsn                                                  | UART7 Clear to Send active low          | I    | AE9/ B19               |
| uart7_rtsn                                                  | UART7 Request to Send active low        | O    | AF8/ C17               |
| <b>Universal Asynchronous Receiver/Transmitter (UART8)</b>  |                                         |      |                        |
| uart8_rxd                                                   | UART8 Receive Data                      | I    | AE8/ R5/ C18/ G20      |
| uart8_txd                                                   | UART8 Transmit Data                     | O    | AD8/ P5/ A21/ G19      |
| uart8_ctsn                                                  | UART8 Clear to Send active low          | I    | AG7/ G16               |
| uart8_rtsn                                                  | UART8 Request to Send active low        | O    | AH6/ D17               |
| <b>Universal Asynchronous Receiver/Transmitter (UART9)</b>  |                                         |      |                        |
| uart9_rxd                                                   | UART9 Receive Data                      | I    | G1/ AA3/ E25           |
| uart9_txd                                                   | UART9 Transmit Data                     | O    | G6/ AB9/ C27           |
| uart9_ctsn                                                  | UART9 Clear to Send active low          | I    | F2/ AB3                |
| uart9_rtsn                                                  | UART9 Request to Send active low        | O    | F3/ AA4                |
| <b>Universal Asynchronous Receiver/Transmitter (UART10)</b> |                                         |      |                        |
| uart10_rxd                                                  | UART10 Receive Data                     | I    | D1/ E21/ AC8/ D27      |
| uart10_txd                                                  | UART10 Transmit Data                    | O    | E2/ F20/ AD6/ C28      |
| uart10_ctsn                                                 | UART10 Clear to Send active low         | I    | D2/ AB8                |
| uart10_rtsn                                                 | UART10 Request to Send active low       | O    | F4/ AB5                |

### 4.3.9 McSPI

#### CAUTION

The I/O timings provided in [Section 5.10, Timing Requirements and Switching Characteristics](#) are applicable for all combinations of signals for SPI1 and SPI2. However, the timings are valid only for SPI3 and SPI4 if signals within a single IOSET are used. The IOSETS are defined in the [Table 5-70](#).

#### NOTE

For more information, see the Serial Communication Interface / McSPI section of the Device TRM.

**Table 4-10. SPI Signal Descriptions**

| SIGNAL NAME                          | DESCRIPTION                                          | TYPE | BALL                           |
|--------------------------------------|------------------------------------------------------|------|--------------------------------|
| <b>Serial Peripheral Interface 1</b> |                                                      |      |                                |
| spi1_sclk <sup>(1)</sup>             | SPI1 Clock                                           | IO   | A25                            |
| spi1_d1                              | SPI1 Data. Can be configured as either MISO or MOSI. | IO   | F16                            |
| spi1_d0                              | SPI1 Data. Can be configured as either MISO or MOSI. | IO   | B25                            |
| spi1_cs0                             | SPI1 Chip Select                                     | IO   | A24                            |
| spi1_cs1                             | SPI1 Chip Select                                     | IO   | A22                            |
| spi1_cs2                             | SPI1 Chip Select                                     | IO   | B21                            |
| spi1_cs3                             | SPI1 Chip Select                                     | IO   | B20                            |
| <b>Serial Peripheral Interface 2</b> |                                                      |      |                                |
| spi2_sclk <sup>(1)</sup>             | SPI2 Clock                                           | IO   | A26                            |
| spi2_d1                              | SPI2 Data. Can be configured as either MISO or MOSI. | IO   | B22                            |
| spi2_d0                              | SPI2 Data. Can be configured as either MISO or MOSI. | IO   | G17                            |
| spi2_cs0                             | SPI2 Chip Select                                     | IO   | B24                            |
| spi2_cs1                             | SPI2 Chip Select                                     | IO   | A22                            |
| spi2_cs2                             | SPI2 Chip Select                                     | IO   | B21                            |
| spi2_cs3                             | SPI2 Chip Select                                     | IO   | B20                            |
| <b>Serial Peripheral Interface 3</b> |                                                      |      |                                |
| spi3_sclk <sup>(1)</sup>             | SPI3 Clock                                           | IO   | AD9/ V2/ B12/ E11/<br>AC4/ C18 |
| spi3_d1                              | SPI3 Data. Can be configured as either MISO or MOSI. | IO   | AF9/ Y1/ B10/ A11/<br>A21/ AC7 |
| spi3_d0                              | SPI3 Data. Can be configured as either MISO or MOSI. | IO   | AE9/ W9/ C11/ B13/<br>AC6/ G16 |
| spi3_cs0                             | SPI3 Chip Select                                     | IO   | AF8/ V9/ D11/ A12/<br>AC9/ D17 |
| spi3_cs1                             | SPI3 Chip Select                                     | IO   | B11/ AC3/ E14                  |
| spi3_cs2                             | SPI3 Chip Select                                     | IO   | F11                            |
| spi3_cs3                             | SPI3 Chip Select                                     | IO   | A10                            |
| <b>Serial Peripheral Interface 4</b> |                                                      |      |                                |
| spi4_sclk <sup>(1)</sup>             | SPI4 Clock                                           | IO   | N7/ G1/ AA3/ V7/<br>AC8        |
| spi4_d1                              | SPI4 Data. Can be configured as either MISO or MOSI. | IO   | R4/ G6/ AB9/ U7/<br>AD6        |
| spi4_d0                              | SPI4 Data. Can be configured as either MISO or MOSI. | IO   | N9/ F2/ AB3/ V6/<br>AB8        |

**Table 4-10. SPI Signal Descriptions (continued)**

| SIGNAL NAME | DESCRIPTION      | TYPE | BALL                 |
|-------------|------------------|------|----------------------|
| spi4_cs0    | SPI4 Chip Select | IO   | P9/ F3/ AA4/ U6/ AB5 |
| spi4_cs1    | SPI4 Chip Select | IO   | P4/ Y1               |
| spi4_cs2    | SPI4 Chip Select | IO   | R3/ W9               |
| spi4_cs3    | SPI4 Chip Select | IO   | T2/ V9               |

(1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between  $V_{IH}$  and  $V_{IL}$  must be less than  $V_{HYS}$ .

#### 4.3.10 QSPI

##### NOTE

For more information, see the Serial Communication Interface / Quad Serial Peripheral Interface section of the Device TRM.

**Table 4-11. QSPI Signal Descriptions**

| SIGNAL NAME  | DESCRIPTION                                                                                                                                       | TYPE | BALL |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------|------|
| qspi1_sclk   | QSPI1 Serial Clock                                                                                                                                | IO   | R2   |
| qspi1_rtcclk | QSPI1 Return Clock Input. Must be connected from QSPI1_SCLK on PCB. Refer to PCB Guidelines for QSPI1                                             | I    | R3   |
| qspi1_d0     | QSPI1 Data[0]. This pin is output data for all commands/writes and for dual read and quad read modes it becomes input data pin during read phase. | IO   | U1   |
| qspi1_d1     | QSPI1 Data[1]. Input read data in all modes.                                                                                                      | I    | P3   |
| qspi1_d2     | QSPI1 Data[2]. This pin is used only in quad read mode as input data pin during read phase                                                        | I    | U2   |
| qspi1_d3     | QSPI1 Data[3]. This pin is used only in quad read mode as input data pin during read phase                                                        | I    | T2   |
| qspi1_cs0    | QSPI1 Chip Select[0]. This pin is Used for QSPI1 boot modes.                                                                                      | O    | P2   |
| qspi1_cs1    | QSPI1 Chip Select[1]                                                                                                                              | O    | P1   |
| qspi1_cs2    | QSPI1 Chip Select[2]                                                                                                                              | O    | T7   |
| qspi1_cs3    | QSPI1 Chip Select[3]                                                                                                                              | O    | P6   |

#### 4.3.11 McASP

##### NOTE

For more information, see the Serial Communication Interface / Multichannel Audio Serial Port (McASP) section of the Device TRM.

**Table 4-12. McASP Signal Descriptions**

| SIGNAL NAME                             | DESCRIPTION                  | TYPE | BALL      |
|-----------------------------------------|------------------------------|------|-----------|
| <b>Multichannel Audio Serial Port 1</b> |                              |      |           |
| mcasp1_axr0                             | McASP1 Transmit/Receive Data | IO   | G12       |
| mcasp1_axr1                             | McASP1 Transmit/Receive Data | IO   | F12       |
| mcasp1_axr2                             | McASP1 Transmit/Receive Data | IO   | G13       |
| mcasp1_axr3                             | McASP1 Transmit/Receive Data | IO   | J11       |
| mcasp1_axr4                             | McASP1 Transmit/Receive Data | IO   | D18/ E12  |
| mcasp1_axr5                             | McASP1 Transmit/Receive Data | IO   | E17 / F13 |
| mcasp1_axr6                             | McASP1 Transmit/Receive Data | IO   | B26 / C12 |
| mcasp1_axr7                             | McASP1 Transmit/Receive Data | IO   | C23 / D12 |

**Table 4-12. McASP Signal Descriptions (continued)**

| SIGNAL NAME                             | DESCRIPTION                                 | TYPE | BALL      |
|-----------------------------------------|---------------------------------------------|------|-----------|
| mcasp1_axr8                             | McASP1 Transmit/Receive Data                | IO   | E21 / B12 |
| mcasp1_axr9                             | McASP1 Transmit/Receive Data                | IO   | F20/ A11  |
| mcasp1_axr10                            | McASP1 Transmit/Receive Data                | IO   | F21 / B13 |
| mcasp1_axr11                            | McASP1 Transmit/Receive Data                | IO   | A12       |
| mcasp1_axr12                            | McASP1 Transmit/Receive Data                | IO   | E14       |
| mcasp1_axr13                            | McASP1 Transmit/Receive Data                | IO   | A13       |
| mcasp1_axr14                            | McASP1 Transmit/Receive Data                | IO   | G14       |
| mcasp1_axr15                            | McASP1 Transmit/Receive Data                | IO   | F14       |
| mcasp1_fsx                              | McASP1 Transmit Frame Sync                  | IO   | D14       |
| mcasp1_aclkr                            | McASP1 Receive Bit Clock                    | IO   | B14       |
| mcasp1_fsr                              | McASP1 Receive Frame Sync                   | IO   | J14       |
| mcasp1_ahclkx                           | McASP1 Transmit High-Frequency Master Clock | O    | D18       |
| mcasp1_aclkx                            | McASP1 Transmit Bit Clock                   | IO   | C14       |
| <b>Multichannel Audio Serial Port 2</b> |                                             |      |           |
| mcasp2_axr0                             | McASP2 Transmit/Receive Data                | IO   | B15       |
| mcasp2_axr1                             | McASP2 Transmit/Receive Data                | IO   | A15       |
| mcasp2_axr2                             | McASP2 Transmit/Receive Data                | IO   | C15       |
| mcasp2_axr3                             | McASP2 Transmit/Receive Data                | IO   | A16       |
| mcasp2_axr4                             | McASP2 Transmit/Receive Data                | IO   | D15       |
| mcasp2_axr5                             | McASP2 Transmit/Receive Data                | IO   | B16       |
| mcasp2_axr6                             | McASP2 Transmit/Receive Data                | IO   | B17       |
| mcasp2_axr7                             | McASP2 Transmit/Receive Data                | IO   | A17       |
| mcasp2_axr8                             | McASP2 Transmit/Receive Data                | IO   | D18       |
| mcasp2_axr9                             | McASP2 Transmit/Receive Data                | IO   | E17       |
| mcasp2_axr10                            | McASP2 Transmit/Receive Data                | IO   | B26       |
| mcasp2_axr11                            | McASP2 Transmit/Receive Data                | IO   | C23       |
| mcasp2_axr12                            | McASP2 Transmit/Receive Data                | IO   | B18       |
| mcasp2_axr13                            | McASP2 Transmit/Receive Data                | IO   | F15       |
| mcasp2_axr14                            | McASP2 Transmit/Receive Data                | IO   | B19       |
| mcasp2_axr15                            | McASP2 Transmit/Receive Data                | IO   | C17       |
| mcasp2_fsx                              | McASP2 Transmit Frame Sync                  | IO   | A18       |
| mcasp2_aclkr <sup>(1)</sup>             | McASP2 Receive Bit Clock                    | IO   | E15       |
| mcasp2_fsr                              | McASP2 Receive Frame Sync                   | IO   | A20       |
| mcasp2_ahclkx                           | McASP2 Transmit High-Frequency Master Clock | O    | E17       |
| mcasp2_aclkx <sup>(1)</sup>             | McASP2 Transmit Bit Clock                   | IO   | A19       |
| <b>Multichannel Audio Serial Port 3</b> |                                             |      |           |
| mcasp3_axr0                             | McASP3 Transmit/Receive Data                | IO   | B19       |
| mcasp3_axr1                             | McASP3 Transmit/Receive Data                | IO   | C17       |
| mcasp3_axr2                             | McASP3 Transmit/Receive Data                | IO   | C15       |
| mcasp3_axr3                             | McASP3 Transmit/Receive Data                | IO   | A16       |
| mcasp3_fsx                              | McASP3 Transmit Frame Sync                  | IO   | F15       |
| mcasp3_ahclkx                           | McASP3 Transmit High-Frequency Master Clock | O    | B26       |
| mcasp3_aclkx <sup>(1)</sup>             | McASP3 Transmit Bit Clock                   | IO   | B18       |
| mcasp3_aclkr <sup>(1)</sup>             | McASP3 Receive Bit Clock                    | IO   | B18       |
| mcasp3_fsr                              | McASP3 Receive Frame Sync                   | IO   | F15       |
| <b>Multichannel Audio Serial Port 4</b> |                                             |      |           |
| mcasp4_axr0                             | McASP4 Transmit/Receive Data                | IO   | G16       |

**Table 4-12. McASP Signal Descriptions (continued)**

| SIGNAL NAME                             | DESCRIPTION                                 | TYPE | BALL |
|-----------------------------------------|---------------------------------------------|------|------|
| mcasp4_axr1                             | McASP4 Transmit/Receive Data                | IO   | D17  |
| mcasp4_axr2                             | McASP4 Transmit/Receive Data                | IO   | E12  |
| mcasp4_axr3                             | McASP4 Transmit/Receive Data                | IO   | F13  |
| mcasp4_fsx                              | McASP4 Transmit Frame Sync                  | IO   | A21  |
| mcasp4_ahclkx                           | McASP4 Transmit High-Frequency Master Clock | O    | C23  |
| mcasp4_aclkx <sup>(1)</sup>             | McASP4 Transmit Bit Clock                   | IO   | C18  |
| mcasp4_aclkr <sup>(1)</sup>             | McASP4 Receive Bit Clock                    | IO   | C18  |
| mcasp4_fsr                              | McASP4 Receive Frame Sync                   | IO   | A21  |
| <b>Multichannel Audio Serial Port 5</b> |                                             |      |      |
| mcasp5_axr0                             | McASP5 Transmit/Receive Data                | IO   | AB3  |
| mcasp5_axr1                             | McASP5 Transmit/Receive Data                | IO   | AA4  |
| mcasp5_axr2                             | McASP5 Transmit/Receive Data                | IO   | C12  |
| mcasp5_axr3                             | McASP5 Transmit/Receive Data                | IO   | D12  |
| mcasp5_fsx                              | McASP5 Transmit Frame Sync                  | IO   | AB9  |
| mcasp5_ahclkx                           | McASP5 Transmit High-Frequency Master Clock | O    | D18  |
| mcasp5_aclkx <sup>(1)</sup>             | McASP5 Transmit Bit Clock                   | IO   | AA3  |
| mcasp5_aclkr <sup>(1)</sup>             | McASP5 Receive Bit Clock                    | IO   | AA3  |
| mcasp5_fsr                              | McASP5 Receive Frame Sync                   | IO   | AB9  |
| <b>Multichannel Audio Serial Port 6</b> |                                             |      |      |
| mcasp6_axr0                             | McASP6 Transmit/Receive Data                | IO   | B12  |
| mcasp6_axr1                             | McASP6 Transmit/Receive Data                | IO   | A11  |
| mcasp6_axr2                             | McASP6 Transmit/Receive Data                | IO   | G13  |
| mcasp6_axr3                             | McASP6 Transmit/Receive Data                | IO   | J11  |
| mcasp6_ahclkx                           | McASP6 Transmit High-Frequency Master Clock | O    | E17  |
| mcasp6_aclkx <sup>(1)</sup>             | McASP6 Transmit Bit Clock                   | IO   | B13  |
| mcasp6_fsx                              | McASP6 Transmit Frame Sync                  | IO   | A12  |
| mcasp6_aclkr <sup>(1)</sup>             | McASP6 Receive Bit Clock                    | IO   | B13  |
| mcasp6_fsr                              | McASP6 Receive Frame Sync                   | IO   | A12  |
| <b>Multichannel Audio Serial Port 7</b> |                                             |      |      |
| mcasp7_axr0                             | McASP7 Transmit/Receive Data                | IO   | E14  |
| mcasp7_axr1                             | McASP7 Transmit/Receive Data                | IO   | A13  |
| mcasp7_axr2                             | McASP7 Transmit/Receive Data                | IO   | B14  |
| mcasp7_axr3                             | McASP7 Transmit/Receive Data                | IO   | J14  |
| mcasp7_ahclkx                           | McASP7 Transmit High-Frequency Master Clock | O    | B26  |
| mcasp7_aclkx <sup>(1)</sup>             | McASP7 Transmit Bit Clock                   | IO   | G14  |
| mcasp7_fsx                              | McASP7 Transmit Frame Sync                  | IO   | F14  |
| mcasp7_aclkr <sup>(1)</sup>             | McASP7 Receive Bit Clock                    | IO   | G14  |
| mcasp7_fsr                              | McASP7 Receive Frame Sync                   | IO   | F14  |
| <b>Multichannel Audio Serial Port 8</b> |                                             |      |      |
| mcasp8_axr0                             | McASP8 Transmit/Receive Data                | IO   | D15  |
| mcasp8_axr1                             | McASP8 Transmit/Receive Data                | IO   | B16  |
| mcasp8_axr2                             | McASP8 Transmit/Receive Data                | IO   | E15  |
| mcasp8_axr3                             | McASP8 Transmit/Receive Data                | IO   | A20  |
| mcasp8_ahclkx                           | McASP8 Transmit High-Frequency Master Clock | O    | C23  |
| mcasp8_aclkx <sup>(1)</sup>             | McASP8 Transmit Bit Clock                   | IO   | B17  |
| mcasp8_fsx                              | McASP8 Transmit Frame Sync                  | IO   | A17  |
| mcasp8_aclkr <sup>(1)</sup>             | McASP8 Receive Bit Clock                    | IO   | B17  |

**Table 4-12. McASP Signal Descriptions (continued)**

| SIGNAL NAME | DESCRIPTION               | TYPE | BALL |
|-------------|---------------------------|------|------|
| mcasp8_fsr  | McASP8 Receive Frame Sync | IO   | A17  |

- (1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between  $V_{IH}$  and  $V_{IL}$  must be less than  $V_{HYS}$ .

### 4.3.12 USB

#### NOTE

For more information, see Serial Communication Interface / SuperSpeed USB DRD Subsystem section of the Device TRM.

**Table 4-13. Universal Serial Bus Signal Descriptions**

| SIGNAL NAME                   | DESCRIPTION                                     | TYPE | BALL      |
|-------------------------------|-------------------------------------------------|------|-----------|
| <b>Universal Serial Bus 1</b> |                                                 |      |           |
| usb1_dp                       | USB1 USB2.0 differential signal pair (positive) | IODS | AD12      |
| usb1_dm                       | USB1 USB2.0 differential signal pair (negative) | IODS | AC12      |
| usb1_drvvbus                  | USB1 Drive VBUS signal                          | O    | AB10      |
| usb_rxn0                      | USB1 USB3.0 receiver negative lane              | IDS  | AF12      |
| usb_rxp0                      | USB1 USB3.0 receiver positive lane              | IDS  | AE12      |
| usb_txn0                      | USB1 USB3.0 transmitter negative lane           | ODS  | AC11      |
| usb_txp0                      | USB1 USB3.0 transmitter positive lane           | ODS  | AD11      |
| <b>Universal Serial Bus 2</b> |                                                 |      |           |
| usb2_dp                       | USB2 USB2.0 differential signal pair (positive) | IODS | AE11      |
| usb2_dm                       | USB2 USB2.0 differential signal pair (negative) | IODS | AF11      |
| usb2_drvvbus                  | USB2 Drive VBUS signal                          | O    | AC10      |
| <b>Universal Serial Bus 3</b> |                                                 |      |           |
| usb3_ulpi_d0                  | USB3 - ULPI 8-bit data bus                      | IO   | AC3 / AE1 |
| usb3_ulpi_d1                  | USB3 - ULPI 8-bit data bus                      | IO   | AC9 / AE5 |
| usb3_ulpi_d2                  | USB3 - ULPI 8-bit data bus                      | IO   | AC6 / AE3 |
| usb3_ulpi_d3                  | USB3 - ULPI 8-bit data bus                      | IO   | AC7 / AF1 |
| usb3_ulpi_d4                  | USB3 - ULPI 8-bit data bus                      | IO   | AC4 / AF4 |
| usb3_ulpi_d5                  | USB3 - ULPI 8-bit data bus                      | IO   | AD4 / AF3 |
| usb3_ulpi_d6                  | USB3 - ULPI 8-bit data bus                      | IO   | AB4 / AF6 |
| usb3_ulpi_d7                  | USB3 - ULPI 8-bit data bus                      | IO   | AC5 / AF2 |
| usb3_ulpi_nxt                 | USB3 - ULPI next                                | I    | AC8 / AE2 |
| usb3_ulpi_dir                 | USB3 - ULPI bus direction                       | I    | AD6 / AE6 |
| usb3_ulpi_stp                 | USB3 - ULPI stop                                | O    | AB8 / AD2 |
| usb3_ulpi_clk                 | USB3 - ULPI functional clock                    | I    | AB5 / AD3 |
| <b>Universal Serial Bus 4</b> |                                                 |      |           |
| usb4_ulpi_d0                  | USB4 - ULPI 8-bit data bus                      | IO   | V6        |
| usb4_ulpi_d1                  | USB4 - ULPI 8-bit data bus                      | IO   | U6        |
| usb4_ulpi_d2                  | USB4 - ULPI 8-bit data bus                      | IO   | U5        |
| usb4_ulpi_d3                  | USB4 - ULPI 8-bit data bus                      | IO   | V5        |
| usb4_ulpi_d4                  | USB4 - ULPI 8-bit data bus                      | IO   | V4        |
| usb4_ulpi_d5                  | USB4 - ULPI 8-bit data bus                      | IO   | V3        |
| usb4_ulpi_d6                  | USB4 - ULPI 8-bit data bus                      | IO   | Y2        |
| usb4_ulpi_d7                  | USB4 - ULPI 8-bit data bus                      | IO   | W2        |
| usb4_ulpi_nxt                 | USB4 - ULPI next                                | I    | U7        |

**Table 4-13. Universal Serial Bus Signal Descriptions (continued)**

| SIGNAL NAME   | DESCRIPTION                  | TYPE | BALL |
|---------------|------------------------------|------|------|
| usb4_ulpi_dir | USB4 - ULPI bus direction    | I    | V7   |
| usb4_ulpi_stp | USB4 - ULPI stop             | O    | V9   |
| usb4_ulpi_clk | USB4 - ULPI functional clock | I    | W9   |

### 4.3.13 SATA

#### NOTE

For more information, see the Serial Communication Interfaces / SATA section of the Device TRM.

**Table 4-14. SATA Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                                   | TYPE | BALL      |
|-------------|-----------------------------------------------|------|-----------|
| sata1_rxn0  | SATA differential negative receiver lane 0    | IDS  | AH9       |
| sata1_rxp0  | SATA differential positive receiver lane 0    | IDS  | AG9       |
| sata1_txn0  | SATA differential negative transmitter lane 0 | ODS  | AG10      |
| sata1_txp0  | SATA differential positive transmitter lane 0 | ODS  | AH10      |
| sata1_led   | SATA channel activity indicator               | O    | A22 / G19 |

### 4.3.14 PCIe

#### NOTE

For more information, see the Serial Communication Interfaces / PCIe section of the Device TRM.

**Table 4-15. PCIe Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                                                                                                              | TYPE | BALL |
|-------------|--------------------------------------------------------------------------------------------------------------------------|------|------|
| pcie_rxn0   | PCle1_PHY_RX Receive Data Lane 0 (negative) - mapped to PCle_SS1 only.                                                   | IDS  | AG13 |
| pcie_rxp0   | PCle1_PHY_RX Receive Data Lane 0 (positive) - mapped to PCle_SS1 only.                                                   | IDS  | AH13 |
| pcie_txn0   | PCle1_PHY_TX Transmit Data Lane 0 (negative) - mapped to PCle_SS1 only.                                                  | ODS  | AG14 |
| pcie_txp0   | PCle1_PHY_TX Transmit Data Lane 0 (positive) - mapped to PCle_SS1 only.                                                  | ODS  | AH14 |
| pcie_rxn1   | PCle2_PHY_RX Receive Data Lane 1 (negative) - mapped to either PCle_SS1 (dual-lane mode) or PCle_SS2 (single-lane mode)  | IDS  | AG11 |
| pcie_rxp1   | PCle2_PHY_RX Receive Data Lane 1 (positive) - mapped to either PCle_SS1 (dual-lane mode) or PCle_SS2 (single-lane mode)  | IDS  | AH11 |
| pcie_txn1   | PCle2_PHY_TX Transmit Data Lane 1 (negative) - mapped to either PCle_SS1 (dual-lane mode) or PCle_SS2 (single-lane mode) | ODS  | AG12 |
| pcie_txp1   | PCle2_PHY_TX Transmit Data Lane 1 (positive) - mapped to either PCle_SS1 (dual-lane mode) or PCle_SS2 (single-lane mode) | ODS  | AH12 |
| ljcb_clkp   | PCle1_PHY shared Reference Clock Input / Output Differential Pair (positive)                                             | IODS | AG15 |
| ljcb_clkn   | PCle1_PHY shared Reference Clock Input / Output Differential Pair (negative)                                             | IODS | AH15 |

### 4.3.15 DCAN and MCAN

#### NOTE

For more information, see the Serial Communication Interface / DCAN and MCAN section of the Device TRM.

**Table 4-16. DCAN Signal Descriptions**

| SIGNAL NAME   | DESCRIPTION             | TYPE | BALL           |
|---------------|-------------------------|------|----------------|
| <b>DCAN 1</b> |                         |      |                |
| dcan1_tx      | DCAN1 transmit data pin | IO   | G20            |
| dcan1_rx      | DCAN1 receive data pin  | IO   | G19/ AD17      |
| <b>DCAN 2</b> |                         |      |                |
| dcan2_tx      | DCAN2 transmit data pin | IO   | E21/ B21       |
| dcan2_rx      | DCAN2 receive data pin  | IO   | F20/ AC17/ B20 |
| <b>MCAN</b>   |                         |      |                |
| mcan_tx       | MCAN transmit data pin  | IO   | E21 / G20      |
| mcan_rx       | MCAN receive data pin   | IO   | F20 / G19      |

### 4.3.16 GMAC\_SW

#### CAUTION

The I/O timings provided in [Section 5.10, Timing Requirements and Switching Characteristics](#) are valid only if signals within a single IOSET are used. The IOSETs are defined in the [Table 5-100](#), [Table 5-103](#), [Table 5-108](#), and [Table 5-115](#).

#### NOTE

For more information, see the Serial Communication Interfaces / Ethernet Controller section of the Device TRM.

**Table 4-17. GMAC Signal Descriptions**

| SIGNAL NAME   | DESCRIPTION            | TYPE | BALL |
|---------------|------------------------|------|------|
| <b>RGMIIO</b> |                        |      |      |
| rgmii0_txc    | RGMIIO Transmit Clock  | O    | W9   |
| rgmii0_txctl  | RGMIIO Transmit Enable | O    | V9   |
| rgmii0_txd3   | RGMIIO Transmit Data   | O    | V7   |
| rgmii0_txd2   | RGMIIO Transmit Data   | O    | U7   |
| rgmii0_txd1   | RGMIIO Transmit Data   | O    | V6   |
| rgmii0_txd0   | RGMIIO Transmit Data   | O    | U6   |
| rgmii0_rxc    | RGMIIO Receive Clock   | I    | U5   |
| rgmii0_rxctl  | RGMIIO Receive Control | I    | V5   |
| rgmii0_rxd3   | RGMIIO Receive Data    | I    | V4   |
| rgmii0_rxd2   | RGMIIO Receive Data    | I    | V3   |
| rgmii0_rxd1   | RGMIIO Receive Data    | I    | Y2   |
| rgmii0_rxd0   | RGMIIO Receive Data    | I    | W2   |
| <b>RGMI1</b>  |                        |      |      |
| rgmii1_rxc    | RGMI1 Receive Clock    | I    | C5   |

**Table 4-17. GMAC Signal Descriptions (continued)**

| SIGNAL NAME  | DESCRIPTION                   | TYPE | BALL |
|--------------|-------------------------------|------|------|
| rgmii1_rxctl | RGMII1 Receive Control        | I    | A3   |
| rgmii1_rxd0  | RGMII1 Receive Data           | I    | A4   |
| rgmii1_rxd1  | RGMII1 Receive Data           | I    | B5   |
| rgmii1_rxd2  | RGMII1 Receive Data           | I    | B4   |
| rgmii1_rxd3  | RGMII1 Receive Data           | I    | B3   |
| rgmii1_txc   | RGMII1 Transmit Clock         | O    | D5   |
| rgmii1_txctl | RGMII1 Transmit Enable        | O    | C2   |
| rgmii1_txd0  | RGMII1 Transmit Data          | O    | D6   |
| rgmii1_txd1  | RGMII1 Transmit Data          | O    | B2   |
| rgmii1_txd2  | RGMII1 Transmit Data          | O    | C4   |
| rgmii1_txd3  | RGMII1 Transmit Data          | O    | C3   |
| <b>MII0</b>  |                               |      |      |
| mii0_rxd1    | MII0 Receive Data             | I    | V6   |
| mii0_rxd2    | MII0 Receive Data             | I    | V9   |
| mii0_rxd3    | MII0 Receive Data             | I    | W9   |
| mii0_rxd0    | MII0 Receive Data             | I    | U6   |
| mii0_rxclk   | MII0 Receive Clock            | I    | Y1   |
| mii0_rxdv    | MII0 Receive Data Valid       | I    | V2   |
| mii0_txclk   | MII0 Transmit Clock           | I    | U5   |
| mii0_txd0    | MII0 Transmit Data            | O    | W2   |
| mii0_txd1    | MII0 Transmit Data            | O    | Y2   |
| mii0_txd2    | MII0 Transmit Data            | O    | V4   |
| mii0_txd3    | MII0 Transmit Data            | O    | V5   |
| mii0_txer    | MII0 Transmit Error           | I    | U4   |
| mii0_rxer    | MII0 Receive Data Error       | I    | U7   |
| mii0_col     | MII0 Collision Detect (Sense) | I    | V1   |
| mii0_crs     | MII0 Carrier Sense            | I    | V7   |
| mii0_txen    | MII0 Transmit Data Enable     | O    | V3   |
| <b>MII1</b>  |                               |      |      |
| mii1_col     | MII1 Collision Detect (Sense) | I    | B4   |
| mii1_crs     | MII1 Carrier Sense            | I    | B5   |
| mii1_rxclk   | MII1 Receive Clock            | I    | D5   |
| mii1_rxd0    | MII1 Receive Data             | I    | E6   |
| mii1_rxd1    | MII1 Receive Data             | I    | C1   |
| mii1_rxd2    | MII1 Receive Data             | I    | E4   |
| mii1_rxd3    | MII1 Receive Data             | I    | F5   |
| mii1_rxdv    | MII1 Receive Data Valid       | I    | C2   |
| mii1_rxer    | MII1 Receive Data Error       | I    | B3   |
| mii1_txclk   | MII1 Transmit Clock           | I    | C3   |
| mii1_txd0    | MII1 Transmit Data            | O    | C4   |
| mii1_txd1    | MII1 Transmit Data            | O    | B2   |
| mii1_txd2    | MII1 Transmit Data            | O    | D6   |
| mii1_txd3    | MII1 Transmit Data            | O    | C5   |
| mii1_txen    | MII1 Transmit Data Enable     | O    | A4   |
| mii1_txer    | MII1 Transmit Error           | I    | A3   |
| <b>RMIIO</b> |                               |      |      |
| rmii0_crs    | RMIIO Carrier Sense           | I    | V7   |

**Table 4-17. GMAC Signal Descriptions (continued)**

| SIGNAL NAME  | DESCRIPTION                  | TYPE | BALL             |
|--------------|------------------------------|------|------------------|
| rmii0_rxd0   | RMII0 Receive Data           | I    | U6               |
| rmii0_rxd1   | RMII0 Receive Data           | I    | V6               |
| rmii0_rxer   | RMII0 Receive Data Error     | I    | U7               |
| rmii0_txd0   | RMII0 Transmit Data          | O    | W2               |
| rmii0_txd1   | RMII0 Transmit Data          | O    | Y2               |
| rmii0_txen   | RMII0 Transmit Data Enable   | O    | V3               |
| <b>RMII1</b> |                              |      |                  |
| rmii1_crs    | RMII1 Carrier Sense          | I    | V2               |
| rmii1_rxd0   | RMII1 Receive Data           | I    | V9               |
| rmii1_rxd1   | RMII1 Receive Data           | I    | W9               |
| rmii1_rxer   | RMII1 Receive Data Error     | I    | Y1               |
| rmii1_txd0   | RMII1 Transmit Data          | O    | V4               |
| rmii1_txd1   | RMII1 Transmit Data          | O    | V5               |
| rmii1_txen   | RMII1 Transmit Data Enable   | O    | U5               |
| <b>MDIO</b>  |                              |      |                  |
| mdio_d       | Management Data              | IO   | AB4/ B20/ F6/ U4 |
| mdio_mclk    | Management Data Serial Clock | O    | AC5/ B21/ D3/ V1 |

#### 4.3.17 eMMC/SD/SDIO

##### NOTE

For more information, see the HS MMC/SDIO section of the Device TRM.

**Table 4-18. eMMC/SD/SDIO Signal Descriptions**

| SIGNAL NAME               | DESCRIPTION        | TYPE | BALL |
|---------------------------|--------------------|------|------|
| <b>Multi Media Card 1</b> |                    |      |      |
| mmc1_clk <sup>(1)</sup>   | MMC1 clock         | IO   | W6   |
| mmc1_cmd                  | MMC1 command       | IO   | Y6   |
| mmc1_sdcd                 | MMC1 Card Detect   | I    | W7   |
| mmc1_sdwp                 | MMC1 Write Protect | I    | Y9   |
| mmc1_dat0                 | MMC1 data bit 0    | IO   | AA6  |
| mmc1_dat1                 | MMC1 data bit 1    | IO   | Y4   |
| mmc1_dat2                 | MMC1 data bit 2    | IO   | AA5  |
| mmc1_dat3                 | MMC1 data bit 3    | IO   | Y3   |
| <b>Multi Media Card 2</b> |                    |      |      |
| mmc2_clk <sup>(1)</sup>   | MMC2 clock         | IO   | J7   |
| mmc2_cmd                  | MMC2 command       | IO   | H6   |
| mmc2_sdcd                 | MMC2 Card Detect   | I    | G20  |
| mmc2_sdwp                 | MMC2 Write Protect | I    | G19  |
| mmc2_dat0                 | MMC2 data bit 0    | IO   | J4   |
| mmc2_dat1                 | MMC2 data bit 1    | IO   | J6   |
| mmc2_dat2                 | MMC2 data bit 2    | IO   | H4   |
| mmc2_dat3                 | MMC2 data bit 3    | IO   | H5   |
| mmc2_dat4                 | MMC2 data bit 4    | IO   | K7   |
| mmc2_dat5                 | MMC2 data bit 5    | IO   | M7   |
| mmc2_dat6                 | MMC2 data bit 6    | IO   | J5   |

**Table 4-18. eMMC/SD/SDIO Signal Descriptions (continued)**

| SIGNAL NAME               | DESCRIPTION        | TYPE | BALL |
|---------------------------|--------------------|------|------|
| mmc2_dat7                 | MMC2 data bit 7    | IO   | K6   |
| <b>Multi Media Card 3</b> |                    |      |      |
| mmc3_clk <sup>(1)</sup>   | MMC3 clock         | IO   | AD4  |
| mmc3_cmd                  | MMC3 command       | IO   | AC4  |
| mmc3_sdcd                 | MMC3 Card Detect   | I    | B21  |
| mmc3_sdwp                 | MMC3 Write Protect | I    | B20  |
| mmc3_dat0                 | MMC3 data bit 0    | IO   | AC7  |
| mmc3_dat1                 | MMC3 data bit 1    | IO   | AC6  |
| mmc3_dat2                 | MMC3 data bit 2    | IO   | AC9  |
| mmc3_dat3                 | MMC3 data bit 3    | IO   | AC3  |
| mmc3_dat4                 | MMC3 data bit 4    | IO   | AC8  |
| mmc3_dat5                 | MMC3 data bit 5    | IO   | AD6  |
| mmc3_dat6                 | MMC3 data bit 6    | IO   | AB8  |
| mmc3_dat7                 | MMC3 data bit 7    | IO   | AB5  |
| <b>Multi Media Card 4</b> |                    |      |      |
| mmc4_sdcd                 | MMC4 Card Detect   | I    | B27  |
| mmc4_sdwp                 | MMC4 Write Protect | I    | C26  |
| mmc4_clk <sup>(1)</sup>   | MMC4 clock         | IO   | E25  |
| mmc4_cmd                  | MMC4 command       | IO   | C27  |
| mmc4_dat0                 | MMC4 data bit 0    | IO   | D28  |
| mmc4_dat1                 | MMC4 data bit 1    | IO   | D26  |
| mmc4_dat2                 | MMC4 data bit 2    | IO   | D27  |
| mmc4_dat3                 | MMC4 data bit 3    | IO   | C28  |

(1) By default, this clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. mmc1\_clk and mmc2\_clk have an optional software programmable setting to use an 'internal loopback clock' instead of the default 'pad loopback clock'. If the 'pad loopback clock' is used, series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between  $V_{IH}$  and  $V_{IL}$  must be less than  $V_{HYS}$ .

#### 4.3.18 GPIO

##### NOTE

For more information, see the General-Purpose Interface section of the Device TRM.

**Table 4-19. GPIOs Signal Descriptions**

| SIGNAL NAME   | DESCRIPTION                  | TYPE | BALL |
|---------------|------------------------------|------|------|
| <b>GPIO 1</b> |                              |      |      |
| gpio1_0       | General-Purpose Input        | I    | AD17 |
| gpio1_1       | General-Purpose Input        | I    | AC17 |
| gpio1_2       | General-Purpose Input        | I    | AB16 |
| gpio1_3       | General-Purpose Input        | I    | AC16 |
| gpio1_4       | General-Purpose Input/Output | IO   | D15  |
| gpio1_5       | General-Purpose Input/Output | IO   | A17  |
| gpio1_6       | General-Purpose Input/Output | IO   | M6   |
| gpio1_7       | General-Purpose Input/Output | IO   | M2   |
| gpio1_8       | General-Purpose Input/Output | IO   | L5   |
| gpio1_9       | General-Purpose Input/Output | IO   | M1   |
| gpio1_10      | General-Purpose Input/Output | IO   | L6   |

**Table 4-19. GPIOs Signal Descriptions (continued)**

| SIGNAL NAME   | DESCRIPTION                  | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio1_11      | General-Purpose Input/Output | IO   | L4   |
| gpio1_12      | General-Purpose Input/Output | IO   | L3   |
| gpio1_13      | General-Purpose Input/Output | IO   | L2   |
| gpio1_14      | General-Purpose Input/Output | IO   | G20  |
| gpio1_15      | General-Purpose Input/Output | IO   | G19  |
| gpio1_16      | General-Purpose Input/Output | IO   | D27  |
| gpio1_17      | General-Purpose Input/Output | IO   | C28  |
| gpio1_18      | General-Purpose Input/Output | IO   | H1   |
| gpio1_19      | General-Purpose Input/Output | IO   | J3   |
| gpio1_20      | General-Purpose Input/Output | IO   | H2   |
| gpio1_21      | General-Purpose Input/Output | IO   | H3   |
| gpio1_22      | General-Purpose Input/Output | IO   | AC8  |
| gpio1_23      | General-Purpose Input/Output | IO   | AD6  |
| gpio1_24      | General-Purpose Input/Output | IO   | AB8  |
| gpio1_25      | General-Purpose Input/Output | IO   | AB5  |
| gpio1_26      | General-Purpose Input/Output | IO   | P6   |
| gpio1_27      | General-Purpose Input/Output | IO   | R9   |
| gpio1_28      | General-Purpose Input/Output | IO   | R5   |
| gpio1_29      | General-Purpose Input/Output | IO   | P5   |
| gpio1_30      | General-Purpose Input/Output | IO   | N7   |
| gpio1_31      | General-Purpose Input/Output | IO   | R4   |
| <b>GPIO 2</b> |                              |      |      |
| gpio2_0       | General-Purpose Input/Output | IO   | N9   |
| gpio2_1       | General-Purpose Input/Output | IO   | P9   |
| gpio2_2       | General-Purpose Input/Output | IO   | P4   |
| gpio2_3       | General-Purpose Input/Output | IO   | R3   |
| gpio2_4       | General-Purpose Input/Output | IO   | T2   |
| gpio2_5       | General-Purpose Input/Output | IO   | U2   |
| gpio2_6       | General-Purpose Input/Output | IO   | U1   |
| gpio2_7       | General-Purpose Input/Output | IO   | P3   |
| gpio2_8       | General-Purpose Input/Output | IO   | R2   |
| gpio2_9       | General-Purpose Input/Output | IO   | K7   |
| gpio2_10      | General-Purpose Input/Output | IO   | M7   |
| gpio2_11      | General-Purpose Input/Output | IO   | J5   |
| gpio2_12      | General-Purpose Input/Output | IO   | K6   |
| gpio2_13      | General-Purpose Input/Output | IO   | J7   |
| gpio2_14      | General-Purpose Input/Output | IO   | J4   |
| gpio2_15      | General-Purpose Input/Output | IO   | J6   |
| gpio2_16      | General-Purpose Input/Output | IO   | H4   |
| gpio2_17      | General-Purpose Input/Output | IO   | H5   |
| gpio2_18      | General-Purpose Input/Output | IO   | H6   |
| gpio2_19      | General-Purpose Input/Output | IO   | T1   |
| gpio2_20      | General-Purpose Input/Output | IO   | P2   |
| gpio2_21      | General-Purpose Input/Output | IO   | P1   |
| gpio2_22      | General-Purpose Input/Output | IO   | P7   |
| gpio2_23      | General-Purpose Input/Output | IO   | N1   |
| gpio2_24      | General-Purpose Input/Output | IO   | M5   |

**Table 4-19. GPIOs Signal Descriptions (continued)**

| SIGNAL NAME   | DESCRIPTION                  | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio2_25      | General-Purpose Input/Output | IO   | M3   |
| gpio2_26      | General-Purpose Input/Output | IO   | N6   |
| gpio2_27      | General-Purpose Input/Output | IO   | M4   |
| gpio2_28      | General-Purpose Input/Output | IO   | N2   |
| gpio2_29      | General-Purpose Input/Output | IO   | B17  |
| gpio2_30      | General-Purpose Input/Output | IO   | AG8  |
| gpio2_31      | General-Purpose Input/Output | IO   | AH7  |
| <b>GPIO 3</b> |                              |      |      |
| gpio3_0       | General-Purpose Input/Output | IO   | AD9  |
| gpio3_1       | General-Purpose Input/Output | IO   | AF9  |
| gpio3_2       | General-Purpose Input/Output | IO   | AE9  |
| gpio3_3       | General-Purpose Input/Output | IO   | AF8  |
| gpio3_4       | General-Purpose Input/Output | IO   | AE8  |
| gpio3_5       | General-Purpose Input/Output | IO   | AD8  |
| gpio3_6       | General-Purpose Input/Output | IO   | AG7  |
| gpio3_7       | General-Purpose Input/Output | IO   | AH6  |
| gpio3_8       | General-Purpose Input/Output | IO   | AH3  |
| gpio3_9       | General-Purpose Input/Output | IO   | AH5  |
| gpio3_10      | General-Purpose Input/Output | IO   | AG6  |
| gpio3_11      | General-Purpose Input/Output | IO   | AH4  |
| gpio3_12      | General-Purpose Input/Output | IO   | AG4  |
| gpio3_13      | General-Purpose Input/Output | IO   | AG2  |
| gpio3_14      | General-Purpose Input/Output | IO   | AG3  |
| gpio3_15      | General-Purpose Input/Output | IO   | AG5  |
| gpio3_16      | General-Purpose Input/Output | IO   | AF2  |
| gpio3_17      | General-Purpose Input/Output | IO   | AF6  |
| gpio3_18      | General-Purpose Input/Output | IO   | AF3  |
| gpio3_19      | General-Purpose Input/Output | IO   | AF4  |
| gpio3_20      | General-Purpose Input/Output | IO   | AF1  |
| gpio3_21      | General-Purpose Input/Output | IO   | AE3  |
| gpio3_22      | General-Purpose Input/Output | IO   | AE5  |
| gpio3_23      | General-Purpose Input/Output | IO   | AE1  |
| gpio3_24      | General-Purpose Input/Output | IO   | AE2  |
| gpio3_25      | General-Purpose Input/Output | IO   | AE6  |
| gpio3_26      | General-Purpose Input/Output | IO   | AD2  |
| gpio3_27      | General-Purpose Input/Output | IO   | AD3  |
| gpio3_28      | General-Purpose Input/Output | IO   | E1   |
| gpio3_29      | General-Purpose Input/Output | IO   | G2   |
| gpio3_30      | General-Purpose Input/Output | IO   | H7   |
| gpio3_31      | General-Purpose Input/Output | IO   | G1   |
| <b>GPIO 4</b> |                              |      |      |
| gpio4_0       | General-Purpose Input/Output | IO   | G6   |
| gpio4_1       | General-Purpose Input/Output | IO   | F2   |
| gpio4_2       | General-Purpose Input/Output | IO   | F3   |
| gpio4_3       | General-Purpose Input/Output | IO   | D1   |
| gpio4_4       | General-Purpose Input/Output | IO   | E2   |
| gpio4_5       | General-Purpose Input/Output | IO   | D2   |

**Table 4-19. GPIOs Signal Descriptions (continued)**

| SIGNAL NAME   | DESCRIPTION                  | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio4_6       | General-Purpose Input/Output | IO   | F4   |
| gpio4_7       | General-Purpose Input/Output | IO   | C1   |
| gpio4_8       | General-Purpose Input/Output | IO   | E4   |
| gpio4_9       | General-Purpose Input/Output | IO   | F5   |
| gpio4_10      | General-Purpose Input/Output | IO   | E6   |
| gpio4_11      | General-Purpose Input/Output | IO   | D3   |
| gpio4_12      | General-Purpose Input/Output | IO   | F6   |
| gpio4_13      | General-Purpose Input/Output | IO   | D5   |
| gpio4_14      | General-Purpose Input/Output | IO   | C2   |
| gpio4_15      | General-Purpose Input/Output | IO   | C3   |
| gpio4_16      | General-Purpose Input/Output | IO   | C4   |
| gpio4_17      | General-Purpose Input/Output | IO   | A12  |
| gpio4_18      | General-Purpose Input/Output | IO   | E14  |
| gpio4_19      | General-Purpose Input/Output | IO   | D11  |
| gpio4_20      | General-Purpose Input/Output | IO   | B10  |
| gpio4_21      | General-Purpose Input/Output | IO   | B11  |
| gpio4_22      | General-Purpose Input/Output | IO   | C11  |
| gpio4_23      | General-Purpose Input/Output | IO   | E11  |
| gpio4_24      | General-Purpose Input/Output | IO   | B2   |
| gpio4_25      | General-Purpose Input/Output | IO   | D6   |
| gpio4_26      | General-Purpose Input/Output | IO   | C5   |
| gpio4_27      | General-Purpose Input/Output | IO   | A3   |
| gpio4_28      | General-Purpose Input/Output | IO   | B3   |
| gpio4_29      | General-Purpose Input/Output | IO   | B4   |
| gpio4_30      | General-Purpose Input/Output | IO   | B5   |
| gpio4_31      | General-Purpose Input/Output | IO   | A4   |
| <b>GPIO 5</b> |                              |      |      |
| gpio5_0       | General-Purpose Input/Output | IO   | B14  |
| gpio5_1       | General-Purpose Input/Output | IO   | J14  |
| gpio5_2       | General-Purpose Input/Output | IO   | G12  |
| gpio5_3       | General-Purpose Input/Output | IO   | F12  |
| gpio5_4       | General-Purpose Input/Output | IO   | G13  |
| gpio5_5       | General-Purpose Input/Output | IO   | J11  |
| gpio5_6       | General-Purpose Input/Output | IO   | E12  |
| gpio5_7       | General-Purpose Input/Output | IO   | F13  |
| gpio5_8       | General-Purpose Input/Output | IO   | C12  |
| gpio5_9       | General-Purpose Input/Output | IO   | D12  |
| gpio5_10      | General-Purpose Input/Output | IO   | B12  |
| gpio5_11      | General-Purpose Input/Output | IO   | A11  |
| gpio5_12      | General-Purpose Input/Output | IO   | B13  |
| gpio5_13      | General-Purpose Input/Output | IO   | B18  |
| gpio5_14      | General-Purpose Input/Output | IO   | F15  |
| gpio5_15      | General-Purpose Input/Output | IO   | V1   |
| gpio5_16      | General-Purpose Input/Output | IO   | U4   |
| gpio5_17      | General-Purpose Input/Output | IO   | U3   |
| gpio5_18      | General-Purpose Input/Output | IO   | V2   |
| gpio5_19      | General-Purpose Input/Output | IO   | Y1   |

**Table 4-19. GPIOs Signal Descriptions (continued)**

| SIGNAL NAME   | DESCRIPTION                  | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio5_20      | General-Purpose Input/Output | IO   | W9   |
| gpio5_21      | General-Purpose Input/Output | IO   | V9   |
| gpio5_22      | General-Purpose Input/Output | IO   | V7   |
| gpio5_23      | General-Purpose Input/Output | IO   | U7   |
| gpio5_24      | General-Purpose Input/Output | IO   | V6   |
| gpio5_25      | General-Purpose Input/Output | IO   | U6   |
| gpio5_26      | General-Purpose Input/Output | IO   | U5   |
| gpio5_27      | General-Purpose Input/Output | IO   | V5   |
| gpio5_28      | General-Purpose Input/Output | IO   | V4   |
| gpio5_29      | General-Purpose Input/Output | IO   | V3   |
| gpio5_30      | General-Purpose Input/Output | IO   | Y2   |
| gpio5_31      | General-Purpose Input/Output | IO   | W2   |
| <b>GPIO 6</b> |                              |      |      |
| gpio6_4       | General-Purpose Input/Output | IO   | A13  |
| gpio6_5       | General-Purpose Input/Output | IO   | G14  |
| gpio6_6       | General-Purpose Input/Output | IO   | F14  |
| gpio6_7       | General-Purpose Input/Output | IO   | B16  |
| gpio6_8       | General-Purpose Input/Output | IO   | C15  |
| gpio6_9       | General-Purpose Input/Output | IO   | A16  |
| gpio6_10      | General-Purpose Input/Output | IO   | AC5  |
| gpio6_11      | General-Purpose Input/Output | IO   | AB4  |
| gpio6_12      | General-Purpose Input/Output | IO   | AB10 |
| gpio6_13      | General-Purpose Input/Output | IO   | AC10 |
| gpio6_14      | General-Purpose Input/Output | IO   | E21  |
| gpio6_15      | General-Purpose Input/Output | IO   | F20  |
| gpio6_16      | General-Purpose Input/Output | IO   | F21  |
| gpio6_17      | General-Purpose Input/Output | IO   | D18  |
| gpio6_18      | General-Purpose Input/Output | IO   | E17  |
| gpio6_19      | General-Purpose Input/Output | IO   | B26  |
| gpio6_20      | General-Purpose Input/Output | IO   | C23  |
| gpio6_21      | General-Purpose Input/Output | IO   | W6   |
| gpio6_22      | General-Purpose Input/Output | IO   | Y6   |
| gpio6_23      | General-Purpose Input/Output | IO   | AA6  |
| gpio6_24      | General-Purpose Input/Output | IO   | Y4   |
| gpio6_25      | General-Purpose Input/Output | IO   | AA5  |
| gpio6_26      | General-Purpose Input/Output | IO   | Y3   |
| gpio6_27      | General-Purpose Input/Output | IO   | W7   |
| gpio6_28      | General-Purpose Input/Output | IO   | Y9   |
| gpio6_29      | General-Purpose Input/Output | IO   | AD4  |
| gpio6_30      | General-Purpose Input/Output | IO   | AC4  |
| gpio6_31      | General-Purpose Input/Output | IO   | AC7  |
| <b>GPIO 7</b> |                              |      |      |
| gpio7_0       | General-Purpose Input/Output | IO   | AC6  |
| gpio7_1       | General-Purpose Input/Output | IO   | AC9  |
| gpio7_2       | General-Purpose Input/Output | IO   | AC3  |
| gpio7_3       | General-Purpose Input/Output | IO   | R6   |
| gpio7_4       | General-Purpose Input/Output | IO   | T9   |

**Table 4-19. GPIOs Signal Descriptions (continued)**

| SIGNAL NAME   | DESCRIPTION                  | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio7_5       | General-Purpose Input/Output | IO   | T6   |
| gpio7_6       | General-Purpose Input/Output | IO   | T7   |
| gpio7_7       | General-Purpose Input/Output | IO   | A25  |
| gpio7_8       | General-Purpose Input/Output | IO   | F16  |
| gpio7_9       | General-Purpose Input/Output | IO   | B25  |
| gpio7_10      | General-Purpose Input/Output | IO   | A24  |
| gpio7_11      | General-Purpose Input/Output | IO   | A22  |
| gpio7_12      | General-Purpose Input/Output | IO   | B21  |
| gpio7_13      | General-Purpose Input/Output | IO   | B20  |
| gpio7_14      | General-Purpose Input/Output | IO   | A26  |
| gpio7_15      | General-Purpose Input/Output | IO   | B22  |
| gpio7_16      | General-Purpose Input/Output | IO   | G17  |
| gpio7_17      | General-Purpose Input/Output | IO   | B24  |
| gpio7_18      | General-Purpose Input/Output | IO   | L1   |
| gpio7_19      | General-Purpose Input/Output | IO   | K2   |
| gpio7_22      | General-Purpose Input/Output | IO   | B27  |
| gpio7_23      | General-Purpose Input/Output | IO   | C26  |
| gpio7_24      | General-Purpose Input/Output | IO   | E25  |
| gpio7_25      | General-Purpose Input/Output | IO   | C27  |
| gpio7_26      | General-Purpose Input/Output | IO   | D28  |
| gpio7_27      | General-Purpose Input/Output | IO   | D26  |
| gpio7_28      | General-Purpose Input/Output | IO   | J1   |
| gpio7_29      | General-Purpose Input/Output | IO   | J2   |
| gpio7_30      | General-Purpose Input/Output | IO   | D14  |
| gpio7_31      | General-Purpose Input/Output | IO   | C14  |
| <b>GPIO 8</b> |                              |      |      |
| gpio8_0       | General-Purpose Input/Output | IO   | F11  |
| gpio8_1       | General-Purpose Input/Output | IO   | G10  |
| gpio8_2       | General-Purpose Input/Output | IO   | F10  |
| gpio8_3       | General-Purpose Input/Output | IO   | G11  |
| gpio8_4       | General-Purpose Input/Output | IO   | E9   |
| gpio8_5       | General-Purpose Input/Output | IO   | F9   |
| gpio8_6       | General-Purpose Input/Output | IO   | F8   |
| gpio8_7       | General-Purpose Input/Output | IO   | E7   |
| gpio8_8       | General-Purpose Input/Output | IO   | E8   |
| gpio8_9       | General-Purpose Input/Output | IO   | D9   |
| gpio8_10      | General-Purpose Input/Output | IO   | D7   |
| gpio8_11      | General-Purpose Input/Output | IO   | D8   |
| gpio8_12      | General-Purpose Input/Output | IO   | A5   |
| gpio8_13      | General-Purpose Input/Output | IO   | C6   |
| gpio8_14      | General-Purpose Input/Output | IO   | C8   |
| gpio8_15      | General-Purpose Input/Output | IO   | C7   |
| gpio8_16      | General-Purpose Input/Output | IO   | B7   |
| gpio8_17      | General-Purpose Input/Output | IO   | B8   |
| gpio8_18      | General-Purpose Input/Output | IO   | A7   |
| gpio8_19      | General-Purpose Input/Output | IO   | A8   |
| gpio8_20      | General-Purpose Input/Output | IO   | C9   |

**Table 4-19. GPIOs Signal Descriptions (continued)**

| SIGNAL NAME | DESCRIPTION                  | TYPE | BALL |
|-------------|------------------------------|------|------|
| gpio8_21    | General-Purpose Input/Output | IO   | A9   |
| gpio8_22    | General-Purpose Input/Output | IO   | B9   |
| gpio8_23    | General-Purpose Input/Output | IO   | A10  |
| gpio8_27    | General-Purpose Input        | I    | D23  |
| gpio8_28    | General-Purpose Input/Output | IO   | F19  |
| gpio8_29    | General-Purpose Input/Output | IO   | E18  |
| gpio8_30    | General-Purpose Input/Output | IO   | G21  |
| gpio8_31    | General-Purpose Input/Output | IO   | D24  |

**4.3.19 PWM****NOTE**

For more information, see the Pulse-Width Modulation (PWM) SS section of the Device TRM.

**Table 4-20. PWM Signal Descriptions**

| SIGNAL NAME                | DESCRIPTION                      | TYPE | BALL     |
|----------------------------|----------------------------------|------|----------|
| <b>PWMSS1</b>              |                                  |      |          |
| eQEP1A_in                  | EQEP1 Quadrature Input A         | I    | E1 / AD9 |
| eQEP1B_in                  | EQEP1 Quadrature Input B         | I    | G2 / AF9 |
| eQEP1_index                | EQEP1 Index Input                | IO   | AE9 / H7 |
| eQEP1_strobe               | EQEP1 Strobe Input               | IO   | G1 / AF8 |
| ehrpwm1A                   | EHRPWM1 Output A                 | O    | AE8 / G6 |
| ehrpwm1B                   | EHRPWM1 Output B                 | O    | AD8 / F2 |
| ehrpwm1_tripzone_in<br>put | EHRPWM1 Trip Zone Input          | IO   | AG7 / F3 |
| eCAP1_in_PWM1_out          | ECAP1 Capture Input / PWM Output | IO   | AH6 / D1 |
| ehrpwm1_synci              | EHRPWM1 Sync Input               | I    | AH3 / E2 |
| ehrpwm1_synco              | EHRPWM1 Sync Output              | O    | AH5 / D2 |
| <b>PWMSS2</b>              |                                  |      |          |
| eQEP2A_in                  | EQEP2 Quadrature Input A         | I    | AG6 / F4 |
| eQEP2B_in                  | EQEP2 Quadrature Input B         | I    | AH4 / C1 |
| eQEP2_index                | EQEP2 Index Input                | IO   | AG4 / E4 |
| eQEP2_strobe               | EQEP2 Strobe Input               | IO   | AG2 / F5 |
| ehrpwm2A                   | EHRPWM2 Output A                 | O    | AC5 / E6 |
| ehrpwm2B                   | EHRPWM2 Output B                 | O    | AB4 / D3 |
| ehrpwm2_tripzone_in<br>put | EHRPWM2 Trip Zone Input          | IO   | AD4 / F6 |
| eCAP2_in_PWM2_out          | ECAP2 Capture Input / PWM Output | IO   | AC4 / D5 |
| <b>PWMSS3</b>              |                                  |      |          |
| eQEP3A_in                  | EQEP3 Quadrature Input A         | I    | AC7 / C2 |
| eQEP3B_in                  | EQEP3 Quadrature Input B         | I    | AC6 / C3 |
| eQEP3_index                | EQEP3 Index Input                | IO   | AC9 / C4 |
| eQEP3_strobe               | EQEP3 Strobe Input               | IO   | AC3 / B2 |
| ehrpwm3A                   | EHRPWM3 Output A                 | O    | AC8 / D6 |
| ehrpwm3B                   | EHRPWM3 Output B                 | O    | AD6 / C5 |
| ehrpwm3_tripzone_in<br>put | EHRPWM3 Trip Zone Input          | IO   | AB8 / A3 |

**Table 4-20. PWM Signal Descriptions (continued)**

| SIGNAL NAME       | DESCRIPTION                      | TYPE | BALL                                     |
|-------------------|----------------------------------|------|------------------------------------------|
| eCAP3_in_PWM3_out | ECAP3 Capture Input / PWM Output | IO   | <a href="#">AB5</a> / <a href="#">B3</a> |

## 4.3.20 System and Miscellaneous

### 4.3.20.1 Sysboot Interface

#### NOTE

For more information, see the Initialization (ROM Code) section of the Device TRM.

**Table 4-21. Sysboot Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                                                                                                                                 | TYPE | BALL |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|------|
| sysboot0    | Boot Mode Configuration 0. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | M6   |
| sysboot1    | Boot Mode Configuration 1. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | M2   |
| sysboot2    | Boot Mode Configuration 2. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | L5   |
| sysboot3    | Boot Mode Configuration 3. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | M1   |
| sysboot4    | Boot Mode Configuration 4. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | L6   |
| sysboot5    | Boot Mode Configuration 5. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | L4   |
| sysboot6    | Boot Mode Configuration 6. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | L3   |
| sysboot7    | Boot Mode Configuration 7. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | L2   |
| sysboot8    | Boot Mode Configuration 8. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | L1   |
| sysboot9    | Boot Mode Configuration 9. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device.  | I    | K2   |
| sysboot10   | Boot Mode Configuration 10. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I    | J1   |
| sysboot11   | Boot Mode Configuration 11. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I    | J2   |
| sysboot12   | Boot Mode Configuration 12. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I    | H1   |
| sysboot13   | Boot Mode Configuration 13. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I    | J3   |
| sysboot14   | Boot Mode Configuration 14. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I    | H2   |
| sysboot15   | Boot Mode Configuration 15. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I    | H3   |

### 4.3.20.2 PRCM

#### NOTE

For more information, see PRCM chapter of the Device TRM.

**Table 4-22. PRCM Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                    | TYPE | BALL    |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------|
| clkout1     | Device Clock output 1. Can be used externally for devices with non-critical timing requirements, or for debug, or as a reference clock on GPMC as described in <a href="#">Table 5-55</a> , <i>GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Default</i> and <a href="#">Table 5-57</a> , <i>GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Alternate</i> . | O    | F21/ P7 |

**Table 4-22. PRCM Signal Descriptions (continued)**

| SIGNAL NAME                    | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | TYPE | BALL    |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------|
| clkout2                        | Device Clock output 2. Can be used externally for devices with non-critical timing requirements, or for debug.                                                                                                                                                                                                                                                                                                                                                                                      | O    | D18/ N1 |
| clkout3                        | Device Clock output 3. Can be used externally for devices with non-critical timing requirements, or for debug.                                                                                                                                                                                                                                                                                                                                                                                      | O    | C23     |
| rstoutn                        | Reset out (Active low) output is asserted low whenever any global reset condition exists. After a brief delay, it will be set high upon removal of the internal global reset condition (i.e. porz, warm reset). It is only functional after its output buffer's reference voltage (vddshv3) is valid. If it is used as a reset for device peripheral components, then it should be AND gated with porz to avoid the possibility of reset signal glitches during a power up sequence. <sup>(2)</sup> | O    | F23     |
| resetrn                        | Reset (active low) input's falling edge can trigger a device warm reset state from an external component. This signal should be high prior to or simultaneous with, porz rising. If the signal is not used in the system, resetrn should be pulled high with an external pull-up resistor to vddshv3.                                                                                                                                                                                               | I    | E23     |
| porz                           | Power-on Reset (active low) input must be asserted low during a device power up sequence or cold reset state when all supplies are disabled. Typically, an external PMIC is the source and sets porz high after all supplies reach valid operating levels. Asserting porz low puts the entire device in a safe reset state.                                                                                                                                                                         | I    | F22     |
| xref_clk0                      | External Reference Clock 0. For Audio and other Peripherals.                                                                                                                                                                                                                                                                                                                                                                                                                                        | I    | D18     |
| xref_clk1                      | External Reference Clock 1. For Audio and other Peripherals.                                                                                                                                                                                                                                                                                                                                                                                                                                        | I    | E17     |
| xref_clk2                      | External Reference Clock 2. For Audio and other Peripherals.                                                                                                                                                                                                                                                                                                                                                                                                                                        | I    | B26     |
| xref_clk3                      | External Reference Clock 3. For Audio and other Peripherals.                                                                                                                                                                                                                                                                                                                                                                                                                                        | I    | C23     |
| xi_osc0                        | System Oscillator OSC0 Crystal input / LVCMOS clock input. Functions as the input connection to a crystal when the internal oscillator OSC0 is used. Functions as an LVCMOS-compatible input clock when an external oscillator is used.                                                                                                                                                                                                                                                             | I    | AE15    |
| xo_osc0                        | System Oscillator OSC0 Crystal output                                                                                                                                                                                                                                                                                                                                                                                                                                                               | O    | AD15    |
| xi_osc1                        | Auxiliary Oscillator OSC1 Crystal input / LVCMOS clock input. Functions as the input connection to a crystal when the internal oscillator OSC1 is used. Functions as an LVCMOS-compatible input clock when an external oscillator is used.                                                                                                                                                                                                                                                          | I    | AC15    |
| xo_osc1                        | Auxiliary Oscillator OSC1 Crystal output                                                                                                                                                                                                                                                                                                                                                                                                                                                            | O    | AC13    |
| RMII_MHZ_50_CLK <sup>(1)</sup> | RMII Reference Clock (50 MHz). This pin is an input when external reference is used or output when internal reference is used.                                                                                                                                                                                                                                                                                                                                                                      | IO   | U3      |

(1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between  $V_{IH}$  and  $V_{IL}$  must be less than  $V_{HYS}$ .

(2) Note that rstoutn is only valid after vddshv3 is valid. If the rstoutn signal will be used as a reset into other devices attached to the SoC, it must be AND'ed with porz. This will prevent glitches occurring during supply ramping being propagated.

### 4.3.20.3 RTC

#### NOTE

For more information, see the Real Time Clock (RTC) SS section of the Device TRM.

**Table 4-23. RTC Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                           | TYPE | BALL |
|-------------|---------------------------------------|------|------|
| Wakeup0     | RTC External Wakeup Input 0           | I    | AD17 |
| Wakeup1     | RTC External Wakeup Input 1           | I    | AC17 |
| Wakeup2     | RTC External Wakeup Input 2           | I    | AB16 |
| Wakeup3     | RTC External Wakeup Input 3           | I    | AC16 |
| rtc_porz    | RTC Power Domain Power-On Reset Input | I    | AB17 |

**Table 4-23. RTC Signal Descriptions (continued)**

| SIGNAL NAME                        | DESCRIPTION                                                                                                                               | TYPE | BALL                 |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------|
| rtc_osc_xi_clk <sub>in3</sub><br>2 | RTC Oscillator Input. Crystal connection to internal RTC oscillator. Functions as an RTC clock input when an external oscillator is used. | I    | <a href="#">AE14</a> |
| rtc_osc_xo                         | RTC Oscillator Output                                                                                                                     | O    | <a href="#">AD14</a> |
| rtc_iso <sup>(1)</sup>             | RTC domain isolation signal                                                                                                               | I    | <a href="#">AF14</a> |
| on_off                             | RTC Power Enable output pin                                                                                                               | O    | <a href="#">Y11</a>  |

(1) This signal must be kept "0" if device power supplies are not valid during RTC mode and "1" during normal operation. This can typically be achieved by connecting rtc\_iso to the same signal driving porz (not rtc\_porz) with appropriate voltage level translation if necessary.

#### 4.3.20.4 SDMA

##### NOTE

For more information, see the DMA Controllers / System DMA section of the Device TRM.

**Table 4-24. System DMA Signal Descriptions**

| SIGNAL NAME | DESCRIPTION              | TYPE | BALL                   |
|-------------|--------------------------|------|------------------------|
| dma_evt1    | System DMA Event Input 1 | I    | <a href="#">P7/ P4</a> |
| dma_evt2    | System DMA Event Input 2 | I    | <a href="#">N1/ R3</a> |
| dma_evt3    | System DMA Event Input 3 | I    | <a href="#">N6</a>     |
| dma_evt4    | System DMA Event Input 4 | I    | <a href="#">M4</a>     |

#### 4.3.20.5 INTC

##### NOTE

For more information, see the Interrupt Controllers section of the Device TRM.

**Table 4-25. INTC Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                | TYPE | BALL                 |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------|
| nmin_dsp    | Non-maskable interrupt input, active-low. This pin can be optionally routed to the DSP NMI input or as generic input to the Arm cores. Note that by default this pin has an internal pulldown resistor enabled. This internal pulldown should be disabled or countered by a stronger external pullup resistor before routing to the DSP or Arm processors. | I    | <a href="#">D21</a>  |
| sys_nirq2   | External interrupt event to any device INTC                                                                                                                                                                                                                                                                                                                | I    | <a href="#">AB16</a> |
| sys_nirq1   | External interrupt event to any device INTC                                                                                                                                                                                                                                                                                                                | I    | <a href="#">AC16</a> |

#### 4.3.20.6 Observability

##### NOTE

For more information, see the Control Module chapter of the Device TRM.

**Table 4-26. Observability Signal Descriptions**

| SIGNAL NAME | DESCRIPTION          | TYPE | BALL                |
|-------------|----------------------|------|---------------------|
| obs0        | Observation Output 0 | O    | <a href="#">F10</a> |
| obs1        | Observation Output 1 | O    | <a href="#">G11</a> |
| obs2        | Observation Output 2 | O    | <a href="#">E9</a>  |
| obs3        | Observation Output 3 | O    | <a href="#">F9</a>  |
| obs4        | Observation Output 4 | O    | <a href="#">F8</a>  |

**Table 4-26. Observability Signal Descriptions (continued)**

| SIGNAL NAME | DESCRIPTION                               | TYPE | BALL |
|-------------|-------------------------------------------|------|------|
| obs5        | Observation Output 5                      | O    | D7   |
| obs6        | Observation Output 6                      | O    | D8   |
| obs7        | Observation Output 7                      | O    | A5   |
| obs8        | Observation Output 8                      | O    | C6   |
| obs9        | Observation Output 9                      | O    | C8   |
| obs10       | Observation Output 10                     | O    | C7   |
| obs11       | Observation Output 11                     | O    | A7   |
| obs12       | Observation Output 12                     | O    | A8   |
| obs13       | Observation Output 13                     | O    | C9   |
| obs14       | Observation Output 14                     | O    | A9   |
| obs15       | Observation Output 15                     | O    | B9   |
| obs16       | Observation Output 16                     | O    | F10  |
| obs17       | Observation Output 17                     | O    | G11  |
| obs18       | Observation Output 18                     | O    | E9   |
| obs19       | Observation Output 19                     | O    | F9   |
| obs20       | Observation Output 20                     | O    | F8   |
| obs21       | Observation Output 21                     | O    | D7   |
| obs22       | Observation Output 22                     | O    | D8   |
| obs23       | Observation Output 23                     | O    | A5   |
| obs24       | Observation Output 24                     | O    | C6   |
| obs25       | Observation Output 25                     | O    | C8   |
| obs26       | Observation Output 26                     | O    | C7   |
| obs27       | Observation Output 27                     | O    | A7   |
| obs28       | Observation Output 28                     | O    | A8   |
| obs29       | Observation Output 29                     | O    | C9   |
| obs30       | Observation Output 30                     | O    | A9   |
| obs31       | Observation Output 31                     | O    | B9   |
| obs_dmarq1  | DMA Request External Observation Output 1 | O    | G11  |
| obs_dmarq2  | DMA Request External Observation Output 2 | O    | D8   |
| obs_irq1    | IRQ External Observation Output 1         | O    | F10  |
| obs_irq2    | IRQ External Observation Output 2         | O    | D7   |

#### 4.3.20.7 Power Supplies

##### NOTE

For more information, see Power, Reset, and Clock Management / PRCM Subsystem Environment / External Voltage Inputs section of the Device TRM.

**Table 4-27. Power Supply Signal Descriptions**

| SIGNAL NAME        | DESCRIPTION                | TYPE | BALL                                                                                                                        |
|--------------------|----------------------------|------|-----------------------------------------------------------------------------------------------------------------------------|
| vdd                | Core voltage domain supply | PWR  | H13/ H14/ J17/ J18/<br>L7/ L8/ N10/ N13/<br>P11/ P12/ P13/ R11/<br>R16/ R19/ T13/ T16/<br>T19/ U8/ U9/ U13/<br>U16/ V8/ V16 |
| vpp <sup>(2)</sup> | eFuse power supply         | PWR  | K14                                                                                                                         |

**Table 4-27. Power Supply Signal Descriptions (continued)**

| SIGNAL NAME    | DESCRIPTION                                                                                                                                                                                                                             | TYPE | BALL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| vss            | Ground                                                                                                                                                                                                                                  | GND  | A1/ A2/ A6/ A14/ A23/<br>A28/ B1/ D13/ D19/<br>E13/ E19/ F1/ F7/ G7/<br>G8/ G9/ H12/ J12/<br>J15/ J28/ K1/ K4/ K5/<br>K15/ K24/ K25/ L13/<br>L14/ M19/ N14/ N15/<br>N19/ N24/ N25/ P28/<br>R1/ R12/ R13/ R15/<br>R21/ T10/ T11/ T12/<br>T14/ T15/ T17/ T18/<br>T21/ U15/ U17/ U20/<br>U21/ V15/ V17/ W1/<br>W15/ W24/ W25/<br>W28/ AA8/ AA9/<br>AA10/ AA14/ AA15/<br>AA20/ AB14/ AB20/<br>AD1/ AD24/ AG1/<br>AH1/ AH2/ AH8/<br>AH20/ AH28 / AB11/<br>AA11 / AE19 / AD19 /<br>AE13 / AD13 / AE10 /<br>AD10 / U14 |
| vdd_dspeve     | DSP-EVE voltage domain supply                                                                                                                                                                                                           | PWR  | J13/ K10/ K11/ K12/<br>K13/ L10/ L11/ L12/<br>M10/ M11/ M12/ M13                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| vdd_iva        | IVA voltage domain supply                                                                                                                                                                                                               | PWR  | U18/ U19/ V18/ V19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| vdd_gpu        | GPU voltage domain supply                                                                                                                                                                                                               | PWR  | U11/ U12/ V10/ V11/<br>V14/ W10/ W11/ W13                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| vdd_mpu        | MPU voltage domain supply                                                                                                                                                                                                               | PWR  | K17/ K18/ L15/ L16/<br>L17/ L18/ L19/ M15/<br>M16/ M17/ M18/ N17/<br>N18/ P17/ P18/ R18                                                                                                                                                                                                                                                                                                                                                                                                                         |
| vdd_rtc        | RTC voltage domain supply                                                                                                                                                                                                               | PWR  | AB15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| vdda_usb1      | DPLL_USB and HS USB1 1.8 V analog power supply                                                                                                                                                                                          | PWR  | AA13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| vdda_usb2      | HS USB2 1.8 V analog power supply                                                                                                                                                                                                       | PWR  | AB12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| vdda33v_usb1   | HS USB1 3.3 V analog power supply. If USB1 is not used, this pin can alternatively be connected to VSS if the following requirements are met:<br>- The usb1_dm/usb1_dp pins are left unconnected<br>- The USB1 PHY is kept powered down | PWR  | AA12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| vdda33v_usb2   | HS USB2 3.3 V analog power supply. If USB2 is not used, this pin can alternatively be connected to VSS if the following requirements are met:<br>- The usb2_dm/usb2_dp pins are left unconnected<br>- The USB2 PHY is kept powered down | PWR  | Y12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_abe_per   | DPLL_ABE, DPLL_PER, and PER HSDIVIDER analog power supply                                                                                                                                                                               | PWR  | M14                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_ddr       | DPLL_DDR and DDR HSDIVIDER analog power supply                                                                                                                                                                                          | PWR  | P16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_debug     | DPLL_DEBUG analog power supply                                                                                                                                                                                                          | PWR  | N11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_dsp_eve   | DPLL_DSP and DPLL_EVE analog power supply                                                                                                                                                                                               | PWR  | N12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_gmac_core | DPLL_CORE and CORE HSDIVIDER analog power supply                                                                                                                                                                                        | PWR  | P15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_gpu       | DPLL_GPU analog power supply                                                                                                                                                                                                            | PWR  | R14                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_hdmi      | PLL_HDMI and HDMI analog power supply                                                                                                                                                                                                   | PWR  | Y17                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_iva       | DPLL_IVA analog power supply                                                                                                                                                                                                            | PWR  | R17                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_pcie      | DPLL_PCIE_REF and PCIe analog power supply                                                                                                                                                                                              | PWR  | W14                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_pcie0     | PCIe ch0 RX/TX analog power supply                                                                                                                                                                                                      | PWR  | AA17                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| vdda_pcie1     | PCIe ch1 RX/TX analog power supply                                                                                                                                                                                                      | PWR  | AA16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| vdda_sata      | DPLL_SATA and SATA RX/TX analog power supply                                                                                                                                                                                            | PWR  | V13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_usb3      | DPLL_USB_OTG_SS and USB3.0 RX/TX analog power supply                                                                                                                                                                                    | PWR  | W12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| vdda_video     | DPLL_VIDEO1 and DPLL_VIDEO2 analog power supply                                                                                                                                                                                         | PWR  | P14                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

**Table 4-27. Power Supply Signal Descriptions (continued)**

| SIGNAL NAME                       | DESCRIPTION                                                                          | TYPE | BALL                                                                                   |
|-----------------------------------|--------------------------------------------------------------------------------------|------|----------------------------------------------------------------------------------------|
| vdds_mlbp                         | MLBP IO power supply                                                                 | PWR  | AA7/ Y7                                                                                |
| vdda_mpu                          | DPLL_MPU analog power supply                                                         | PWR  | N16                                                                                    |
| vdda_osc                          | HFOSC analog power supply                                                            | PWR  | AE16/ AD16                                                                             |
| vssa_osc0                         | OSC0 analog ground                                                                   | GND  | AF15                                                                                   |
| vssa_osc1                         | OSC1 analog ground                                                                   | GND  | AC14                                                                                   |
| vdda_rtc                          | RTC bias and RTC LFOSC analog power supply                                           | PWR  | AB13                                                                                   |
| vdds18v                           | 1.8 V power supply                                                                   | PWR  | W17/ W18/ V21/ V22/<br>T8/ R8/ P8/ N8/ M8/<br>M9/ H17/ G18                             |
| vdds18v_ddr1                      | DDR1 bias power supply                                                               | PWR  | AA18/ AA19/ Y21/<br>W21                                                                |
| vdds18v_ddr2                      | DDR2 bias power supply                                                               | PWR  | P20/ P21/ N21/ J21/<br>J22                                                             |
| vdds_ddr2                         | DDR2 power supply (1.8 V for DDR2 mode/ 1.5 V for DDR3 mode / 1.35 V for DDR3L mode) | PWR  | T24/ T25/ M20/ M21/<br>L20/ L21/ J27/ H20/<br>H21/ H22/ G22/ G23/<br>E24               |
| vdds_ddr1                         | DDR1 power supply (1.8 V for DDR2 mode/ 1.5 V for DDR3 mode / 1.35 V for DDR3L mode) | PWR  | AH27/ AG20/ AG28/<br>AD26/ AC22/ AB21/<br>AB22/ AB24/ AB25/<br>AA21/ AA22/ W16/<br>W27 |
| vddshv5                           | Dual Voltage (1.8 V or 3.3 V) power supply for the RTC Power Group pins              | PWR  | V12                                                                                    |
| vddshv1                           | Dual Voltage (1.8 V or 3.3 V) power supply for the VIN2 Power Group pins             | PWR  | H8/ H9/ G4/ G5/ E3/<br>E5                                                              |
| vddshv10                          | Dual Voltage (1.8 V or 3.3 V) power supply for the GPMC Power Group pins             | PWR  | T4/ T5/ R7/ R10/ P10/<br>N4/ N5                                                        |
| vddshv11                          | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC2 Power Group pins             | PWR  | K8/ J8                                                                                 |
| vddshv2                           | Dual Voltage (1.8 V or 3.3 V) power supply for the VOUT Power Group pins             | PWR  | H10/ H11/ E10/ D10/<br>B6                                                              |
| vddshv3                           | Dual Voltage (1.8 V or 3.3 V) power supply for the GENERAL Power Group pins          | PWR  | H15/ H16/ H18/ H19/<br>G15/ E16/ E22/ D16/<br>D22/ B23                                 |
| vddshv4                           | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC4 Power Group pins             | PWR  | C24                                                                                    |
| vddshv6                           | Dual Voltage (1.8 V or 3.3 V) power supply for the VIN1 Power Group pins             | PWR  | AF5/ AE7/ AD5/ AD7                                                                     |
| vddshv7                           | Dual Voltage (1.8 V or 3.3 V) power supply for the WIFI Power Group pins             | PWR  | AB6/ AB7                                                                               |
| vddshv8                           | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC1 Power Group pins             | PWR  | Y8/ W8                                                                                 |
| vddshv9                           | Dual Voltage (1.8 V or 3.3 V) power supply for the RGMII Power Group pins            | PWR  | W4/ W5/ U10                                                                            |
| cap_vddram_dspeve2 <sup>(1)</sup> | External capacitor connection for the DSP-EVE SRAM array ldo2 output                 | CAP  | J9                                                                                     |
| cap_vddram_dspeve1 <sup>(1)</sup> | External capacitor connection for the DSP-EVE SRAM array ldo1 output                 | CAP  | J10                                                                                    |
| cap_vbbldo_mpu <sup>(1)</sup>     | External capacitor connection for the MPU vbb ldo output                             | CAP  | J16                                                                                    |
| cap_vddram_core2 <sup>(1)</sup>   | External capacitor connection for the Core SRAM array ldo2 output                    | CAP  | J19                                                                                    |
| cap_vbbldo_dspeve <sup>(1)</sup>  | External capacitor connection for the DSP-EVE vbb ldo output                         | CAP  | K9                                                                                     |
| cap_vddram_mpu1 <sup>(1)</sup>    | External capacitor connection for the MPU SRAM array ldo1 output                     | CAP  | K16                                                                                    |
| cap_vddram_mpu2 <sup>(1)</sup>    | External capacitor connection for the MPU SRAM array ldo2 output                     | CAP  | K19                                                                                    |
| cap_vddram_core1 <sup>(1)</sup>   | External capacitor connection for the Core SRAM array ldo1 output                    | CAP  | L9                                                                                     |

**Table 4-27. Power Supply Signal Descriptions (continued)**

| SIGNAL NAME                     | DESCRIPTION                                                       | TYPE | BALL |
|---------------------------------|-------------------------------------------------------------------|------|------|
| cap_vddram_core4 <sup>(1)</sup> | External capacitor connection for the Core SRAM array Ido4 output | CAP  | P19  |
| cap_vbbldo_iva <sup>(1)</sup>   | External capacitor connection for the IVA vbb Ido output          | CAP  | R20  |
| cap_vddram_iva <sup>(1)</sup>   | External capacitor connection for the IVA SRAM array Ido output   | CAP  | T20  |
| cap_vddram_gpu <sup>(1)</sup>   | External capacitor connection for the GPU SRAM array Ido output   | CAP  | Y13  |
| cap_vbbldo_gpu <sup>(1)</sup>   | External capacitor connection for the GPU vbb Ido output          | CAP  | Y14  |
| cap_vddram_core3 <sup>(1)</sup> | External capacitor connection for the Core SRAM array Ido3 output | CAP  | Y15  |
| cap_vddram_core5 <sup>(1)</sup> | External capacitor connection for the Core SRAM array Ido5 output | CAP  | Y16  |

(1) This pin must always be connected via a 1  $\mu$ F capacitor to vss.

(2) This signal is valid only for High-Security devices. For more details, see [Section 5.8](#), *VPP Specification for One-Time Programmable (OTP) eFUSES*. For General-purpose devices do not connect any signal, test point, or board trace to this signal.

### 4.3.21 Test Interfaces

#### CAUTION

The I/O timings provided in [Section 5.10](#), *Timing Requirements and Switching Characteristics* are valid only if signals within a single IOSET are used. The IOSETs are defined in the [Table 5-168](#).

#### NOTE

For more information, see the On-Chip Debug Support / Debug Ports section of the Device TRM.

**Table 4-28. Debug Signal Descriptions**

| SIGNAL NAME | DESCRIPTION                                                                          | TYPE | BALL    |
|-------------|--------------------------------------------------------------------------------------|------|---------|
| tms         | JTAG test port mode select. An external pullup resistor should be used on this ball. | IO   | F18     |
| tdi         | JTAG test data                                                                       | I    | D23     |
| tdo         | JTAG test port data                                                                  | O    | F19     |
| tclk        | JTAG test clock                                                                      | I    | E20     |
| trstn       | JTAG test reset                                                                      | I    | D20     |
| rtck        | JTAG return clock                                                                    | O    | E18     |
| emu0        | Emulator pin 0                                                                       | IO   | G21     |
| emu1        | Emulator pin 1                                                                       | IO   | D24     |
| emu2        | Emulator pin 2                                                                       | O    | F10     |
| emu3        | Emulator pin 3                                                                       | O    | D7      |
| emu4        | Emulator pin 4                                                                       | O    | A7      |
| emu5        | Emulator pin 5                                                                       | O    | E1/ G11 |
| emu6        | Emulator pin 6                                                                       | O    | G2/ E9  |
| emu7        | Emulator pin 7                                                                       | O    | H7/ F9  |
| emu8        | Emulator pin 8                                                                       | O    | G1/ F8  |
| emu9        | Emulator pin 9                                                                       | O    | G6/ E7  |
| emu10       | Emulator pin 10                                                                      | O    | F2/ D8  |
| emu11       | Emulator pin 11                                                                      | O    | F3/ A5  |
| emu12       | Emulator pin 12                                                                      | O    | D1/ C6  |
| emu13       | Emulator pin 13                                                                      | O    | E2/ C8  |
| emu14       | Emulator pin 14                                                                      | O    | D2/ C7  |

**Table 4-28. Debug Signal Descriptions (continued)**

| SIGNAL NAME | DESCRIPTION     | TYPE | BALL                    |
|-------------|-----------------|------|-------------------------|
| emu15       | Emulator pin 15 | O    | <a href="#">F4/ A8</a>  |
| emu16       | Emulator pin 16 | O    | <a href="#">C1/ C9</a>  |
| emu17       | Emulator pin 17 | O    | <a href="#">E4/ A9</a>  |
| emu18       | Emulator pin 18 | O    | <a href="#">F5/ B9</a>  |
| emu19       | Emulator pin 19 | O    | <a href="#">E6/ A10</a> |

## 4.4 Pin Multiplexing

[Table 4-29](#) describes the device pin multiplexing (no characteristics are provided in this table).

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### NOTE

[Table 4-29](#), *Pin Multiplexing* doesn't take into account subsystem multiplexing signals. Subsystem multiplexing signals are described in [Section 4.3](#), *Signal Descriptions*.

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### NOTE

For more information, see the Control Module / Control Module Functional Description / PAD Functional Multiplexing and Configuration section of the Device TRM.

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### NOTE

Configuring two pins to the same input signal is not supported as it can yield unexpected results. This can be easily prevented with the proper software configuration (Hi-Z mode is not an input signal).

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### NOTE

In some cases [Table 4-29](#) may present more than one signal name per muxmode for the same ball. First signal in the list is the dominant function as selected via CTRL\_CORE\_PAD\_\* register. All other signals are virtual functions that present alternate multiplexing options. This virtual functions are controlled via CTRL\_CORE\_ALT\_SELECT\_MUX or CTRL\_CORE\_VIP\_MUX\_SELECT register. For more information on how to use this options, please refer to the Device TRM, Chapter Control Module, Section Pad Configuration Registers.

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### NOTE

When a pad is set into a pin multiplexing mode which is not defined, that pad's behavior is undefined. This should be avoided.

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### CAUTION

The I/O timings provided in [Section 5.10](#), *Timing Requirements and Switching Characteristics* are valid only if signals within a single IOSET are used. The IOSETs are defined in the corresponding tables.

Table 4-29. Pin Multiplexing

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |   |    |   |   |   |   |   |   |   |    |     |    |
|---------|---------------|-------------|-----------------------------------------------|---|----|---|---|---|---|---|---|---|----|-----|----|
|         |               |             | 0*                                            | 1 | 2* | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 14* | 15 |
|         |               | P25         | ddr2_a6                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y23         | ddr1_d26                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y19         | ddr1_d21                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE15        | xi_osc0                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH24        | ddr1_nck                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG15        | ljcb_clkp                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF24        | ddr1_d4                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | U25         | ddr2_wen                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | F27         | ddr2_d5                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | V25         | ddr1_ecc_d6                                   |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | M27         | ddr2_dqsn3                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | G26         | ddr2_d12                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG19        | hdmi1_data2x                                  |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF21        | ddr1_a4                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | E27         | ddr2_d6                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | F24         | ddr2_d3                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | H26         | ddr2_d11                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | W23         | ddr1_ecc_d3                                   |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y27         | ddr1_dqsn3                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC24        | ddr1_d14                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | J24         | ddr2_d15                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | R26         | ddr2_a1                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | G27         | ddr2_dqsn0                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF28        | ddr1_d11                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AA23        | ddr1_d24                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AD18        | ddr1_a15                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | H23         | ddr2_d8                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH16        | hdmi1_clocky                                  |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC20        | ddr1_a2                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AA24        | ddr1_d27                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | W19         | ddr1_ecc_d2                                   |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | L24         | ddr2_d20                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG11        | pcie_rxn1                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG21        | ddr1_rst                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE28        | ddr1_dqsn1                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC11        | usb_txn0                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | L22         | ddr2_d16                                      |   |    |   |   |   |   |   |   |   |    |     |    |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |   |    |   |   |   |   |   |   |   |    |     |    |
|---------|---------------|----------------|-----------------------------------------------|---|----|---|---|---|---|---|---|---|----|-----|----|
|         |               |                | 0*                                            | 1 | 2* | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 14* | 15 |
|         |               | U28            | ddr2_casn                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | K22            | ddr2_d22                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG25           | ddr1_dqsn0                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | W20            | ddr1_d17                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF14           | rtc_iso                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AA27           | ddr1_dqm3                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF25           | ddr1_d0                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF23           | ddr1_d6                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG18           | hdmi1_data1<br>x                              |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG10           | sata1_txn0                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF20           | ddr1_rasn                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | V26            | ddr1_dqm_e<br>cc                              |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | V20            | ddr1_d16                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | G25            | ddr2_d1                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH13           | pcie_rxp0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC18           | ddr1_casn                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG9            | sata1_rxp0                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH23           | ddr1_csn0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE11           | usb2_dp                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | R25            | ddr2_a0                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y24            | ddr1_d28                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH15           | ljcb_clkn                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AD20           | ddr1_a0                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AA25           | ddr1_d30                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | L23            | ddr2_d19                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AD14           | rtc_osc_xo                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | J25            | ddr2_d13                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC25           | ddr1_d13                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AB23           | ddr1_dqm1                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | U22            | ddr2_a15                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | T22            | ddr2_a13                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH19           | hdmi1_data2<br>y                              |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | M26            | ddr2_d31                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AB27           | ddr1_d22                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG14           | pcie_txn0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y28            | ddr1_dqs3                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | J20            | ddr2_d23                                      |   |    |   |   |   |   |   |   |   |    |     |    |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |   |    |   |   |   |   |   |   |   |    |     |    |
|---------|---------------|----------------|-----------------------------------------------|---|----|---|---|---|---|---|---|---|----|-----|----|
|         |               |                | 0*                                            | 1 | 2* | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 14* | 15 |
|         |               | AB19           | ddr1_a3                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH10           | sata1_txp0                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | G28            | ddr2_dqs0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG24           | ddr1_ck                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE24           | ddr1_d5                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC15           | xi_osc1                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC21           | ddr1_a12                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | K28            | ddr2_dqsn2                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF12           | usb_rxn0                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | L28            | ddr2_d27                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | M24            | ddr2_d29                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH9            | sata1_rxn0                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC26           | ddr1_dqm2                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AA28           | ddr1_d31                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | H28            | ddr2_dqsn1                                    |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AD23           | ddr1_dqm0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | E26            | ddr2_d0                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE27           | ddr1_dqs1                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF27           | ddr1_d9                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | V24            | ddr1_ecc_d5                                   |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | K23            | ddr2_dqm2                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | K20            | ddr2_d17                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | T28            | ddr2_ck                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | H24            | ddr2_d10                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG27           | ddr1_d10                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | R23            | ddr2_odt0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | U27            | ddr2_ba1                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF22           | ddr1_a8                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | U23            | ddr2_ba0                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH21           | ddr1_wen                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE21           | ddr1_a7                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC12           | usb1_dm                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH12           | pcie_txp1                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y20            | ddr1_d23                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC27           | ddr1_d20                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE23           | ddr1_d7                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | T27            | ddr2_nck                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG22           | ddr1_cke                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AD27           | ddr1_dqs2                                     |   |    |   |   |   |   |   |   |   |    |     |    |

**Table 4-29. Pin Multiplexing (continued)**

| ADDRESS | REGISTER NAME | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |   |    |   |   |   |   |   |   |   |    |     |    |
|---------|---------------|----------------|-----------------------------------------------|---|----|---|---|---|---|---|---|---|----|-----|----|
|         |               |                | 0*                                            | 1 | 2* | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 14* | 15 |
|         |               | AH14           | pcie_txp0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH26           | ddr1_d3                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AD21           | ddr1_a10                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | N28            | ddr2_a12                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y25            | ddr1_ecc_d4                                   |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE17           | ddr1_a14                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH18           | hdmi1_data1<br>y                              |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH22           | ddr1_a5                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | J26            | ddr2_d14                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | W22            | ddr1_ecc_d0                                   |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | V23            | ddr1_ecc_d1                                   |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE12           | usb_rxp0                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE14           | rtc_osc_xi_cl<br>kin32                        |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AH11           | pcie_rxp1                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG23           | ddr1_a6                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | H27            | ddr2_dqs1                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AB18           | ddr1_ba2                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG17           | hdmi1_data0<br>x                              |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF26           | ddr1_d1                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | H25            | ddr2_d9                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | M25            | ddr2_d30                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AD11           | usb_txp0                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | L27            | ddr2_d24                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | V27            | ddr1_dqs_ec<br>c                              |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AF17           | ddr1_ba0                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AE26           | ddr1_d12                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | G24            | ddr2_dqm1                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | K27            | ddr2_dqs2                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AC19           | ddr1_a1                                       |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AG13           | pcie_rxn0                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | L26            | ddr2_d25                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | AB28           | ddr1_d18                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | N23            | ddr2_a10                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | M22            | ddr2_dqm3                                     |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | U26            | ddr2_ba2                                      |   |    |   |   |   |   |   |   |   |    |     |    |
|         |               | Y26            | ddr1_ecc_d7                                   |   |    |   |   |   |   |   |   |   |    |     |    |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME          | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |   |           |           |           |   |           |   |   |   |    |          |            |
|---------|------------------------|----------------|-----------------------------------------------|---|-----------|-----------|-----------|---|-----------|---|---|---|----|----------|------------|
|         |                        |                | 0*                                            | 1 | 2*        | 3         | 4         | 5 | 6         | 7 | 8 | 9 | 10 | 14*      | 15         |
|         |                        | P24            | ddr2_csn0                                     |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | R22            | ddr2_a14                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AD22           | ddr1_a11                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | N20            | ddr2_a7                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | M23            | ddr2_d28                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AD28           | ddr1_dqsn2                                    |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | U24            | ddr2_cke                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | P22            | ddr2_a5                                       |   |           |           |           |   |           |   |   |   |    |          |            |
| 0x17D4  | CTRL_CORE_PAD_DCAN1_RX | G19            | dcan1_rx<br>mcan_rx                           |   | uart8_txd | mmc2_sdwp | sata1_led |   | hdmi1_cec |   |   |   |    | gpio1_15 | Driver off |
|         |                        | AE18           | ddr1_ba1                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | F26            | ddr2_d4                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AE20           | ddr1_odt0                                     |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | N22            | ddr2_vref0                                    |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | E28            | ddr2_d7                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | F25            | ddr2_d2                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AF11           | usb2_dm                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | R24            | ddr2_rst                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AD15           | xo_osc0                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | R27            | ddr2_a3                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AE22           | ddr1_a9                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | Y18            | ddr1_vref0                                    |   |           |           |           |   |           |   |   |   |    |          |            |
| 0x17D0  | CTRL_CORE_PAD_DCAN1_TX | G20            | dcan1_tx<br>mcan_tx                           |   | uart8_rxd | mmc2_sdcd |           |   | hdmi1_hpd |   |   |   |    | gpio1_14 | Driver off |
|         |                        | AC13           | xo_osc1                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | F28            | ddr2_dqm0                                     |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | J23            | ddr2_d21                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | P26            | ddr2_a11                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | M28            | ddr2_dqs3                                     |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AD12           | usb1_dp                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | Y22            | ddr1_d25                                      |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | T23            | ddr2_rasn                                     |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AH17           | hdmi1_data0<br>y                              |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | N27            | ddr2_a9                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | P23            | ddr2_a4                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AG26           | ddr1_d2                                       |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AH25           | ddr1_dqs0                                     |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AG12           | pcie_txn1                                     |   |           |           |           |   |           |   |   |   |    |          |            |
|         |                        | AF18           | ddr1_a13                                      |   |           |           |           |   |           |   |   |   |    |          |            |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME           | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |           |           |           |          |   |          |           |            |   |    |                                 |            |
|---------|-------------------------|----------------|-----------------------------------------------|-----------|-----------|-----------|----------|---|----------|-----------|------------|---|----|---------------------------------|------------|
|         |                         |                | 0*                                            | 1         | 2*        | 3         | 4        | 5 | 6        | 7         | 8          | 9 | 10 | 14*                             | 15         |
|         |                         | K21            | ddr2_d18                                      |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | AC28           | ddr1_d19                                      |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | V28            | ddr1_dqsn_e<br>cc                             |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | P27            | ddr2_a8                                       |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | AC23           | ddr1_d8                                       |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | F22            | porz                                          |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | L25            | ddr2_d26                                      |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | AG16           | hdmi1_clock<br>x                              |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | R28            | ddr2_a2                                       |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | AA26           | ddr1_d29                                      |           |           |           |          |   |          |           |            |   |    |                                 |            |
|         |                         | AD25           | ddr1_d15                                      |           |           |           |          |   |          |           |            |   |    |                                 |            |
| 0x1400  | CTRL_CORE_PAD_GPMC_AD0  | M6             | gpmc_ad0                                      |           | vin3a_d0  | vout3_d0  |          |   |          |           |            |   |    | gpio1_6                         | sysboot0   |
| 0x1404  | CTRL_CORE_PAD_GPMC_AD1  | M2             | gpmc_ad1                                      |           | vin3a_d1  | vout3_d1  |          |   |          |           |            |   |    | gpio1_7                         | sysboot1   |
| 0x1408  | CTRL_CORE_PAD_GPMC_AD2  | L5             | gpmc_ad2                                      |           | vin3a_d2  | vout3_d2  |          |   |          |           |            |   |    | gpio1_8                         | sysboot2   |
| 0x140C  | CTRL_CORE_PAD_GPMC_AD3  | M1             | gpmc_ad3                                      |           | vin3a_d3  | vout3_d3  |          |   |          |           |            |   |    | gpio1_9                         | sysboot3   |
| 0x1410  | CTRL_CORE_PAD_GPMC_AD4  | L6             | gpmc_ad4                                      |           | vin3a_d4  | vout3_d4  |          |   |          |           |            |   |    | gpio1_10                        | sysboot4   |
| 0x1414  | CTRL_CORE_PAD_GPMC_AD5  | L4             | gpmc_ad5                                      |           | vin3a_d5  | vout3_d5  |          |   |          |           |            |   |    | gpio1_11                        | sysboot5   |
| 0x1418  | CTRL_CORE_PAD_GPMC_AD6  | L3             | gpmc_ad6                                      |           | vin3a_d6  | vout3_d6  |          |   |          |           |            |   |    | gpio1_12                        | sysboot6   |
| 0x141C  | CTRL_CORE_PAD_GPMC_AD7  | L2             | gpmc_ad7                                      |           | vin3a_d7  | vout3_d7  |          |   |          |           |            |   |    | gpio1_13                        | sysboot7   |
| 0x1420  | CTRL_CORE_PAD_GPMC_AD8  | L1             | gpmc_ad8                                      |           | vin3a_d8  | vout3_d8  |          |   |          |           |            |   |    | gpio7_18                        | sysboot8   |
| 0x1424  | CTRL_CORE_PAD_GPMC_AD9  | K2             | gpmc_ad9                                      |           | vin3a_d9  | vout3_d9  |          |   |          |           |            |   |    | gpio7_19                        | sysboot9   |
| 0x1428  | CTRL_CORE_PAD_GPMC_AD10 | J1             | gpmc_ad10                                     |           | vin3a_d10 | vout3_d10 |          |   |          |           |            |   |    | gpio7_28                        | sysboot10  |
| 0x142C  | CTRL_CORE_PAD_GPMC_AD11 | J2             | gpmc_ad11                                     |           | vin3a_d11 | vout3_d11 |          |   |          |           |            |   |    | gpio7_29                        | sysboot11  |
| 0x1430  | CTRL_CORE_PAD_GPMC_AD12 | H1             | gpmc_ad12                                     |           | vin3a_d12 | vout3_d12 |          |   |          |           |            |   |    | gpio1_18                        | sysboot12  |
| 0x1434  | CTRL_CORE_PAD_GPMC_AD13 | J3             | gpmc_ad13                                     |           | vin3a_d13 | vout3_d13 |          |   |          |           |            |   |    | gpio1_19                        | sysboot13  |
| 0x1438  | CTRL_CORE_PAD_GPMC_AD14 | H2             | gpmc_ad14                                     |           | vin3a_d14 | vout3_d14 |          |   |          |           |            |   |    | gpio1_20                        | sysboot14  |
| 0x143C  | CTRL_CORE_PAD_GPMC_AD15 | H3             | gpmc_ad15                                     |           | vin3a_d15 | vout3_d15 |          |   |          |           |            |   |    | gpio1_21                        | sysboot15  |
| 0x1440  | CTRL_CORE_PAD_GPMC_A0   | R6             | gpmc_a0                                       |           | vin3a_d16 | vout3_d16 | vin4a_d0 |   | vin4b_d0 | i2c4_scl  | uart5_rxd  |   |    | gpio7_3<br>gpmc_a26<br>gpmc_a16 | Driver off |
| 0x1444  | CTRL_CORE_PAD_GPMC_A1   | T9             | gpmc_a1                                       |           | vin3a_d17 | vout3_d17 | vin4a_d1 |   | vin4b_d1 | i2c4_sda  | uart5_txd  |   |    | gpio7_4                         | Driver off |
| 0x1448  | CTRL_CORE_PAD_GPMC_A2   | T6             | gpmc_a2                                       |           | vin3a_d18 | vout3_d18 | vin4a_d2 |   | vin4b_d2 | uart7_rxd | uart5_ctsn |   |    | gpio7_5                         | Driver off |
| 0x144C  | CTRL_CORE_PAD_GPMC_A3   | T7             | gpmc_a3                                       | qspi1_cs2 | vin3a_d19 | vout3_d19 | vin4a_d3 |   | vin4b_d3 | uart7_txd | uart5_rtsn |   |    | gpio7_6                         | Driver off |
| 0x1450  | CTRL_CORE_PAD_GPMC_A4   | P6             | gpmc_a4                                       | qspi1_cs3 | vin3a_d20 | vout3_d20 | vin4a_d4 |   | vin4b_d4 | i2c5_scl  | uart6_rxd  |   |    | gpio1_26                        | Driver off |
| 0x1454  | CTRL_CORE_PAD_GPMC_A5   | R9             | gpmc_a5                                       |           | vin3a_d21 | vout3_d21 | vin4a_d5 |   | vin4b_d5 | i2c5_sda  | uart6_txd  |   |    | gpio1_27                        | Driver off |
| 0x1458  | CTRL_CORE_PAD_GPMC_A6   | R5             | gpmc_a6                                       |           | vin3a_d22 | vout3_d22 | vin4a_d6 |   | vin4b_d6 | uart8_rxd | uart6_ctsn |   |    | gpio1_28                        | Driver off |
| 0x145C  | CTRL_CORE_PAD_GPMC_A7   | P5             | gpmc_a7                                       |           | vin3a_d23 | vout3_d23 | vin4a_d7 |   | vin4b_d7 | uart8_txd | uart6_rtsn |   |    | gpio1_29                        | Driver off |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME                | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |             |              |              |              |           |              |         |           |          |    |                                  |            |
|---------|------------------------------|-------------|-----------------------------------------------|-------------|--------------|--------------|--------------|-----------|--------------|---------|-----------|----------|----|----------------------------------|------------|
|         |                              |             | 0*                                            | 1           | 2*           | 3            | 4            | 5         | 6            | 7       | 8         | 9        | 10 | 14*                              | 15         |
| 0x1460  | CTRL_CORE_PAD_GPMC_A8        | N7          | gpmc_a8                                       |             | vin3a_hsync0 | vout3_hsync  |              |           | vin4b_hsync1 | timer12 | spi4_sclk |          |    | gpio1_30                         | Driver off |
| 0x1464  | CTRL_CORE_PAD_GPMC_A9        | R4          | gpmc_a9                                       |             | vin3a_vsync0 | vout3_vsync  |              |           | vin4b_vsync1 | timer11 | spi4_d1   |          |    | gpio1_31                         | Driver off |
| 0x1468  | CTRL_CORE_PAD_GPMC_A10       | N9          | gpmc_a10                                      |             | vin3a_de0    | vout3_de     |              |           | vin4b_clk1   | timer10 | spi4_d0   |          |    | gpio2_0                          | Driver off |
| 0x146C  | CTRL_CORE_PAD_GPMC_A11       | P9          | gpmc_a11                                      |             | vin3a_fld0   | vout3_fld    | vin4a_fld0   |           | vin4b_de1    | timer9  | spi4_cs0  |          |    | gpio2_1                          | Driver off |
| 0x1470  | CTRL_CORE_PAD_GPMC_A12       | P4          | gpmc_a12                                      |             |              |              | vin4a_clk0   | gpmc_a0   | vin4b_fld1   | timer8  | spi4_cs1  | dma_evt1 |    | gpio2_2                          | Driver off |
| 0x1474  | CTRL_CORE_PAD_GPMC_A13       | R3          | gpmc_a13                                      | qspi1_rtclk |              |              | vin4a_hsync0 |           |              | timer7  | spi4_cs2  | dma_evt2 |    | gpio2_3                          | Driver off |
| 0x1478  | CTRL_CORE_PAD_GPMC_A14       | T2          | gpmc_a14                                      | qspi1_d3    |              |              | vin4a_vsync0 |           |              | timer6  | spi4_cs3  |          |    | gpio2_4                          | Driver off |
| 0x147C  | CTRL_CORE_PAD_GPMC_A15       | U2          | gpmc_a15                                      | qspi1_d2    |              |              | vin4a_d8     |           |              | timer5  |           |          |    | gpio2_5                          | Driver off |
| 0x1480  | CTRL_CORE_PAD_GPMC_A16       | U1          | gpmc_a16                                      | qspi1_d0    |              |              | vin4a_d9     |           |              |         |           |          |    | gpio2_6                          | Driver off |
| 0x1484  | CTRL_CORE_PAD_GPMC_A17       | P3          | gpmc_a17                                      | qspi1_d1    |              |              | vin4a_d10    |           |              |         |           |          |    | gpio2_7                          | Driver off |
| 0x1488  | CTRL_CORE_PAD_GPMC_A18       | R2          | gpmc_a18                                      | qspi1_sclk  |              |              | vin4a_d11    |           |              |         |           |          |    | gpio2_8                          | Driver off |
| 0x148C  | CTRL_CORE_PAD_GPMC_A19       | K7          | gpmc_a19                                      | mmc2_dat4   | gpmc_a13     |              | vin4a_d12    |           | vin3b_d0     |         |           |          |    | gpio2_9                          | Driver off |
| 0x1490  | CTRL_CORE_PAD_GPMC_A20       | M7          | gpmc_a20                                      | mmc2_dat5   | gpmc_a14     |              | vin4a_d13    |           | vin3b_d1     |         |           |          |    | gpio2_10                         | Driver off |
| 0x1494  | CTRL_CORE_PAD_GPMC_A21       | J5          | gpmc_a21                                      | mmc2_dat6   | gpmc_a15     |              | vin4a_d14    |           | vin3b_d2     |         |           |          |    | gpio2_11                         | Driver off |
| 0x1498  | CTRL_CORE_PAD_GPMC_A22       | K6          | gpmc_a22                                      | mmc2_dat7   | gpmc_a16     |              | vin4a_d15    |           | vin3b_d3     |         |           |          |    | gpio2_12                         | Driver off |
| 0x149C  | CTRL_CORE_PAD_GPMC_A23       | J7          | gpmc_a23                                      | mmc2_clk    | gpmc_a17     |              | vin4a_fld0   |           | vin3b_d4     |         |           |          |    | gpio2_13                         | Driver off |
| 0x14A0  | CTRL_CORE_PAD_GPMC_A24       | J4          | gpmc_a24                                      | mmc2_dat0   | gpmc_a18     |              |              |           | vin3b_d5     |         |           |          |    | gpio2_14                         | Driver off |
| 0x14A4  | CTRL_CORE_PAD_GPMC_A25       | J6          | gpmc_a25                                      | mmc2_dat1   | gpmc_a19     |              |              |           | vin3b_d6     |         |           |          |    | gpio2_15                         | Driver off |
| 0x14A8  | CTRL_CORE_PAD_GPMC_A26       | H4          | gpmc_a26                                      | mmc2_dat2   | gpmc_a20     |              |              |           | vin3b_d7     |         |           |          |    | gpio2_16                         | Driver off |
| 0x14AC  | CTRL_CORE_PAD_GPMC_A27       | H5          | gpmc_a27                                      | mmc2_dat3   | gpmc_a21     |              |              |           | vin3b_hsync1 |         |           |          |    | gpio2_17                         | Driver off |
| 0x14B0  | CTRL_CORE_PAD_GPMC_CS1       | H6          | gpmc_cs1                                      | mmc2_cmd    | gpmc_a22     |              | vin4a_de0    |           | vin3b_vsync1 |         |           |          |    | gpio2_18                         | Driver off |
| 0x14B4  | CTRL_CORE_PAD_GPMC_CS0       | T1          | gpmc_cs0                                      |             |              |              |              |           |              |         |           |          |    | gpio2_19                         | Driver off |
| 0x14B8  | CTRL_CORE_PAD_GPMC_CS2       | P2          | gpmc_cs2                                      | qspi1_cs0   |              |              |              |           |              |         |           |          |    | gpio2_20<br>gpmc_a23<br>gpmc_a13 | Driver off |
| 0x14BC  | CTRL_CORE_PAD_GPMC_CS3       | P1          | gpmc_cs3                                      | qspi1_cs1   | vin3a_clk0   | vout3_clk    |              | gpmc_a1   |              |         |           |          |    | gpio2_21<br>gpmc_a24<br>gpmc_a14 | Driver off |
| 0x14C0  | CTRL_CORE_PAD_GPMC_CLK       | P7          | gpmc_clk                                      | gpmc_cs7    | clkout1      | gpmc_wait1   | vin4a_hsync0 | vin4a_de0 | vin3b_clk1   | timer4  | i2c3_scl  | dma_evt1 |    | gpio2_22<br>gpmc_a20             | Driver off |
| 0x14C4  | CTRL_CORE_PAD_GPMC_ADVْنَALE | N1          | gpmc_advْنَale                                | gpmc_cs6    | clkout2      | gpmc_wait1   | vin4a_vsync0 | gpmc_a2   | gpmc_a23     | timer3  | i2c3_sda  | dma_evt2 |    | gpio2_23<br>gpmc_a19             | Driver off |
| 0x14C8  | CTRL_CORE_PAD_GPMC_OEN_REN   | M5          | gpmc_oen_ren                                  |             |              |              |              |           |              |         |           |          |    | gpio2_24                         | Driver off |
| 0x14CC  | CTRL_CORE_PAD_GPMC_WEN       | M3          | gpmc_wen                                      |             |              |              |              |           |              |         |           |          |    | gpio2_25                         | Driver off |
| 0x14D0  | CTRL_CORE_PAD_GPMC_BEN0      | N6          | gpmc_ben0                                     | gpmc_cs4    |              | vin1b_hsync1 |              |           | vin3b_de1    | timer2  |           | dma_evt3 |    | gpio2_26<br>gpmc_a21             | Driver off |

**Table 4-29. Pin Multiplexing (continued)**

| ADDRESS | REGISTER NAME              | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |              |                   |           |             |            |            |         |           |          |                            |                                  |            |
|---------|----------------------------|-------------|-----------------------------------------------|--------------|-------------------|-----------|-------------|------------|------------|---------|-----------|----------|----------------------------|----------------------------------|------------|
|         |                            |             | 0*                                            | 1            | 2*                | 3         | 4           | 5          | 6          | 7       | 8         | 9        | 10                         | 14*                              | 15         |
| 0x14D4  | CTRL_CORE_PAD_GPMC_BEN1    | M4          | gpmc_ben1                                     | gpmc_cs5     |                   | vin1b_de1 | vin3b_clk1  | gpmc_a3    | vin3b_fld1 | timer1  |           | dma_evt4 |                            | gpio2_27<br>gpmc_a22             | Driver off |
| 0x14D8  | CTRL_CORE_PAD_GPMC_WAIT0   | N2          | gpmc_wait0                                    |              |                   |           |             |            |            |         |           |          |                            | gpio2_28<br>gpmc_a25<br>gpmc_a15 | Driver off |
| 0x14DC  | CTRL_CORE_PAD_VIN1A_CLK0   | AG8         | vin1a_clk0                                    |              |                   | vout3_d16 | vout3_fld   |            |            |         |           |          |                            | gpio2_30                         | Driver off |
| 0x14E0  | CTRL_CORE_PAD_VIN1B_CLK1   | AH7         | vin1b_clk1                                    |              |                   |           |             |            | vin3a_clk0 |         |           |          |                            | gpio2_31                         | Driver off |
| 0x14E4  | CTRL_CORE_PAD_VIN1A_DE0    | AD9         | vin1a_de0                                     | vin1b_hsync1 |                   | vout3_d17 | vout3_de    | uart7_rxd  |            | timer16 | spi3_sclk |          | eQEP1A_in                  | gpio3_0                          | Driver off |
| 0x14E8  | CTRL_CORE_PAD_VIN1A_FLD0   | AF9         | vin1a_fld0                                    | vin1b_vsync1 |                   |           | vout3_clk   | uart7_txd  |            | timer15 | spi3_d1   |          | eQEP1B_in                  | gpio3_1                          | Driver off |
| 0x14EC  | CTRL_CORE_PAD_VIN1A_HSYNC0 | AE9         | vin1a_hsync0                                  | vin1b_fld1   |                   |           | vout3_hsync | uart7_ctsn |            | timer14 | spi3_d0   |          | eQEP1_inde<br>x            | gpio3_2                          | Driver off |
| 0x14F0  | CTRL_CORE_PAD_VIN1A_VSYNC0 | AF8         | vin1a_vsync0                                  | vin1b_de1    |                   |           | vout3_vsync | uart7_rtsn |            | timer13 | spi3_cs0  |          | eQEP1_stro<br>be           | gpio3_3                          | Driver off |
| 0x14F4  | CTRL_CORE_PAD_VIN1A_D0     | AE8         | vin1a_d0                                      |              |                   | vout3_d7  | vout3_d23   | uart8_rxd  |            |         |           |          | ehrpwm1A                   | gpio3_4                          | Driver off |
| 0x14F8  | CTRL_CORE_PAD_VIN1A_D1     | AD8         | vin1a_d1                                      |              |                   | vout3_d6  | vout3_d22   | uart8_txd  |            |         |           |          | ehrpwm1B                   | gpio3_5                          | Driver off |
| 0x14FC  | CTRL_CORE_PAD_VIN1A_D2     | AG7         | vin1a_d2                                      |              |                   | vout3_d5  | vout3_d21   | uart8_ctsn |            |         |           |          | ehrpwm1_tri<br>pzone_input | gpio3_6                          | Driver off |
| 0x1500  | CTRL_CORE_PAD_VIN1A_D3     | AH6         | vin1a_d3                                      |              |                   | vout3_d4  | vout3_d20   | uart8_rtsn |            |         |           |          | eCAP1_in_P<br>WM1_out      | gpio3_7                          | Driver off |
| 0x1504  | CTRL_CORE_PAD_VIN1A_D4     | AH3         | vin1a_d4                                      |              |                   | vout3_d3  | vout3_d19   |            |            |         |           |          | ehrpwm1_sy<br>nci          | gpio3_8                          | Driver off |
| 0x1508  | CTRL_CORE_PAD_VIN1A_D5     | AH5         | vin1a_d5                                      |              |                   | vout3_d2  | vout3_d18   |            |            |         |           |          | ehrpwm1_sy<br>nco          | gpio3_9                          | Driver off |
| 0x150C  | CTRL_CORE_PAD_VIN1A_D6     | AG6         | vin1a_d6                                      |              |                   | vout3_d1  | vout3_d17   |            |            |         |           |          | eQEP2A_in                  | gpio3_10                         | Driver off |
| 0x1510  | CTRL_CORE_PAD_VIN1A_D7     | AH4         | vin1a_d7                                      |              |                   | vout3_d0  | vout3_d16   |            |            |         |           |          | eQEP2B_in                  | gpio3_11                         | Driver off |
| 0x1514  | CTRL_CORE_PAD_VIN1A_D8     | AG4         | vin1a_d8                                      | vin1b_d7     |                   |           | vout3_d15   |            |            |         |           |          | eQEP2_inde<br>x            | gpio3_12                         | Driver off |
| 0x1518  | CTRL_CORE_PAD_VIN1A_D9     | AG2         | vin1a_d9                                      | vin1b_d6     |                   |           | vout3_d14   |            |            |         |           |          | eQEP2_stro<br>be           | gpio3_13                         | Driver off |
| 0x151C  | CTRL_CORE_PAD_VIN1A_D10    | AG3         | vin1a_d10                                     | vin1b_d5     |                   |           | vout3_d13   |            |            |         |           |          |                            | gpio3_14                         | Driver off |
| 0x1520  | CTRL_CORE_PAD_VIN1A_D11    | AG5         | vin1a_d11                                     | vin1b_d4     |                   |           | vout3_d12   | gpmc_a23   |            |         |           |          |                            | gpio3_15                         | Driver off |
| 0x1524  | CTRL_CORE_PAD_VIN1A_D12    | AF2         | vin1a_d12                                     | vin1b_d3     | usb3_ulpi_d7      |           | vout3_d11   | gpmc_a24   |            |         |           |          |                            | gpio3_16                         | Driver off |
| 0x1528  | CTRL_CORE_PAD_VIN1A_D13    | AF6         | vin1a_d13                                     | vin1b_d2     | usb3_ulpi_d6      |           | vout3_d10   | gpmc_a25   |            |         |           |          |                            | gpio3_17                         | Driver off |
| 0x152C  | CTRL_CORE_PAD_VIN1A_D14    | AF3         | vin1a_d14                                     | vin1b_d1     | usb3_ulpi_d5      |           | vout3_d9    | gpmc_a26   |            |         |           |          |                            | gpio3_18                         | Driver off |
| 0x1530  | CTRL_CORE_PAD_VIN1A_D15    | AF4         | vin1a_d15                                     | vin1b_d0     | usb3_ulpi_d4      |           | vout3_d8    | gpmc_a27   |            |         |           |          |                            | gpio3_19                         | Driver off |
| 0x1534  | CTRL_CORE_PAD_VIN1A_D16    | AF1         | vin1a_d16                                     | vin1b_d7     | usb3_ulpi_d3      |           | vout3_d7    |            | vin3a_d0   |         |           |          |                            | gpio3_20                         | Driver off |
| 0x1538  | CTRL_CORE_PAD_VIN1A_D17    | AE3         | vin1a_d17                                     | vin1b_d6     | usb3_ulpi_d2      |           | vout3_d6    |            | vin3a_d1   |         |           |          |                            | gpio3_21                         | Driver off |
| 0x153C  | CTRL_CORE_PAD_VIN1A_D18    | AE5         | vin1a_d18                                     | vin1b_d5     | usb3_ulpi_d1      |           | vout3_d5    |            | vin3a_d2   |         |           |          |                            | gpio3_22                         | Driver off |
| 0x1540  | CTRL_CORE_PAD_VIN1A_D19    | AE1         | vin1a_d19                                     | vin1b_d4     | usb3_ulpi_d0      |           | vout3_d4    |            | vin3a_d3   |         |           |          |                            | gpio3_23                         | Driver off |
| 0x1544  | CTRL_CORE_PAD_VIN1A_D20    | AE2         | vin1a_d20                                     | vin1b_d3     | usb3_ulpi_nx<br>t |           | vout3_d3    |            | vin3a_d4   |         |           |          |                            | gpio3_24                         | Driver off |
| 0x1548  | CTRL_CORE_PAD_VIN1A_D21    | AE6         | vin1a_d21                                     | vin1b_d2     | usb3_ulpi_dir     |           | vout3_d2    |            | vin3a_d5   |         |           |          |                            | gpio3_25                         | Driver off |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME              | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |            |                   |                  |             |       |           |   |            |             |                            |                                  |            |
|---------|----------------------------|----------------|-----------------------------------------------|------------|-------------------|------------------|-------------|-------|-----------|---|------------|-------------|----------------------------|----------------------------------|------------|
|         |                            |                | 0*                                            | 1          | 2*                | 3                | 4           | 5     | 6         | 7 | 8          | 9           | 10                         | 14*                              | 15         |
| 0x154C  | CTRL_CORE_PAD_VIN1A_D22    | AD2            | vin1a_d22                                     | vin1b_d1   | usb3_ulpi_st<br>p |                  | vout3_d1    |       | vin3a_d6  |   |            |             |                            | gpio3_26                         | Driver off |
| 0x1550  | CTRL_CORE_PAD_VIN1A_D23    | AD3            | vin1a_d23                                     | vin1b_d0   | usb3_ulpi_cl<br>k |                  | vout3_d0    |       | vin3a_d7  |   |            |             |                            | gpio3_27                         | Driver off |
| 0x1554  | CTRL_CORE_PAD_VIN2A_CLK0   | E1             | vin2a_clk0                                    |            |                   |                  | vout2_fld   | emu5  |           |   |            |             | eQEP1A_in                  | gpio3_28<br>gpmc_a27<br>gpmc_a17 | Driver off |
| 0x1558  | CTRL_CORE_PAD_VIN2A_DE0    | G2             | vin2a_de0                                     | vin2a_fld0 | vin2b_fld1        | vin2b_de1        | vout2_de    | emu6  |           |   |            |             | eQEP1B_in                  | gpio3_29                         | Driver off |
| 0x155C  | CTRL_CORE_PAD_VIN2A_FLD0   | H7             | vin2a_fld0                                    |            | vin2b_clk1        |                  | vout2_clk   | emu7  |           |   |            |             | eQEP1_inde<br>x            | gpio3_30<br>gpmc_a27<br>gpmc_a18 | Driver off |
| 0x1560  | CTRL_CORE_PAD_VIN2A_HSYNC0 | G1             | vin2a_hsync<br>0                              |            |                   | vin2b_hsync<br>1 | vout2_hsync | emu8  |           |   | uart9_rxd  | spi4_sclk   | eQEP1_stro<br>be           | gpio3_31<br>gpmc_a27             | Driver off |
| 0x1564  | CTRL_CORE_PAD_VIN2A_VSYNC0 | G6             | vin2a_vsync<br>0                              |            |                   | vin2b_vsync<br>1 | vout2_vsync | emu9  |           |   | uart9_txd  | spi4_d1     | ehrpwm1A                   | gpio4_0                          | Driver off |
| 0x1568  | CTRL_CORE_PAD_VIN2A_D0     | F2             | vin2a_d0                                      |            |                   |                  | vout2_d23   | emu10 |           |   | uart9_ctsn | spi4_d0     | ehrpwm1B                   | gpio4_1                          | Driver off |
| 0x156C  | CTRL_CORE_PAD_VIN2A_D1     | F3             | vin2a_d1                                      |            |                   |                  | vout2_d22   | emu11 |           |   | uart9_rtsn | spi4_cs0    | ehrpwm1_tri<br>pzone_input | gpio4_2                          | Driver off |
| 0x1570  | CTRL_CORE_PAD_VIN2A_D2     | D1             | vin2a_d2                                      |            |                   |                  | vout2_d21   | emu12 |           |   |            | uart10_rxd  | eCAP1_in_P<br>WM1_out      | gpio4_3                          | Driver off |
| 0x1574  | CTRL_CORE_PAD_VIN2A_D3     | E2             | vin2a_d3                                      |            |                   |                  | vout2_d20   | emu13 |           |   |            | uart10_txd  | ehrpwm1_sy<br>nci          | gpio4_4                          | Driver off |
| 0x1578  | CTRL_CORE_PAD_VIN2A_D4     | D2             | vin2a_d4                                      |            |                   |                  | vout2_d19   | emu14 |           |   |            | uart10_ctsn | ehrpwm1_sy<br>nco          | gpio4_5                          | Driver off |
| 0x157C  | CTRL_CORE_PAD_VIN2A_D5     | F4             | vin2a_d5                                      |            |                   |                  | vout2_d18   | emu15 |           |   |            | uart10_rtsn | eQEP2A_in                  | gpio4_6                          | Driver off |
| 0x1580  | CTRL_CORE_PAD_VIN2A_D6     | C1             | vin2a_d6                                      |            |                   |                  | vout2_d17   | emu16 |           |   |            | mii1_rxd1   | eQEP2B_in                  | gpio4_7                          | Driver off |
| 0x1584  | CTRL_CORE_PAD_VIN2A_D7     | E4             | vin2a_d7                                      |            |                   |                  | vout2_d16   | emu17 |           |   |            | mii1_rxd2   | eQEP2_inde<br>x            | gpio4_8                          | Driver off |
| 0x1588  | CTRL_CORE_PAD_VIN2A_D8     | F5             | vin2a_d8                                      |            |                   |                  | vout2_d15   | emu18 |           |   |            | mii1_rxd3   | eQEP2_stro<br>be           | gpio4_9<br>gpmc_a26              | Driver off |
| 0x158C  | CTRL_CORE_PAD_VIN2A_D9     | E6             | vin2a_d9                                      |            |                   |                  | vout2_d14   | emu19 |           |   |            | mii1_rxd0   | ehrpwm2A                   | gpio4_10<br>gpmc_a25             | Driver off |
| 0x1590  | CTRL_CORE_PAD_VIN2A_D10    | D3             | vin2a_d10                                     |            |                   | mdio_mclk        | vout2_d13   |       |           |   |            |             | ehrpwm2B                   | gpio4_11<br>gpmc_a24             | Driver off |
| 0x1594  | CTRL_CORE_PAD_VIN2A_D11    | F6             | vin2a_d11                                     |            |                   | mdio_d           | vout2_d12   |       |           |   |            |             | ehrpwm2_tri<br>pzone_input | gpio4_12<br>gpmc_a23             | Driver off |
| 0x1598  | CTRL_CORE_PAD_VIN2A_D12    | D5             | vin2a_d12                                     |            |                   | rgmii1_txc       | vout2_d11   |       |           |   |            | mii1_rxclk  | eCAP2_in_P<br>WM2_out      | gpio4_13                         | Driver off |
| 0x159C  | CTRL_CORE_PAD_VIN2A_D13    | C2             | vin2a_d13                                     |            |                   | rgmii1_txctl     | vout2_d10   |       |           |   |            | mii1_rxdv   | eQEP3A_in                  | gpio4_14                         | Driver off |
| 0x15A0  | CTRL_CORE_PAD_VIN2A_D14    | C3             | vin2a_d14                                     |            |                   | rgmii1_txd3      | vout2_d9    |       |           |   |            | mii1_txclk  | eQEP3B_in                  | gpio4_15                         | Driver off |
| 0x15A4  | CTRL_CORE_PAD_VIN2A_D15    | C4             | vin2a_d15                                     |            |                   | rgmii1_txd2      | vout2_d8    |       |           |   |            | mii1_txd0   | eQEP3_inde<br>x            | gpio4_16                         | Driver off |
| 0x15A8  | CTRL_CORE_PAD_VIN2A_D16    | B2             | vin2a_d16                                     |            | vin2b_d7          | rgmii1_txd1      | vout2_d7    |       | vin3a_d8  |   |            | mii1_txd1   | eQEP3_stro<br>be           | gpio4_24                         | Driver off |
| 0x15AC  | CTRL_CORE_PAD_VIN2A_D17    | D6             | vin2a_d17                                     |            | vin2b_d6          | rgmii1_txd0      | vout2_d6    |       | vin3a_d9  |   |            | mii1_txd2   | ehrpwm3A                   | gpio4_25                         | Driver off |
| 0x15B0  | CTRL_CORE_PAD_VIN2A_D18    | C5             | vin2a_d18                                     |            | vin2b_d5          | rgmii1_rxc       | vout2_d5    |       | vin3a_d10 |   |            | mii1_txd3   | ehrpwm3B                   | gpio4_26                         | Driver off |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME             | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |            |           |                  |                  |                  |           |            |           |   |                            |          |            |
|---------|---------------------------|-------------|-----------------------------------------------|------------|-----------|------------------|------------------|------------------|-----------|------------|-----------|---|----------------------------|----------|------------|
|         |                           |             | 0*                                            | 1          | 2*        | 3                | 4                | 5                | 6         | 7          | 8         | 9 | 10                         | 14*      | 15         |
| 0x15B4  | CTRL_CORE_PAD_VIN2A_D19   | A3          | vin2a_d19                                     |            | vin2b_d4  | rgmii1_rxtcl     | vout2_d4         |                  | vin3a_d11 |            | mii1_txer |   | ehrpwm3_tri<br>pzone_input | gpio4_27 | Driver off |
| 0x15B8  | CTRL_CORE_PAD_VIN2A_D20   | B3          | vin2a_d20                                     |            | vin2b_d3  | rgmii1_rxd3      | vout2_d3         | vin3a_de0        | vin3a_d12 |            | mii1_rxer |   | eCAP3_in_P<br>WM3_out      | gpio4_28 | Driver off |
| 0x15BC  | CTRL_CORE_PAD_VIN2A_D21   | B4          | vin2a_d21                                     |            | vin2b_d2  | rgmii1_rxd2      | vout2_d2         | vin3a_fld0       | vin3a_d13 |            | mii1_col  |   |                            | gpio4_29 | Driver off |
| 0x15C0  | CTRL_CORE_PAD_VIN2A_D22   | B5          | vin2a_d22                                     |            | vin2b_d1  | rgmii1_rxd1      | vout2_d1         | vin3a_hsync<br>0 | vin3a_d14 |            | mii1_crs  |   |                            | gpio4_30 | Driver off |
| 0x15C4  | CTRL_CORE_PAD_VIN2A_D23   | A4          | vin2a_d23                                     |            | vin2b_d0  | rgmii1_rxd0      | vout2_d0         | vin3a_vsync<br>0 | vin3a_d15 |            | mii1_txen |   |                            | gpio4_31 | Driver off |
| 0x15C8  | CTRL_CORE_PAD_VOUT1_CLK   | D11         | vout1_clk                                     |            |           | vin4a_fld0       | vin3a_fld0       |                  |           |            | spi3_cs0  |   |                            | gpio4_19 | Driver off |
| 0x15CC  | CTRL_CORE_PAD_VOUT1_DE    | B10         | vout1_de                                      |            |           | vin4a_de0        | vin3a_de0        |                  |           |            | spi3_d1   |   |                            | gpio4_20 | Driver off |
| 0x15D0  | CTRL_CORE_PAD_VOUT1_FLD   | B11         | vout1_fld                                     |            |           | vin4a_clk0       | vin3a_clk0       |                  |           |            | spi3_cs1  |   |                            | gpio4_21 | Driver off |
| 0x15D4  | CTRL_CORE_PAD_VOUT1_HSYNC | C11         | vout1_hsync                                   |            |           | vin4a_hsync<br>0 | vin3a_hsync<br>0 |                  |           |            | spi3_d0   |   |                            | gpio4_22 | Driver off |
| 0x15D8  | CTRL_CORE_PAD_VOUT1_VSYNC | E11         | vout1_vsync                                   |            |           | vin4a_vsync<br>0 | vin3a_vsync<br>0 |                  |           |            | spi3_sclk |   |                            | gpio4_23 | Driver off |
| 0x15DC  | CTRL_CORE_PAD_VOUT1_D0    | F11         | vout1_d0                                      |            | uart5_rxd | vin4a_d16        | vin3a_d16        |                  |           |            | spi3_cs2  |   |                            | gpio8_0  | Driver off |
| 0x15E0  | CTRL_CORE_PAD_VOUT1_D1    | G10         | vout1_d1                                      |            | uart5_txd | vin4a_d17        | vin3a_d17        |                  |           |            |           |   |                            | gpio8_1  | Driver off |
| 0x15E4  | CTRL_CORE_PAD_VOUT1_D2    | F10         | vout1_d2                                      |            | emu2      | vin4a_d18        | vin3a_d18        | obs0             | obs16     | obs_irq1   |           |   |                            | gpio8_2  | Driver off |
| 0x15E8  | CTRL_CORE_PAD_VOUT1_D3    | G11         | vout1_d3                                      |            | emu5      | vin4a_d19        | vin3a_d19        | obs1             | obs17     | obs_dmarq1 |           |   |                            | gpio8_3  | Driver off |
| 0x15EC  | CTRL_CORE_PAD_VOUT1_D4    | E9          | vout1_d4                                      |            | emu6      | vin4a_d20        | vin3a_d20        | obs2             | obs18     |            |           |   |                            | gpio8_4  | Driver off |
| 0x15F0  | CTRL_CORE_PAD_VOUT1_D5    | F9          | vout1_d5                                      |            | emu7      | vin4a_d21        | vin3a_d21        | obs3             | obs19     |            |           |   |                            | gpio8_5  | Driver off |
| 0x15F4  | CTRL_CORE_PAD_VOUT1_D6    | F8          | vout1_d6                                      |            | emu8      | vin4a_d22        | vin3a_d22        | obs4             | obs20     |            |           |   |                            | gpio8_6  | Driver off |
| 0x15F8  | CTRL_CORE_PAD_VOUT1_D7    | E7          | vout1_d7                                      |            | emu9      | vin4a_d23        | vin3a_d23        |                  |           |            |           |   |                            | gpio8_7  | Driver off |
| 0x15FC  | CTRL_CORE_PAD_VOUT1_D8    | E8          | vout1_d8                                      |            | uart6_rxd | vin4a_d8         | vin3a_d8         |                  |           |            |           |   |                            | gpio8_8  | Driver off |
| 0x1600  | CTRL_CORE_PAD_VOUT1_D9    | D9          | vout1_d9                                      |            | uart6_txd | vin4a_d9         | vin3a_d9         |                  |           |            |           |   |                            | gpio8_9  | Driver off |
| 0x1604  | CTRL_CORE_PAD_VOUT1_D10   | D7          | vout1_d10                                     |            | emu3      | vin4a_d10        | vin3a_d10        | obs5             | obs21     | obs_irq2   |           |   |                            | gpio8_10 | Driver off |
| 0x1608  | CTRL_CORE_PAD_VOUT1_D11   | D8          | vout1_d11                                     |            | emu10     | vin4a_d11        | vin3a_d11        | obs6             | obs22     | obs_dmarq2 |           |   |                            | gpio8_11 | Driver off |
| 0x160C  | CTRL_CORE_PAD_VOUT1_D12   | A5          | vout1_d12                                     |            | emu11     | vin4a_d12        | vin3a_d12        | obs7             | obs23     |            |           |   |                            | gpio8_12 | Driver off |
| 0x1610  | CTRL_CORE_PAD_VOUT1_D13   | C6          | vout1_d13                                     |            | emu12     | vin4a_d13        | vin3a_d13        | obs8             | obs24     |            |           |   |                            | gpio8_13 | Driver off |
| 0x1614  | CTRL_CORE_PAD_VOUT1_D14   | C8          | vout1_d14                                     |            | emu13     | vin4a_d14        | vin3a_d14        | obs9             | obs25     |            |           |   |                            | gpio8_14 | Driver off |
| 0x1618  | CTRL_CORE_PAD_VOUT1_D15   | C7          | vout1_d15                                     |            | emu14     | vin4a_d15        | vin3a_d15        | obs10            | obs26     |            |           |   |                            | gpio8_15 | Driver off |
| 0x161C  | CTRL_CORE_PAD_VOUT1_D16   | B7          | vout1_d16                                     |            | uart7_rxd | vin4a_d0         | vin3a_d0         |                  |           |            |           |   |                            | gpio8_16 | Driver off |
| 0x1620  | CTRL_CORE_PAD_VOUT1_D17   | B8          | vout1_d17                                     |            | uart7_txd | vin4a_d1         | vin3a_d1         |                  |           |            |           |   |                            | gpio8_17 | Driver off |
| 0x1624  | CTRL_CORE_PAD_VOUT1_D18   | A7          | vout1_d18                                     |            | emu4      | vin4a_d2         | vin3a_d2         | obs11            | obs27     |            |           |   |                            | gpio8_18 | Driver off |
| 0x1628  | CTRL_CORE_PAD_VOUT1_D19   | A8          | vout1_d19                                     |            | emu15     | vin4a_d3         | vin3a_d3         | obs12            | obs28     |            |           |   |                            | gpio8_19 | Driver off |
| 0x162C  | CTRL_CORE_PAD_VOUT1_D20   | C9          | vout1_d20                                     |            | emu16     | vin4a_d4         | vin3a_d4         | obs13            | obs29     |            |           |   |                            | gpio8_20 | Driver off |
| 0x1630  | CTRL_CORE_PAD_VOUT1_D21   | A9          | vout1_d21                                     |            | emu17     | vin4a_d5         | vin3a_d5         | obs14            | obs30     |            |           |   |                            | gpio8_21 | Driver off |
| 0x1634  | CTRL_CORE_PAD_VOUT1_D22   | B9          | vout1_d22                                     |            | emu18     | vin4a_d6         | vin3a_d6         | obs15            | obs31     |            |           |   |                            | gpio8_22 | Driver off |
| 0x1638  | CTRL_CORE_PAD_VOUT1_D23   | A10         | vout1_d23                                     |            | emu19     | vin4a_d7         | vin3a_d7         |                  |           |            | spi3_cs3  |   |                            | gpio8_23 | Driver off |
| 0x163C  | CTRL_CORE_PAD_MDIO_MCLK   | V1          | mdio_mclk                                     | uart3_rtsn |           | mii0_col         | vin2a_clk0       | vin4b_clk1       |           |            |           |   |                            | gpio5_15 | Driver off |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME                 | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |              |               |               |               |              |               |           |              |          |          |          |            |
|---------|-------------------------------|-------------|-----------------------------------------------|--------------|---------------|---------------|---------------|--------------|---------------|-----------|--------------|----------|----------|----------|------------|
|         |                               |             | 0*                                            | 1            | 2*            | 3             | 4             | 5            | 6             | 7         | 8            | 9        | 10       | 14*      | 15         |
| 0x1640  | CTRL_CORE_PAD_MDIO_D          | U4          | mdio_d                                        | uart3_ctsn   |               | mii0_txer     | vin2a_d0      | vin4b_d0     |               |           |              |          |          | gpio5_16 | Driver off |
| 0x1644  | CTRL_CORE_PAD_RMII_MHZ_50_CLK | U3          | RMII_MHZ_50_CLK                               |              |               |               | vin2a_d11     |              |               |           |              |          |          | gpio5_17 | Driver off |
| 0x1648  | CTRL_CORE_PAD_UART3_RXD       | V2          | uart3_rxd                                     |              | rmii1_crs     | mii0_rxdv     | vin2a_d1      | vin4b_d1     |               | spi3_sclk |              |          |          | gpio5_18 | Driver off |
| 0x164C  | CTRL_CORE_PAD_UART3_TXD       | Y1          | uart3_txd                                     |              | rmii1_rxer    | mii0_rxclk    | vin2a_d2      | vin4b_d2     |               | spi3_d1   | spi4_cs1     |          |          | gpio5_19 | Driver off |
| 0x1650  | CTRL_CORE_PAD_RGMII0_TXC      | W9          | rgmii0_txc                                    | uart3_ctsn   | rmii1_rxd1    | mii0_rxd3     | vin2a_d3      | vin4b_d3     | usb4_ulpi_clk | spi3_d0   | spi4_cs2     |          |          | gpio5_20 | Driver off |
| 0x1654  | CTRL_CORE_PAD_RGMII0_TXCTL    | V9          | rgmii0_txctl                                  | uart3_rtsn   | rmii1_rxd0    | mii0_rxd2     | vin2a_d4      | vin4b_d4     | usb4_ulpi_stp | spi3_cs0  | spi4_cs3     |          |          | gpio5_21 | Driver off |
| 0x1658  | CTRL_CORE_PAD_RGMII0_TXD3     | V7          | rgmii0_txd3                                   | rmii0_crs    |               | mii0_crs      | vin2a_de0     | vin4b_de1    | usb4_ulpi_dir | spi4_sclk | uart4_rxd    |          |          | gpio5_22 | Driver off |
| 0x165C  | CTRL_CORE_PAD_RGMII0_TXD2     | U7          | rgmii0_txd2                                   | rmii0_rxer   |               | mii0_rxer     | vin2a_hsync0  | vin4b_hsync1 | usb4_ulpi_nxt | spi4_d1   | uart4_txd    |          |          | gpio5_23 | Driver off |
| 0x1660  | CTRL_CORE_PAD_RGMII0_TXD1     | V6          | rgmii0_txd1                                   | rmii0_rxd1   |               | mii0_rxd1     | vin2a_vsync0  | vin4b_vsync1 | usb4_ulpi_d0  | spi4_d0   | uart4_ctsn   |          |          | gpio5_24 | Driver off |
| 0x1664  | CTRL_CORE_PAD_RGMII0_TXD0     | U6          | rgmii0_txd0                                   | rmii0_rxd0   |               | mii0_rxd0     | vin2a_d10     |              | usb4_ulpi_d1  | spi4_cs0  | uart4_rtsn   |          |          | gpio5_25 | Driver off |
| 0x1668  | CTRL_CORE_PAD_RGMII0_RXC      | U5          | rgmii0_rxc                                    |              | rmii1_txen    | mii0_txclk    | vin2a_d5      | vin4b_d5     | usb4_ulpi_d2  |           |              |          |          | gpio5_26 | Driver off |
| 0x166C  | CTRL_CORE_PAD_RGMII0_RXCTL    | V5          | rgmii0_rxctl                                  |              | rmii1_txd1    | mii0_txd3     | vin2a_d6      | vin4b_d6     | usb4_ulpi_d3  |           |              |          |          | gpio5_27 | Driver off |
| 0x1670  | CTRL_CORE_PAD_RGMII0_RXD3     | V4          | rgmii0_rxd3                                   |              | rmii1_txd0    | mii0_txd2     | vin2a_d7      | vin4b_d7     | usb4_ulpi_d4  |           |              |          |          | gpio5_28 | Driver off |
| 0x1674  | CTRL_CORE_PAD_RGMII0_RXD2     | V3          | rgmii0_rxd2                                   | rmii0_txen   |               | mii0_txen     | vin2a_d8      |              | usb4_ulpi_d5  |           |              |          |          | gpio5_29 | Driver off |
| 0x1678  | CTRL_CORE_PAD_RGMII0_RXD1     | Y2          | rgmii0_rxd1                                   | rmii0_txd1   |               | mii0_txd1     | vin2a_d9      |              | usb4_ulpi_d6  |           |              |          |          | gpio5_30 | Driver off |
| 0x167C  | CTRL_CORE_PAD_RGMII0_RXD0     | W2          | rgmii0_rxd0                                   | rmii0_txd0   |               | mii0_txd0     | vin2a_fld0    | vin4b_fld1   | usb4_ulpi_d7  |           |              |          |          | gpio5_31 | Driver off |
| 0x1680  | CTRL_CORE_PAD_USB1_DRVVBUS    | AB10        | usb1_drvvbuss                                 |              |               |               |               |              |               | timer16   |              |          |          | gpio6_12 | Driver off |
| 0x1684  | CTRL_CORE_PAD_USB2_DRVVBUS    | AC10        | usb2_drvvbuss                                 |              |               |               |               |              |               | timer15   |              |          |          | gpio6_13 | Driver off |
| 0x1688  | CTRL_CORE_PAD_GPIO6_14        | E21         | gpio6_14                                      | mcasp1_axr8  | dcn2_txmcn_tx | uart10_rxd    |               |              | vout2_hsync   |           | vin4a_hsync0 | i2c3_sda | timer1   | gpio6_14 | Driver off |
| 0x168C  | CTRL_CORE_PAD_GPIO6_15        | F20         | gpio6_15                                      | mcasp1_axr9  | dcn2_rxmcn_rx | uart10_txd    |               |              | vout2_vsync   |           | vin4a_vsync0 | i2c3_scl | timer2   | gpio6_15 | Driver off |
| 0x1690  | CTRL_CORE_PAD_GPIO6_16        | F21         | gpio6_16                                      | mcasp1_axr10 |               |               |               |              | vout2_fld     |           | vin4a_fld0   | clkout1  | timer3   | gpio6_16 | Driver off |
| 0x1694  | CTRL_CORE_PAD_XREF_CLK0       | D18         | xref_clk0                                     | mcasp2_axr8  | mcasp1_axr4   | mcasp1_ahclkx | mcasp5_ahclkx |              |               |           | clkout2      | timer13  |          | gpio6_17 | Driver off |
| 0x1698  | CTRL_CORE_PAD_XREF_CLK1       | E17         | xref_clk1                                     | mcasp2_axr9  | mcasp1_axr5   | mcasp2_ahclkx | mcasp6_ahclkx |              |               |           |              | timer14  |          | gpio6_18 | Driver off |
| 0x169C  | CTRL_CORE_PAD_XREF_CLK2       | B26         | xref_clk2                                     | mcasp2_axr10 | mcasp1_axr6   | mcasp3_ahclkx | mcasp7_ahclkx |              | vout2_clk     |           | vin4a_clk0   |          | timer15  | gpio6_19 | Driver off |
| 0x16A0  | CTRL_CORE_PAD_XREF_CLK3       | C23         | xref_clk3                                     | mcasp2_axr11 | mcasp1_axr7   | mcasp4_ahclkx | mcasp8_ahclkx |              | vout2_de      |           | vin4a_de0    | clkout3  | timer16  | gpio6_20 | Driver off |
| 0x16A4  | CTRL_CORE_PAD_MCASP1_ACLKX    | C14         | mcasp1_aclkx                                  |              |               |               |               |              |               |           |              |          | i2c3_sda | gpio7_31 | Driver off |
| 0x16A8  | CTRL_CORE_PAD_MCASP1_FSX      | D14         | mcasp1_fsx                                    |              |               |               |               |              |               |           |              |          | i2c3_scl | gpio7_30 | Driver off |
| 0x16AC  | CTRL_CORE_PAD_MCASP1_ACLKR    | B14         | mcasp1_aclkr                                  | mcasp7_axr2  |               |               |               |              | vout2_d0      |           | vin4a_d0     | i2c4_sda |          | gpio5_0  | Driver off |

**Table 4-29. Pin Multiplexing (continued)**

| ADDRESS | REGISTER NAME              | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |              |              |            |   |   |           |   |           |   |          |          |            |
|---------|----------------------------|-------------|-----------------------------------------------|--------------|--------------|------------|---|---|-----------|---|-----------|---|----------|----------|------------|
|         |                            |             | 0*                                            | 1            | 2*           | 3          | 4 | 5 | 6         | 7 | 8         | 9 | 10       | 14*      | 15         |
| 0x16B0  | CTRL_CORE_PAD_MCASP1_FSR   | J14         | mcasp1_fsr                                    | mcasp7_axr3  |              |            |   |   | vout2_d1  |   | vin4a_d1  |   | i2c4_scl | gpio5_1  | Driver off |
| 0x16B4  | CTRL_CORE_PAD_MCASP1_AXR0  | G12         | mcasp1_axr0                                   |              |              | uart6_rxd  |   |   |           |   |           |   | i2c5_sda | gpio5_2  | Driver off |
| 0x16B8  | CTRL_CORE_PAD_MCASP1_AXR1  | F12         | mcasp1_axr1                                   |              |              | uart6_txd  |   |   |           |   |           |   | i2c5_scl | gpio5_3  | Driver off |
| 0x16BC  | CTRL_CORE_PAD_MCASP1_AXR2  | G13         | mcasp1_axr2                                   | mcasp6_axr2  |              | uart6_ctsn |   |   | vout2_d2  |   | vin4a_d2  |   |          | gpio5_4  | Driver off |
| 0x16C0  | CTRL_CORE_PAD_MCASP1_AXR3  | J11         | mcasp1_axr3                                   | mcasp6_axr3  |              | uart6_rtsn |   |   | vout2_d3  |   | vin4a_d3  |   |          | gpio5_5  | Driver off |
| 0x16C4  | CTRL_CORE_PAD_MCASP1_AXR4  | E12         | mcasp1_axr4                                   | mcasp4_axr2  |              |            |   |   | vout2_d4  |   | vin4a_d4  |   |          | gpio5_6  | Driver off |
| 0x16C8  | CTRL_CORE_PAD_MCASP1_AXR5  | F13         | mcasp1_axr5                                   | mcasp4_axr3  |              |            |   |   | vout2_d5  |   | vin4a_d5  |   |          | gpio5_7  | Driver off |
| 0x16CC  | CTRL_CORE_PAD_MCASP1_AXR6  | C12         | mcasp1_axr6                                   | mcasp5_axr2  |              |            |   |   | vout2_d6  |   | vin4a_d6  |   |          | gpio5_8  | Driver off |
| 0x16D0  | CTRL_CORE_PAD_MCASP1_AXR7  | D12         | mcasp1_axr7                                   | mcasp5_axr3  |              |            |   |   | vout2_d7  |   | vin4a_d7  |   | timer4   | gpio5_9  | Driver off |
| 0x16D4  | CTRL_CORE_PAD_MCASP1_AXR8  | B12         | mcasp1_axr8                                   | mcasp6_axr0  |              | spi3_sclk  |   |   |           |   |           |   | timer5   | gpio5_10 | Driver off |
| 0x16D8  | CTRL_CORE_PAD_MCASP1_AXR9  | A11         | mcasp1_axr9                                   | mcasp6_axr1  |              | spi3_d1    |   |   |           |   |           |   | timer6   | gpio5_11 | Driver off |
| 0x16DC  | CTRL_CORE_PAD_MCASP1_AXR10 | B13         | mcasp1_axr10                                  | mcasp6_aclkr | mcasp6_aclkr | spi3_d0    |   |   |           |   |           |   | timer7   | gpio5_12 | Driver off |
| 0x16E0  | CTRL_CORE_PAD_MCASP1_AXR11 | A12         | mcasp1_axr11                                  | mcasp6_fsx   | mcasp6_fsr   | spi3_cs0   |   |   |           |   |           |   | timer8   | gpio4_17 | Driver off |
| 0x16E4  | CTRL_CORE_PAD_MCASP1_AXR12 | E14         | mcasp1_axr12                                  | mcasp7_axr0  |              | spi3_cs1   |   |   |           |   |           |   | timer9   | gpio4_18 | Driver off |
| 0x16E8  | CTRL_CORE_PAD_MCASP1_AXR13 | A13         | mcasp1_axr13                                  | mcasp7_axr1  |              |            |   |   |           |   |           |   | timer10  | gpio6_4  | Driver off |
| 0x16EC  | CTRL_CORE_PAD_MCASP1_AXR14 | G14         | mcasp1_axr14                                  | mcasp7_aclkr | mcasp7_aclkr |            |   |   |           |   |           |   | timer11  | gpio6_5  | Driver off |
| 0x16F0  | CTRL_CORE_PAD_MCASP1_AXR15 | F14         | mcasp1_axr15                                  | mcasp7_fsx   | mcasp7_fsr   |            |   |   |           |   |           |   | timer12  | gpio6_6  | Driver off |
| 0x16F4  | CTRL_CORE_PAD_MCASP2_ACLKX | A19         | mcasp2_aclkr                                  |              |              |            |   |   |           |   |           |   |          |          | Driver off |
| 0x16F8  | CTRL_CORE_PAD_MCASP2_FSX   | A18         | mcasp2_fsx                                    |              |              |            |   |   |           |   |           |   |          |          | Driver off |
| 0x16FC  | CTRL_CORE_PAD_MCASP2_ACLKR | E15         | mcasp2_aclkr                                  | mcasp8_axr2  |              |            |   |   | vout2_d8  |   | vin4a_d8  |   |          |          | Driver off |
| 0x1700  | CTRL_CORE_PAD_MCASP2_FSR   | A20         | mcasp2_fsr                                    | mcasp8_axr3  |              |            |   |   | vout2_d9  |   | vin4a_d9  |   |          |          | Driver off |
| 0x1704  | CTRL_CORE_PAD_MCASP2_AXR0  | B15         | mcasp2_axr0                                   |              |              |            |   |   | vout2_d10 |   | vin4a_d10 |   |          |          | Driver off |
| 0x1708  | CTRL_CORE_PAD_MCASP2_AXR1  | A15         | mcasp2_axr1                                   |              |              |            |   |   | vout2_d11 |   | vin4a_d11 |   |          |          | Driver off |
| 0x170C  | CTRL_CORE_PAD_MCASP2_AXR2  | C15         | mcasp2_axr2                                   | mcasp3_axr2  |              |            |   |   |           |   |           |   |          | gpio6_8  | Driver off |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME              | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |              |              |              |              |   |           |   |           |          |          |            |
|---------|----------------------------|----------------|-----------------------------------------------|--------------|--------------|--------------|--------------|---|-----------|---|-----------|----------|----------|------------|
|         |                            |                | 0*                                            | 1            | 2*           | 3            | 4            | 5 | 6         | 7 | 8         | 9        | 10       | 14*        |
| 0x1710  | CTRL_CORE_PAD_MCASP2_AXR3  | A16            | mcasp2_axr3                                   | mcasp3_axr3  |              |              |              |   |           |   |           |          | gpio6_9  | Driver off |
| 0x1714  | CTRL_CORE_PAD_MCASP2_AXR4  | D15            | mcasp2_axr4                                   | mcasp8_axr0  |              |              |              |   | vout2_d12 |   | vin4a_d12 |          | gpio1_4  | Driver off |
| 0x1718  | CTRL_CORE_PAD_MCASP2_AXR5  | B16            | mcasp2_axr5                                   | mcasp8_axr1  |              |              |              |   | vout2_d13 |   | vin4a_d13 |          | gpio6_7  | Driver off |
| 0x171C  | CTRL_CORE_PAD_MCASP2_AXR6  | B17            | mcasp2_axr6                                   | mcasp8_aclkr | mcasp8_aclkr |              |              |   | vout2_d14 |   | vin4a_d14 |          | gpio2_29 | Driver off |
| 0x1720  | CTRL_CORE_PAD_MCASP2_AXR7  | A17            | mcasp2_axr7                                   | mcasp8_fsr   | mcasp8_fsr   |              |              |   | vout2_d15 |   | vin4a_d15 |          | gpio1_5  | Driver off |
| 0x1724  | CTRL_CORE_PAD_MCASP3_ACLKX | B18            | mcasp3_aclkr                                  | mcasp3_aclkr | mcasp2_axr12 | uart7_rxd    |              |   |           |   |           |          | gpio5_13 | Driver off |
| 0x1728  | CTRL_CORE_PAD_MCASP3_FSX   | F15            | mcasp3_fsr                                    | mcasp3_fsr   | mcasp2_axr13 | uart7_txd    |              |   |           |   |           |          | gpio5_14 | Driver off |
| 0x172C  | CTRL_CORE_PAD_MCASP3_AXR0  | B19            | mcasp3_axr0                                   |              | mcasp2_axr14 | uart7_ctsn   | uart5_rxd    |   |           |   |           |          |          | Driver off |
| 0x1730  | CTRL_CORE_PAD_MCASP3_AXR1  | C17            | mcasp3_axr1                                   |              | mcasp2_axr15 | uart7_rtsn   | uart5_txd    |   |           |   |           |          |          | Driver off |
| 0x1734  | CTRL_CORE_PAD_MCASP4_ACLKX | C18            | mcasp4_aclkr                                  | mcasp4_aclkr | spi3_sclk    | uart8_rxd    | i2c4_sda     |   | vout2_d16 |   | vin4a_d16 |          |          | Driver off |
| 0x1738  | CTRL_CORE_PAD_MCASP4_FSX   | A21            | mcasp4_fsr                                    | mcasp4_fsr   | spi3_d1      | uart8_txd    | i2c4_scl     |   | vout2_d17 |   | vin4a_d17 |          |          | Driver off |
| 0x173C  | CTRL_CORE_PAD_MCASP4_AXR0  | G16            | mcasp4_axr0                                   |              | spi3_d0      | uart8_ctsn   | uart4_rxd    |   | vout2_d18 |   | vin4a_d18 |          |          | Driver off |
| 0x1740  | CTRL_CORE_PAD_MCASP4_AXR1  | D17            | mcasp4_axr1                                   |              | spi3_cs0     | uart8_rtsn   | uart4_txd    |   | vout2_d19 |   | vin4a_d19 |          |          | Driver off |
| 0x1744  | CTRL_CORE_PAD_MCASP5_ACLKX | AA3            | mcasp5_aclkr                                  | mcasp5_aclkr | spi4_sclk    | uart9_rxd    | i2c5_sda     |   | vout2_d20 |   | vin4a_d20 |          |          | Driver off |
| 0x1748  | CTRL_CORE_PAD_MCASP5_FSX   | AB9            | mcasp5_fsr                                    | mcasp5_fsr   | spi4_d1      | uart9_txd    | i2c5_scl     |   | vout2_d21 |   | vin4a_d21 |          |          | Driver off |
| 0x174C  | CTRL_CORE_PAD_MCASP5_AXR0  | AB3            | mcasp5_axr0                                   |              | spi4_d0      | uart9_ctsn   | uart3_rxd    |   | vout2_d22 |   | vin4a_d22 |          |          | Driver off |
| 0x1750  | CTRL_CORE_PAD_MCASP5_AXR1  | AA4            | mcasp5_axr1                                   |              | spi4_cs0     | uart9_rtsn   | uart3_txd    |   | vout2_d23 |   | vin4a_d23 |          |          | Driver off |
| 0x1754  | CTRL_CORE_PAD_MMC1_CLK     | W6             | mmc1_clk                                      |              |              |              |              |   |           |   |           |          | gpio6_21 | Driver off |
| 0x1758  | CTRL_CORE_PAD_MMC1_CMD     | Y6             | mmc1_cmd                                      |              |              |              |              |   |           |   |           |          | gpio6_22 | Driver off |
| 0x175C  | CTRL_CORE_PAD_MMC1_DAT0    | AA6            | mmc1_dat0                                     |              |              |              |              |   |           |   |           |          | gpio6_23 | Driver off |
| 0x1760  | CTRL_CORE_PAD_MMC1_DAT1    | Y4             | mmc1_dat1                                     |              |              |              |              |   |           |   |           |          | gpio6_24 | Driver off |
| 0x1764  | CTRL_CORE_PAD_MMC1_DAT2    | AA5            | mmc1_dat2                                     |              |              |              |              |   |           |   |           |          | gpio6_25 | Driver off |
| 0x1768  | CTRL_CORE_PAD_MMC1_DAT3    | Y3             | mmc1_dat3                                     |              |              |              |              |   |           |   |           |          | gpio6_26 | Driver off |
| 0x176C  | CTRL_CORE_PAD_MMC1_SD_CD   | W7             | mmc1_sdcd                                     |              |              | uart6_rxd    | i2c4_sda     |   |           |   |           |          | gpio6_27 | Driver off |
| 0x1770  | CTRL_CORE_PAD_MMC1_SDWP    | Y9             | mmc1_sdwp                                     |              |              | uart6_txd    | i2c4_scl     |   |           |   |           |          | gpio6_28 | Driver off |
| 0x1774  | CTRL_CORE_PAD_GPIO6_10     | AC5            | gpio6_10                                      | mdio_mclk    | i2c3_sda     | usb3_ulpi_d7 | vin2b_hsync1 |   |           |   |           | ehrpwm2A | gpio6_10 | Driver off |
| 0x1778  | CTRL_CORE_PAD_GPIO6_11     | AB4            | gpio6_11                                      | mdio_d       | i2c3_scl     | usb3_ulpi_d6 | vin2b_vsync1 |   |           |   |           | ehrpwm2B | gpio6_11 | Driver off |

**Table 4-29. Pin Multiplexing (continued)**

| ADDRESS | REGISTER NAME            | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |                   |             |                   |            |            |           |   |   |   |                            |          |            |
|---------|--------------------------|-------------|-----------------------------------------------|-------------------|-------------|-------------------|------------|------------|-----------|---|---|---|----------------------------|----------|------------|
|         |                          |             | 0*                                            | 1                 | 2*          | 3                 | 4          | 5          | 6         | 7 | 8 | 9 | 10                         | 14*      | 15         |
| 0x177C  | CTRL_CORE_PAD_MMC3_CLK   | AD4         | mmc3_clk                                      |                   |             | usb3_ulpi_d5      | vin2b_d7   |            |           |   |   |   | ehrpwm2_tri<br>pzone_input | gpio6_29 | Driver off |
| 0x1780  | CTRL_CORE_PAD_MMC3_CMD   | AC4         | mmc3_cmd                                      | spi3_sclk         |             | usb3_ulpi_d4      | vin2b_d6   |            |           |   |   |   | eCAP2_in_P<br>WM2_out      | gpio6_30 | Driver off |
| 0x1784  | CTRL_CORE_PAD_MMC3_DAT0  | AC7         | mmc3_dat0                                     | spi3_d1           | uart5_rxd   | usb3_ulpi_d3      | vin2b_d5   |            |           |   |   |   | eQEP3A_in                  | gpio6_31 | Driver off |
| 0x1788  | CTRL_CORE_PAD_MMC3_DAT1  | AC6         | mmc3_dat1                                     | spi3_d0           | uart5_txd   | usb3_ulpi_d2      | vin2b_d4   |            |           |   |   |   | eQEP3B_in                  | gpio7_0  | Driver off |
| 0x178C  | CTRL_CORE_PAD_MMC3_DAT2  | AC9         | mmc3_dat2                                     | spi3_cs0          | uart5_ctsn  | usb3_ulpi_d1      | vin2b_d3   |            |           |   |   |   | eQEP3_inde<br>x            | gpio7_1  | Driver off |
| 0x1790  | CTRL_CORE_PAD_MMC3_DAT3  | AC3         | mmc3_dat3                                     | spi3_cs1          | uart5_rtsn  | usb3_ulpi_d0      | vin2b_d2   |            |           |   |   |   | eQEP3_stro<br>be           | gpio7_2  | Driver off |
| 0x1794  | CTRL_CORE_PAD_MMC3_DAT4  | AC8         | mmc3_dat4                                     | spi4_sclk         | uart10_rxd  | usb3_ulpi_nx<br>t | vin2b_d1   |            |           |   |   |   | ehrpwm3A                   | gpio1_22 | Driver off |
| 0x1798  | CTRL_CORE_PAD_MMC3_DAT5  | AD6         | mmc3_dat5                                     | spi4_d1           | uart10_txd  | usb3_ulpi_dir     | vin2b_d0   |            |           |   |   |   | ehrpwm3B                   | gpio1_23 | Driver off |
| 0x179C  | CTRL_CORE_PAD_MMC3_DAT6  | AB8         | mmc3_dat6                                     | spi4_d0           | uart10_ctsn | usb3_ulpi_st<br>p | vin2b_de1  |            |           |   |   |   | ehrpwm3_tri<br>pzone_input | gpio1_24 | Driver off |
| 0x17A0  | CTRL_CORE_PAD_MMC3_DAT7  | AB5         | mmc3_dat7                                     | spi4_cs0          | uart10_rtsn | usb3_ulpi_cl<br>k | vin2b_clk1 |            |           |   |   |   | eCAP3_in_P<br>WM3_out      | gpio1_25 | Driver off |
| 0x17A4  | CTRL_CORE_PAD_SPI1_SCLK  | A25         | spi1_sclk                                     |                   |             |                   |            |            |           |   |   |   |                            | gpio7_7  | Driver off |
| 0x17A8  | CTRL_CORE_PAD_SPI1_D1    | F16         | spi1_d1                                       |                   |             |                   |            |            |           |   |   |   |                            | gpio7_8  | Driver off |
| 0x17AC  | CTRL_CORE_PAD_SPI1_D0    | B25         | spi1_d0                                       |                   |             |                   |            |            |           |   |   |   |                            | gpio7_9  | Driver off |
| 0x17B0  | CTRL_CORE_PAD_SPI1_CS0   | A24         | spi1_cs0                                      |                   |             |                   |            |            |           |   |   |   |                            | gpio7_10 | Driver off |
| 0x17B4  | CTRL_CORE_PAD_SPI1_CS1   | A22         | spi1_cs1                                      |                   | sata1_led   | spi2_cs1          |            |            |           |   |   |   |                            | gpio7_11 | Driver off |
| 0x17B8  | CTRL_CORE_PAD_SPI1_CS2   | B21         | spi1_cs2                                      | uart4_rxd         | mmc3_sdcd   | spi2_cs2          | dcan2_tx   | mdio_mclk  | hdmi1_hpd |   |   |   |                            | gpio7_12 | Driver off |
| 0x17BC  | CTRL_CORE_PAD_SPI1_CS3   | B20         | spi1_cs3                                      | uart4_txd         | mmc3_sdwp   | spi2_cs3          | dcan2_rx   | mdio_d     | hdmi1_cec |   |   |   |                            | gpio7_13 | Driver off |
| 0x17C0  | CTRL_CORE_PAD_SPI2_SCLK  | A26         | spi2_sclk                                     | uart3_rxd         |             |                   |            |            |           |   |   |   |                            | gpio7_14 | Driver off |
| 0x17C4  | CTRL_CORE_PAD_SPI2_D1    | B22         | spi2_d1                                       | uart3_txd         |             |                   |            |            |           |   |   |   |                            | gpio7_15 | Driver off |
| 0x17C8  | CTRL_CORE_PAD_SPI2_D0    | G17         | spi2_d0                                       | uart3_ctsn        | uart5_rxd   |                   |            |            |           |   |   |   |                            | gpio7_16 | Driver off |
| 0x17CC  | CTRL_CORE_PAD_SPI2_CS0   | B24         | spi2_cs0                                      | uart3_rtsn        | uart5_txd   |                   |            |            |           |   |   |   |                            | gpio7_17 | Driver off |
| 0x17E0  | CTRL_CORE_PAD_UART1_RXD  | B27         | uart1_rxd                                     |                   |             | mmc4_sdcd         |            |            |           |   |   |   |                            | gpio7_22 | Driver off |
| 0x17E4  | CTRL_CORE_PAD_UART1_TXD  | C26         | uart1_txd                                     |                   |             | mmc4_sdwp         |            |            |           |   |   |   |                            | gpio7_23 | Driver off |
| 0x17E8  | CTRL_CORE_PAD_UART1_CTSN | E25         | uart1_ctsn                                    |                   | uart9_rxd   | mmc4_clk          |            |            |           |   |   |   |                            | gpio7_24 | Driver off |
| 0x17EC  | CTRL_CORE_PAD_UART1_RTSN | C27         | uart1_rtsn                                    |                   | uart9_txd   | mmc4_cmd          |            |            |           |   |   |   |                            | gpio7_25 | Driver off |
| 0x17F0  | CTRL_CORE_PAD_UART2_RXD  | D28         |                                               | uart3_ctsn        | uart3_rctx  | mmc4_dat0         | uart2_rxd  | uart1_dcdn |           |   |   |   |                            | gpio7_26 | Driver off |
| 0x17F4  | CTRL_CORE_PAD_UART2_TXD  | D26         | uart2_txd                                     | uart3_rtsn        | uart3_sd    | mmc4_dat1         | uart2_txd  | uart1_dsrn |           |   |   |   |                            | gpio7_27 | Driver off |
| 0x17F8  | CTRL_CORE_PAD_UART2_CTSN | D27         | uart2_ctsn                                    |                   | uart3_rxd   | mmc4_dat2         | uart10_rxd | uart1_dtrn |           |   |   |   |                            | gpio1_16 | Driver off |
| 0x17FC  | CTRL_CORE_PAD_UART2_RTSN | C28         | uart2_rtsn                                    | uart3_txd         | uart3_irtx  | mmc4_dat3         | uart10_txd | uart1_rin  |           |   |   |   |                            | gpio1_17 | Driver off |
| 0x1800  | CTRL_CORE_PAD_I2C1_SDA   | C21         | i2c1_sda                                      |                   |             |                   |            |            |           |   |   |   |                            |          |            |
| 0x1804  | CTRL_CORE_PAD_I2C1_SCL   | C20         | i2c1_scl                                      |                   |             |                   |            |            |           |   |   |   |                            |          |            |
| 0x1808  | CTRL_CORE_PAD_I2C2_SDA   | C25         | i2c2_sda                                      | hdmi1_ddc_s<br>cl |             |                   |            |            |           |   |   |   |                            |          | Driver off |
| 0x180C  | CTRL_CORE_PAD_I2C2_SCL   | F17         | i2c2_scl                                      | hdmi1_ddc_s<br>da |             |                   |            |            |           |   |   |   |                            |          | Driver off |

Table 4-29. Pin Multiplexing (continued)

| ADDRESS | REGISTER NAME          | BALL<br>NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) |           |    |   |   |   |   |   |   |   |    |          |            |
|---------|------------------------|----------------|-----------------------------------------------|-----------|----|---|---|---|---|---|---|---|----|----------|------------|
|         |                        |                | 0*                                            | 1         | 2* | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 14*      | 15         |
| 0x1818  | CTRL_CORE_PAD_WAKEUP0  | AD17           | Wakeup0                                       | dcan1_rx  |    |   |   |   |   |   |   |   |    | gpio1_0  | Driver off |
| 0x181C  | CTRL_CORE_PAD_WAKEUP1  | AC17           | Wakeup1                                       | dcan2_rx  |    |   |   |   |   |   |   |   |    | gpio1_1  | Driver off |
| 0x1820  | CTRL_CORE_PAD_WAKEUP2  | AB16           | Wakeup2                                       | sys_nirq2 |    |   |   |   |   |   |   |   |    | gpio1_2  | Driver off |
| 0x1824  | CTRL_CORE_PAD_WAKEUP3  | AC16           | Wakeup3                                       | sys_nirq1 |    |   |   |   |   |   |   |   |    | gpio1_3  | Driver off |
| 0x1828  | CTRL_CORE_PAD_ON_OFF   | Y11            | on_off                                        |           |    |   |   |   |   |   |   |   |    |          |            |
| 0x182C  | CTRL_CORE_PAD_RTC_PORZ | AB17           | rtc_porz                                      |           |    |   |   |   |   |   |   |   |    |          |            |
| 0x1830  | CTRL_CORE_PAD_TMS      | F18            | tms                                           |           |    |   |   |   |   |   |   |   |    |          |            |
| 0x1834  | CTRL_CORE_PAD_TDI      | D23            | tdi                                           |           |    |   |   |   |   |   |   |   |    | gpio8_27 |            |
| 0x1838  | CTRL_CORE_PAD_TDO      | F19            | tdo                                           |           |    |   |   |   |   |   |   |   |    | gpio8_28 |            |
| 0x183C  | CTRL_CORE_PAD_TCLK     | E20            | tclk                                          |           |    |   |   |   |   |   |   |   |    |          |            |
| 0x1840  | CTRL_CORE_PAD_TRSTN    | D20            | trstn                                         |           |    |   |   |   |   |   |   |   |    |          |            |
| 0x1844  | CTRL_CORE_PAD_RTCK     | E18            | rtck                                          |           |    |   |   |   |   |   |   |   |    | gpio8_29 |            |
| 0x1848  | CTRL_CORE_PAD_EMU0     | G21            | emu0                                          |           |    |   |   |   |   |   |   |   |    | gpio8_30 |            |
| 0x184C  | CTRL_CORE_PAD_EMU1     | D24            | emu1                                          |           |    |   |   |   |   |   |   |   |    | gpio8_31 |            |
| 0x185C  | CTRL_CORE_PAD_RESETN   | E23            | resetn                                        |           |    |   |   |   |   |   |   |   |    |          |            |
| 0x1860  | CTRL_CORE_PAD_NMIN_DSP | D21            | nmin_dsp                                      |           |    |   |   |   |   |   |   |   |    |          |            |
| 0x1864  | CTRL_CORE_PAD_RSTOUTN  | F23            | rstoutn                                       |           |    |   |   |   |   |   |   |   |    |          |            |

1. NA in this table stands for Not Applicable.

## 4.5 Connections for Unused Pins

This section describes the Unused/Reserved balls connection requirements.

### NOTE

The following balls are reserved: A27 / Y5 / Y10 / AA1 / AA2 / AB1 / AB2 / AC1 / AC2 / B28

These balls must be left unconnected.

### NOTE

All unused power supply balls must be supplied with the voltages specified in the [Section 5.4, Recommended Operating Conditions](#), unless alternative tie-off options are included in [Section 4.3, Signal Descriptions](#).

**Table 4-30. Unused Balls Specific Connection Requirements**

| Balls                                                                                                         | Connection Requirements                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AE15 / AC15 / AE14 / D20 / AD17 / AC17 / AC16 / AB16 / V27 / AH25 / AE27 / AD27 / Y28 / G28 / H27 / K27 / M28 | These balls must be connected to GND through an external pull resistor if unused                                                                                                                 |
| V28 / F18 / E20 / E23 / D21 / C20 / C21 / AG25 / AE28 / AD28 / Y27 / G27 / H28 / K28 / M27 / F17 / C25        | These balls must be connected to the corresponding power supply through an external pull resistor if unused                                                                                      |
| AF14 (rtc_iso)                                                                                                | This ball should be connected to the corresponding power supply through an external pull resistor if unused; or can be connected to F22 (porz) when RTC unused (level translation may be needed) |
| AB17 (rtc_porz)                                                                                               | This ball should be connected to VSS when RTC is unused; or can be connected to F22 (porz) when RTC unused (level translation may be needed)                                                     |
| K14 (vpp)                                                                                                     | This ball must be left unconnected if unused.                                                                                                                                                    |

### NOTE

All other unused signal balls **with** a Pad Configuration Register can be left unconnected with their internal pullup or pulldown resistor enabled.

### NOTE

All other unused signal balls **without** Pad Configuration Register can be left unconnected.

## 5 Specifications

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### NOTE

For more information, see Power, Reset and Clock Management / PRCM Subsystem Environment / External Voltage Inputs or Initialization / Preinitialization / Power Requirements section of the Device TRM.

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### NOTE

The index numbers 1 and 2 which is part of the EMIF1 and EMIF2 signal prefixes (ddr1\_\* and ddr2\_\*) listed in [Table 4-5](#), *EMIF Signal Descriptions*, column "SIGNAL NAME" not to be confused with DDR1 and DDR2 types of SDRAM memories.

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### NOTE

Audio Back End (ABE) module is not supported for this family of devices, but "ABE" name is still present in some clock or DPLL names.

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### CAUTION

All IO cells are NOT Fail-safe compliant and should not be externally driven in absence of their IO supply.

## 5.1 Absolute Maximum Ratings<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted)

| PARAMETER <sup>(2)</sup>                           |                                                                                                                                                                                                               |                                                                                                                                                                                                                                   | MIN  | MAX                           | UNIT |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------------|------|
| V <sub>SUPPLY</sub> (Steady-State)                 | Supply Voltage Ranges (Steady-State)                                                                                                                                                                          | Core (vdd, vdd_mpu, vdd_gpu, vdd_dspeve, vdd_iva, vdd_rtc)                                                                                                                                                                        | -0.3 | 1.5                           | V    |
|                                                    |                                                                                                                                                                                                               | Analog (vdda_usb1, vdda_usb2, vdda_abe_per, vdda_ddr, vdda_debug, vdda_dsp_eve, vdda_gmac_core, vdda_gpu, vdda_hdmi, vdda_iva, vdda_pcie, vdda_pcie0, vdda_pcie1, vdda_sata, vdda_usb3, vdda_video, vdda_mpu, vdda_osc, vdda_rtc) | -0.3 | 2.0                           | V    |
|                                                    |                                                                                                                                                                                                               | Analog 3.3 V (vdda33v_usb1, vdda33v_usb2)                                                                                                                                                                                         | -0.3 | 3.8                           | V    |
|                                                    |                                                                                                                                                                                                               | vdds18v, vdds18v_ddr1, vdds18v_ddr2, vdds_mlbp, vdds_ddr1, vdds_ddr2                                                                                                                                                              | -0.3 | 2.1                           | V    |
|                                                    |                                                                                                                                                                                                               | vddshv1-11 (1.8 V mode)                                                                                                                                                                                                           | -0.3 | 2.1                           | V    |
|                                                    |                                                                                                                                                                                                               | vddshv1-7 (3.3 V mode), vddshv9-11 (3.3 V mode)                                                                                                                                                                                   | -0.3 | 3.8                           | V    |
|                                                    |                                                                                                                                                                                                               | vddshv8 (3.3 V mode)                                                                                                                                                                                                              | -0.3 | 3.6                           | V    |
| V <sub>IO</sub> (Steady-State)                     | Input and Output Voltage Ranges (Steady-State)                                                                                                                                                                | Core I/Os                                                                                                                                                                                                                         | -0.3 | 1.5                           | V    |
|                                                    |                                                                                                                                                                                                               | Analog I/Os (except HDMI)                                                                                                                                                                                                         | -0.3 | 2.0                           | V    |
|                                                    |                                                                                                                                                                                                               | HDMI I/Os                                                                                                                                                                                                                         | -0.3 | 3.5                           | V    |
|                                                    |                                                                                                                                                                                                               | I/O 1.35 V                                                                                                                                                                                                                        | -0.3 | 1.65                          | V    |
|                                                    |                                                                                                                                                                                                               | I/O 1.5 V                                                                                                                                                                                                                         | -0.3 | 1.8                           | V    |
|                                                    |                                                                                                                                                                                                               | 1.8 V I/Os                                                                                                                                                                                                                        | -0.3 | 2.1                           | V    |
|                                                    |                                                                                                                                                                                                               | 3.3 V I/Os (except those powered by vddshv8)                                                                                                                                                                                      | -0.3 | 3.8                           | V    |
|                                                    |                                                                                                                                                                                                               | 3.3 V I/Os (powered by vddshv8)                                                                                                                                                                                                   | -0.3 | 3.6                           | V    |
| SR                                                 | Maximum slew rate, all supplies                                                                                                                                                                               |                                                                                                                                                                                                                                   |      | 10 <sup>5</sup>               | V/s  |
| V <sub>IO</sub> (Transient Overshoot / Undershoot) | Input and Output Voltage Ranges (Transient Overshoot/Undershoot)<br>Note: valid for up to 20 % of the signal period. See <a href="#">Figure 5-1</a> , $T_{overshoot} + T_{undershoot} < 20\%$ of $T_{period}$ |                                                                                                                                                                                                                                   |      | 0.2 × VDD <sup>(3)</sup>      | V    |
| T <sub>J</sub>                                     | Operating junction temperature range                                                                                                                                                                          | Automotive                                                                                                                                                                                                                        | -40  | + 125                         | °C   |
| T <sub>STG</sub>                                   | Storage temperature range after soldered onto PC Board                                                                                                                                                        |                                                                                                                                                                                                                                   | -55  | + 150                         | °C   |
| Latch-up I-Test                                    | I-test <sup>(4)</sup> , All I/Os (if different levels then one line per level)                                                                                                                                |                                                                                                                                                                                                                                   | -100 | 100                           | mA   |
| Latch-up OV-Test                                   | Over-voltage Test <sup>(5)</sup> , All supplies (if different levels then one line per level)                                                                                                                 |                                                                                                                                                                                                                                   | N/A  | 1.5 × V <sub>supply max</sub> | V    |

(1) Stresses beyond those listed as absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those listed under [Section 5.4, Recommended Operating Conditions](#), is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

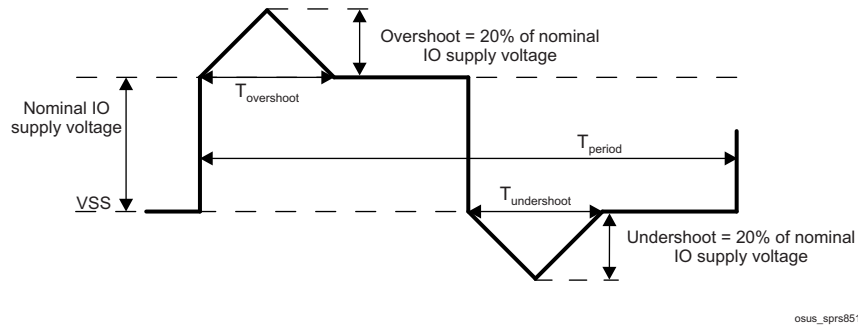
(2) See I/Os supplied by this power pin in [Table 4-1, Pin Attributes](#).

(3) VDD is the voltage on the corresponding power-supply pin(s) for the IO.

(4) Per JEDEC JESD78 at 125 °C with specified I/O pin injection current and clamp voltage of 1.5 times maximum recommended I/O voltage and negative 0.5 times maximum recommended I/O voltage.

(5) Per JEDEC JESD78 at 125 °C.

(6) The maximum valid input voltage on an IO pin cannot exceed 0.3 volts when the supply powering the IO is turned off. This requirement applies to all the IO pins which are not fail-safe and for all values of IO supply voltage. Special attention should be applied anytime peripheral devices are not powered from the same power sources used to power the respective IO supply. It is important the attached peripheral never sources a voltage outside the valid input voltage range, including power supply ramp-up and ramp-down sequences.



**Figure 5-1.**  $T_{\text{overshoot}} + T_{\text{undershoot}} < 20\%$  of  $T_{\text{period}}$

## 5.2 ESD Ratings

|                                            |                                                         |                                  | VALUE | UNIT |
|--------------------------------------------|---------------------------------------------------------|----------------------------------|-------|------|
| $V_{\text{(ESD)}}$ Electrostatic discharge | Human-Body model (HBM), per AEC Q100-002 <sup>(1)</sup> |                                  | ±1000 | V    |
|                                            | Charged-device model (CDM), per AEC Q100-011            | All pins                         | ±250  |      |
|                                            |                                                         | Corner pins (A1, AH1, A28, AH28) | ±750  |      |

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

## 5.3 Power-On Hours (POH) Limits

| IP  | Duty Cycle | Voltage Domain | Voltage (V) (max)  | Frequency (MHz) (max) | T <sub>j</sub> (°C)               | POH   |
|-----|------------|----------------|--------------------|-----------------------|-----------------------------------|-------|
| All | 100%       | All            | All Supported OPPs |                       | Automotive Profile <sup>(3)</sup> | 20000 |

- (1) The information in the section below is provided solely for your convenience and does not extend or modify the warranty provided under TI's standard terms and conditions for TI semiconductor products.
- (2) POH is a functional of voltage, temperature and time. Usage at higher voltages and temperatures will result in a reduction in POH to achieve the same reliability performance. For assessment of alternate use cases, contact your local TI representative.
- (3) Automotive profile is defined as 20000 power on hours with junction temperature as follows: 5%@-40°C, 65%@70°C, 20%@110°C, 10%@125°C.

## 5.4 Recommended Operating Conditions<sup>(5)</sup>

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                               | DESCRIPTION                                    | MIN <sup>(2)</sup>              | NOM  | MAX DC <sup>(3)</sup> | MAX <sup>(2)</sup> | UNIT                |
|-----------------------------------------|------------------------------------------------|---------------------------------|------|-----------------------|--------------------|---------------------|
| <b>Input Power Supply Voltage Range</b> |                                                |                                 |      |                       |                    |                     |
| vdd                                     | Core voltage domain supply                     | See <a href="#">Section 5.5</a> |      |                       |                    | V                   |
| vdd_mpu                                 | Supply voltage range for MPU domain            | See <a href="#">Section 5.5</a> |      |                       |                    | V                   |
| vdd_gpu                                 | GPU voltage domain supply                      | See <a href="#">Section 5.5</a> |      |                       |                    | V                   |
| vdd_dspeve                              | DSP-EVE voltage domain supply                  | See <a href="#">Section 5.5</a> |      |                       |                    | V                   |
| vdd_iva                                 | IVA voltage domain supply                      | See <a href="#">Section 5.5</a> |      |                       |                    | V                   |
| vdd_rtc                                 | RTC voltage domain supply                      | See <a href="#">Section 5.5</a> |      |                       |                    | V                   |
| vdda_usb1                               | DPLL_USB and HS USB1 1.8 V analog power supply | 1.71                            | 1.80 | 1.836                 | 1.89               | V                   |
|                                         | Maximum noise (peak-peak)                      | 50                              |      |                       |                    | mV <sub>PPmax</sub> |
| vdda_usb2                               | HS USB2 1.8 V analog power supply              | 1.71                            | 1.80 | 1.836                 | 1.89               | V                   |
|                                         | Maximum noise (peak-peak)                      | 50                              |      |                       |                    | mV <sub>PPmax</sub> |

## Recommended Operating Conditions<sup>(5)</sup> (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER      | DESCRIPTION                                                                                                                                                                                                                             | MIN <sup>(2)</sup> | NOM  | MAX DC <sup>(3)</sup> | MAX <sup>(2)</sup> | UNIT                |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------|-----------------------|--------------------|---------------------|
| vdda33v_usb1   | HS USB1 3.3 V analog power supply. If USB1 is not used, this pin can alternatively be connected to VSS if the following requirements are met:<br>- The usb1_dm/usb1_dp pins are left unconnected<br>- The USB1 PHY is kept powered down | 3.135              | 3.3  | 3.366                 | 3.465              | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda33v_usb2   | HS USB2 3.3 V analog power supply. If USB2 is not used, this pin can alternatively be connected to VSS if the following requirements are met:<br>- The usb2_dm/usb2_dp pins are left unconnected<br>- The USB2 PHY is kept powered down | 3.135              | 3.3  | 3.366                 | 3.465              | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_abe_per   | DPLL_ABE, DPLL_PER, and PER HSDIVIDER analog power supply                                                                                                                                                                               | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_ddr       | DPLL_DDR and DDR HSDIVIDER analog power supply                                                                                                                                                                                          | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_debug     | DPLL_DEBUG analog power supply                                                                                                                                                                                                          | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_dsp_eve   | DPLL_DSP and DPLL_EVE analog power supply                                                                                                                                                                                               | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_gmac_core | DPLL_CORE and CORE HSDIVIDER analog power supply                                                                                                                                                                                        | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_gpu       | DPLL_GPU analog power supply                                                                                                                                                                                                            | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_hdmi      | PLL_HDMI and HDMI analog power supply                                                                                                                                                                                                   | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_iva       | DPLL_IVA analog power supply                                                                                                                                                                                                            | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_pcie      | DPLL_PCIE_REF and PCIe analog power supply                                                                                                                                                                                              | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_pcie0     | PCIe ch0 RX/TX analog power supply                                                                                                                                                                                                      | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_pcie1     | PCIe ch1 RX/TX analog power supply                                                                                                                                                                                                      | 1.71               | 1.80 |                       | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_sata      | DPLL_SATA and SATA RX/TX analog power supply                                                                                                                                                                                            | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |
| vdda_usb3      | DPLL_USB_OTG_SS and USB3.0 RX/TX analog power supply                                                                                                                                                                                    | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                | Maximum noise (peak-peak)                                                                                                                                                                                                               |                    | 50   |                       |                    | mV <sub>PPmax</sub> |

## Recommended Operating Conditions<sup>(5)</sup> (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                   | DESCRIPTION                                                                          |             | MIN <sup>(2)</sup> | NOM  | MAX DC <sup>(3)</sup> | MAX <sup>(2)</sup> | UNIT                |
|-----------------------------|--------------------------------------------------------------------------------------|-------------|--------------------|------|-----------------------|--------------------|---------------------|
| vdda_video                  | DPLL_VIDEO1 and DPLL_VIDEO2 analog power supply                                      |             | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdds_milbp                  | MLBP IO power supply                                                                 |             | 1.71               | 1.80 |                       | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdda_mpu                    | DPLL_MPU analog power supply                                                         |             | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdda_osc                    | HFOSC analog power supply                                                            |             | 1.71               | 1.80 |                       | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdda_rtc                    | RTC bias and RTC LFOSC analog power supply                                           |             | 1.71               | 1.80 |                       | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdds18v                     | 1.8 V power supply                                                                   |             | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdds18v_ddr1 <sup>(4)</sup> | DDR1 bias power supply                                                               |             | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdds18v_ddr2 <sup>(4)</sup> | DDR2 bias power supply                                                               |             | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                             | Maximum noise (peak-peak)                                                            |             | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
| vdds_ddr1 <sup>(4)</sup>    | DDR1 power supply (1.8 V for DDR2 mode/ 1.5 V for DDR3 mode / 1.35 V for DDR3L mode) | 1.35-V Mode | 1.28               | 1.35 | 1.377                 | 1.42               | V                   |
|                             |                                                                                      | 1.5-V Mode  | 1.43               | 1.50 | 1.53                  | 1.57               |                     |
|                             |                                                                                      | 1.8-V Mode  | 1.71               | 1.80 | 1.836                 | 1.89               |                     |
|                             | Maximum noise (peak-peak)                                                            | 1.35-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|                             |                                                                                      | 1.5-V Mode  |                    |      |                       |                    |                     |
|                             |                                                                                      | 1.8-V Mode  |                    |      |                       |                    |                     |
| vdds_ddr2 <sup>(4)</sup>    | DDR2 power supply (1.8 V for DDR2 mode/ 1.5 V for DDR3 mode / 1.35 V for DDR3L mode) | 1.35-V Mode | 1.28               | 1.35 | 1.377                 | 1.42               | V                   |
|                             |                                                                                      | 1.5-V Mode  | 1.43               | 1.50 | 1.53                  | 1.57               |                     |
|                             |                                                                                      | 1.8-V Mode  | 1.71               | 1.80 | 1.836                 | 1.89               |                     |
|                             | Maximum noise (peak-peak)                                                            | 1.35-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|                             |                                                                                      | 1.5-V Mode  |                    |      |                       |                    |                     |
|                             |                                                                                      | 1.8-V Mode  |                    |      |                       |                    |                     |
| vddshv5                     | Dual Voltage (1.8 V or 3.3 V) power supply for the INTC Power Group pins             | 1.8-V Mode  | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                             |                                                                                      | 3.3-V Mode  | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|                             | Maximum noise (peak-peak)                                                            | 1.8-V Mode  | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|                             |                                                                                      | 3.3-V Mode  |                    |      |                       |                    |                     |
| vddshv1                     | Dual Voltage (1.8 V or 3.3 V) power supply for the VIN2 Power Group pins             | 1.8-V Mode  | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|                             |                                                                                      | 3.3-V Mode  | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|                             | Maximum noise (peak-peak)                                                            | 1.8-V Mode  | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|                             |                                                                                      | 3.3-V Mode  |                    |      |                       |                    |                     |

## Recommended Operating Conditions<sup>(5)</sup> (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | DESCRIPTION                                                                 |            | MIN <sup>(2)</sup> | NOM  | MAX DC <sup>(3)</sup> | MAX <sup>(2)</sup> | UNIT                |
|-----------|-----------------------------------------------------------------------------|------------|--------------------|------|-----------------------|--------------------|---------------------|
| vddshv10  | Dual Voltage (1.8 V or 3.3 V) power supply for the GPMC Power Group pins    | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv11  | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC2 Power Group pins    | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv2   | Dual Voltage (1.8 V or 3.3 V) power supply for the VOUT Power Group pins    | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv3   | Dual Voltage (1.8 V or 3.3 V) power supply for the GENERAL Power Group pins | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv4   | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC4 Power Group pins    | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv6   | Dual Voltage (1.8 V or 3.3 V) power supply for the VIN1 Power Group pins    | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv7   | Dual Voltage (1.8 V or 3.3 V) power supply for the WIFI Power Group pins    | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv8   | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC1 Power Group pins    | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vddshv9   | Dual Voltage (1.8 V or 3.3 V) power supply for the RGMII Power Group pins   | 1.8-V Mode | 1.71               | 1.80 | 1.836                 | 1.89               | V                   |
|           |                                                                             | 3.3-V Mode | 3.135              | 3.30 | 3.366                 | 3.465              |                     |
|           | Maximum noise (peak-peak)                                                   | 1.8-V Mode | 50                 |      |                       |                    | mV <sub>PPmax</sub> |
|           |                                                                             | 3.3-V Mode |                    |      |                       |                    |                     |
| vss       | Ground supply                                                               |            | 0                  |      |                       |                    | V                   |

## Recommended Operating Conditions<sup>(5)</sup> (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                     | DESCRIPTION                          | MIN <sup>(2)</sup> | NOM             | MAX DC <sup>(3)</sup> | MAX <sup>(2)</sup> | UNIT |
|-------------------------------|--------------------------------------|--------------------|-----------------|-----------------------|--------------------|------|
| vssa_osc0                     | OSC0 analog ground                   |                    | 0               |                       |                    | V    |
| vssa_osc1                     | OSC1 analog ground                   |                    | 0               |                       |                    | V    |
| T <sub>J</sub> <sup>(1)</sup> | Operating junction temperature range | Automotive         | -40             |                       | 125 <sup>(6)</sup> | °C   |
| ddr1_vref0                    | Reference Power Supply for DDR1      |                    | 0.5 × vdds_ddr1 |                       |                    | V    |
| ddr2_vref0                    | Reference Power Supply for DDR2      |                    | 0.5 × vdds_ddr2 |                       |                    | V    |

(1) Refer to [Section 5.3, Power-On Hours \(POH\)](#) for limitations.

(2) The voltage at the device ball should never be below the MIN voltage or above the MAX voltage for any amount of time. This requirement includes dynamic voltage events such as AC ripple, voltage transients, voltage dips, etc.

(3) The DC voltage at the device ball should never be above the MAX DC voltage to avoid impact on device reliability and lifetime POH (Power-On Hours). The MAX DC voltage is defined as the highest allowed DC regulated voltage, without transients, seen at the ball.

(4) If DDR2 type of memories are used, the EMIF power supply (vdds\_ddrx) and the corresponding bias power supply (vdds18v\_ddrx) must be sourced from single power source.

(5) Logic functions and parameter values are not assured out of the range specified in the recommended operating conditions.

(6) The TSHUT feature of the SoC resets the device by default when one of the on-die temp sensors reports 123°C. This is intended to protect the device from exceeding 125°C. Though not recommended, the TSHUT temperature threshold can be modified in software if other mechanisms are in place to avoid exceeding 125°C. Refer to the device TRM for details on the TSHUT feature.

## 5.5 Operating Performance Points

This section describes the operating conditions of the device. This section also contains the description of each OPP (operating performance point) for processor clocks and device core clocks.

[Table 5-1](#) describes the maximum supported frequency per speed grade for the devices.

**Table 5-1. Speed Grade Maximum Frequency**

| Device Speed | Maximum frequency (MHz) |      |     |     |     |     |       |     |                 |                |
|--------------|-------------------------|------|-----|-----|-----|-----|-------|-----|-----------------|----------------|
|              | MPU                     | DSP  | EVE | IVA | ISP | GPU | IPU   | L3  | DDR3/ DDR3L     | DDR2           |
| TDA2PxxD     | 500                     | 500  | 500 | 430 | 532 | 500 | 212.8 | 266 | 667 (DDR3-1333) | 400 (DDR2-800) |
| TDA2PxxF     | 650                     | 650  | 600 | 532 | 532 | 500 | 212.8 | 266 | 667 (DDR3-1333) | 400 (DDR2-800) |
| TDA2PxxR     | 750                     | 750  | 650 | 532 | 532 | 500 | 212.8 | 266 | 667 (DDR3-1333) | 400 (DDR2-800) |
| TDA2PxxT     | 1176                    | 750  | 650 | 532 | 532 | 532 | 212.8 | 266 | 667 (DDR3-1333) | 400 (DDR2-800) |
| TDA2PxxU     | 1176                    | 1000 | 900 | 532 | 532 | 665 | 212.8 | 266 | 667 (DDR3-1333) | 400 (DDR2-800) |

### 5.5.1 AVS and ABB Requirements

Adaptive Voltage Scaling (AVS) and Adaptive Body Biasing (ABB) are required on most of the vdd\_\* supplies as defined in [Table 5-2](#).

**Table 5-2. AVS and ABB Requirements per vdd\_\* Supply**

| Supply     | AVS Required?     | ABB Required?     |
|------------|-------------------|-------------------|
| vdd_core   | Yes, for all OPPs | No                |
| vdd_mpu    | Yes, for all OPPs | Yes, for all OPPs |
| vdd_iva    | Yes, for all OPPs | Yes, for all OPPs |
| vdd_dspeve | Yes, for all OPPs | Yes, for all OPPs |
| vdd_gpu    | Yes, for all OPPs | Yes, for all OPPs |
| vdd_rtc    | No                | No                |

## 5.5.2 Voltage And Core Clock Specifications

Table 5-3 shows the recommended OPP per voltage domain.

**Table 5-3. Voltage Domains Operating Performance Points**

| DOMAIN                    | CONDITION                                   | OPP_LOW                           |                            |                                 | OPP_NOM                           |                            |                    | OPP_OD                            |                            |                                 | OPP_HIGH                          |                            |                                 |                                 |
|---------------------------|---------------------------------------------|-----------------------------------|----------------------------|---------------------------------|-----------------------------------|----------------------------|--------------------|-----------------------------------|----------------------------|---------------------------------|-----------------------------------|----------------------------|---------------------------------|---------------------------------|
|                           |                                             | MIN <sup>(2)</sup>                | NOM <sup>(1)</sup>         | MAX <sup>(2)</sup>              | MIN <sup>(2)</sup>                | NOM <sup>(1)</sup>         | MAX <sup>(2)</sup> | MIN <sup>(2)</sup>                | NOM <sup>(1)</sup>         | MAX <sup>(2)</sup>              | MIN <sup>(2)</sup>                | NOM <sup>(1)</sup>         | MAX DC <sup>(3)</sup>           | MAX <sup>(2)</sup>              |
| VD_CORE (V)               | BOOT (Before AVS is enabled) <sup>(4)</sup> | Not Applicable                    |                            |                                 | 1.11                              | 1.15                       | 1.2                | Not Applicable                    |                            |                                 | Not Applicable                    |                            |                                 |                                 |
|                           | After AVS is enabled <sup>(4)</sup>         | Not Applicable                    |                            |                                 | AVS <sup>(5)</sup> – 3.5%         | AVS <sup>(5)</sup>         | 1.2                | Not Applicable                    |                            |                                 | Not Applicable                    |                            |                                 |                                 |
| VD_MPU (V)                | BOOT (Before AVS is enabled) <sup>(4)</sup> | Not Applicable                    |                            |                                 | 1.11                              | 1.15                       | 1.2                | Not Applicable                    |                            |                                 | Not Applicable                    |                            |                                 |                                 |
|                           | After AVS is enabled <sup>(4)</sup>         | AVS Voltage <sup>(5)</sup> – 3.5% | AVS Voltage <sup>(5)</sup> | AVS Voltage <sup>(5)</sup> + 5% | AVS Voltage <sup>(5)</sup> – 3.5% | AVS Voltage <sup>(5)</sup> | 1.2                | AVS Voltage <sup>(5)</sup> – 3.5% | AVS Voltage <sup>(5)</sup> | AVS Voltage <sup>(5)</sup> + 5% | AVS Voltage <sup>(5)</sup> – 3.5% | AVS Voltage <sup>(5)</sup> | AVS Voltage <sup>(5)</sup> + 2% | AVS Voltage <sup>(5)</sup> + 5% |
| VD_RTC (V) <sup>(6)</sup> | -                                           | Not Applicable                    |                            |                                 | 0.84                              | 0.88 to 1.06               | 1.2                | Not Applicable                    |                            |                                 | Not Applicable                    |                            |                                 |                                 |
| Others (V)                | BOOT (Before AVS is enabled) <sup>(4)</sup> | Not Applicable                    |                            |                                 | 1.02                              | 1.06                       | 1.2                | Not Applicable                    |                            |                                 | Not Applicable                    |                            |                                 |                                 |
|                           | After AVS is enabled <sup>(4)</sup>         | Not Applicable                    |                            |                                 | AVS Voltage <sup>(5)</sup> – 3.5% | AVS Voltage <sup>(5)</sup> | 1.2                | AVS Voltage <sup>(5)</sup> – 3.5% | AVS Voltage <sup>(5)</sup> | AVS Voltage <sup>(5)</sup> + 5% | AVS Voltage <sup>(5)</sup> – 3.5% | AVS Voltage <sup>(5)</sup> | AVS Voltage <sup>(5)</sup> + 2% | AVS Voltage <sup>(5)</sup> + 5% |

- (1) In a typical implementation, the power supply should target the NOM voltage.
- (2) The voltage at the device ball should never be below the MIN voltage or above the MAX voltage for any amount of time. This requirement includes dynamic voltage events such as AC ripple, voltage transients, voltage dips, etc.
- (3) The DC voltage at the device ball should never be above the MAX DC voltage to avoid impact on device reliability and lifetime POH (Power-On Hours). The MAX DC voltage is defined as the highest allowed DC regulated voltage, without transients, seen at the ball.
- (4) For all OPPs, AVS must be enabled to avoid impact on device reliability, lifetime POH (Power-On Hours), and device power.
- (5) The AVS voltages are device-dependent, voltage domain-dependent, and OPP-dependent. They must be read from the STD\_FUSE\_OPP. For information about STD\_FUSE\_OPP Registers address, please refer to Control Module section of the Device TRM. The power supply should be adjustable over the following ranges for each required OPP:
  - OPP\_LOW for MPU: 0.85 V - 1.15 V
  - OPP\_NOM for MPU: 0.85 V - 1.15 V
  - OPP\_NOM for CORE and Others: 0.85 V - 1.15 V
  - OPP\_OD: 0.885 V - 1.15 V
  - OPP\_HIGH: 0.95 V - 1.25 V
The AVS voltages will be within the above specified ranges.
- (6) VD\_RTC can optionally be tied to VD\_CORE and operate at the VD\_CORE AVS voltages.
- (7) The power supply must be programmed with the AVS voltages for the MPU and the CORE voltage domain, either just after the ROM boot or at the earliest possible time in the secondary boot loader before there is significant activity seen on these domains.

Table 5-4 describes the standard processor clocks speed characteristics vs OPP of the device.

**Table 5-4. Supported OPP vs Max Frequency<sup>(1)(2)</sup>**

| DESCRIPTION      | OPP_LOW         | OPP_NOM         | OPP_OD          | OPP_HIGH        |
|------------------|-----------------|-----------------|-----------------|-----------------|
|                  | Max Freq. (MHz) | Max Freq. (MHz) | Max Freq. (MHz) | Max Freq. (MHz) |
| <b>VD_MPU</b>    |                 |                 |                 |                 |
| MPU_CLK          | 750             | 1000            | 1176            | 1176            |
| <b>VD_DSPEVE</b> |                 |                 |                 |                 |
| DSP_CLK          | N/A             | 600             | 700             | 750             |
| EVE_FCLK         | N/A             | 535             | 650             | 650             |
| ISP_CLK          | N/A             | 355             | 355             | 532             |
| <b>VD_IVA</b>    |                 |                 |                 |                 |
| IVA_GCLK         | N/A             | 388.3           | 430             | 532             |
| <b>VD_GPU</b>    |                 |                 |                 |                 |
| GPU_CLK          | N/A             | 425.6           | 500             | 532             |
| <b>VD_CORE</b>   |                 |                 |                 |                 |
| CORE_IPUx_CLK    | N/A             | 212.8           | N/A             | N/A             |
| L3_CLK           | N/A             | 266             | N/A             | N/A             |
| DDR2             | N/A             | 400 (DDR2-800)  | N/A             | N/A             |
| DDR3 / DDR3L     | N/A             | 667 (DDR3-1333) | N/A             | N/A             |
| <b>VD_RTC</b>    |                 |                 |                 |                 |
| RTC_FCLK         | N/A             | 0.034           | N/A             | N/A             |

(1) N/A in this table stands for Not Applicable.

(2) Maximum supported frequency is limited according to the Device Speed Grade (see Table 5-1).

### 5.5.3 Maximum Supported Frequency

Device modules either receive their clock directly from an external clock input, directly from a PLL, or from a PRCM. Table 5-5 lists the clock source options for each module on this device, along with the maximum frequency that module can accept. To ensure proper module functionality, the device PLLs and dividers must be programmed not to exceed the maximum frequencies listed in this table.

**Table 5-5. Maximum Supported Frequency**

| Module              |                  |            |                          | Clock Sources          |                               |                         |
|---------------------|------------------|------------|--------------------------|------------------------|-------------------------------|-------------------------|
| Instance Name       | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name        | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| AES1                | AES1_L3_CLK      | Int        | 266                      | L4SEC_L3_GICLK         | CORE_X2_CLK                   | DPLL_CORE               |
| AES2                | AES2_L3_CLK      | Int        | 266                      | L4SEC_L3_GICLK         | CORE_X2_CLK                   | DPLL_CORE               |
| BB2D                | BB2D_FCLK        | Func       | 354.6                    | BB2D_GFCLK             | BB2D_GFCLK                    | DPLL_CORE               |
|                     | BB2D_ICLK        | Int        | 266                      | DSS_L3_GICLK           | CORE_X2_CLK                   | DPLL_CORE               |
| COUNTER_32K         | COUNTER_32K_FCLK | Func       | 0.032                    | FUNC_32K_CLK           | SYS_CLK1/610                  | OSC0                    |
|                     | COUNTER_32K_ICLK | Int        | 38.4                     | WKUPAON_GICLK          | SYS_CLK1                      | OSC0                    |
|                     |                  |            |                          |                        | DPLL_ABE_X2_CLK               | DPLL_ABE                |
| CTRL_MODULE_BANDGAP | L3INSTR_TS_GCLK  | Int        | 4.8                      | L3INSTR_TS_GCLK        | SYS_CLK1                      | OSC0                    |
|                     |                  |            |                          |                        | DPLL_ABE_X2_CLK               | DPLL_ABE                |
| CTRL_MODULE_CORE    | L4CFG_L4_GICLK   | Int        | 133                      | L4CFG_L4_GICLK         | CORE_X2_CLK                   | DPLL_CORE               |
| CTRL_MODULE_WKUP    | WKUPAON_GICLK    | Int        | 38.4                     | WKUPAON_GICLK          | SYS_CLK1                      | OSC0                    |
|                     |                  |            |                          |                        | DPLL_ABE_X2_CLK               | DPLL_ABE                |
| DCAN1               | DCAN1_FCLK       | Func       | 38.4                     | DCAN1_SYS_CLK          | SYS_CLK1                      | OSC0                    |
|                     |                  |            |                          |                        | SYS_CLK2                      | OSC1                    |
|                     | DCAN1_ICLK       | Int        | 266                      | WKUPAON_GICLK          | SYS_CLK1                      | OSC0                    |
| DCAN2               | DCAN2_FCLK       | Func       | 38.4                     | DCAN2_SYS_CLK          | SYS_CLK1                      | OSC0                    |
|                     | DCAN2_ICLK       | Int        | 266                      | L4PER2_L3_GICLK        | CORE_X2_CLK                   | DPLL_CORE               |
| DES3DES             | DES_CLK_L3       | Int        | 266                      | L4SEC_L3_GICLK         | CORE_X2_CLK                   | DPLL_CORE               |
| DLL                 | EMIF_DLL_FCLK    | Func       | EMIF_DLL_FCLK            | EMIF_DLL_GCLK          | EMIF_DLL_GCLK                 | DPLL_DDR                |
| DLL_AGING           | FCLK             | Int        | 38.4                     | L3INSTR_DLL_AGING_GCLK | SYS_CLK1                      | OSC0                    |
|                     |                  |            |                          |                        | DPLL_ABE_X2_CLK               | DPLL_ABE                |
| DMA_CRYPT0          | DMA_CRYPT0_FCLK  | Int & Func | 266                      | L4SEC_L3_GICLK         | CORE_X2_CLK                   | DPLL_CORE               |
|                     | DMA_CRYPT0_ICLK  | Int        | 133                      | L4SEC_L4_GICLK         | CORE_X2_CLK                   | DPLL_CORE               |
| DMM                 | DMM_CLK          | Int        | 266                      | EMIF_L3_GICLK          | CORE_X2_CLK                   | DPLL_CORE               |
| DPLL_DEBUG          | SYSCLK           | Int        | 38.4                     | EMU_SYS_CLK            | SYS_CLK1                      | OSC0                    |
| DSP1                | DSP1_FICLK       | Int & Func | DSP_CLK                  | DSP1_GFCLK             | DSP_GFCLK                     | DPLL_DSP                |
| DSP2                | DSP2_FICLK       | Int & Func | DSP_CLK                  | DSP2_GFCLK             | DSP_GFCLK                     | DPLL_DSP                |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module          |                  |            |                          | Clock Sources       |                               |                                |
|-----------------|------------------|------------|--------------------------|---------------------|-------------------------------|--------------------------------|
| Instance Name   | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name     | PLL / OSC / Source Clock Name | PLL / OSC / Source Name        |
| DSS             | DSS_HDMI_CEC_CLK | Func       | 0.032                    | HDMI_CEC_GFCLK      | SYS_CLK1/610                  | OSC0                           |
|                 | DSS_HDMI_PHY_CLK | Func       | 48                       | HDMI_PHY_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                       |
|                 | DSS_CLK          | Func       | 192                      | DSS_GFCLK           | DSS_CLK                       | DPLL_PER                       |
|                 | HDMI_CLKINP      | Func       | 38.4                     | HDMI_DPLL_CLK       | SYS_CLK1                      | OSC0                           |
|                 |                  |            |                          |                     | SYS_CLK2                      | OSC1                           |
|                 | DSS_L3_ICLK      | Int        | 266                      | DSS_L3_GICLK        | CORE_X2_CLK                   | DPLL_CORE                      |
|                 | VIDEO1_CLKINP    | Func       | 38.4                     | VIDEO1_DPLL_CLK     | SYS_CLK1                      | OSC0                           |
|                 |                  |            |                          |                     | SYS_CLK2                      | OSC1                           |
|                 | VIDEO2_CLKINP    | Func       | 38.4                     | VIDEO2_DPLL_CLK     | SYS_CLK1                      | OSC0                           |
|                 |                  |            |                          |                     | SYS_CLK2                      | OSC1                           |
|                 | DPLL_DSI1_A_CLK1 | Func       | 209.3                    | N/A                 | HDMI_CLK                      | DPLL_HDMI                      |
|                 |                  |            |                          |                     | VIDEO1_CLKOUT1                | DPLL_VIDEO1                    |
|                 | DPLL_DSI1_B_CLK1 | Func       | 209.3                    | N/A                 | VIDEO1_CLKOUT3                | DPLL_VIDEO1                    |
|                 |                  |            |                          |                     | VIDEO2_CLKOUT3                | DPLL_VIDEO2                    |
|                 |                  |            |                          |                     | HDMI_CLK                      | DPLL_HDMI                      |
|                 |                  |            |                          |                     | DPLL_ABE_X2_CLK               | DPLL_ABE                       |
|                 | DPLL_DSI1_C_CLK1 | Func       | 209.3                    | N/A                 | HDMI_CLK                      | DPLL_HDMI                      |
|                 |                  |            |                          |                     | VIDEO1_CLKOUT3                | DPLL_VIDEO1                    |
|                 |                  |            |                          |                     | VIDEO2_CLKOUT1                | DPLL_VIDEO2                    |
|                 | DPLL_HDMI_CLK1   | Func       | 185.6                    | N/A                 | HDMI_CLK                      | DPLL_HDMI                      |
| DSS DISPC       | LCD1_CLK         | Func       | 209.3                    | N/A                 | DPLL_DSI1_A_CLK1              | See DSS data in the rows above |
|                 |                  |            |                          |                     | DSS_CLK                       |                                |
|                 | LCD2_CLK         | Func       | 209.3                    | N/A                 | DPLL_DSI1_B_CLK1              |                                |
|                 |                  |            |                          |                     | DSS_CLK                       |                                |
|                 | LCD3_CLK         | Func       | 209.3                    | N/A                 | DPLL_DSI1_C_CLK1              |                                |
|                 |                  |            |                          |                     | DSS_CLK                       |                                |
|                 | F_CLK            | Func       | 209.3                    | N/A                 | DPLL_DSI1_A_CLK1              |                                |
|                 |                  |            |                          |                     | DPLL_DSI1_B_CLK1              |                                |
|                 |                  |            |                          |                     | DPLL_DSI1_C_CLK1              |                                |
|                 |                  |            |                          |                     | DSS_CLK                       |                                |
|                 |                  |            |                          |                     | DPLL_HDMI_CLK1                |                                |
| ISP             | ISS_MAIN_FCLK    | Func       | ISP_CLK                  | CORE_ISS_MAIN_CLK   | CORE_ISS_MAIN_CLK             | DPLL_CORE                      |
|                 | PCLK             | Func       |                          | ISS_MAIN_FCLK       | ISS_MAIN_FCLK                 |                                |
| EFUSE_CTRL_CUST | ocp_clk          | Int        | 133                      | CUSTEFUSE_L4_GICLK  | CORE_X2_CLK                   | DPLL_CORE                      |
|                 | sys_clk          | Func       | 38.4                     | CUSTEFUSE_SYS_GFCLK | SYS_CLK1                      | OSC0                           |
| ELM             | ELM_ICLK         | Int        | 266                      | L4PER_L3_GICLK      | CORE_X2_CLK                   | DPLL_CORE                      |
| EMIF_OCP_FW     | L3_CLK           | Int        | 266                      | EMIF_L3_GICLK       | CORE_X2_CLK                   | DPLL_CORE                      |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources      |                               |                         |
|---------------|------------------|------------|--------------------------|--------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name    | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| EMIF_PHY1     | EMIF_PHY1_FCLK   | Func       | DDR                      | EMIF_PHY_GCLK      | EMIF_PHY_GCLK                 | DPLL_DDR                |
| EMIF_PHY2     | EMIF_PHY2_FCLK   | Func       | DDR                      | EMIF_PHY_GCLK      | EMIF_PHY_GCLK                 | DPLL_DDR                |
| EMIF1         | EMIF1_ICLK       | Int        | 266                      | EMIF_L3_GICLK      | CORE_X2_CLK                   | DPLL_CORE               |
| EMIF2         | EMIF2_ICLK       | Int        | 266                      | EMIF_L3_GICLK      | CORE_X2_CLK                   | DPLL_CORE               |
| EVE1          | EVE1_FCLK        | Func       | EVE_FCLK                 | EVE1_GFCLK         | -                             | DPLL_DSP                |
|               |                  |            |                          |                    | EVE_GFCLK                     | DPLL_EVE                |
| EVE2          | EVE2_FCLK        | Func       | EVE_FCLK                 | EVE2_GFCLK         | -                             | DPLL_DSP                |
|               |                  |            |                          |                    | EVE_GFCLK                     | DPLL_EVE                |
| FPKA          | PKA_CLK          | Int & Func | 266                      | L4SEC_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
| GMAC_SW       | CPTS_RFT_CLK     | Func       | 266                      | GMAC_RFT_CLK       | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                    | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                    | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                    | HDMI_CLK                      | DPLL_HDMI               |
|               |                  |            |                          |                    | CORE_X2_CLK                   | DPLL_CORE               |
|               | MAIN_CLK         | Int        | 125                      | GMAC_MAIN_CLK      | GMAC_250M_CLK                 | DPLL_GMAC               |
|               | MHZ_250_CLK      | Func       | 250                      | GMII_250MHZ_CLK    | GMII_250MHZ_CLK               | DPLL_GMAC               |
|               | MHZ_5_CLK        | Func       | 5                        | RGMII_5MHZ_CLK     | GMAC_RMII_HS_CLK              | DPLL_GMAC               |
|               | MHZ_50_CLK       | Func       | 50                       | RMII_50MHZ_CLK     | GMAC_RMII_HS_CLK              | DPLL_GMAC               |
|               | RMII1_MHZ_50_CLK | Func       | 50                       | RMII_50MHZ_CLK     | GMAC_RMII_HS_CLK              | DPLL_GMAC               |
|               | RMII2_MHZ_50_CLK | Func       | 50                       | RMII_50MHZ_CLK     | GMAC_RMII_HS_CLK              | DPLL_GMAC               |
| GPIO1         | GPIO1_ICLK       | Int        | 38.4                     | WKUPAON_GICLK      | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                    | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               | GPIO1_DBCLK      | Func       | 0.032                    | WKUPAON_SYS_GFCCLK | WKUPAON_32K_GFCLK             | OSC0 <sup>(1)</sup>     |
| GPIO2         | GPIO2_ICLK       | Int        | 266                      | L4PER_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | GPIO2_DBCLK      | Func       | 0.032                    | GPIO_GFCLK         | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
| GPIO3         | GPIO3_ICLK       | Int        | 266                      | L4PER_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | GPIO3_DBCLK      | Func       | 0.032                    | GPIO_GFCLK         | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
| GPIO4         | GPIO4_ICLK       | Int        | 266                      | L4PER_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | GPIO4_DBCLK      | Func       | 0.032                    | GPIO_GFCLK         | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               | PIDBCLK          | Func       | 0.032                    | GPIO_GFCLK         |                               |                         |
| GPIO5         | GPIO5_ICLK       | Int        | 266                      | L4PER_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | GPIO5_DBCLK      | Func       | 0.032                    | GPIO_GFCLK         | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               | PIDBCLK          | Func       | 0.032                    | GPIO_GFCLK         |                               |                         |
| GPIO6         | GPIO6_ICLK       | Int        | 266                      | L4PER_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | GPIO6_DBCLK      | Func       | 0.032                    | GPIO_GFCLK         | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               | PIDBCLK          | Func       | 0.032                    | GPIO_GFCLK         |                               |                         |
| GPIO7         | GPIO7_ICLK       | Int        | 266                      | L4PER_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | GPIO7_DBCLK      | Func       | 0.032                    | GPIO_GFCLK         | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               | PIDBCLK          | Func       | 0.032                    | GPIO_GFCLK         |                               |                         |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module         |                  |            |                          | Clock Sources    |                               |                         |
|----------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name  | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| GPIO8          | GPIO8_ICLK       | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|                | GPIO8_DBCLK      | Func       | 0.032                    | GPIO_GFCLK       | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|                | PIDBCLK          | Func       | 0.032                    | GPIO_GFCLK       |                               |                         |
| GPMC           | GPMC_FCLK        | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| GPU            | GPU_FCLK1        | Func       | GPU_CLK                  | GPU_CORE_GCLK    | CORE_GPU_CLK                  | DPLL_CORE               |
|                |                  |            |                          |                  | PER_GPU_CLK                   | DPLL_PER                |
|                |                  |            |                          |                  | GPU_GCLK                      | DPLL_GPU                |
|                | GPU_FCLK2        | Func       | GPU_CLK                  | GPU_HYD_GCLK     | CORE_GPU_CLK                  | DPLL_CORE               |
|                |                  |            |                          |                  | PER_GPU_CLK                   | DPLL_PER                |
|                |                  |            |                          |                  | GPU_GCLK                      | DPLL_GPU                |
|                | GPU_ICLK         | Int        | 266                      | GPU_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
| HDMI PHY       | DSS_HDMI_PHY_CLK | Func       | 38.4                     | HDMI_PHY_GFCLK   | FUNC_192M_CLK                 | DPLL_PER                |
| I2C1           | I2C1_ICLK        | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|                | I2C1_FCLK        | Func       | 96                       | PER_96M_GFCLK    | FUNC_192M_CLK                 | DPLL_PER                |
| I2C2           | I2C2_ICLK        | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|                | I2C2_FCLK        | Func       | 96                       | PER_96M_GFCLK    | FUNC_192M_CLK                 | DPLL_PER                |
| I2C3           | I2C3_ICLK        | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|                | I2C3_FCLK        | Func       | 96                       | PER_96M_GFCLK    | FUNC_192M_CLK                 | DPLL_PER                |
| I2C4           | I2C4_ICLK        | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|                | I2C4_FCLK        | Func       | 96                       | PER_96M_GFCLK    | FUNC_192M_CLK                 | DPLL_PER                |
| I2C5           | I2C5_ICLK        | Int        | 266                      | IPU_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|                | I2C5_FCLK        | Func       | 96                       | IPU_96M_GFCLK    | FUNC_192M_CLK                 | DPLL_PER                |
| IEEE1500_2_OCP | PI_L3CLK         | Int & Func | 266                      | L3INIT_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| IPU1           | IPU1_GFCLK       | Int & Func | 425.6                    | IPU1_GFCLK       | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|                |                  |            |                          |                  | CORE_IPU_ISS_BOOST_CLK        | DPLL_CORE               |
| IPU2           | IPU2_GFCLK       | Int & Func | 425.6                    | IPU2_GFCLK       | CORE_IPU_ISS_BOOST_CLK        | DPLL_CORE               |
| IVA            | IVA_GCLK         | Int        | IVA_GCLK                 | IVA_GCLK         | IVA_GFCLK                     | DPLL_IVA                |
| L3_INSTR       | L3_CLK           | Int        | L3_CLK                   | L3INSTR_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| L3_MAIN        | L3_CLK1          | Int        | L3_CLK                   | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|                | L3_CLK2          | Int        | L3_CLK                   | L3INSTR_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| L4_CFG         | L4_CFG_CLK       | Int        | 133                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| L4_PER1        | L4_PER1_CLK      | Int        | 133                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| L4_PER2        | L4_PER2_CLK      | Int        | 133                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| L4_PER3        | L4_PER3_CLK      | Int        | 133                      | L4PER3_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| L4_WKUP        | L4_WKUP_CLK      | Int        | 38.4                     | WKUPAON_GICLK    | SYS_CLK1                      | OSC0                    |
|                |                  |            |                          |                  | DPLL_ABE_X2_CLK               | DPLL_ABE                |
| MAILBOX1       | MAILBOX1_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX2       | MAILBOX2_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX3       | MAILBOX3_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX4       | MAILBOX4_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX5       | MAILBOX5_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources    |                               |                         |
|---------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| MAILBOX6      | MAILBOX6_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX7      | MAILBOX7_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX8      | MAILBOX8_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX9      | MAILBOX9_FLCK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX10     | MAILBOX10_FLCK   | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX11     | MAILBOX11_FLCK   | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX12     | MAILBOX12_FLCK   | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| MAILBOX13     | MAILBOX13_FLCK   | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| McASP1        | MCASP1_AHCLKR    | Func       | 100                      | MCASP1_AHCLKR    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP1_AHCLKX    | Func       | 100                      | MCASP1_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP1_FCLK      | Func       | 192                      | MCASP1_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP1_ICLK      | Int        | 266                      | IPU_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources    |                               |                         |
|---------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| McASP2        | MCASP2_AHCLKR    | Func       | 100                      | MCASP2_AHCLKR    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP2_AHCLKX    | Func       | 100                      | MCASP2_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP2_FCLK      | Func       | 192                      | MCASP2_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP2_ICLK      | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources    |                               |                         |
|---------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| McASP3        | MCASP3_AHCLKX    | Func       | 100                      | MCASP3_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP3_FCLK      | Func       | 192                      | MCASP3_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP3_ICLK      | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| McASP4        | MCASP4_AHCLKX    | Func       | 100                      | MCASP4_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP4_FCLK      | Func       | 192                      | MCASP4_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP4_ICLK      | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources    |                               |                         |
|---------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| McASP5        | MCASP5_AHCLKX    | Func       | 100                      | MCASP5_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP5_FCLK      | Func       | 192                      | MCASP5_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP5_ICLK      | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| McASP6        | MCASP6_AHCLKX    | Func       | 100                      | MCASP6_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               | MCASP6_FCLK      | Func       | 192                      | MCASP6_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP6_ICLK      | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources    |                               |                         |
|---------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| McASP7        | MCASP7_AHCLKX    | Func       | 100                      | MCASP7_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP7_FCLK      | Func       | 192                      | MCASP7_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP7_ICLK      | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| McASP8        | MCASP8_AHCLKX    | Func       | 100                      | MCASP8_AHCLKX    | ABE_24M_GFCLK                 | DPLL_ABE                |
|               |                  |            |                          |                  | ABE_SYS_CLK                   | OSC0                    |
|               |                  |            |                          |                  | FUNC_24M_GFCLK                | DPLL_PER                |
|               |                  |            |                          |                  | ATL_CLK3                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK2                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK1                      | Module ATL              |
|               |                  |            |                          |                  | ATL_CLK0                      | Module ATL              |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | MLB_CLK                       | Module MLB              |
|               |                  |            |                          |                  | MLBP_CLK                      | Module MLB              |
|               | MCASP8_FCLK      | Func       | 192                      | MCASP8_AUX_GFCLK | PER_ABE_X1_GFCLK              | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
|               | MCASP8_ICLK      | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| McSPI1        | SPI1_ICLK        | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | SPI1_FCLK        | Func       | 48                       | PER_48M_GFCLK    | PER_48M_GFCLK                 | DPLL_PER                |
| McSPI2        | SPI2_ICLK        | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | SPI2_FCLK        | Func       | 48                       | PER_48M_GFCLK    | PER_48M_GFCLK                 | DPLL_PER                |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                          |            |                          | Clock Sources    |                               |                         |
|---------------|--------------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name         | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| McSPI3        | SPI3_ICLK                | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | SPI3_FCLK                | Func       | 48                       | PER_48M_GFCLK    | PER_48M_GFCLK                 | DPLL_PER                |
| McSPI4        | SPI4_ICLK                | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | SPI4_FCLK                | Func       | 48                       | PER_48M_GFCLK    | PER_48M_GFCLK                 | DPLL_PER                |
| MMC1          | MMC1_CLK_32K             | Func       | 0.032                    | L3INIT_32K_GFCLK | FUNC_32K_CLK                  | OSC0                    |
|               | MMC1_FCLK                | Func       | 192                      | MMC1_GFCLK       | FUNC_192M_CLK                 | DPLL_PER                |
|               |                          |            | 128                      |                  | FUNC_256M_CLK                 | DPLL_PER                |
|               | MMC1_ICLK1               | Int        | 266                      | L3INIT_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | MMC1_ICLK2               | Int        | 133                      | L3INIT_L4_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| MMC2          | MMC2_CLK_32K             | Func       | 0.032                    | L3INIT_32K_GFCLK | FUNC_32K_CLK                  | OSC0                    |
|               | MMC2_FCLK                | Func       | 192                      | MMC2_GFCLK       | FUNC_192M_CLK                 | DPLL_PER                |
|               |                          |            | 128                      |                  | FUNC_256M_CLK                 | DPLL_PER                |
|               | MMC2_ICLK1               | Int        | 266                      | L3INIT_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | MMC2_ICLK2               | Int        | 133                      | L3INIT_L4_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| MMC3          | MMC3_ICLK                | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | MMC3_CLK_32K             | Func       | 0.032                    | L4PER_32K_GFCLK  | FUNC_32K_CLK                  | OSC0                    |
|               | MMC3_FCLK                | Func       | 48                       | MMC3_GFCLK       | FUNC_192M_CLK                 | DPLL_PER                |
|               |                          |            | 192                      |                  |                               |                         |
| MMC4          | MMC4_ICLK                | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | MMC4_CLK_32K             | Func       | 0.032                    | L4PER_32K_GFCLK  | FUNC_32K_CLK                  | OSC0                    |
|               | MMC4_FCLK                | Func       | 48                       | MMC4_GFCLK       | FUNC_192M_CLK                 | DPLL_PER                |
|               |                          |            | 192                      |                  |                               |                         |
| MMU_EDMA      | MMU1_CLK                 | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| MMU_PCIESS    | MMU2_CLK                 | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| MPU           | MPU_CLK                  | Int & Func | MPU_CLK                  | MPU_GCLK         | MPU_GCLK                      | DPLL_MPU                |
| MPU_EMU_DBG   | FCLK                     | Int        | 38.4                     | EMU_SYS_CLK      | SYS_CLK1                      | OSC0                    |
|               |                          |            |                          |                  | MPU_GCLK                      | DPLL_MPU                |
| OCMC_RAM1     | OCMC1_L3_CLK             | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| OCMC_RAM2     | OCMC2_L3_CLK             | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| OCMC_RAM3     | OCMC3_L3_CLK             | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| OCMC_ROM      | OCMC_L3_CLK              | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| OCP_WP_NOC    | PICLKOCPL3               | Int        | 266                      | L3INSTR_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| OCP2SCP1      | L4CFG1_ADAPTE<br>R_CLKIN | Int        | 133                      | L3INIT_L4_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| OCP2SCP2      | L4CFG2_ADAPTE<br>R_CLKIN | Int        | 133                      | L4CFG_L4_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| OCP2SCP3      | L4CFG3_ADAPTE<br>R_CLKIN | Int        | 133                      | L3INIT_L4_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                     |            |                          | Clock Sources     |                               |                         |
|---------------|---------------------|------------|--------------------------|-------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name    | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name   | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| PCIESS1       | PCIE1_PHY_WKU_P_CLK | Func       | 0.032                    | PCIE_32K_GFCLK    | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               | PCle_SS1_FICLK      | Int        | 266                      | PCIE_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | PCIEPHY_CLK         | Func       | 2500                     | PCIE_PHY_GCLK     | PCIE_PHY_GCLK                 | APLL_PCIE               |
|               | PCIEPHY_CLK_DIV     | Func       | 1250                     | PCIE_PHY_DIV_GCLK | PCIE_PHY_DIV_GCLK             | APLL_PCIE               |
|               | PCIE1_REF_CLKIN     | Func       | 34.3                     | PCIE_REF_GFCLK    | CORE_USB_OTG_SS_LFPS_TX_CLK   | DPLL_CORE               |
|               | PCIE1_PWR_CLK       | Func       | 38.4                     | PCIE_SYS_GFCLK    | SYS_CLK1                      | OSC0                    |
| PCIESS2       | PCIE2_PHY_WKU_P_CLK | Func       | 0.032                    | PCIE_32K_GFCLK    | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               | PCle_SS2_FICLK      | Func       | 266                      | PCIE_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
|               | PCIEPHY_CLK         | Func       | 2500                     | PCIE_PHY_GCLK     | PCIE_PHY_GCLK                 | APLL_PCIE               |
|               | PCIEPHY_CLK_DIV     | Func       | 1250                     | PCIE_PHY_DIV_GCLK | PCIE_PHY_DIV_GCLK             | APLL_PCIE               |
|               | PCIE2_REF_CLKIN     | Func       | 34.3                     | PCIE_REF_GFCLK    | CORE_USB_OTG_SS_LFPS_TX_CLK   | DPLL_CORE               |
|               | PCIE2_PWR_CLK       | Func       | 38.4                     | PCIE_SYS_GFCLK    | SYS_CLK1                      | OSC0                    |
| PRCM_MPU      | 32K_CLK             | Func       | 0.032                    | FUNC_32K_CLK      | SYS_CLK1/610                  | OSC0                    |
|               | SYS_CLK             | Func       | 38.4                     | WKUPAON_ICLK      | SYS_CLK1                      | OSC0                    |
|               |                     |            |                          |                   | DPLL_ABE_X2_CLK               | DPLL_ABE                |
| PWMSS1        | PWMSS1_GICLK        | Int & Func | 266                      | L4PER2_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| PWMSS2        | PWMSS2_GICLK        | Int & Func | 266                      | L4PER2_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| PWMSS3        | PWMSS3_GICLK        | Int & Func | 266                      | L4PER2_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| QSPI          | QSPI_ICLK           | Int        | 266                      | L4PER2_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | QSPI_FCLK           | Func       | 128                      | QSPI_GFCLK        | FUNC_256M_CLK                 | DPLL_PER                |
|               |                     |            |                          |                   | PER_QSPI_CLK                  | DPLL_PER                |
| RNG           | RNG_ICLK            | Int        | 266                      | L4SEC_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
| RTC_SS        | RTC_ICLK            | Int        | 133                      | RTC_L4_GICLK      | CORE_X2_CLK                   | DPLL_CORE               |
|               | RTC_FCLK            | Func       | RTC_FCLK                 | RTC_AUX_CLK       | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                     |            |                          | FUNC_32K_CLK      | SYS_CLK1/610                  | OSC0                    |
| SAR_ROM       | PRCM_ROM_CLOCK      | Int        | 266                      | L4CFG_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
| SATA          | SATA_FICLK          | Int        | 266                      | L3INIT_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
|               | SATA_PMA_LIVE_FCLK  | Func       | 48                       | L3INIT_48M_GFCLK  | FUNC_192M_CLK                 | DPLL_PER                |
|               | REF_CLK             | Func       | 38                       | SATA_REF_GFCLK    | SYS_CLK1                      | OSC0                    |
| SDMA          | SDMA_FCLK           | Int & Func | 266                      | DMA_L3_GICLK      | CORE_X2_CLK                   | DPLL_CORE               |
| SHA2MD51      | SHAM_1_CLK          | Int        | 266                      | L4SEC_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
| SHA2MD52      | SHAM_2_CLK          | Int        | 266                      | L4SEC_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
| SL2           | IVA_GCLK            | Int        | IVA_GCLK                 | IVA_GCLK          | IVA_GFCLK                     | DPLL_IVA                |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module             |                  |            |                          | Clock Sources    |                               |                         |
|--------------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name      | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| SMARTREFLEX_CORE   | MCLK             | Int        | 133                      | COREAON_L4_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|                    | SYSCLK           | Func       | 38.4                     | WKUPAON_ICLK     | SYS_CLK1<br>DPLL_ABE_X2_CLK   | OSC0<br>DPLL_ABE        |
| SMARTREFLEX_DSPEVE | MCLK             | Int        | 133                      | COREAON_L4_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|                    | SYSCLK           | Func       | 38.4                     | WKUPAON_ICLK     | SYS_CLK1<br>DPLL_ABE_X2_CLK   | OSC0<br>DPLL_ABE        |
| SMARTREFLEX_GPU    | MCLK             | Int        | 133                      | COREAON_L4_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|                    | SYSCLK           | Func       | 38.4                     | WKUPAON_ICLK     | SYS_CLK1<br>DPLL_ABE_X2_CLK   | OSC0<br>DPLL_ABE        |
| SMARTREFLEX_IVAHD  | MCLK             | Int        | 133                      | COREAON_L4_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|                    | SYSCLK           | Func       | 38.4                     | WKUPAON_ICLK     | SYS_CLK1<br>DPLL_ABE_X2_CLK   | OSC0<br>DPLL_ABE        |
| SMARTREFLEX_MPU    | MCLK             | Int        | 133                      | COREAON_L4_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|                    | SYSCLK           | Func       | 38.4                     | WKUPAON_ICLK     | SYS_CLK1<br>DPLL_ABE_X2_CLK   | OSC0<br>DPLL_ABE        |
| SPINLOCK           | SPINLOCK_ICLK    | Int        | 266                      | L4CFG_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| TIMER1             | TIMER1_ICLK      | Int        | 38.4                     | WKUPAON_GICLK    | SYS_CLK1                      | OSC0                    |
|                    |                  |            |                          |                  | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|                    | TIMER1_FCLK      | Func       | 100                      | TIMER1_GFCLK     | SYS_CLK1                      | OSC0                    |
|                    |                  |            |                          |                  | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|                    |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|                    |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|                    |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|                    |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|                    |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|                    |                  |            |                          |                  | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|                    |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_VIDEO1             |
|                    |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|                    |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources   |                               |                         |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| TIMER2        | TIMER2_ICLK      | Int        | 266                      | L4PER_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER2_FCLK      | Func       | 100                      | TIMER2_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
| TIMER3        | TIMER3_ICLK      | Int        | 266                      | L4PER_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER3_FCLK      | Func       | 100                      | TIMER3_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
| TIMER4        | TIMER4_ICLK      | Int        | 266                      | L4PER_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER4_FCLK      | Func       | 100                      | TIMER4_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources   |                               |                         |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| TIMER5        | TIMER5_ICLK      | Int        | 266                      | IPU_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER5_FCLK      | Func       | 100                      | TIMER5_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
|               |                  |            |                          |                 | CLKOUTMUX[0]                  | CLKOUTMUX[0]            |
| TIMER6        | TIMER6_ICLK      | Int        | 266                      | IPU_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER6_FCLK      | Func       | 100                      | TIMER6_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
|               |                  |            |                          |                 | CLKOUTMUX[0]                  | CLKOUTMUX[0]            |
| TIMER7        | TIMER7_ICLK      | Int        | 266                      | IPU_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER7_FCLK      | Func       | 100                      | TIMER7_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
|               |                  |            |                          |                 | CLKOUTMUX[0]                  | CLKOUTMUX[0]            |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources   |                               |                         |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| TIMER8        | TIMER8_ICLK      | Int        | 266                      | IPU_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER8_FCLK      | Func       | 100                      | TIMER8_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
| CLKOUTMUX[0]  | CLKOUTMUX[0]     |            |                          |                 |                               |                         |
| TIMER9        | TIMER9_ICLK      | Int        | 266                      | L4PER_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER9_FCLK      | Func       | 100                      | TIMER9_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
| TIMER10       | TIMER10_ICLK     | Int        | 266                      | L4PER_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER10_FCLK     | Func       | 100                      | TIMER10_GFCLK   | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources   |                               |                         |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| TIMER11       | TIMER11_ICLK     | Int        | 266                      | L4PER_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER11_FCLK     | Func       | 100                      | TIMER11_GFCLK   | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
| TIMER12       | TIMER12_ICLK     | Int        | 38.4                     | WKUPAON_GICLK   | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               | TIMER12_FCLK     | Func       | 0.032                    | OSC_32K_CLK     | RC_CLK                        | OSC0 <sup>(1)</sup>     |
| TIMER13       | TIMER13_ICLK     | Int        | 266                      | L4PER3_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER13_FCLK     | Func       | 100                      | TIMER13_GFCLK   | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |
| TIMER14       | TIMER14_ICLK     | Int        | 266                      | L4PER3_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER14_FCLK     | Func       | 100                      | TIMER14_GFCLK   | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                 | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                 | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                 | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                 | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                 | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                 | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                 | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                 | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                 | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                 | HDMI_CLK                      | DPLL_HDMI               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                  |            |                          | Clock Sources    |                               |                         |
|---------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name  | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| TIMER15       | TIMER15_ICLK     | Int        | 266                      | L4PER3_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER15_FCLK     | Func       | 100                      | TIMER15_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                  | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
| TIMER16       | TIMER16_ICLK     | Int        | 266                      | L4PER3_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
|               | TIMER16_FCLK     | Func       | 100                      | TIMER16_GFCLK    | SYS_CLK1                      | OSC0                    |
|               |                  |            |                          |                  | FUNC_32K_CLK                  | OSC0 <sup>(1)</sup>     |
|               |                  |            |                          |                  | SYS_CLK2                      | OSC1                    |
|               |                  |            |                          |                  | XREF_CLK0                     | XREF_CLK0               |
|               |                  |            |                          |                  | XREF_CLK1                     | XREF_CLK1               |
|               |                  |            |                          |                  | XREF_CLK2                     | XREF_CLK2               |
|               |                  |            |                          |                  | XREF_CLK3                     | XREF_CLK3               |
|               |                  |            |                          |                  | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               |                  |            |                          |                  | VIDEO1_CLK                    | DPLL_VIDEO1             |
|               |                  |            |                          |                  | VIDEO2_CLK                    | DPLL_VIDEO2             |
|               |                  |            |                          |                  | HDMI_CLK                      | DPLL_HDMI               |
| TPCC          | TPCC_GCLK        | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| TPTC1         | TPTC0_GCLK       | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| TPTC2         | TPTC1_GCLK       | Int        | 266                      | L3MAIN1_L3_GICLK | CORE_X2_CLK                   | DPLL_CORE               |
| UART1         | UART1_FCLK       | Func       | 48                       | UART1_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART1_ICLK       | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| UART2         | UART2_FCLK       | Func       | 48                       | UART2_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART2_ICLK       | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| UART3         | UART3_FCLK       | Func       | 48                       | UART3_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART3_ICLK       | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| UART4         | UART4_FCLK       | Func       | 48                       | UART4_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART4_ICLK       | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| UART5         | UART5_FCLK       | Func       | 48                       | UART5_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART5_ICLK       | Int        | 266                      | L4PER_L3_GICLK   | CORE_X2_CLK                   | DPLL_CORE               |
| UART6         | UART6_FCLK       | Func       | 48                       | UART6_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART6_ICLK       | Int        | 266                      | IPU_L3_GICLK     | CORE_X2_CLK                   | DPLL_CORE               |
| UART7         | UART7_FCLK       | Func       | 48                       | UART7_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART7_ICLK       | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |
| UART8         | UART8_FCLK       | Func       | 48                       | UART8_GFCLK      | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART8_ICLK       | Int        | 266                      | L4PER2_L3_GICLK  | CORE_X2_CLK                   | DPLL_CORE               |

**Table 5-5. Maximum Supported Frequency (continued)**

| Module        |                    |            |                          | Clock Sources      |                               |                         |
|---------------|--------------------|------------|--------------------------|--------------------|-------------------------------|-------------------------|
| Instance Name | Input Clock Name   | Clock Type | Max. Clock Allowed (MHz) | PRCM Clock Name    | PLL / OSC / Source Clock Name | PLL / OSC / Source Name |
| UART9         | UART9_FCLK         | Func       | 48                       | UART9_GFCLK        | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART9_ICLK         | Int        | 266                      | L4PER2_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
| UART10        | UART10_FCLK        | Func       | 48                       | UART10_GFCLK       | FUNC_192M_CLK                 | DPLL_PER                |
|               | UART10_ICLK        | Int        | 38.4                     | WKUPAON_GICLK      | SYS_CLK1                      | OSC0                    |
| USB1          | USB1_MICLK         | Int        | 266                      | L3INIT_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | USB3PHY_REF_CLK    | Func       | 34.3                     | USB_LFPS_TX_GFCLK  | CORE_USB_OTG_SS_LFPS_TX_CLK   | DPLL_CORE               |
|               | USB2PHY1_TREF_CLK  | Func       | 38.4                     | USB_OTG_SS_REF_CLK | SYS_CLK1                      | OSC0                    |
|               | USB2PHY1_REF_CLK   | Func       | 960                      | L3INIT_960M_GFCLK  | L3INIT_960_GFCLK              | DPLL_USB                |
| USB2          | USB2_MICLK         | Int        | 266                      | L3INIT_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | USB2PHY2_TREF_CLK  | Func       | 38.4                     | USB_OTG_SS_REF_CLK | SYS_CLK1                      | OSC0                    |
|               | USB2PHY2_REF_CLK   | Func       | 960                      | L3INIT_960M_GFCLK  | L3INIT_960_GFCLK              | DPLL_USB                |
| USB3          | USB3_MICLK         | Int        | 266                      | L3INIT_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | USB3PHY_PWRS_CLK   | Func       | 38.4                     | USB_OTG_SS_REF_CLK | SYS_CLK1                      | OSC0                    |
| USB4          | USB4_MICLK         | Int        | 266                      | L3INIT_L3_GICLK    | CORE_X2_CLK                   | DPLL_CORE               |
|               | DPLL_USBSS_REF_CLK | Func       | 38.4                     | USB_OTG_SS_REF_CLK | SYS_CLK1                      | OSC0                    |
| USB_PHY1_CORE | USB2PHY1_WKUP_CLK  | Func       | 0.032                    | COREAON_32K_GFCLK  | SYS_CLK1/610                  | OSC0                    |
| USB_PHY2_CORE | USB2PHY2_WKUP_CLK  | Func       | 0.032                    | COREAON_32K_GFCLK  | SYS_CLK1/610                  | OSC0                    |
| USB_PHY3_CORE | USB3PHY_WKUP_CLK   | Func       | 0.032                    | COREAON_32K_GFCLK  | SYS_CLK1/610                  | OSC0                    |
| VIP1          | L3_CLK_PROC_CLK    | Int & Func | 266                      | VIP1_GCLK          | CORE_X2_CLK                   | DPLL_CORE               |
|               |                    |            |                          |                    | CORE_ISS_MAIN_CLK             | DPLL_CORE               |
| VIP2          | L3_CLK_PROC_CLK    | Int & Func | 266                      | VIP2_GCLK          | CORE_X2_CLK                   | DPLL_CORE               |
|               |                    |            |                          |                    | CORE_ISS_MAIN_CLK             | DPLL_CORE               |
| VPE           | L3_CLK_PROC_CLK    | Int & Func | 300                      | VPE_GCLK           | CORE_ISS_MAIN_CLK             | DPLL_CORE               |
|               |                    |            |                          |                    | VIDEO1_CLKOUT4                | DPLL_VIDEO1             |
| WD_TIMER1     | PIOCPCLK           | Int        | 38.4                     | WKUPAON_GICLK      | SYS_CLK1                      | OSC0                    |
|               |                    |            |                          |                    | DPLL_ABE_X2_CLK               | DPLL_ABE                |
|               | PITIMERCLK         | Func       | 0.032                    | OSC_32K_CLK        | RC_CLK                        | OSC0 <sup>(1)</sup>     |
| WD_TIMER2     | WD_TIMER2_ICLK     | Int        | 38.4                     | WKUPAON_GICLK      | SYS_CLK1                      | OSC0                    |
|               | WD_TIMER2_FCLK     | Func       | 0.032                    | WKUPAON_SYS_GFCCLK | WKUPAON_32K_GFCCLK            | OSC0 <sup>(1)</sup>     |

- (1) RTC oscillator can be used as an optional clock source instead of OSC1.

## 5.6 Power Consumption Summary

### NOTE

Maximum power consumption for this SoC depends on the specific use conditions for the end system. Contact your TI representative for assistance in estimating maximum power consumption for the end system use case.

## 5.7 Electrical Characteristics

### NOTE

The data specified in through [Section 5.7.4](#) are subject to change.

### NOTE

The interfaces or signals described in through [Section 5.7.4](#) correspond to the interfaces or signals available in multiplexing mode 0 (Function 1).

All interfaces or signals multiplexed on the balls described in these tables have the same DC electrical characteristics, unless multiplexing involves a PHY/GPIO combination in which case different DC electrical characteristics are specified for the different multiplexing modes (Functions).

**Table 5-6. LVCMOS DDR DC Electrical Characteristics<sup>(3)</sup>**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                        | MIN                  | NOM                     | MAX                     | UNIT |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|----------------------|-------------------------|-------------------------|------|
| <b>Signal Names in MUXMODE 0 (Single-Ended Signals):</b> ddr1_d[31:0], ddr1_a[15:0], ddr1_dqm[3:0], ddr1_ba[2:0], ddr1_csn[0], ddr1_cke, ddr1_odt[0], ddr1_casn, ddr1_rasn, ddr1_wen, ddr1_rst, ddr1_ecc_d[7:0], ddr1_dqm_ecc, ddr2_d[31:0], ddr2_a[15:0], ddr2_dqm[3:0], ddr2_ba[2:0], ddr2_csn[0], ddr2_cke, ddr2_odt[0], ddr2_casn, ddr2_rasn, ddr2_wen, ddr2_rst;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                        |                      |                         |                         |      |
| <b>Balls:</b> AA28 / AA25 / AA26 / Y24 / AA24 / Y23 / Y22 / AA23 / Y20 / AB27 / Y19 / AC27 / AC28 / AB28 / W20 / V20 / AD25 / AC24 / AC25 / AE26 / AF28 / AG27 / AF27 / AC23 / AE23 / AF23 / AE24 / AF24 / AH26 / AG26 / AF26 / AF25 / AD18 / AE17 / AF18 / AC21 / AD22 / AD21 / AE22 / AF22 / AE21 / AE21 / AH22 / AF21 / AB19 / AC20 / AC19 / AD20 / AA27 / AC26 / AB23 / AD23 / AB18 / AE18 / AF17 / AH23 / AG22 / AE20 / AC18 / AF20 / AH21 / AG21 / Y26 / V25 / V24 / Y25 / W23 / W19 / V23 / W22 / V26 / M26 / M25 / M24 / M23 / L28 / L25 / L26 / L27 / J20 / K22 / J23 / L24 / L23 / K21 / K20 / L22 / J24 / J26 / J25 / G26 / H26 / H24 / H25 / H23 / E28 / E27 / F27 / F26 / F24 / F25 / G25 / E26 / U22 / R22 / T22 / N28 / P26 / N23 / N27 / P27 / N20 / P25 / P22 / P23 / R27 / R28 / R26 / R25 / M22 / K23 / G24 / F28 / U26 / U27 / U23 / P24 / U24 / R23 / U28 / T23 / U25 / R24; |                                                        |                      |                         |                         |      |
| <b>Driver Mode</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                        |                      |                         |                         |      |
| V <sub>OH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | High-level output threshold (I <sub>OH</sub> = 0.1 mA) |                      | 0.9 × V <sub>DD</sub> S |                         | V    |
| V <sub>OL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Low-level output threshold (I <sub>OL</sub> = 0.1 mA)  |                      | 0.1 × V <sub>DD</sub> S |                         | V    |
| C <sub>PAD</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Pad capacitance (including package capacitance)        |                      | 3                       |                         | pF   |
| Z <sub>O</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Output impedance (drive strength)                      | I[2:0] = 000 (Imp80) | 80                      |                         | Ω    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                        | I[2:0] = 001 (Imp60) | 60                      |                         |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                        | I[2:0] = 010 (Imp48) | 48                      |                         |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                        | I[2:0] = 011 (Imp40) | 40                      |                         |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                        | I[2:0] = 100 (Imp34) | 34                      |                         |      |
| <b>Single-Ended Receiver Mode</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                        |                      |                         |                         |      |
| V <sub>IH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | High-level input threshold                             | DDR3/DDR3L           | VREF + 0.1              | V <sub>DD</sub> S + 0.2 | V    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                        | DDR2                 | VREF + 0.125            | V <sub>DD</sub> S + 0.3 |      |

**Table 5-6. LVCMOS DDR DC Electrical Characteristics<sup>(3)</sup> (continued)**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                                                                                                                                         |                                                        |                      | MIN                                          | NOM        | MAX                                          | UNIT |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|----------------------|----------------------------------------------|------------|----------------------------------------------|------|
| V <sub>IL</sub>                                                                                                                                                                   | Low-level input threshold                              | DDR3/DDR3L           | -0.2                                         | VREF-0.1   |                                              | V    |
|                                                                                                                                                                                   |                                                        | DDR2                 | -0.3                                         | VREF-0.125 |                                              |      |
| V <sub>CM</sub>                                                                                                                                                                   | Input common-mode voltage                              |                      | VREF - 10%VDD5                               |            | VREF + 10%VDD5                               | V    |
| C <sub>PAD</sub>                                                                                                                                                                  | Pad capacitance (including package capacitance)        |                      |                                              | 3          |                                              | pF   |
| Signal Names in MUXMODE 0 (Differential Signals): ddr1_dqs[3:0], ddr1_dqsn[3:0], ddr1_ck, ddr1_nck, ddr2_dqs[3:0], ddr2_dqsn[3:0], ddr2_ck, ddr2_nck, ddr1_dqs_ecc, ddr1_dqsn_ecc |                                                        |                      |                                              |            |                                              |      |
| Bottom Balls: Y28 / AD27 / AE27 / AH25 / Y27 / AD28 / AE28 / AG25 / AG24 / AH24 / M28 / K27 / H27 / G28 / M27 / K28 / H28 / G27 / T28 / T27 / V27 / V28                           |                                                        |                      |                                              |            |                                              |      |
| Driver Mode                                                                                                                                                                       |                                                        |                      |                                              |            |                                              |      |
| V <sub>OH</sub>                                                                                                                                                                   | High-level output threshold (I <sub>OH</sub> = 0.1 mA) |                      | 0.9 × VDD5 <sup>(1)</sup>                    |            |                                              | V    |
| V <sub>OL</sub>                                                                                                                                                                   | Low-level output threshold (I <sub>OL</sub> = 0.1 mA)  |                      | 0.1 × VDD5 <sup>(1)</sup>                    |            |                                              | V    |
| C <sub>PAD</sub>                                                                                                                                                                  | Pad capacitance (including package capacitance)        |                      |                                              | 3          |                                              | pF   |
| Z <sub>O</sub>                                                                                                                                                                    | Output impedance (drive strength)                      | I[2:0] = 000 (Imp80) | 80                                           |            | Ω                                            |      |
|                                                                                                                                                                                   |                                                        | I[2:0] = 001 (Imp60) | 60                                           |            |                                              |      |
|                                                                                                                                                                                   |                                                        | I[2:0] = 010 (Imp48) | 48                                           |            |                                              |      |
|                                                                                                                                                                                   |                                                        | I[2:0] = 011 (Imp40) | 40                                           |            |                                              |      |
|                                                                                                                                                                                   |                                                        | I[2:0] = 100 (Imp34) | 34                                           |            |                                              |      |
| Single-Ended Receiver Mode                                                                                                                                                        |                                                        |                      |                                              |            |                                              |      |
| V <sub>IH</sub>                                                                                                                                                                   | High-level input threshold                             | DDR3/DDR3L           | VREF <sup>(2)</sup> + 0.1                    |            | VDD5 <sup>(1)</sup> + 0.2                    | V    |
|                                                                                                                                                                                   |                                                        | DDR2                 | VREF <sup>(2)</sup> + 0.125                  |            | VDD5 <sup>(1)</sup> + 0.3                    |      |
| V <sub>IL</sub>                                                                                                                                                                   | Low-level input threshold                              | DDR3/DDR3L           | -0.2                                         |            | VREF <sup>(2)</sup> -0.1                     | V    |
|                                                                                                                                                                                   |                                                        | DDR2                 | -0.3                                         |            | VREF <sup>(2)</sup> -0.125                   |      |
| V <sub>CM</sub>                                                                                                                                                                   | Input common-mode voltage                              |                      | VREF <sup>(2)</sup> - 10%VDD5 <sup>(1)</sup> |            | VREF <sup>(2)</sup> + 10%VDD5 <sup>(1)</sup> | V    |
| C <sub>PAD</sub>                                                                                                                                                                  | Pad capacitance (including package capacitance)        |                      |                                              | 3          |                                              | pF   |
| Differential Receiver Mode                                                                                                                                                        |                                                        |                      |                                              |            |                                              |      |
| V <sub>SWING</sub>                                                                                                                                                                | Input voltage swing                                    | DDR3/DDR3L           | 0.2                                          |            | VDD5 + 0.4                                   | V    |
|                                                                                                                                                                                   |                                                        | DDR2                 | 0.25                                         |            | VDD5 + 0.6                                   |      |
| V <sub>CM</sub>                                                                                                                                                                   | Input common-mode voltage                              |                      | VREF <sup>(2)</sup> - 10%VDD5 <sup>(1)</sup> |            | VREF <sup>(2)</sup> + 10%VDD5 <sup>(1)</sup> | V    |
| C <sub>PAD</sub>                                                                                                                                                                  | Pad capacitance (including package capacitance)        |                      |                                              | 3          |                                              | pF   |

(1) VDD5 in this table stands for corresponding power supply (i.e. vdds\_ddr1 or vdds\_ddr2). For more information on the power supply name and the corresponding ball, see [Table 4-1, POWER \[11\]](#) column.

(2) VREF in this table stands for corresponding Reference Power Supply (i.e. ddr1\_vref0 or ddr2\_vref0). For more information on the power supply name and the corresponding ball, see [Table 4-1, POWER \[11\]](#) column.

(3) For more information on the I/O cell configurations (i[2:0], sr[1:0]), see chapter Control Module of the Device TRM.

**Table 5-7. Dual Voltage LVCMOS I2C DC Electrical Characteristics<sup>(2)</sup>**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                                 | MIN | NOM | MAX | UNIT |
|---------------------------------------------------------------------------|-----|-----|-----|------|
| <b>Signal Names in MUXMODE 0:</b> i2c1_sda, i2c1_scl, i2c2_sda, i2c2_scl; |     |     |     |      |
| <b>Balls:</b> F17 / C20 / C21 / C25                                       |     |     |     |      |
| <b>I<sup>2</sup>C Standard Mode – 1.8 V</b>                               |     |     |     |      |

**Table 5-7. Dual Voltage LVCMOS I2C DC Electrical Characteristics<sup>(2)</sup> (continued)**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                   |                                                                                                                                                                                                                                                                                                       | MIN                                    | NOM | MAX                                   | UNIT |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----|---------------------------------------|------|
| V <sub>IH</sub>                             | Input high-level threshold                                                                                                                                                                                                                                                                            | 0.7 × V <sub>DD5</sub> <sup>(1)</sup>  |     |                                       | V    |
| V <sub>IL</sub>                             | Input low-level threshold                                                                                                                                                                                                                                                                             |                                        |     | 0.3 × V <sub>DD5</sub> <sup>(1)</sup> | V    |
| V <sub>hys</sub>                            | Hysteresis                                                                                                                                                                                                                                                                                            | 0.1 × V <sub>DD5</sub> <sup>(1)</sup>  |     |                                       | V    |
| I <sub>IN</sub>                             | Input current at each I/O pin with an input voltage between 0.1 × V <sub>DD5</sub> to 0.9 × V <sub>DD5</sub>                                                                                                                                                                                          |                                        |     | 12                                    | μA   |
| I <sub>OZ</sub>                             | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V <sub>DD5</sub> and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> |                                        |     | 12                                    | μA   |
| C <sub>IN</sub>                             | Input capacitance                                                                                                                                                                                                                                                                                     |                                        |     | 10                                    | pF   |
| V <sub>OL3</sub>                            | Output low-level threshold open-drain at 3-mA sink current                                                                                                                                                                                                                                            |                                        |     | 0.2 × V <sub>DD5</sub> <sup>(1)</sup> | V    |
| I <sub>OLmin</sub>                          | Low-level output current @V <sub>OL</sub> = 0.2 × V <sub>DD5</sub>                                                                                                                                                                                                                                    | 3                                      |     |                                       | mA   |
| t <sub>OF</sub>                             | Output fall time from V <sub>IHmin</sub> to V <sub>ILmax</sub> with a bus capacitance C <sub>B</sub> from 5 pF to 400 pF                                                                                                                                                                              |                                        |     | 250                                   | ns   |
| <b>I<sup>2</sup>C Fast Mode – 1.8 V</b>     |                                                                                                                                                                                                                                                                                                       |                                        |     |                                       |      |
| V <sub>IH</sub>                             | Input high-level threshold                                                                                                                                                                                                                                                                            | 0.7 × V <sub>DD5</sub> <sup>(1)</sup>  |     |                                       | V    |
| V <sub>IL</sub>                             | Input low-level threshold                                                                                                                                                                                                                                                                             |                                        |     | 0.3 × V <sub>DD5</sub> <sup>(1)</sup> | V    |
| V <sub>hys</sub>                            | Hysteresis                                                                                                                                                                                                                                                                                            | 0.1 × V <sub>DD5</sub> <sup>(1)</sup>  |     |                                       | V    |
| I <sub>IN</sub>                             | Input current at each I/O pin with an input voltage between 0.1 × V <sub>DD5</sub> to 0.9 × V <sub>DD5</sub>                                                                                                                                                                                          |                                        |     | 12                                    | μA   |
| I <sub>OZ</sub>                             | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V <sub>DD5</sub> and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> |                                        |     | 12                                    | μA   |
| C <sub>IN</sub>                             | Input capacitance                                                                                                                                                                                                                                                                                     |                                        |     | 10                                    | pF   |
| V <sub>OL3</sub>                            | Output low-level threshold open-drain at 3-mA sink current                                                                                                                                                                                                                                            |                                        |     | 0.2 × V <sub>DD5</sub> <sup>(1)</sup> | V    |
| I <sub>OLmin</sub>                          | Low-level output current @V <sub>OL</sub> = 0.2 × V <sub>DD5</sub>                                                                                                                                                                                                                                    | 3                                      |     |                                       | mA   |
| t <sub>OF</sub>                             | Output fall time from V <sub>IHmin</sub> to V <sub>ILmax</sub> with a bus capacitance C <sub>B</sub> from 10 pF to 400 pF                                                                                                                                                                             | 20 + 0.1 × C <sub>B</sub>              |     | 250                                   | ns   |
| <b>I<sup>2</sup>C Standard Mode – 3.3 V</b> |                                                                                                                                                                                                                                                                                                       |                                        |     |                                       |      |
| V <sub>IH</sub>                             | Input high-level threshold                                                                                                                                                                                                                                                                            | 0.7 × V <sub>DD5</sub> <sup>(1)</sup>  |     |                                       | V    |
| V <sub>IL</sub>                             | Input low-level threshold                                                                                                                                                                                                                                                                             |                                        |     | 0.3 × V <sub>DD5</sub> <sup>(1)</sup> | V    |
| V <sub>hys</sub>                            | Hysteresis                                                                                                                                                                                                                                                                                            | 0.05 × V <sub>DD5</sub> <sup>(1)</sup> |     |                                       | V    |
| I <sub>IN</sub>                             | Input current at each I/O pin with an input voltage between 0.1 × V <sub>DD5</sub> to 0.9 × V <sub>DD5</sub>                                                                                                                                                                                          | 31                                     |     | 80                                    | μA   |
| I <sub>OZ</sub>                             | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V <sub>DD5</sub> and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> | 31                                     |     | 80                                    | μA   |
| C <sub>IN</sub>                             | Input capacitance                                                                                                                                                                                                                                                                                     |                                        |     | 10                                    | pF   |
| V <sub>OL3</sub>                            | Output low-level threshold open-drain at 3-mA sink current                                                                                                                                                                                                                                            |                                        |     | 0.4                                   | V    |
| I <sub>OLmin</sub>                          | Low-level output current @V <sub>OL</sub> = 0.4 V                                                                                                                                                                                                                                                     | 3                                      |     |                                       | mA   |
| I <sub>OLmin</sub>                          | Low-level output current @V <sub>OL</sub> = 0.6 V for full drive load (400 pF / 400 kHz)                                                                                                                                                                                                              | 6                                      |     |                                       | mA   |
| t <sub>OF</sub>                             | Output fall time from V <sub>IHmin</sub> to V <sub>ILmax</sub> with a bus capacitance C <sub>B</sub> from 5 pF to 400 pF                                                                                                                                                                              |                                        |     | 250                                   | ns   |
| <b>I<sup>2</sup>C Fast Mode – 3.3 V</b>     |                                                                                                                                                                                                                                                                                                       |                                        |     |                                       |      |

**Table 5-7. Dual Voltage LVCMOS I2C DC Electrical Characteristics<sup>(2)</sup> (continued)**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER          |                                                                                                                                                                                                                                                                                                       | MIN                                    | NOM | MAX                                   | UNIT |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----|---------------------------------------|------|
| V <sub>IH</sub>    | Input high-level threshold                                                                                                                                                                                                                                                                            | 0.7 × V <sub>DD5</sub> <sup>(1)</sup>  |     |                                       | V    |
| V <sub>IL</sub>    | Input low-level threshold                                                                                                                                                                                                                                                                             |                                        |     | 0.3 × V <sub>DD5</sub> <sup>(1)</sup> | V    |
| V <sub>hys</sub>   | Hysteresis                                                                                                                                                                                                                                                                                            | 0.05 × V <sub>DD5</sub> <sup>(1)</sup> |     |                                       | V    |
| I <sub>IN</sub>    | Input current at each I/O pin with an input voltage between 0.1 × V <sub>DD5</sub> to 0.9 × V <sub>DD5</sub>                                                                                                                                                                                          | 31                                     |     | 80                                    | μA   |
| I <sub>OZ</sub>    | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V <sub>DD5</sub> and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> | 31                                     |     | 80                                    | μA   |
| C <sub>IN</sub>    | Input capacitance                                                                                                                                                                                                                                                                                     |                                        |     | 10                                    | pF   |
| V <sub>OL3</sub>   | Output low-level threshold open-drain at 3-mA sink current                                                                                                                                                                                                                                            |                                        |     | 0.4                                   | V    |
| I <sub>OLmin</sub> | Low-level output current @V <sub>OL</sub> = 0.4 V                                                                                                                                                                                                                                                     | 3                                      |     |                                       | mA   |
| I <sub>OLmin</sub> | Low-level output current @V <sub>OL</sub> = 0.6 V for full drive load (400 pF/400 kHz)                                                                                                                                                                                                                | 6                                      |     |                                       | mA   |
| t <sub>OF</sub>    | Output fall time from V <sub>IHmin</sub> to V <sub>ILmax</sub> with a bus capacitance C <sub>B</sub> from 10 pF to 200 pF (Proper External Resistor Value should be used as per I2C spec)                                                                                                             | 20 + 0.1 × C <sub>B</sub>              |     | 250                                   | ns   |
|                    | Output fall time from V <sub>IHmin</sub> to V <sub>ILmax</sub> with a bus capacitance C <sub>B</sub> from 300 pF to 400 pF (Proper External Resistor Value should be used as per I2C spec)                                                                                                            | 40                                     |     | 290                                   |      |

(1) V<sub>DD5</sub> in this table stands for corresponding power supply (i.e. vddshv3). For more information on the power supply name and the corresponding ball, see [Table 4-1](#), POWER [11] column.

(2) For more information on the I/O cell configurations, see the Control Module section of the Device TRM.

**Table 5-8. IQ1833 Buffers DC Electrical Characteristics**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                               |                                                                   | MIN                     | NOM | MAX                     | UNIT |
|-----------------------------------------|-------------------------------------------------------------------|-------------------------|-----|-------------------------|------|
| <b>Signal Names in MUXMODE 0:</b> tclk; |                                                                   |                         |     |                         |      |
| <b>Balls:</b> E20;                      |                                                                   |                         |     |                         |      |
| <b>1.8-V Mode</b>                       |                                                                   |                         |     |                         |      |
| V <sub>IH</sub>                         | Input high-level threshold (Does not meet JEDEC V <sub>IH</sub> ) | 0.75 × V <sub>DD5</sub> |     |                         | V    |
| V <sub>IL</sub>                         | Input low-level threshold (Does not meet JEDEC V <sub>IL</sub> )  |                         |     | 0.25 × V <sub>DD5</sub> | V    |
| V <sub>HYS</sub>                        | Input hysteresis voltage                                          | 100                     |     |                         | mV   |
| I <sub>IN</sub>                         | Input current at each I/O pin                                     | 2                       |     | 11                      | μA   |
| C <sub>PAD</sub>                        | Pad capacitance (including package capacitance)                   |                         |     | 1                       | pF   |
| <b>3.3-V Mode</b>                       |                                                                   |                         |     |                         |      |
| V <sub>IH</sub>                         | Input high-level threshold (Does not meet JEDEC V <sub>IH</sub> ) | 2.0                     |     |                         | V    |
| V <sub>IL</sub>                         | Input low-level threshold (Does not meet JEDEC V <sub>IL</sub> )  |                         |     | 0.6                     | V    |
| V <sub>HYS</sub>                        | Input hysteresis voltage                                          | 400                     |     |                         | mV   |
| I <sub>IN</sub>                         | Input current at each I/O pin                                     | 5                       |     | 11                      | μA   |
| C <sub>PAD</sub>                        | Pad capacitance (including package capacitance)                   |                         |     | 1                       | pF   |

(1) V<sub>DD5</sub> in this table stands for corresponding power supply (i.e. vddshv3). For more information on the power supply name and the corresponding ball, see [Table 4-1](#), POWER [11] column.

**Table 5-9. IHHV1833 Buffers DC Electrical Characteristics**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                                   |                                                 | MIN  | NOM | MAX | UNIT |
|-----------------------------------------------------------------------------|-------------------------------------------------|------|-----|-----|------|
| <b>Signal Names in MUXMODE 0:</b> porz / rtc_iso / rtc_porz / wakeup [3:0]; |                                                 |      |     |     |      |
| <b>Balls:</b> F22 / AF14 / AB17 / AD17 / AC17 / AB16 / AC16;                |                                                 |      |     |     |      |
| <b>1.8-V Mode</b>                                                           |                                                 |      |     |     |      |
| V <sub>IH</sub>                                                             | Input high-level threshold                      | 1.2  |     |     | V    |
| V <sub>IL</sub>                                                             | Input low-level threshold                       |      |     | 0.4 | V    |
| V <sub>HYS</sub>                                                            | Input hysteresis voltage                        | 40   |     |     | mV   |
| I <sub>IN</sub>                                                             | Input current at each I/O pin                   | 0.02 |     | 1   | μA   |
| C <sub>PAD</sub>                                                            | Pad capacitance (including package capacitance) |      |     | 1   | pF   |
| <b>3.3-V Mode</b>                                                           |                                                 |      |     |     |      |
| V <sub>IH</sub>                                                             | Input high-level threshold                      | 1.2  |     |     | V    |
| V <sub>IL</sub>                                                             | Input low-level threshold                       |      |     | 0.4 | V    |
| V <sub>HYS</sub>                                                            | Input hysteresis voltage                        | 40   |     |     | mV   |
| I <sub>IN</sub>                                                             | Input current at each I/O pin                   | 5    |     | 8   | μA   |
| C <sub>PAD</sub>                                                            | Pad capacitance (including package capacitance) |      |     | 1   | pF   |

**Table 5-10. LVCMOS OSC Buffers DC Electrical Characteristics**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                          |                                                 | MIN                     | NOM | MAX                     | UNIT |
|--------------------------------------------------------------------|-------------------------------------------------|-------------------------|-----|-------------------------|------|
| <b>Signal Names in MUXMODE 0:</b> rtc_osc_xi_clkin32 / rtc_osc_xo; |                                                 |                         |     |                         |      |
| <b>Balls:</b> AE14 / AD14;                                         |                                                 |                         |     |                         |      |
| <b>1.8-V Mode</b>                                                  |                                                 |                         |     |                         |      |
| V <sub>IH</sub>                                                    | Input high-level threshold                      | 0.65 × V <sub>DDS</sub> |     |                         | V    |
| V <sub>IL</sub>                                                    | Input low-level threshold                       |                         |     | 0.35 × V <sub>DDS</sub> | V    |
| V <sub>HYS</sub>                                                   | Input hysteresis voltage                        | 150                     |     |                         | mV   |
| C <sub>PAD</sub>                                                   | Pad capacitance (including package capacitance) |                         |     | 3                       | pF   |

(1) V<sub>DDS</sub> in this table stands for corresponding power supply (i.e. vdda\_rtc). For more information on the power supply name and the corresponding ball, see [Table 4-1](#), POWER [11] column.

**Table 5-11. BC1833IHHV Buffers DC Electrical Characteristics**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                 |                                                                                                                                                                                                                                                                                                       | MIN                                    | NOM | MAX  | UNIT |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----|------|------|
| <b>Signal Names in MUXMODE 0:</b> on_off; |                                                                                                                                                                                                                                                                                                       |                                        |     |      |      |
| <b>Balls:</b> Y11;                        |                                                                                                                                                                                                                                                                                                       |                                        |     |      |      |
| <b>1.8-V Mode</b>                         |                                                                                                                                                                                                                                                                                                       |                                        |     |      |      |
| V <sub>OH</sub>                           | Output high-level threshold (I <sub>OH</sub> = 2 mA)                                                                                                                                                                                                                                                  | V <sub>DDS</sub> <sup>(1)</sup> - 0.45 |     |      | V    |
| V <sub>OL</sub>                           | Output low-level threshold (I <sub>OL</sub> = 2 mA)                                                                                                                                                                                                                                                   |                                        |     | 0.45 | V    |
| I <sub>DRIVE</sub>                        | Pin Drive strength at PAD Voltage = 0.45 V or V <sub>DDS</sub> - 0.45 V                                                                                                                                                                                                                               | 6                                      |     |      | mA   |
| I <sub>IN</sub>                           | Input current at each I/O pin                                                                                                                                                                                                                                                                         | 6                                      |     | 12   | μA   |
| I <sub>OZ</sub>                           | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BiDi cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V <sub>DDS</sub> and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> |                                        |     | 6    | μA   |
| C <sub>PAD</sub>                          | Pad capacitance (including package capacitance)                                                                                                                                                                                                                                                       |                                        |     | 4    | pF   |
| <b>3.3-V Mode</b>                         |                                                                                                                                                                                                                                                                                                       |                                        |     |      |      |
| V <sub>OH</sub>                           | Output high-level threshold (I <sub>OH</sub> = 100 μA)                                                                                                                                                                                                                                                | V <sub>DDS</sub> <sup>(1)</sup> - 0.2  |     |      | V    |

**Table 5-11. BC1833IHHV Buffers DC Electrical Characteristics (continued)**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER          |                                                                                                                                                                                                                                                                                           | MIN | NOM | MAX | UNIT |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|
| V <sub>OL</sub>    | Output low-level threshold (I <sub>OL</sub> = 100 µA)                                                                                                                                                                                                                                     |     |     | 0.2 | V    |
| I <sub>DRIVE</sub> | Pin Drive strength at PAD Voltage = 0.45 V or VDD5 - 0.45 V                                                                                                                                                                                                                               | 6   |     |     | mA   |
| I <sub>IN</sub>    | Input current at each I/O pin                                                                                                                                                                                                                                                             |     |     | 60  | µA   |
| I <sub>OZ</sub>    | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> |     |     | 60  | µA   |
| C <sub>PAD</sub>   | Pad capacitance (including package capacitance)                                                                                                                                                                                                                                           |     |     | 4   | pF   |

(1) VDD5 in this table stands for corresponding power supply (i.e. vddshv5). For more information on the power supply name and the corresponding ball, see [Table 4-1](#), POWER [11] column.

**Table 5-12. Dual Voltage SDIO1833 DC Electrical Characteristics**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                                                         |                                                                                                                                                                                                                                                                                           | MIN                         | NOM | MAX                        | UNIT |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-----|----------------------------|------|
| <b>Signal Names in Mode 0:</b> mmc1_clk, mmc1_cmd, mmc1_data[3:0] |                                                                                                                                                                                                                                                                                           |                             |     |                            |      |
| <b>Bottom Balls:</b> W6 / Y6 / AA6 / Y4 / AA5 / Y3                |                                                                                                                                                                                                                                                                                           |                             |     |                            |      |
| <b>1.8-V Mode</b>                                                 |                                                                                                                                                                                                                                                                                           |                             |     |                            |      |
| V <sub>IH</sub>                                                   | Input high-level threshold                                                                                                                                                                                                                                                                | 1.27                        |     |                            | V    |
| V <sub>IL</sub>                                                   | Input low-level threshold                                                                                                                                                                                                                                                                 |                             |     | 0.58                       | V    |
| V <sub>HYS</sub>                                                  | Input hysteresis voltage                                                                                                                                                                                                                                                                  | 50 <sup>(2)</sup>           |     |                            | mV   |
| I <sub>IN</sub>                                                   | Input current at each I/O pin                                                                                                                                                                                                                                                             |                             |     | 30                         | µA   |
| I <sub>OZ</sub>                                                   | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> |                             |     | 30                         | µA   |
| I <sub>IN</sub> with pulldown enabled                             | Input current at each I/O pin with weak pulldown enabled measured when PAD = VDD5                                                                                                                                                                                                         | 50                          | 120 | 210                        | µA   |
| I <sub>IN</sub> with pullup enabled                               | Input current at each I/O pin with weak pullup enabled measured when PAD = 0                                                                                                                                                                                                              | 60                          | 120 | 200                        | µA   |
| C <sub>PAD</sub>                                                  | Pad capacitance (including package capacitance)                                                                                                                                                                                                                                           |                             |     | 5                          | pF   |
| V <sub>OH</sub>                                                   | Output high-level threshold (I <sub>OH</sub> = 2 mA)                                                                                                                                                                                                                                      | 1.4                         |     |                            | V    |
| V <sub>OL</sub>                                                   | Output low-level threshold (I <sub>OL</sub> = 2 mA)                                                                                                                                                                                                                                       |                             |     | 0.45                       | V    |
| <b>3.3-V Mode</b>                                                 |                                                                                                                                                                                                                                                                                           |                             |     |                            |      |
| V <sub>IH</sub>                                                   | Input high-level threshold                                                                                                                                                                                                                                                                | 0.625 × VDD5 <sup>(1)</sup> |     |                            | V    |
| V <sub>IL</sub>                                                   | Input low-level threshold                                                                                                                                                                                                                                                                 |                             |     | 0.25 × VDD5 <sup>(1)</sup> | V    |
| V <sub>HYS</sub>                                                  | Input hysteresis voltage                                                                                                                                                                                                                                                                  | 40 <sup>(2)</sup>           |     |                            | mV   |
| I <sub>IN</sub>                                                   | Input current at each I/O pin                                                                                                                                                                                                                                                             |                             |     | 110                        | µA   |
| I <sub>OZ</sub>                                                   | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the Max(I <sub>PAD</sub> ) is measured and is reported as I <sub>OZ</sub> |                             |     | 110                        | µA   |
| I <sub>IN</sub> with pulldown enabled                             | Input current at each I/O pin with weak pulldown enabled measured when PAD = VDD5                                                                                                                                                                                                         | 40                          | 100 | 290                        | µA   |
| I <sub>IN</sub> with pullup enabled                               | Input current at each I/O pin with weak pullup enabled measured when PAD = 0                                                                                                                                                                                                              | 10                          | 100 | 290                        | µA   |
| C <sub>PAD</sub>                                                  | Pad capacitance (including package capacitance)                                                                                                                                                                                                                                           |                             |     | 5                          | pF   |

**Table 5-12. Dual Voltage SDIO1833 DC Electrical Characteristics (continued)**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER       |                                                      | MIN                                     | NOM | MAX | UNIT |
|-----------------|------------------------------------------------------|-----------------------------------------|-----|-----|------|
| V <sub>OH</sub> | Output high-level threshold (I <sub>OH</sub> = 2 mA) | 0.75 × V <sub>DD5</sub> <sup>(1)</sup>  |     |     | V    |
| V <sub>OL</sub> | Output low-level threshold (I <sub>OL</sub> = 2 mA)  | 0.125 × V <sub>DD5</sub> <sup>(1)</sup> |     |     | V    |

(1) V<sub>DD5</sub> in this table stands for corresponding power supply (i.e. vddshv8). For more information on the power supply name and the corresponding ball, see [Table 4-1, POWER \[11\]](#) column.

(2) Hysteresis is enabled/disabled with CTRL\_CORE\_CONTROL\_HYST\_1.SDCARD\_HYST register.

**Table 5-13. Dual Voltage LVCMOS DC Electrical Characteristics**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                             |                                                                                                                                                                                                                                                                                                         | MIN                     | NOM | MAX | UNIT |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----|-----|------|
| 1.8-V Mode                            |                                                                                                                                                                                                                                                                                                         |                         |     |     |      |
| V <sub>IH</sub>                       | Input high-level threshold                                                                                                                                                                                                                                                                              | 0.65 × V <sub>DD5</sub> |     |     | V    |
| V <sub>IL</sub>                       | Input low-level threshold                                                                                                                                                                                                                                                                               | 0.35 × V <sub>DD5</sub> |     |     | V    |
| V <sub>HYS</sub>                      | Input hysteresis voltage                                                                                                                                                                                                                                                                                | 100                     |     |     | mV   |
| V <sub>OH</sub>                       | Output high-level threshold (I <sub>OH</sub> = 2 mA)                                                                                                                                                                                                                                                    | V <sub>DD5</sub> - 0.45 |     |     | V    |
| V <sub>OL</sub>                       | Output low-level threshold (I <sub>OL</sub> = 2 mA)                                                                                                                                                                                                                                                     | 0.45                    |     |     | V    |
| I <sub>DRIVE</sub>                    | Pin Drive strength at PAD Voltage = 0.45 V or V <sub>DD5</sub> - 0.45 V                                                                                                                                                                                                                                 | 6                       |     |     | mA   |
| I <sub>IN</sub>                       | Input current at each I/O pin                                                                                                                                                                                                                                                                           | 16                      |     |     | μA   |
| I <sub>OZ</sub>                       | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V <sub>DD5</sub> and the Max(I <sub>(PAD)</sub> ) is measured and is reported as I <sub>OZ</sub> | 16                      |     |     | μA   |
| I <sub>IN</sub> with pulldown enabled | Input current at each I/O pin with weak pulldown enabled measured when PAD = V <sub>DD5</sub>                                                                                                                                                                                                           | 50                      | 120 | 210 | μA   |
| I <sub>IN</sub> with pullup enabled   | Input current at each I/O pin with weak pullup enabled measured when PAD = 0                                                                                                                                                                                                                            | 60                      | 120 | 200 | μA   |
| C <sub>PAD</sub>                      | Pad capacitance (including package capacitance)                                                                                                                                                                                                                                                         | 4                       |     |     | pF   |
| Z <sub>O</sub>                        | Output impedance (drive strength)                                                                                                                                                                                                                                                                       | 40                      |     |     | Ω    |
| 3.3-V Mode                            |                                                                                                                                                                                                                                                                                                         |                         |     |     |      |
| V <sub>IH</sub>                       | Input high-level threshold                                                                                                                                                                                                                                                                              | 2                       |     |     | V    |
| V <sub>IL</sub>                       | Input low-level threshold                                                                                                                                                                                                                                                                               | 0.8                     |     |     | V    |
| V <sub>HYS</sub>                      | Input hysteresis voltage                                                                                                                                                                                                                                                                                | 200                     |     |     | mV   |
| V <sub>OH</sub>                       | Output high-level threshold (I <sub>OH</sub> = 100 μA)                                                                                                                                                                                                                                                  | V <sub>DD5</sub> - 0.2  |     |     | V    |
| V <sub>OL</sub>                       | Output low-level threshold (I <sub>OL</sub> = 100 μA)                                                                                                                                                                                                                                                   | 0.2                     |     |     | V    |
| I <sub>DRIVE</sub>                    | Pin Drive strength at PAD Voltage = 0.45 V or V <sub>DD5</sub> - 0.45 V                                                                                                                                                                                                                                 | 6                       |     |     | mA   |
| I <sub>IN</sub>                       | Input current at each I/O pin                                                                                                                                                                                                                                                                           | 65                      |     |     | μA   |
| I <sub>OZ</sub>                       | I <sub>OZ</sub> (I <sub>PAD</sub> Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V <sub>DD5</sub> and the Max(I <sub>(PAD)</sub> ) is measured and is reported as I <sub>OZ</sub> | 65                      |     |     | μA   |
| I <sub>IN</sub> with pulldown enabled | Input current at each I/O pin with weak pulldown enabled measured when PAD = V <sub>DD5</sub>                                                                                                                                                                                                           | 40                      | 100 | 200 | μA   |
| I <sub>IN</sub> with pullup enabled   | Input current at each I/O pin with weak pullup enabled measured when PAD = 0                                                                                                                                                                                                                            | 10                      | 100 | 290 | μA   |
| C <sub>PAD</sub>                      | Pad capacitance (including package capacitance)                                                                                                                                                                                                                                                         | 4                       |     |     | pF   |
| Z <sub>O</sub>                        | Output impedance (drive strength)                                                                                                                                                                                                                                                                       | 40                      |     |     | Ω    |

**Table 5-13. Dual Voltage LVC MOS DC Electrical Characteristics (continued)**

over operating free-air temperature range (unless otherwise noted)

- (1) VDDS in this table stands for corresponding power supply. For more information on the power supply name and the corresponding ball, see [Table 4-1](#), POWER [11] column.

### 5.7.1 HDMIPHY DC Electrical Characteristics

The HDMIPHY DC Electrical Characteristics are compliant with the HDMI 1.4a specification and are not reproduced here.

### 5.7.2 SATAPHY DC Electrical Characteristics

#### NOTE

The SATA module is compliant with the electrical parameters specified in the *SATA-IO SATA Specification*, Revision 3.2, August 7, 2013.

### 5.7.3 USBPHY DC Electrical Characteristics

#### NOTE

USB1 instance is compliant with the USB3.0 SuperSpeed Transmitter and Receiver Normative Electrical Parameters as defined in the USB3.0 Specification Rev 1.0 dated Jun 6, 2011.

#### NOTE

USB1 and USB2 Electrical Characteristics are compliant with USB2.0 Specification Rev 2.0 dated April 27, 2000 including ECNs and Errata as applicable.

### 5.7.4 PCIEPHY DC Electrical Characteristics

#### NOTE

The PCIe interfaces are compliant with the electrical parameters specified in PCI Express® Base Specification Revision 3.0.

## 5.8 VPP Specifications for One-Time Programmable (OTP) eFuses

This section specifies the operating conditions required for programming the OTP eFuses and is applicable only for High-Security Devices.

**Table 5-14. Recommended Operating Conditions for OTP eFuse Programming**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | DESCRIPTION                                                                            | MIN  | NOM  | MAX | UNIT |
|-----------|----------------------------------------------------------------------------------------|------|------|-----|------|
| vdd_core  | Supply voltage range for the core domain during OTP operation; OPP NOM (BOOT)          | 1.11 | 1.15 | 1.2 | V    |
| vpp       | Supply voltage range for the eFuse ROM domain during normal operation                  | NC   |      |     | V    |
|           | Supply voltage range for the eFuse ROM domain during OTP programming <sup>(1)(2)</sup> | 1.8  |      |     | V    |
| I(vpp)    |                                                                                        |      |      | 100 | mA   |
| Tj        | Temperature (junction)                                                                 | 0    | 25   | 85  | °C   |

- (1) Supply voltage range includes DC errors and peak-to-peak noise. TI power management solutions [TLV70018-Q1](#) from the TLV700xx family meet the supply voltage range needed for vpp.

## Recommended Operating Conditions for OTP eFuse Programming (*continued*)

over operating free-air temperature range (unless otherwise noted)

- (2) During normal operation, no voltage should be applied to vpp. This can be typically achieved by disabling the regulator attached to the vpp terminal. For more details, see [TLV700xx-Q1 300-mA, Low-IQ, Low-Dropout Regulator](#).

### 5.8.1 Hardware Requirements

The following hardware requirements must be met when programming keys in the OTP eFuses:

- The vpp power supply must be disabled when not programming OTP registers.
- The vpp power supply must be ramped up after the proper device power-up sequence (for more details, see [Section 5.10.3](#)).

### 5.8.2 Programming Sequence

Programming sequence for OTP eFuses:

- Power on the board per the power-up sequencing. No voltage should be applied on the vpp terminal during power up and normal operation.
- Load the OTP write software required to program the eFuse (contact your local TI representative for the OTP software package).
- Apply the voltage on the vpp terminal according to the specification in [Table 5-14](#).
- Run the software that programs the OTP registers.
- After validating the content of the OTP registers, remove the voltage from the vpp terminal.

### 5.8.3 Impact to Your Hardware Warranty

You accept that e-Fusing the TI Devices with security keys permanently alters them. You acknowledge that the e-Fuse can fail, for example, due to incorrect or aborted program sequence or if you omit a sequence step. Further the TI Device may fail to secure boot if the error code correction check fails for the Production Keys or if the image is not signed and optionally encrypted with the current active Production Keys. These types of situations will render the TI Device inoperable and TI will be unable to confirm whether the TI Devices conformed to their specifications prior to the attempted e-Fuse. CONSEQUENTLY, TI WILL HAVE NO LIABILITY (WARRANTY OR OTHERWISE) FOR ANY TI DEVICES THAT HAVE BEEN e-FUSED WITH SECURITY KEYS.

## 5.9 Thermal Resistance Characteristics

For reliability and operability concerns, the maximum junction temperature of the Device has to be at or below the  $T_j$  value identified in , *Recommended Operating Conditions*.

A BCI compact thermal model for this Device is available and recommended for use when modeling thermal performance in a system.

Therefore, it is recommended to perform thermal simulations at the system level with the worst case device power consumption.

### 5.9.1 Package Thermal Characteristics

[Table 5-15](#) provides the thermal resistance characteristics for the package used on this device.

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#### NOTE

Power dissipation of 1.5 W and an ambient temperature of 85°C is assumed for ABZ package.

---

**Table 5-15. Thermal Resistance Characteristics**

| NO. | PARAMETER       | DESCRIPTION             | °C/W <sup>(1) (3)</sup> | AIR FLOW (m/s) <sup>(2)</sup> |
|-----|-----------------|-------------------------|-------------------------|-------------------------------|
| T1  | R $\theta_{JC}$ | Junction-to-case        | 0.16                    | N/A                           |
| T2  | R $\theta_{JB}$ | Junction-to-board       | 3.12                    | N/A                           |
| T3  | R $\theta_{JA}$ | Junction-to-free air    | 13.02                   | 0                             |
| T4  |                 | Junction-to-moving air  | 7.71                    | 1                             |
| T5  |                 |                         | 6.76                    | 2                             |
| T6  |                 |                         | 6.24                    | 3                             |
| T7  | $\Psi_{JT}$     | Junction-to-package top | 0.09                    | 0                             |
| T8  |                 |                         | 0.09                    | 1                             |
| T9  |                 |                         | 0.09                    | 2                             |
| T10 |                 |                         | 0.09                    | 3                             |
| T11 | $\Psi_{JB}$     | Junction-to-board       | 2.88                    | 0                             |
| T12 |                 |                         | 2.74                    | 1                             |
| T13 |                 |                         | 2.67                    | 2                             |
| T14 |                 |                         | 2.61                    | 3                             |

(1) These values are based on a JEDEC defined 2S2P system (with the exception of the Theta JC [R $\theta_{JC}$ ] value, which is based on a JEDEC defined 1S0P system) and will change based on environment as well as application. For more information, see these EIA/JEDEC standards:

- JESD51-2, *Integrated Circuits Thermal Test Method Environment Conditions - Natural Convection (Still Air)*
- JESD51-3, *Low Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*
- JESD51-6, *Integrated Circuit Thermal Test Method Environmental Conditions - Forced Convection (Moving Air)*
- JESD51-7, *High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*
- JESD51-9, *Test Boards for Area Array Surface Mount Packages*

(2) m/s = meters per second.

(3) °C/W = degrees Celsius per watt.

## 5.10 Timing Requirements and Switching Characteristics

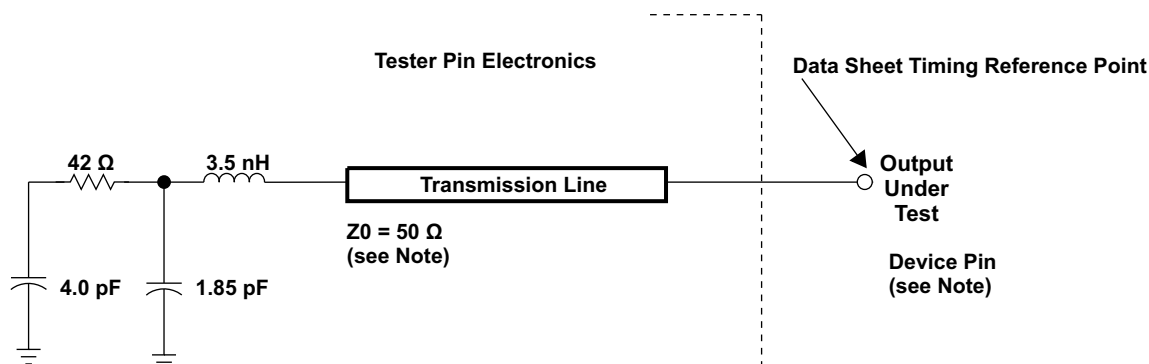
### 5.10.1 Timing Parameters and Information

The timing parameter symbols used in the timing requirement and switching characteristic tables are created in accordance with JEDEC Standard 100. To shorten the symbols, some of pin names and other related terminologies have been abbreviated as follows:

**Table 5-16. Timing Parameters**

| SUBSCRIPTS |                                        |
|------------|----------------------------------------|
| SYMBOL     | PARAMETER                              |
| c          | Cycle time (period)                    |
| d          | Delay time                             |
| dis        | Disable time                           |
| en         | Enable time                            |
| h          | Hold time                              |
| su         | Setup time                             |
| START      | Start bit                              |
| t          | Transition time                        |
| v          | Valid time                             |
| w          | Pulse duration (width)                 |
| X          | Unknown, changing, or don't care level |
| F          | Fall time                              |
| H          | High                                   |
| L          | Low                                    |
| R          | Rise time                              |
| V          | Valid                                  |
| IV         | Invalid                                |
| AE         | Active Edge                            |
| FE         | First Edge                             |
| LE         | Last Edge                              |
| Z          | High impedance                         |

### 5.10.1.1 Parameter Information



NOTE: The data sheet provides timing at the device pin. For output timing analysis, the tester pin electronics and its transmission line effects must be taken into account. A transmission line with a delay of 2 ns can be used to produce the desired transmission line effect. The transmission line is intended as a load only. It is not necessary to add or subtract the transmission line delay (2 ns) from the data sheet timings.

Input requirements in this data sheet are tested with an input slew rate of < 4 Volts per nanosecond (4 V/ns) at the device pin.

pm\_tstcirc\_prs403

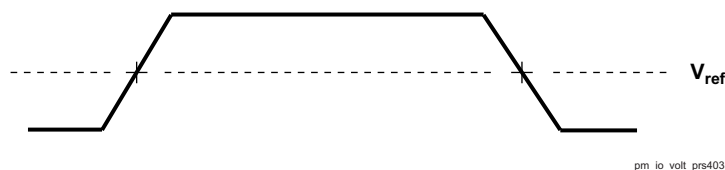
**Figure 5-2. Test Load Circuit for AC Timing Measurements**

The load capacitance value stated is only for characterization and measurement of AC timing signals.

This load capacitance value does not indicate the maximum load the device is capable of driving.

#### 5.10.1.1.1 1.8V and 3.3V Signal Transition Levels

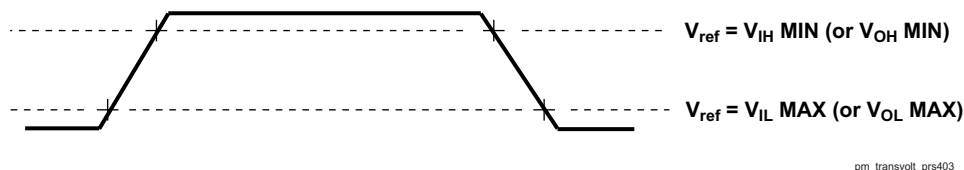
All input and output timing parameters are referenced to  $V_{ref}$  for both "0" and "1" logic levels.  $V_{ref} = (V_{DD} I/O)/2$ .



pm\_io\_volt\_prs403

**Figure 5-3. Input and Output Voltage Reference Levels for AC Timing Measurements**

All rise and fall transition timing parameters are referenced to  $V_{IL}$  MAX and  $V_{IH}$  MIN for input clocks,  $V_{OL}$  MAX and  $V_{OH}$  MIN for output clocks.



pm\_transvolt\_prs403

**Figure 5-4. Rise and Fall Transition Time Voltage Reference Levels**

#### 5.10.1.1.2 1.8V and 3.3V Signal Transition Rates

The default SLEWCONTROL settings in each pad configuration register must be used to guarantee timings, unless specific instructions otherwise are given in the individual timing subsections of the datasheet.

All timings are tested with an input edge rate of 4 volts per nanosecond (4 V/ns).

### 5.10.1.1.3 Timing Parameters and Board Routing Analysis

The timing parameter values specified in this Data Manual do not include delays by board routes. As a good board design practice, such delays must always be taken into account. Timing values may be adjusted by increasing/decreasing such delays. TI recommends using the available I/O buffer information specification (IBIS) models to analyze the timing characteristics correctly. To properly use IBIS models to attain accurate timing analysis for a given system, see the *Using IBIS Models for timing Analysis* application report (literature number [SPRA839](#)). If needed, external logic hardware such as buffers may be used to compensate any timing differences.

## 5.10.2 Interface Clock Specifications

### 5.10.2.1 Interface Clock Terminology

The interface clock is used at the system level to sequence the data and/or to control transfers accordingly with the interface protocol.

### 5.10.2.2 Interface Clock Frequency

The two interface clock characteristics are:

- The maximum clock frequency
- The maximum operating frequency

The interface clock frequency documented in this document is the maximum clock frequency, which corresponds to the maximum frequency programmable on this output clock. This frequency defines the maximum limit supported by the Device IC and does not take into account any system consideration (PCB, peripherals).

The system designer will have to consider these system considerations and the Device IC timing characteristics as well to define properly the maximum operating frequency that corresponds to the maximum frequency supported to transfer the data on this interface.

## 5.10.3 Power Supply Sequences

This section describes the power-up and power-down sequence required to ensure proper device operation. The power supply names described in this section comprise a superset of a family of compatible devices. Some members of this family will not include a subset of these power supplies and their associated device modules. Refer to [Section 4.2, Pin Attributes](#) for a specific device to determine which power supplies are applicable.

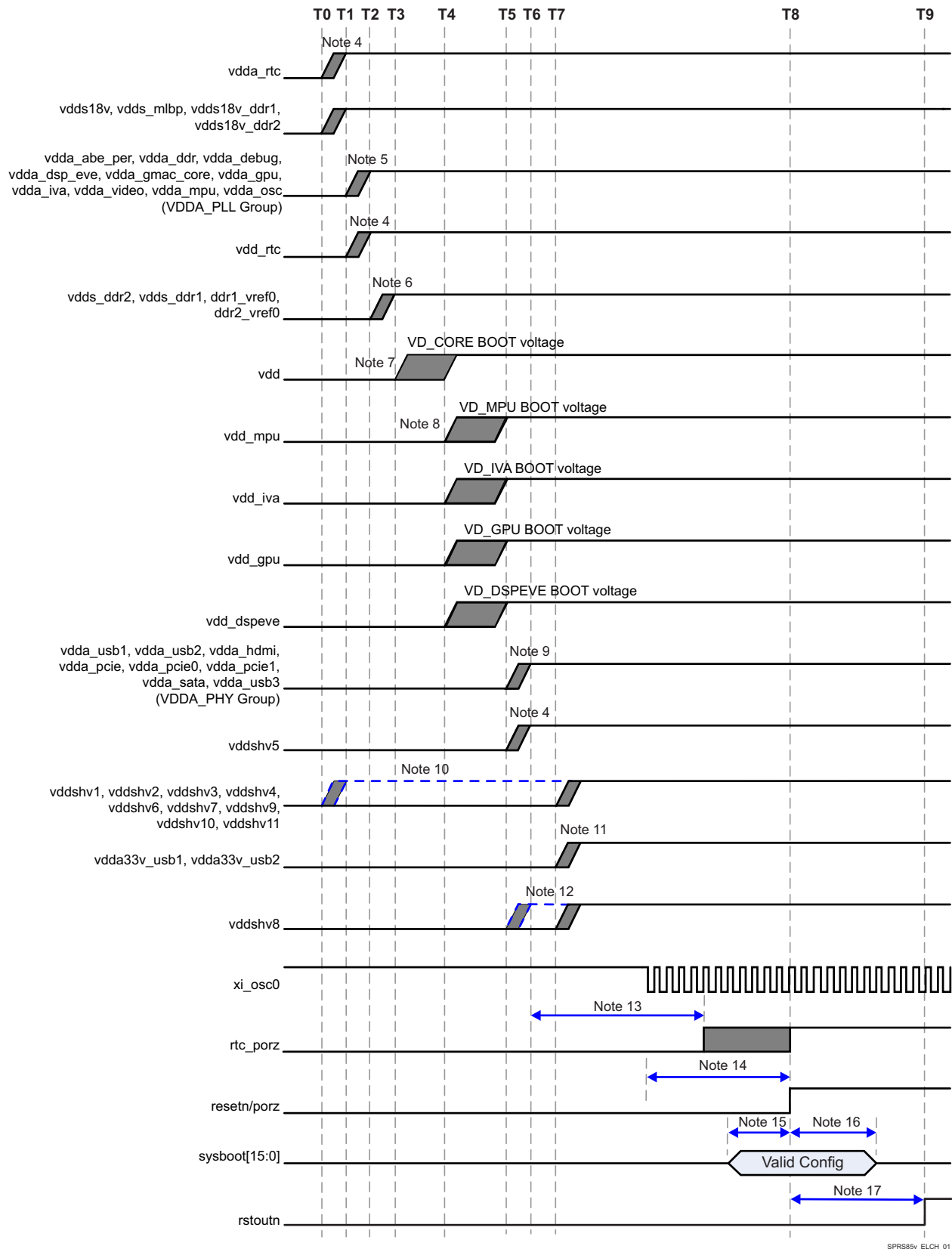
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#### NOTE

For more information, see Power, Reset and Clock Management / Reset Management Functional Description / Reset Sequences of the Device TRM.

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[Figure 5-5](#) and [Figure 5-6](#), describes the device power sequencing.



SPRS85v\_ELCH\_01

Figure 5-5. Recommended Power-Up Sequencing

(1) Time stamps:

- T0 = 0 ms; T1 = 0.55 ms; T2 = 1.1 ms; T3 = 1.65 ms; T4 = 2.2 ms; T5 = 2.75 ms; T6 = 3.3 ms; T7 = 5.85 ms; T8 = 6.4 ms; T9 = 8.4

ms. All "Tn" markers show total elapsed time from T0.

(2) Terminology:

- $V_{OPR\ MIN}$  = Minimum Operational Voltage level that ensures device functionality and specified performance per [Section 5.4, Recommended Operating Conditions](#).
- Ramp Up = transition time from  $V_{OFF}$  to  $V_{OPR\ MIN}$ .

(3) General timing diagram items:

- Grey shaded areas show valid transition times for supplies between  $V_{OPR\ MIN}$  and  $V_{OFF}$ .
- Dashed horizontal lines are not valid ramp times but show alternate transition times based upon common sources and clarified in associated note.
- Dashed vertical lines show approximate elapse times based upon TI recommended PMIC power sequencer circuit performance.

(4) vddshv5, vdd\_rtc, and vdda\_rtc domains:

- If RTC mode is used, then vdda\_rtc, vdd\_rtc and vddshv5 must be individually powered with separate power supplies and cannot be combined with other rails.
  - If RTC-mode is not supported then the following combinations are approved:
    - vdda\_rtc can be combined with vdds18v
    - vdd\_rtc can be combined with vdd
    - vddshv5 can be combined with other 1.8 V or 3.3 V vddshvn rails
- If combinations listed above are not followed then sequencing for these 3 voltage rails should follow the RTC mode timing requirements.

(5) vdda\_\* rails should not be combined with vdds18v\_\* for best performance to avoid transient switching noise impacts on analog domains. vdda\_\* should not ramp-up before vdds18v\_\* but could ramp concurrently if design ensures final operational voltage will not be reached until after vdds18v. The preferred sequence is to follow all vdds18v\_\* to ensure circuit components and PCB design do not cause an inadvertent violation.

(6) vdds\_dds\* should not ramp-up before vdds18v\_\*. The preferred sequence has vdds\_dds1 following vdds18v\_\* to ensure circuit components and PCB design do not cause an inadvertent violation. vdds\_dds1 can ramp-up before, concurrently or after vdda\_\*, there are no dependencies between vdds\_dds1 and vdda\_\* domains.

(7) vdd should not ramp-up before vdds18v\_\* or vdds\_dds\* domains have reached  $V_{OPR\ MIN}$ .

(8) vdd\_mpu, vdd\_iva, vdd\_gpu, vdd\_dspeve domains should follow vdd core supply as preferred sequence. If vdd\_mpu, vdd\_iva, vdd\_gpu, vdd\_dspeve domains ramp concurrently or quicker than vdd core, then vdd core must remain at least 150 mV greater than vdd\_mpu, vdd\_iva, vdd\_gpu, vdd\_dspeve domains during ramp. Circuit design (components and PCB) must ensure vdd reaches final operational voltage before any of the vdd\_mpu, vdd\_iva, vdd\_gpu, vdd\_dspeve domains.

(9) VDDA\_PHY group should not be combined with VDDA\_PLL group to avoid transient switching noise impacts.

(10) vddshv[1-4, 6, 7, 9-11] domains:

- If 1.8 V I/O signaling is needed, then 1.8 V must be sourced from common vdds18v supply and ramp up concurrently with vdds18v.
- If 3.3 V I/O signaling is needed, then 3.3 V vddshvx rails must ramp up after vdd\_mpu, vdd\_iva, vdd\_gpu, vdd\_dspeve, and VDDA\_PHY group domains.

(11) vdda33v\_usb[1-2] domain:

- If USB1 and USB2 interfaces are used, should be supplied from independent analog supply.
- If USB1/USB2 interface is not used, could be connected to VSS/GND if both conditions are met:
  - USB1/USB2 diff pair (usb1\_dm/usb1\_dp; usb2\_dm/usb2\_dp) pins are left unconnected
  - vdda\_usb1 and/or vdda\_usb2 PHY is not energized

(12) vddshv8 shows two ramp up options for 1.8 V I/O or 3.3 V I/O or SD Card operation:

- If 1.8 V I/O signaling is needed, then vddshv8 must ramp up after vdd and before or concurrently with 3.3 V vddshv\* rails.
- If 3.3 V I/O signaling is needed, then vddshv8 must be combined with other 3.3 V vddshv\* rails.
- If SD Card operation is needed, then vddshv8 must be sourced from a dual voltage (3.3 V / 1.8 V) power source per SDIO specifications and ramp up concurrently with 3.3 V vddshv\* rails.

(13) Pulse duration: rtc\_porz must remain low 1ms after vdda\_rtc, vddshv5, and vdd\_rtc are ramped and stable or can be de-asserted before but no later than porz. The FUNK\_32K\_CLK source must be stable and at a valid frequency 1 ms prior to de-asserting rtc\_porz high.

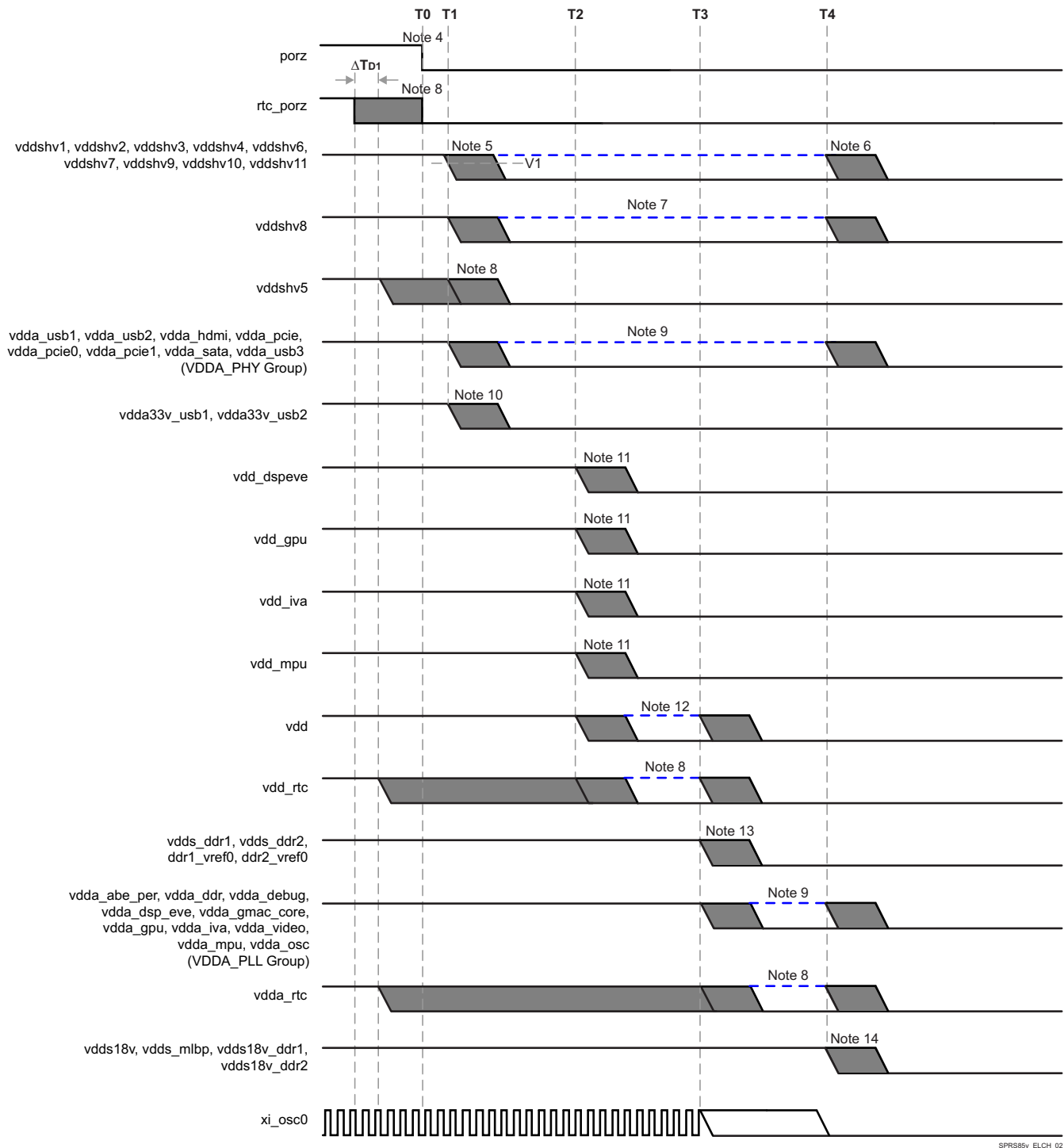
(14) porz must remain asserted low until both of the following conditions are met:

- Minimum of  $12 \times P$ , where  $P = 1 / (\text{SYS\_CLK1} / 610)$ , units in ns.
- All device supply rails reach stable operational levels.

(15) Setup time: sysboot[15:0] pins must be valid  $2P^{(14)}$  before porz is de-asserted high.

(16) Hold time: sysboot[15:0] pins must be valid  $15P^{(14)}$  after porz is de-asserted high.

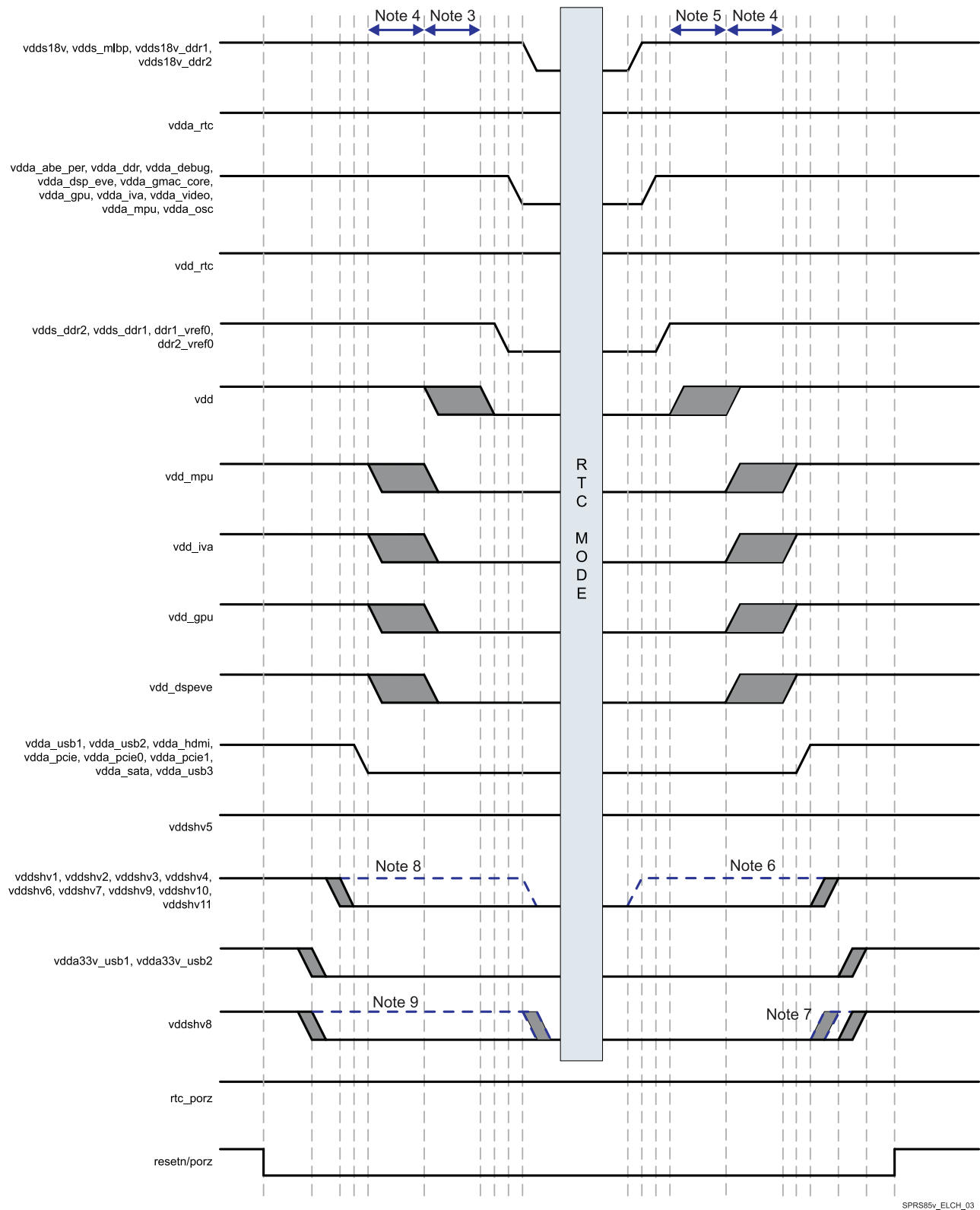
(17) rstoutn will be set high after global reset, due to porz, is de-asserted following an internal 2 ms delay. rstoutn is only valid after vddshv3 reaches an operational level. If used as a peripheral component reset, it should be AND gated with porz to avoid possible reset glitches during power up.


**Figure 5-6. Recommended Power-Down Sequencing**

- (1) Time stamps:
  - T0 = 0 ms, T1 > 100  $\mu$ s, T2 = 0.5 ms, T3 = 1.0 ms, T4 = 1.5 ms; V1 = 2.7 V. All “Tn” markers are intended to show elapsed times from T0. Delta time:  $\Delta T_{D1} > 100 \mu$ s.
- (2) Terminology:
  - V<sub>OPR MIN</sub> = Minimum Operational Voltage level that ensures device functionality and specified performance per [Section 5.4, Recommended Operating Conditions](#).
  - V<sub>OFF</sub> = OFF Voltage level is defined to be less than 0.6 V where any current draw has no impact to POH.
  - Ramp Down = transition time from V<sub>OPR MIN</sub> to V<sub>OFF</sub> and is slew rate independent.
- (3) General timing diagram items:

- Grey shaded areas show valid transition times for supplies between  $V_{OPR\_MIN}$  and  $V_{OFF}$ .
  - Dashed horizontal lines are not valid ramp times but show alternate transition times based upon common sources and clarified in associated note.
  - Dashed vertical lines show approximate elapse times based upon TI recommended PMIC power-down sequencer circuit performance.
- (4) porz signals must be asserted low for 100  $\mu$ s min to ensure SoC is set to a safe functional state before any voltage begins to ramp down.
- (5) vddshv\* domains supplied by 3.3 V:
- must remain greater than 2.7 V to enable Dual Voltage GPIO selector circuit operation for 100  $\mu$ s min after porz is asserted low.
  - must be in first group of supplies ramping down after porz has been asserted low for 100  $\mu$ s min.
  - must not exceed vdds18v by more than 2 V during ramp down, see [Figure 5-10](#) “vdds18v and vdda\_\* Discharge Relationship”.
- (6) vddshv\* domains supplied by 1.8 V:
- must ramp down concurrently with vdds18v and be sourced from the same vdds18v supply.
- (7) vddshv8 domain:
- must be in first group of supplies to ramp down after porz has been asserted low for 100  $\mu$ s min.
  - if SDIO operation is needed, must be sourced from independent power resource that can provide dual voltage (3.3 V / 1.8 V) operation as required to be compliant to SDIO specification
  - if SDIO operation is not needed, must be grouped and ramped down with other vddshv\* domains as noted above.
- (8) RTC domains (vddshv5, vdd\_rtc, and vdda\_rtc):
- If RTC mode is used:
    - rtc\_porz can be asserted low before porz and RTC domains can be ramped down after 100  $\mu$ s elapsed time.
    - must be sourced from independent supplies and must not be combined with other rails.
    - timing diagram shows this mode of operation.
  - If RTC mode is not used, then:
    - rtc\_porz must be connected to porz signal.
    - vddshv5 must be grouped and ramped down with other vddshv\* domains as noted above.
    - vdd\_rtc must be grouped and ramped down with vdd.
    - vdda\_rtc must be grouped and ramped down with either VDDA\_PHY group or vdds18v.
- (9) vdda\_\* domains:
- should not be combined with vdds18v for best performance to avoid transient switching noise impacts on analog domains.
  - can ramp down before or concurrently with vdds18v.
  - must satisfy the vdds18v and vdda\_\* Discharge Relationship (see [Figure 5-10](#)) if vdda\_\* disable point is later or discharge rate is slower than vdds18v.
  - can ramp down before, concurrently or after vdds\_ddr\*, there is no dependency between these supplies.
- (10) vdda33v\_usb\* domains:
- can start ramping down 100  $\mu$ s after low assertion of porz
  - can ramp down concurrently or before VDDA\_PHY group
- (11) vdd\_dspeve, vdd\_gpu, vdd\_iva, vdd\_mpu domains can ramp down before or concurrently with vdd.
- (12) vdd can ramp down concurrently or after with vdd\_dspeve, vdd\_gpu, vdd\_iva, vdd\_mpu domains.
- (13) vdds\_ddr\* domains:
- should ramp down after vdd begins ramping down.
- (14) vdds18v domain:
- should maintain  $V_{OPR\_MIN}$  ( $V_{NOM} - 5\% = 1.71$  V) until all other supplies start to ramp down.
  - must satisfy the vdds18v versus vddshv[1-7, 9-11] Discharge Relationship (see [Figure 5-8](#)) if vddshv\* is operating at 3.3 V
  - must satisfy the vdds18v and vdds\_ddr\* Discharge Relationship (see [Figure 5-9](#)) if vdds\_ddr\* discharge rate is slower than vdds18v.

[Figure 5-7](#) describes the RTC-mode power sequencing.



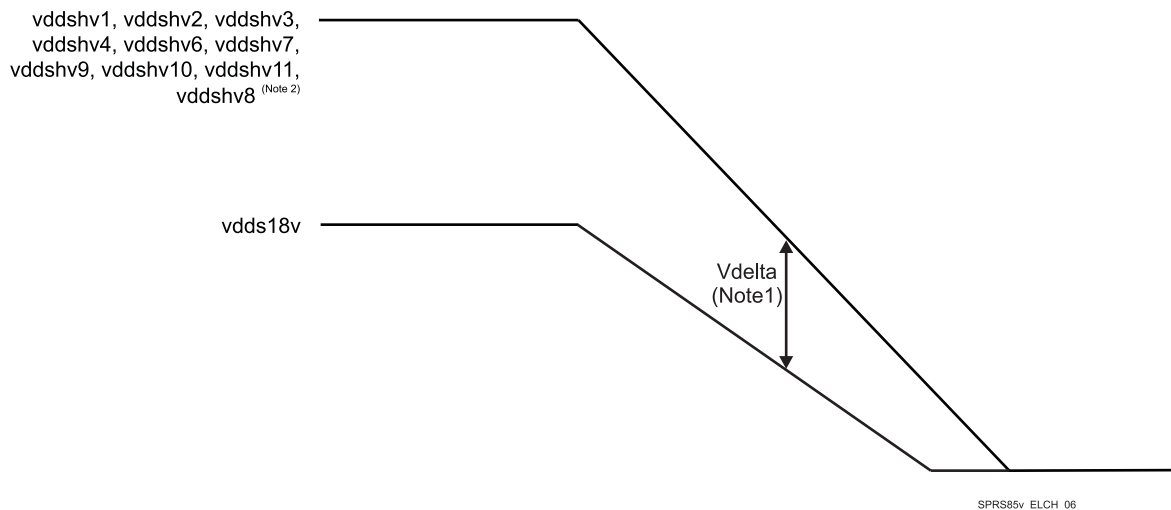
SPRS85v\_ELCH\_03

**Figure 5-7. RTC Mode Sequencing**

- (1) Grey shaded areas are windows where it is valid to ramp the voltage rail.
- (2) Blue dashed lines are not valid windows but show alternate ramp possibilities based on the associated note.

- (3) vdd must ramp down after or at the same time as vdd\_mpu, vdd\_gpu, vdd\_dspeve and vdd\_iva.
- (4) vdd\_mpu, vdd\_gpu, vdd\_dspeve, vdd\_iva can be ramped at the same time or can be staggered.
- (5) vdd must ramp up before or at the same time as vdd\_mpu, vdd\_gpu, vdd\_dspeve and vdd\_iva.
- (6) If any of the vddshv[1-7,9-11] rails (not including vddshv8) are used as 1.8 V only, then these rails can be combined with vdds18v.
- (7) vddshv8 is separated out to show support for dual voltage. If single voltage is used then vddshv8 can be combined with other vddshvn rails but vddshv8 must ramp down before vdd and must ramp up after vdd.
- (8) If any of the vddshv[1-7,9-11] rails (not including vddshv8) are used as 1.8 V only, then these rails can be combined with vdds18v. vddshv[1-7,9-11] is allowed to ramp down at either of the two points shown in the timing diagram in either 1.8 V mode or in 3.3 V mode. If vddshv[1-7,9-11] ramps down at the later time in the diagram then the board design must guarantee that the vddshvn rail is never higher than 2.0 V above the vdds18v rail.
- (9) vddshv8 is separated out to show support for dual voltage. If a dedicated LDO/supply source is used for vddshv8, then vddshv8 ramp down should occur at one of the two earliest points in the timing diagram. If vddshv8 is powered by the same supply source as the other vddshvn rails, then it is allowed to ramp down at either of the last two points in the timing diagram.

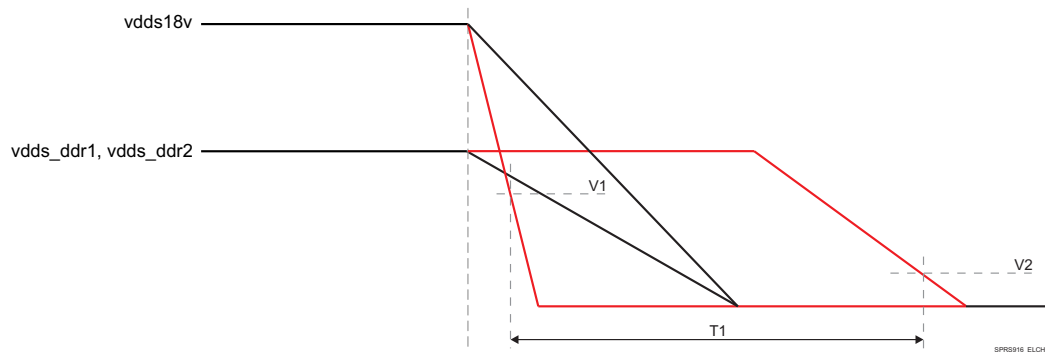
Figure 5-8 describes vddshv[1-7,9-11] supplies falling before vdds18v supplies delta.



**Figure 5-8. vdds18v versus vddshv[1-7, 9-11] Discharge Relationship**

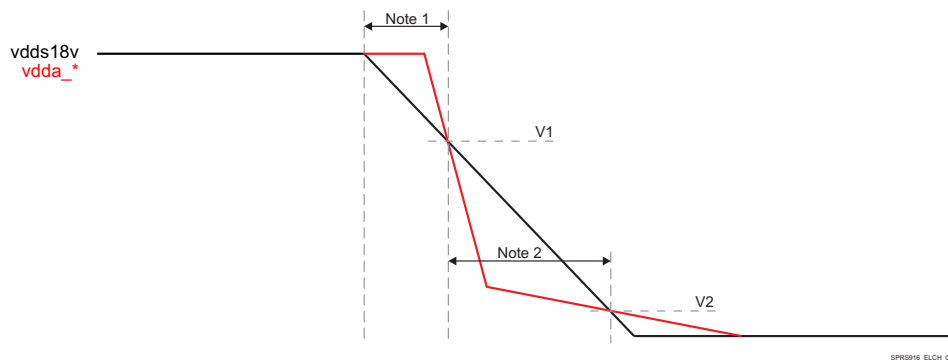
- (1) Vdelta MAX = 2 V.
- (2) If vddshv8 is powered by the same supply source as the other vddshv[1-7,9-11] rails.

If vdds18v and vdds\_dds\* are disabled at the same time due to a loss of input power event or if vdds\_dds\* discharges more slowly than vdds18v, analysis has shown no reliability impacts when the elapsed time period beginning with vdds18v dropping below 1.0 V and ending with vdds\_dds\* dropping below 0.6 V is less than 10 ms (Figure 5-9).



**Figure 5-9. vdds18v and vdds\_dds\* Discharge Relationship<sup>(1)</sup>**

- (1) V1 > 1.0 V; V2 < 0.6V; T1 < 10ms.

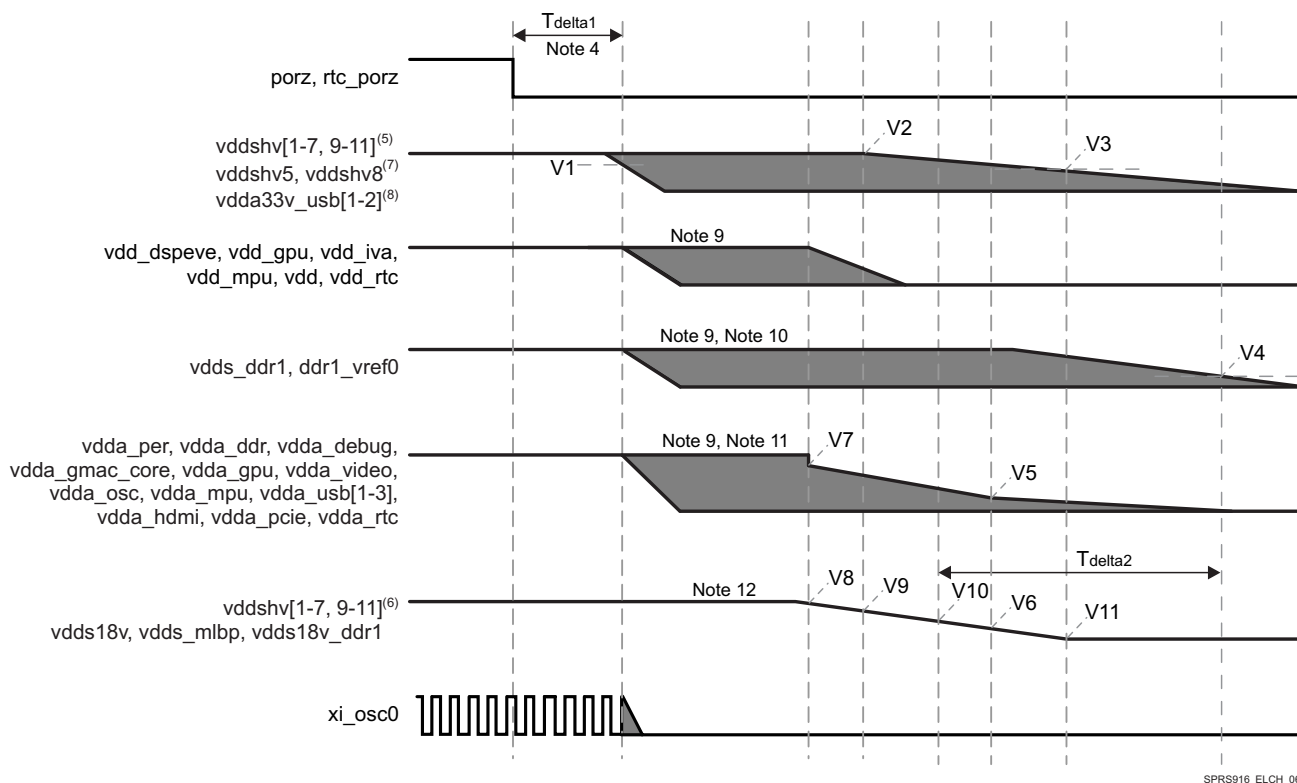


**Figure 5-10. vdds18v and vdda\_\* Discharge Relationship<sup>(3)</sup>**

- (1) vdda\_\* can be  $\geq$  vdds18v, until vdds18v drops below 1.62 V.
- (2) vdds18v must be  $\geq$  vdda\_\*, until vdds18v reaches 0.6 V.
- (3) V1 = 1.62 V; V2 < 0.6 V.

Figure 5-8 through Figure 5-11 and associated notes described the device abrupt power down sequence.

A "loss of input power event" occurs when the system's input power is unexpectedly removed. Normally, the recommended power-down sequence should be followed and can be accomplished within 1.5-2 ms of elapsed time. This is the typical range of elapsed time available following a loss of power event, see Section 7.3.7 for design recommendations. If sufficient elapse time is not provided, then an "abrupt" power down sequence can be supported without impacting POH reliability if all of the following conditions are met (Figure 5-11).



**Figure 5-11. Abrupt Power-Down Sequencing<sup>(1)</sup>**

- (1) Time stamps:
  - V1 = 2.7 V; V2 = 3.3 V; V3 = 2.0 V; V4 = V5 = V6 = 0.6 V; V7 = V8 = 1.62 V; V9 = 1.3 V; V10 = 1.0 V; V11 = 0.0 V;  $T_{\text{delta1}} > 100 \mu\text{s}$ ;  $T_{\text{delta2}} < 10 \text{ ms}$ .

- (2) Terminology:
  - $V_{OPR\ MIN}$  = Minimum Operational Voltage level that ensures device functionality and specified performance in [Section 5.4, Recommended Operating Conditions table](#).
  - $V_{OFF}$  = OFF Voltage level is defined to be less than 0.6 V, where any current draw has no impact to POH.
  - Ramp Down = transition time from  $V_{OPR\ MIN}$  to  $V_{OFF}$  and is slew rate independent.
- (3) General timing diagram items:
  - Grey shaded areas show valid transition times for supplies between  $V_{OPR\ MIN}$  and  $V_{OFF}$ .
  - Dashed vertical lines show approximate elapse times based upon TI recommended PMIC power-down sequencer circuit performance.
- (4) porz and rtc\_porz must be asserted low for 100  $\mu$ s min to ensure SoC is set to a safe functional state before any voltage begins to ramp down.
  - Only if using RTC-mode with an independent RTC input power source, then rtc\_porz can remain high and RTC-domains (vdd\_rtc, vdda\_rtc, and vddshv5) can remain energized while all other domains sourced from the system input power are powered down.
- (5) vddshv[1-7, 9-11] domains supplied by 3.3 V:
  - must remain greater than 2.7 V to enable Dual Voltage GPIO selector circuit operation for 100  $\mu$ s min, after porz is asserted low.
  - must not exceed vdds18v voltage level by more than 2 V during ramp down, until vdds18v drops below  $V_{OFF}$  (0.6 V).
- (6) vddshv[1-7, 9-11] domains supplied by 1.8 V must ramp down concurrently with vdds18v and be sourced from common vdds18v supply.
- (7) vddshv8 supporting SD Card:
  - must be in first group of supplies to ramp down after porz has been asserted low for 100  $\mu$ s min.
  - must be sourced from independent power resource that can provide dual voltage (3.3 V / 1.8 V) operation as required to be compliant to SDIO specification.
  - if SDIO operation is not needed, must be grouped with other vddshv[1-7, 9-11] domains.
- (8) vdda33v\_usb[1-2] domains must be in first group of supplies to ramp down after porz has been asserted low for 100  $\mu$ s min.
- (9) vdd\_dspeve, vdd\_gpu, vdd\_iva, vdd\_mpu, vdd, vdd\_rtc, vdds\_ddr1, vdda\_\* domains can all start to ramp down in any order after 100  $\mu$ s low assertion of porz.
- (10) vdds\_ddr1 domains:
  - can remain at  $V_{OPR\ MIN}$  or a level greater than vdds18v during ramp down.
  - elapsed time from vdds18v dropping below 1.0 V to vdds\_ddr[1-3] dropping below 0.6 V must not exceed 10 ms.
- (11) vdda\_\* domains:
  - can start to ramp down before or concurrently with vdds18v.
  - must not exceed vdds18v voltage level after vdds18v drops below 1.62 V until vdds18v drops below  $V_{OFF}$  (0.6 V).
- (12) vdds18v domain should maintain a minimum level of 1.62 V ( $V_{NOM} - 10\%$ ) until vdd\_dspeve and vdd start to ramp down.

#### 5.10.4 Clock Specifications

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**NOTE**

For more information, see Power, Reset, and Clock Management / PRCM Environment / External Clock Signal and Power Reset / PRCM Functional Description / PRCM Clock Manager Functional Description section of the Device TRM.

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**NOTE**

Audio Back End (ABE) module is not supported for this family of devices, but “ABE” name is still present in some clock or DPLL names.

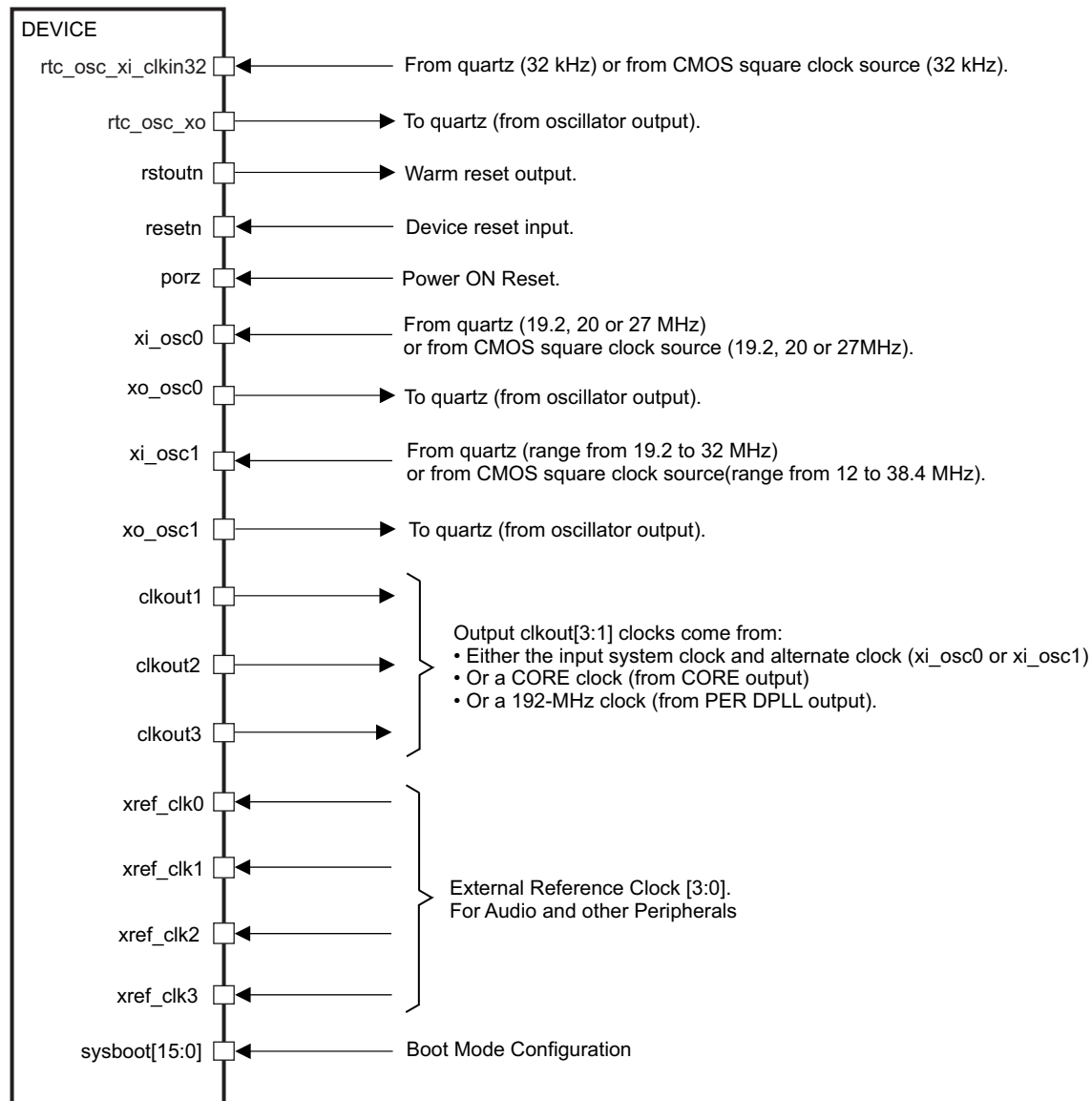
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The device operation requires the following clocks:

- The 32 kHz frequency is used for low frequency operation. It supplies the wake-up domain for operation in lowest power mode. This is an optional clock and will be supplied by on chip divider + mux (FUNC\_32K\_CLK) incase it is not available on external pin.
- The system clocks, SYS\_CLK1 (Mandatory) and SYS\_CLK2 (Optional) are the main clock sources of the device. They supply the reference clock to the DPLLs as well as functional clock to several modules.

The Device also embeds an internal free-running 32-kHz oscillator that is always active as long as the the wake-up (WKUP) domain is supplied.

[Figure 5-12](#) shows the external input clock sources and the output clocks to peripherals.



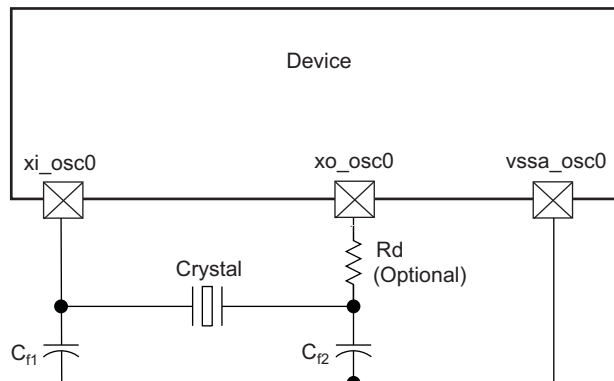
### Figure 5-12. Clock Interface

#### 5.10.4.1 Input Clocks / Oscillators

- The source of the internal system clock (SYS\_CLK1) could be either:
  - A CMOS clock that enters on the xi\_osc0 ball (with xo\_osc0 left unconnected on the CMOS clock case).
  - A crystal oscillator clock managed by xi\_osc0 and xo\_osc0.
- The source of the internal system clock (SYS\_CLK2) could be either:
  - A CMOS clock that enters on the xi\_osc1 ball (with xo\_osc1 left unconnected on the CMOS clock case).
  - A crystal oscillator clock managed by xi\_osc1 and xo\_osc1.
- The source of the internal system clock (FUNC\_32K\_CLK) could be either:
  - A CMOS clock that enters on the rtc\_osc\_xi\_clkin32 ball and supports external LVCMOS clock generators
  - A crystal oscillator clock managed by rtc\_osc\_xi\_clkin32 and rtc\_osc\_xo.

#### 5.10.4.1.1 OSC0 External Crystal

An external crystal is connected to the device pins. [Figure 5-13](#) describes the crystal implementation.



**Figure 5-13. Crystal Implementation**

#### NOTE

The load capacitors,  $C_{f1}$  and  $C_{f2}$  in [Figure 5-13](#), should be chosen such that the below equation is satisfied.  $C_L$  in the equation is the load specified by the crystal manufacturer. All discrete components used to implement the oscillator circuit should be placed as close as possible to the associated oscillator  $xi\_osc0$ ,  $xo\_osc0$ , and  $vssa\_osc0$  pins.

$$C_L = \frac{C_{f1} C_{f2}}{C_{f1} + C_{f2}}$$

**Figure 5-14. Load Capacitance Equation**

The crystal must be in the fundamental mode of operation and parallel resonant. [Table 5-17](#) summarizes the required electrical constraints.

**Table 5-17. OSC0 Crystal Electrical Characteristics**

| NAME                  | DESCRIPTION                                                                     |                                        | MIN                      | TYP   | MAX           | UNIT     |
|-----------------------|---------------------------------------------------------------------------------|----------------------------------------|--------------------------|-------|---------------|----------|
| $f_p$                 | Parallel resonance crystal frequency                                            |                                        | 19.2, 20, 27             |       |               | MHz      |
| $C_{f1}$              | $C_{f1}$ load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ |                                        | 12                       |       | 24            | pF       |
| $C_{f2}$              | $C_{f2}$ load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ |                                        | 12                       |       | 24            | pF       |
| $ESR(C_{f1}, C_{f2})$ | Crystal ESR                                                                     |                                        |                          |       | 100           | $\Omega$ |
| $C_O$                 | Crystal shunt capacitance                                                       | ESR = 30 $\Omega$<br>ESR = 40 $\Omega$ | 19.2 MHz, 20 MHz, 27 MHz |       | 7             | pF       |
|                       |                                                                                 | ESR = 50 $\Omega$                      | 19.2 MHz, 20 MHz         |       | 7             | pF       |
|                       |                                                                                 |                                        | 27 MHz                   |       | 5             | pF       |
|                       |                                                                                 | ESR = 60 $\Omega$                      | 19.2 MHz, 20 MHz         |       | 7             | pF       |
|                       |                                                                                 |                                        | 27 MHz                   |       | Not Supported |          |
|                       |                                                                                 | ESR = 80 $\Omega$                      | 19.2 MHz, 20 MHz         |       | 5             | pF       |
|                       |                                                                                 |                                        | 27 MHz                   |       | Not Supported |          |
|                       |                                                                                 | ESR = 100 $\Omega$                     | 19.2 MHz, 20 MHz         |       | 3             | pF       |
|                       |                                                                                 |                                        | 27 MHz                   |       | Not Supported |          |
| $L_M$                 | Crystal motional inductance for $f_p = 20$ MHz                                  |                                        |                          | 10.16 |               | mH       |
| $C_M$                 | Crystal motional capacitance                                                    |                                        |                          | 3.42  |               | fF       |

**Table 5-17. OSC0 Crystal Electrical Characteristics (continued)**

| NAME              | DESCRIPTION                                 | MIN                                         | TYP | MAX  | UNIT |
|-------------------|---------------------------------------------|---------------------------------------------|-----|------|------|
| $t_{j(xi\_osc0)}$ | Frequency accuracy <sup>(1)</sup> , xi_osc0 | Ethernet and MLB not used                   |     | ±200 | ppm  |
|                   |                                             | Ethernet RGMII and RMII using derived clock |     | ±50  |      |
|                   |                                             | Ethernet MII using derived clock            |     | ±100 |      |
|                   |                                             | MLB using derived clock                     |     | ±50  |      |

(1) Crystal characteristics should account for tolerance+stability+aging.

When selecting a crystal, the system design must take into account the temperature and aging characteristics of a crystal versus the user environment and expected lifetime of the system.

Table 5-18 details the switching characteristics of the oscillator and the requirements of the input clock.

**Table 5-18. Oscillator Switching Characteristics—Crystal Mode**

| NAME     | DESCRIPTION           | MIN              | TYP | MAX | UNIT |
|----------|-----------------------|------------------|-----|-----|------|
| $f_p$    | Oscillation frequency | 19.2, 20, 27 MHz |     |     | MHz  |
| $t_{sx}$ | Start-up time         |                  |     | 4   | ms   |

#### 5.10.4.1.2 OSC0 Input Clock

A 1.8-V LVCMOS-compatible clock input can be used instead of the internal oscillator to provide the SYS\_CLK1 clock input to the system. The external connections to support this are shown in Figure 5-15. The xi\_osc0 pin is connected to the 1.8-V LVCMOS-compatible clock source. The xi\_osc0 pin is left unconnected. The vssa\_osc0 pin is connected to board ground (VSS).

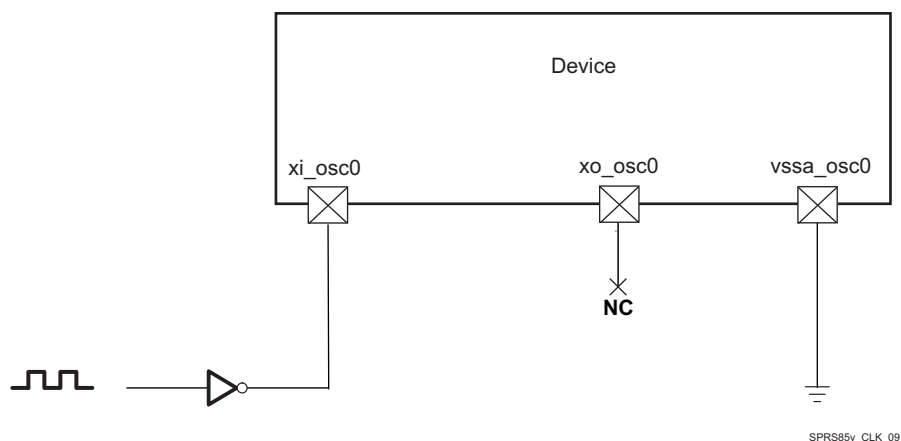
**Figure 5-15. 1.8-V LVCMOS-Compatible Clock Input**

Table 5-19 summarizes the OSC0 input clock electrical characteristics.

**Table 5-19. OSC0 Input Clock Electrical Characteristics—Bypass Mode**

| NAME     | DESCRIPTION               | MIN          | TYP   | MAX   | UNIT |
|----------|---------------------------|--------------|-------|-------|------|
| $f$      | Frequency                 | 19.2, 20, 27 |       |       | MHz  |
| $C_{IN}$ | Input capacitance         | 2.184        | 2.384 | 2.584 | pF   |
| $I_{IN}$ | Input current (3.3V mode) | 4            | 6     | 10    | μA   |

Table 5-20 details the OSC0 input clock timing requirements.

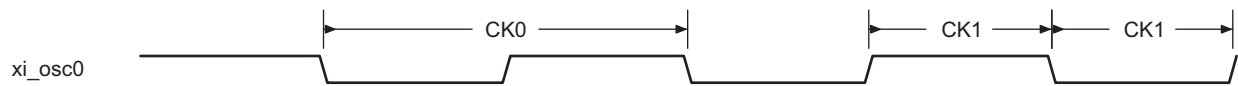
**Table 5-20. OSC0 Input Clock Timing Requirements**

| NAME | DESCRIPTION           |                                             | MIN                                         | TYP | MAX                           | UNIT |
|------|-----------------------|---------------------------------------------|---------------------------------------------|-----|-------------------------------|------|
| CK0  | $1 / t_{c(xi\_osc0)}$ | Frequency, xi_osc0                          | 19.2, 20, 27                                |     |                               | MHz  |
| CK1  | $t_{w(xi\_osc0)}$     | Pulse duration, xi_osc0 low or high         | $0.45 \times t_{c(xi\_osc0)}$               |     | $0.55 \times t_{c(xi\_osc0)}$ | ns   |
|      | $t_{j(xi\_osc0)}$     | Period jitter <sup>(1)</sup> , xi_osc0      |                                             |     | $0.01 \times t_{c(xi\_osc0)}$ | ns   |
|      | $t_{R(xi\_osc0)}$     | Rise time, xi_osc0                          |                                             |     | 5                             | ns   |
|      | $t_{F(xi\_osc0)}$     | Fall time, xi_osc0                          |                                             |     | 5                             | ns   |
|      | $t_{f(xi\_osc0)}$     | Frequency accuracy <sup>(2)</sup> , xi_osc0 | Ethernet and MLB not used                   |     | ±200                          | ppm  |
|      |                       |                                             | Ethernet RGMII and RMII using derived clock |     | ±50                           |      |
|      |                       |                                             | Ethernet MII using derived clock            |     | ±100                          |      |
|      |                       |                                             | MLB using derived clock                     |     | ±50                           |      |

(1) Period jitter is meant here as follows:

- The maximum value is the difference between the longest measured clock period and the expected clock period
- The minimum value is the difference between the shortest measured clock period and the expected clock period

(2) Crystal characteristics should account for tolerance+stability+aging.



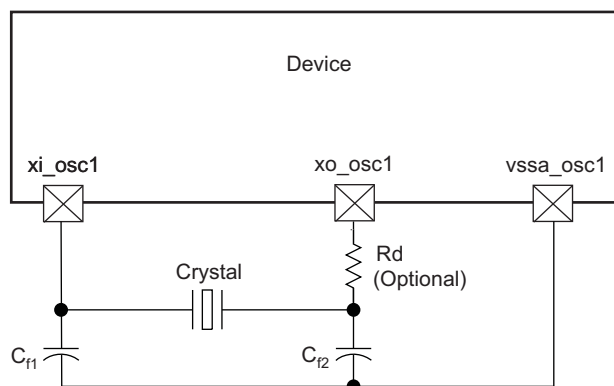
**Figure 5-16. xi\_osc0 Input Clock**

#### 5.10.4.1.3 Auxiliary Oscillator OSC1 Input Clock

SYS\_CLK2 is received directly from oscillator OSC1. For more information about SYS\_CLK2, see the Power, Reset, and Clock Management chapter of the Device TRM.

##### 5.10.4.1.3.1 OSC1 External Crystal

An external crystal is connected to the device pins. Figure 5-17 describes the crystal implementation.



**Figure 5-17. Crystal Implementation**

**NOTE**

The load capacitors,  $C_{f1}$  and  $C_{f2}$  in [Figure 5-17](#), should be chosen such that the below equation is satisfied.  $C_L$  in the equation is the load specified by the crystal manufacturer. All discrete components used to implement the oscillator circuit should be placed as close as possible to the associated oscillator  $xi\_osc1$ ,  $xo\_osc1$ , and  $vssa\_osc1$  pins.

$$C_L = \frac{C_{f1} C_{f2}}{(C_{f1} + C_{f2})}$$

**Figure 5-18. Load Capacitance Equation**

The crystal must be in the fundamental mode of operation and parallel resonant. [Table 5-21](#) summarizes the required electrical constraints.

**Table 5-21. OSC1 Crystal Electrical Characteristics**

| NAME                                   | DESCRIPTION                                                                                            |                                             |                                    | MIN                   | TYP   | MAX  | UNIT |
|----------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------|------------------------------------|-----------------------|-------|------|------|
| f <sub>p</sub>                         | Parallel resonance crystal frequency                                                                   |                                             |                                    | Range from 19.2 to 32 |       |      | MHz  |
| C <sub>f1</sub>                        | C <sub>f1</sub> load capacitance for crystal parallel resonance with C <sub>f1</sub> = C <sub>f2</sub> |                                             |                                    | 12                    |       | 24   | pF   |
| C <sub>f2</sub>                        | C <sub>f2</sub> load capacitance for crystal parallel resonance with C <sub>f1</sub> = C <sub>f2</sub> |                                             |                                    | 12                    |       | 24   | pF   |
| ESR(C <sub>f1</sub> ,C <sub>f2</sub> ) | Crystal ESR                                                                                            |                                             |                                    |                       |       | 100  | Ω    |
| C <sub>O</sub>                         | Crystal shunt capacitance                                                                              | ESR = 30 Ω                                  | 19.2 MHz ≤ f <sub>p</sub> ≤ 32 MHz |                       |       | 7    | pF   |
|                                        |                                                                                                        | ESR = 40 Ω                                  | 19.2 MHz ≤ f <sub>p</sub> ≤ 32 MHz |                       |       | 5    | pF   |
|                                        |                                                                                                        | ESR = 50 Ω                                  | 19.2 MHz ≤ f <sub>p</sub> ≤ 25 MHz |                       |       | 7    | pF   |
|                                        |                                                                                                        |                                             | 25 MHz < f <sub>p</sub> ≤ 27 MHz   |                       |       | 5    | pF   |
|                                        |                                                                                                        |                                             | 27 MHz < f <sub>p</sub> ≤ 32 MHz   | Not Supported         |       |      | -    |
|                                        |                                                                                                        | ESR = 60 Ω                                  | 19.2 MHz ≤ f <sub>p</sub> ≤ 23 MHz |                       |       | 7    | pF   |
|                                        |                                                                                                        |                                             | 23 MHz < f <sub>p</sub> ≤ 25 MHz   |                       |       | 5    | pF   |
|                                        |                                                                                                        |                                             | 25 MHz < f <sub>p</sub> ≤ 32 MHz   | Not Supported         |       |      | -    |
|                                        |                                                                                                        | ESR = 80 Ω                                  | 19.2 MHz ≤ f <sub>p</sub> ≤ 23 MHz |                       |       | 5    | pF   |
|                                        |                                                                                                        |                                             | 23 MHz ≤ f <sub>p</sub> ≤ 25 MHz   |                       |       | 3    | pF   |
|                                        |                                                                                                        |                                             | 25 MHz < f <sub>p</sub> ≤ 32 MHz   | Not Supported         |       |      | -    |
|                                        |                                                                                                        | ESR = 100 Ω                                 | 19.2 MHz ≤ f <sub>p</sub> ≤ 20 MHz |                       |       | 3    | pF   |
|                                        |                                                                                                        |                                             | 20 MHz < f <sub>p</sub> ≤ 32 MHz   | Not Supported         |       |      | -    |
| L <sub>M</sub>                         | Crystal motional inductance for f <sub>p</sub> = 20 MHz                                                |                                             |                                    |                       | 10.16 |      | mH   |
| C <sub>M</sub>                         | Crystal motional capacitance                                                                           |                                             |                                    |                       | 3.42  |      | fF   |
| t <sub>j(xiosc1)</sub>                 | Frequency accuracy <sup>(1)</sup> , xi_osc1                                                            | Ethernet and MLB not used                   |                                    |                       |       | ±200 | ppm  |
|                                        |                                                                                                        | Ethernet RGMII and RMII using derived clock |                                    |                       |       | ±50  |      |
|                                        |                                                                                                        | Ethernet MII using derived clock            |                                    |                       |       | ±100 |      |
|                                        |                                                                                                        | MLB using derived clock                     |                                    |                       |       | ±50  |      |

(1) Crystal characteristics should account for tolerance+stability+aging.

When selecting a crystal, the system design must consider the temperature and aging characteristics of a based on the worst case environment and expected life expectancy of the system.

[Table 5-22](#) details the switching characteristics of the oscillator and the requirements of the input clock.

**Table 5-22. Oscillator Switching Characteristics—Crystal Mode**

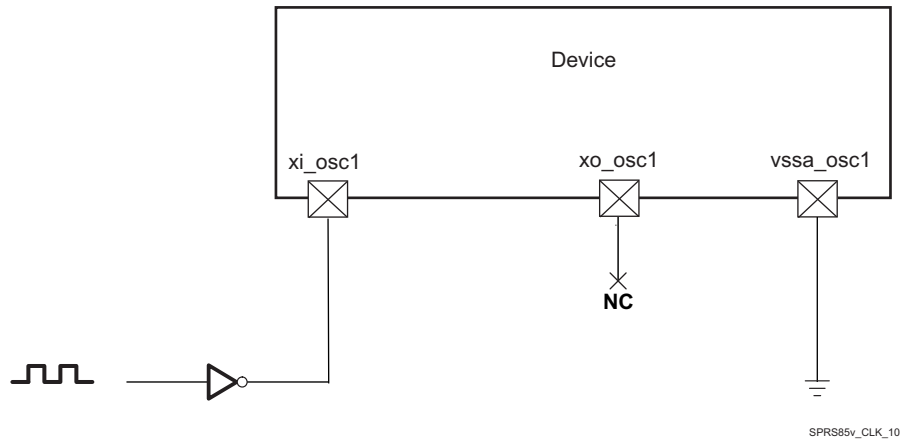
| NAME  | DESCRIPTION           | MIN                   | TYP | MAX | UNIT |
|-------|-----------------------|-----------------------|-----|-----|------|
| $f_p$ | Oscillation frequency | Range from 19.2 to 32 |     |     | MHz  |

**Table 5-22. Oscillator Switching Characteristics—Crystal Mode (continued)**

| NAME     | DESCRIPTION   | MIN | TYP | MAX | UNIT |
|----------|---------------|-----|-----|-----|------|
| $t_{SX}$ | Start-up time |     |     | 4   | ms   |

#### 5.10.4.1.3.2 OSC1 Input Clock

A 1.8-V LVCMOS-compatible clock input can be used instead of the internal oscillator to provide the SYS\_CLK2 clock input to the system. The external connections to support this are shown in [Figure 5-19](#). The xi\_osc1 pin is connected to the 1.8-V LVCMOS-compatible clock sources. The xo\_osc1 pin is left unconnected. The vssa\_osc1 pin is connected to board ground (vss).



**Figure 5-19. 1.8-V LVCMOS-Compatible Clock Input**

[Table 5-23](#) summarizes the OSC1 input clock electrical characteristics.

**Table 5-23. OSC1 Input Clock Electrical Characteristics—Bypass Mode**

| NAME     | DESCRIPTION                  | MIN                   | TYP   | MAX   | UNIT    |
|----------|------------------------------|-----------------------|-------|-------|---------|
| f        | Frequency                    | Range from 12 to 38.4 |       |       | MHz     |
| $C_{IN}$ | Input capacitance            | 2.819                 | 3.019 | 3.219 | pF      |
| $I_{IN}$ | Input current (3.3V mode)    | 4                     | 6     | 10    | $\mu$ A |
| $t_{SX}$ | Start-up time <sup>(1)</sup> | See <sup>(2)</sup>    |       |       | ms      |

- (1) To switch from bypass mode to crystal or from crystal mode to bypass mode, there is a waiting time about 100  $\mu$ s; however, if the chip comes from bypass mode to crystal mode the crystal will start-up after time mentioned in [Table 5-22](#),  $t_{SX}$  parameter.
- (2) Before the processor boots up and the oscillator is set to bypass mode, there is a waiting time when the internal oscillator is in application mode and receives a wave. The switching time in this case is about 100  $\mu$ s.

[Table 5-24](#) details the OSC1 input clock timing requirements.

**Table 5-24. OSC1 Input Clock Timing Requirements**

| NAME | DESCRIPTION          |                                        | MIN                          | TYP | MAX                                         | UNIT |
|------|----------------------|----------------------------------------|------------------------------|-----|---------------------------------------------|------|
| CK0  | $1 / t_{c(xi_osc1)}$ | Frequency, xi_osc1                     | Range from 12 to 38.4        |     |                                             | MHz  |
| CK1  | $t_{w(xi_osc1)}$     | Pulse duration, xi_osc1 low or high    | $0.45 \times t_{c(xi_osc1)}$ |     | $0.55 \times t_{c(xi_osc1)}$                | ns   |
|      | $t_{j(xi_osc1)}$     | Period jitter <sup>(1)</sup> , xi_osc1 |                              |     | $0.01 \times t_{c(xi_osc1)}$ <sup>(3)</sup> | ns   |
|      | $t_{R(xi_osc1)}$     | Rise time, xi_osc1                     |                              |     | 5                                           | ns   |
|      | $t_{F(xi_osc1)}$     | Fall time, xi_osc1                     |                              |     | 5                                           | ns   |

**Table 5-24. OSC1 Input Clock Timing Requirements (continued)**

| NAME            | DESCRIPTION                                 |                                             | MIN | TYP | MAX  | UNIT |
|-----------------|---------------------------------------------|---------------------------------------------|-----|-----|------|------|
| $t_{j(xiosc1)}$ | Frequency accuracy <sup>(2)</sup> , xi_osc1 | Ethernet and MLB not used                   |     |     | ±200 | ppm  |
|                 |                                             | Ethernet RGMII and RMII using derived clock |     |     | ±50  |      |
|                 |                                             | Ethernet MII using derived clock            |     |     | ±100 |      |
|                 |                                             | MLB using derived clock                     |     |     | ±50  |      |

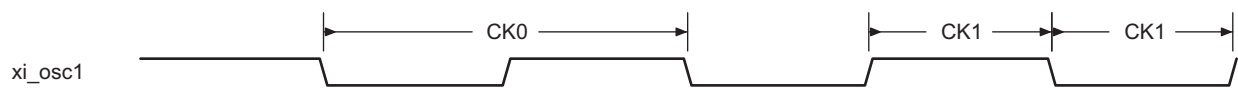
(1) Period jitter is meant here as follows:

- The maximum value is the difference between the longest measured clock period and the expected clock period
- The minimum value is the difference between the shortest measured clock period and the expected clock period

(2) Crystal characteristics should account for tolerance+stability+aging.

(3) The Period jitter requirement for osc1 can be relaxed to  $0.02 \times t_{c(xiosc1)}$  under the following constraints:

- The osc1/SYS\_CLK2 clock bypasses all device PLLs
- The osc1/SYS\_CLK2 clock is only used to source the DSS pixel clock outputs

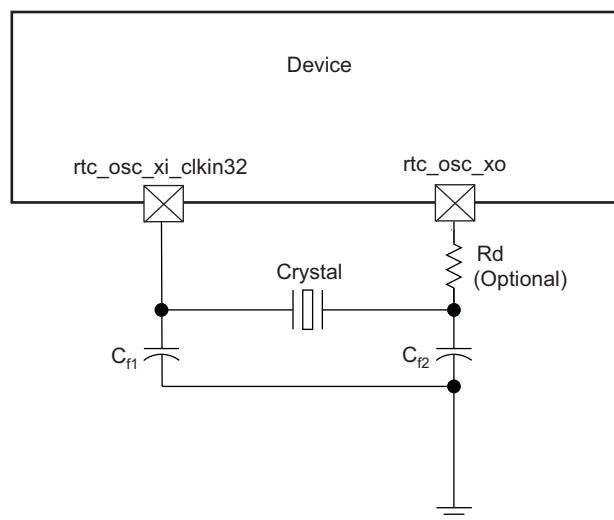
**Figure 5-20. xi\_osc1 Input Clock**

#### 5.10.4.1.4 RTC Oscillator Input Clock

FUNC\_32K\_CLK is received directly from RTC Oscillator. For more information about FUNC\_32K\_CLK, see the Power, Reset, and Clock Management chapter of the Device TRM.

##### 5.10.4.1.4.1 RTC Oscillator External Crystal

An external crystal is connected to the device pins. [Figure 5-13](#) describes the crystal implementation.

**Figure 5-21. Crystal Implementation**

#### NOTE

The load capacitors,  $C_{f1}$  and  $C_{f2}$  in [Figure 5-21](#), should be chosen such that the below equation is satisfied.  $C_L$  in the equation is the load specified by the crystal manufacturer. All discrete components used to implement the oscillator circuit should be placed as close as possible to the associated oscillator  $rtc\_osc\_xi\_clkin32$  and  $rtc\_osc\_xo$  pins.

$$C_L = \frac{C_{f1} C_{f2}}{(C_{f1} + C_{f2})}$$

**Figure 5-22. Load Capacitance Equation**

The crystal must be in the fundamental mode of operation and parallel resonant. [Table 5-25](#) summarizes the required electrical constraints.

**Table 5-25. RTC Crystal Electrical Characteristics**

| NAME                           | DESCRIPTION                                                                     | MIN | TYP    | MAX  | UNIT |
|--------------------------------|---------------------------------------------------------------------------------|-----|--------|------|------|
| $f_p$                          | Parallel resonance crystal frequency                                            |     | 32.768 |      | kHz  |
| $C_{f1}$                       | $C_{f1}$ load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12  |        | 24   | pF   |
| $C_{f2}$                       | $C_{f2}$ load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12  |        | 24   | pF   |
| $ESR(C_{f1}, C_{f2})$          | Crystal ESR                                                                     |     |        | 80   | kΩ   |
| $C_O$                          | Crystal shunt capacitance                                                       |     |        | 5    | pF   |
| $L_M$                          | Crystal motional inductance for $f_p = 32,768$ kHz                              |     | 10.7   |      | mH   |
| $C_M$                          | Crystal motional capacitance                                                    |     | 2.2    |      | fF   |
| $t_{j(rtc\_osc\_xi\_clkin32)}$ | Frequency accuracy, rtc_osc_xi_clkin32                                          |     |        | ±200 | ppm  |

When selecting a crystal, the system design must take into account the temperature and aging characteristics of a crystal versus the user environment and expected lifetime of the system.

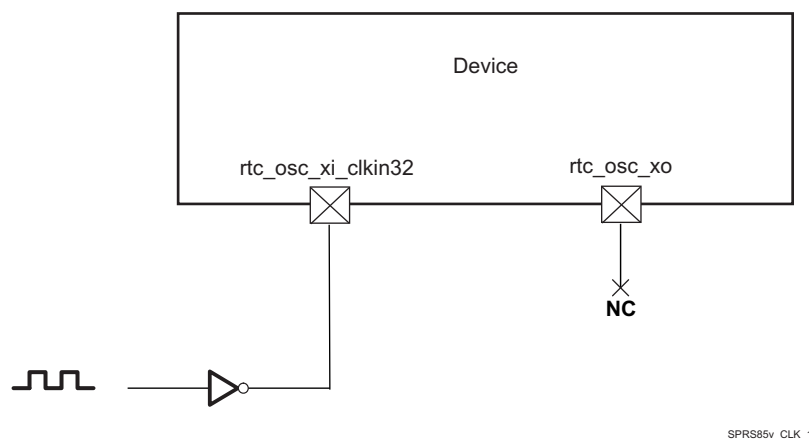
[Table 5-26](#) details the switching characteristics of the oscillator and the requirements of the input clock.

**Table 5-26. Oscillator Switching Characteristics—Crystal Mode**

| NAME     | DESCRIPTION           | MIN | TYP    | MAX | UNIT |
|----------|-----------------------|-----|--------|-----|------|
| $f_p$    | Oscillation frequency |     | 32.768 |     | kHz  |
| $t_{sX}$ | Start-up time         |     |        | 4   | ms   |

#### 5.10.4.1.4.2 RTC Oscillator Input Clock

A 1.8-V LVCMOS-compatible clock input can be used instead of the internal oscillator to provide the FUNC\_32K\_CLK clock input to the system. The external connections to support this are shown in [Figure 5-23](#). The rtc\_osc\_xi\_clkin32 pin is connected to the 1.8-V LVCMOS-compatible clock sources. The rtc\_osc\_xo pin is left unconnected.



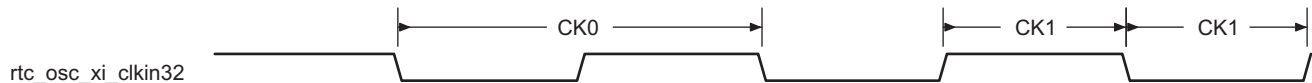
**Figure 5-23. LVCMOS-Compatible Clock Input**

[Table 5-27](#) summarizes the RTC Oscillator input clock electrical characteristics.

**Table 5-27. RTC Oscillator Input Clock Electrical Characteristics—Bypass Mode**

|     | NAME                             | DESCRIPTION                                    | MIN                                        | TYP   | MAX                                        | UNIT |
|-----|----------------------------------|------------------------------------------------|--------------------------------------------|-------|--------------------------------------------|------|
| CK0 | $1/t_{c(rtc\_osc\_xi\_clkin32)}$ | Frequency, rtc_osc_xi_clkin32                  | 32.768                                     |       |                                            | kHz  |
| CK1 | $t_{w(rtc\_osc\_xi\_clkin32)}$   | Pulse duration, rtc_osc_xi_clkin32 low or high | $0.45 \times t_{c(rtc\_osc\_xi\_clkin32)}$ |       | $0.55 \times t_{c(rtc\_osc\_xi\_clkin32)}$ | ns   |
|     | $C_{IN}$                         | Input capacitance                              | 2.178                                      | 2.378 | 2.578                                      | pF   |
|     | $I_{IN}$                         | Input current (3.3V mode)                      | 4                                          | 6     | 10                                         | μA   |
|     | $t_{SX}$                         | Start-up time                                  | See <sup>(1)</sup>                         |       |                                            | ms   |

(1) Before the processor boots up and the oscillator is set to bypass mode, there is a waiting time when the internal oscillator is in application mode and receives a wave. The switching time in this case is about 100 μs.

**Figure 5-24. rtc\_osc\_xi\_clkin32 Input Clock**

#### 5.10.4.2 RC On-die Oscillator Clock

##### NOTE

The OSC\_32K\_CLK clock, provided by the On-die 32K RC oscillator, inside of the SoC, is not accurate 32 kHz clock.

The frequency may significantly vary with temperature and silicon characteristics.

For more information about OSC\_32K\_CLK see the Device TRM, Chapter: *Power, Reset, and Clock Management*.

#### 5.10.4.3 Output Clocks

The device provides three output clocks. Summary of these output clocks are as follows:

- clkout1 - Device Clock output 1. Can be used as a system clock for other devices. The source of the clkout1 could be either:
  - The input system clock and alternate clock (xi\_osc0 or xi\_osc1)
  - CORE clock (from CORE output)
  - 192-MHz clock (from PER DPLL output)
- clkout2 - Device Clock output 2. Can be used as a system clock for other devices. The source of the clkout2 could be either:
  - The input system clock and alternate clock (xi\_osc0 or xi\_osc1)
  - CORE clock (from CORE output)
  - 192-MHz clock (from PER DPLL output)
- clkout3 - Device Clock output 3. Can be used as a system clock for other devices. The source of the clkout3 could be either:
  - The input system clock and alternate clock (xi\_osc0 or xi\_osc1)
  - CORE clock (from CORE output)
  - 192-MHz clock (from PER DPLL output)

For more information about Output Clocks see Device TRM, Chapter: *Power, Reset, and Clock Management*.

#### 5.10.4.4 DPLLs, DLLs

##### NOTE

For more information, see:

- Power, Reset, and Clock Management / Clock Management Functional / Internal Clock Sources / Generators / Generic DPLL Overview Section and
- Display Subsystem / Display Subsystem Overview section of the Device TRM.

To generate high-frequency clocks, the device supports multiple on-chip DPLLs controlled directly by the PRCM module. They are of two types: type A and type B DPLLs.

- They have their own independent power domain (each one embeds its own switch and can be controlled as an independent functional power domain)
- They are fed with ALWAYS ON system clock, with independent control per DPLL.

The different DPLLs managed by the PRCM are listed below:

- DPLL\_MPU: It supplies the MPU subsystem clocking internally.
- DPLL\_IVA: It feeds the IVA subsystem clocking.
- DPLL\_CORE: It supplies all interface clocks and also few module functional clocks.
- DPLL\_PER: It supplies several clock sources: a 192-MHz clock for the display functional clock, a 96-MHz functional clock to subsystems and peripherals.
- DPLL\_ABE: It provides clocks to various modules within the device.
- DPLL\_USB: It provides 960M clock for USB modules (USB1/2/3/4).
- DPLL\_GMAC: It supplies several clocks for the Gigabit Ethernet Switch (GMAC\_SW).
- DPLL\_EVE: It provides the Embedded Vision Engine Subsystem (EVE1 and EVE2) clocking.
- DPLL\_DSP: It feeds the DSP Subsystem clocking.
- DPLL\_GPU: It supplies clock for the GPU Subsystem.
- DPLL\_DDR: It generates clocks for the two External Memory Interface (EMIF) controllers and their associated EMIF PHYs.
- DPLL\_PCIE\_REF: It provides reference clock for the APLL\_PCIE in PCIE Subsystem.
- APLL\_PCIE: It feeds clocks for the device Peripheral Component Interconnect Express (PCIe) controllers.

##### NOTE

The following DPLLs are controlled by the clock manager located in the always-on Core power domain (CM\_CORE\_AON):

- DPLL\_MPU, DPLL\_IVA, DPLL\_CORE, DPLL\_ABE, DPLL\_DDR, DPLL\_GMAC, DPLL\_PCIE\_REF, DPLL\_PER, DPLL\_USB, DPLL\_EVE, DPLL\_DSP, DPLL\_GPU, APLL\_PCIE\_REF.

For more information on CM\_CORE\_AON and CM\_CORE or PRCM DPLLs, see Power, Reset, and Clock Management (PRCM) chapter of the Device TRM.

The following DPLLs are not managed by the PRCM:

- DPLL\_VIDEO1; (It is controlled from DSS)
- DPLL\_VIDEO2; (It is controlled from DSS)
- DPLL\_HDMI; (It is controlled from DSS)
- DPLL\_SATA; (It is controlled from SATA)
- DPLL\_DEBUG; (It is controlled from DEBUGSS)
- DPLL\_USB\_OTG\_SS; (It is controlled from OCP2SCP1)

**NOTE**

For more information for not controlled from PRCM DPLL's see the related chapters in TRM.

**5.10.4.4.1 DPLL Characteristics**

The DPLL has three relevant input clocks. One of them is the reference clock (CLKINP) used to generated the synthesized clock but can also be used as the bypass clock whenever the DPLL enters a bypass mode. It is therefore mandatory. The second one is a fast bypass clock (CLKINPULOW) used when selected as the bypass clock and is optional. The third clock (CLKINPHIF) is explained in the next paragraph.

The DPLL has three output clocks (namely CLKOUT, CLKOUTX2, and CLKOUTHIF). CLKOUT and CLKOUTX2 run at the bypass frequency whenever the DPLL enters a bypass mode. Both of them are generated from the lock frequency divided by a post-divider (namely M2 post-divider). The third clock, CLKOUTHIF, has no automatic bypass capability. It is an output of a post-divider (M3 post-divider) with the input clock selectable between the internal lock clock (Fdpll) and CLKINPHIF input of the PLL through an asynchronous multiplexing.

For more information, see the Power Reset Controller Management chapter of the Device TRM.

**Table 5-28** summarizes DPLL type described in [Section 5.10.4.4](#), *DPLLs, DLLs Specifications* introduction.

**Table 5-28. DPLL Control Type**

| DPLL NAME       | TYPE                                | CONTROLLED BY PRCM |
|-----------------|-------------------------------------|--------------------|
| DPLL_ABE        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_CORE       | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_DEBUGSS    | <a href="#">Table 5-29</a> (Type A) | No <sup>(2)</sup>  |
| DPLL_DSP        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_EVE        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_GMAC       | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_HDMI       | <a href="#">Table 5-30</a> (Type B) | No <sup>(2)</sup>  |
| DPLL_IVA        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_MPU        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_PER        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| APLL_PCIE       | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_PCIE_REF   | <a href="#">Table 5-30</a> (Type B) | Yes <sup>(1)</sup> |
| DPLL_SATA       | <a href="#">Table 5-30</a> (Type B) | No <sup>(2)</sup>  |
| DPLL_USB        | <a href="#">Table 5-30</a> (Type B) | Yes <sup>(1)</sup> |
| DPLL_USB_OTG_SS | <a href="#">Table 5-30</a> (Type B) | No <sup>(2)</sup>  |
| DPLL_VIDEO1     | <a href="#">Table 5-29</a> (Type A) | No <sup>(2)</sup>  |
| DPLL_VIDEO2     | <a href="#">Table 5-29</a> (Type A) | No <sup>(2)</sup>  |
| DPLL_DDR        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |
| DPLL_GPU        | <a href="#">Table 5-29</a> (Type A) | Yes <sup>(1)</sup> |

(1) DPLL is in the always-on domain.

(2) DPLL is not controlled by the PRCM.

**Table 5-29** and **Table 5-30** summarize the DPLL characteristics and assume testing over recommended operating conditions.

**Table 5-29. DPLL Type A Characteristics**

| NAME               | DESCRIPTION            | MIN   | TYP | MAX | UNIT | COMMENTS         |
|--------------------|------------------------|-------|-----|-----|------|------------------|
| f <sub>input</sub> | CLKINP input frequency | 0.032 |     | 52  | MHz  | F <sub>INP</sub> |

**Table 5-29. DPLL Type A Characteristics (continued)**

| NAME                    | DESCRIPTION                                                              | MIN               | TYP | MAX                               | UNIT          | COMMENTS                                                                                            |
|-------------------------|--------------------------------------------------------------------------|-------------------|-----|-----------------------------------|---------------|-----------------------------------------------------------------------------------------------------|
| $f_{\text{internal}}$   | Internal reference frequency                                             | 0.15              |     | 52                                | MHz           | REFCLK                                                                                              |
| $f_{\text{CLKINPHIF}}$  | CLKINPHIF input frequency                                                | 10                |     | 1400                              | MHz           | $F_{\text{INPHIF}}$                                                                                 |
| $f_{\text{CLKINPULOW}}$ | CLKINPULOW input frequency                                               | 0.001             |     | 600                               | MHz           | Bypass mode: $f_{\text{CLKOUT}} = f_{\text{CLKINPULOW}} / (M1 + 1)$ if $\text{ulowclken} = 1^{(6)}$ |
| $f_{\text{CLKOUT}}$     | CLKOUT output frequency                                                  | 20 <sup>(4)</sup> |     | 1800 <sup>(2)</sup>               | MHz           | $[M / (N + 1)] \times F_{\text{INP}} \times [1 / M2]$ (in locked condition)                         |
| $f_{\text{CLKOUTx2}}$   | CLKOUTx2 output frequency                                                | 40 <sup>(4)</sup> |     | 2200 <sup>(2)</sup>               | MHz           | $2 \times [M / (N + 1)] \times F_{\text{INP}} \times [1 / M2]$ (in locked condition)                |
| $f_{\text{CLKOUTHIF}}$  | CLKOUTHIF output frequency                                               | 20 <sup>(3)</sup> |     | 1400 <sup>(4)</sup>               | MHz           | $F_{\text{INPHIF}} / M3$ if $\text{clkinphifsel} = 1$                                               |
|                         |                                                                          | 40 <sup>(3)</sup> |     | 2200 <sup>(4)</sup>               | MHz           | $2 \times [M / (N + 1)] \times F_{\text{INP}} \times [1 / M3]$ if $\text{clkinphifsel} = 0$         |
| $f_{\text{CLKDCOLDO}}$  | DCOCLKLDO output frequency                                               | 40                |     | 2800                              | MHz           | $2 \times [M / (N + 1)] \times F_{\text{INP}}$ (in locked condition)                                |
| $t_{\text{lock}}$       | Frequency lock time                                                      |                   |     | $6 + 350 \times \text{REFCLK}$    | $\mu\text{s}$ |                                                                                                     |
| $p_{\text{lock}}$       | Phase lock time                                                          |                   |     | $6 + 500 \times \text{REFCLK}$    | $\mu\text{s}$ |                                                                                                     |
| $t_{\text{relock-L}}$   | Relock time—Frequency lock <sup>(5)</sup> (LP relock time from bypass)   |                   |     | $6 + 70 \times \text{REFCLK}$     | $\mu\text{s}$ | DPLL in LP relock time: $\text{lowcurrstdby} = 1$                                                   |
| $p_{\text{relock-L}}$   | Relock time—Phase lock <sup>(5)</sup> (LP relock time from bypass)       |                   |     | $6 + 120 \times \text{REFCLK}$    | $\mu\text{s}$ | DPLL in LP relock time: $\text{lowcurrstdby} = 1$                                                   |
| $t_{\text{relock-F}}$   | Relock time—Frequency lock <sup>(5)</sup> (fast relock time from bypass) |                   |     | $3.55 + 70 \times \text{REFCLK}$  | $\mu\text{s}$ | DPLL in fast relock time: $\text{lowcurrstdby} = 0$                                                 |
| $p_{\text{relock-F}}$   | Relock time—Phase lock <sup>(5)</sup> (fast relock time from bypass)     |                   |     | $3.55 + 120 \times \text{REFCLK}$ | $\mu\text{s}$ | DPLL in fast relock time: $\text{lowcurrstdby} = 0$                                                 |

(1) The minimum frequencies on CLKOUT and CLKOUTX2 are assuming  $M2 = 1$ .

For  $M2 > 1$ , the minimum frequency on these clocks will further scale down by factor of  $M2$ .

(2) The maximum frequencies on CLKOUT and CLKOUTX2 are assuming  $M2 = 1$ .

(3) The minimum frequency on CLKOUTHIF is assuming  $M3 = 1$ . For  $M3 > 1$ , the minimum frequency on this clock will further scale down by factor of  $M3$ .

(4) The maximum frequency on CLKOUTHIF is assuming  $M3 = 1$ .

(5) Relock time assumes typical operating conditions, 10 °C maximum temperature drift.

(6) Bypass mode:  $f_{\text{CLKOUT}} = F_{\text{INP}}$  if  $\text{ulowclken} = 0$ . For more information, see the Device TRM.

**Table 5-30. DPLL Type B Characteristics**

| NAME                    | DESCRIPTION                                      | MIN                  | TYP | MAX                    | UNIT | COMMENTS                                                                                            |
|-------------------------|--------------------------------------------------|----------------------|-----|------------------------|------|-----------------------------------------------------------------------------------------------------|
| $f_{\text{input}}$      | CLKINP input clock frequency                     | 0.62                 |     | 60                     | MHz  | $F_{\text{INP}}$                                                                                    |
| $f_{\text{internal}}$   | REFCLK internal reference clock frequency        | 0.62                 |     | 2.5                    | MHz  | $[1 / (N + 1)] \times F_{\text{INP}}$                                                               |
| $f_{\text{CLKINPULOW}}$ | CLKINPULOW bypass input clock frequency          | 0.001                |     | 600                    | MHz  | Bypass mode: $f_{\text{CLKOUT}} = f_{\text{CLKINPULOW}} / (M1 + 1)$ if $\text{ulowclken} = 1^{(4)}$ |
| $f_{\text{CLKLDOOUT}}$  | CLKOUTLDO output clock frequency                 | 20 <sup>(4)(5)</sup> |     | 2500 <sup>(2)(5)</sup> | MHz  | $M / (N + 1) \times F_{\text{INP}} \times [1 / M2]$ (in locked condition)                           |
| $f_{\text{CLKOUT}}$     | CLKOUT output clock frequency                    | 20 <sup>(4)(5)</sup> |     | 1450 <sup>(2)(5)</sup> | MHz  | $[M / (N + 1)] \times F_{\text{INP}} \times [1 / M2]$ (in locked condition)                         |
| $f_{\text{CLKDCOLDO}}$  | Internal oscillator (DCO) output clock frequency | 750 <sup>(5)</sup>   |     | 1500 <sup>(5)</sup>    | MHz  | $[M / (N + 1)] \times F_{\text{INP}}$ (in locked condition)                                         |
|                         |                                                  | 1250 <sup>(5)</sup>  |     | 2500 <sup>(5)</sup>    | MHz  |                                                                                                     |

**Table 5-30. DPLL Type B Characteristics (continued)**

| NAME           | DESCRIPTION                                                            | MIN    | TYP | MAX                             | UNIT          | COMMENTS                                                           |
|----------------|------------------------------------------------------------------------|--------|-----|---------------------------------|---------------|--------------------------------------------------------------------|
| $t_j$          | CLKOUTLDO period jitter                                                | –2.5 % |     | 2.5 %                           |               | The period jitter at the output clocks is $\pm 2.5$ % peak to peak |
|                | CLKOUT period jitter                                                   |        |     |                                 |               |                                                                    |
|                | CLKDCOLDO period jitter                                                |        |     |                                 |               |                                                                    |
| $t_{lock}$     | Frequency lock time                                                    |        |     | $350 \times \text{REFCLKs}$     | $\mu\text{s}$ |                                                                    |
| $p_{lock}$     | Phase lock time                                                        |        |     | $500 \times \text{REFCLKs}$     | $\mu\text{s}$ |                                                                    |
| $t_{relock-L}$ | Relock time—Frequency lock <sup>(3)</sup> (LP relock time from bypass) |        |     | $9 + 30 \times \text{REFCLKs}$  | $\mu\text{s}$ |                                                                    |
| $p_{relock-L}$ | Relock time—Phase lock <sup>(3)</sup> (LP relock time from bypass)     |        |     | $9 + 125 \times \text{REFCLKs}$ | $\mu\text{s}$ |                                                                    |

(1) The minimum frequency on CLKOUT is assuming  $M2 = 1$ .

For  $M2 > 1$ , the minimum frequency on this clock will further scale down by factor of  $M2$ .

(2) The maximum frequency on CLKOUT is assuming  $M2 = 1$ .

(3) Relock time assumes typical operating conditions, 10 °C maximum temperature drift.

(4) Bypass mode:  $f_{CLKOUT} = F_{INP}$  if  $ULOWCLKEN = 0$ . For more information, see the Device TRM.

(5) For output clocks, there are two frequency ranges according to the SELFREQDCO setting. For more information, see the Device TRM.

#### 5.10.4.4.2 DLL Characteristics

Table 5-31 summarizes the DLL characteristics and assumes testing over recommended operating conditions.

**Table 5-31. DLL Characteristics**

| NAME         | DESCRIPTION                                                              | MIN | TYP | MAX | UNIT   |
|--------------|--------------------------------------------------------------------------|-----|-----|-----|--------|
| $f_{input}$  | Input clock frequency (EMIF_DLL_FCLK)                                    |     |     | 266 | MHz    |
| $t_{lock}$   | Lock time                                                                |     |     | 50k | cycles |
| $t_{relock}$ | Relock time (a change of the DLL frequency implies that DLL must relock) |     |     | 50k | cycles |

#### 5.10.4.4.3 DPLL and DLL Noise Isolation

##### NOTE

For more information on DPLL and DLL decoupling capacitor requirements, see the External Capacitors / Voltage Decoupling Capacitors / I/O and Analog Voltage Decoupling / VDDA Power Domain section.

#### 5.10.5 Recommended Clock and Control Signal Transition Behavior

All clocks and control signals must transition between  $V_{IH}$  and  $V_{IL}$  (or between  $V_{IL}$  and  $V_{IH}$ ) in a monotonic manner. Monotonic transitions are more easily guaranteed with faster switching signals. Slower input transitions are more susceptible to glitches due to noise and special care should be taken for slow input clocks.

#### 5.10.6 Peripherals

##### 5.10.6.1 Timing Test Conditions

All timing requirements and switching characteristics are valid over the recommended operating conditions unless otherwise specified.

### 5.10.6.2 Virtual and Manual I/O Timing Modes

Some of the timings described in the following sections require the use of Virtual or Manual I/O Timing Modes. [Table 5-32](#) provides a summary of the Virtual and Manual I/O Timing Modes across all device interfaces. The individual interface timing sections found later in this document provide the full description of each applicable Virtual and Manual I/O Timing Mode. Refer to the Pad Configuration section of the Device TRM for the procedure on implementing the Virtual and Manual Timing Modes in a system.

**Table 5-32. Modes Summary**

| Virtual or Manual IO Mode Name               | Datasheet Timing Mode                                                 |
|----------------------------------------------|-----------------------------------------------------------------------|
| <b>VIP</b>                                   |                                                                       |
| <a href="#">VIP1_MANUAL1</a>                 | VIN1A/1B/2A Rise-Edge Capture Mode Timings                            |
| <a href="#">VIP1_2B_MANUAL1</a>              | VIN2B Rise-Edge Capture Mode Timings                                  |
| <a href="#">VIP1_MANUAL2</a>                 | VIN1A/1B/2A Fall-Edge Capture Mode Timings                            |
| <a href="#">VIP1_2B_MANUAL2</a>              | VIN2B Fall-Edge Capture Mode Timings                                  |
| <a href="#">VIP2_MANUAL1</a>                 | VIN3A and VIN3B IOSET1 Rise-Edge Capture Mode Timings                 |
| <a href="#">VIP2_4A_MANUAL1</a>              | VIN4A IOSET1/2 Rise-Edge Capture Mode Timings                         |
| <a href="#">VIP2_4A_IOSET3_MANUAL1</a>       | VIN4A IOSET3 Rise-Edge Capture Mode Timings                           |
| <a href="#">VIP2_4B_MANUAL1</a>              | VIN4B Rise-Edge Capture Mode Timings                                  |
| <a href="#">VIP2_3B_IOSET2_MANUAL1</a>       | VIN3B IOSET2 Rise-Edge Capture Mode Timings                           |
| <a href="#">VIP2_3B_IOSET2_MANUAL2</a>       | VIN3B IOSET2 Fall-Edge Capture Mode Timings                           |
| <a href="#">VIP2_MANUAL2</a>                 | VIN3A, VIN3B IOSET1 Fall-Edge Capture Mode Timings                    |
| <a href="#">VIP2_4A_MANUAL2</a>              | VIN4A IOSET1/2 Fall-Edge Capture Mode Timings                         |
| <a href="#">VIP2_4A_IOSET3_MANUAL2</a>       | VIN4A IOSET3 Fall-Edge Capture Mode Timings                           |
| <a href="#">VIP2_4B_MANUAL2</a>              | VIN4B Fall-Edge Capture Mode Timings                                  |
| <b>DPI Video Output</b>                      |                                                                       |
| <a href="#">VOUT1_MANUAL1</a>                | DPI1 Video Output Alternate Timings                                   |
| <a href="#">VOUT1_MANUAL2</a>                | DPI1 Video Output Default Timings                                     |
| <a href="#">VOUT1_MANUAL3</a>                | DPI1 Video Output MANUAL3 Timings                                     |
| <a href="#">VOUT1_MANUAL4</a>                | DPI1 Video Output MANUAL4 Timings                                     |
| <a href="#">VOUT2_IOSET1_MANUAL1</a>         | DPI2 Video Output IOSET1 Alternate Timings                            |
| <a href="#">VOUT2_IOSET1_MANUAL2</a>         | DPI2 Video Output IOSET1 Default Timings                              |
| <a href="#">VOUT2_IOSET1_MANUAL3</a>         | DPI2 Video Output IOSET1 MANUAL3 Timings                              |
| <a href="#">VOUT2_IOSET1_MANUAL4</a>         | DPI2 Video Output IOSET1 MANUAL4 Timings                              |
| <a href="#">VOUT2_IOSET2_MANUAL1</a>         | DPI2 Video Output IOSET2 Alternate Timings                            |
| <a href="#">VOUT2_IOSET2_MANUAL2</a>         | DPI2 Video Output IOSET2 Default Timings                              |
| <a href="#">VOUT2_IOSET2_MANUAL3</a>         | DPI2 Video Output IOSET2 MANUAL3 Timings                              |
| <a href="#">VOUT2_IOSET2_MANUAL4</a>         | DPI2 Video Output IOSET2 MANUAL4 Timings                              |
| <a href="#">VOUT3_MANUAL1</a>                | DPI3 Video Output Alternate Timings                                   |
| <a href="#">VOUT3_MANUAL2</a>                | DPI3 Video Output Default Timings                                     |
| <a href="#">VOUT3_MANUAL3</a>                | DPI3 Video Output MANUAL3 Timings                                     |
| <a href="#">VOUT3_MANUAL4</a>                | DPI3 Video Output MANUAL4 Timings                                     |
| <b>GPMC</b>                                  |                                                                       |
| No Virtual or Manual IO Timing Mode Required | GPMC Asynchronous Mode Timings and Synchronous Mode - Default Timings |
| <a href="#">GPMC_VIRTUAL1</a>                | GPMC Synchronous Mode - Alternate Timings                             |
| <b>McASP</b>                                 |                                                                       |
| No Virtual or Manual IO Timing Mode Required | McASP1 Synchronous Transmit Timings                                   |
| <a href="#">MCASP1_VIRTUAL1_ASYNC_TX</a>     | See <a href="#">Table 5-80</a>                                        |
| <a href="#">MCASP1_VIRTUAL2_SYNC_RX</a>      | See <a href="#">Table 5-80</a>                                        |
| <a href="#">MCASP1_VIRTUAL3_ASYNC_RX</a>     | See <a href="#">Table 5-80</a>                                        |

**Table 5-32. Modes Summary (continued)**

| Virtual or Manual IO Mode Name                                                                             | Datasheet Timing Mode                                                                                                       |
|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| No Virtual or Manual IO Timing Mode Required                                                               | McASP2 Synchronous Transmit Timings                                                                                         |
| <a href="#">MCASP2_VIRTUAL1_ASYNC_RX_80M</a>                                                               | See <a href="#">Table 5-81</a>                                                                                              |
| <a href="#">MCASP2_VIRTUAL2_ASYNC_RX</a>                                                                   | See <a href="#">Table 5-81</a>                                                                                              |
| <a href="#">MCASP2_VIRTUAL3_ASYNC_TX</a>                                                                   | See <a href="#">Table 5-81</a>                                                                                              |
| <a href="#">MCASP2_VIRTUAL4_SYNC_RX</a>                                                                    | See <a href="#">Table 5-81</a>                                                                                              |
| <a href="#">MCASP2_VIRTUAL5_SYNC_RX_80M</a>                                                                | See <a href="#">Table 5-81</a>                                                                                              |
| No Virtual or Manual IO Timing Mode Required                                                               | McASP3 Synchronous Transmit Timings                                                                                         |
| <a href="#">MCASP3_VIRTUAL2_SYNC_RX</a>                                                                    | See <a href="#">Table 5-82</a>                                                                                              |
| No Virtual or Manual IO Timing Mode Required                                                               | McASP4 Synchronous Transmit Timings                                                                                         |
| <a href="#">MCASP4_VIRTUAL1_SYNC_RX</a>                                                                    | See <a href="#">Table 5-83</a>                                                                                              |
| No Virtual or Manual IO Timing Mode Required                                                               | McASP5 Synchronous Transmit Timings                                                                                         |
| <a href="#">MCASP5_VIRTUAL1_SYNC_RX</a>                                                                    | See <a href="#">Table 5-84</a>                                                                                              |
| No Virtual or Manual IO Timing Mode Required                                                               | McASP6 Synchronous Transmit Timings                                                                                         |
| <a href="#">MCASP6_VIRTUAL1_SYNC_RX</a>                                                                    | See <a href="#">Table 5-85</a>                                                                                              |
| No Virtual or Manual IO Timing Mode Required                                                               | McASP7 Synchronous Transmit Timings                                                                                         |
| <a href="#">MCASP7_VIRTUAL2_SYNC_RX</a>                                                                    | See <a href="#">Table 5-86</a>                                                                                              |
| No Virtual or Manual IO Timing Mode Required                                                               | McASP8 Synchronous Transmit Timings                                                                                         |
| <a href="#">MCASP8_VIRTUAL1_SYNC_RX</a>                                                                    | See <a href="#">Table 5-87</a>                                                                                              |
| <b>eMMC/SD/SDIO</b>                                                                                        |                                                                                                                             |
| No Virtual or Manual IO Timing Mode Required                                                               | MMC1 DS (Pad Loopback) and SDR12 (Pad Loopback) Timings                                                                     |
| <a href="#">MMC1_VIRTUAL1</a>                                                                              | MMC1 HS (Internal Loopback and Pad Loopback), SDR12 (Internal Loopback), SDR25 Timings (Internal Loopback and Pad Loopback) |
| <a href="#">MMC1_VIRTUAL2</a>                                                                              | SDR50 (Pad Loopback) Timings                                                                                                |
| <a href="#">MMC1_VIRTUAL5</a>                                                                              | MMC1 DS (Internal Loopback) Timings                                                                                         |
| <a href="#">MMC1_VIRTUAL6</a>                                                                              | MMC1 SDR50 (Internal Loopback) Timings                                                                                      |
| <a href="#">MMC1_VIRTUAL7</a>                                                                              | MMC1 DDR50 (Internal Loopback) Timings                                                                                      |
| <a href="#">MMC1_DDR_MANUAL1</a>                                                                           | MMC1 DDR50 (Pad Loopback) Timings                                                                                           |
| <a href="#">MMC1_SDR104_MANUAL1</a>                                                                        | MMC1 SDR104 Timings                                                                                                         |
| No Virtual or Manual IO Timing Mode Required                                                               | MMC2 Standard (Pad Loopback), High Speed (Pad Loopback), and DDR (Pad Loopback) Timings                                     |
| <a href="#">MMC2_DDR_LB_MANUAL1</a>                                                                        | MMC2 DDR (Internal Loopback) Timings                                                                                        |
| <a href="#">MMC2_HS200_MANUAL1</a>                                                                         | MMC2 HS200 Timings                                                                                                          |
| <a href="#">MMC2_STD_HS_LB_MANUAL1</a>                                                                     | MMC2 Standard (Internal Loopback), High Speed (Internal Loopback) Timings                                                   |
| <a href="#">MMC3_MANUAL1</a>                                                                               | MMC3 DS, SDR12, HS, SDR25 Timings                                                                                           |
| <a href="#">MMC3_MANUAL2</a>                                                                               | MMC3 SDR50 Timings                                                                                                          |
| <a href="#">MMC4_MANUAL1</a>                                                                               | MMC4 SDR12, HS, SDR25 Timings                                                                                               |
| <a href="#">MMC4_DS_MANUAL1</a>                                                                            | MMC4 DS Timings                                                                                                             |
| <b>QSPI</b>                                                                                                |                                                                                                                             |
| No Virtual or Manual IO Timing Mode Required                                                               | QSPI Mode 3 Boot Timing Mode                                                                                                |
| <a href="#">QSPI_MODE3_MANUAL1</a>                                                                         | QSPI Mode 3 Default Timing Mode                                                                                             |
| <a href="#">QSPI_MODE0_MANUAL1</a>                                                                         | QSPI Mode 0 Default Timing Mode                                                                                             |
| <b>GMAC</b>                                                                                                |                                                                                                                             |
| No Virtual or Manual IO Timing Mode Required                                                               | GMAC MII0/1 Timings                                                                                                         |
| <a href="#">GMAC_RMII0_MANUAL1</a>                                                                         | GMAC RMII0 Timings                                                                                                          |
| <a href="#">GMAC_RMII1_MANUAL1</a>                                                                         | GMAC RMII1 Timings                                                                                                          |
| <a href="#">GMAC_RGMII0_MANUAL1</a>                                                                        | GMAC RGMII0 Internal Delay Enabled Timings                                                                                  |
| <a href="#">GMAC_RGMII1_MANUAL1</a>                                                                        | GMAC RGMII1 Internal Delay Enabled Timings                                                                                  |
| <b>HDMI, EMIF, Timers, I2C, UART, McSPI, USB, SATA, PCIe, DCAN, GPIO, PWM, JTAG, TPIU, RTC, SDMA, INTC</b> |                                                                                                                             |

**Table 5-32. Modes Summary (continued)**

| Virtual or Manual IO Mode Name               | Datasheet Timing Mode |
|----------------------------------------------|-----------------------|
| No Virtual or Manual IO Timing Mode Required | All Modes             |

### 5.10.6.3 VIP

The Device includes 2 Video Input Ports (VIP).

Table 5-33, Figure 5-25 and Figure 5-26 present timings and switching characteristics of the VIPs.

#### CAUTION

The IO timings provided in this section are applicable for all combinations of signals for vin1. However, the timings are only valid for vin2, vin3, and vin4 if signals within a single IOSET are used. The IOSETs are defined in the Table 5-34.

**Table 5-33. Timing Requirements for VIP** <sup>(3)(4)(5)</sup>

| NO. | PARAMETER                     | DESCRIPTION                                                                                                                                        | MODE         | MIN                  | MAX | UNIT |
|-----|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------|----------------------|-----|------|
| V1  | $t_{c}(\text{CLK})$           | Cycle time, vinx_clki <sup>(3) (5)</sup>                                                                                                           |              | 6.06                 |     | ns   |
| V2  | $t_{w}(\text{CLKH})$          | Pulse duration, vinx_clki high <sup>(3) (5)</sup>                                                                                                  |              | 0.45P <sup>(2)</sup> |     | ns   |
| V3  | $t_{w}(\text{CLKL})$          | Pulse duration, vinx_clki low <sup>(3) (5)</sup>                                                                                                   |              | 0.45P <sup>(2)</sup> |     | ns   |
| V4  | $t_{su}(\text{CTL/DATA-CLK})$ | Input setup time, Control (vinx_dei, vinx_vsynci, vinx_fldi, vinx_hsynci) and Data (vinx_dn) valid to vinx_clki transition <sup>(3) (4) (5)</sup>  | vin1x, vin2x | 2.93                 |     | ns   |
|     |                               |                                                                                                                                                    | vin3x, vin4x | 3.11                 |     | ns   |
| V5  | $t_{h}(\text{CLK-CTL/DATA})$  | Input hold time, Control (vinx_dei, vinx_vsynci, vinx_fldi, vinx_hsynci) and Data (vinx_dn) valid from vinx_clki transition <sup>(3) (4) (5)</sup> |              | -0.05                |     | ns   |

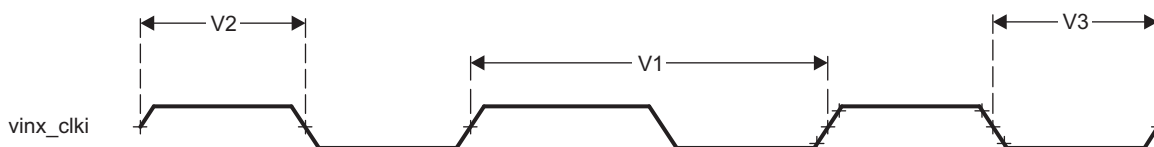
(1) For maximum frequency of 165 MHz.

(2) P = vinx\_clki period.

(3) x in vinx = 1a, 1b, 2a, 2b, 3a, 3b, 4a, 4b.

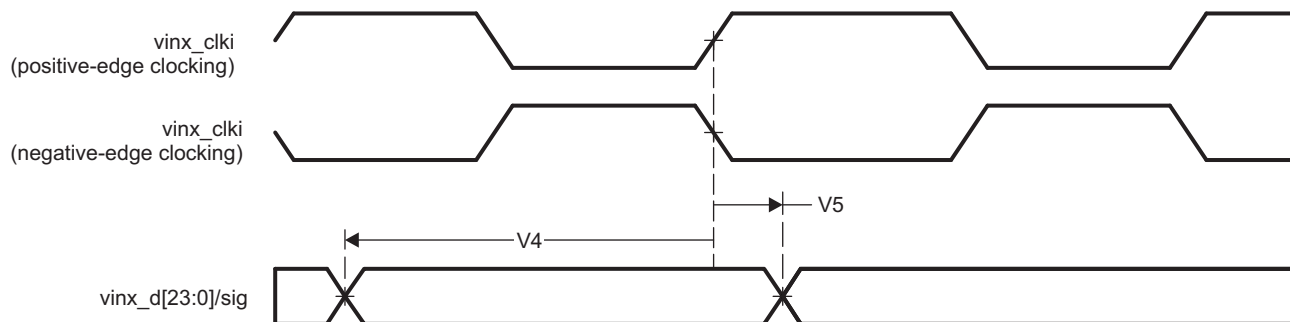
(4) n in dn = 0 to 7 when x = 1b, 2b, 3b and 4b;  
n = 0 to 23 when x = 1a, 2a, 3a and 4a;

(5) i in clki, dei, vsynci, hsynci and fldi = 0 or 1.



SPRS8xx\_VIP\_01

**Figure 5-25. Video Input Ports clock signal**



SPRS8xx\_VIP\_02

**Figure 5-26. Video Input Ports timings**

In [Table 5-34](#), [Table 5-35](#) and [Table 5-36](#) are presented the specific groupings of signals (IOSET) for use with vin2, vin3, and vin4.

**Table 5-34. VIN2 IOSETs**

| Signals      | IOSET1 |     | IOSET2 |     | IOSET3 |     |
|--------------|--------|-----|--------|-----|--------|-----|
|              | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| <b>vin2a</b> |        |     |        |     |        |     |
| vin2a_d0     | F2     | 0   | F2     | 0   | U4     | 4   |
| vin2a_d1     | F3     | 0   | F3     | 0   | V2     | 4   |
| vin2a_d2     | D1     | 0   | D1     | 0   | Y1     | 4   |
| vin2a_d3     | E2     | 0   | E2     | 0   | W9     | 4   |
| vin2a_d4     | D2     | 0   | D2     | 0   | V9     | 4   |
| vin2a_d5     | F4     | 0   | F4     | 0   | U5     | 4   |
| vin2a_d6     | C1     | 0   | C1     | 0   | V5     | 4   |
| vin2a_d7     | E4     | 0   | E4     | 0   | V4     | 4   |
| vin2a_d8     | F5     | 0   | F5     | 0   | V3     | 4   |
| vin2a_d9     | E6     | 0   | E6     | 0   | Y2     | 4   |
| vin2a_d10    | D3     | 0   | D3     | 0   | U6     | 4   |
| vin2a_d11    | F6     | 0   | F6     | 0   | U3     | 4   |
| vin2a_d12    | D5     | 0   | D5     | 0   | -      | -   |
| vin2a_d13    | C2     | 0   | C2     | 0   | -      | -   |
| vin2a_d14    | C3     | 0   | C3     | 0   | -      | -   |
| vin2a_d15    | C4     | 0   | C4     | 0   | -      | -   |
| vin2a_d16    | B2     | 0   | B2     | 0   | -      | -   |
| vin2a_d17    | D6     | 0   | D6     | 0   | -      | -   |
| vin2a_d18    | C5     | 0   | C5     | 0   | -      | -   |
| vin2a_d19    | A3     | 0   | A3     | 0   | -      | -   |
| vin2a_d20    | B3     | 0   | B3     | 0   | -      | -   |
| vin2a_d21    | B4     | 0   | B4     | 0   | -      | -   |
| vin2a_d22    | B5     | 0   | B5     | 0   | -      | -   |
| vin2a_d23    | A4     | 0   | A4     | 0   | -      | -   |
| vin2a_hsync0 | G1     | 0   | G1     | 0   | U7     | 4   |
| vin2a_vsync0 | G6     | 0   | G6     | 0   | V6     | 4   |
| vin2a_de0    | G2     | 0   | -      | -   | V7     | 4   |
| vin2a_fld0   | H7     | 0   | G2     | 1   | W2     | 4   |
| vin2a_clk0   | E1     | 0   | E1     | 0   | V1     | 4   |
| <b>vin2b</b> |        |     |        |     |        |     |
| vin2b_clk1   | H7     | 2   | H7     | 2   | AB5    | 4   |
| vin2b_de1    | -      | -   | G2     | 3   | AB8    | 4   |
| vin2b_fld1   | G2     | 2   | -      | -   | -      | -   |
| vin2b_d0     | A4     | 2   | A4     | 2   | AD6    | 4   |
| vin2b_d1     | B5     | 2   | B5     | 2   | AC8    | 4   |
| vin2b_d2     | B4     | 2   | B4     | 2   | AC3    | 4   |
| vin2b_d3     | B3     | 2   | B3     | 2   | AC9    | 4   |
| vin2b_d4     | A3     | 2   | A3     | 2   | AC6    | 4   |
| vin2b_d5     | C5     | 2   | C5     | 2   | AC7    | 4   |
| vin2b_d6     | D6     | 2   | D6     | 2   | AC4    | 4   |
| vin2b_d7     | B2     | 2   | B2     | 2   | AD4    | 4   |
| vin2b_hsync1 | G1     | 3   | G1     | 3   | AC5    | 4   |

Table 5-34. VIN2 IOSETs (continued)

| Signals      | IOSET1 |     | IOSET2 |     | IOSET3 |     |
|--------------|--------|-----|--------|-----|--------|-----|
|              | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| vin2b_vsync1 | G6     | 3   | G6     | 3   | AB4    | 4   |

Table 5-35. VIN3 IOSETs

| Signals      | IOSET1 |     | IOSET2 |     | IOSET3 |     | IOSET4 |     |
|--------------|--------|-----|--------|-----|--------|-----|--------|-----|
|              | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| vin3a        |        |     |        |     |        |     |        |     |
| vin3a_d0     | M6     | 2   | AF1    | 6   | AF1    | 6   | B7     | 4   |
| vin3a_d1     | M2     | 2   | AE3    | 6   | AE3    | 6   | B8     | 4   |
| vin3a_d2     | L5     | 2   | AE5    | 6   | AE5    | 6   | A7     | 4   |
| vin3a_d3     | M1     | 2   | AE1    | 6   | AE1    | 6   | A8     | 4   |
| vin3a_d4     | L6     | 2   | AE2    | 6   | AE2    | 6   | C9     | 4   |
| vin3a_d5     | L4     | 2   | AE6    | 6   | AE6    | 6   | A9     | 4   |
| vin3a_d6     | L3     | 2   | AD2    | 6   | AD2    | 6   | B9     | 4   |
| vin3a_d7     | L2     | 2   | AD3    | 6   | AD3    | 6   | A10    | 4   |
| vin3a_d8     | L1     | 2   | B2     | 6   | B2     | 6   | E8     | 4   |
| vin3a_d9     | K2     | 2   | D6     | 6   | D6     | 6   | D9     | 4   |
| vin3a_d10    | J1     | 2   | C5     | 6   | C5     | 6   | D7     | 4   |
| vin3a_d11    | J2     | 2   | A3     | 6   | A3     | 6   | D8     | 4   |
| vin3a_d12    | H1     | 2   | B3     | 6   | -      | -   | A5     | 4   |
| vin3a_d13    | J3     | 2   | B4     | 6   | -      | -   | C6     | 4   |
| vin3a_d14    | H2     | 2   | B5     | 6   | -      | -   | C8     | 4   |
| vin3a_d15    | H3     | 2   | A4     | 6   | -      | -   | C7     | 4   |
| vin3a_d16    | R6     | 2   | -      | -   | -      | -   | F11    | 4   |
| vin3a_d17    | T9     | 2   | -      | -   | -      | -   | G10    | 4   |
| vin3a_d18    | T6     | 2   | -      | -   | -      | -   | F10    | 4   |
| vin3a_d19    | T7     | 2   | -      | -   | -      | -   | G11    | 4   |
| vin3a_d20    | P6     | 2   | -      | -   | -      | -   | E9     | 4   |
| vin3a_d21    | R9     | 2   | -      | -   | -      | -   | F9     | 4   |
| vin3a_d22    | R5     | 2   | -      | -   | -      | -   | F8     | 4   |
| vin3a_d23    | P5     | 2   | -      | -   | -      | -   | E7     | 4   |
| vin3a_hsync0 | N7     | 2   | N7     | 2   | B5     | 5   | C11    | 4   |
| vin3a_vsync0 | R4     | 2   | R4     | 2   | A4     | 5   | E11    | 4   |
| vin3a_de0    | N9     | 2   | N9     | 2   | B3     | 5   | B10    | 4   |
| vin3a_fld0   | P9     | 2   | P9     | 2   | B4     | 5   | D11    | 4   |
| vin3a_clk0   | P1     | 2   | AH7    | 6   | AH7    | 6   | B11    | 4   |
| vin3b        |        |     |        |     |        |     |        |     |
| vin3b_clk1   | P7     | 6   | M4     | 4   | -      | -   | -      | -   |
| vin3b_de1    | N6     | 6   | N6     | 6   | -      | -   | -      | -   |
| vin3b_fld1   | M4     | 6   | -      | -   | -      | -   | -      | -   |
| vin3b_d0     | K7     | 6   | K7     | 6   | -      | -   | -      | -   |
| vin3b_d1     | M7     | 6   | M7     | 6   | -      | -   | -      | -   |
| vin3b_d2     | J5     | 6   | J5     | 6   | -      | -   | -      | -   |
| vin3b_d3     | K6     | 6   | K6     | 6   | -      | -   | -      | -   |
| vin3b_d4     | J7     | 6   | J7     | 6   | -      | -   | -      | -   |
| vin3b_d5     | J4     | 6   | J4     | 6   | -      | -   | -      | -   |
| vin3b_d6     | J6     | 6   | J6     | 6   | -      | -   | -      | -   |

**Table 5-35. VIN3 IOSETs (continued)**

| Signals      | IOSET1 |     | IOSET2 |     | IOSET3 |     | IOSET4 |     |
|--------------|--------|-----|--------|-----|--------|-----|--------|-----|
|              | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| vin3b_d7     | H4     | 6   | H4     | 6   | -      | -   | -      | -   |
| vin3b_hsync1 | H5     | 6   | H5     | 6   | -      | -   | -      | -   |
| vin3b_vsync1 | H6     | 6   | H6     | 6   | -      | -   | -      | -   |

**Table 5-36. VIN4 IOSETs**

| Signals      | IOSET1 |       | IOSET2 |     | IOSET3 |     |
|--------------|--------|-------|--------|-----|--------|-----|
|              | BALL   | MUX   | BALL   | MUX | BALL   | MUX |
| <b>vin4a</b> |        |       |        |     |        |     |
| vin4a_d0     | R6     | 4     | B7     | 3   | B14    | 8   |
| vin4a_d1     | T9     | 4     | B8     | 3   | J14    | 8   |
| vin4a_d2     | T6     | 4     | A7     | 3   | G13    | 8   |
| vin4a_d3     | T7     | 4     | A8     | 3   | J11    | 8   |
| vin4a_d4     | P6     | 4     | C9     | 3   | E12    | 8   |
| vin4a_d5     | R9     | 4     | A9     | 3   | F13    | 8   |
| vin4a_d6     | R5     | 4     | B9     | 3   | C12    | 8   |
| vin4a_d7     | P5     | 4     | A10    | 3   | D12    | 8   |
| vin4a_d8     | U2     | 4     | E8     | 3   | E15    | 8   |
| vin4a_d9     | U1     | 4     | D9     | 3   | A20    | 8   |
| vin4a_d10    | P3     | 4     | D7     | 3   | B15    | 8   |
| vin4a_d11    | R2     | 4     | D8     | 3   | A15    | 8   |
| vin4a_d12    | K7     | 4     | A5     | 3   | D15    | 8   |
| vin4a_d13    | M7     | 4     | C6     | 3   | B16    | 8   |
| vin4a_d14    | J5     | 4     | C8     | 3   | B17    | 8   |
| vin4a_d15    | K6     | 4     | C7     | 3   | A17    | 8   |
| vin4a_d16    | -      | -     | F11    | 3   | C18    | 8   |
| vin4a_d17    | -      | -     | G10    | 3   | A21    | 8   |
| vin4a_d18    | -      | -     | F10    | 3   | G16    | 8   |
| vin4a_d19    | -      | -     | G11    | 3   | D17    | 8   |
| vin4a_d20    | -      | -     | E9     | 3   | AA3    | 8   |
| vin4a_d21    | -      | -     | F9     | 3   | AB9    | 8   |
| vin4a_d22    | -      | -     | F8     | 3   | AB3    | 8   |
| vin4a_d23    | -      | -     | E7     | 3   | AA4    | 8   |
| vin4a_hsync0 | R3/ P7 | 4 / 4 | C11    | 3   | E21    | 8   |
| vin4a_vsync0 | T2/ N1 | 4 / 4 | E11    | 3   | F20    | 8   |
| vin4a_de0    | H6/ P7 | 4 / 5 | B10    | 3   | C23    | 8   |
| vin4a_fld0   | P9/ J7 | 4 / 4 | D11    | 3   | F21    | 8   |
| vin4a_clk0   | P4     | 4     | B11    | 3   | B26    | 8   |
| <b>vin4b</b> |        |       |        |     |        |     |
| vin4b_clk1   | N9     | 6     | V1     | 5   | -      | -   |
| vin4b_de1    | P9     | 6     | V7     | 5   | -      | -   |
| vin4b_fld1   | P4     | 6     | W2     | 5   | -      | -   |
| vin4b_d0     | R6     | 6     | U4     | 5   | -      | -   |
| vin4b_d1     | T9     | 6     | V2     | 5   | -      | -   |
| vin4b_d2     | T6     | 6     | Y1     | 5   | -      | -   |
| vin4b_d3     | T7     | 6     | W9     | 5   | -      | -   |
| vin4b_d4     | P6     | 6     | V9     | 5   | -      | -   |

**Table 5-36. VIN4 IOSETs (continued)**

| Signals      | IOSET1 |     | IOSET2 |     | IOSET3 |     |
|--------------|--------|-----|--------|-----|--------|-----|
|              | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| vin4b_d5     | R9     | 6   | U5     | 5   | -      | -   |
| vin4b_d6     | R5     | 6   | V5     | 5   | -      | -   |
| vin4b_d7     | P5     | 6   | V4     | 5   | -      | -   |
| vin4b_hsync1 | N7     | 6   | U7     | 5   | -      | -   |
| vin4b_vsync1 | R4     | 6   | V6     | 5   | -      | -   |

**NOTE**

To configure the desired Manual IO Timing Mode the user must follow the steps described in section "*Manual IO Timing Modes*" of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information please see the *Control Module Chapter* in the Device TRM.

Manual IO Timings Modes must be used to guarantee some IO timings for VIP1. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-37, Manual Functions Mapping for VIP1](#) for a definition of the Manual modes.

[Table 5-37](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-37. Manual Functions Mapping for VIP1

| BAL<br>L | BALL NAME       | VIP1_MANUAL1    |                 | VIP1_MANUAL2    |                 | CFG REGISTER           | MUXMODE    |          |   |              |              |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------------|------------|----------|---|--------------|--------------|
|          |                 | A_DELAY<br>(ps) | G_DELAY<br>(ps) | A_DELAY<br>(ps) | G_DELAY<br>(ps) |                        | 0          | 1        | 2 | 3            | 4            |
| U3       | RMII_MHZ_50_CLK | 1973            | 184             | 2257            | 0               | CFG_RMII_MHZ_50_CLK_IN | -          | -        | - | -            | vin2a_d11    |
| N6       | gpmc_ben0       | 2133            | 486             | 2582            | 77              | CFG_GPMC_BEN0_IN       | -          | -        | - | vin1b_hsync1 | -            |
| M4       | gpmc_ben1       | 2034            | 577             | 2545            | 109             | CFG_GPMC_BEN1_IN       | -          | -        | - | vin1b_de1    | -            |
| U4       | mdio_d          | 1897            | 35              | 1999            | 0               | CFG_MDIO_D_IN          | -          | -        | - | -            | vin2a_d0     |
| V1       | mdio_mclk       | 0               | 0               | 0               | 0               | CFG_MDIO_MCLK_IN       | -          | -        | - | -            | vin2a_clk0   |
| U5       | rgmii0_rxc      | 1945            | 97              | 2072            | 0               | CFG_RGMII0_RXC_IN      | -          | -        | - | -            | vin2a_d5     |
| V5       | rgmii0_rxctl    | 1939            | 440             | 2326            | 93              | CFG_RGMII0_RXCTL_IN    | -          | -        | - | -            | vin2a_d6     |
| W2       | rgmii0_rxd0     | 1990            | 141             | 2147            | 0               | CFG_RGMII0_RXD0_IN     | -          | -        | - | -            | vin2a_fld0   |
| Y2       | rgmii0_rxd1     | 1928            | 527             | 2298            | 246             | CFG_RGMII0_RXD1_IN     | -          | -        | - | -            | vin2a_d9     |
| V3       | rgmii0_rxd2     | 1901            | 425             | 2280            | 134             | CFG_RGMII0_RXD2_IN     | -          | -        | - | -            | vin2a_d8     |
| V4       | rgmii0_rxd3     | 1972            | 637             | 2331            | 362             | CFG_RGMII0_RXD3_IN     | -          | -        | - | -            | vin2a_d7     |
| W9       | rgmii0_txc      | 1933            | 382             | 2347            | 28              | CFG_RGMII0_TXC_IN      | -          | -        | - | -            | vin2a_d3     |
| V9       | rgmii0_txctl    | 2019            | 479             | 2372            | 217             | CFG_RGMII0_TXCTL_IN    | -          | -        | - | -            | vin2a_d4     |
| U6       | rgmii0_txd0     | 1934            | 203             | 2205            | 0               | CFG_RGMII0_TXD0_IN     | -          | -        | - | -            | vin2a_d10    |
| V6       | rgmii0_txd1     | 2015            | 604             | 2360            | 362             | CFG_RGMII0_TXD1_IN     | -          | -        | - | -            | vin2a_vsync0 |
| U7       | rgmii0_txd2     | 1839            | 496             | 2249            | 158             | CFG_RGMII0_TXD2_IN     | -          | -        | - | -            | vin2a_hsync0 |
| V7       | rgmii0_txd3     | 2087            | 423             | 2426            | 108             | CFG_RGMII0_TXD3_IN     | -          | -        | - | -            | vin2a_de0    |
| V2       | uart3_rxd       | 1578            | 0               | 1530            | 0               | CFG_UART3_RXD_IN       | -          | -        | - | -            | vin2a_d1     |
| Y1       | uart3_txd       | 1869            | 99              | 1967            | 0               | CFG_UART3_TXD_IN       | -          | -        | - | -            | vin2a_d2     |
| AG8      | vin1a_clk0      | 0               | 0               | 0               | 0               | CFG_VIN1A_CLK0_IN      | vin1a_clk0 | -        | - | -            | -            |
| AE8      | vin1a_d0        | 2051            | 708             | 2439            | 275             | CFG_VIN1A_D0_IN        | vin1a_d0   | -        | - | -            | -            |
| AD8      | vin1a_d1        | 1931            | 812             | 2337            | 447             | CFG_VIN1A_D1_IN        | vin1a_d1   | -        | - | -            | -            |
| AG3      | vin1a_d10       | 2049            | 804             | 2420            | 448             | CFG_VIN1A_D10_IN       | vin1a_d10  | vin1b_d5 | - | -            | -            |
| AG5      | vin1a_d11       | 1921            | 766             | 2331            | 438             | CFG_VIN1A_D11_IN       | vin1a_d11  | vin1b_d4 | - | -            | -            |
| AF2      | vin1a_d12       | 2078            | 1220            | 2397            | 915             | CFG_VIN1A_D12_IN       | vin1a_d12  | vin1b_d3 | - | -            | -            |
| AF6      | vin1a_d13       | 1986            | 1138            | 2366            | 788             | CFG_VIN1A_D13_IN       | vin1a_d13  | vin1b_d2 | - | -            | -            |
| AF3      | vin1a_d14       | 2077            | 1242            | 2403            | 947             | CFG_VIN1A_D14_IN       | vin1a_d14  | vin1b_d1 | - | -            | -            |
| AF4      | vin1a_d15       | 2070            | 1581            | 2337            | 1407            | CFG_VIN1A_D15_IN       | vin1a_d15  | vin1b_d0 | - | -            | -            |
| AF1      | vin1a_d16       | 2008            | 1432            | 2321            | 1202            | CFG_VIN1A_D16_IN       | vin1a_d16  | vin1b_d7 | - | -            | -            |
| AE3      | vin1a_d17       | 2077            | 1571            | 2370            | 1351            | CFG_VIN1A_D17_IN       | vin1a_d17  | vin1b_d6 | - | -            | -            |
| AE5      | vin1a_d18       | 2075            | 1527            | 2357            | 1292            | CFG_VIN1A_D18_IN       | vin1a_d18  | vin1b_d5 | - | -            | -            |

**Table 5-37. Manual Functions Mapping for VIP1 (continued)**

| BAL<br>L | BALL NAME    | VIP1_MANUAL1    |                 | VIP1_MANUAL2    |                 | CFG REGISTER        | MUXMODE      |              |          |   |   |
|----------|--------------|-----------------|-----------------|-----------------|-----------------|---------------------|--------------|--------------|----------|---|---|
|          |              | A_DELAY<br>(ps) | G_DELAY<br>(ps) | A_DELAY<br>(ps) | G_DELAY<br>(ps) |                     | 0            | 1            | 2        | 3 | 4 |
| AE1      | vin1a_d19    | 2055            | 1636            | 2358            | 1422            | CFG_VIN1A_D19_IN    | vin1a_d19    | vin1b_d4     | -        | - | - |
| AG7      | vin1a_d2     | 1871            | 1037            | 2301            | 620             | CFG_VIN1A_D2_IN     | vin1a_d2     | -            | -        | - | - |
| AE2      | vin1a_d20    | 2046            | 1452            | 2351            | 1163            | CFG_VIN1A_D20_IN    | vin1a_d20    | vin1b_d3     | -        | - | - |
| AE6      | vin1a_d21    | 2135            | 1292            | 2405            | 1024            | CFG_VIN1A_D21_IN    | vin1a_d21    | vin1b_d2     | -        | - | - |
| AD2      | vin1a_d22    | 2034            | 1430            | 2348            | 1206            | CFG_VIN1A_D22_IN    | vin1a_d22    | vin1b_d1     | -        | - | - |
| AD3      | vin1a_d23    | 2191            | 813             | 2502            | 447             | CFG_VIN1A_D23_IN    | vin1a_d23    | vin1b_d0     | -        | - | - |
| AH6      | vin1a_d3     | 1938            | 984             | 2299            | 658             | CFG_VIN1A_D3_IN     | vin1a_d3     | -            | -        | - | - |
| AH3      | vin1a_d4     | 2034            | 597             | 2424            | 178             | CFG_VIN1A_D4_IN     | vin1a_d4     | -            | -        | - | - |
| AH5      | vin1a_d5     | 1961            | 927             | 2359            | 554             | CFG_VIN1A_D5_IN     | vin1a_d5     | -            | -        | - | - |
| AG6      | vin1a_d6     | 1909            | 930             | 2323            | 549             | CFG_VIN1A_D6_IN     | vin1a_d6     | -            | -        | - | - |
| AH4      | vin1a_d7     | 1999            | 901             | 2383            | 557             | CFG_VIN1A_D7_IN     | vin1a_d7     | -            | -        | - | - |
| AG4      | vin1a_d8     | 2040            | 856             | 2426            | 448             | CFG_VIN1A_D8_IN     | vin1a_d8     | vin1b_d7     | -        | - | - |
| AG2      | vin1a_d9     | 2133            | 799             | 2472            | 388             | CFG_VIN1A_D9_IN     | vin1a_d9     | vin1b_d6     | -        | - | - |
| AD9      | vin1a_de0    | 1842            | 861             | 2258            | 352             | CFG_VIN1A_DE0_IN    | vin1a_de0    | vin1b_hsync1 | -        | - | - |
| AF9      | vin1a_fld0   | 1968            | 1029            | 2347            | 622             | CFG_VIN1A_FLD0_IN   | vin1a_fld0   | vin1b_vsync1 | -        | - | - |
| AE9      | vin1a_hsync0 | 1871            | 1264            | 2257            | 881             | CFG_VIN1A_HSYNC0_IN | vin1a_hsync0 | vin1b_fld1   | -        | - | - |
| AF8      | vin1a_vsync0 | 1798            | 1000            | 2243            | 649             | CFG_VIN1A_VSYNC0_IN | vin1a_vsync0 | vin1b_de1    | -        | - | - |
| AH7      | vin1b_clk1   | 160             | 0               | 227             | 0               | CFG_VIN1B_CLK1_IN   | vin1b_clk1   | -            | -        | - | - |
| E1       | vin2a_clk0   | 0               | 0               | 0               | 0               | CFG_VIN2A_CLK0_IN   | vin2a_clk0   | -            | -        | - | - |
| F2       | vin2a_d0     | 1920            | 227             | 2180            | 0               | CFG_VIN2A_D0_IN     | vin2a_d0     | -            | -        | - | - |
| F3       | vin2a_d1     | 1957            | 476             | 2326            | 309             | CFG_VIN2A_D1_IN     | vin2a_d1     | -            | -        | - | - |
| D3       | vin2a_d10    | 1865            | 337             | 2297            | 110             | CFG_VIN2A_D10_IN    | vin2a_d10    | -            | -        | - | - |
| F6       | vin2a_d11    | 1753            | 19              | 1938            | 0               | CFG_VIN2A_D11_IN    | vin2a_d11    | -            | -        | - | - |
| D5       | vin2a_d12    | 1654            | 487             | 2135            | 182             | CFG_VIN2A_D12_IN    | vin2a_d12    | -            | -        | - | - |
| C2       | vin2a_d13    | 1927            | 132             | 2134            | 0               | CFG_VIN2A_D13_IN    | vin2a_d13    | -            | -        | - | - |
| C3       | vin2a_d14    | 1715            | 0               | 1753            | 0               | CFG_VIN2A_D14_IN    | vin2a_d14    | -            | -        | - | - |
| C4       | vin2a_d15    | 1745            | 381             | 2222            | 63              | CFG_VIN2A_D15_IN    | vin2a_d15    | -            | -        | - | - |
| B2       | vin2a_d16    | 1670            | 319             | 2137            | 58              | CFG_VIN2A_D16_IN    | vin2a_d16    | -            | vin2b_d7 | - | - |
| D6       | vin2a_d17    | 1709            | 409             | 2192            | 79              | CFG_VIN2A_D17_IN    | vin2a_d17    | -            | vin2b_d6 | - | - |
| C5       | vin2a_d18    | 2033            | 334             | 2378            | 21              | CFG_VIN2A_D18_IN    | vin2a_d18    | -            | vin2b_d5 | - | - |
| A3       | vin2a_d19    | 1957            | 193             | 2207            | 0               | CFG_VIN2A_D19_IN    | vin2a_d19    | -            | vin2b_d4 | - | - |
| D1       | vin2a_d2     | 1912            | 5               | 2057            | 0               | CFG_VIN2A_D2_IN     | vin2a_d2     | -            | -        | - | - |

Table 5-37. Manual Functions Mapping for VIP1 (continued)

| BALL | BALL NAME    | VIP1_MANUAL1 |              | VIP1_MANUAL2 |              | CFG REGISTER        | MUXMODE      |            |            |              |   |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|--------------|------------|------------|--------------|---|
|      |              | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) |                     | 0            | 1          | 2          | 3            | 4 |
| B3   | vin2a_d20    | 1938         | 619          | 2325         | 388          | CFG_VIN2A_D20_IN    | vin2a_d20    | -          | vin2b_d3   | -            | - |
| B4   | vin2a_d21    | 1899         | 546          | 2320         | 221          | CFG_VIN2A_D21_IN    | vin2a_d21    | -          | vin2b_d2   | -            | - |
| B5   | vin2a_d22    | 1800         | 272          | 2219         | 30           | CFG_VIN2A_D22_IN    | vin2a_d22    | -          | vin2b_d1   | -            | - |
| A4   | vin2a_d23    | 1807         | 476          | 2225         | 200          | CFG_VIN2A_D23_IN    | vin2a_d23    | -          | vin2b_d0   | -            | - |
| E2   | vin2a_d3     | 2095         | 421          | 2440         | 257          | CFG_VIN2A_D3_IN     | vin2a_d3     | -          | -          | -            | - |
| D2   | vin2a_d4     | 2008         | 0            | 2142         | 0            | CFG_VIN2A_D4_IN     | vin2a_d4     | -          | -          | -            | - |
| F4   | vin2a_d5     | 2137         | 406          | 2455         | 252          | CFG_VIN2A_D5_IN     | vin2a_d5     | -          | -          | -            | - |
| C1   | vin2a_d6     | 1717         | 0            | 1883         | 0            | CFG_VIN2A_D6_IN     | vin2a_d6     | -          | -          | -            | - |
| E4   | vin2a_d7     | 1850         | 171          | 2229         | 0            | CFG_VIN2A_D7_IN     | vin2a_d7     | -          | -          | -            | - |
| F5   | vin2a_d8     | 1841         | 340          | 2250         | 151          | CFG_VIN2A_D8_IN     | vin2a_d8     | -          | -          | -            | - |
| E6   | vin2a_d9     | 1836         | 289          | 2279         | 27           | CFG_VIN2A_D9_IN     | vin2a_d9     | -          | -          | -            | - |
| G2   | vin2a_de0    | 1772         | 316          | 2202         | 0            | CFG_VIN2A_DE0_IN    | vin2a_de0    | vin2a_fld0 | vin2b_fld1 | vin2b_de1    | - |
| H7   | vin2a_fld0   | 2117         | 507          | 2453         | 357          | CFG_VIN2A_FLD0_IN   | vin2a_fld0   | -          | vin2b_clk1 | -            | - |
| G1   | vin2a_hsync0 | 1969         | 231          | 2233         | 0            | CFG_VIN2A_HSYNC0_IN | vin2a_hsync0 | -          | -          | vin2b_hsync1 | - |
| G6   | vin2a_vsync0 | 1793         | 110          | 1936         | 0            | CFG_VIN2A_VSYNC0_IN | vin2a_vsync0 | -          | -          | vin2b_vsync1 | - |

Manual IO Timings Modes must be used to guarantee some IO timings for VIP1. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-38, Manual Functions Mapping for VIP1 2B](#) for a definition of the Manual modes.

[Table 5-38](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-38. Manual Functions Mapping for VIP1 2B

| BALL | BALL NAME | VIP1_2B_MANUAL1 |              | VIP1_2B_MANUAL2 |              | CFG REGISTER     | MUXMODE |   |              |
|------|-----------|-----------------|--------------|-----------------|--------------|------------------|---------|---|--------------|
|      |           | A_DELAY (ps)    | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                  | 2       | 3 | 4            |
| AC5  | gpio6_10  | 2207            | 0            | 2288            | 0            | CFG_GPIO6_10_IN  | -       | - | vin2b_hsync1 |
| AB4  | gpio6_11  | 2183            | 225          | 2486            | 77           | CFG_GPIO6_11_IN  | -       | - | vin2b_vsync1 |
| AD4  | mmc3_clk  | 2262            | 114          | 2452            | 0            | CFG_MMC3_CLK_IN  | -       | - | vin2b_d7     |
| AC4  | mmc3_cmd  | 2228            | 108          | 2425            | 0            | CFG_MMC3_CMD_IN  | -       | - | vin2b_d6     |
| AC7  | mmc3_dat0 | 2137            | 170          | 2463            | 0            | CFG_MMC3_DAT0_IN | -       | - | vin2b_d5     |
| AC6  | mmc3_dat1 | 2116            | 154          | 2393            | 0            | CFG_MMC3_DAT1_IN | -       | - | vin2b_d4     |
| AC9  | mmc3_dat2 | 1891            | 0            | 1945            | 0            | CFG_MMC3_DAT2_IN | -       | - | vin2b_d3     |
| AC3  | mmc3_dat3 | 2202            | 197          | 2516            | 22           | CFG_MMC3_DAT3_IN | -       | - | vin2b_d2     |
| AC8  | mmc3_dat4 | 1966            | 0            | 1991            | 0            | CFG_MMC3_DAT4_IN | -       | - | vin2b_d1     |

Table 5-38. Manual Functions Mapping for VIP1 2B (continued)

| BALL | BALL NAME    | VIP1_2B_MANUAL1 |              | VIP1_2B_MANUAL2 |              | CFG REGISTER        | MUXMODE    |              |            |
|------|--------------|-----------------|--------------|-----------------|--------------|---------------------|------------|--------------|------------|
|      |              | A_DELAY (ps)    | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                     | 2          | 3            | 4          |
| AD6  | mmc3_dat5    | 2163            | 15           | 2361            | 0            | CFG_MMC3_DAT5_IN    | -          | -            | vin2b_d0   |
| AB8  | mmc3_dat6    | 2162            | 51           | 2319            | 0            | CFG_MMC3_DAT6_IN    | -          | -            | vin2b_de1  |
| AB5  | mmc3_dat7    | 0               | 0            | 0               | 0            | CFG_MMC3_DAT7_IN    | -          | -            | vin2b_clk1 |
| B2   | vin2a_d16    | 1175            | 0            | 1413            | 0            | CFG_VIN2A_D16_IN    | vin2b_d7   | -            | -          |
| D6   | vin2a_d17    | 1323            | 0            | 1522            | 0            | CFG_VIN2A_D17_IN    | vin2b_d6   | -            | -          |
| C5   | vin2a_d18    | 1513            | 0            | 1580            | 0            | CFG_VIN2A_D18_IN    | vin2b_d5   | -            | -          |
| A3   | vin2a_d19    | 1278            | 0            | 1396            | 0            | CFG_VIN2A_D19_IN    | vin2b_d4   | -            | -          |
| B3   | vin2a_d20    | 1676            | 0            | 1895            | 0            | CFG_VIN2A_D20_IN    | vin2b_d3   | -            | -          |
| B4   | vin2a_d21    | 1610            | 0            | 1774            | 0            | CFG_VIN2A_D21_IN    | vin2b_d2   | -            | -          |
| B5   | vin2a_d22    | 1250            | 0            | 1497            | 0            | CFG_VIN2A_D22_IN    | vin2b_d1   | -            | -          |
| A4   | vin2a_d23    | 1434            | 0            | 1643            | 0            | CFG_VIN2A_D23_IN    | vin2b_d0   | -            | -          |
| G2   | vin2a_de0    | 1539            | 147          | 1793            | 0            | CFG_VIN2A_DE0_IN    | vin2b_fld1 | vin2b_de1    | -          |
| H7   | vin2a_fld0   | 0               | 0            | 0               | 0            | CFG_VIN2A_FLD0_IN   | vin2b_clk1 | -            | -          |
| G1   | vin2a_hsync0 | 1475            | 0            | 1542            | 0            | CFG_VIN2A_HSYNC0_IN | -          | vin2b_hsync1 | -          |
| G6   | vin2a_vsync0 | 1163            | 0            | 1218            | 0            | CFG_VIN2A_VSYNC0_IN | -          | vin2b_vsync1 | -          |

(1) The CFG\_MMC3\_CLK\_IN register should remain at its Default value, which is programmed automatically by hardware during the recalibration process.

Manual IO Timings Modes must be used to guarantee some IO timings for VIP2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-39, Manual Functions Mapping for VIP2](#) for a definition of the Manual modes.

[Table 5-39](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-39. Manual Functions Mapping for VIP2

| BALL | BALL NAME | VIP2_MANUAL 1 |              | VIP2_MANUAL2 |              | CFG REGISTER    | MUXMODE    |   |            |   |          |
|------|-----------|---------------|--------------|--------------|--------------|-----------------|------------|---|------------|---|----------|
|      |           | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) |                 | 2          | 3 | 4          | 5 | 6        |
| R6   | gpmc_a0   | 2558          | 565          | 2920         | 260          | CFG_GPMC_A0_IN  | vin3a_d16  | - | vin4a_d0   | - | -        |
| T9   | gpmc_a1   | 2421          | 648          | 2782         | 349          | CFG_GPMC_A1_IN  | vin3a_d17  | - | vin4a_d1   | - | -        |
| N9   | gpmc_a10  | 2378          | 477          | 2765         | 0            | CFG_GPMC_A10_IN | vin3a_de0  | - | -          | - | -        |
| P9   | gpmc_a11  | 2409          | 579          | 2783         | 295          | CFG_GPMC_A11_IN | vin3a_fld0 | - | vin4a_fld0 | - | -        |
| K7   | gpmc_a19  | 1887          | 0            | 1735         | 0            | CFG_GPMC_A19_IN | -          | - | vin4a_d12  | - | vin3b_d0 |
| T6   | gpmc_a2   | 2624          | 893          | 2882         | 682          | CFG_GPMC_A2_IN  | vin3a_d18  | - | vin4a_d2   | - | -        |
| M7   | gpmc_a20  | 1670          | 0            | 1508         | 0            | CFG_GPMC_A20_IN | -          | - | vin4a_d13  | - | vin3b_d1 |
| J5   | gpmc_a21  | 1925          | 0            | 1763         | 0            | CFG_GPMC_A21_IN | -          | - | vin4a_d14  | - | vin3b_d2 |

Table 5-39. Manual Functions Mapping for VIP2 (continued)

| BAL<br>L | BALL NAME | VIP2_MANUAL 1   |                 | VIP2_MANUAL2    |                 | CFG REGISTER     | MUXMODE      |   |              |           |              |
|----------|-----------|-----------------|-----------------|-----------------|-----------------|------------------|--------------|---|--------------|-----------|--------------|
|          |           | A_DELAY<br>(ps) | G_DELAY<br>(ps) | A_DELAY<br>(ps) | G_DELAY<br>(ps) |                  | 2            | 3 | 4            | 5         | 6            |
| K6       | gpmc_a22  | 1777            | 0               | 1631            | 0               | CFG_GPMC_A22_IN  | -            | - | vin4a_d15    | -         | vin3b_d3     |
| J7       | gpmc_a23  | 1716            | 0               | 1717            | 0               | CFG_GPMC_A23_IN  | -            | - | vin4a_fld0   | -         | vin3b_d4     |
| J4       | gpmc_a24  | 1758            | 111             | 1756            | 0               | CFG_GPMC_A24_IN  | -            | - | -            | -         | vin3b_d5     |
| J6       | gpmc_a25  | 1805            | 0               | 1667            | 0               | CFG_GPMC_A25_IN  | -            | - | -            | -         | vin3b_d6     |
| H4       | gpmc_a26  | 1800            | 54              | 1699            | 0               | CFG_GPMC_A26_IN  | -            | - | -            | -         | vin3b_d7     |
| H5       | gpmc_a27  | 1661            | 0               | 1540            | 0               | CFG_GPMC_A27_IN  | -            | - | -            | -         | vin3b_hsync1 |
| T7       | gpmc_a3   | 2589            | 902             | 2855            | 715             | CFG_GPMC_A3_IN   | vin3a_d19    | - | vin4a_d3     | -         | -            |
| P6       | gpmc_a4   | 2616            | 808             | 2874            | 597             | CFG_GPMC_A4_IN   | vin3a_d20    | - | vin4a_d4     | -         | -            |
| R9       | gpmc_a5   | 2514            | 733             | 2842            | 491             | CFG_GPMC_A5_IN   | vin3a_d21    | - | vin4a_d5     | -         | -            |
| R5       | gpmc_a6   | 2511            | 417             | 2837            | 146             | CFG_GPMC_A6_IN   | vin3a_d22    | - | vin4a_d6     | -         | -            |
| P5       | gpmc_a7   | 2752            | 618             | 3035            | 325             | CFG_GPMC_A7_IN   | vin3a_d23    | - | vin4a_d7     | -         | -            |
| N7       | gpmc_a8   | 2457            | 603             | 2812            | 203             | CFG_GPMC_A8_IN   | vin3a_hsync0 | - | -            | -         | -            |
| R4       | gpmc_a9   | 2536            | 749             | 2857            | 409             | CFG_GPMC_A9_IN   | vin3a_vsync0 | - | -            | -         | -            |
| M6       | gpmc_ad0  | 2139            | 232             | 2444            | 0               | CFG_GPMC_AD0_IN  | vin3a_d0     | - | -            | -         | -            |
| M2       | gpmc_ad1  | 2429            | 212             | 2711            | 0               | CFG_GPMC_AD1_IN  | vin3a_d1     | - | -            | -         | -            |
| J1       | gpmc_ad10 | 2294            | 337             | 2703            | 16              | CFG_GPMC_AD10_IN | vin3a_d10    | - | -            | -         | -            |
| J2       | gpmc_ad11 | 2184            | 327             | 2600            | 0               | CFG_GPMC_AD11_IN | vin3a_d11    | - | -            | -         | -            |
| H1       | gpmc_ad12 | 2222            | 182             | 2471            | 0               | CFG_GPMC_AD12_IN | vin3a_d12    | - | -            | -         | -            |
| J3       | gpmc_ad13 | 2179            | 152             | 2421            | 0               | CFG_GPMC_AD13_IN | vin3a_d13    | - | -            | -         | -            |
| H2       | gpmc_ad14 | 2166            | 16              | 2263            | 0               | CFG_GPMC_AD14_IN | vin3a_d14    | - | -            | -         | -            |
| H3       | gpmc_ad15 | 2191            | 254             | 2535            | 0               | CFG_GPMC_AD15_IN | vin3a_d15    | - | -            | -         | -            |
| L5       | gpmc_ad2  | 2412            | 314             | 2776            | 41              | CFG_GPMC_AD2_IN  | vin3a_d2     | - | -            | -         | -            |
| M1       | gpmc_ad3  | 2249            | 227             | 2503            | 0               | CFG_GPMC_AD3_IN  | vin3a_d3     | - | -            | -         | -            |
| L6       | gpmc_ad4  | 2317            | 256             | 2613            | 0               | CFG_GPMC_AD4_IN  | vin3a_d4     | - | -            | -         | -            |
| L4       | gpmc_ad5  | 2254            | 108             | 2441            | 0               | CFG_GPMC_AD5_IN  | vin3a_d5     | - | -            | -         | -            |
| L3       | gpmc_ad6  | 2164            | 279             | 2533            | 0               | CFG_GPMC_AD6_IN  | vin3a_d6     | - | -            | -         | -            |
| L2       | gpmc_ad7  | 2278            | 230             | 2597            | 0               | CFG_GPMC_AD7_IN  | vin3a_d7     | - | -            | -         | -            |
| L1       | gpmc_ad8  | 2246            | 449             | 2701            | 84              | CFG_GPMC_AD8_IN  | vin3a_d8     | - | -            | -         | -            |
| K2       | gpmc_ad9  | 2222            | 298             | 2607            | 0               | CFG_GPMC_AD9_IN  | vin3a_d9     | - | -            | -         | -            |
| N6       | gpmc_ben0 | 1767            | 0               | 1686            | 0               | CFG_GPMC_BEN0_IN | -            | - | -            | -         | vin3b_de1    |
| M4       | gpmc_ben1 | 1838            | 0               | 1766            | 0               | CFG_GPMC_BEN1_IN | -            | - | vin3b_clk1   | -         | vin3b_fld1   |
| P7       | gpmc_clk  | 0               | 0               | 0               | 0               | CFG_GPMC_CLK_IN  | -            | - | vin4a_hsync0 | vin4a_de0 | vin3b_clk1   |

**Table 5-39. Manual Functions Mapping for VIP2 (continued)**

| BAL<br>L | BALL NAME  | VIP2_MANUAL 1   |                 | VIP2_MANUAL2    |                 | CFG REGISTER      | MUXMODE    |            |            |              |              |
|----------|------------|-----------------|-----------------|-----------------|-----------------|-------------------|------------|------------|------------|--------------|--------------|
|          |            | A_DELAY<br>(ps) | G_DELAY<br>(ps) | A_DELAY<br>(ps) | G_DELAY<br>(ps) |                   | 2          | 3          | 4          | 5            | 6            |
| H6       | gpmc_cs1   | 1611            | 0               | 1450            | 0               | CFG_GPMC_CS1_IN   | -          | -          | vin4a_de0  | -            | vin3b_vsync1 |
| P1       | gpmc_cs3   | 0               | 0               | 0               | 0               | CFG_GPMC_CS3_IN   | vin3a_clk0 | -          | -          | -            | -            |
| AF1      | vin1a_d16  | 2152            | 1311            | 2633            | 790             | CFG_VIN1A_D16_IN  | -          | -          | -          | -            | vin3a_d0     |
| AE3      | vin1a_d17  | 2211            | 1381            | 2690            | 849             | CFG_VIN1A_D17_IN  | -          | -          | -          | -            | vin3a_d1     |
| AE5      | vin1a_d18  | 2220            | 1393            | 2669            | 879             | CFG_VIN1A_D18_IN  | -          | -          | -          | -            | vin3a_d2     |
| AE1      | vin1a_d19  | 2186            | 1418            | 2680            | 870             | CFG_VIN1A_D19_IN  | -          | -          | -          | -            | vin3a_d3     |
| AE2      | vin1a_d20  | 2183            | 1292            | 2666            | 707             | CFG_VIN1A_D20_IN  | -          | -          | -          | -            | vin3a_d4     |
| AE6      | vin1a_d21  | 2280            | 1155            | 2721            | 601             | CFG_VIN1A_D21_IN  | -          | -          | -          | -            | vin3a_d5     |
| AD2      | vin1a_d22  | 2144            | 1098            | 2664            | 517             | CFG_VIN1A_D22_IN  | -          | -          | -          | -            | vin3a_d6     |
| AD3      | vin1a_d23  | 2355            | 643             | 2816            | 0               | CFG_VIN1A_D23_IN  | -          | -          | -          | -            | vin3a_d7     |
| AH7      | vin1b_clk1 | 0               | 0               | 0               | 0               | CFG_VIN1B_CLK1_IN | -          | -          | -          | -            | vin3a_clk0   |
| B2       | vin2a_d16  | 1624            | 239             | 1772            | 0               | CFG_VIN2A_D16_IN  | -          | -          | -          | -            | vin3a_d8     |
| D6       | vin2a_d17  | 1541            | 406             | 1838            | 0               | CFG_VIN2A_D17_IN  | -          | -          | -          | -            | vin3a_d9     |
| C5       | vin2a_d18  | 1942            | 313             | 2047            | 0               | CFG_VIN2A_D18_IN  | -          | -          | -          | -            | vin3a_d10    |
| A3       | vin2a_d19  | 1851            | 0               | 1667            | 0               | CFG_VIN2A_D19_IN  | -          | -          | -          | -            | vin3a_d11    |
| B3       | vin2a_d20  | 1837            | 430             | 2187            | 0               | CFG_VIN2A_D20_IN  | -          | -          | -          | vin3a_de0    | vin3a_d12    |
| B4       | vin2a_d21  | 1805            | 400             | 2042            | 0               | CFG_VIN2A_D21_IN  | -          | -          | -          | vin3a_fld0   | vin3a_d13    |
| B5       | vin2a_d22  | 1667            | 213             | 1786            | 0               | CFG_VIN2A_D22_IN  | -          | -          | -          | vin3a_hsync0 | vin3a_d14    |
| A4       | vin2a_d23  | 1700            | 408             | 2010            | 0               | CFG_VIN2A_D23_IN  | -          | -          | -          | vin3a_vsync0 | vin3a_d15    |
| D11      | vout1_clk  | 2405            | 379             | 2780            | 257             | CFG_VOUT1_CLK_IN  | -          | vin4a_fld0 | vin3a_fld0 | -            | -            |
| F11      | vout1_d0   | 2475            | 548             | 2806            | 469             | CFG_VOUT1_D0_IN   | -          | vin4a_d16  | vin3a_d16  | -            | -            |
| G10      | vout1_d1   | 2382            | 554             | 2771            | 418             | CFG_VOUT1_D1_IN   | -          | vin4a_d17  | vin3a_d17  | -            | -            |
| D7       | vout1_d10  | 2379            | 420             | 2784            | 267             | CFG_VOUT1_D10_IN  | -          | vin4a_d10  | vin3a_d10  | -            | -            |
| D8       | vout1_d11  | 2472            | 453             | 2810            | 367             | CFG_VOUT1_D11_IN  | -          | vin4a_d11  | vin3a_d11  | -            | -            |
| A5       | vout1_d12  | 2370            | 401             | 2777            | 247             | CFG_VOUT1_D12_IN  | -          | vin4a_d12  | vin3a_d12  | -            | -            |
| C6       | vout1_d13  | 2437            | 375             | 2819            | 229             | CFG_VOUT1_D13_IN  | -          | vin4a_d13  | vin3a_d13  | -            | -            |
| C8       | vout1_d14  | 2466            | 433             | 2785            | 342             | CFG_VOUT1_D14_IN  | -          | vin4a_d14  | vin3a_d14  | -            | -            |
| C7       | vout1_d15  | 2465            | 383             | 2846            | 255             | CFG_VOUT1_D15_IN  | -          | vin4a_d15  | vin3a_d15  | -            | -            |
| B7       | vout1_d16  | 2411            | 236             | 2733            | 167             | CFG_VOUT1_D16_IN  | -          | vin4a_d0   | vin3a_d0   | -            | -            |
| B8       | vout1_d17  | 2541            | 435             | 2840            | 379             | CFG_VOUT1_D17_IN  | -          | vin4a_d1   | vin3a_d1   | -            | -            |
| A7       | vout1_d18  | 2451            | 244             | 2761            | 186             | CFG_VOUT1_D18_IN  | -          | vin4a_d2   | vin3a_d2   | -            | -            |
| A8       | vout1_d19  | 2366            | 0               | 2564            | 0               | CFG_VOUT1_D19_IN  | -          | vin4a_d3   | vin3a_d3   | -            | -            |

Table 5-39. Manual Functions Mapping for VIP2 (continued)

| BALL | BALL NAME   | VIP2_MANUAL 1 |              | VIP2_MANUAL2 |              | CFG REGISTER       | MUXMODE |              |              |   |   |
|------|-------------|---------------|--------------|--------------|--------------|--------------------|---------|--------------|--------------|---|---|
|      |             | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) |                    | 2       | 3            | 4            | 5 | 6 |
| F10  | vout1_d2    | 2373          | 639          | 2740         | 526          | CFG_VOUT1_D2_IN    | -       | vin4a_d18    | vin3a_d18    | - | - |
| C9   | vout1_d20   | 2381          | 578          | 2758         | 454          | CFG_VOUT1_D20_IN   | -       | vin4a_d4     | vin3a_d4     | - | - |
| A9   | vout1_d21   | 2349          | 104          | 2706         | 0            | CFG_VOUT1_D21_IN   | -       | vin4a_d5     | vin3a_d5     | - | - |
| B9   | vout1_d22   | 2372          | 248          | 2745         | 127          | CFG_VOUT1_D22_IN   | -       | vin4a_d6     | vin3a_d6     | - | - |
| A10  | vout1_d23   | 2088          | 392          | 2608         | 124          | CFG_VOUT1_D23_IN   | -       | vin4a_d7     | vin3a_d7     | - | - |
| G11  | vout1_d3    | 2475          | 523          | 2771         | 475          | CFG_VOUT1_D3_IN    | -       | vin4a_d19    | vin3a_d19    | - | - |
| E9   | vout1_d4    | 2481          | 458          | 2772         | 410          | CFG_VOUT1_D4_IN    | -       | vin4a_d20    | vin3a_d20    | - | - |
| F9   | vout1_d5    | 2335          | 451          | 2711         | 328          | CFG_VOUT1_D5_IN    | -       | vin4a_d21    | vin3a_d21    | - | - |
| F8   | vout1_d6    | 2485          | 461          | 2739         | 459          | CFG_VOUT1_D6_IN    | -       | vin4a_d22    | vin3a_d22    | - | - |
| E7   | vout1_d7    | 2496          | 514          | 2767         | 495          | CFG_VOUT1_D7_IN    | -       | vin4a_d23    | vin3a_d23    | - | - |
| E8   | vout1_d8    | 2459          | 492          | 2789         | 414          | CFG_VOUT1_D8_IN    | -       | vin4a_d8     | vin3a_d8     | - | - |
| D9   | vout1_d9    | 2463          | 532          | 2790         | 441          | CFG_VOUT1_D9_IN    | -       | vin4a_d9     | vin3a_d9     | - | - |
| B10  | vout1_de    | 2326          | 134          | 2713         | 0            | CFG_VOUT1_DE_IN    | -       | vin4a_de0    | vin3a_de0    | - | - |
| B11  | vout1_fld   | 0             | 0            | 0            | 0            | CFG_VOUT1_FLD_IN   | -       | vin4a_clk0   | vin3a_clk0   | - | - |
| C11  | vout1_hsync | 2058          | 180          | 2456         | 0            | CFG_VOUT1_HSYNC_IN | -       | vin4a_hsync0 | vin3a_hsync0 | - | - |
| E11  | vout1_vsync | 2226          | 18           | 2332         | 0            | CFG_VOUT1_VSYNC_IN | -       | vin4a_vsync0 | vin3a_vsync0 | - | - |

Manual IO Timings Modes must be used to guarantee some IO timings for VIP2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-40, Manual Functions Mapping for VIP2 4A](#) for a definition of the Manual modes.

[Table 5-40](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-40. Manual Functions Mapping for VIP2 4A

| BALL | BALL NAME | VIP2_4A_MANUAL1 |              | VIP2_4A_MANUAL2 |              | CFG REGISTER    | MUXMODE |              |   |
|------|-----------|-----------------|--------------|-----------------|--------------|-----------------|---------|--------------|---|
|      |           | A_DELAY (ps)    | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                 | 3       | 4            | 5 |
| R6   | gpmc_a0   | 2108            | 183          | 2229            | 0            | CFG_GPMC_A0_IN  | -       | vin4a_d0     | - |
| T9   | gpmc_a1   | 1977            | 152          | 2082            | 0            | CFG_GPMC_A1_IN  | -       | vin4a_d1     | - |
| P9   | gpmc_a11  | 1973            | 0            | 1964            | 0            | CFG_GPMC_A11_IN | -       | vin4a_fld0   | - |
| P4   | gpmc_a12  | 0               | 0            | 0               | 0            | CFG_GPMC_A12_IN | -       | vin4a_clk0   | - |
| R3   | gpmc_a13  | 2042            | 263          | 2251            | 0            | CFG_GPMC_A13_IN | -       | vin4a_hsync0 | - |
| T2   | gpmc_a14  | 2124            | 726          | 2678            | 158          | CFG_GPMC_A14_IN | -       | vin4a_vsync0 | - |
| U2   | gpmc_a15  | 1922            | 307          | 2226            | 0            | CFG_GPMC_A15_IN | -       | vin4a_d8     | - |
| U1   | gpmc_a16  | 2082            | 318          | 2340            | 0            | CFG_GPMC_A16_IN | -       | vin4a_d9     | - |

**Table 5-40. Manual Functions Mapping for VIP2 4A (continued)**

| BALL | BALL NAME     | VIP2_4A_MANUAL1 |              | VIP2_4A_MANUAL2 |              | CFG REGISTER          | MUXMODE    |              |           |
|------|---------------|-----------------|--------------|-----------------|--------------|-----------------------|------------|--------------|-----------|
|      |               | A_DELAY (ps)    | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                       | 3          | 4            | 5         |
| P3   | gpmc_a17      | 1987            | 328          | 2216            | 0            | CFG_GPMC_A17_IN       | -          | vin4a_d10    | -         |
| R2   | gpmc_a18      | 1428            | 0            | 1323            | 0            | CFG_GPMC_A18_IN       | -          | vin4a_d11    | -         |
| K7   | gpmc_a19      | 1755            | 0            | 1599            | 0            | CFG_GPMC_A19_IN       | -          | vin4a_d12    | -         |
| T6   | gpmc_a2       | 2202            | 359          | 2518            | 0            | CFG_GPMC_A2_IN        | -          | vin4a_d2     | -         |
| M7   | gpmc_a20      | 1561            | 0            | 1394            | 0            | CFG_GPMC_A20_IN       | -          | vin4a_d13    | -         |
| J5   | gpmc_a21      | 1795            | 41           | 1665            | 0            | CFG_GPMC_A21_IN       | -          | vin4a_d14    | -         |
| K6   | gpmc_a22      | 1637            | 0            | 1454            | 0            | CFG_GPMC_A22_IN       | -          | vin4a_d15    | -         |
| J7   | gpmc_a23      | 1489            | 0            | 1492            | 0            | CFG_GPMC_A23_IN       | -          | vin4a_fld0   | -         |
| T7   | gpmc_a3       | 2131            | 389          | 2502            | 0            | CFG_GPMC_A3_IN        | -          | vin4a_d3     | -         |
| P6   | gpmc_a4       | 2179            | 275          | 2403            | 0            | CFG_GPMC_A4_IN        | -          | vin4a_d4     | -         |
| R9   | gpmc_a5       | 2013            | 281          | 2248            | 0            | CFG_GPMC_A5_IN        | -          | vin4a_d5     | -         |
| R5   | gpmc_a6       | 1989            | 0            | 1920            | 0            | CFG_GPMC_A6_IN        | -          | vin4a_d6     | -         |
| P5   | gpmc_a7       | 2338            | 106          | 2348            | 0            | CFG_GPMC_A7_IN        | -          | vin4a_d7     | -         |
| N1   | gpmc_advn_ale | 1960            | 0            | 1927            | 0            | CFG_GPMC_ADV_N_ALE_IN | -          | vin4a_vsync0 | -         |
| P7   | gpmc_clk      | 1941            | 0            | 1901            | 0            | CFG_GPMC_CLK_IN       | -          | vin4a_hsync0 | vin4a_de0 |
| H6   | gpmc_cs1      | 1412            | 0            | 1282            | 0            | CFG_GPMC_CS1_IN       | -          | vin4a_de0    | -         |
| D11  | vout1_clk     | 2425            | 88           | 2765            | 20           | CFG_VOUT1_CLK_IN      | vin4a_fld0 | -            | -         |
| F11  | vout1_d0      | 2460            | 555          | 2772            | 515          | CFG_VOUT1_D0_IN       | vin4a_d16  | -            | -         |
| G10  | vout1_d1      | 2307            | 500          | 2725            | 354          | CFG_VOUT1_D1_IN       | vin4a_d17  | -            | -         |
| D7   | vout1_d10     | 2367            | 275          | 2755            | 160          | CFG_VOUT1_D10_IN      | vin4a_d10  | -            | -         |
| D8   | vout1_d11     | 2480            | 337          | 2788            | 301          | CFG_VOUT1_D11_IN      | vin4a_d11  | -            | -         |
| A5   | vout1_d12     | 2344            | 290          | 2744            | 162          | CFG_VOUT1_D12_IN      | vin4a_d12  | -            | -         |
| C6   | vout1_d13     | 2381            | 184          | 2779            | 56           | CFG_VOUT1_D13_IN      | vin4a_d13  | -            | -         |
| C8   | vout1_d14     | 2459            | 533          | 2752            | 512          | CFG_VOUT1_D14_IN      | vin4a_d14  | -            | -         |
| C7   | vout1_d15     | 2386            | 263          | 2811            | 111          | CFG_VOUT1_D15_IN      | vin4a_d15  | -            | -         |
| B7   | vout1_d16     | 2378            | 197          | 2705            | 142          | CFG_VOUT1_D16_IN      | vin4a_d0   | -            | -         |
| B8   | vout1_d17     | 2538            | 171          | 2837            | 133          | CFG_VOUT1_D17_IN      | vin4a_d1   | -            | -         |
| A7   | vout1_d18     | 2433            | 69           | 2749            | 25           | CFG_VOUT1_D18_IN      | vin4a_d2   | -            | -         |
| A8   | vout1_d19     | 2158            | 0            | 2412            | 0            | CFG_VOUT1_D19_IN      | vin4a_d3   | -            | -         |
| F10  | vout1_d2      | 2401            | 291          | 2753            | 211          | CFG_VOUT1_D2_IN       | vin4a_d18  | -            | -         |
| C9   | vout1_d20     | 2361            | 401          | 2741            | 295          | CFG_VOUT1_D20_IN      | vin4a_d4   | -            | -         |
| A9   | vout1_d21     | 2181            | 0            | 2454            | 0            | CFG_VOUT1_D21_IN      | vin4a_d5   | -            | -         |

Table 5-40. Manual Functions Mapping for VIP2 4A (continued)

| BALL | BALL NAME   | VIP2_4A_MANUAL1 |              | VIP2_4A_MANUAL2 |              | CFG REGISTER       | MUXMODE      |   |   |
|------|-------------|-----------------|--------------|-----------------|--------------|--------------------|--------------|---|---|
|      |             | A_DELAY (ps)    | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                    | 3            | 4 | 5 |
| B9   | vout1_d22   | 2276            | 0            | 2548            | 0            | CFG_VOUT1_D22_IN   | vin4a_d6     | - | - |
| A10  | vout1_d23   | 2070            | 274          | 2591            | 26           | CFG_VOUT1_D23_IN   | vin4a_d7     | - | - |
| G11  | vout1_d3    | 2419            | 403          | 2749            | 341          | CFG_VOUT1_D3_IN    | vin4a_d19    | - | - |
| E9   | vout1_d4    | 2465            | 311          | 2754            | 294          | CFG_VOUT1_D4_IN    | vin4a_d20    | - | - |
| F9   | vout1_d5    | 2306            | 319          | 2696            | 201          | CFG_VOUT1_D5_IN    | vin4a_d21    | - | - |
| F8   | vout1_d6    | 2450            | 312          | 2716            | 318          | CFG_VOUT1_D6_IN    | vin4a_d22    | - | - |
| E7   | vout1_d7    | 2477            | 403          | 2747            | 405          | CFG_VOUT1_D7_IN    | vin4a_d23    | - | - |
| E8   | vout1_d8    | 2407            | 425          | 2744            | 360          | CFG_VOUT1_D8_IN    | vin4a_d8     | - | - |
| D9   | vout1_d9    | 2512            | 277          | 2783            | 278          | CFG_VOUT1_D9_IN    | vin4a_d9     | - | - |
| B10  | vout1_de    | 2266            | 36           | 2576            | 0            | CFG_VOUT1_DE_IN    | vin4a_de0    | - | - |
| B11  | vout1_fld   | 0               | 0            | 0               | 0            | CFG_VOUT1_FLD_IN   | vin4a_clk0   | - | - |
| C11  | vout1_hsync | 2016            | 50           | 2300            | 0            | CFG_VOUT1_HSYNC_IN | vin4a_hsync0 | - | - |
| E11  | vout1_vsync | 1953            | 0            | 2088            | 0            | CFG_VOUT1_VSYNC_IN | vin4a_vsync0 | - | - |

Manual IO Timings Modes must be used to guarantee some IO timings for VIP2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-41, Manual Functions Mapping for VIP2 4A IOSET3](#) for a definition of the Manual modes.

[Table 5-41](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-41. Manual Functions Mapping for VIP2 4A IOSET3

| BALL | BALL NAME    | VIP2_4A_IOSET3_MANUAL1 |              | VIP2_4A_IOSET3_MANUAL2 |              | CFG REGISTER        | MUXMODE      |
|------|--------------|------------------------|--------------|------------------------|--------------|---------------------|--------------|
|      |              | A_DELAY (ps)           | G_DELAY (ps) | A_DELAY (ps)           | G_DELAY (ps) |                     | 8            |
| E21  | gpio6_14     | 599                    | 0            | 901                    | 0            | CFG_GPIO6_14_IN     | vin4a_hsync0 |
| F20  | gpio6_15     | 1291                   | 0            | 1593                   | 0            | CFG_GPIO6_15_IN     | vin4a_vsync0 |
| F21  | gpio6_16     | 926                    | 0            | 1228                   | 0            | CFG_GPIO6_16_IN     | vin4a_fld0   |
| B14  | mcasp1_aclkr | 1768                   | 0            | 2071                   | 0            | CFG_MCASP1_ACLKR_IN | vin4a_d0     |
| G13  | mcasp1_axr2  | 2326                   | 851          | 2737                   | 792          | CFG_MCASP1_AXR2_IN  | vin4a_d2     |
| J11  | mcasp1_axr3  | 2406                   | 562          | 2858                   | 434          | CFG_MCASP1_AXR3_IN  | vin4a_d3     |
| E12  | mcasp1_axr4  | 2219                   | 678          | 2742                   | 464          | CFG_MCASP1_AXR4_IN  | vin4a_d4     |
| F13  | mcasp1_axr5  | 2226                   | 676          | 2728                   | 517          | CFG_MCASP1_AXR5_IN  | vin4a_d5     |
| C12  | mcasp1_axr6  | 2265                   | 510          | 2806                   | 271          | CFG_MCASP1_AXR6_IN  | vin4a_d6     |
| D12  | mcasp1_axr7  | 2302                   | 781          | 2708                   | 726          | CFG_MCASP1_AXR7_IN  | vin4a_d7     |
| J14  | mcasp1_fsr   | 1901                   | 184          | 2386                   | 0            | CFG_MCASP1_FSR_IN   | vin4a_d1     |

**Table 5-41. Manual Functions Mapping for VIP2 4A IOSET3 (continued)**

| BALL | BALL NAME    | VIP2_4A_IOSET3_MANUAL1 |              | VIP2_4A_IOSET3_MANUAL2 |              | CFG REGISTER        | MUXMODE    |  |
|------|--------------|------------------------|--------------|------------------------|--------------|---------------------|------------|--|
|      |              | A_DELAY (ps)           | G_DELAY (ps) | A_DELAY (ps)           | G_DELAY (ps) |                     | 8          |  |
| E15  | mcasp2_aclkr | 1555                   | 0            | 1857                   | 0            | CFG_MCASP2_ACLKR_IN | vin4a_d8   |  |
| B15  | mcasp2_axr0  | 1790                   | 658          | 2407                   | 343          | CFG_MCASP2_AXR0_IN  | vin4a_d10  |  |
| A15  | mcasp2_axr1  | 1939                   | 279          | 2527                   | 0            | CFG_MCASP2_AXR1_IN  | vin4a_d11  |  |
| D15  | mcasp2_axr4  | 1924                   | 369          | 2541                   | 53           | CFG_MCASP2_AXR4_IN  | vin4a_d12  |  |
| B16  | mcasp2_axr5  | 1719                   | 400          | 2337                   | 84           | CFG_MCASP2_AXR5_IN  | vin4a_d13  |  |
| B17  | mcasp2_axr6  | 1116                   | 0            | 1418                   | 0            | CFG_MCASP2_AXR6_IN  | vin4a_d14  |  |
| A17  | mcasp2_axr7  | 1477                   | 362          | 2094                   | 47           | CFG_MCASP2_AXR7_IN  | vin4a_d15  |  |
| A20  | mcasp2_fsr   | 1521                   | 8            | 1830                   | 0            | CFG_MCASP2_FSR_IN   | vin4a_d9   |  |
| C18  | mcasp4_aclkx | 1258                   | 0            | 1418                   | 0            | CFG_MCASP4_ACLKX_IN | vin4a_d16  |  |
| G16  | mcasp4_axr0  | 2334                   | 227          | 2813                   | 26           | CFG_MCASP4_AXR0_IN  | vin4a_d18  |  |
| D17  | mcasp4_axr1  | 2334                   | 529          | 2777                   | 437          | CFG_MCASP4_AXR1_IN  | vin4a_d19  |  |
| A21  | mcasp4_fsx   | 2293                   | 0            | 2570                   | 0            | CFG_MCASP4_FSX_IN   | vin4a_d17  |  |
| AA3  | mcasp5_aclkx | 3053                   | 2527         | 3352                   | 2409         | CFG_MCASP5_ACLKX_IN | vin4a_d20  |  |
| AB3  | mcasp5_axr0  | 3058                   | 3254         | 3315                   | 3285         | CFG_MCASP5_AXR0_IN  | vin4a_d22  |  |
| AA4  | mcasp5_axr1  | 3090                   | 3358         | 3331                   | 3446         | CFG_MCASP5_AXR1_IN  | vin4a_d23  |  |
| AB9  | mcasp5_fsx   | 3060                   | 2699         | 3329                   | 2686         | CFG_MCASP5_FSX_IN   | vin4a_d21  |  |
| B26  | xref_clk2    | 0                      | 0            | 0                      | 0            | CFG_XREF_CLK2_IN    | vin4a_clk0 |  |
| C23  | xref_clk3    | 962                    | 0            | 1265                   | 0            | CFG_XREF_CLK3_IN    | vin4a_de0  |  |

Manual IO Timings Modes must be used to guarantee some IO timings for VIP2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-42, Manual Functions Mapping for VIP2 4B](#) for a definition of the Manual modes.

[Table 5-42](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-42. Manual Functions Mapping for VIP2 4B**

| BALL | BALL NAME | VIP2_4B_MANUAL1 |              | VIP2_4B_MANUAL2 |              | CFG REGISTER    | MUXMODE |            |
|------|-----------|-----------------|--------------|-----------------|--------------|-----------------|---------|------------|
|      |           | A_DELAY (ps)    | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                 | 5       | 6          |
| R6   | gpmc_a0   | 2199            | 621          | 2416            | 398          | CFG_GPMC_A0_IN  | -       | vin4b_d0   |
| T9   | gpmc_a1   | 1989            | 612          | 2267            | 323          | CFG_GPMC_A1_IN  | -       | vin4b_d1   |
| N9   | gpmc_a10  | 0               | 0            | 0               | 0            | CFG_GPMC_A10_IN | -       | vin4b_clk1 |
| P9   | gpmc_a11  | 2133            | 859          | 2303            | 720          | CFG_GPMC_A11_IN | -       | vin4b_de1  |
| P4   | gpmc_a12  | 2258            | 562          | 2399            | 393          | CFG_GPMC_A12_IN | -       | vin4b_fld1 |
| T6   | gpmc_a2   | 2218            | 912          | 2365            | 720          | CFG_GPMC_A2_IN  | -       | vin4b_d2   |

Table 5-42. Manual Functions Mapping for VIP2 4B (continued)

| BALL | BALL NAME    | VIP2_4B_MANUAL1 |              | VIP2_4B_MANUAL2 |              | CFG REGISTER        | MUXMODE      |              |
|------|--------------|-----------------|--------------|-----------------|--------------|---------------------|--------------|--------------|
|      |              | A_DELAY (ps)    | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                     | 5            | 6            |
| T7   | gpmc_a3      | 2168            | 963          | 2341            | 781          | CFG_GPMC_A3_IN      | -            | vin4b_d3     |
| P6   | gpmc_a4      | 2196            | 813          | 2362            | 594          | CFG_GPMC_A4_IN      | -            | vin4b_d4     |
| R9   | gpmc_a5      | 2082            | 782          | 2329            | 525          | CFG_GPMC_A5_IN      | -            | vin4b_d5     |
| R5   | gpmc_a6      | 2098            | 407          | 2320            | 171          | CFG_GPMC_A6_IN      | -            | vin4b_d6     |
| P5   | gpmc_a7      | 2343            | 585          | 2522            | 305          | CFG_GPMC_A7_IN      | -            | vin4b_d7     |
| N7   | gpmc_a8      | 2030            | 685          | 2290            | 284          | CFG_GPMC_A8_IN      | -            | vin4b_hsync1 |
| R4   | gpmc_a9      | 2116            | 832          | 2335            | 548          | CFG_GPMC_A9_IN      | -            | vin4b_vsync1 |
| U4   | mdio_d       | 1860            | 189          | 2164            | 0            | CFG_MDIO_D_IN       | vin4b_d0     | -            |
| V1   | mdio_mclk    | 0               | 0            | 0               | 0            | CFG_MDIO_MCLK_IN    | vin4b_clk1   | -            |
| U5   | rgmii0_rxc   | 1965            | 550          | 2306            | 279          | CFG_RGMII0_RXC_IN   | vin4b_d5     | -            |
| V5   | rgmii0_rxctl | 1911            | 605          | 2235            | 369          | CFG_RGMII0_RXCTL_IN | vin4b_d6     | -            |
| W2   | rgmii0_rxd0  | 1954            | 304          | 2294            | 26           | CFG_RGMII0_RXD0_IN  | vin4b_fld1   | -            |
| V4   | rgmii0_rxd3  | 1925            | 835          | 2252            | 613          | CFG_RGMII0_RXD3_IN  | vin4b_d7     | -            |
| W9   | rgmii0_txc   | 1937            | 849          | 2291            | 633          | CFG_RGMII0_TXC_IN   | vin4b_d3     | -            |
| V9   | rgmii0_txctl | 1997            | 872          | 2272            | 744          | CFG_RGMII0_TXCTL_IN | vin4b_d4     | -            |
| V6   | rgmii0_txd1  | 1989            | 771          | 2264            | 643          | CFG_RGMII0_TXD1_IN  | vin4b_vsync1 | -            |
| U7   | rgmii0_txd2  | 1788            | 682          | 2193            | 334          | CFG_RGMII0_TXD2_IN  | vin4b_hsync1 | -            |
| V7   | rgmii0_txd3  | 2091            | 591          | 2345            | 411          | CFG_RGMII0_TXD3_IN  | vin4b_de1    | -            |
| V2   | uart3_rxd    | 1711            | 0            | 1699            | 0            | CFG_UART3_RXD_IN    | vin4b_d1     | -            |
| Y1   | uart3_txd    | 1830            | 318          | 2176            | 0            | CFG_UART3_TXD_IN    | vin4b_d2     | -            |

Manual IO Timings Modes must be used to guarantee some IO timings for VIP2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-43, Manual Functions Mapping for VIP2 3B IOSET2](#) for a definition of the Manual modes.

[Table 5-43](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-43. Manual Functions Mapping for VIP2 3B IOSET2

| BALL | BALL NAME | VIP2_3B_IOSET2_MANUAL1 |              | VIP2_3B_IOSET2_MANUAL2 |              | CFG REGISTER    | MUXMODE |          |
|------|-----------|------------------------|--------------|------------------------|--------------|-----------------|---------|----------|
|      |           | A_DELAY (ps)           | G_DELAY (ps) | A_DELAY (ps)           | G_DELAY (ps) |                 | 4       | 6        |
| K7   | gpmc_a19  | 1801                   | 826          | 2145                   | 501          | CFG_GPMC_A19_IN | -       | vin3b_d0 |
| M7   | gpmc_a20  | 1706                   | 697          | 2037                   | 373          | CFG_GPMC_A20_IN | -       | vin3b_d1 |
| J5   | gpmc_a21  | 1767                   | 937          | 2101                   | 612          | CFG_GPMC_A21_IN | -       | vin3b_d2 |
| K6   | gpmc_a22  | 1678                   | 895          | 1998                   | 584          | CFG_GPMC_A22_IN | -       | vin3b_d3 |

**Table 5-43. Manual Functions Mapping for VIP2 3B IOSET2 (continued)**

| BALL | BALL NAME | VIP2_3B_IOSET2_MANUAL1 |              | VIP2_3B_IOSET2_MANUAL2 |              | CFG REGISTER     | MUXMODE    |              |
|------|-----------|------------------------|--------------|------------------------|--------------|------------------|------------|--------------|
|      |           | A_DELAY (ps)           | G_DELAY (ps) | A_DELAY (ps)           | G_DELAY (ps) |                  | 4          | 6            |
| J7   | gpmc_a23  | 1680                   | 769          | 2016                   | 619          | CFG_GPMC_A23_IN  | -          | vin3b_d4     |
| J4   | gpmc_a24  | 1585                   | 1015         | 1931                   | 690          | CFG_GPMC_A24_IN  | -          | vin3b_d5     |
| J6   | gpmc_a25  | 1643                   | 893          | 2001                   | 531          | CFG_GPMC_A25_IN  | -          | vin3b_d6     |
| H4   | gpmc_a26  | 1627                   | 958          | 1978                   | 586          | CFG_GPMC_A26_IN  | -          | vin3b_d7     |
| H5   | gpmc_a27  | 1709                   | 686          | 2036                   | 412          | CFG_GPMC_A27_IN  | -          | vin3b_hsync1 |
| N6   | gpmc_ben0 | 1993                   | 579          | 2297                   | 340          | CFG_GPMC_BEN0_IN | -          | vin3b_de1    |
| M4   | gpmc_ben1 | 0                      | 0            | 0                      | 0            | CFG_GPMC_BEN1_IN | vin3b_clk1 | vin3b_fld1   |
| H6   | gpmc_cs1  | 1492                   | 850          | 1829                   | 486          | CFG_GPMC_CS1_IN  | -          | vin3b_vsync1 |

#### 5.10.6.4 DSS

Three Display Parallel Interfaces (DPI) channels are available in DSS named DPI Video Output 1, DPI Video Output 2 and DPI Video Output 3.

##### NOTE

The DPI Video Output  $i$  ( $i = 1$  to  $3$ ) interface is also referred to as VOUT $i$ .

Every VOUT interface consists of:

- 24-bit data bus (data[23:0])
- Horizontal synchronization signal (HSYNC)
- Vertical synchronization signal (VSYNC)
- Data enable (DE)
- Field ID (FID)
- Pixel clock (CLK)

##### NOTE

For more information, see the Display Subsystem chapter of the Device TRM.

##### CAUTION

The I/O timings provided in this section are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 5-48](#) and [Table 5-49](#).

##### CAUTION

The I/O Timings provided in this section are valid only for some DSS usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

##### CAUTION

All pads/balls configured as vout $i$  \* signals are recommended to use slow slew rate by setting the corresponding CTRL\_CORE\_PAD\_\*[SLEWCONTROL] register field to SLOW (0b1). FAST slew setting is allowed, but results in faster edge rates on the VOUT $n$  bus, higher power/ground noise, and higher EMI emissions compared to SLOW slew rate.

[Table 5-44](#), [Table 5-45](#) and [Figure 5-27](#) assume testing over the recommended operating conditions and electrical characteristic conditions.

**Table 5-44. DPI Video Output  $i$  ( $i = 1..3$ ) Default Switching Characteristics**

| NO. | PARAMETER            | DESCRIPTION                                           | MODE | MIN                    | MAX | UNIT |
|-----|----------------------|-------------------------------------------------------|------|------------------------|-----|------|
| D1  | $t_{c(\text{clk})}$  | Cycle time, output pixel clock vout $i$ _clk          |      | 11.76 <sup>(2)</sup>   |     | ns   |
| D2  | $t_{w(\text{clkL})}$ | Pulse duration, output pixel clock vout $i$ _clk low  |      | P*0.5-1 <sup>(1)</sup> |     | ns   |
| D3  | $t_{w(\text{clkH})}$ | Pulse duration, output pixel clock vout $i$ _clk high |      | P*0.5-1 <sup>(1)</sup> |     | ns   |

**Table 5-44. DPI Video Output i (i = 1..3) Default Switching Characteristics (continued)**

| NO. | PARAMETER                | DESCRIPTION                                                                                                                           | MODE | MIN  | MAX | UNIT |
|-----|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------|------|-----|------|
| D5  | $t_{d(\text{clk-dv})}$   | Delay time, output pixel clock vouti_clk transition to output data vouti_d[23:0] valid                                                |      | -2.5 | 2.5 | ns   |
| D6  | $t_{d(\text{clk-ctlv})}$ | Delay time, output pixel clock vouti_clk transition to output control signals vouti_vsync, vouti_hsync, vouti_de, and vouti_fld valid |      | -2.5 | 2.5 | ns   |

(1) P = output vouti\_clk period in ns.

(2) SERDES transceivers may be sensitive to the jitter profile of vouti\_clk. See Application Note [SPRAC62](#) for additional guidance.**Table 5-45. DPI Video Output i (i = 1..3) Alternate Switching Characteristics**

| NO. | PARAMETER                | DESCRIPTION                                                                                                                           | MODE | MIN                    | MAX  | UNIT |
|-----|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------|------------------------|------|------|
| D1  | $t_{c(\text{clk})}$      | Cycle time, output pixel clock vouti_clk                                                                                              |      | 6.06 <sup>(2)</sup>    |      | ns   |
| D2  | $t_{w(\text{clkL})}$     | Pulse duration, output pixel clock vouti_clk low                                                                                      |      | P*0.5-1 <sup>(1)</sup> |      | ns   |
| D3  | $t_{w(\text{clkH})}$     | Pulse duration, output pixel clock vouti_clk high                                                                                     |      | P*0.5-1 <sup>(1)</sup> |      | ns   |
| D5  | $t_{d(\text{clk-ctlv})}$ | Delay time, output pixel clock vouti_clk transition to output data vouti_d[23:0] valid                                                |      | 1.51                   | 4.55 | ns   |
| D6  | $t_{d(\text{clk-dv})}$   | Delay time, output pixel clock vouti_clk transition to output control signals vouti_vsync, vouti_hsync, vouti_de, and vouti_fld valid |      | 1.51                   | 4.55 | ns   |

(1) P = output vouti\_clk period in ns.

(2) SERDES transceivers may be sensitive to the jitter profile of vouti\_clk. See Application Note [SPRAC62](#) for additional guidance.**Table 5-46. DPI Video Output i (i = 1..3) MANUAL3 Switching Characteristics**

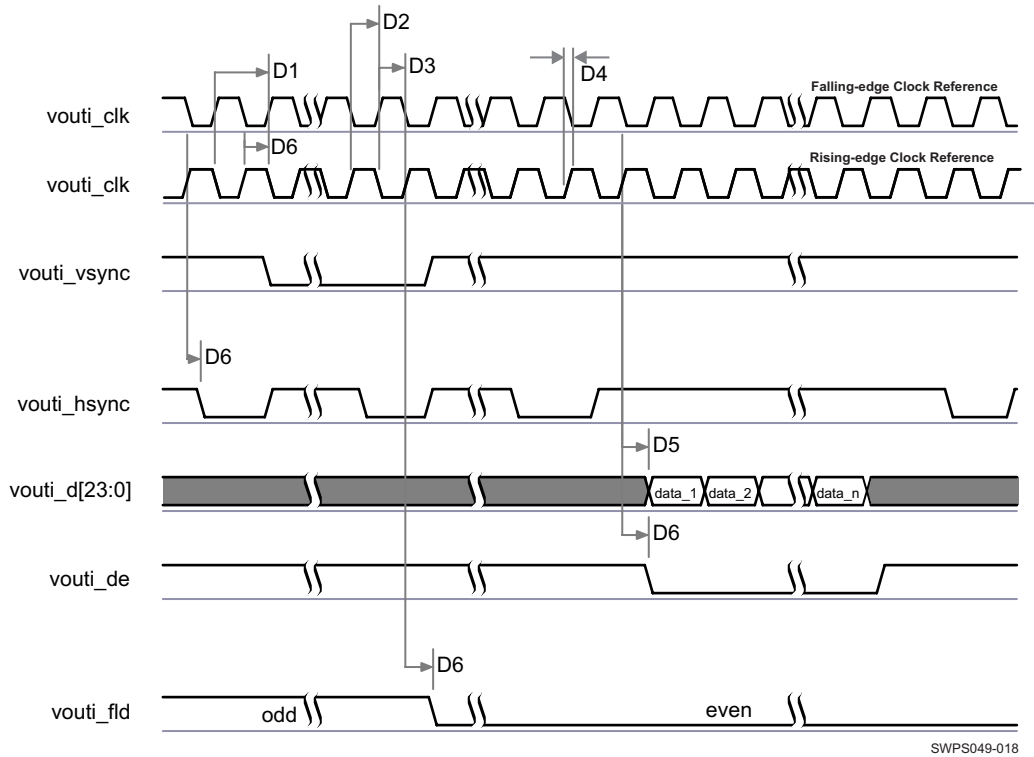
| NO. | PARAMETER                | DESCRIPTION                                                                                                                           | MODE | MIN                    | MAX  | UNIT |
|-----|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------|------------------------|------|------|
| D1  | $t_{c(\text{clk})}$      | Cycle time, output pixel clock vouti_clk                                                                                              |      | 6.06 <sup>(2)</sup>    |      | ns   |
| D2  | $t_{w(\text{clkL})}$     | Pulse duration, output pixel clock vouti_clk low                                                                                      |      | P*0.5-1 <sup>(1)</sup> |      | ns   |
| D3  | $t_{w(\text{clkH})}$     | Pulse duration, output pixel clock vouti_clk high                                                                                     |      | P*0.5-1 <sup>(1)</sup> |      | ns   |
| D5  | $t_{d(\text{clk-ctlv})}$ | Delay time, output pixel clock vouti_clk transition to output data vouti_d[23:0] valid                                                |      | 2.85                   | 5.56 | ns   |
| D6  | $t_{d(\text{clk-dv})}$   | Delay time, output pixel clock vouti_clk transition to output control signals vouti_vsync, vouti_hsync, vouti_de, and vouti_fld valid |      | 2.85                   | 5.56 | ns   |

(1) P = output vouti\_clk period in ns.

(2) SERDES transceivers may be sensitive to the jitter profile of vouti\_clk. See Application Note [SPRAC62](#) for additional guidance.**Table 5-47. DPI Video Output i (i = 1..3) MANUAL4 Switching Characteristics**

| NO. | PARAMETER                | DESCRIPTION                                                                                                                           | MODE | MIN                    | MAX  | UNIT |
|-----|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------|------------------------|------|------|
| D1  | $t_{c(\text{clk})}$      | Cycle time, output pixel clock vouti_clk                                                                                              |      | 6.06 <sup>(2)</sup>    |      | ns   |
| D2  | $t_{w(\text{clkL})}$     | Pulse duration, output pixel clock vouti_clk low                                                                                      |      | P*0.5-1 <sup>(1)</sup> |      | ns   |
| D3  | $t_{w(\text{clkH})}$     | Pulse duration, output pixel clock vouti_clk high                                                                                     |      | P*0.5-1 <sup>(1)</sup> |      | ns   |
| D5  | $t_{d(\text{clk-ctlv})}$ | Delay time, output pixel clock vouti_clk transition to output data vouti_d[23:0] valid                                                |      | 3.55                   | 6.61 | ns   |
| D6  | $t_{d(\text{clk-dv})}$   | Delay time, output pixel clock vouti_clk transition to output control signals vouti_vsync, vouti_hsync, vouti_de, and vouti_fld valid |      | 3.55                   | 6.61 | ns   |

- (1) P = output vouti\_clk period in ns.
- (2) SERDES transceivers may be sensitive to the jitter profile of vouti\_clk. See Application Note [SPRAC62](#) for additional guidance.



**Figure 5-27. DPI Video Output<sup>(1)(2)(3)</sup>**

- (1) The configuration of assertion of the data can be programmed on the falling or rising edge of the pixel clock.
- (2) The polarity and the pulse width of vouti\_hsync and vouti\_vsync are programmable, refer to the DSS section of the Device TRM.
- (3) The vouti\_clk frequency can be configured, refer to the DSS section of the Device TRM.

**NOTE**

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bitfield for each corresponding pad control register.

The pad control registers are presented [Table 4-29](#) and described in Device TRM, *Control Module Chapter*.

In [Table 5-48](#) are presented the specific groupings of signals (IOSET) for use with VOUT2.

**Table 5-48. VOUT2 IOSETs**

| SIGNALS   | IOSET1 |     | IOSET2 |     |
|-----------|--------|-----|--------|-----|
|           | BALL   | MUX | BALL   | MUX |
| vout2_d23 | F2     | 4   | AA4    | 6   |
| vout2_d22 | F3     | 4   | AB3    | 6   |
| vout2_d21 | D1     | 4   | AB9    | 6   |
| vout2_d20 | E2     | 4   | AA3    | 6   |
| vout2_d19 | D2     | 4   | D17    | 6   |
| vout2_d18 | F4     | 4   | G16    | 6   |
| vout2_d17 | C1     | 4   | A21    | 6   |
| vout2_d16 | E4     | 4   | C18    | 6   |
| vout2_d15 | F5     | 4   | A17    | 6   |

**Table 5-48. VOUT2 IOSETs (continued)**

| SIGNALS     | IOSET1 |     | IOSET2 |     |
|-------------|--------|-----|--------|-----|
|             | BALL   | MUX | BALL   | MUX |
| vout2_d14   | E6     | 4   | B17    | 6   |
| vout2_d13   | D3     | 4   | B16    | 6   |
| vout2_d12   | F6     | 4   | D15    | 6   |
| vout2_d11   | D5     | 4   | A15    | 6   |
| vout2_d10   | C2     | 4   | B15    | 6   |
| vout2_d9    | C3     | 4   | A20    | 6   |
| vout2_d8    | C4     | 4   | E15    | 6   |
| vout2_d7    | B2     | 4   | D12    | 6   |
| vout2_d6    | D6     | 4   | C12    | 6   |
| vout2_d5    | C5     | 4   | F13    | 6   |
| vout2_d4    | A3     | 4   | E12    | 6   |
| vout2_d3    | B3     | 4   | J11    | 6   |
| vout2_d2    | B4     | 4   | G13    | 6   |
| vout2_d1    | B5     | 4   | J14    | 6   |
| vout2_d0    | A4     | 4   | B14    | 6   |
| vout2_vsync | G6     | 4   | F20    | 6   |
| vout2_hsync | G1     | 4   | E21    | 6   |
| vout2_clk   | H7     | 4   | B26    | 6   |
| vout2_fld   | E1     | 4   | F21    | 6   |
| vout2_de    | G2     | 4   | C23    | 6   |

In [Table 5-49](#) are presented the specific groupings of signals (IOSET) for use with VOUT3.

**Table 5-49. VOUT3 IOSETs**

| SIGNALS   | IOSET1 |     | IOSET2 |     | IOSET3 |     |
|-----------|--------|-----|--------|-----|--------|-----|
|           | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| vout3_d23 | P5     | 3   | AE8    | 4   |        |     |
| vout3_d22 | R5     | 3   | AD8    | 4   |        |     |
| vout3_d21 | R9     | 3   | AG7    | 4   |        |     |
| vout3_d20 | P6     | 3   | AH6    | 4   |        |     |
| vout3_d19 | T7     | 3   | AH3    | 4   |        |     |
| vout3_d18 | T6     | 3   | AH5    | 4   |        |     |
| vout3_d17 | T9     | 3   | AG6    | 4   | AD9    | 3   |
| vout3_d16 | R6     | 3   | AH4    | 4   | AG8    | 3   |
| vout3_d15 | H3     | 3   | AG4    | 4   | AG4    | 4   |
| vout3_d14 | H2     | 3   | AG2    | 4   | AG2    | 4   |
| vout3_d13 | J3     | 3   | AG3    | 4   | AG3    | 4   |
| vout3_d12 | H1     | 3   | AG5    | 4   | AG5    | 4   |
| vout3_d11 | J2     | 3   | AF2    | 4   | AF2    | 4   |
| vout3_d10 | J1     | 3   | AF6    | 4   | AF6    | 4   |
| vout3_d9  | K2     | 3   | AF3    | 4   | AF3    | 4   |
| vout3_d8  | L1     | 3   | AF4    | 4   | AF4    | 4   |
| vout3_d7  | L2     | 3   | AF1    | 4   | AE8    | 3   |
| vout3_d6  | L3     | 3   | AE3    | 4   | AD8    | 3   |
| vout3_d5  | L4     | 3   | AE5    | 4   | AG7    | 3   |
| vout3_d4  | L6     | 3   | AE1    | 4   | AH6    | 3   |
| vout3_d3  | M1     | 3   | AE2    | 4   | AH3    | 3   |

**Table 5-49. VOUT3 IOSETs (continued)**

| SIGNALS     | IOSET1 |     | IOSET2 |     | IOSET3 |     |
|-------------|--------|-----|--------|-----|--------|-----|
|             | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| vout3_d2    | L5     | 3   | AE6    | 4   | AH5    | 3   |
| vout3_d1    | M2     | 3   | AD2    | 4   | AG6    | 3   |
| vout3_d0    | M6     | 3   | AD3    | 4   | AH4    | 3   |
| vout3_de    | N9     | 3   | AD9    | 4   |        |     |
| vout3_vsync | R4     | 3   | AF8    | 4   | AF8    | 4   |
| vout3_clk   | P1     | 3   | AF9    | 4   | AF9    | 4   |
| vout3_hsync | N7     | 3   | AE9    | 4   | AE9    | 4   |
| vout3_fld   | P9     | 3   | AG8    | 4   |        |     |

#### NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section *"Manual IO Timing Modes"* of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information please see the *Control Module Chapter* in the Device TRM.

Manual IO Timings Modes must be used to guarantee some IO timings for VOUT1. See [Table 5-32 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-50 Manual Functions Mapping for DSS VOUT1](#) for a definition of the Manual modes.

[Table 5-50](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-50. Manual Functions Mapping for DSS VOUT1**

| BALL | BALL NAME   | VOUT1_MANUAL1 |              | VOUT1_MANUAL2 |              | VOUT1_MANUAL3 |              | VOUT1_MANUAL4 |              | CFG REGISTER        | MUXMODE     |
|------|-------------|---------------|--------------|---------------|--------------|---------------|--------------|---------------|--------------|---------------------|-------------|
|      |             | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) |                     | 0           |
| D11  | vout1_clk   | 0             | 29           | 1281          | 497          | 0             | 0            | 0             | 0            | CFG_VOUT1_CLK_OUT   | vout1_clk   |
| F11  | vout1_d0    | 1878          | 0            | 379           | 0            | 3126          | 0            | 4185          | 0            | CFG_VOUT1_D0_OUT    | vout1_d0    |
| G10  | vout1_d1    | 1978          | 0            | 475           | 0            | 3226          | 0            | 4284          | 0            | CFG_VOUT1_D1_OUT    | vout1_d1    |
| D7   | vout1_d10   | 1943          | 0            | 441           | 0            | 3191          | 0            | 4249          | 0            | CFG_VOUT1_D10_OUT   | vout1_d10   |
| D8   | vout1_d11   | 1964          | 0            | 461           | 0            | 3212          | 0            | 4271          | 0            | CFG_VOUT1_D11_OUT   | vout1_d11   |
| A5   | vout1_d12   | 2726          | 0            | 1189          | 0            | 3974          | 0            | 5033          | 0            | CFG_VOUT1_D12_OUT   | vout1_d12   |
| C6   | vout1_d13   | 1807          | 0            | 312           | 0            | 3055          | 0            | 4114          | 0            | CFG_VOUT1_D13_OUT   | vout1_d13   |
| C8   | vout1_d14   | 1793          | 0            | 298           | 0            | 3041          | 0            | 4099          | 0            | CFG_VOUT1_D14_OUT   | vout1_d14   |
| C7   | vout1_d15   | 1778          | 0            | 284           | 0            | 3026          | 0            | 4085          | 0            | CFG_VOUT1_D15_OUT   | vout1_d15   |
| B7   | vout1_d16   | 1652          | 0            | 152           | 0            | 2887          | 0            | 3946          | 0            | CFG_VOUT1_D16_OUT   | vout1_d16   |
| B8   | vout1_d17   | 1706          | 0            | 216           | 0            | 2954          | 0            | 4013          | 0            | CFG_VOUT1_D17_OUT   | vout1_d17   |
| A7   | vout1_d18   | 1908          | 0            | 408           | 0            | 3156          | 0            | 4215          | 0            | CFG_VOUT1_D18_OUT   | vout1_d18   |
| A8   | vout1_d19   | 2024          | 0            | 519           | 0            | 3272          | 0            | 4330          | 0            | CFG_VOUT1_D19_OUT   | vout1_d19   |
| F10  | vout1_d2    | 1757          | 0            | 264           | 0            | 3005          | 0            | 4064          | 0            | CFG_VOUT1_D2_OUT    | vout1_d2    |
| C9   | vout1_d20   | 1811          | 0            | 316           | 0            | 3059          | 0            | 4118          | 0            | CFG_VOUT1_D20_OUT   | vout1_d20   |
| A9   | vout1_d21   | 1640          | 0            | 59            | 0            | 2814          | 0            | 3850          | 0            | CFG_VOUT1_D21_OUT   | vout1_d21   |
| B9   | vout1_d22   | 1712          | 0            | 221           | 0            | 2960          | 0            | 4019          | 0            | CFG_VOUT1_D22_OUT   | vout1_d22   |
| A10  | vout1_d23   | 1581          | 0            | 96            | 0            | 2829          | 0            | 3888          | 0            | CFG_VOUT1_D23_OUT   | vout1_d23   |
| G11  | vout1_d3    | 1921          | 0            | 421           | 0            | 3169          | 0            | 4228          | 0            | CFG_VOUT1_D3_OUT    | vout1_d3    |
| E9   | vout1_d4    | 2797          | 0            | 1257          | 0            | 4045          | 0            | 5104          | 0            | CFG_VOUT1_D4_OUT    | vout1_d4    |
| F9   | vout1_d5    | 1933          | 0            | 432           | 0            | 3181          | 0            | 4240          | 0            | CFG_VOUT1_D5_OUT    | vout1_d5    |
| F8   | vout1_d6    | 1937          | 0            | 436           | 0            | 3185          | 0            | 4244          | 0            | CFG_VOUT1_D6_OUT    | vout1_d6    |
| E7   | vout1_d7    | 1941          | 0            | 440           | 0            | 3189          | 0            | 4248          | 0            | CFG_VOUT1_D7_OUT    | vout1_d7    |
| E8   | vout1_d8    | 1701          | 0            | 81            | 100          | 2918          | 0            | 3977          | 0            | CFG_VOUT1_D8_OUT    | vout1_d8    |
| D9   | vout1_d9    | 1973          | 0            | 471           | 0            | 3221          | 0            | 4280          | 0            | CFG_VOUT1_D9_OUT    | vout1_d9    |
| B10  | vout1_de    | 1573          | 0            | 0             | 0            | 2747          | 0            | 3725          | 0            | CFG_VOUT1_DE_OUT    | vout1_de    |
| B11  | vout1_fld   | 1709          | 0            | 224           | 0            | 2983          | 0            | 4004          | 0            | CFG_VOUT1_FLD_OUT   | vout1_fld   |
| C11  | vout1_hsync | 1514          | 0            | 0             | 0            | 2688          | 0            | 3666          | 0            | CFG_VOUT1_HSYNC_OUT | vout1_hsync |
| E11  | vout1_vsync | 2316          | 0            | 815           | 0            | 3564          | 0            | 4623          | 0            | CFG_VOUT1_VSYNC_OUT | vout1_vsync |

Manual IO Timings Modes must be used to guarantee some IO timings for VOUT2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-51, Manual Functions Mapping for DSS VOUT2](#) for a definition of the Manual modes.

[Table 5-51](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-51. Manual Functions Mapping for DSS VOUT2 IOSET1**

| BALL | BALL NAME  | VOUT2_IOSET1<br>_MANUAL1 |                 | VOUT2_IOSET1<br>_MANUAL2 |                 | VOUT2_IOSET1<br>_MANUAL3 |                 | VOUT2_IOSET1<br>_MANUAL4 |                 | CFG REGISTER       | MUXMODE<br>4 |
|------|------------|--------------------------|-----------------|--------------------------|-----------------|--------------------------|-----------------|--------------------------|-----------------|--------------------|--------------|
|      |            | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) |                    |              |
| E1   | vin2a_clk0 | 2587                     | 0               | 1178                     | 0               | 3748                     | 0               | 4694                     | 0               | CFG_VIN2A_CLK0_OUT | vout2_fld    |
| F2   | vin2a_d0   | 2199                     | 0               | 449                      | 337             | 3360                     | 0               | 4306                     | 0               | CFG_VIN2A_D0_OUT   | vout2_d23    |
| F3   | vin2a_d1   | 2141                     | 0               | 731                      | 0               | 3302                     | 0               | 4248                     | 0               | CFG_VIN2A_D1_OUT   | vout2_d22    |
| D3   | vin2a_d10  | 1449                     | 0               | 261                      | 0               | 2810                     | 0               | 3756                     | 0               | CFG_VIN2A_D10_OUT  | vout2_d13    |
| F6   | vin2a_d11  | 2010                     | 0               | 425                      | 181             | 3171                     | 0               | 4117                     | 0               | CFG_VIN2A_D11_OUT  | vout2_d12    |
| D5   | vin2a_d12  | 2487                     | 291             | 1649                     | 73              | 3864                     | 475             | 4680                     | 605             | CFG_VIN2A_D12_OUT  | vout2_d11    |
| C2   | vin2a_d13  | 2235                     | 363             | 1594                     | 148             | 3812                     | 548             | 4629                     | 677             | CFG_VIN2A_D13_OUT  | vout2_d10    |
| C3   | vin2a_d14  | 2211                     | 364             | 1456                     | 167             | 3688                     | 548             | 4504                     | 678             | CFG_VIN2A_D14_OUT  | vout2_d9     |
| C4   | vin2a_d15  | 2462                     | 128             | 1542                     | 0               | 3839                     | 312             | 4656                     | 441             | CFG_VIN2A_D15_OUT  | vout2_d8     |
| B2   | vin2a_d16  | 2396                     | 56              | 1554                     | 0               | 3923                     | 240             | 4740                     | 370             | CFG_VIN2A_D16_OUT  | vout2_d7     |
| D6   | vin2a_d17  | 2426                     | 130             | 1510                     | 0               | 3803                     | 314             | 4620                     | 444             | CFG_VIN2A_D17_OUT  | vout2_d6     |
| C5   | vin2a_d18  | 2022                     | 0               | 617                      | 0               | 3183                     | 0               | 4129                     | 0               | CFG_VIN2A_D18_OUT  | vout2_d5     |
| A3   | vin2a_d19  | 1826                     | 0               | 430                      | 0               | 2987                     | 0               | 3933                     | 0               | CFG_VIN2A_D19_OUT  | vout2_d4     |
| D1   | vin2a_d2   | 1973                     | 0               | 571                      | 0               | 3134                     | 0               | 4080                     | 0               | CFG_VIN2A_D2_OUT   | vout2_d21    |
| B3   | vin2a_d20  | 1514                     | 0               | 110                      | 0               | 2668                     | 0               | 3618                     | 0               | CFG_VIN2A_D20_OUT  | vout2_d3     |
| B4   | vin2a_d21  | 1454                     | 0               | 36                       | 0               | 2608                     | 0               | 3558                     | 0               | CFG_VIN2A_D21_OUT  | vout2_d2     |
| B5   | vin2a_d22  | 1432                     | 0               | 0                        | 0               | 2586                     | 0               | 3536                     | 0               | CFG_VIN2A_D22_OUT  | vout2_d1     |
| A4   | vin2a_d23  | 1452                     | 0               | 20                       | 0               | 2606                     | 0               | 3556                     | 0               | CFG_VIN2A_D23_OUT  | vout2_d0     |
| E2   | vin2a_d3   | 2007                     | 0               | 603                      | 0               | 3168                     | 0               | 4114                     | 0               | CFG_VIN2A_D3_OUT   | vout2_d20    |
| D2   | vin2a_d4   | 2306                     | 0               | 1366                     | 0               | 3967                     | 0               | 4913                     | 0               | CFG_VIN2A_D4_OUT   | vout2_d19    |
| F4   | vin2a_d5   | 2122                     | 0               | 904                      | 0               | 3483                     | 0               | 4429                     | 0               | CFG_VIN2A_D5_OUT   | vout2_d18    |
| C1   | vin2a_d6   | 1867                     | 0               | 660                      | 0               | 3228                     | 0               | 4174                     | 0               | CFG_VIN2A_D6_OUT   | vout2_d17    |
| E4   | vin2a_d7   | 1940                     | 0               | 539                      | 0               | 3101                     | 0               | 4047                     | 0               | CFG_VIN2A_D7_OUT   | vout2_d16    |
| F5   | vin2a_d8   | 1752                     | 0               | 359                      | 0               | 2913                     | 0               | 3859                     | 0               | CFG_VIN2A_D8_OUT   | vout2_d15    |
| E6   | vin2a_d9   | 1631                     | 0               | 46                       | 198             | 2792                     | 0               | 3738                     | 0               | CFG_VIN2A_D9_OUT   | vout2_d14    |
| G2   | vin2a_de0  | 2136                     | 0               | 726                      | 0               | 3297                     | 0               | 4243                     | 0               | CFG_VIN2A_DE0_OUT  | vout2_de     |
| H7   | vin2a_fld0 | 0                        | 274             | 1409                     | 698             | 0                        | 161             | 0                        | 55              | CFG_VIN2A_FLD0_OUT | vout2_clk    |

**Table 5-51. Manual Functions Mapping for DSS VOUT2 IOSET1 (continued)**

| BALL | BALL NAME    | VOUT2_IOSET1<br>_MANUAL1 |                 | VOUT2_IOSET1<br>_MANUAL2 |                 | VOUT2_IOSET1<br>_MANUAL3 |                 | VOUT2_IOSET1<br>_MANUAL4 |                 | CFG REGISTER         | MUXMODE<br>4 |
|------|--------------|--------------------------|-----------------|--------------------------|-----------------|--------------------------|-----------------|--------------------------|-----------------|----------------------|--------------|
|      |              | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) |                      |              |
| G1   | vin2a_hsync0 | 2610                     | 0               | 1200                     | 0               | 3771                     | 0               | 4717                     | 0               | CFG_VIN2A_HSYNC0_OUT | vout2_hsync  |
| G6   | vin2a_vsync0 | 2214                     | 0               | 822                      | 0               | 3375                     | 0               | 4321                     | 0               | CFG_VIN2A_VSYNC0_OUT | vout2_vsync  |

Manual IO Timings Modes must be used to guarantee some IO timings for VOUT2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-52, Manual Functions Mapping for DSS VOUT2 IOSET2](#) for a definition of the Manual modes.

[Table 5-52](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-52. Manual Functions Mapping for DSS VOUT2 IOSET2**

| BALL | BALL NAME    | VOUT2_IOSET2<br>_MANUAL1 |                 | VOUT2_IOSET2<br>_MANUAL2 |                 | VOUT2_IOSET2<br>_MANUAL3 |                 | VOUT2_IOSET2<br>_MANUAL4 |                 | CFG REGISTER         | MUXMODE<br>6 |
|------|--------------|--------------------------|-----------------|--------------------------|-----------------|--------------------------|-----------------|--------------------------|-----------------|----------------------|--------------|
|      |              | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) | A_DELAY<br>(ps)          | G_DELAY<br>(ps) |                      |              |
| E21  | gpio6_14     | 1193                     | 0               | 274                      | 0               | 2474                     | 0               | 3298                     | 0               | CFG_GPIO6_14_OUT     | vout2_hsync  |
| F20  | gpio6_15     | 1006                     | 0               | 27                       | 0               | 2226                     | 0               | 3039                     | 0               | CFG_GPIO6_15_OUT     | vout2_vsync  |
| F21  | gpio6_16     | 921                      | 0               | 0                        | 0               | 2141                     | 0               | 2955                     | 0               | CFG_GPIO6_16_OUT     | vout2_fid    |
| B14  | mcasp1_aclkr | 3224                     | 0               | 2192                     | 0               | 4505                     | 0               | 5328                     | 0               | CFG_MCASP1_ACLKR_OUT | vout2_d0     |
| G13  | mcasp1_axr2  | 2197                     | 0               | 1211                     | 0               | 3478                     | 0               | 4302                     | 0               | CFG_MCASP1_AXR2_OUT  | vout2_d2     |
| J11  | mcasp1_axr3  | 1989                     | 0               | 1013                     | 0               | 3271                     | 0               | 4094                     | 0               | CFG_MCASP1_AXR3_OUT  | vout2_d3     |
| E12  | mcasp1_axr4  | 2452                     | 0               | 1455                     | 0               | 3733                     | 0               | 4557                     | 0               | CFG_MCASP1_AXR4_OUT  | vout2_d4     |
| F13  | mcasp1_axr5  | 2507                     | 0               | 1507                     | 0               | 3788                     | 0               | 4612                     | 0               | CFG_MCASP1_AXR5_OUT  | vout2_d5     |
| C12  | mcasp1_axr6  | 2212                     | 0               | 1225                     | 0               | 3493                     | 0               | 4316                     | 0               | CFG_MCASP1_AXR6_OUT  | vout2_d6     |
| D12  | mcasp1_axr7  | 2204                     | 0               | 1218                     | 0               | 3485                     | 0               | 4309                     | 0               | CFG_MCASP1_AXR7_OUT  | vout2_d7     |
| J14  | mcasp1_fsr   | 1933                     | 0               | 959                      | 0               | 3214                     | 0               | 4037                     | 0               | CFG_MCASP1_FSR_OUT   | vout2_d1     |
| E15  | mcasp2_aclkr | 3074                     | 0               | 2048                     | 0               | 4355                     | 0               | 5178                     | 0               | CFG_MCASP2_ACLKR_OUT | vout2_d8     |
| B15  | mcasp2_axr0  | 1798                     | 0               | 830                      | 0               | 3080                     | 0               | 3903                     | 0               | CFG_MCASP2_AXR0_OUT  | vout2_d10    |
| A15  | mcasp2_axr1  | 2031                     | 0               | 542                      | 510             | 3312                     | 0               | 4135                     | 0               | CFG_MCASP2_AXR1_OUT  | vout2_d11    |
| D15  | mcasp2_axr4  | 2050                     | 0               | 1071                     | 0               | 3331                     | 0               | 4155                     | 0               | CFG_MCASP2_AXR4_OUT  | vout2_d12    |
| B16  | mcasp2_axr5  | 1627                     | 0               | 667                      | 0               | 2908                     | 0               | 3732                     | 0               | CFG_MCASP2_AXR5_OUT  | vout2_d13    |
| B17  | mcasp2_axr6  | 2924                     | 0               | 1905                     | 0               | 4205                     | 0               | 5028                     | 0               | CFG_MCASP2_AXR6_OUT  | vout2_d14    |
| A17  | mcasp2_axr7  | 1555                     | 0               | 598                      | 0               | 2836                     | 0               | 3660                     | 0               | CFG_MCASP2_AXR7_OUT  | vout2_d15    |
| A20  | mcasp2_fsr   | 1689                     | 0               | 188                      | 539             | 2971                     | 0               | 3794                     | 0               | CFG_MCASP2_FSR_OUT   | vout2_d9     |

Table 5-52. Manual Functions Mapping for DSS VOUT2 IOSET2 (continued)

| BALL | BALL NAME    | VOUT2_IOSET2_MANUAL1 |              | VOUT2_IOSET2_MANUAL2 |              | VOUT2_IOSET2_MANUAL3 |              | VOUT2_IOSET2_MANUAL4 |              | CFG REGISTER         | MUXMODE   |
|------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|-----------|
|      |              | A_DELAY (ps)         | G_DELAY (ps) | A_DELAY (ps)         | G_DELAY (ps) | A_DELAY (ps)         | G_DELAY (ps) | A_DELAY (ps)         | G_DELAY (ps) |                      |           |
| C18  | mcasp4_aclkx | 2607                 | 0            | 1603                 | 0            | 3889                 | 0            | 4712                 | 0            | CFG_MCASP4_ACLKX_OUT | vout2_d16 |
| G16  | mcasp4_axr0  | 1690                 | 0            | 727                  | 0            | 2971                 | 0            | 3795                 | 0            | CFG_MCASP4_AXR0_OUT  | vout2_d18 |
| D17  | mcasp4_axr1  | 1408                 | 0            | 457                  | 0            | 2689                 | 0            | 3512                 | 0            | CFG_MCASP4_AXR1_OUT  | vout2_d19 |
| A21  | mcasp4_fsx   | 1564                 | 0            | 606                  | 0            | 2845                 | 0            | 3668                 | 0            | CFG_MCASP4_FSX_OUT   | vout2_d17 |
| AA3  | mcasp5_aclkx | 4355                 | 1633         | 3732                 | 1100         | 5399                 | 1869         | 6062                 | 2030         | CFG_MCASP5_ACLKX_OUT | vout2_d20 |
| AB3  | mcasp5_axr0  | 4307                 | 1362         | 3675                 | 853          | 5352                 | 1599         | 6014                 | 1759         | CFG_MCASP5_AXR0_OUT  | vout2_d22 |
| AA4  | mcasp5_axr1  | 4276                 | 971          | 3633                 | 492          | 5321                 | 1208         | 5984                 | 1369         | CFG_MCASP5_AXR1_OUT  | vout2_d23 |
| AB9  | mcasp5_fsx   | 4272                 | 981          | 3628                 | 503          | 5317                 | 1217         | 5980                 | 1378         | CFG_MCASP5_FSX_OUT   | vout2_d21 |
| B26  | xref_clk2    | 0                    | 51           | 2016                 | 507          | 0                    | 0            | 0                    | 0            | CFG_XREF_CLK2_OUT    | vout2_clk |
| C23  | xref_clk3    | 2331                 | 0            | 1339                 | 0            | 3612                 | 0            | 4436                 | 0            | CFG_XREF_CLK3_OUT    | vout2_de  |

Manual IO Timings Modes must be used to guarantee some IO timings for VOUT3. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-53, Manual Functions Mapping for DSS VOUT3](#) for a definition of the Manual modes.

[Table 5-53](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-53. Manual Functions Mapping for DSS VOUT3

| BALL | BALL NAME | VOUT3_MANUAL1 |              | VOUT3_MANUAL2 |              | VOUT3_MANUAL3 |              | VOUT3_MANUAL4 |              | CFG REGISTER     | MUXMODE     |   |
|------|-----------|---------------|--------------|---------------|--------------|---------------|--------------|---------------|--------------|------------------|-------------|---|
|      |           | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) |                  | 3           | 4 |
| R6   | gpmc_a0   | 1627          | 0            | 787           | 0            | 2798          | 0            | 3781          | 0            | CFG_GPMC_A0_OUT  | vout3_d16   | - |
| T9   | gpmc_a1   | 1527          | 0            | 592           | 0            | 2698          | 0            | 3680          | 0            | CFG_GPMC_A1_OUT  | vout3_d17   | - |
| N9   | gpmc_a10  | 1907          | 0            | 1181          | 0            | 3122          | 0            | 4194          | 0            | CFG_GPMC_A10_OUT | vout3_de    | - |
| P9   | gpmc_a11  | 2406          | 0            | 1676          | 0            | 3622          | 0            | 4693          | 0            | CFG_GPMC_A11_OUT | vout3_fld   | - |
| T6   | gpmc_a2   | 1508          | 0            | 641           | 0            | 2679          | 0            | 3661          | 0            | CFG_GPMC_A2_OUT  | vout3_d18   | - |
| T7   | gpmc_a3   | 2222          | 0            | 1481          | 0            | 3437          | 0            | 4508          | 0            | CFG_GPMC_A3_OUT  | vout3_d19   | - |
| P6   | gpmc_a4   | 2529          | 0            | 1775          | 0            | 3744          | 0            | 4815          | 0            | CFG_GPMC_A4_OUT  | vout3_d20   | - |
| R9   | gpmc_a5   | 1492          | 0            | 785           | 0            | 2708          | 0            | 3779          | 0            | CFG_GPMC_A5_OUT  | vout3_d21   | - |
| R5   | gpmc_a6   | 1578          | 0            | 848           | 0            | 2774          | 0            | 3845          | 0            | CFG_GPMC_A6_OUT  | vout3_d22   | - |
| P5   | gpmc_a7   | 1586          | 0            | 851           | 0            | 2778          | 0            | 3849          | 0            | CFG_GPMC_A7_OUT  | vout3_d23   | - |
| N7   | gpmc_a8   | 2519          | 0            | 1783          | 0            | 3734          | 0            | 4805          | 0            | CFG_GPMC_A8_OUT  | vout3_hsync | - |
| R4   | gpmc_a9   | 1886          | 0            | 951           | 0            | 2864          | 0            | 3935          | 0            | CFG_GPMC_A9_OUT  | vout3_vsync | - |

Table 5-53. Manual Functions Mapping for DSS VOUT3 (continued)

| BALL | BALL NAME  | VOUT3_MANUAL1 |              | VOUT3_MANUAL2 |              | VOUT3_MANUAL3 |              | VOUT3_MANUAL4 |              | CFG REGISTER       | MUXMODE   |           |
|------|------------|---------------|--------------|---------------|--------------|---------------|--------------|---------------|--------------|--------------------|-----------|-----------|
|      |            | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) |                    | 3         | 4         |
| M6   | gpmc_ad0   | 1813          | 0            | 1091          | 0            | 3028          | 0            | 4099          | 0            | CFG_GPMC_AD0_OUT   | vout3_d0  | -         |
| M2   | gpmc_ad1   | 1652          | 0            | 937           | 0            | 2868          | 0            | 3939          | 0            | CFG_GPMC_AD1_OUT   | vout3_d1  | -         |
| J1   | gpmc_ad10  | 1746          | 0            | 1027          | 0            | 2962          | 0            | 4033          | 0            | CFG_GPMC_AD10_OUT  | vout3_d10 | -         |
| J2   | gpmc_ad11  | 1534          | 0            | 824           | 0            | 2749          | 0            | 3820          | 0            | CFG_GPMC_AD11_OUT  | vout3_d11 | -         |
| H1   | gpmc_ad12  | 1923          | 0            | 1196          | 0            | 3138          | 0            | 4209          | 0            | CFG_GPMC_AD12_OUT  | vout3_d12 | -         |
| J3   | gpmc_ad13  | 1496          | 0            | 754           | 0            | 2676          | 0            | 3747          | 0            | CFG_GPMC_AD13_OUT  | vout3_d13 | -         |
| H2   | gpmc_ad14  | 1379          | 0            | 665           | 0            | 2582          | 0            | 3653          | 0            | CFG_GPMC_AD14_OUT  | vout3_d14 | -         |
| H3   | gpmc_ad15  | 1746          | 0            | 1027          | 0            | 2961          | 0            | 4032          | 0            | CFG_GPMC_AD15_OUT  | vout3_d15 | -         |
| L5   | gpmc_ad2   | 1894          | 0            | 1168          | 0            | 3110          | 0            | 4181          | 0            | CFG_GPMC_AD2_OUT   | vout3_d2  | -         |
| M1   | gpmc_ad3   | 1584          | 0            | 872           | 0            | 2800          | 0            | 3871          | 0            | CFG_GPMC_AD3_OUT   | vout3_d3  | -         |
| L6   | gpmc_ad4   | 1815          | 0            | 1092          | 0            | 3030          | 0            | 4101          | 0            | CFG_GPMC_AD4_OUT   | vout3_d4  | -         |
| L4   | gpmc_ad5   | 1436          | 0            | 576           | 0            | 2607          | 0            | 3589          | 0            | CFG_GPMC_AD5_OUT   | vout3_d5  | -         |
| L3   | gpmc_ad6   | 1837          | 0            | 1113          | 0            | 3052          | 0            | 4123          | 0            | CFG_GPMC_AD6_OUT   | vout3_d6  | -         |
| L2   | gpmc_ad7   | 1658          | 0            | 943           | 0            | 2874          | 0            | 3945          | 0            | CFG_GPMC_AD7_OUT   | vout3_d7  | -         |
| L1   | gpmc_ad8   | 515           | 0            | 0             | 0            | 1686          | 0            | 2757          | 0            | CFG_GPMC_AD8_OUT   | vout3_d8  | -         |
| K2   | gpmc_ad9   | 853           | 0            | 0             | 0            | 2024          | 0            | 3006          | 0            | CFG_GPMC_AD9_OUT   | vout3_d9  | -         |
| P1   | gpmc_cs3   | 0             | 234          | 1801          | 948          | 0             | 167          | 0             | 177          | CFG_GPMC_CS3_OUT   | vout3_clk | -         |
| AG8  | vin1a_clk0 | 1954          | 0            | 1244          | 0            | 3240          | 0            | 4298          | 0            | CFG_VIN1A_CLK0_OUT | vout3_d16 | vout3_fld |
| AE8  | vin1a_d0   | 1991          | 0            | 1261          | 0            | 3277          | 0            | 4336          | 0            | CFG_VIN1A_D0_OUT   | vout3_d7  | vout3_d23 |
| AD8  | vin1a_d1   | 1911          | 0            | 1185          | 0            | 3197          | 0            | 4256          | 0            | CFG_VIN1A_D1_OUT   | vout3_d6  | vout3_d22 |
| AG3  | vin1a_d10  | 2460          | 0            | 1647          | 0            | 3754          | 0            | 4813          | 0            | CFG_VIN1A_D10_OUT  | -         | vout3_d13 |
| AG5  | vin1a_d11  | 2098          | 0            | 1302          | 0            | 3392          | 0            | 4451          | 0            | CFG_VIN1A_D11_OUT  | -         | vout3_d12 |
| AF2  | vin1a_d12  | 2703          | 0            | 1880          | 0            | 3997          | 0            | 5056          | 0            | CFG_VIN1A_D12_OUT  | -         | vout3_d11 |
| AF6  | vin1a_d13  | 2049          | 0            | 1255          | 0            | 3343          | 0            | 4402          | 0            | CFG_VIN1A_D13_OUT  | -         | vout3_d10 |
| AF3  | vin1a_d14  | 2815          | 0            | 1987          | 0            | 4109          | 0            | 5131          | 37           | CFG_VIN1A_D14_OUT  | -         | vout3_d9  |
| AF4  | vin1a_d15  | 1973          | 0            | 1183          | 0            | 3267          | 0            | 4326          | 0            | CFG_VIN1A_D15_OUT  | -         | vout3_d8  |
| AF1  | vin1a_d16  | 2084          | 0            | 1289          | 0            | 3379          | 0            | 4437          | 0            | CFG_VIN1A_D16_OUT  | -         | vout3_d7  |
| AE3  | vin1a_d17  | 2100          | 0            | 1304          | 0            | 3394          | 0            | 4453          | 0            | CFG_VIN1A_D17_OUT  | -         | vout3_d6  |
| AE5  | vin1a_d18  | 2069          | 0            | 1274          | 0            | 3363          | 0            | 4422          | 0            | CFG_VIN1A_D18_OUT  | -         | vout3_d5  |
| AE1  | vin1a_d19  | 2171          | 0            | 1372          | 0            | 3465          | 0            | 4524          | 0            | CFG_VIN1A_D19_OUT  | -         | vout3_d4  |
| AG7  | vin1a_d2   | 1956          | 0            | 1227          | 0            | 3241          | 0            | 4300          | 0            | CFG_VIN1A_D2_OUT   | vout3_d5  | vout3_d21 |
| AE2  | vin1a_d20  | 2251          | 0            | 1448          | 0            | 3546          | 0            | 4604          | 0            | CFG_VIN1A_D20_OUT  | -         | vout3_d3  |

Table 5-53. Manual Functions Mapping for DSS VOUT3 (continued)

| BALL                | BALL NAME    | VOUT3_MANUAL1 |              | VOUT3_MANUAL2 |              | VOUT3_MANUAL3 |              | VOUT3_MANUAL4 |              | CFG REGISTER         | MUXMODE   |             |
|---------------------|--------------|---------------|--------------|---------------|--------------|---------------|--------------|---------------|--------------|----------------------|-----------|-------------|
|                     |              | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) | A_DELAY (ps)  | G_DELAY (ps) |                      | 3         | 4           |
| <a href="#">AE6</a> | vin1a_d21    | 2252          | 0            | 1449          | 0            | 3546          | 0            | 4605          | 0            | CFG_VIN1A_D21_OUT    | -         | vout3_d2    |
| <a href="#">AD2</a> | vin1a_d22    | 2199          | 0            | 1187          | 211          | 3494          | 0            | 4552          | 0            | CFG_VIN1A_D22_OUT    | -         | vout3_d1    |
| <a href="#">AD3</a> | vin1a_d23    | 2316          | 0            | 1510          | 0            | 3610          | 0            | 4669          | 0            | CFG_VIN1A_D23_OUT    | -         | vout3_d0    |
| <a href="#">AH6</a> | vin1a_d3     | 2053          | 0            | 1320          | 0            | 3338          | 0            | 4397          | 0            | CFG_VIN1A_D3_OUT     | vout3_d4  | vout3_d20   |
| <a href="#">AH3</a> | vin1a_d4     | 2760          | 0            | 1995          | 0            | 4045          | 0            | 5015          | 89           | CFG_VIN1A_D4_OUT     | vout3_d3  | vout3_d19   |
| <a href="#">AH5</a> | vin1a_d5     | 1755          | 0            | 1007          | 0            | 3010          | 0            | 4069          | 0            | CFG_VIN1A_D5_OUT     | vout3_d2  | vout3_d18   |
| <a href="#">AG6</a> | vin1a_d6     | 1948          | 0            | 1220          | 0            | 3233          | 0            | 4292          | 0            | CFG_VIN1A_D6_OUT     | vout3_d1  | vout3_d17   |
| <a href="#">AH4</a> | vin1a_d7     | 1925          | 0            | 1198          | 0            | 3211          | 0            | 4270          | 0            | CFG_VIN1A_D7_OUT     | vout3_d0  | vout3_d16   |
| <a href="#">AG4</a> | vin1a_d8     | 2104          | 0            | 1307          | 0            | 3398          | 0            | 4457          | 0            | CFG_VIN1A_D8_OUT     | -         | vout3_d15   |
| <a href="#">AG2</a> | vin1a_d9     | 2192          | 0            | 1392          | 0            | 3487          | 0            | 4545          | 0            | CFG_VIN1A_D9_OUT     | -         | vout3_d14   |
| <a href="#">AD9</a> | vin1a_de0    | 2202          | 0            | 1462          | 0            | 3487          | 0            | 4546          | 0            | CFG_VIN1A_DE0_OUT    | vout3_d17 | vout3_de    |
| <a href="#">AF9</a> | vin1a_fld0   | 0             | 0            | 2007          | 454          | 0             | 0            | 0             | 0            | CFG_VIN1A_FLD0_OUT   | -         | vout3_clk   |
| <a href="#">AE9</a> | vin1a_hsync0 | 2015          | 0            | 1240          | 0            | 3309          | 0            | 4367          | 0            | CFG_VIN1A_HSYNC0_OUT | -         | vout3_hsync |
| <a href="#">AF8</a> | vin1a_vsync0 | 1829          | 0            | 1063          | 0            | 3123          | 0            | 4182          | 0            | CFG_VIN1A_VSYNC0_OUT | -         | vout3_vsync |

### 5.10.6.5 HDMI

The High-Definition Multimedia Interface is provided for transmitting digital television audiovisual signals from DVD players, set-top boxes and other audiovisual sources to television sets, projectors and other video displays. The HDMI interface is aligned with the HDMI TMDS single stream standard v1.4a (720p @60Hz to 1080p @24Hz) and the HDMI v1.3 (1080p @60Hz): 3 data channels, plus 1 clock channel is supported (differential).

#### NOTE

For more information, see the High-Definition Multimedia Interface chapter of the Device TRM.

### 5.10.6.6 EMIF

The device has a dedicated interface to DDR3 and DDR2 SDRAM. It supports JEDEC standard compliant DDR2 and DDR3 SDRAM devices with the following features:

- 16-bit or 32-bit data path to external SDRAM memory
- Memory device capacity: 128Mb, 256Mb, 512Mb, 1Gb, 2Gb, 4Gb and 8Gb devices (Single die only)
- One interface with associated DDR2/DDR3 PHYs

#### NOTE

For more information, see the EMIF Controller section of the Device TRM.

### 5.10.6.7 GPMC

The GPMC is the unified memory controller that interfaces external memory devices such as:

- Asynchronous SRAM-like memories and ASIC devices
- Asynchronous page mode and synchronous burst NOR flash
- NAND flash

#### NOTE

For more information, see the General-Purpose Memory Controller section of the Device TRM.

#### 5.10.6.7.1 GPMC/NOR Flash Interface Synchronous Timing

#### CAUTION

The IO Timings provided in this section are only valid for some GPMC usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

Table 5-54 and Table 5-55 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 5-28, Figure 5-29, Figure 5-30, Figure 5-31, Figure 5-32, and Figure 5-33).

**Table 5-54. GPMC/NOR Flash Interface Timing Requirements - Synchronous Mode - Default**

| NO. | PARAMETER            | DESCRIPTION                                               | MIN | MAX | UNIT |
|-----|----------------------|-----------------------------------------------------------|-----|-----|------|
| F12 | $t_{su(dV-clkH)}$    | Setup time, read gpmc_ad[15:0] valid before gpmc_clk high | 1.9 |     | ns   |
| F13 | $t_{h(clkH-dV)}$     | Hold time, read gpmc_ad[15:0] valid after gpmc_clk high   | 1   |     | ns   |
| F21 | $t_{su(waitV-clkH)}$ | Setup time, gpmc_wait[1:0] valid before gpmc_clk high     | 1.9 |     | ns   |

**Table 5-54. GPMC/NOR Flash Interface Timing Requirements - Synchronous Mode - Default (continued)**

| NO. | PARAMETER                  | DESCRIPTION                                         | MIN | MAX | UNIT |
|-----|----------------------------|-----------------------------------------------------|-----|-----|------|
| F22 | $t_{h(\text{clkH-waitV})}$ | Hold Time, gpmc_wait[1:0] valid after gpmc_clk high | 1   |     | ns   |

### NOTE

Wait monitoring support is limited to a WaitMonitoringTime value > 0. For a full description of wait monitoring feature, see General-Purpose Memory Controller section in the Device TRM.

**Table 5-55. GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Default**

| NO. | PARAMETER                   | DESCRIPTION                                                               | MIN                    | MAX                         | UNIT |
|-----|-----------------------------|---------------------------------------------------------------------------|------------------------|-----------------------------|------|
| F0  | $t_{c(\text{clk})}$         | Cycle time, output clock gpmc_clk period                                  | 11.3                   |                             | ns   |
| F2  | $t_{d(\text{clkH-nCSV})}$   | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] transition               | F <sup>(6)</sup> -0.8  | F <sup>(6)</sup> +3.17      | ns   |
| F3  | $t_{d(\text{clkH-nCSIV})}$  | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] invalid                  | E <sup>(5)</sup> -0.8  | E <sup>(5)</sup> +3.1       | ns   |
| F4  | $t_{d(\text{ADDV-clk})}$    | Delay time, gpmc_a[27:0] address bus valid to gpmc_clk first edge         | B <sup>(2)</sup> -0.8  | B <sup>(2)</sup> +3.43      | ns   |
| F5  | $t_{d(\text{clkH-ADDIV})}$  | Delay time, gpmc_clk rising edge to gpmc_a[27:0] gpmc address bus invalid | -0.8                   |                             | ns   |
| F6  | $t_{d(\text{nBEV-clk})}$    | Delay time, gpmc_ben[1:0] valid to gpmc_clk rising edge                   | B <sup>(2)</sup> -3.8  | B <sup>(2)</sup> +2.37      | ns   |
| F7  | $t_{d(\text{clkH-nBEIV})}$  | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] invalid                 | D <sup>(4)</sup> -0.4  | D <sup>(4)</sup> +1.1       | ns   |
| F8  | $t_{d(\text{clkH-nADV})}$   | Delay time, gpmc_clk rising edge to gpmc_adv_nale transition              | G <sup>(7)</sup> -0.8  | G <sup>(7)</sup> +3.1       | ns   |
| F9  | $t_{d(\text{clkH-nADVIV})}$ | Delay time, gpmc_clk rising edge to gpmc_adv_nale invalid                 | D <sup>(4)</sup> -0.8  | D <sup>(4)</sup> +3.1       | ns   |
| F10 | $t_{d(\text{clkH-nOE})}$    | Delay time, gpmc_clk rising edge to gpmc_oen_ren transition               | H <sup>(8)</sup> -0.8  | H <sup>(8)</sup> +2.45      | ns   |
| F11 | $t_{d(\text{clkH-nOEIV})}$  | Delay time, gpmc_clk rising edge to gpmc_oen_ren invalid                  | E <sup>(5)</sup> -0.8  | E <sup>(5)</sup> +2.1       | ns   |
| F14 | $t_{d(\text{clkH-nWE})}$    | Delay time, gpmc_clk rising edge to gpmc_wen transition                   | I <sup>(9)</sup> -0.8  | I <sup>(9)</sup> +3.1       | ns   |
| F15 | $t_{d(\text{clkH-Data})}$   | Delay time, gpmc_clk rising edge to gpmc_ad[15:0] data bus transition     | J <sup>(10)</sup> -1.1 | J <sup>(10)</sup> +4.8<br>9 | ns   |
| F17 | $t_{d(\text{clkH-nBE})}$    | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] transition              | J <sup>(10)</sup> -1.1 | J <sup>(10)</sup> +3.8      | ns   |
| F18 | $t_{w(\text{nCSV})}$        | Pulse duration, gpmc_cs[7:0] low                                          | A <sup>(1)</sup>       |                             | ns   |
| F19 | $t_{w(\text{nBEV})}$        | Pulse duration, gpmc_ben[1:0] low                                         | C <sup>(3)</sup>       |                             | ns   |
| F20 | $t_{w(\text{nADV})}$        | Pulse duration, gpmc_adv_nale low                                         | K <sup>(11)</sup>      |                             | ns   |
| F23 | $t_{d(\text{CLK-GPIO})}$    | Delay time, gpmc_clk transition to gpio6_16 transition                    | 1.2                    | 6.1                         | ns   |

**Table 5-56. GPMC/NOR Flash Interface Timing Requirements - Synchronous Mode - Alternate**

| NO. | PARAMETER                   | DESCRIPTION                                               | MIN | MAX | UNIT |
|-----|-----------------------------|-----------------------------------------------------------|-----|-----|------|
| F12 | $t_{su(\text{dV-clkH})}$    | Setup time, read gpmc_ad[15:0] valid before gpmc_clk high | 2.5 |     | ns   |
| F13 | $t_{h(\text{clkH-dV})}$     | Hold time, read gpmc_ad[15:0] valid after gpmc_clk high   | 1.9 |     | ns   |
| F21 | $t_{su(\text{waitV-clkH})}$ | Setup time, gpmc_wait[1:0] valid before gpmc_clk high     | 2.5 |     | ns   |
| F22 | $t_{h(\text{clkH-waitV})}$  | Hold Time, gpmc_wait[1:0] valid after gpmc_clk high       | 1.9 |     | ns   |

**Table 5-57. GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Alternate**

| NO. | PARAMETER                  | DESCRIPTION                                                                 | MIN                    | MAX                   | UNIT |
|-----|----------------------------|-----------------------------------------------------------------------------|------------------------|-----------------------|------|
| F0  | $t_{c(\text{clk})}$        | Cycle time, output clock gpmc_clk period <sup>(12)</sup>                    | 15.04                  |                       | ns   |
| F2  | $t_{d(\text{clkH-nCSV})}$  | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] transition <sup>(14)</sup> | F <sup>(6)</sup> -0.13 | F <sup>(6)</sup> +6.1 | ns   |
| F3  | $t_{d(\text{clkH-nCSIV})}$ | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] invalid <sup>(14)</sup>    | E <sup>(5)</sup> +0.7  | E <sup>(5)</sup> +6.1 | ns   |
| F4  | $t_{d(\text{ADDV-clk})}$   | Delay time, gpmc_a[27:0] address bus valid to gpmc_clk first edge           | B <sup>(2)</sup> +0.21 | B <sup>(2)</sup> +6.1 | ns   |
| F5  | $t_{d(\text{clkH-ADDIV})}$ | Delay time, gpmc_clk rising edge to gpmc_a[27:0] gpmc address bus invalid   | 0.7                    |                       | ns   |
| F6  | $t_{d(\text{nBEV-clk})}$   | Delay time, gpmc_ben[1:0] valid to gpmc_clk rising edge                     | B <sup>(2)</sup> -4.9  | B <sup>(2)</sup> +0.4 | ns   |

**Table 5-57. GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Alternate (continued)**

| NO. | PARAMETER                   | DESCRIPTION                                                                   | MIN                    | MAX                         | UNIT |
|-----|-----------------------------|-------------------------------------------------------------------------------|------------------------|-----------------------------|------|
| F7  | $t_{d(\text{clkH-nBEIV})}$  | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] invalid                     | D <sup>(4)</sup> -0.4  | D <sup>(4)</sup> +4.9       | ns   |
| F8  | $t_{d(\text{clkH-nADV})}$   | Delay time, gpmc_clk rising edge to gpmc_adv_n_ale transition <sup>(14)</sup> | G <sup>(7)</sup> +0.7  | G <sup>(7)</sup> +6.1       | ns   |
| F9  | $t_{d(\text{clkH-nADVIV})}$ | Delay time, gpmc_clk rising edge to gpmc_adv_n_ale invalid <sup>(14)</sup>    | D <sup>(4)</sup> +0.7  | D <sup>(4)</sup> +6.1       | ns   |
| F10 | $t_{d(\text{clkH-nOE})}$    | Delay time, gpmc_clk rising edge to gpmc_oen_ren transition <sup>(14)</sup>   | H <sup>(8)</sup> +0.42 | H <sup>(8)</sup> +5.1       | ns   |
| F11 | $t_{d(\text{clkH-nOEIV})}$  | Delay time, gpmc_clk rising edge to gpmc_oen_ren invalid <sup>(14)</sup>      | E <sup>(5)</sup> +0.7  | E <sup>(5)</sup> +5.1       | ns   |
| F14 | $t_{d(\text{clkH-nWE})}$    | Delay time, gpmc_clk rising edge to gpmc_wen transition <sup>(14)</sup>       | I <sup>(9)</sup> +0.46 | I <sup>(9)</sup> +6.1       | ns   |
| F15 | $t_{d(\text{clkH-Data})}$   | Delay time, gpmc_clk rising edge to gpmc_ad[15:0] data bus transition         | J <sup>(10)</sup> -0.4 | J <sup>(10)</sup> +4.9      | ns   |
| F17 | $t_{d(\text{clkH-nBE})}$    | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] transition                  | J <sup>(10)</sup> -0.4 | J <sup>(10)</sup> +5.6<br>3 | ns   |
| F18 | $t_{w(\text{nCSV})}$        | Pulse duration, gpmc_cs[7:0] low                                              | A <sup>(1)</sup>       |                             | ns   |
| F19 | $t_{w(\text{nBEV})}$        | Pulse duration, gpmc_ben[1:0] low                                             | C <sup>(3)</sup>       |                             | ns   |
| F20 | $t_{w(\text{nADV})}$        | Pulse duration, gpmc_adv_n_ale low                                            | K <sup>(11)</sup>      |                             | ns   |
| F23 | $t_{d(\text{CLK-GPIO})}$    | Delay time, gpmc_clk transition to gpio6_16 transition <sup>(13)</sup>        | 0.96                   | 6.1                         | ns   |

- (1) For single read:  $A = (\text{CSRdOffTime} - \text{CSOnTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK period}$   
 For burst read:  $A = (\text{CSRdOffTime} - \text{CSOnTime} + (n - 1) \times \text{PageBurstAccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK period}$   
 For burst write:  $A = (\text{CSWrOffTime} - \text{CSOnTime} + (n - 1) \times \text{PageBurstAccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK period}$   
 with n the page burst access number.
- (2)  $B = \text{ClkActivationTime} \times \text{GPMC\_FCLK}$
- (3) For single read:  $C = \text{RdCycleTime} \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$   
 For burst read:  $C = (\text{RdCycleTime} + (n - 1) \times \text{PageBurstAccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$   
 For burst write:  $C = (\text{WrCycleTime} + (n - 1) \times \text{PageBurstAccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$  with n the page burst access number.
- (4) For single read:  $D = (\text{RdCycleTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$   
 For burst read:  $D = (\text{RdCycleTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$   
 For burst write:  $D = (\text{WrCycleTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$
- (5) For single read:  $E = (\text{CSRdOffTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$   
 For burst read:  $E = (\text{CSRdOffTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$   
 For burst write:  $E = (\text{CSWrOffTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$
- (6) For nCS falling edge (CS activated):  
 Case GpmcFCLKDivider = 0 :  
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC\_FCLK}$  Case GpmcFCLKDivider = 1:  
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC\_FCLK}$  if (ClkActivationTime and CSOnTime are odd) or (ClkActivationTime and CSOnTime are even)  
 $F = (1 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC\_FCLK}$  otherwise  
 Case GpmcFCLKDivider = 2:  
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC\_FCLK}$  if ((CSOnTime - ClkActivationTime) is a multiple of 3)  
 $F = (1 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC\_FCLK}$  if ((CSOnTime - ClkActivationTime - 1) is a multiple of 3)  
 $F = (2 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC\_FCLK}$  if ((CSOnTime - ClkActivationTime - 2) is a multiple of 3)  
 Case GpmcFCLKDivider = 3:  
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC\_FCLK}$  if ((CSOnTime - ClkActivationTime) is a multiple of 4)  
 $F = (1 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC\_FCLK}$  if ((CSOnTime - ClkActivationTime - 1) is a multiple of 4)  
 $F = (2 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC\_FCLK}$  if ((CSOnTime - ClkActivationTime - 2) is a multiple of 4)  
 $F = (3 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC\_FCLK}$  if ((CSOnTime - ClkActivationTime - 3) is a multiple of 4)
- (7) For ADV falling edge (ADV activated):  
 Case GpmcFCLKDivider = 0 :  
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$   
 Case GpmcFCLKDivider = 1:  
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if (ClkActivationTime and ADVOnTime are odd) or (ClkActivationTime and ADVOnTime are even)  
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  otherwise  
 Case GpmcFCLKDivider = 2:  
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if ((ADVOnTime - ClkActivationTime) is a multiple of 3)  
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVOnTime - ClkActivationTime - 1) is a multiple of 3)  
 $G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVOnTime - ClkActivationTime - 2) is a multiple of 3)  
 For ADV rising edge (ADV deactivated) in Reading mode:  
 Case GpmcFCLKDivider = 0:  
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$   
 Case GpmcFCLKDivider = 1:  
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if (ClkActivationTime and ADVrOffTime are odd) or (ClkActivationTime and ADVrOffTime are even)

$G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  otherwise

Case GpmcFCLKDivider = 2:

$G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if ((ADVrDOffTime – ClkActivationTime) is a multiple of 3)

$G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVrDOffTime – ClkActivationTime – 1) is a multiple of 3)

$G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVrDOffTime – ClkActivationTime – 2) is a multiple of 3)

Case GpmcFCLKDivider = 3:

$G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if ((ADVrDOffTime – ClkActivationTime) is a multiple of 4)

$G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVrDOffTime – ClkActivationTime – 1) is a multiple of 4)

$G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVrDOffTime – ClkActivationTime – 2) is a multiple of 4)

$G = (3 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVrDOffTime – ClkActivationTime – 3) is a multiple of 4)

For ADV rising edge (ADV deactivated) in Writing mode:

Case GpmcFCLKDivider = 0:

$G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$

Case GpmcFCLKDivider = 1:

$G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if (ClkActivationTime and ADVWrOffTime are odd) or (ClkActivationTime and ADVWrOffTime are even)

$G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  otherwise

Case GpmcFCLKDivider = 2:

$G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if ((ADVWrOffTime – ClkActivationTime) is a multiple of 3)

$G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVWrOffTime – ClkActivationTime – 1) is a multiple of 3)

$G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVWrOffTime – ClkActivationTime – 2) is a multiple of 3)

Case GpmcFCLKDivider = 3:

$G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC\_FCLK}$  if ((ADVWrOffTime – ClkActivationTime) is a multiple of 4)

$G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVWrOffTime – ClkActivationTime – 1) is a multiple of 4)

$G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVWrOffTime – ClkActivationTime – 2) is a multiple of 4)

$G = (3 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC\_FCLK}$  if ((ADVWrOffTime – ClkActivationTime – 3) is a multiple of 4)

(8) For OE falling edge (OE activated):

Case GpmcFCLKDivider = 0:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$

Case GpmcFCLKDivider = 1:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$  if (ClkActivationTime and OEOnTime are odd) or (ClkActivationTime and OEOnTime are even)

$H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  otherwise

Case GpmcFCLKDivider = 2:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$  if ((OEOnTime – ClkActivationTime) is a multiple of 3)

$H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOnTime – ClkActivationTime – 1) is a multiple of 3)

$H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOnTime – ClkActivationTime – 2) is a multiple of 3)

Case GpmcFCLKDivider = 3:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$  if ((OEOnTime – ClkActivationTime) is a multiple of 4)

$H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOnTime – ClkActivationTime – 1) is a multiple of 4)

$H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOnTime – ClkActivationTime – 2) is a multiple of 4)

$H = (3 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOnTime – ClkActivationTime – 3) is a multiple of 4)

For OE rising edge (OE deactivated):

Case GpmcFCLKDivider = 0:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$

Case GpmcFCLKDivider = 1:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$  if (ClkActivationTime and OEOffTime are odd) or (ClkActivationTime and OEOffTime are even)

$H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  otherwise

Case GpmcFCLKDivider = 2:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$  if ((OEOffTime – ClkActivationTime) is a multiple of 3)

$H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOffTime – ClkActivationTime – 1) is a multiple of 3)

$H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOffTime – ClkActivationTime – 2) is a multiple of 3)

Case GpmcFCLKDivider = 3:

$H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC\_FCLK}$  if ((OEOffTime – ClkActivationTime) is a multiple of 4)

$H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOffTime – ClkActivationTime – 1) is a multiple of 4)

$H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOffTime – ClkActivationTime – 2) is a multiple of 4)

$H = (3 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((OEOffTime – ClkActivationTime – 3) is a multiple of 4)

(9) For WE falling edge (WE activated):

Case GpmcFCLKDivider = 0:

$I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC\_FCLK}$

Case GpmcFCLKDivider = 1:

$I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC\_FCLK}$  if (ClkActivationTime and WEOnTime are odd) or (ClkActivationTime and WEOnTime are even)

$I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC\_FCLK}$  otherwise

Case GpmcFCLKDivider = 2:

$I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC\_FCLK}$  if ((WEOnTime – ClkActivationTime) is a multiple of 3)

$I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((WEOnTime – ClkActivationTime – 1) is a multiple of 3)

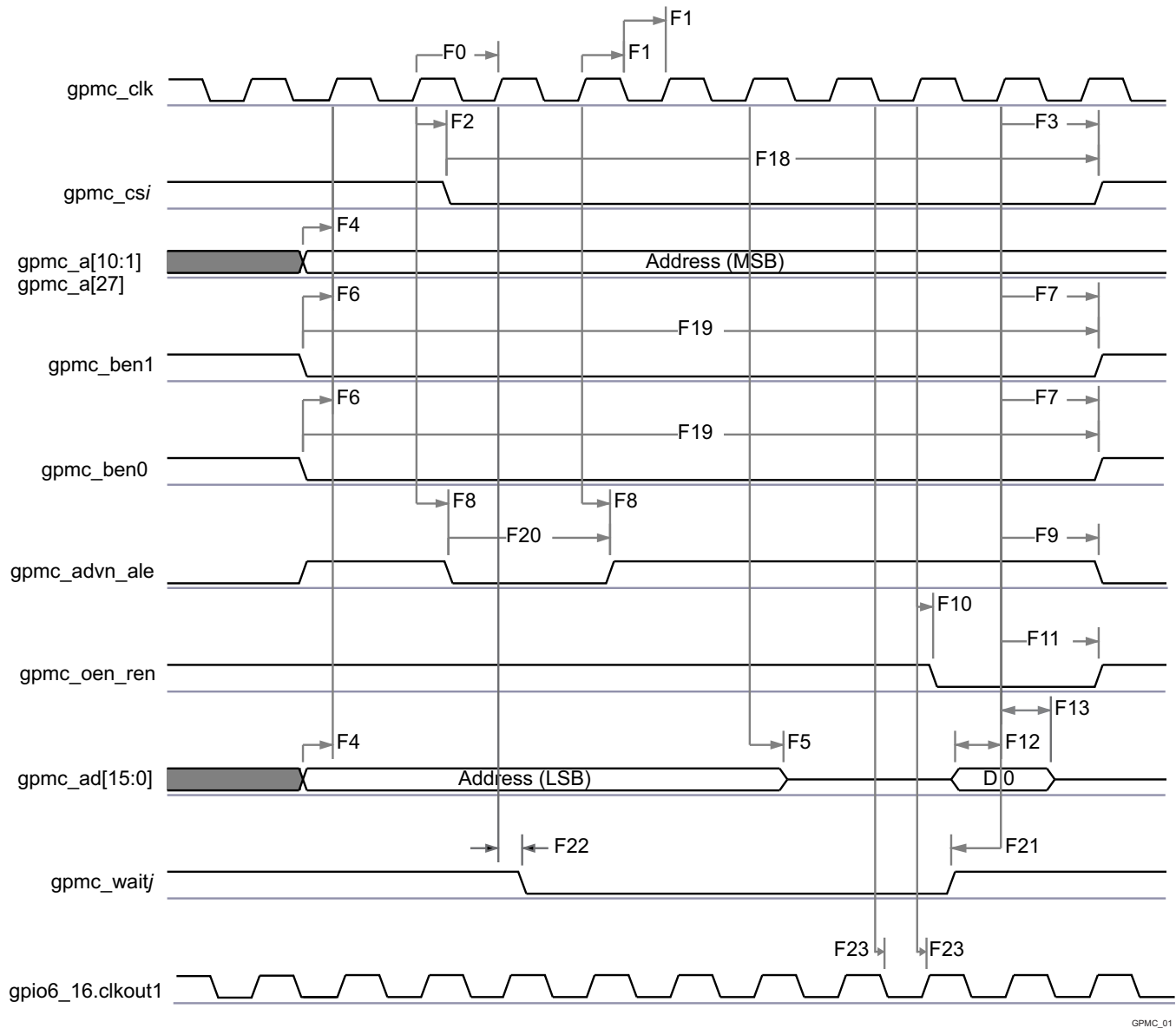
$I = (2 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((WEOnTime – ClkActivationTime – 2) is a multiple of 3)

Case GpmcFCLKDivider = 3:

$I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC\_FCLK}$  if ((WEOnTime – ClkActivationTime) is a multiple of 4)

$I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC\_FCLK}$  if ((WEOnTime – ClkActivationTime – 1) is a multiple of 4)

- $I = (2 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  if  $((WEOnTime - ClkActivationTime - 2)$  is a multiple of 4)
- $I = (3 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  if  $((WEOnTime - ClkActivationTime - 3)$  is a multiple of 4)
- For WE rising edge (WE deactivated):
- Case GpmcFCLKDivider = 0:
- $I = 0.5 \times WEExtraDelay \times GPMC\_FCLK$
- Case GpmcFCLKDivider = 1:
- $I = 0.5 \times WEExtraDelay \times GPMC\_FCLK$  if  $(ClkActivationTime$  and  $WEOffTime$  are odd) or  $(ClkActivationTime$  and  $WEOffTime$  are even)
- $I = (1 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  otherwise
- Case GpmcFCLKDivider = 2:
- $I = 0.5 \times WEExtraDelay \times GPMC\_FCLK$  if  $((WEOffTime - ClkActivationTime)$  is a multiple of 3)
- $I = (1 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  if  $((WEOffTime - ClkActivationTime - 1)$  is a multiple of 3)
- $I = (2 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  if  $((WEOffTime - ClkActivationTime - 2)$  is a multiple of 3)
- Case GpmcFCLKDivider = 3:
- $I = 0.5 \times WEExtraDelay \times GPMC\_FCLK$  if  $((WEOffTime - ClkActivationTime)$  is a multiple of 4)
- $I = (1 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  if  $((WEOffTime - ClkActivationTime - 1)$  is a multiple of 4)
- $I = (2 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  if  $((WEOffTime - ClkActivationTime - 2)$  is a multiple of 4)
- $I = (3 + 0.5 \times WEExtraDelay) \times GPMC\_FCLK$  if  $((WEOffTime - ClkActivationTime - 3)$  is a multiple of 4)
- (10)  $J = GPMC\_FCLK$  period, where  $GPMC\_FCLK$  is the General Purpose Memory Controller internal functional clock
- (11) For read:  
 $K = (ADVrdOffTime - ADVOnTime) \times (TimeParaGranularity + 1) \times GPMC\_FCLK$   
 For write:  $K = (ADVWrOffTime - ADVOnTime) \times (TimeParaGranularity + 1) \times GPMC\_FCLK$
- (12) The gpmc\_clk output clock maximum and minimum frequency is programmable in the I/F module by setting the GPMC\_CONFIG1\_CSx configuration register bit fields GpmcFCLKDivider
- (13) gpio6\_16 programmed to MUXMODE=9 (clkout1), CM\_CLKSEL\_CLKOUTMUX1 programmed to 7 (CORE\_DPLL\_OUT\_DCLK), CM\_CLKSEL\_CORE\_DPLL\_OUT\_CLK\_CLKOUTMUX programmed to 1.
- (14) CSEXTRADELAY = 0, ADVEXTRADELAY = 0, WEEXTRADELAY = 0, OEEXTRADELAY = 0. Extra half-GPMC\_FCLK cycle delay mode is not timed.

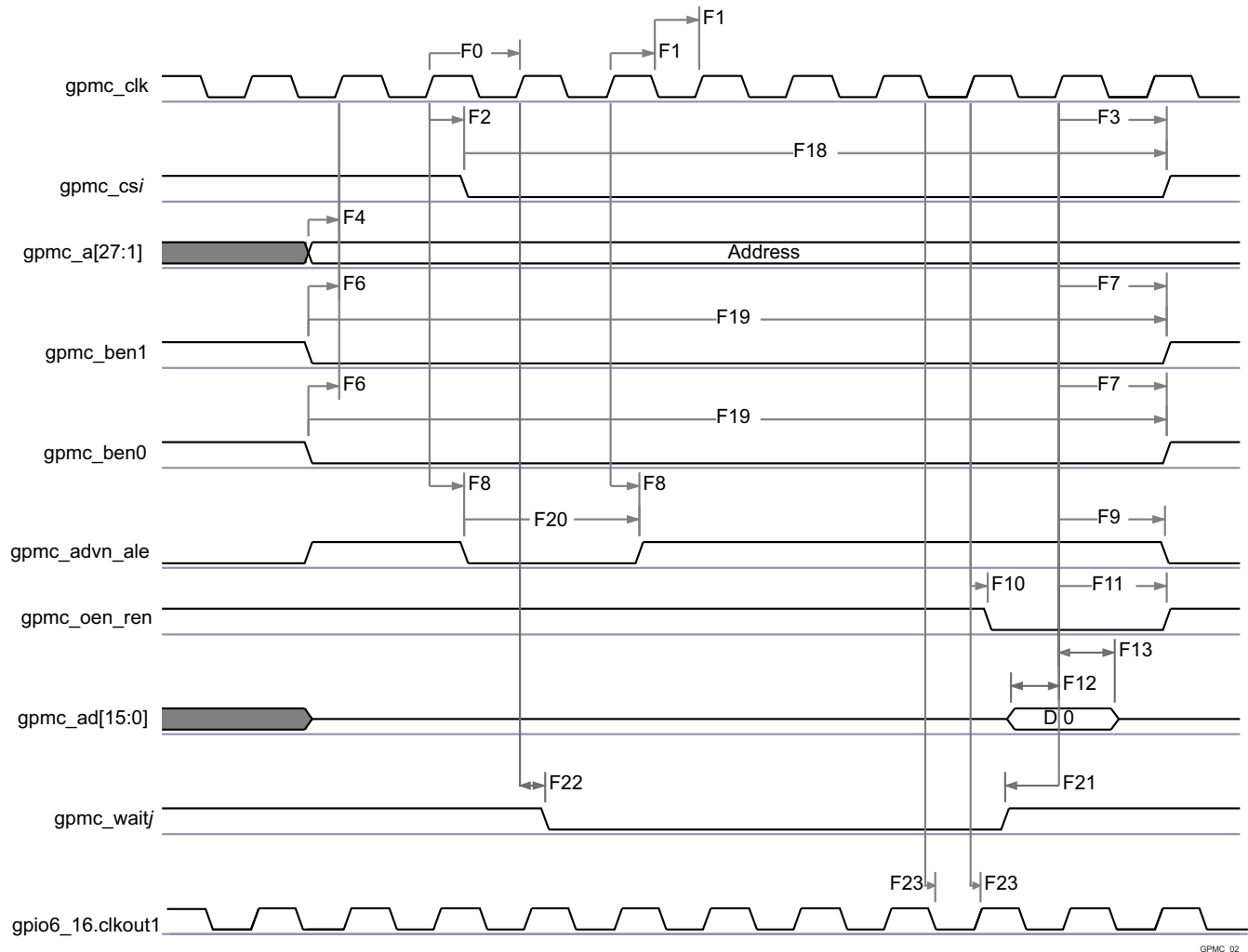


GPMC\_01

**Figure 5-28. GPMC / Multiplexed 16bits NOR Flash - Synchronous Single Read -**  
**(GpmcFCLKDivider = 0)<sup>(1)(2)</sup>**

(1) In gpmc\_csi, i = 0 to 7.

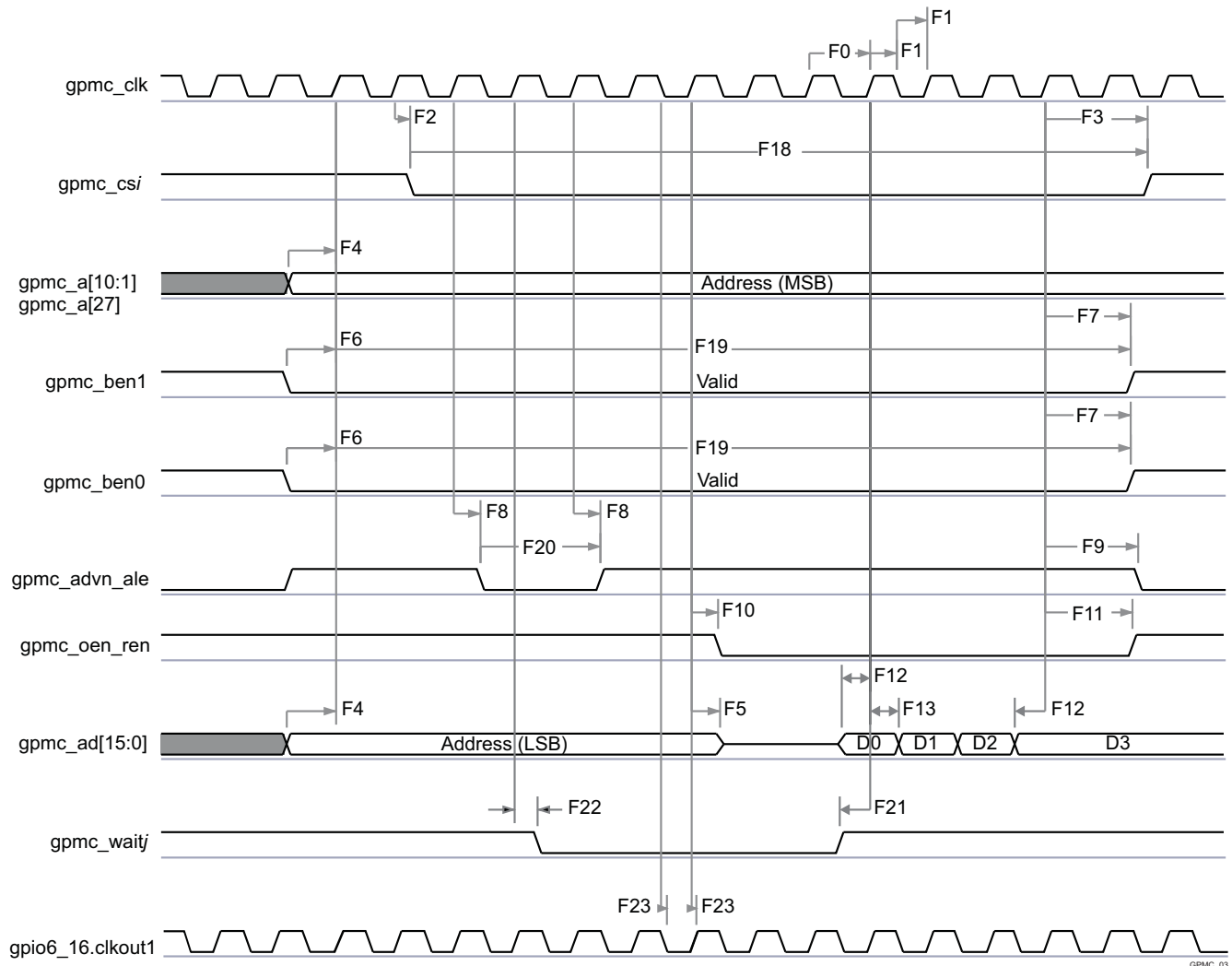
(2) In gpmc\_waitj, j = 0 to 1.



**Figure 5-29. GPMC / Nonmultiplexed 16bits NOR Flash - Synchronous Single Read -**  
**(GpmcFCLKDivider = 0)<sup>(1)(2)</sup>**

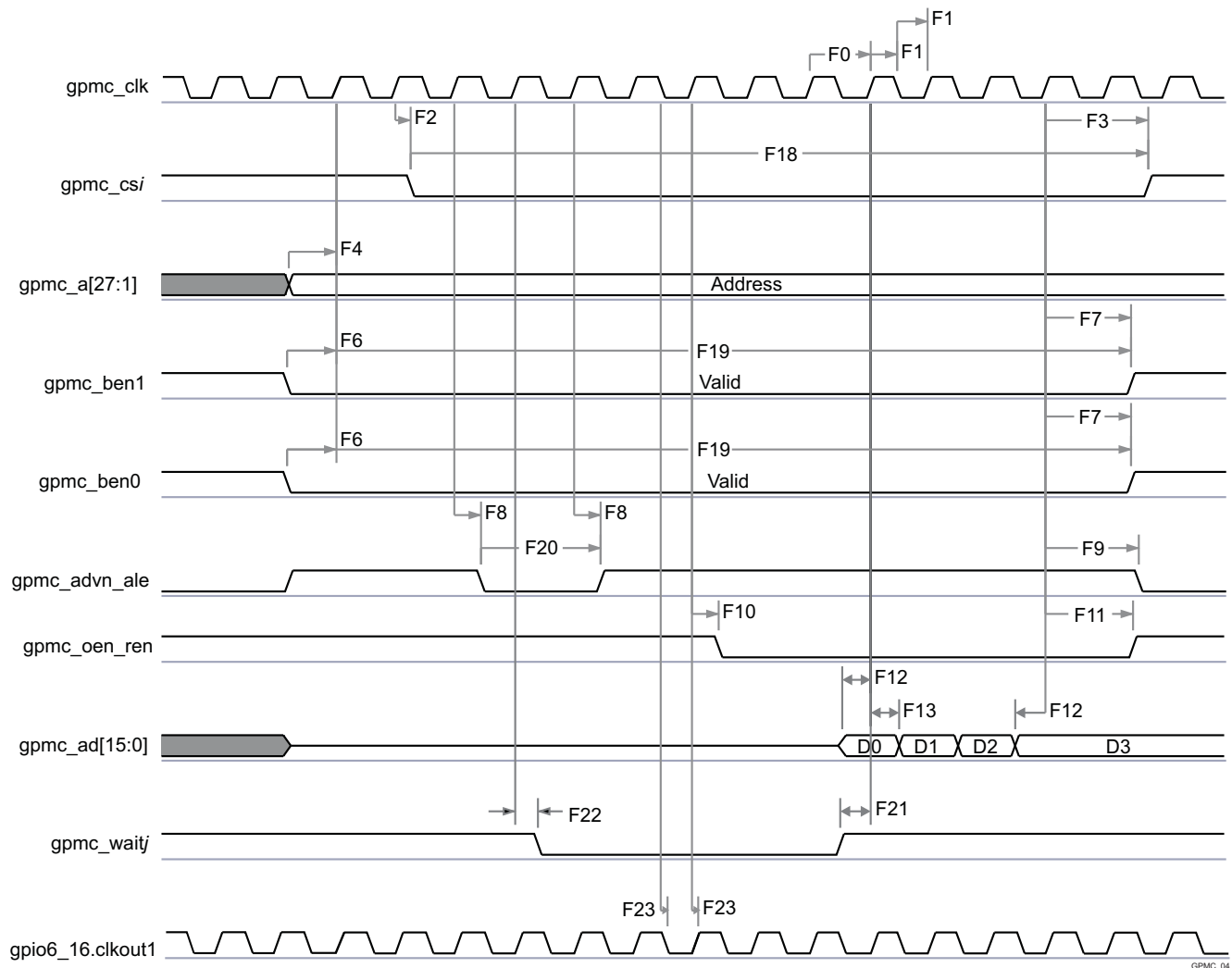
(1) In gpmc\_csi, i = 0 to 7.

(2) In gpmc\_waitj, j = 0 to 1.



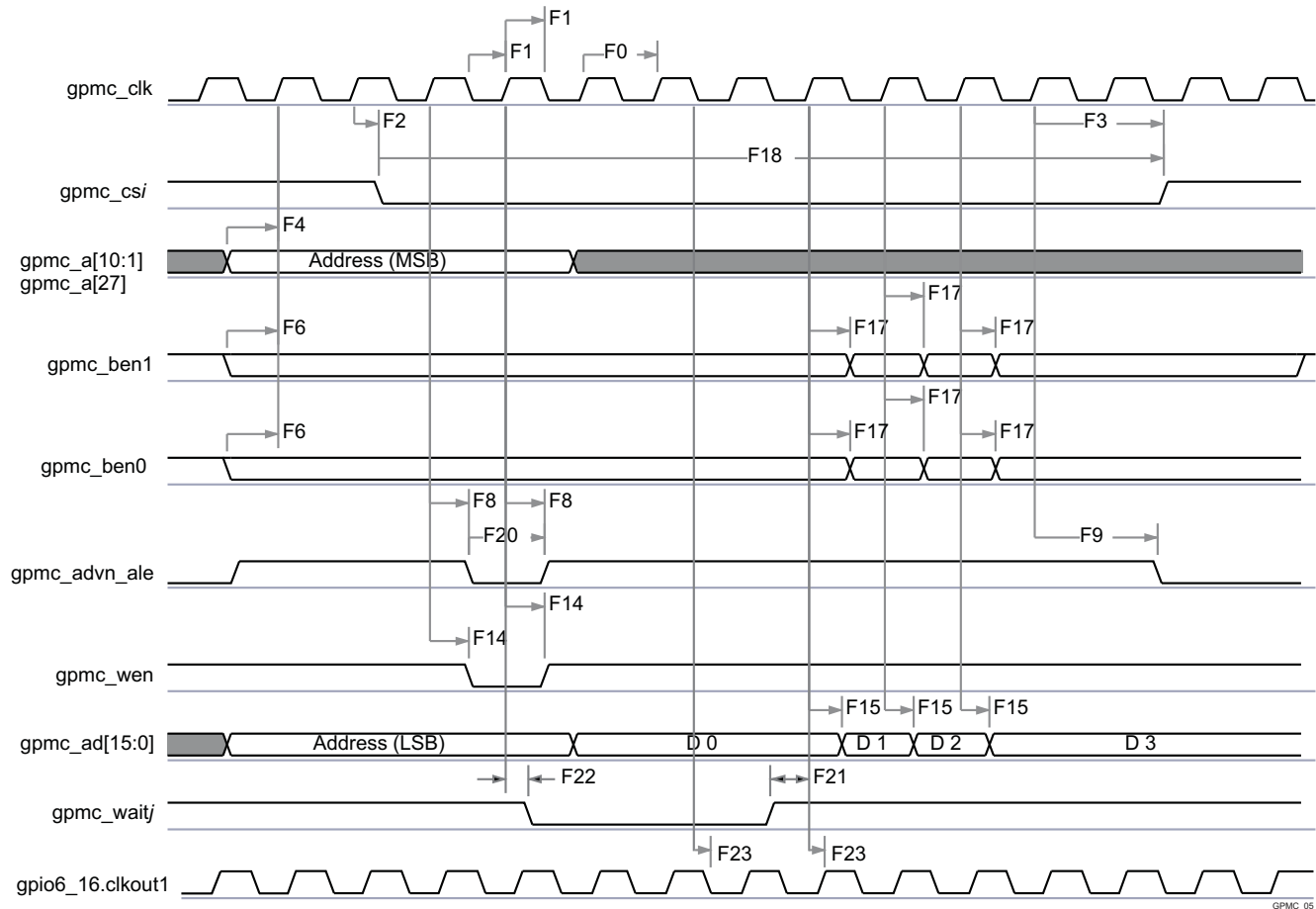
**Figure 5-30. GPMC / Multiplexed 16bits NOR Flash - Synchronous Burst Read 4x16 bits - (GpmcFCLKDivider = 0)<sup>(1)(2)</sup>**

- (1) In gpmc\_csi, i = 0 to 7.  
(2) In gpmc\_waitj, j = 0 to 1.



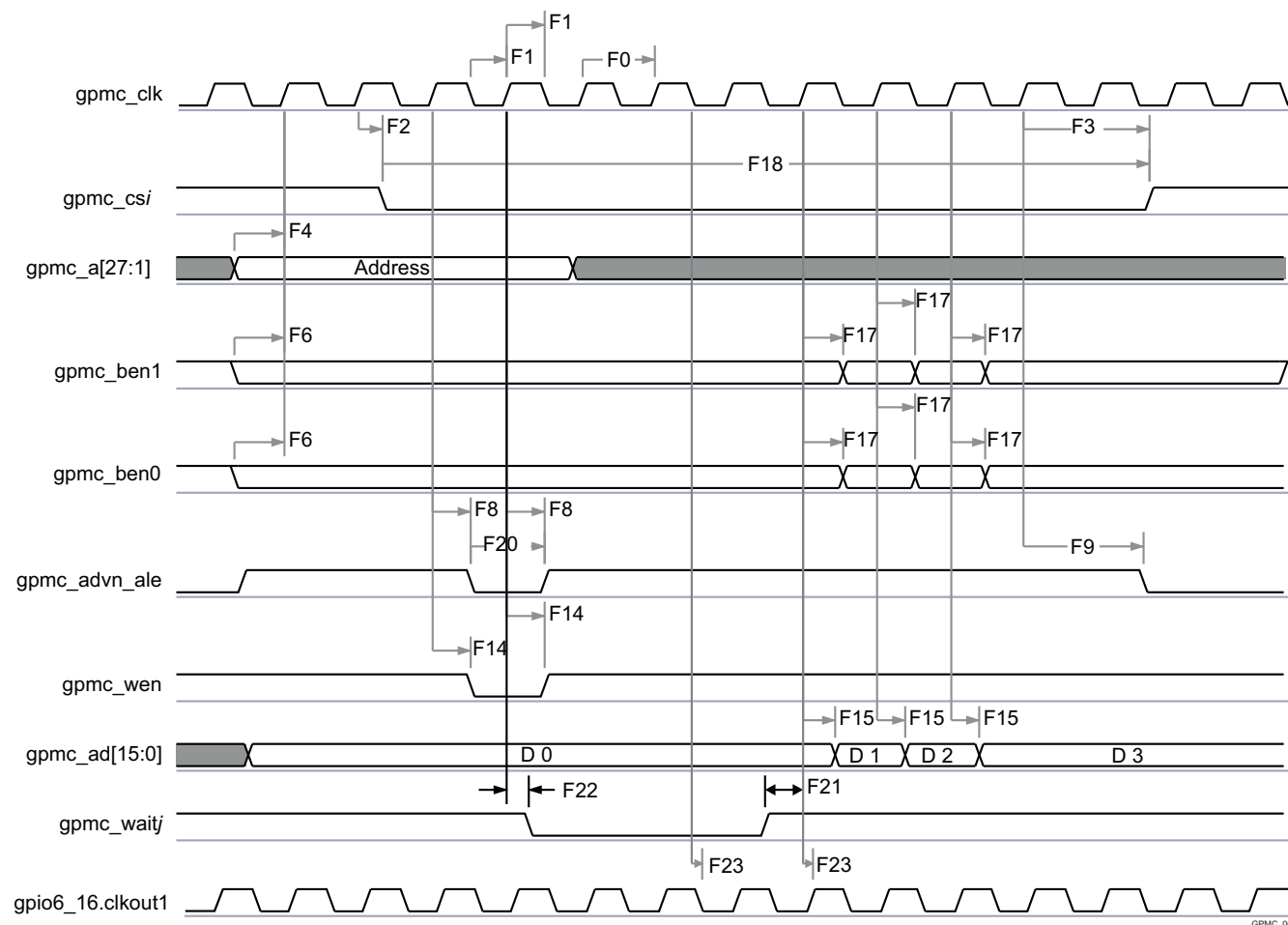
**Figure 5-31. GPMC / Nonmultiplexed 16bits NOR Flash - Synchronous Burst Read 4x16 bits - (GpmcFCLKDivider = 0)<sup>(1)(2)</sup>**

- (1) In gpmc\_csi, i = 0 to 7.  
 (2) In gpmc\_waitj, j = 0 to 1.



**Figure 5-32. GPMC / Multiplexed 16bits NOR Flash - Synchronous Burst Write 4x16bits - (GpmcFCLKDivider = 0)<sup>(1)(2)</sup>**

- (1) In gpmc\_csi, i = 0 to 7.  
(2) In gpmc\_waitj, j = 0 to 1.



**Figure 5-33. GPMC / Nonmultiplexed 16bits NOR Flash - Synchronous Burst Write 4x16bits -**  
**(GpmcFCLKDivider = 0)<sup>(1)(2)</sup>**

(1) In gpmc\_csi, i = 1 to 7.

(2) In gpmc\_waitj, j = 0 to 1.

#### 5.10.6.7.2 GPMC/NOR Flash Interface Asynchronous Timing

##### CAUTION

The IO Timings provided in this section are only valid for some GPMC usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

Table 5-58 and Table 5-59 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 5-34, Figure 5-35, Figure 5-36, Figure 5-37, Figure 5-38, and Figure 5-39).

**Table 5-58. GPMC/NOR Flash Interface Timing Requirements - Asynchronous Mode**

| NO.  | PARAMETER              | DESCRIPTION                                                      | MIN | MAX              | UNIT   |
|------|------------------------|------------------------------------------------------------------|-----|------------------|--------|
| FA5  | $t_{acc(DAT)}$         | Data Maximum Access Time (GPMC_FCLK cycles)                      |     | H <sup>(1)</sup> | cycles |
| FA20 | $t_{acc1-pgmode(DAT)}$ | Page Mode Successive Data Maximum Access Time (GPMC_FCLK cycles) |     | P <sup>(2)</sup> | cycles |

**Table 5-58. GPMC/NOR Flash Interface Timing Requirements - Asynchronous Mode (continued)**

| NO.  | PARAMETER                     | DESCRIPTION                                                   | MIN | MAX              | UNIT   |
|------|-------------------------------|---------------------------------------------------------------|-----|------------------|--------|
| FA21 | $t_{\text{acc2-pgmode(DAT)}}$ | Page Mode First Data Maximum Access Time (GPMC_FCLK cycles)   |     | H <sup>(1)</sup> | cycles |
| -    | $t_{\text{su(DV-OEH)}}$       | Setup time, read gpmc_ad[15:0] valid before gpmc_oen_ren high | 1.9 |                  | ns     |
| -    | $t_{\text{h(OEH-DV)}}$        | Hold time, read gpmc_ad[15:0] valid after gpmc_oen_ren high   | 1   |                  | ns     |

(1) H = Access Time × (TimeParaGranularity + 1)

(2) P = PageBurstAccessTime × (TimeParaGranularity + 1)

**Table 5-59. GPMC/NOR Flash Interface Switching Characteristics - Asynchronous Mode**

| NO.  | PARAMETER                   | DESCRIPTION                                                                       | MIN                   | MAX                   | UNIT |
|------|-----------------------------|-----------------------------------------------------------------------------------|-----------------------|-----------------------|------|
| FA0  | $t_{\text{w(nBEV)}}$        | Pulse duration, gpmc_ben[1:0] valid time                                          |                       | N <sup>(1)</sup>      | ns   |
| FA1  | $t_{\text{w(nCSV)}}$        | Pulse duration, gpmc_cs[7:0] low                                                  |                       | A <sup>(2)</sup>      | ns   |
| FA3  | $t_{\text{d(nCSV-nADVIV)}}$ | Delay time, gpmc_cs[7:0] valid to gpmc_advn_ale invalid                           | B - 2 <sup>(3)</sup>  | B + 4 <sup>(3)</sup>  | ns   |
| FA4  | $t_{\text{d(nCSV-nOEIV)}}$  | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren invalid (Single read)              | C - 2 <sup>(4)</sup>  | C + 4 <sup>(4)</sup>  | ns   |
| FA9  | $t_{\text{d(AV-nCSV)}}$     | Delay time, address bus valid to gpmc_cs[7:0] valid                               | J - 2 <sup>(5)</sup>  | J + 4 <sup>(5)</sup>  | ns   |
| FA10 | $t_{\text{d(nBEV-nCSV)}}$   | Delay time, gpmc_ben[1:0] valid to gpmc_cs[7:0] valid                             | J - 2 <sup>(5)</sup>  | J + 4 <sup>(5)</sup>  | ns   |
| FA12 | $t_{\text{d(nCSV-nADVIV)}}$ | Delay time, gpmc_cs[7:0] valid to gpmc_advn_ale valid                             | K - 2 <sup>(6)</sup>  | K + 4 <sup>(6)</sup>  | ns   |
| FA13 | $t_{\text{d(nCSV-nOEIV)}}$  | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren valid                              | L - 2 <sup>(7)</sup>  | L + 4 <sup>(7)</sup>  | ns   |
| FA16 | $t_{\text{w(AIV)}}$         | Pulse duration, address invalid between 2 successive R/W accesses                 | G <sup>(8)</sup>      |                       | ns   |
| FA18 | $t_{\text{d(nCSV-nOEIV)}}$  | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren invalid (Burst read)               | I - 2 <sup>(9)</sup>  | I + 4 <sup>(9)</sup>  | ns   |
| FA20 | $t_{\text{w(AV)}}$          | Pulse duration, address valid : 2nd, 3rd and 4th accesses                         | D <sup>(10)</sup>     |                       | ns   |
| FA25 | $t_{\text{d(nCSV-nWEV)}}$   | Delay time, gpmc_cs[7:0] valid to gpmc_wen valid                                  | E - 2 <sup>(11)</sup> | E + 4 <sup>(11)</sup> | ns   |
| FA27 | $t_{\text{d(nCSV-nWEIV)}}$  | Delay time, gpmc_cs[7:0] valid to gpmc_wen invalid                                | F - 2 <sup>(12)</sup> | F + 4 <sup>(12)</sup> | ns   |
| FA28 | $t_{\text{d(nWEV-DV)}}$     | Delay time, gpmc_wen valid to data bus valid                                      |                       | 2                     | ns   |
| FA29 | $t_{\text{d(DV-nCSV)}}$     | Delay time, data bus valid to gpmc_cs[7:0] valid                                  | J - 2 <sup>(5)</sup>  | J + 4 <sup>(5)</sup>  | ns   |
| FA37 | $t_{\text{d(nOEIV-AIV)}}$   | Delay time, gpmc_oen_ren valid to gpmc_ad[15:0] multiplexed address bus phase end |                       | 2                     | ns   |

(1) For single read: N = RdCycleTime × (TimeParaGranularity + 1) × GPMC\_FCLK

For single write: N = WrCycleTime × (TimeParaGranularity + 1) × GPMC\_FCLK

For burst read: N = (RdCycleTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC\_FCLK

For burst write: N = (WrCycleTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC\_FCLK

(2) For single read: A = (CSRdOffTime - CSOnTime) × (TimeParaGranularity + 1) × GPMC\_FCLK

For single write: A = (CSWrOffTime - CSOnTime) × (TimeParaGranularity + 1) × GPMC\_FCLK

For burst read: A = (CSRdOffTime - CSOnTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC\_FCLK

For burst write: A = (CSWrOffTime - CSOnTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC\_FCLK

(3) For reading: B = ((ADVrOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (ADVExtraDelay - CSEExtraDelay)) × GPMC\_FCLK

For writing: B = ((ADVWrOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (ADVExtraDelay - CSEExtraDelay)) × GPMC\_FCLK

(4) C = ((OEOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (OEExtraDelay - CSEExtraDelay)) × GPMC\_FCLK

(5) J = (CSOnTime × (TimeParaGranularity + 1) + 0.5 × CSEExtraDelay) × GPMC\_FCLK

(6) K = ((ADVOnTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (ADVExtraDelay - CSEExtraDelay)) × GPMC\_FCLK

(7) L = ((OEOnTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (OEExtraDelay - CSEExtraDelay)) × GPMC\_FCLK

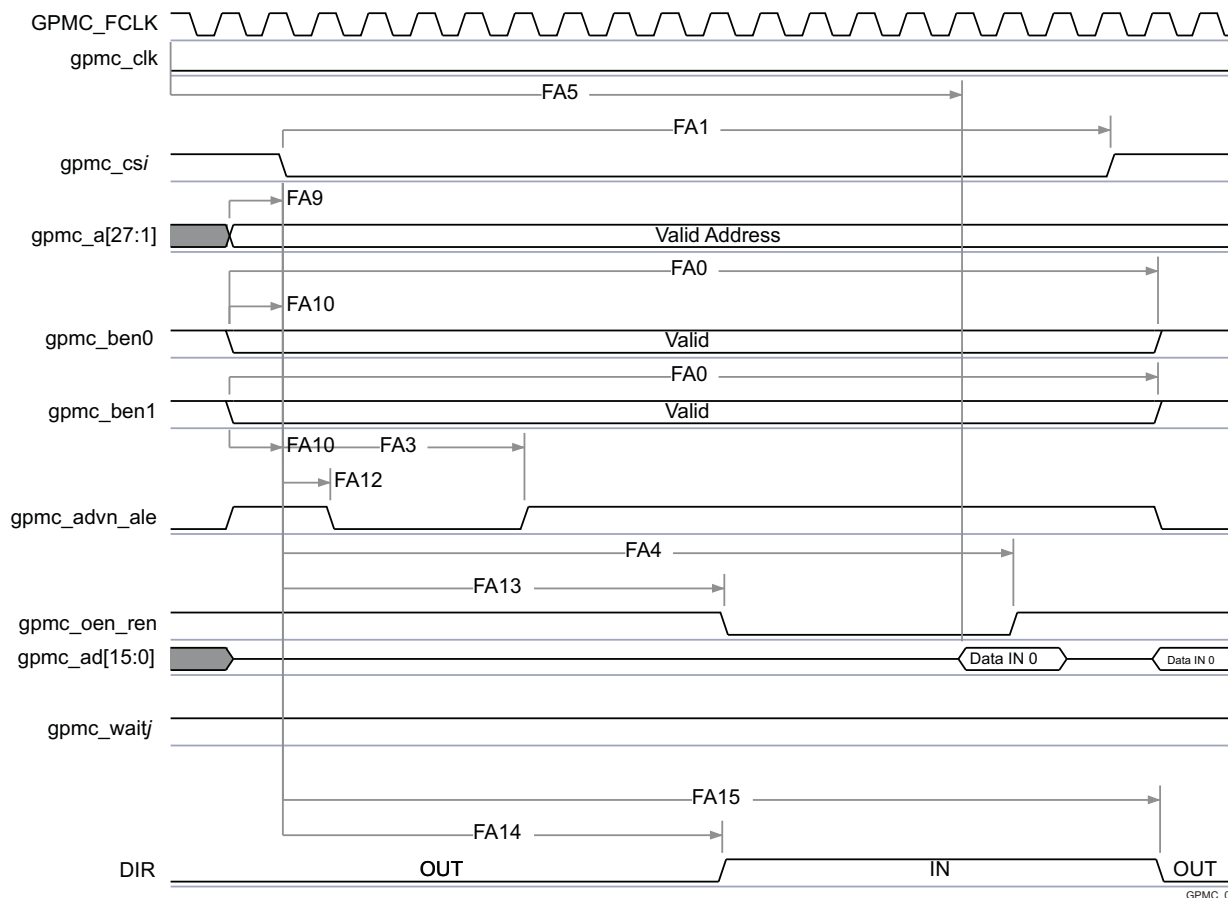
(8) G = Cycle2CycleDelay × GPMC\_FCLK × (TimeParaGranularity + 1)

(9) I = ((OEOffTime + (n - 1) × PageBurstAccessTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (OEExtraDelay - CSEExtraDelay)) × GPMC\_FCLK

(10) D = PageBurstAccessTime × (TimeParaGranularity + 1) × GPMC\_FCLK

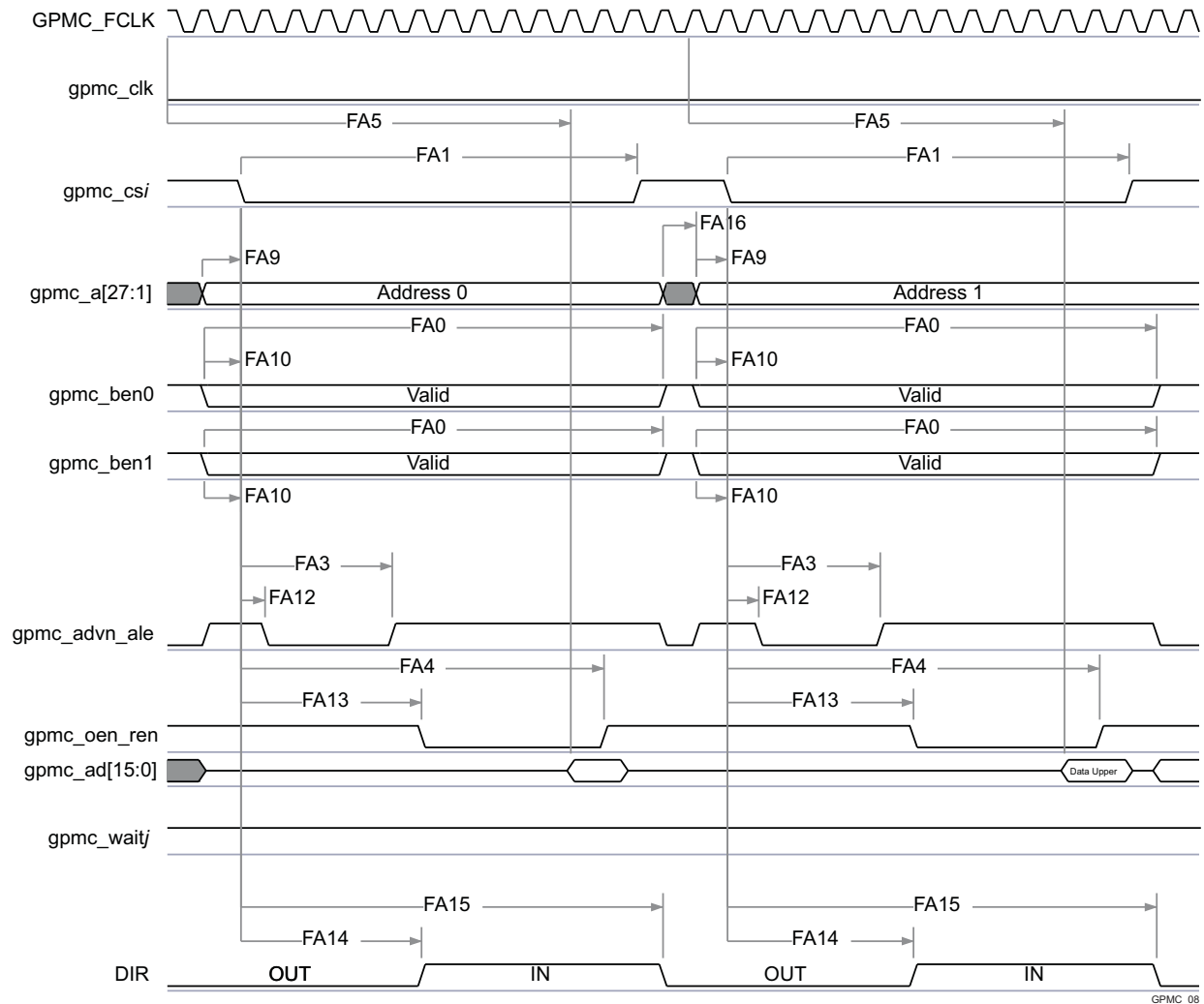
(11) E = ((WEOnTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (WEExtraDelay - CSEExtraDelay)) × GPMC\_FCLK

(12) F = ((WEOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (WEExtraDelay - CSEExtraDelay)) × GPMC\_FCLK



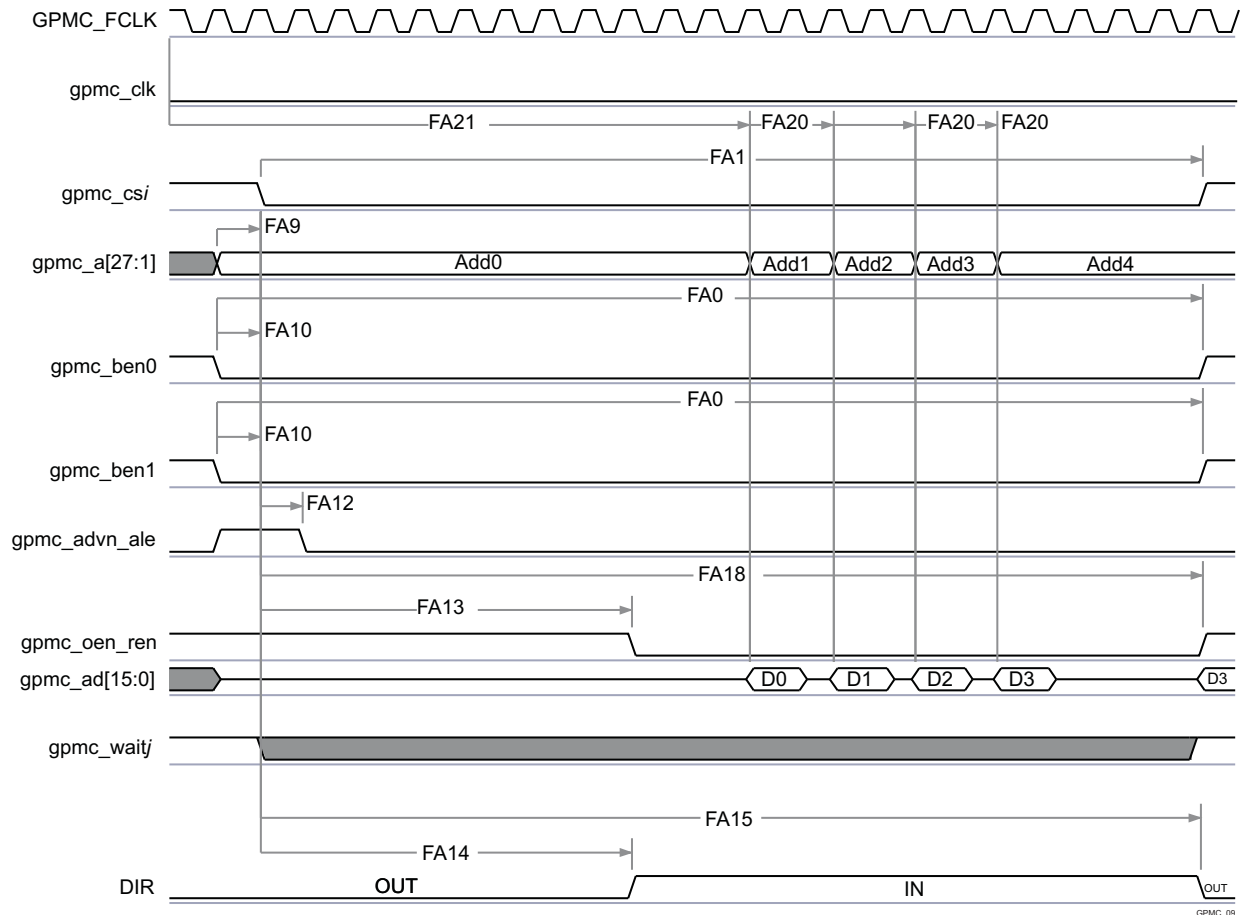
**Figure 5-34. GPMC / NOR Flash - Asynchronous Read - Single Word Timing<sup>(1)(2)(3)(4)</sup>**

- (1) In gpmc\_csi, i = 0 to 7. In gpmc\_waitj, j = 0 to 1.
- (2) FA5 parameter illustrates amount of time required to internally sample input data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA5 functional clock cycles, input Data will be internally sampled by active functional clock edge. FA5 value must be stored inside AccessTime register bits field.
- (3) GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.
- (4) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.



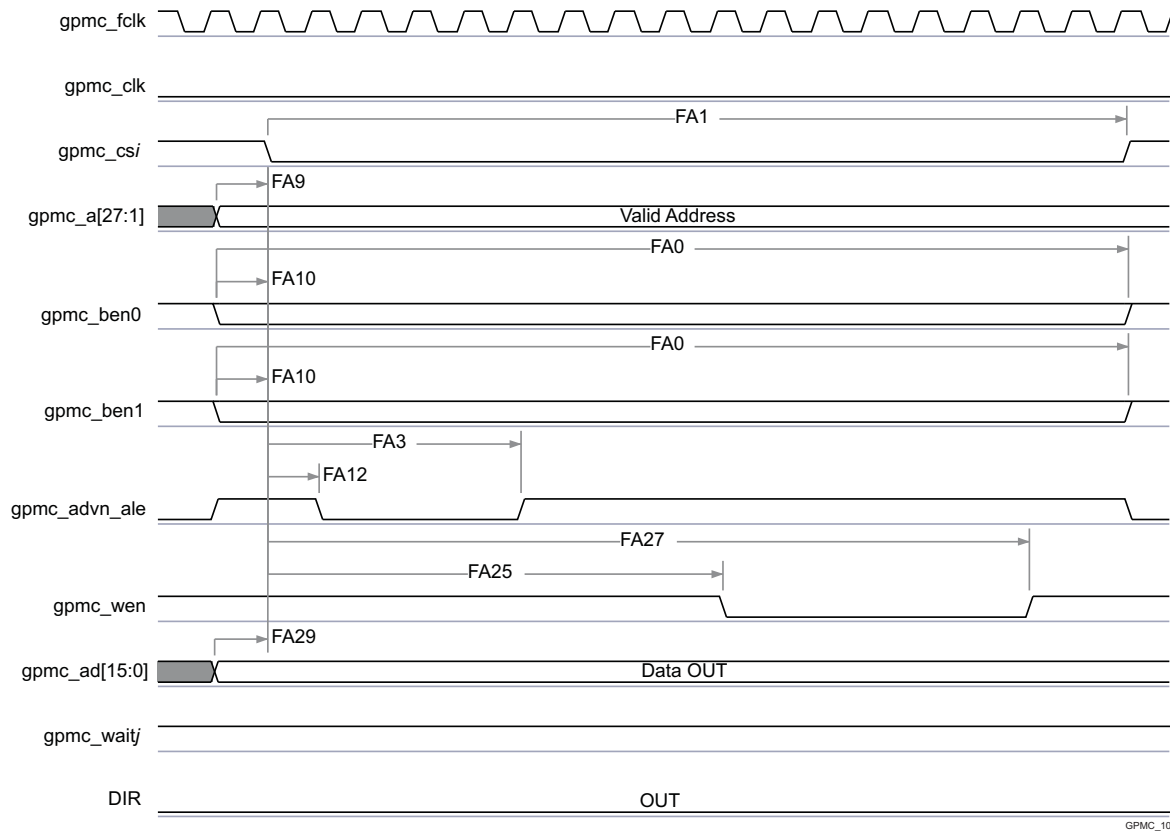
**Figure 5-35. GPMC / NOR Flash - Asynchronous Read - 32-bit Timing<sup>(1)(2)(3)(4)</sup>**

- (1) In gpmc\_csi, i = 0 to 7. In gpmc\_waitj, j = 0 to 1.
- (2) FA5 parameter illustrates amount of time required to internally sample input Data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA5 functional clock cycles, input Data will be internally sampled by active functional clock edge. FA5 value should be stored inside AccessTime register bits field.
- (3) GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.
- (4) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.



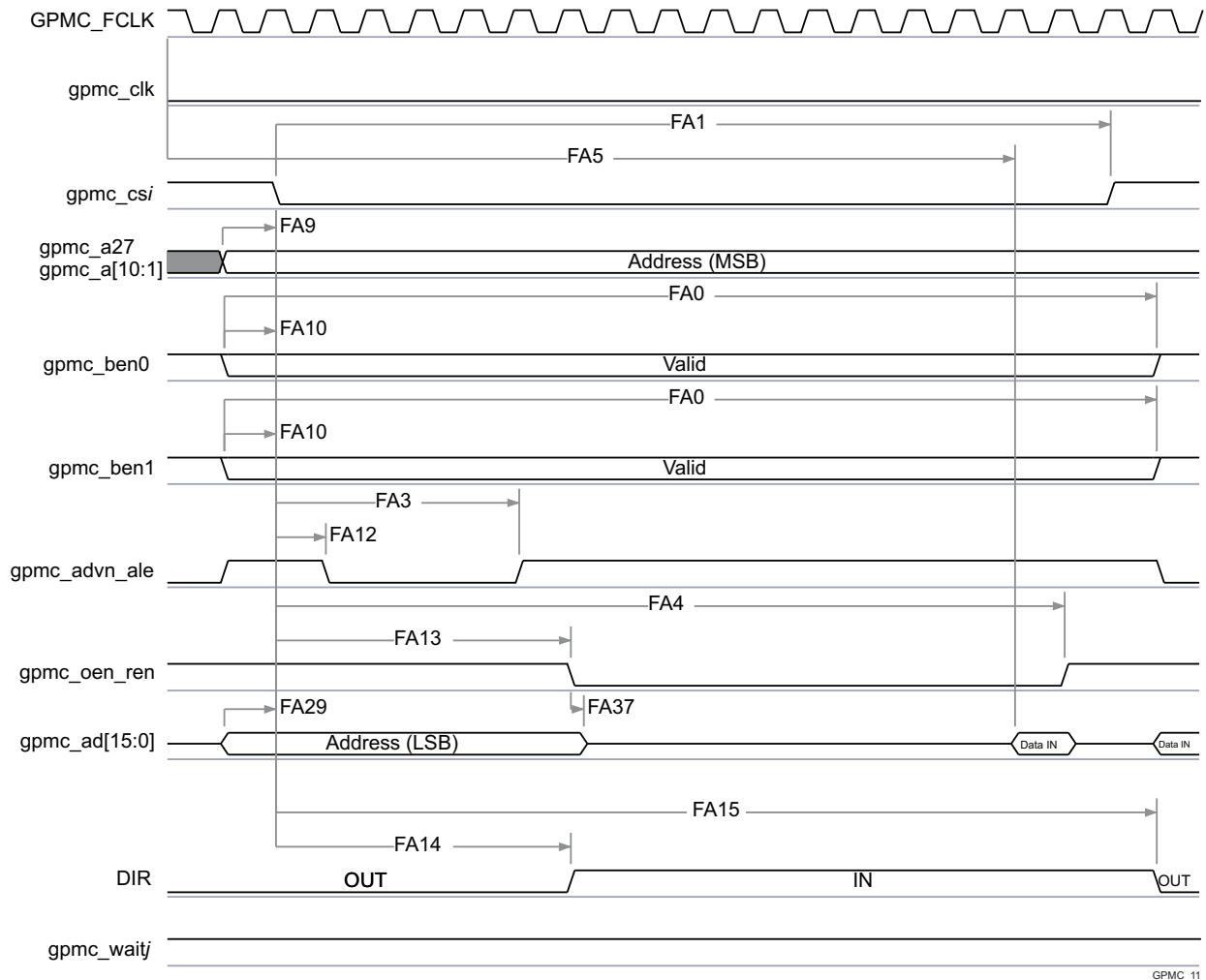
**Figure 5-36. GPMC / NOR Flash - Asynchronous Read - Page Mode 4x16-bit Timing<sup>(1)(2)(3)(4)(5)</sup>**

- (1) In gpmc\_csi, i = 0 to 7. In gpmc\_waitj, j = 0 to 1.
- (2) FA21 parameter illustrates amount of time required to internally sample first input Page Data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA21 functional clock cycles, First input Page Data will be internally sampled by active functional clock edge. FA21 calculation is detailed in a separated application note and should be stored inside AccessTime register bits field.
- (3) FA20 parameter illustrates amount of time required to internally sample successive input Page Data. It is expressed in number of GPMC functional clock cycles. After each access to input Page Data, next input Page Data will be internally sampled by active functional clock edge after FA20 functional clock cycles. FA20 is also the duration of address phases for successive input Page Data (excluding first input Page Data). FA20 value should be stored in PageBurstAccessTime register bits field.
- (4) GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.
- (5) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.



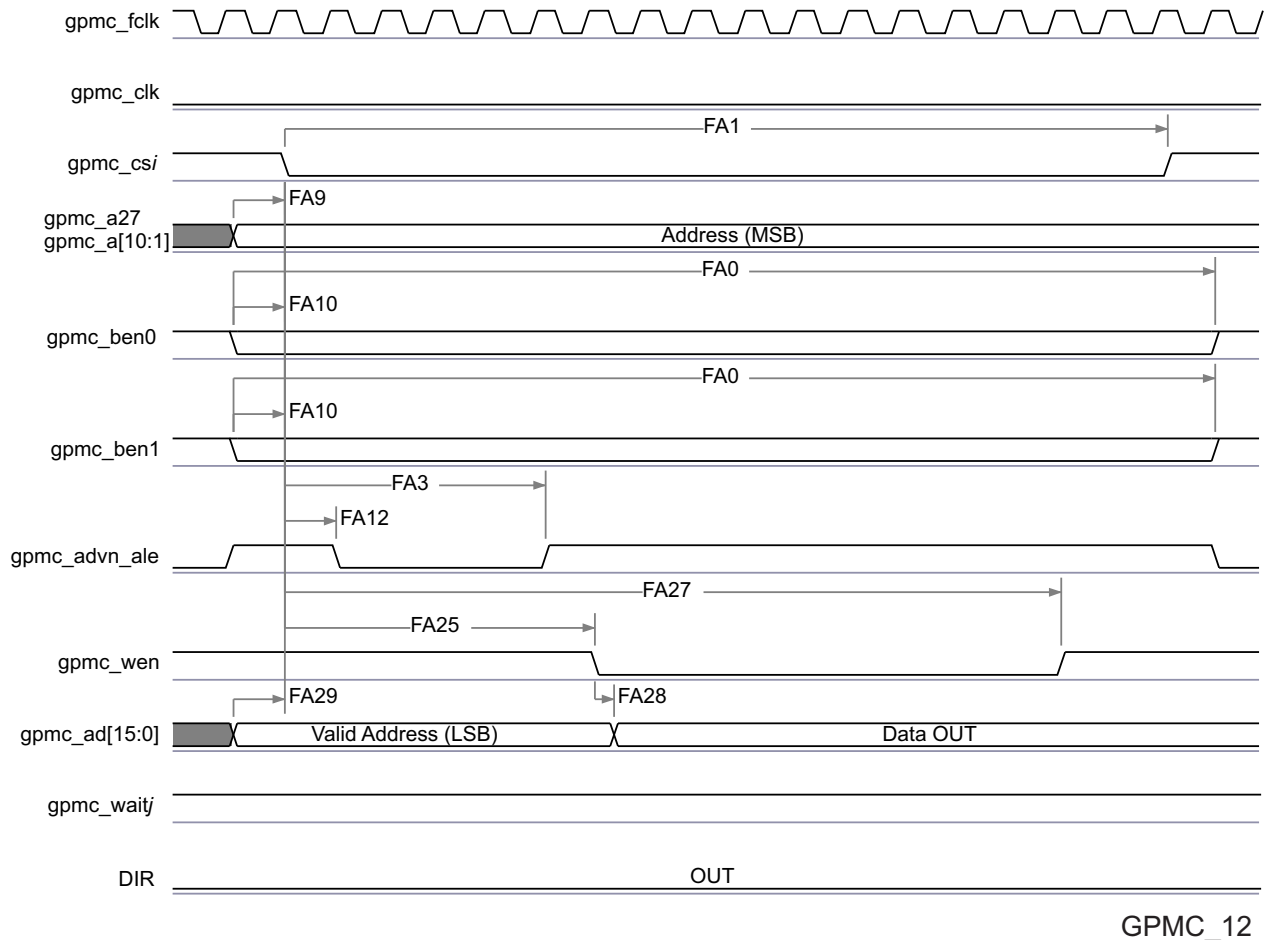
**Figure 5-37. GPMC / NOR Flash - Asynchronous Write - Single Word Timing<sup>(1)(2)</sup>**

- (1) In gpmc\_csi, i = 0 to 7. In gpmc\_waitj, j = 0 to 1.
- (2) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.



**Figure 5-38. GPMC / Multiplexed NOR Flash - Asynchronous Read - Single Word Timing<sup>(1)(2)(3)(4)</sup>**

- (1) In gpmc\_csi, i = 0 to 7. In gpmc\_waitj, j = 0 to 1
- (2) FA5 parameter illustrates amount of time required to internally sample input Data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA5 functional clock cycles, input Data will be internally sampled by active functional clock edge. FA5 value should be stored inside AccessTime register bits field.
- (3) GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally
- (4) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.



**Figure 5-39. GPMC / Multiplexed NOR Flash - Asynchronous Write - Single Word Timing<sup>(1)(2)</sup>**

- (1) In gpmc\_csi, i = 0 to 7. In gpmc\_waitj, j = 0 to 1.  
 (2) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.

### 5.10.6.7.3 GPMC/NAND Flash Interface Asynchronous Timing

#### CAUTION

The IO Timings provided in this section are only valid for some GPMC usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

Table 5-60 and Table 5-61 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 5-40, Figure 5-41, Figure 5-42, and Figure 5-43).

**Table 5-60. GPMC/NAND Flash Interface Timing Requirements**

| NO.   | PARAMETER        | DESCRIPTION                                                   | MIN | MAX              | UNIT   |
|-------|------------------|---------------------------------------------------------------|-----|------------------|--------|
| GNF12 | $t_{acc}(DAT)$   | Data maximum access time (GPMC_FCLK Cycles)                   |     | J <sup>(1)</sup> | cycles |
| -     | $t_{su}(DV-OEH)$ | Setup time, read gpmc_ad[15:0] valid before gpmc_oen_ren high | 1.9 |                  | ns     |
| -     | $t_h(OEH-DV)$    | Hold time, read gpmc_ad[15:0] valid after gpmc_oen_ren high   | 1   |                  | ns     |

$$(1) J = \text{AccessTime} * (\text{TimeParaGranularity} + 1)$$

**Table 5-61. GPMC/NAND Flash Interface Switching Characteristics**

| NO.   | PARAMETER            | DESCRIPTION                                              | MIN                   | MAX                   | UNIT |
|-------|----------------------|----------------------------------------------------------|-----------------------|-----------------------|------|
| GNF0  | $t_{w(nWEV)}$        | Pulse duration, gpmc_wen valid time                      |                       | A <sup>(1)</sup>      | ns   |
| GNF1  | $t_{d(nCSV-nWEV)}$   | Delay time, gpmc_cs[7:0] valid to gpmc_wen valid         | B - 2 <sup>(2)</sup>  | B + 4 <sup>(2)</sup>  | ns   |
| GNF2  | $t_{d(CLEH-nWEV)}$   | Delay time, gpmc_ben[1:0] high to gpmc_wen valid         | C - 2 <sup>(3)</sup>  | C + 4 <sup>(3)</sup>  | ns   |
| GNF3  | $t_{d(nWEV-DV)}$     | Delay time, gpmc_ad[15:0] valid to gpmc_wen valid        | D - 2 <sup>(4)</sup>  | D + 4 <sup>(4)</sup>  | ns   |
| GNF4  | $t_{d(nWEIV-DIV)}$   | Delay time, gpmc_wen invalid to gpmc_ad[15:0] invalid    | E - 2 <sup>(5)</sup>  | E + 4 <sup>(5)</sup>  | ns   |
| GNF5  | $t_{d(nWEIV-CLEIV)}$ | Delay time, gpmc_wen invalid to gpmc_ben[1:0] invalid    | F - 2 <sup>(6)</sup>  | F + 4 <sup>(6)</sup>  | ns   |
| GNF6  | $t_{d(nWEIV-nCSIV)}$ | Delay time, gpmc_wen invalid to gpmc_cs[7:0] invalid     | G - 2 <sup>(7)</sup>  | G + 4 <sup>(7)</sup>  | ns   |
| GNF7  | $t_{d(ALEH-nWEV)}$   | Delay time, gpmc_advn_ale high to gpmc_wen valid         | C - 2 <sup>(3)</sup>  | C + 4 <sup>(3)</sup>  | ns   |
| GNF8  | $t_{d(nWEIV-ALEIV)}$ | Delay time, gpmc_wen invalid to gpmc_advn_ale invalid    | F - 2 <sup>(6)</sup>  | F + 4 <sup>(6)</sup>  | ns   |
| GNF9  | $t_{c(nWE)}$         | Cycle time, write cycle time                             |                       | H <sup>(8)</sup>      | ns   |
| GNF10 | $t_{d(nCSV-nOEIV)}$  | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren valid     | I - 2 <sup>(9)</sup>  | I + 4 <sup>(9)</sup>  | ns   |
| GNF13 | $t_{w(nOEIV)}$       | Pulse duration, gpmc_oen_ren valid time                  |                       | K <sup>(10)</sup>     | ns   |
| GNF14 | $t_{c(nOE)}$         | Cycle time, read cycle time                              |                       | L <sup>(11)</sup>     | ns   |
| GNF15 | $t_{d(nOEIV-nCSIV)}$ | Delay time, gpmc_oen_ren invalid to gpmc_cs[7:0] invalid | M - 2 <sup>(12)</sup> | M + 4 <sup>(12)</sup> | ns   |

$$(1) A = (\text{WEOffTime} - \text{WEOntime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC\_FCLK}$$

$$(2) B = ((\text{WEOntime} - \text{CSOnTime}) \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{WEEExtraDelay} - \text{CSEExtraDelay})) \times \text{GPMC\_FCLK}$$

$$(3) C = ((\text{WEOntime} - \text{ADVOnTime}) \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{WEEExtraDelay} - \text{ADVExtraDelay})) \times \text{GPMC\_FCLK}$$

$$(4) D = (\text{WEOntime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC\_FCLK}$$

$$(5) E = (\text{WrCycleTime} - \text{WEOffTime} \times (\text{TimeParaGranularity} + 1) - 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC\_FCLK}$$

$$(6) F = (\text{ADVWrOffTime} - \text{WEOffTime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{ADVExtraDelay} - \text{WEEExtraDelay})) \times \text{GPMC\_FCLK}$$

$$(7) G = (\text{CSWrOffTime} - \text{WEOffTime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{CSEExtraDelay} - \text{WEEExtraDelay})) \times \text{GPMC\_FCLK}$$

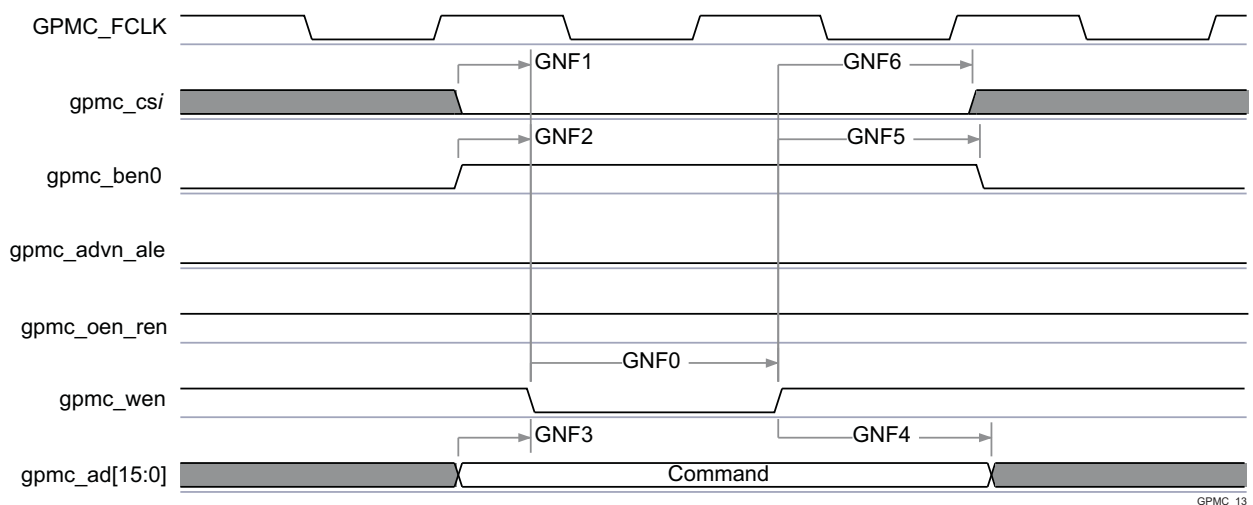
$$(8) H = \text{WrCycleTime} \times (1 + \text{TimeParaGranularity}) \times \text{GPMC\_FCLK}$$

$$(9) I = ((\text{OEOffTime} + (n - 1) \times \text{PageBurstAccessTime} - \text{CSOnTime}) \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{OEEExtraDelay} - \text{CSEExtraDelay})) \times \text{GPMC\_FCLK}$$

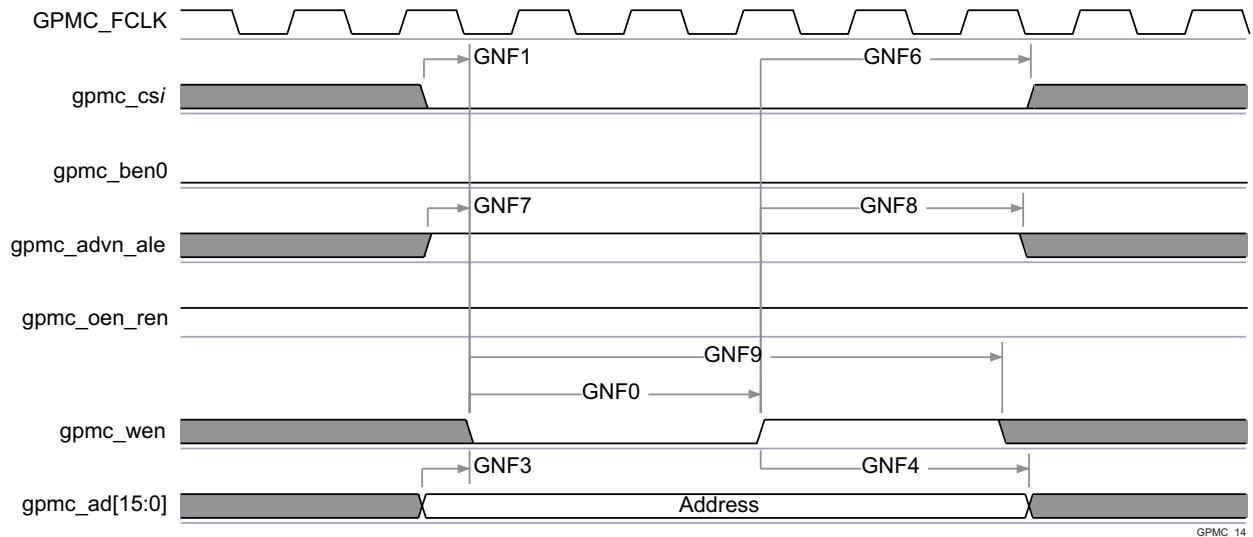
$$(10) K = (\text{OEOffTime} - \text{OEOnTime}) \times (1 + \text{TimeParaGranularity}) \times \text{GPMC\_FCLK}$$

$$(11) L = \text{RdCycleTime} \times (1 + \text{TimeParaGranularity}) \times \text{GPMC\_FCLK}$$

$$(12) M = (\text{CSRdOffTime} - \text{OEOffTime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{CSEExtraDelay} - \text{OEEExtraDelay})) \times \text{GPMC\_FCLK}$$

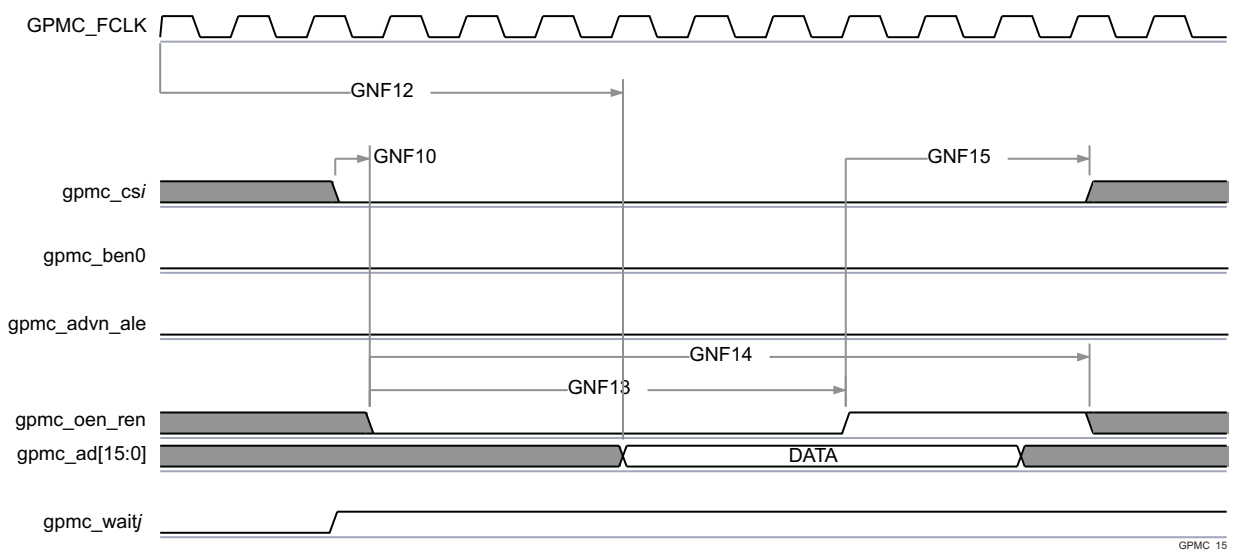
**Figure 5-40. GPMC / NAND Flash - Command Latch Cycle Timing<sup>(1)</sup>**

(1) In gpmc\_csi, i = 0 to 7.



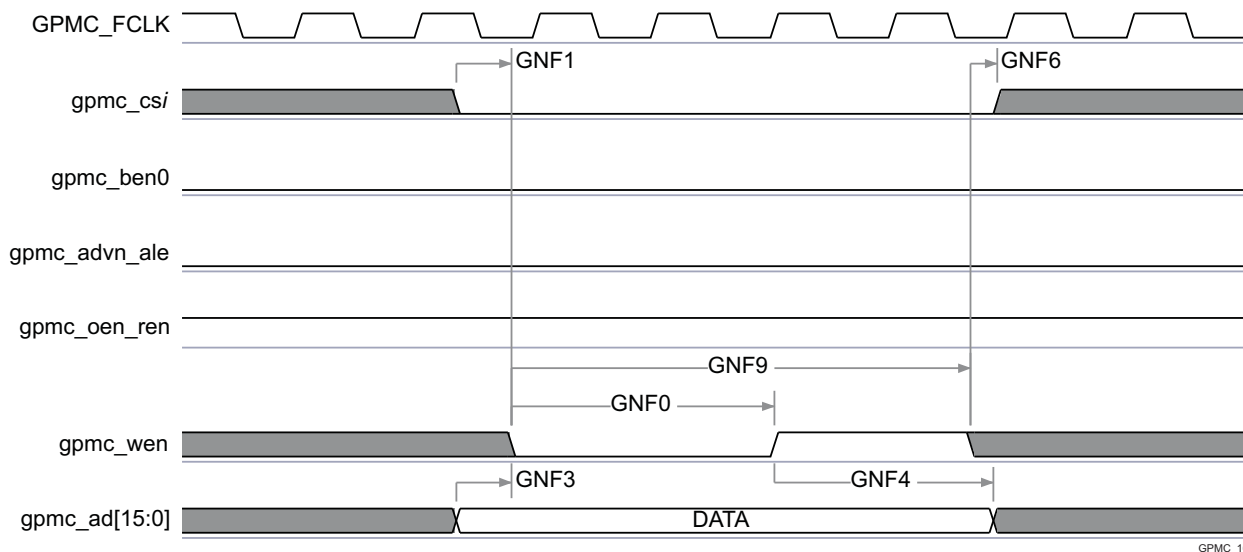
**Figure 5-41. GPMC / NAND Flash - Address Latch Cycle Timing<sup>(1)</sup>**

(1) In gpmc\_csi, i = 0 to 7.



**Figure 5-42. GPMC / NAND Flash - Data Read Cycle Timing<sup>(1)(2)(3)</sup>**

- (1) GNF12 parameter illustrates amount of time required to internally sample input Data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after GNF12 functional clock cycles, input data will be internally sampled by active functional clock edge. GNF12 value must be stored inside AccessTime register bits field.
- (2) GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.
- (3) In gpmc\_csi, i = 0 to 7. In gpmc\_waitj, j = 0 to 1.



**Figure 5-43. GPMC / NAND Flash - Data Write Cycle Timing<sup>(1)</sup>**

(1) In gpmc\_csi, i = 0 to 7.

#### NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bitfield for each corresponding pad control register.

The pad control registers are presented in [Table 4-29](#) and described in Device TRM, *Chapter 18 - Control Module*.

Virtual IO Timings Modes must be used to guarantee some IO timings for GPMC. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 5-62, Virtual Functions Mapping for GPMC](#) for a definition of the Virtual modes.

[Table 5-62](#) presents the values for DELAYMODE bitfield.

Table 5-62. Virtual Functions Mapping for GPMC

| BALL | BALL NAME | Delay Mode Value | MUXMODE[15:0] |   |   |   |         |   |                   |                   |
|------|-----------|------------------|---------------|---|---|---|---------|---|-------------------|-------------------|
|      |           | GPMC_VIRTUAL1    | 0             | 1 | 2 | 3 | 5       | 6 | 14 <sup>(1)</sup> | 14 <sup>(1)</sup> |
| M6   | gpmc_ad0  | 11               | gpmc_ad0      |   |   |   |         |   |                   |                   |
| M2   | gpmc_ad1  | 11               | gpmc_ad1      |   |   |   |         |   |                   |                   |
| L5   | gpmc_ad2  | 11               | gpmc_ad2      |   |   |   |         |   |                   |                   |
| M1   | gpmc_ad3  | 11               | gpmc_ad3      |   |   |   |         |   |                   |                   |
| L6   | gpmc_ad4  | 11               | gpmc_ad4      |   |   |   |         |   |                   |                   |
| L4   | gpmc_ad5  | 11               | gpmc_ad5      |   |   |   |         |   |                   |                   |
| L3   | gpmc_ad6  | 11               | gpmc_ad6      |   |   |   |         |   |                   |                   |
| L2   | gpmc_ad7  | 11               | gpmc_ad7      |   |   |   |         |   |                   |                   |
| L1   | gpmc_ad8  | 11               | gpmc_ad8      |   |   |   |         |   |                   |                   |
| K2   | gpmc_ad9  | 11               | gpmc_ad9      |   |   |   |         |   |                   |                   |
| J1   | gpmc_ad10 | 11               | gpmc_ad10     |   |   |   |         |   |                   |                   |
| J2   | gpmc_ad11 | 11               | gpmc_ad11     |   |   |   |         |   |                   |                   |
| H1   | gpmc_ad12 | 11               | gpmc_ad12     |   |   |   |         |   |                   |                   |
| J3   | gpmc_ad13 | 11               | gpmc_ad13     |   |   |   |         |   |                   |                   |
| H2   | gpmc_ad14 | 11               | gpmc_ad14     |   |   |   |         |   |                   |                   |
| H3   | gpmc_ad15 | 11               | gpmc_ad15     |   |   |   |         |   |                   |                   |
| R6   | gpmc_a0   | 11               | gpmc_a0       |   |   |   |         |   | gpmc_a26          | gpmc_a16          |
| T9   | gpmc_a1   | 11               | gpmc_a1       |   |   |   |         |   |                   |                   |
| T6   | gpmc_a2   | 11               | gpmc_a2       |   |   |   |         |   |                   |                   |
| T7   | gpmc_a3   | 10               | gpmc_a3       |   |   |   |         |   |                   |                   |
| P6   | gpmc_a4   | 10               | gpmc_a4       |   |   |   |         |   |                   |                   |
| R9   | gpmc_a5   | 11               | gpmc_a5       |   |   |   |         |   |                   |                   |
| R5   | gpmc_a6   | 11               | gpmc_a6       |   |   |   |         |   |                   |                   |
| P5   | gpmc_a7   | 11               | gpmc_a7       |   |   |   |         |   |                   |                   |
| N7   | gpmc_a8   | 12               | gpmc_a8       |   |   |   |         |   |                   |                   |
| R4   | gpmc_a9   | 12               | gpmc_a9       |   |   |   |         |   |                   |                   |
| N9   | gpmc_a10  | 12               | gpmc_a10      |   |   |   |         |   |                   |                   |
| P9   | gpmc_a11  | 11               | gpmc_a11      |   |   |   |         |   |                   |                   |
| P4   | gpmc_a12  | 13               | gpmc_a12      |   |   |   | gpmc_a0 |   |                   |                   |
| R3   | gpmc_a13  | 12               | gpmc_a13      |   |   |   |         |   |                   |                   |
| T2   | gpmc_a14  | 12               | gpmc_a14      |   |   |   |         |   |                   |                   |
| U2   | gpmc_a15  | 12               | gpmc_a15      |   |   |   |         |   |                   |                   |

Table 5-62. Virtual Functions Mapping for GPMC (continued)

| BALL | BALL NAME      | Delay Mode Value | MUXMODE[15:0]  |          |          |            |          |          |                   |                   |
|------|----------------|------------------|----------------|----------|----------|------------|----------|----------|-------------------|-------------------|
|      |                | GPMC_VIRTUAL1    | 0              | 1        | 2        | 3          | 5        | 6        | 14 <sup>(1)</sup> | 14 <sup>(1)</sup> |
| U1   | gpmc_a16       | 12               | gpmc_a16       |          |          |            |          |          |                   |                   |
| P3   | gpmc_a17       | 12               | gpmc_a17       |          |          |            |          |          |                   |                   |
| R2   | gpmc_a18       | 12               | gpmc_a18       |          |          |            |          |          |                   |                   |
| K7   | gpmc_a19       | 11               | gpmc_a19       |          | gpmc_a13 |            |          |          |                   |                   |
| M7   | gpmc_a20       | 11               | gpmc_a20       |          | gpmc_a14 |            |          |          |                   |                   |
| J5   | gpmc_a21       | 11               | gpmc_a21       |          | gpmc_a15 |            |          |          |                   |                   |
| K6   | gpmc_a22       | 11               | gpmc_a22       |          | gpmc_a16 |            |          |          |                   |                   |
| J7   | gpmc_a23       | 11               | gpmc_a23       |          | gpmc_a17 |            |          |          |                   |                   |
| J4   | gpmc_a24       | 11               | gpmc_a24       |          | gpmc_a18 |            |          |          |                   |                   |
| J6   | gpmc_a25       | 11               | gpmc_a25       |          | gpmc_a19 |            |          |          |                   |                   |
| H4   | gpmc_a26       | 11               | gpmc_a26       |          | gpmc_a20 |            |          |          |                   |                   |
| H5   | gpmc_a27       | 11               | gpmc_a27       |          | gpmc_a21 |            |          |          |                   |                   |
| H6   | gpmc_cs1       | 11               | gpmc_cs1       |          | gpmc_a22 |            |          |          |                   |                   |
| T1   | gpmc_cs0       | 14               | gpmc_cs0       |          |          |            |          |          |                   |                   |
| P2   | gpmc_cs2       | 12               | gpmc_cs2       |          |          |            |          |          | gpmc_a23          | gpmc_a13          |
| P1   | gpmc_cs3       | 10               | gpmc_cs3       |          |          |            | gpmc_a1  |          | gpmc_a24          | gpmc_a14          |
| P7   | gpmc_clk       | 12               | gpmc_clk       | gpmc_cs7 |          | gpmc_wait1 |          |          | gpmc_a20          |                   |
| N1   | gpmc_adv_n_ale | 13               | gpmc_adv_n_ale | gpmc_cs6 |          | gpmc_wait1 | gpmc_a2  | gpmc_a23 | gpmc_a19          |                   |
| M5   | gpmc_oen_ren   | 14               | gpmc_oen_ren   |          |          |            |          |          |                   |                   |
| M3   | gpmc_wen       | 14               | gpmc_wen       |          |          |            |          |          |                   |                   |
| N6   | gpmc_ben0      | 11               | gpmc_ben0      | gpmc_cs4 |          |            |          |          | gpmc_a21          |                   |
| M4   | gpmc_ben1      | 11               | gpmc_ben1      | gpmc_cs5 |          |            | gpmc_a3  |          | gpmc_a22          |                   |
| N2   | gpmc_wait0     | 14               | gpmc_wait0     |          |          |            |          |          | gpmc_a25          | gpmc_a15          |
| E1   | vin2a_clk0     | 11               |                |          |          |            |          |          | gpmc_a27          | gpmc_a17          |
| H7   | vin2a_fld0     | 11               |                |          |          |            |          |          | gpmc_a27          | gpmc_a18          |
| G1   | vin2a_hsync0   | 9                |                |          |          |            |          |          | gpmc_a27          |                   |
| F5   | vin2a_d8       | 9                |                |          |          |            |          |          | gpmc_a26          |                   |
| E6   | vin2a_d9       | 9                |                |          |          |            |          |          | gpmc_a25          |                   |
| D3   | vin2a_d10      | 9                |                |          |          |            |          |          | gpmc_a24          |                   |
| F6   | vin2a_d11      | 9                |                |          |          |            |          |          | gpmc_a23          |                   |
| F6   | vin2a_d11      | 9                |                |          |          |            |          |          | gpmc_a23          |                   |
| AG5  | vin1a_d11      | 9                |                |          |          |            | gpmc_a23 |          |                   |                   |

Table 5-62. Virtual Functions Mapping for GPMC (continued)

| BALL | BALL NAME | Delay Mode Value | MUXMODE[15:0] |   |   |   |          |   |                   |                   |
|------|-----------|------------------|---------------|---|---|---|----------|---|-------------------|-------------------|
|      |           | GPMC_VIRTUAL1    | 0             | 1 | 2 | 3 | 5        | 6 | 14 <sup>(1)</sup> | 14 <sup>(1)</sup> |
| AF2  | vin1a_d12 | 9                |               |   |   |   | gpmc_a24 |   |                   |                   |
| AF6  | vin1a_d13 | 9                |               |   |   |   | gpmc_a25 |   |                   |                   |
| AF3  | vin1a_d14 | 9                |               |   |   |   | gpmc_a26 |   |                   |                   |
| AF4  | vin1a_d15 | 9                |               |   |   |   | gpmc_a27 |   |                   |                   |

(1) Some signals listed are virtual functions that present alternate multiplexing options. These virtual functions are controlled via CTRL\_CORE\_ALT\_SELECT\_MUX or CTRL\_CORE\_VIP\_MUX\_SELECT registers. For more information on how to use these options, please refer to Device TRM, chapter Control Module, section Pad Configuration Registers.

#### 5.10.6.8 Timers

The device has 16 general-purpose (GP) timers (TIMER1 - TIMER16), two watchdog timers, and a 32-kHz synchronized timer (COUNTER\_32K) that have the following features:

- Dedicated input trigger for capture mode and dedicated output trigger/pulse width modulation (PWM) signal
- Interrupts generated on overflow, compare, and capture
- Free-running 32-bit upward counter
- Supported modes:
  - Compare and capture modes
  - Auto-reload mode
  - Start-stop mode
- On-the-fly read/write register (while counting)

The device has two system watchdog timer (WD\_TIMER1 and WD\_TIMER2) that have the following features:

- Free-running 32-bit upward counter
- On-the-fly read/write register (while counting)
- Reset upon occurrence of a timer overflow condition

The device includes one instance of the 32-bit watchdog timer: WD\_TIMER2, also called the MPU watchdog timer.

The watchdog timer is used to provide a recovery mechanism for the device in the event of a fault condition, such as a non-exiting code loop.

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#### NOTE

For additional information on the Timer Module, see the Device TRM.

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#### 5.10.6.9 I2C

The device includes 5 inter-integrated circuit (I2C) modules which provide an interface to other devices compliant with Philips Semiconductors Inter-IC bus (I2C-bus™) specification version 2.1. External components attached to this 2-wire serial bus can transmit/receive 8-bit data to/from the device through the I2C module.

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#### NOTE

Note that, on I2C1 and I2C2, due to characteristics of the open drain IO cells, HS mode is not supported

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#### NOTE

Inter-integrated circuit i (i=1 to 5) module is also referred to as I2Ci

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#### NOTE

For more information, see the Multimaster High-Speed I2C Controller section of the Device TRM.

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Table 5-63, Table 5-64 and Figure 5-44 assume testing over the recommended operating conditions and electrical characteristic conditions below.

**Table 5-63. Timing Requirements for I2C Input Timings<sup>(1)</sup>**

| NO. | PARAMETER            | DESCRIPTION                                                                   | STANDARD MODE    |                     | FAST MODE                    |                    | UNIT |
|-----|----------------------|-------------------------------------------------------------------------------|------------------|---------------------|------------------------------|--------------------|------|
|     |                      |                                                                               | MIN              | MAX                 | MIN                          | MAX                |      |
| I1  | $t_{c(SCL)}$         | Cycle time, SCL                                                               | 10               |                     | 2.5                          |                    | μs   |
| I2  | $t_{su(SCLH-SDAL)}$  | Setup time, SCL high before SDA low (for a repeated START condition)          | 4.7              |                     | 0.6                          |                    | μs   |
| I3  | $t_{h(SDAL-SCLL)}$   | Hold time, SCL low after SDA low (for a START and a repeated START condition) | 4                |                     | 0.6                          |                    | μs   |
| I4  | $t_{w(SCLL)}$        | Pulse duration, SCL low                                                       | 4.7              |                     | 1.3                          |                    | μs   |
| I5  | $t_{w(SCLH)}$        | Pulse duration, SCL high                                                      | 4                |                     | 0.6                          |                    | μs   |
| I6  | $t_{su(SDAV-SCLH)}$  | Setup time, SDA valid before SCL high                                         | 250              |                     | 100 <sup>(2)</sup>           |                    | ns   |
| I7  | $t_{h(SCLL-SDAV)}$   | Hold time, SDA valid after SCL low                                            | 0 <sup>(3)</sup> | 3.45 <sup>(4)</sup> | 0 <sup>(3)</sup>             | 0.9 <sup>(4)</sup> | μs   |
| I8  | $t_{w(SDAH)}$        | Pulse duration, SDA high between STOP and START conditions                    | 4.7              |                     | 1.3                          |                    | μs   |
| I9  | $t_{r(SDA)}$         | Rise time, SDA                                                                |                  | 1000                | $20 + 0.1C_b$ <sup>(5)</sup> | 300 <sup>(3)</sup> | ns   |
| I10 | $t_{r(SCL)}$         | Rise time, SCL                                                                |                  | 1000                | $20 + 0.1C_b$ <sup>(5)</sup> | 300 <sup>(3)</sup> | ns   |
| I11 | $t_{f(SDA)}$         | Fall time, SDA                                                                |                  | 300                 | $20 + 0.1C_b$ <sup>(5)</sup> | 300 <sup>(3)</sup> | ns   |
| I12 | $t_{f(SCL)}$         | Fall time, SCL                                                                |                  | 300                 | $20 + 0.1C_b$ <sup>(5)</sup> | 300 <sup>(3)</sup> | ns   |
| I13 | $t_{su(SCLH-SDAH)}$  | Setup time, SCL high before SDA high (for STOP condition)                     | 4                |                     | 0.6                          |                    | μs   |
| I14 | $t_{w(SP)}$          | Pulse duration, spike (must be suppressed)                                    |                  |                     | 0                            | 50                 | ns   |
| I15 | $C_B$ <sup>(5)</sup> | Capacitive load for each bus line                                             |                  | 400                 |                              | 400                | pF   |

- (1) The I2C pins SDA and SCL do not feature fail-safe I/O buffers. These pins could potentially draw current when the device is powered down.
- (2) A Fast-mode I<sup>2</sup>C-bus™ device can be used in a Standard-mode I<sup>2</sup>C-bus system, but the requirement  $t_{su(SDA-SCLH)} \geq 250$  ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line  $t_r \max + t_{su(SDA-SCLH)} = 1000 + 250 = 1250$  ns (according to the Standard-mode I<sup>2</sup>C-Bus Specification) before the SCL line is released.
- (3) A device must internally provide a hold time of at least 300 ns for the SDA signal (referred to the  $V_{IHmin}$  of the SCL signal) to bridge the undefined region of the falling edge of SCL.
- (4) The maximum  $t_{h(SDA-SCLL)}$  has only to be met if the device does not stretch the low period [ $t_{w(SCLL)}$ ] of the SCL signal.
- (5)  $C_B$  = total capacitance of one bus line in pF. If mixed with HS-mode devices, faster fall-times are allowed.

**Table 5-64. Timing Requirements for I<sup>2</sup>C HS-Mode (I<sup>2</sup>C3/4/5 Only)<sup>(1)</sup>**

| NO. | PARAMETER           | DESCRIPTION                                                           | $C_b = 100$ pF MAX |     | $C_b = 400$ pF <sup>(2)</sup> |     | UNIT |
|-----|---------------------|-----------------------------------------------------------------------|--------------------|-----|-------------------------------|-----|------|
|     |                     |                                                                       | MIN                | MAX | MIN                           | MAX |      |
| I1  | $t_{c(SCL)}$        | Cycle time, SCL                                                       | 0.294              |     | 0.588                         |     | μs   |
| I2  | $t_{su(SCLH-SDAL)}$ | Set-up time, SCL high before SDA low (for a repeated START condition) | 160                |     | 160                           |     | ns   |
| I3  | $t_{h(SDAL-SCLL)}$  | Hold time, SCL low after SDA low (for a repeated START condition)     | 160                |     | 160                           |     | ns   |
| I4  | $t_{w(SCLL)}$       | LOW period of the SCLH clock                                          | 160                |     | 320                           |     | ns   |
| I5  | $t_{w(SCLH)}$       | HIGH period of the SCLH clock                                         | 60                 |     | 120                           |     | ns   |
| I6  | $t_{su(SDAV-SCLH)}$ | Setup time, SDA valid before SCL high                                 | 10                 |     | 10                            |     | ns   |
| I7  | $t_{h(SCLL-SDAV)}$  | Hold time, SDA valid after SCL low                                    | 0 <sup>(3)</sup>   | 70  | 0 <sup>(3)</sup>              | 150 | ns   |
| I13 | $t_{su(SCLH-SDAH)}$ | Setup time, SCL high before SDA high (for a STOP condition)           | 160                |     | 160                           |     | ns   |

**Table 5-64. Timing Requirements for I<sup>2</sup>C HS-Mode (I<sup>2</sup>C3/4/5 Only)<sup>(1)</sup> (continued)**

| NO. | PARAMETER                     | DESCRIPTION                                             | C <sub>b</sub> = 100 pF MAX |     | C <sub>b</sub> = 400 pF <sup>(2)</sup> |     | UNIT |
|-----|-------------------------------|---------------------------------------------------------|-----------------------------|-----|----------------------------------------|-----|------|
|     |                               |                                                         | MIN                         | MAX | MIN                                    | MAX |      |
| I14 | t <sub>w(SP)</sub>            | Pulse duration, spike (must be suppressed)              | 0                           | 10  | 0                                      | 10  | ns   |
| I15 | C <sub>B</sub> <sup>(2)</sup> | Capacitive load for SDAH and SCLH lines                 |                             | 100 |                                        | 400 | pF   |
| I16 | C <sub>B</sub>                | Capacitive load for SDAH + SDA line and SCLH + SCL line |                             | 400 |                                        | 400 | pF   |

(1) I<sup>2</sup>C HS-Mode is only supported on I<sup>2</sup>C3/4/5. I<sup>2</sup>C HS-Mode is not supported on I<sup>2</sup>C1/2.

(2) For bus line loads C<sub>B</sub> between 100 pF and 400 pF the timing parameters must be linearly interpolated.

(3) A device must internally provide a Data hold time to bridge the undefined part between V<sub>IH</sub> and V<sub>IL</sub> of the falling edge of the SCLH signal. An input circuit with a threshold as low as possible for the falling edge of the SCLH signal minimizes this hold time.

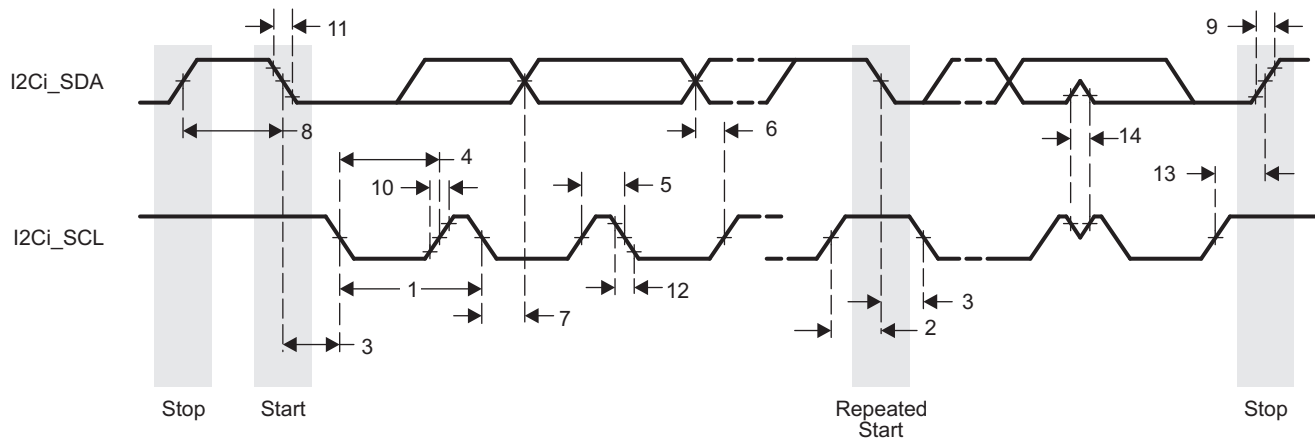
**Figure 5-44. I2C Receive Timing**

Table 5-65 and Figure 5-45 assume testing over the recommended operating conditions and electrical characteristic conditions below.

**Table 5-65. Switching Characteristics Over Recommended Operating Conditions for I2C Output Timings<sup>(2)</sup>**

| NO. | PARAMETER                  | DESCRIPTION                                                                   | STANDARD MODE |      | FAST MODE                                    |                    | UNIT |
|-----|----------------------------|-------------------------------------------------------------------------------|---------------|------|----------------------------------------------|--------------------|------|
|     |                            |                                                                               | MIN           | MAX  | MIN                                          | MAX                |      |
| I16 | t <sub>c(SCL)</sub>        | Cycle time, SCL                                                               | 10            |      | 2.5                                          |                    | μs   |
| I17 | t <sub>su(SCLH-SDAL)</sub> | Setup time, SCL high before SDA low (for a repeated START condition)          | 4.7           |      | 0.6                                          |                    | μs   |
| I18 | t <sub>h(SDAL-SCLL)</sub>  | Hold time, SCL low after SDA low (for a START and a repeated START condition) | 4             |      | 0.6                                          |                    | μs   |
| I19 | t <sub>w(SCLL)</sub>       | Pulse duration, SCL low                                                       | 4.7           |      | 1.3                                          |                    | μs   |
| I20 | t <sub>w(SCLH)</sub>       | Pulse duration, SCL high                                                      | 4             |      | 0.6                                          |                    | μs   |
| I21 | t <sub>su(SDAV-SCLH)</sub> | Setup time, SDA valid before SCL high                                         | 250           |      | 100                                          |                    | ns   |
| I22 | t <sub>h(SCLL-SDAV)</sub>  | Hold time, SDA valid after SCL low (for I2C bus devices)                      | 0             | 3.45 | 0                                            | 0.9                | μs   |
| I23 | t <sub>w(SDAH)</sub>       | Pulse duration, SDA high between STOP and START conditions                    | 4.7           |      | 1.3                                          |                    | μs   |
| I24 | t <sub>r(SDA)</sub>        | Rise time, SDA                                                                |               | 1000 | 20 + 0.1C <sub>b</sub><br><sup>(1) (3)</sup> | 300 <sup>(3)</sup> | ns   |
| I25 | t <sub>r(SCL)</sub>        | Rise time, SCL                                                                |               | 1000 | 20 + 0.1C <sub>b</sub><br><sup>(1) (3)</sup> | 300 <sup>(3)</sup> | ns   |
| I26 | t <sub>f(SDA)</sub>        | Fall time, SDA                                                                |               | 300  | 20 + 0.1C <sub>b</sub><br><sup>(1) (3)</sup> | 300 <sup>(3)</sup> | ns   |

**Table 5-65. Switching Characteristics Over Recommended Operating Conditions for I2C Output Timings<sup>(2)</sup> (continued)**

| NO. | PARAMETER           | DESCRIPTION                                               | STANDARD MODE |     | FAST MODE                |                    | UNIT |
|-----|---------------------|-----------------------------------------------------------|---------------|-----|--------------------------|--------------------|------|
|     |                     |                                                           | MIN           | MAX | MIN                      | MAX                |      |
| I27 | $t_{f(SCL)}$        | Fall time, SCL                                            |               | 300 | $20 + 0.1C_B$<br>(1) (3) | 300 <sup>(3)</sup> | ns   |
| I28 | $t_{su(SCLH-SDAH)}$ | Setup time, SCL high before SDA high (for STOP condition) | 4             |     | 0.6                      |                    | μs   |
| I29 | $C_p$               | Capacitance for each I2C pin                              |               | 10  |                          | 10                 | pF   |

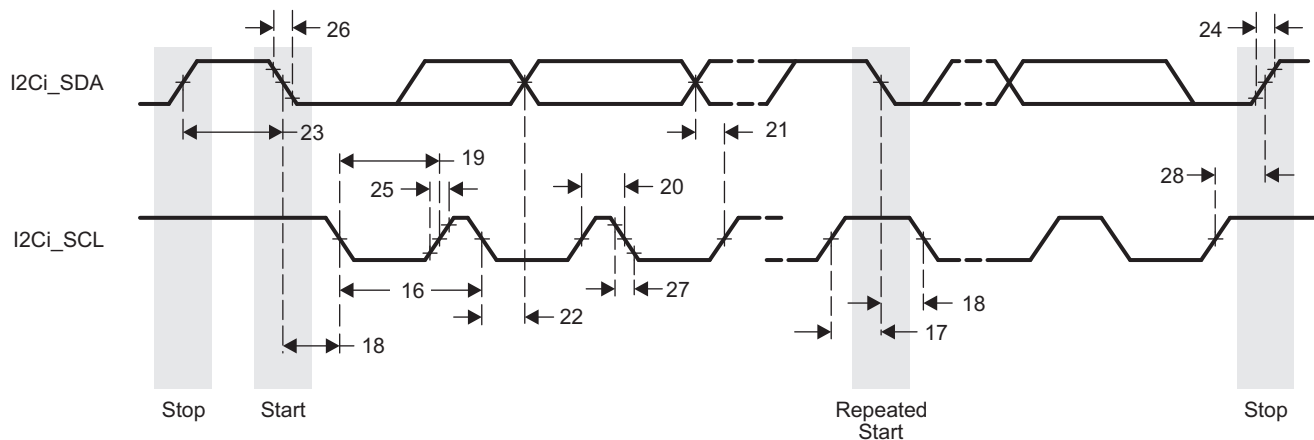
(1)  $C_B$  = total capacitance of one bus line in pF. If mixed with HS-mode devices, faster fall-times are allowed.

(2) Software must properly configure the I2C module registers to achieve the timings shown in this table. For more details, see the Device TRM.

(3) These timings apply only to I2C1 and I2C2. I2C3, I2C4, and I2C5 use standard LVCMOS buffers to emulate open-drain buffers and their rise/fall times should be referenced in the device IBIS model.

**NOTE**

I2C emulation is achieved by configuring the LVCMOS buffers to output Hi-Z instead of driving high when transmitting logic-1.



**Figure 5-45. I2C Transmit Timing**

### 5.10.6.10 UART

The UART performs serial-to-parallel conversions on data received from a peripheral device and parallel-to-serial conversion on data received from the CPU. There are 10 UART modules in the device. Only one UART supports IrDA features. Each UART can be used for configuration and data exchange with a number of external peripheral devices or interprocessor communication between devices

The UARTi (where i = 1 to 10) include the following features:

- 16C750 compatibility
- 64-byte FIFO buffer for receiver and 64-byte FIFO for transmitter
- Baud generation based on programmable divisors N (where N = 1...16 384) operating from a fixed functional clock of 48 MHz or 192 MHz
- Break character detection and generation
- Configurable data format:
  - Data bit: 5, 6, 7, or 8 bits
  - Parity bit: Even, odd, none
  - Stop-bit: 1, 1.5, 2 bit(s)
- Flow control: Hardware (RTS/CTS) or software (XON/XOFF)

- Only UART1 module has extended modem control signals (CD, RI, DTR, DSR)
- Only UART3 supports IrDA

**NOTE**

For more information, see the UART section of the Device TRM.

Table 5-66, Table 5-67 and Figure 5-46 assume testing over the recommended operating conditions and electrical characteristic conditions below.

**Table 5-66. Timing Requirements for UART**

| NO. | PARAMETER       | DESCRIPTION                                             | MIN           | MAX           | UNIT |
|-----|-----------------|---------------------------------------------------------|---------------|---------------|------|
| U1  | $t_{w(RX)}$     | Pulse width, receive data bit, 15/30/100pF high or low  | $0.96U^{(1)}$ | $1.05U^{(1)}$ | ns   |
| U2  | $t_{w(CTS)}$    | Pulse width, receive start bit, 15/30/100pF high or low | $0.96U^{(1)}$ | $1.05U^{(1)}$ | ns   |
| U3  | $t_{d(RTS-TX)}$ | Delay time, transmit start bit to transmit data         | $P^{(2)}$     |               | ns   |
| U4  | $t_{d(CTS-TX)}$ | Delay time, receive start bit to transmit data          | $P^{(2)}$     |               | ns   |

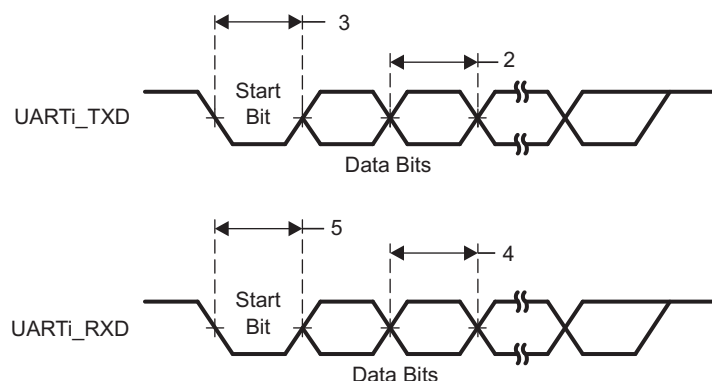
(1)  $U$  = UART baud time =  $1/\text{programmed baud rate}$

(2)  $P$  = Clock period of the reference clock (FCLK, usually 48 MHz or 192MHz).

**Table 5-67. Switching Characteristics Over Recommended Operating Conditions for UART**

| NO. | PARAMETER           | DESCRIPTION                                               | MIN           | MAX           | UNIT |
|-----|---------------------|-----------------------------------------------------------|---------------|---------------|------|
|     | $f_{(\text{baud})}$ | Maximum programmable baud rate                            |               |               |      |
|     |                     | 15 pF                                                     |               | 12            |      |
|     |                     | 30 pF                                                     |               | 0.23          | MHz  |
|     |                     | 100 pF                                                    |               | 0.115         |      |
| U5  | $t_{w(TX)}$         | Pulse width, transmit data bit, 15/30/100 pF high or low  | $U^{(1)} - 2$ | $U^{(1)} + 2$ | ns   |
| U6  | $t_{w(RTS)}$        | Pulse width, transmit start bit, 15/30/100 pF high or low | $U^{(1)} - 2$ | $U^{(1)} + 2$ | ns   |

(1)  $U$  = UART baud time =  $1/\text{programmed baud rate}$

**Figure 5-46. UART Timing****5.10.6.11 McSPI**

The McSPI is a master/slave synchronous serial bus. There are four separate McSPI modules (SPI1, SPI2, SPI3, and SPI4) in the device. All these four modules support up to four external devices (four chip selects) and are able to work as both master and slave.

The McSPI modules include the following main features:

- Serial clock with programmable frequency, polarity, and phase for each channel
- Wide selection of SPI word lengths, ranging from 4 to 32 bits
- Up to four master channels, or single channel in slave mode

- Master multichannel mode:
  - Full duplex/half duplex
  - Transmit-only/receive-only/transmit-and-receive modes
  - Flexible input/output (I/O) port controls per channel
  - Programmable clock granularity
  - SPI configuration per channel. This means, clock definition, polarity enabling and word width
- Power management through wake-up capabilities
- Programmable timing control between chip select and external clock generation
- Built-in FIFO available for a single channel.
- Each SPI module supports multiple chip select pins `spim_cs[i]`, where `i = 1` to `4`.

#### NOTE

For more information, see the Serial Communication Interface section of the Device TRM.

#### NOTE

The McSPIm module (`m = 1` to `4`) is also referred to as SPIm.

#### CAUTION

The IO timings provided in this section are applicable for all combinations of signals for SPI1 and SPI2. However, the timings are only valid for SPI3 and SPI4 if signals within a single IOSET are used. The IOSETS are defined in the [Table 5-70](#).

[Table 5-68](#), [Figure 5-47](#) and [Figure 5-48](#) present timing requirements for McSPI - Master Mode.

**Table 5-68. Timing Requirements for SPI - Master Mode <sup>(1)(8)</sup>**

| NO. | PARAMETER                    | DESCRIPTION                                                                                      | MODE                       | MIN                    | MAX  | UNIT |
|-----|------------------------------|--------------------------------------------------------------------------------------------------|----------------------------|------------------------|------|------|
| SM1 | $t_c(\text{SPICLK})$         | Cycle time, <code>spi_sclk</code> <sup>(1) (2)</sup>                                             | SPI1/2/3/4                 | 20.8 <sup>(3)</sup>    |      | ns   |
| SM2 | $t_w(\text{SPICLK})$         | Typical Pulse duration, <code>spi_sclk</code> low <sup>(1)</sup>                                 |                            | 0.5*P-1 <sup>(4)</sup> |      | ns   |
| SM3 | $t_w(\text{SPICLK})$         | Typical Pulse duration, <code>spi_sclk</code> high <sup>(1)</sup>                                |                            | 0.5*P-1 <sup>(4)</sup> |      | ns   |
| SM4 | $t_{su}(\text{MISO-SPICLK})$ | Setup time, <code>spi_d[x]</code> valid before <code>spi_sclk</code> active edge <sup>(1)</sup>  |                            | 4.4                    |      | ns   |
| SM5 | $t_h(\text{SPICLK-MISO})$    | Hold time, <code>spi_d[x]</code> valid after <code>spi_sclk</code> active edge <sup>(1)</sup>    |                            | 3.9                    |      | ns   |
| SM6 | $t_d(\text{SPICLK-SIMO})$    | Delay time, <code>spi_sclk</code> active edge to <code>spi_d[x]</code> transition <sup>(1)</sup> | SPI1                       | -4.27                  | 4.27 | ns   |
|     |                              |                                                                                                  | SPI2                       | -4.32                  | 4.32 | ns   |
|     |                              |                                                                                                  | SPI3                       | -5.37                  | 4.23 | ns   |
|     |                              |                                                                                                  | SPI4                       | -3.81                  | 4.41 | ns   |
| SM7 | $t_d(\text{CS-SIMO})$        | Delay time, <code>spi_cs[x]</code> active edge to <code>spi_d[x]</code> transition               |                            |                        | 5    | ns   |
| SM8 | $t_d(\text{CS-SPICLK})$      | Delay time, <code>spi_cs[x]</code> active to <code>spi_sclk</code> first edge <sup>(1)</sup>     | MASTER_PHA0 <sup>(5)</sup> | B-4.6 <sup>(6)</sup>   |      | ns   |
|     |                              |                                                                                                  | MASTER_PHA1 <sup>(5)</sup> | A-4.6 <sup>(7)</sup>   |      | ns   |
| SM9 | $t_d(\text{SPICLK-CS})$      | Delay time, <code>spi_sclk</code> last edge to <code>spi_cs[x]</code> inactive <sup>(1)</sup>    | MASTER_PHA0 <sup>(5)</sup> | A-4.6 <sup>(7)</sup>   |      | ns   |
|     |                              |                                                                                                  | MASTER_PHA1 <sup>(5)</sup> | B-4.6 <sup>(6)</sup>   |      | ns   |

- (1) This timing applies to all configurations regardless of SPI\_CLK polarity and which clock edges are used to drive output data and capture input data.
- (2) Related to the SPI\_CLK maximum frequency.
- (3) 20.8 ns cycle time = 48 MHz
- (4) P = SPICLK period.
- (5) SPI\_CLK phase is programmable with the PHA bit of the SPI\_CH(i)CONF register.
- (6)  $B = (TCS + 0.5) \times TSPICLKREF \times Fratio$ , where TCS is a bit field of the SPI\_CH(i)CONF register and Fratio = Even  $\geq 2$ .
- (7) When P = 20.8 ns,  $A = (TCS + 1) \times TSPICLKREF$ , where TCS is a bit field of the SPI\_CH(i)CONF register. When P > 20.8 ns,  $A = (TCS + 0.5) \times Fratio \times TSPICLKREF$ , where TCS is a bit field of the SPI\_CH(i)CONF register.
- (8) The IO timings provided in this section are applicable for all combinations of signals for spi1 and spi2. However, the timings are only valid for spi3 and spi4 if signals within a single IOSET are used. The IOSETs are defined in the following tables.

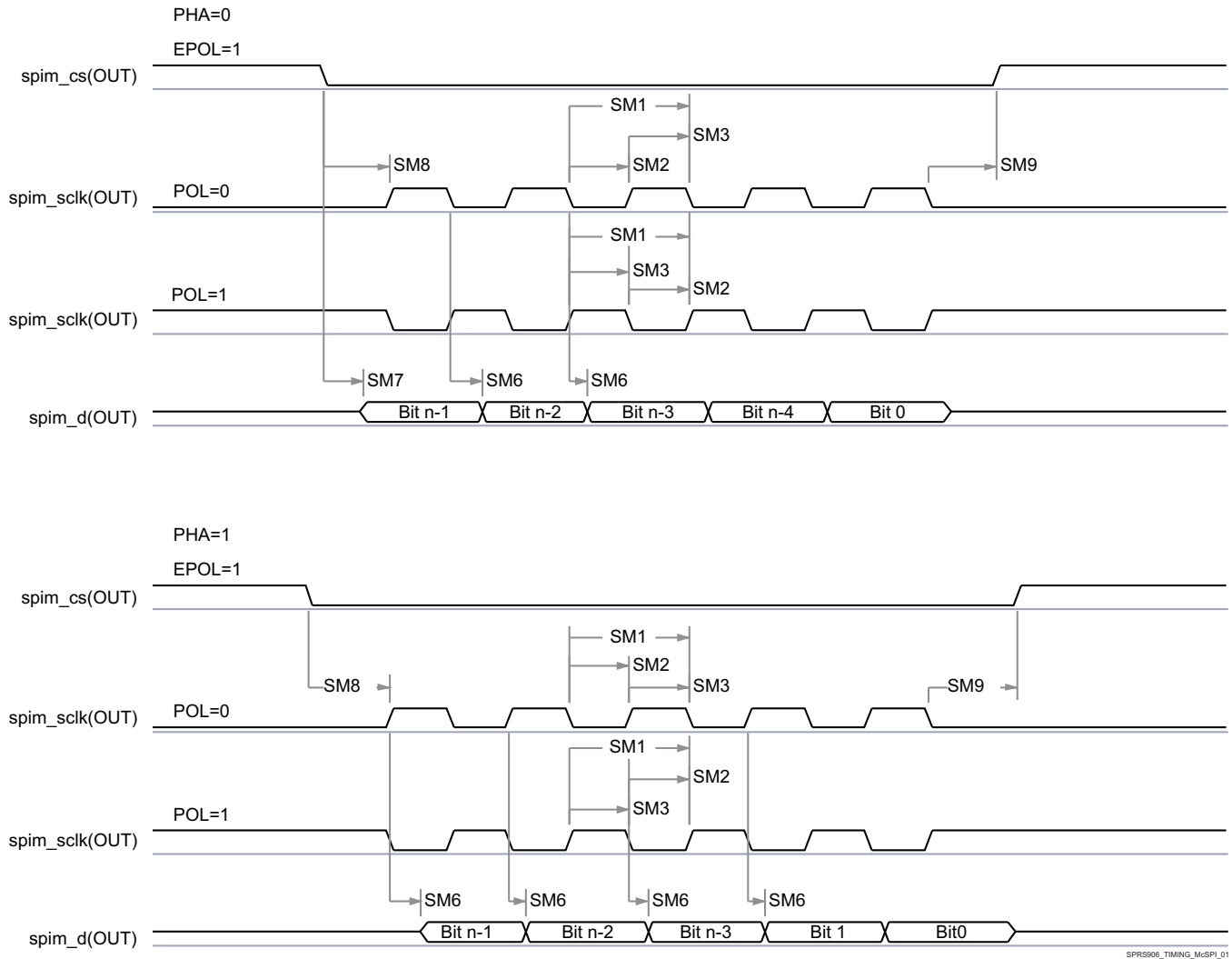
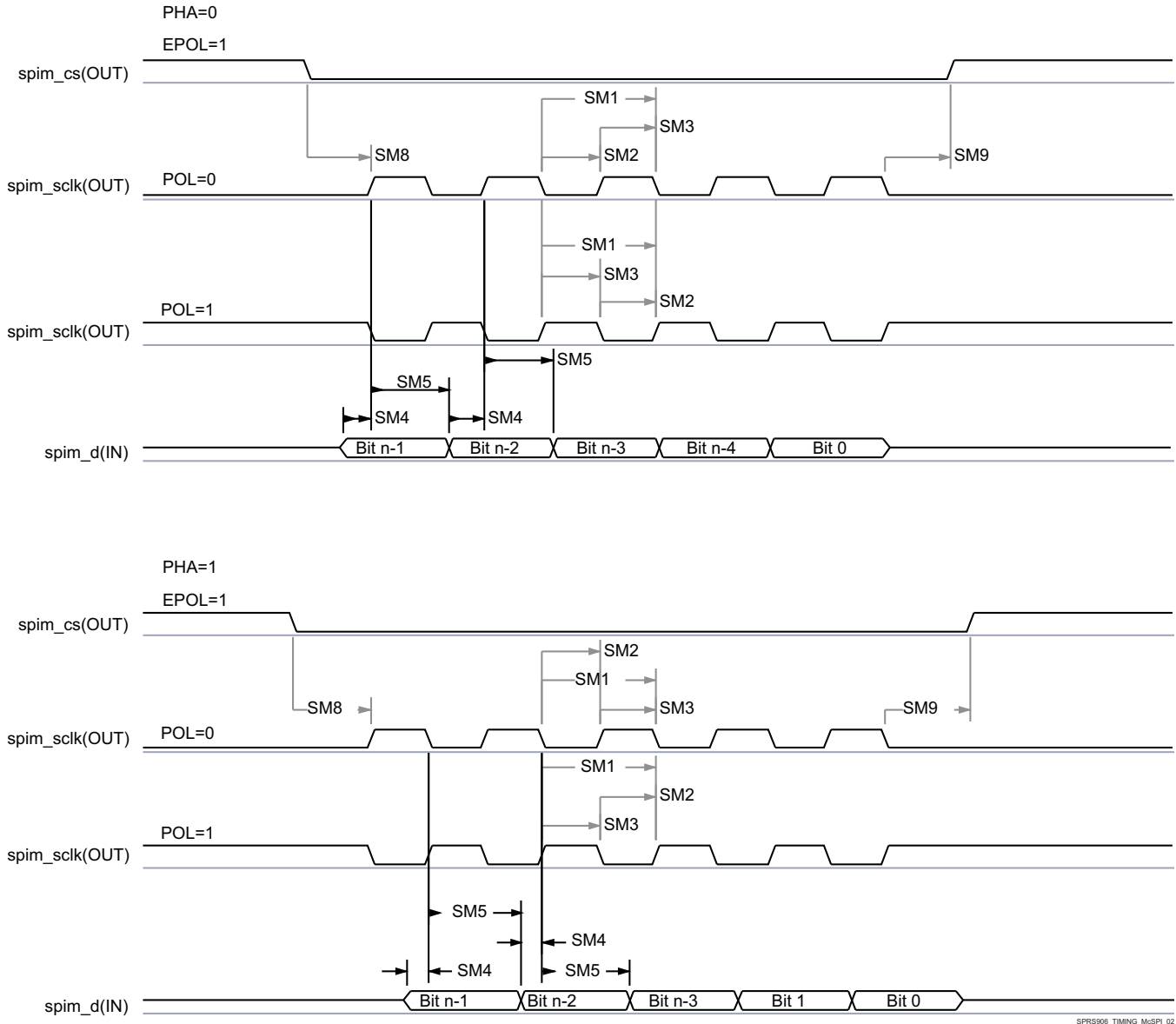


Figure 5-47. McSPI - Master Mode Transmit

SPRS990F\_TIMING\_McSPI\_01



**Figure 5-48. McSPI - Master Mode Receive**

Table 5-69, Figure 5-49 and Figure 5-50 present timing requirements for McSPI - Slave Mode.

**Table 5-69. Timing Requirements for SPI - Slave Mode<sup>(6)</sup>**

| NO.                | PARAMETER                    | DESCRIPTION                                                | MODE     | MIN                  | MAX   | UNIT |
|--------------------|------------------------------|------------------------------------------------------------|----------|----------------------|-------|------|
| SS1                | $t_c(\text{SPICLK})$         | Cycle time, spi_sclk <sup>(1) (2)</sup>                    |          | 62.5 <sup>(3)</sup>  |       | ns   |
| SS2                | $t_w(\text{SPICLK}_L)$       | Typical Pulse duration, spi_sclk low <sup>(1)</sup>        |          | 0.45P <sup>(4)</sup> |       | ns   |
| SS3                | $t_w(\text{SPICLK}_H)$       | Typical Pulse duration, spi_sclk high <sup>(1)</sup>       |          | 0.45P <sup>(4)</sup> |       | ns   |
| SS4 <sup>(1)</sup> | $t_{su}(\text{SIMO-SPICLK})$ | Setup time, spi_d[x] valid before spi_sclk active edge     |          | 5                    |       | ns   |
| SS5 <sup>(1)</sup> | $t_h(\text{SPICLK-SIMO})$    | Hold time, spi_d[x] valid after spi_sclk active edge       |          | 5                    |       | ns   |
| SS6 <sup>(1)</sup> | $t_d(\text{SPICLK-SOMI})$    | Delay time, spi_sclk active edge to mcspi_somi transition  | SPI1/2/3 | 2                    | 26.1  | ns   |
|                    |                              |                                                            | SPI4     | 2                    | 18    | ns   |
| SS7 <sup>(5)</sup> | $t_d(\text{CS-SOMI})$        | Delay time, spi_cs[x] active edge to mcspi_somi transition |          |                      | 20.95 | ns   |
| SS8 <sup>(1)</sup> | $t_{su}(\text{CS-SPICLK})$   | Setup time, spi_cs[x] valid before spi_sclk first edge     |          | 5                    |       | ns   |
| SS9 <sup>(1)</sup> | $t_h(\text{SPICLK-CS})$      | Hold time, spi_cs[x] valid after spi_sclk last edge        |          | 5                    |       | ns   |

- (1) This timing applies to all configurations regardless of SPI\_CLK polarity and which clock edges are used to drive output data and capture input data.
- (2) When operating the SPI interface in RX-only mode, the minimum Cycle time is 26 ns (38.4 MHz)
- (3) 62.5 ns Cycle time = 16 MHz
- (4) P = SPICLK period.
- (5) PHA = 0; SPI\_CLK phase is programmable with the PHA bit of the SPI\_CH(i)CONF register.
- (6) The IO timings provided in this section are applicable for all combinations of signals for spi1 and spi2. However, the timings are only valid for spi3 and spi4 if signals within a single IOSET are used. The IOSETs are defined in the following tables.

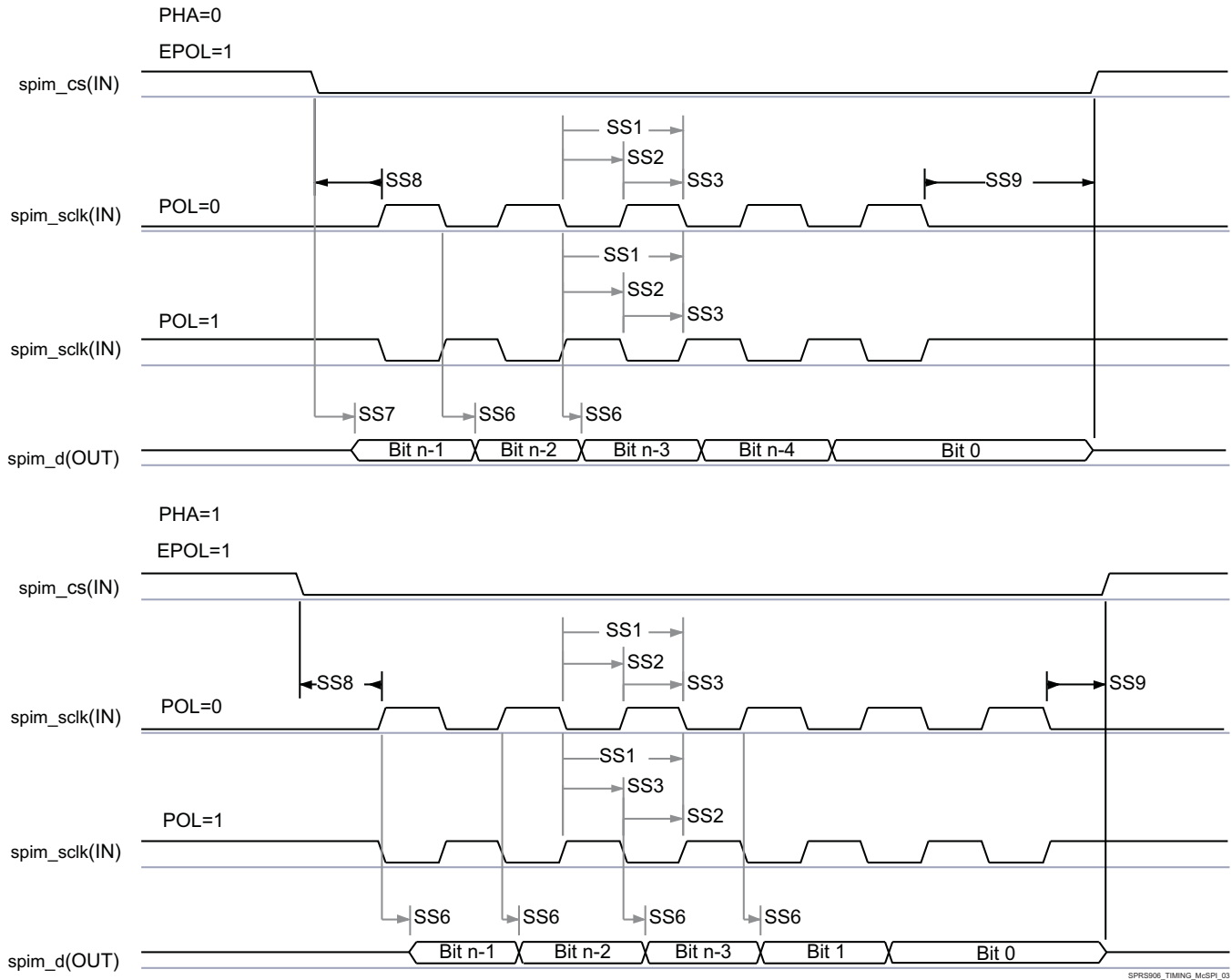


Figure 5-49. McSPI - Slave Mode Transmit

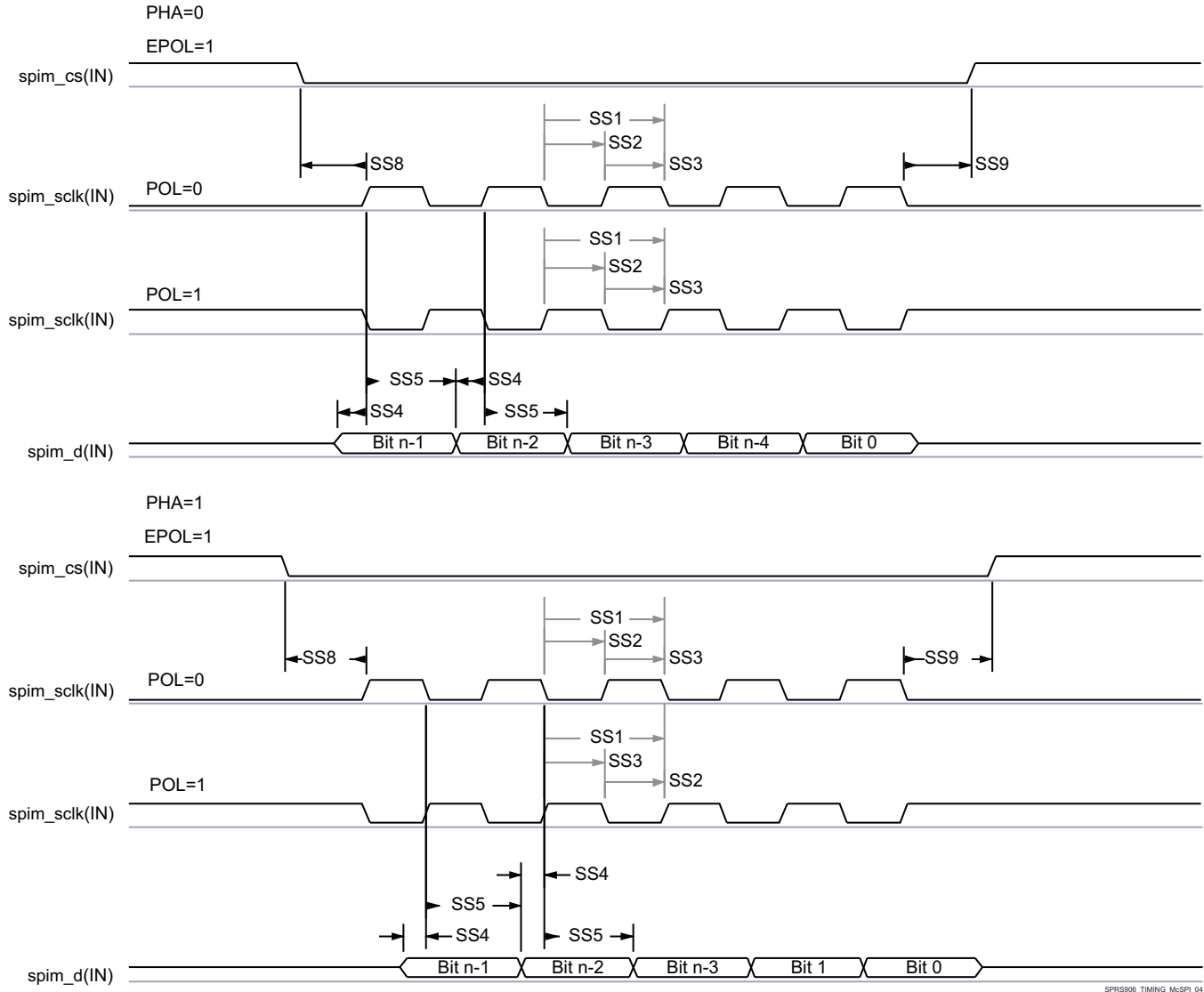


Figure 5-50. McSPI - Slave Mode Receive

In Table 5-70 are presented the specific groupings of signals (IOSET) for use with SPI3 and SPI4.

Table 5-70. McSPI3/4 IOSETs

| Signal    | IOSET1 |     | IOSET2 |     | IOSET3 |     | IOSET4 |     | IOSET5 |     | IOSET6 |     |
|-----------|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|
|           | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| SPI3      |        |     |        |     |        |     |        |     |        |     |        |     |
| spi3_sclk | AD9    | 8   | E11    | 8   | V2     | 7   | B12    | 3   | C18    | 2   | AC4    | 1   |
| spi3_d1   | AF9    | 8   | B10    | 8   | Y1     | 7   | A11    | 3   | A21    | 2   | AC7    | 1   |
| spi3_d0   | AE9    | 8   | C11    | 8   | W9     | 7   | B13    | 3   | G16    | 2   | AC6    | 1   |
| spi3_cs0  | AF8    | 8   | D11    | 8   | V9     | 7   | A12    | 3   | D17    | 2   | AC9    | 1   |
| spi3_cs1  | AC3    | 1   | B11    | 8   | AC3    | 1   | E14    | 3   | B11    | 8   | AC3    | 1   |
| spi3_cs2  | -      | -   | F11    | 8   | -      | -   | F11    | 8   | F11    | 8   | -      | -   |
| spi3_cs3  | -      | -   | A10    | 8   | -      | -   | A10    | 8   | A10    | 8   | -      | -   |
| SPI4      |        |     |        |     |        |     |        |     |        |     |        |     |
| spi4_sclk | N7     | 8   | G1     | 8   | V7     | 7   | AA3    | 2   | AC8    | 1   | -      | -   |

**Table 5-70. McSPI3/4 IOSETs (continued)**

| Signal   | IOSET1 |     | IOSET2 |     | IOSET3 |     | IOSET4 |     | IOSET5 |     | IOSET6 |     |
|----------|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|
|          | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL   | MUX |
| spi4_d1  | R4     | 8   | G6     | 8   | U7     | 7   | AB9    | 2   | AD6    | 1   | -      | -   |
| spi4_d0  | N9     | 8   | F2     | 8   | V6     | 7   | AB3    | 2   | AB8    | 1   | -      | -   |
| spi4_cs0 | P9     | 8   | F3     | 8   | U6     | 7   | AA4    | 2   | AB5    | 1   | -      | -   |
| spi4_cs1 | P4     | 8   | P4     | 8   | Y1     | 8   | Y1     | 8   | Y1     | 8   | -      | -   |
| spi4_cs2 | R3     | 8   | R3     | 8   | W9     | 8   | W9     | 8   | W9     | 8   | -      | -   |
| spi4_cs3 | T2     | 8   | T2     | 8   | V9     | 8   | V9     | 8   | V9     | 8   | -      | -   |

**5.10.6.12 QSPI**

The Quad SPI (QSPI) module is a type of SPI module that allows single, dual or quad read access to external SPI devices. This module has a memory mapped register interface, which provides a direct interface for accessing data from external SPI devices and thus simplifying software requirements. It works as a master only. There is one QSPI module in the device and it is primary intended for fast booting from quad-SPI flash memories.

General SPI features:

- Programmable clock divider
- Six pin interface (DCLK, CS\_N, DOUT, DIN, QDIN1, QDIN2)
- 4 external chip select signals
- Support for 3-, 4- or 6-pin SPI interface
- Programmable CS\_N to DOUT delay from 0 to 3 DCLKs
- Programmable signal polarities
- Programmable active clock edge
- Software controllable interface allowing for any type of SPI transfer

**NOTE**

For more information, see the Quad Serial Peripheral Interface section of the Device TRM.

**CAUTION**

The IO Timings provided in this section are only valid for some QSPI usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

**CAUTION**

The IO Timings provided in this section are only valid when all QSPI Chip Selects used in a system are configured to use the same Clock Mode (either Clock Mode 0 or Clock Mode3).

Table 5-71 and Table 5-72 present timing and switching characteristics for Quad SPI interface.

**Table 5-71. Switching Characteristics for QSPI**

| No | PARAMETER          | DESCRIPTION                                                  | Mode                                 | MIN                                    | MAX                                    | UNIT |
|----|--------------------|--------------------------------------------------------------|--------------------------------------|----------------------------------------|----------------------------------------|------|
| Q1 | $t_{c(SCLK)}$      | Cycle time, sclk                                             | Manual IO Timing Modes, Clock Mode 0 | 10.41                                  |                                        | ns   |
|    |                    |                                                              | Manual IO Timing Modes, Clock Mode 3 | 13.02                                  |                                        | ns   |
|    |                    |                                                              | Bootmode, Clock Mode 3               | 20.8                                   |                                        |      |
| Q2 | $t_{w(SCLKL)}$     | Pulse duration, sclk low                                     | All                                  | $Y \times P - 1$ <sup>(1)</sup>        |                                        | ns   |
| Q3 | $t_{w(SCLKH)}$     | Pulse duration, sclk high                                    | All                                  | $Y \times P - 1$ <sup>(1)</sup>        |                                        | ns   |
| Q4 | $t_{d(CS-SCLK)}$   | Delay time, sclk falling edge to cs active edge, CS3:0       | Manual IO Timing Modes               | $-M \times P - 1$ <sup>(2) (3)</sup>   | $-M \times P + 2$ <sup>(2) (3)</sup>   | ns   |
|    |                    |                                                              | Bootmode                             | $-M \times P - 2.5$ <sup>(2) (3)</sup> | $-M \times P + 2.5$ <sup>(2) (3)</sup> |      |
| Q5 | $t_{d(SCLK-CS)}$   | Delay time, sclk falling edge to cs inactive edge, CS3:0     | Manual IO Timing Modes               | $N \times P - 1$ <sup>(2) (3)</sup>    | $N \times P + 2$ <sup>(2) (3)</sup>    | ns   |
|    |                    |                                                              | Bootmode                             | $N \times P - 2.5$ <sup>(2) (3)</sup>  | $N \times P + 2.5$ <sup>(2) (3)</sup>  |      |
| Q6 | $t_{d(SCLK-D1)}$   | Delay time, sclk falling edge to d[0] transition             | Manual IO Timing Modes               | -1                                     | 2                                      | ns   |
|    |                    |                                                              | Bootmode                             | -2.5                                   | 2.5                                    |      |
| Q7 | $t_{ena(CS-D1LZ)}$ | Enable time, cs active edge to d[0] driven (lo-z)            | All                                  | -P-3.5                                 | -P+2.5                                 | ns   |
| Q8 | $t_{dis(CS-D1Z)}$  | Disable time, cs active edge to d[0] tri-stated (Hi-Z)       | All                                  | -P-2.5                                 | -P+2.0                                 | ns   |
| Q9 | $t_{d(SCLK-D0)}$   | Delay time, sclk first falling edge to first d[0] transition | Manual IO Timing Modes, PHA=0 Only   | -1-P                                   | 2-P                                    | ns   |
|    |                    |                                                              | Bootmode, PHA=0 Only                 | -2.5-P                                 | 2.5-P                                  |      |

(1) The Y parameter is defined as follows:

If DCLK\_DIV is 0 or ODD then, Y equals 0.5.

If DCLK\_DIV is EVEN then, Y equals  $(DCLK\_DIV/2) / (DCLK\_DIV+1)$ .

For best performance, it is recommended to use a DCLK\_DIV of 0 or ODD to minimize the duty cycle distortion. The HSDIVIDER on CLKOUTX2\_H13 output of DPLL\_PER can be used to achieve the desired clock divider ratio. All required details about clock division factor DCLK\_DIV can be found in the Device TRM.

(2) P = SCLK period.

(3) M = QSPI\_SPI\_DC\_REG.DDx + 1 when Clock Mode 0.

M = QSPI\_SPI\_DC\_REG.DDx when Clock Mode 3.

N = 2 when Clock Mode 0.

N = 3 when Clock Mode 3.

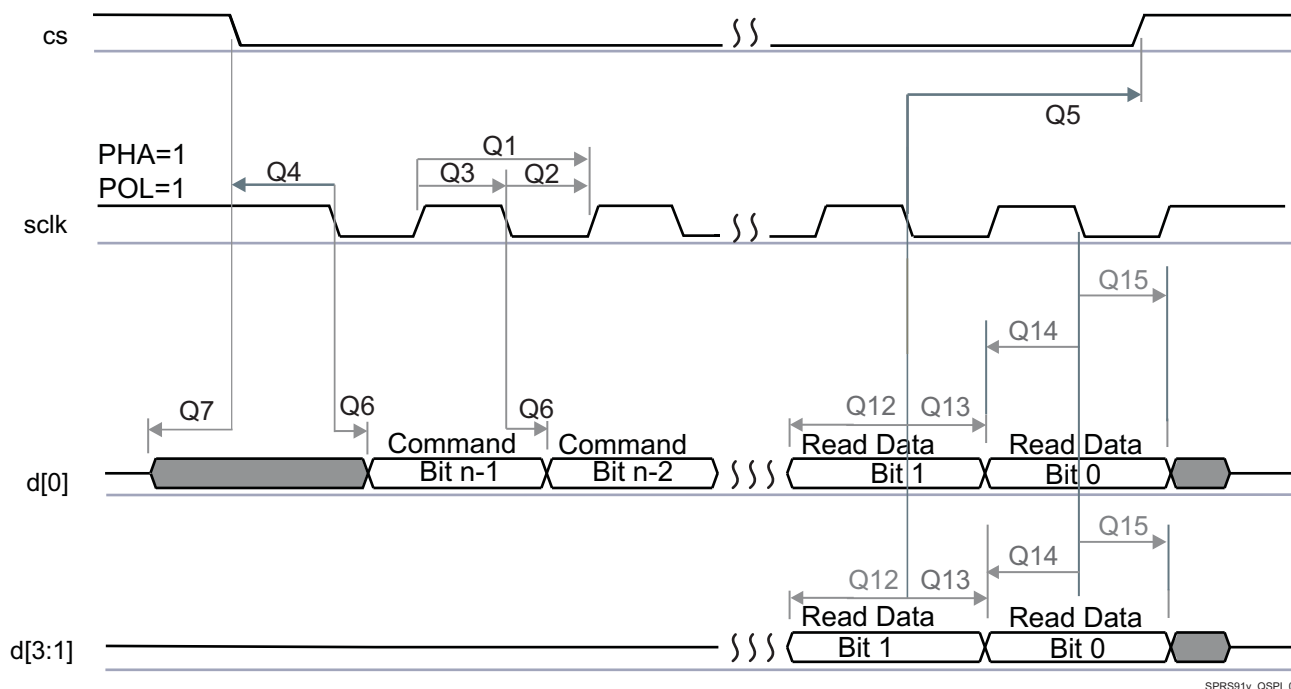


Figure 5-51. QSPI Read (Clock Mode 3)

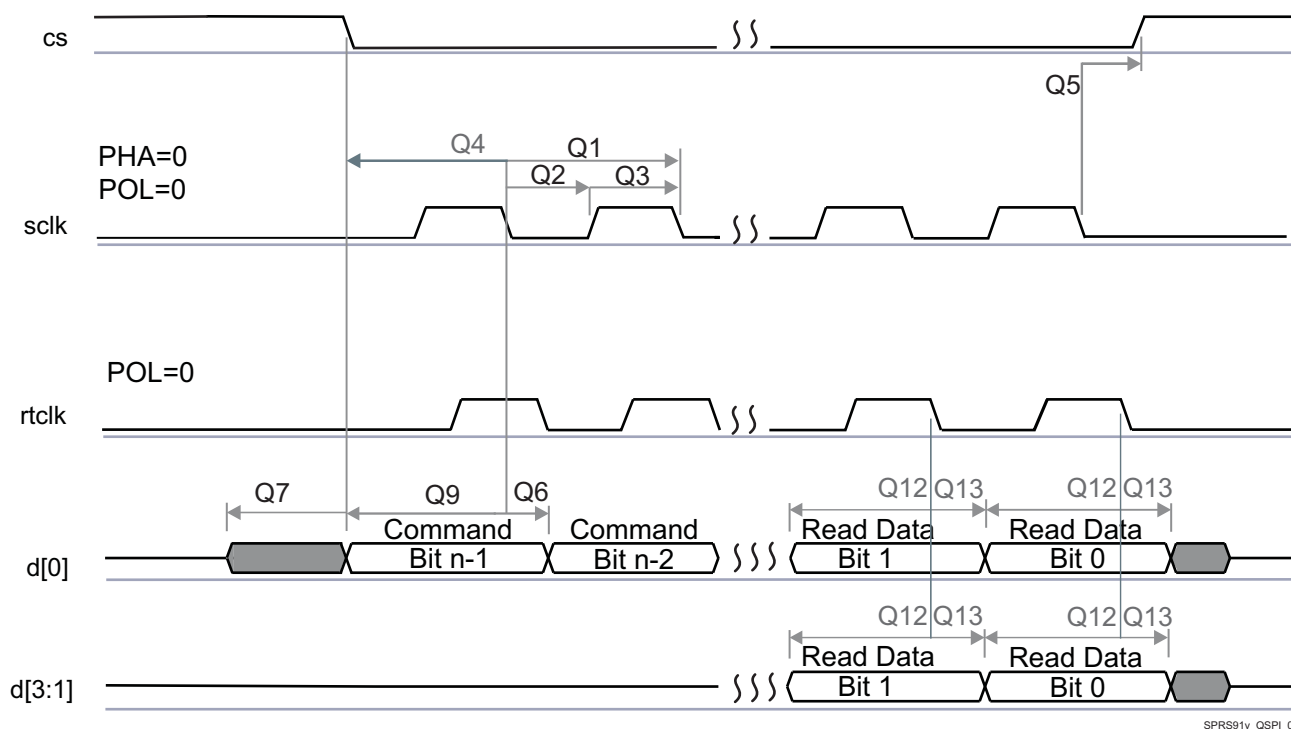


Figure 5-52. QSPI Read (Clock Mode 0)

**CAUTION**

The IO Timings provided in this section are only valid for some QSPI usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

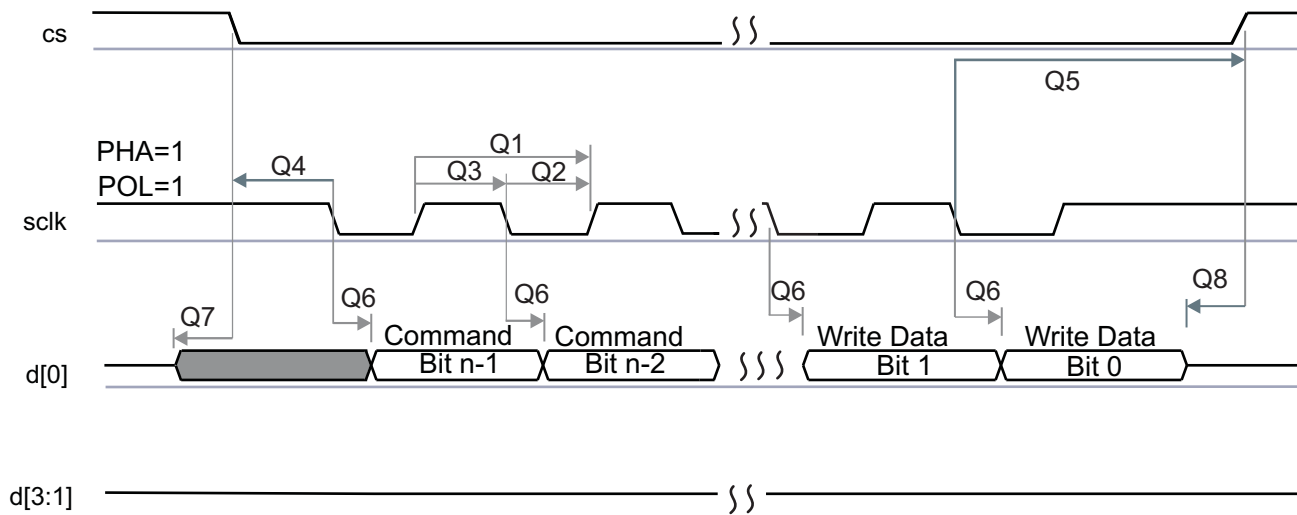
**Table 5-72. Timing Requirements for QSPI<sup>(2)(3)</sup>**

| No  | PARAMETER         | DESCRIPTION                                                       | Mode                                 | MIN                   | MAX | UNIT |
|-----|-------------------|-------------------------------------------------------------------|--------------------------------------|-----------------------|-----|------|
| Q12 | $t_{su}(D-RTCLK)$ | Setup time, d[3:0] valid before falling rtclk edge                | Manual IO Timing Modes, Clock Mode 0 | 2.9                   |     | ns   |
|     | $t_{su}(D-SCLK)$  | Setup time, d[3:0] valid before falling sclk edge                 | Manual IO Timing Modes, Clock Mode 3 | 5.7                   |     | ns   |
|     |                   |                                                                   | Boot Mode, Clock Mode 3              | 12.3                  |     | ns   |
| Q13 | $t_h(RTCLK-D)$    | Hold time, d[3:0] valid after falling rtclk edge                  | Manual IO Timing Mode, Clock Mode 0  | -0.1                  |     | ns   |
|     | $t_h(SCLK-D)$     | Hold time, d[3:0] valid after falling sclk edge                   | Manual IO Timing Mode, Clock Mode 3  | 0.1                   |     | ns   |
|     |                   |                                                                   | Boot Mode, Clock Mode 3              | 0.1                   |     | ns   |
| Q14 | $t_{su}(D-SCLK)$  | Setup time, final d[3:0] bit valid before final falling sclk edge | Manual IO Timing Mode, Clock Mode 3  | 5.7-P <sup>(1)</sup>  |     | ns   |
|     |                   |                                                                   | Boot Mode, Clock Mode 3              | 12.3-P <sup>(1)</sup> |     | ns   |
| Q15 | $t_h(SCLK-D)$     | Hold time, final d[3:0] bit valid after final falling sclk edge   | Manual IO Timing Mode, Clock Mode 3  | 0.1+P <sup>(1)</sup>  |     | ns   |
|     |                   |                                                                   | Boot Mode, Clock Mode 3              | 0.1+P <sup>(1)</sup>  |     | ns   |

(1) P = SCLK period.

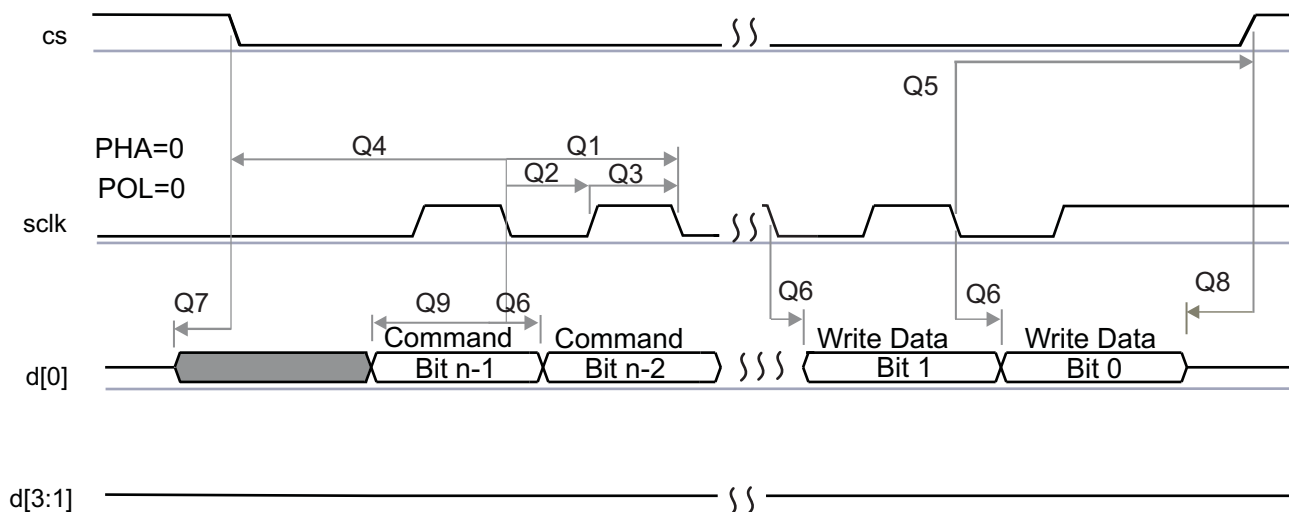
(2) Clock Modes 1 and 2 are not supported.

(3) The Device captures data on the falling clock edge in Clock Mode 0 and 3, as opposed to the traditional rising clock edge. Although non-standard, the falling-edge-based setup and hold time timings have been designed to be compatible with standard SPI devices that launch data on the falling edge in Clock Modes 0 and 3.



SPRS991v\_QSPI\_03

**Figure 5-53. QSPI Write (Clock Mode 3)**



SPRS91v\_QSPI\_04

**Figure 5-54. QSPI Write (Clock Mode 0)****NOTE**

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information see the Control Module chapter in the Device TRM.

Manual IO Timings Modes must be used to guarantee some IO timings for QSPI. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-73, Manual Functions Mapping for QSPI](#) for a definition of the Manual modes.

[Table 5-73](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-73. Manual Functions Mapping for QSPI

| BALL | BALL NAME | QSPI_MODE0_MANUAL1 |              | QSPI_MODE3_MANUAL1 |              | CFG REGISTER     | MUXMODE      |
|------|-----------|--------------------|--------------|--------------------|--------------|------------------|--------------|
|      |           | A_DELAY (ps)       | G_DELAY (ps) | A_DELAY (ps)       | G_DELAY (ps) |                  | 1            |
| R3   | gpmc_a13  | 0                  | 0            | 0                  | 0            | CFG_GPMC_A13_IN  | qspi1_rtcclk |
| T2   | gpmc_a14  | 2149               | 1052         | 0                  | 0            | CFG_GPMC_A14_IN  | qspi1_d3     |
| U2   | gpmc_a15  | 2121               | 997          | 0                  | 0            | CFG_GPMC_A15_IN  | qspi1_d2     |
| U1   | gpmc_a16  | 2159               | 1134         | 0                  | 0            | CFG_GPMC_A16_IN  | qspi1_d0     |
| U1   | gpmc_a16  | 0                  | 0            | 0                  | 0            | CFG_GPMC_A16_OUT | qspi1_d0     |
| P3   | gpmc_a17  | 2135               | 1085         | 0                  | 0            | CFG_GPMC_A17_IN  | qspi1_d1     |
| R2   | gpmc_a18  | 0                  | 0            | 151                | 0            | CFG_GPMC_A18_OUT | qspi1_sclk   |
| T7   | gpmc_a3   | 0                  | 0            | 0                  | 0            | CFG_GPMC_A3_OUT  | qspi1_cs2    |
| P6   | gpmc_a4   | 0                  | 0            | 0                  | 0            | CFG_GPMC_A4_OUT  | qspi1_cs3    |
| P2   | gpmc_cs2  | 0                  | 0            | 0                  | 0            | CFG_GPMC_CS2_OUT | qspi1_cs0    |
| P1   | gpmc_cs3  | 0                  | 0            | 22                 | 0            | CFG_GPMC_CS3_OUT | qspi1_cs1    |

### 5.10.6.13 McASP

The multichannel audio serial port (McASP) functions as a general-purpose audio serial port optimized for the needs of multichannel audio applications. The McASP is useful for time-division multiplexed (TDM) stream, Inter-Integrated Sound (I2S) protocols, and inter-component digital audio interface transmission (DIT).

The device have integrated 8 McASP modules (McASP1-McASP8) with:configure the desired virtual

- McASP1 and McASP2 modules supporting 16 channels with independent TX/RX clock/sync domain
- McASP3 through McASP8 modules supporting 4 channels with independent TX/RX clock/sync domain

#### NOTE

For more information, see the Multichannel Audio Serial Port section of the Device TRM.

#### CAUTION

The IO Timings provided in this section are only valid for some McASP usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

Table 5-74, Table 5-75, Table 5-76, and Figure 5-55 present timing requirements for McASP1 to McASP8.

**Table 5-74. Timing Requirements for McASP1 <sup>(1)</sup>**

| NO.  | PARAMETER            | DESCRIPTION                                   | MODE                              | MIN                     | MAX | UNIT |
|------|----------------------|-----------------------------------------------|-----------------------------------|-------------------------|-----|------|
| ASP1 | $t_{c(AHCLKX)}$      | Cycle time, AHCLKX                            |                                   | 20                      |     | ns   |
| ASP2 | $t_{w(AHCLKX)}$      | Pulse duration, AHCLKX high or low            |                                   | 0.35P <sup>(2)</sup>    |     | ns   |
| ASP3 | $t_{c(ACLKR/X)}$     | Cycle time, ACLKR/X                           |                                   | 20                      |     | ns   |
| ASP4 | $t_{w(ACLKR/X)}$     | Pulse duration, ACLKR/X high or low           |                                   | 0.5R <sup>(3)</sup> - 3 |     | ns   |
| ASP5 | $t_{su(AFSRX-ACLK)}$ | Setup time, AFSR/X input valid before ACLKR/X | ACLKR/X int                       | 20                      |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out | 4                       |     | ns   |
| ASP6 | $t_{h(ACLK-AFSRX)}$  | Hold time, AFSR/X input valid after ACLKR/X   | ACLKR/X int                       | -1                      |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out | 2.21                    |     | ns   |
| ASP7 | $t_{su(AXR-ACLK)}$   | Setup time, AXR input valid before ACLKR/X    | ACLKR/X int                       | 21.9                    |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out | 4.42                    |     | ns   |
| ASP8 | $t_{h(ACLK-AXR)}$    | Hold time, AXR input valid after ACLKR/X      | ACLKR/X int                       | -1                      |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out | 2.52                    |     | ns   |

- (1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1  
 ACLKR external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1

(2) P = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.

**Table 5-75. Timing Requirements for McASP2 <sup>(1)</sup>**

| NO.  | PARAMETER            | DESCRIPTION                                   | MODE                                                                                                        | MIN                     | MAX | UNIT |
|------|----------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------|-----|------|
| ASP1 | $t_{c(AHCLKX)}$      | Cycle time, AHCLKX                            |                                                                                                             | 20                      |     | ns   |
| ASP2 | $t_{w(AHCLKX)}$      | Pulse duration, AHCLKX high or low            |                                                                                                             | 0.35P <sup>(2)</sup>    |     | ns   |
| ASP3 | $t_{c(ACLKR/X)}$     | Cycle time, ACLKR/X                           | Any Other Conditions                                                                                        | 20                      |     | ns   |
|      |                      |                                               | ACLKX/AFSX (In Sync Mode), ACLKR/AFSR (In Async Mode), and AXR are all inputs "80M" Virtual IO Timing Mode  | 12.5                    |     | ns   |
| ASP4 | $t_{w(ACLKR/X)}$     | Pulse duration, ACLKR/X high or low           | Any Other Conditions                                                                                        | 0.5R <sup>(3)</sup> - 3 |     | ns   |
|      |                      |                                               | ACLKX/AFSX (In Sync Mode), ACLKR/AFSR (In Async Mode), and AXR are all inputs "80M" Virtual IO Timing Modes | 0.38R <sup>(3)</sup>    |     | ns   |
| ASP5 | $t_{su(AFSRX-ACLK)}$ | Setup time, AFSR/X input valid before ACLKR/X | ACLKR/X int                                                                                                 | 20.7                    |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out                                                                           | 3.9                     |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out "80M" Virtual IO Timing Modes                                             | 3                       |     | ns   |
| ASP6 | $t_{h(ACLK-AFSRX)}$  | Hold time, AFSR/X input valid after ACLKR/X   | ACLKR/X int                                                                                                 | -1                      |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out                                                                           | 3.2                     |     | ns   |
|      |                      |                                               | ACLKR/X ext in<br>ACLKR/X ext out "80M" Virtual IO Timing Modes                                             | 3                       |     | ns   |

**Table 5-75. Timing Requirements for McASP2 <sup>(1)</sup> (continued)**

| NO.  | PARAMETER          | DESCRIPTION                                 | MODE                                                                 | MIN  | MAX | UNIT |
|------|--------------------|---------------------------------------------|----------------------------------------------------------------------|------|-----|------|
| ASP7 | $t_{su}(AXR-ACLK)$ | Setup time, AXR input valid before ACLK/R/X | ACLK/R/X int                                                         | 21.4 |     | ns   |
|      |                    |                                             | ACLK/R/X ext in<br>ACLK/R/X ext out                                  | 3.9  |     | ns   |
|      |                    |                                             | ACLK/R/X ext in<br>ACLK/R/X ext out "80M"<br>Virtual IO Timing Modes | 3    |     | ns   |
| ASP8 | $t_h(ACLK-AXR)$    | Hold time, AXR input valid after ACLK/R/X   | ACLK/R/X int                                                         | -1   |     | ns   |
|      |                    |                                             | ACLK/R/X ext in<br>ACLK/R/X ext out                                  | 3.2  |     | ns   |
|      |                    |                                             | ACLK/R/X ext in<br>ACLK/R/X ext out "80M"<br>Virtual IO Timing Modes | 3    |     | ns   |

- (1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1  
 ACLKR external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1

(2) P = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.

**Table 5-76. Timing Requirements for McASP3/4/5/6/7/8 <sup>(1)</sup>**

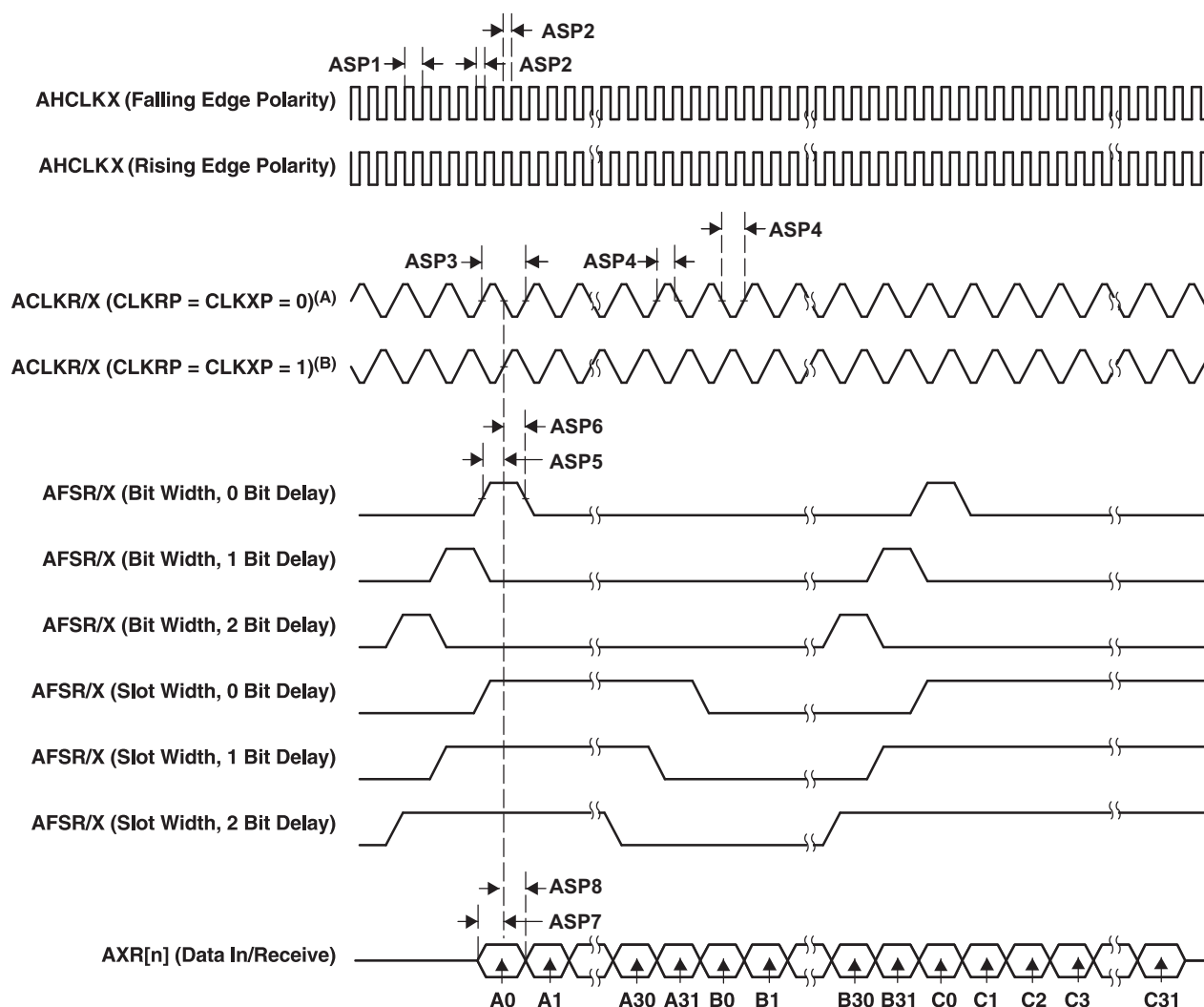
| NO.  | PARAMETER            | DESCRIPTION                                   | MODE                                | MIN                        | MAX | UNIT |
|------|----------------------|-----------------------------------------------|-------------------------------------|----------------------------|-----|------|
| ASP1 | $t_c(AHCLKX)$        | Cycle time, AHCLKX                            |                                     | 20                         |     | ns   |
| ASP2 | $t_w(AHCLKX)$        | Pulse duration, AHCLKX high or low            |                                     | 0.35P <sup>(2)</sup>       |     | ns   |
| ASP3 | $t_c(ACLKRX)$        | Cycle time, ACLKR/X                           |                                     | 20                         |     | ns   |
| ASP4 | $t_w(ACLKRX)$        | Pulse duration, ACLKR/X high or low           |                                     | 0.5R <sup>(3)</sup> -<br>3 |     | ns   |
| ASP5 | $t_{su}(AFSRX-ACLK)$ | Setup time, AFSR/X input valid before ACLKR/X | ACLK/R/X int                        | 20.2                       |     | ns   |
|      |                      |                                               | ACLK/R/X ext in<br>ACLK/R/X ext out | 4.9                        |     | ns   |
| ASP6 | $t_h(ACLK-AFSRX)$    | Hold time, AFSR/X input valid after ACLKR/X   | ACLK/R/X int                        | -1                         |     | ns   |
|      |                      |                                               | ACLK/R/X ext in<br>ACLK/R/X ext out | 2.26                       |     | ns   |
| ASP7 | $t_{su}(AXR-ACLK)$   | Setup time, AXR input valid before ACLKX      | ACLKX int<br>(ASYNCR = 0)           | 20.8                       |     | ns   |
|      |                      |                                               | ACLK/R/X ext in<br>ACLK/R/X ext out | 5.75                       |     | ns   |
| ASP8 | $t_h(ACLK-AXR)$      | Hold time, AXR input valid after ACLKX        | ACLKX int<br>(ASYNCR = 0)           | -0.9                       |     | ns   |
|      |                      |                                               | ACLK/R/X ext in<br>ACLK/R/X ext out | 2.87                       |     | ns   |

- (1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1 (NOT SUPPORTED)

ACLK external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1

(2) P = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.



- A. For CLKRP = CLKXP = 0, the McASP transmitter is configured for rising edge (to shift data out) and the McASP receiver is configured for falling edge (to shift data in).
- B. For CLKRP = CLKXP = 1, the McASP transmitter is configured for falling edge (to shift data out) and the McASP receiver is configured for rising edge (to shift data in).

**Figure 5-55. McASP Input Timing**
**CAUTION**

The IO Timings provided in this section are only valid for some McASP usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

Table 5-77, Table 5-78, Table 5-79, and Figure 5-56 present switching characteristics over recommended operating conditions for McASP1 to McASP8.

**Table 5-77. Switching Characteristics Over Recommended Operating Conditions for McASP1 <sup>(1)</sup>**

| NO.   | PARAMETER       | DESCRIPTION                        | MODE | MIN                       | MAX | UNIT |
|-------|-----------------|------------------------------------|------|---------------------------|-----|------|
| ASP9  | $t_{c(AHCLKX)}$ | Cycle time, AHCLKX                 |      | 20                        |     | ns   |
| ASP10 | $t_{w(AHCLKX)}$ | Pulse duration, AHCLKX high or low |      | 0.5P - 2.5 <sup>(2)</sup> |     | ns   |

**Table 5-77. Switching Characteristics Over Recommended Operating Conditions for McASP1**  
(1) (continued)

| NO.   | PARAMETER           | DESCRIPTION                                             | MODE                            | MIN                       | MAX  | UNIT |
|-------|---------------------|---------------------------------------------------------|---------------------------------|---------------------------|------|------|
| ASP11 | $t_{c(ACLKRX)}$     | Cycle time, ACLKRX                                      |                                 | 20                        |      | ns   |
| ASP12 | $t_{w(ACLKRX)}$     | Pulse duration, ACLKRX high or low                      |                                 | 0.5R <sup>(3)</sup> - 2.5 |      | ns   |
| ASP13 | $t_{d(ACLK-AFSXR)}$ | Delay time, ACLKRX transmit edge to AFSX/R output valid | ACLKRX int                      | -0.21                     | 6    | ns   |
|       |                     |                                                         | ACLKRX ext in<br>ACLKRX ext out | 2                         | 23.9 | ns   |
| ASP14 | $t_{d(ACLK-AXR)}$   | Delay time, ACLKRX transmit edge to AXR output valid    | ACLKRX int                      | -1.8                      | 6.9  | ns   |
|       |                     |                                                         | ACLKRX ext in<br>ACLKRX ext out | 2                         | 25.6 | ns   |

- (1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1  
 ACLKR external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1

(2) P = AHCLKX period in ns.

(3) R = ACLKRX period in ns.

**Table 5-78. Switching Characteristics Over Recommended Operating Conditions for McASP2** (1)

| NO.   | PARAMETER           | DESCRIPTION                                             | MODE                            | MIN                       | MAX  | UNIT |
|-------|---------------------|---------------------------------------------------------|---------------------------------|---------------------------|------|------|
| ASP9  | $t_{c(AHCLKX)}$     | Cycle time, AHCLKX                                      |                                 | 20                        |      | ns   |
| ASP10 | $t_{w(AHCLKX)}$     | Pulse duration, AHCLKX high or low                      |                                 | 0.5P - 2.5 <sup>(2)</sup> |      | ns   |
| ASP11 | $t_{c(ACLKRX)}$     | Cycle time, ACLKRX                                      |                                 | 20                        |      | ns   |
| ASP12 | $t_{w(ACLKRX)}$     | Pulse duration, ACLKRX high or low                      |                                 | 0.5R <sup>(3)</sup> - 2.5 |      | ns   |
| ASP13 | $t_{d(ACLK-AFSXR)}$ | Delay time, ACLKRX transmit edge to AFSX/R output valid | ACLKRX int                      | 0                         | 6    | ns   |
|       |                     |                                                         | ACLKRX ext in<br>ACLKRX ext out | 2                         | 25.2 | ns   |
| ASP14 | $t_{d(ACLK-AXR)}$   | Delay time, ACLKRX transmit edge to AXR output valid    | ACLKRX int                      | -1.29                     | 6.11 | ns   |
|       |                     |                                                         | ACLKRX ext in<br>ACLKRX ext out | 2                         | 24.8 | ns   |

- (1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1  
 ACLKR external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1

(2) P = AHCLKX period in ns.

(3) R = ACLKRX period in ns.

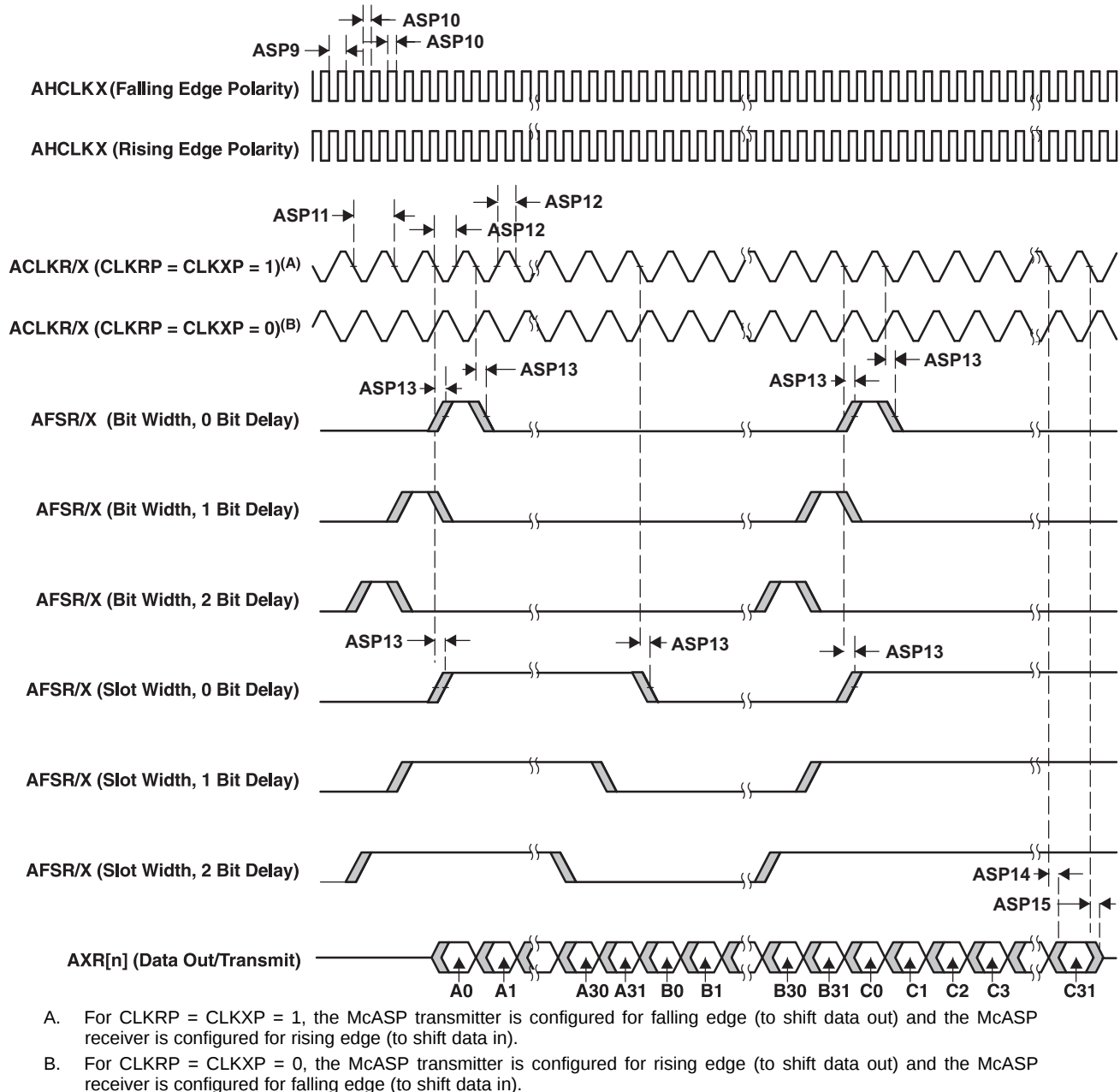
**Table 5-79. Switching Characteristics Over Recommended Operating Conditions for McASP3/4/5/6/7/8** (1)

| NO.   | PARAMETER           | DESCRIPTION                                             | MODE                            | MIN                       | MAX  | UNIT |
|-------|---------------------|---------------------------------------------------------|---------------------------------|---------------------------|------|------|
| ASP9  | $t_{c(AHCLKX)}$     | Cycle time, AHCLKX                                      |                                 | 20                        |      | ns   |
| ASP10 | $t_{w(AHCLKX)}$     | Pulse duration, AHCLKX high or low                      |                                 | 0.5P - 2.5 <sup>(2)</sup> |      | ns   |
| ASP11 | $t_{c(ACLKRX)}$     | Cycle time, ACLKRX                                      |                                 | 20                        |      | ns   |
| ASP12 | $t_{w(ACLKRX)}$     | Pulse duration, ACLKRX high or low                      |                                 | 0.5R <sup>(3)</sup> - 2.5 |      | ns   |
| ASP13 | $t_{d(ACLK-AFSXR)}$ | Delay time, ACLKRX transmit edge to AFSX/R output valid | ACLKRX int                      | -0.74                     | 6    | ns   |
|       |                     |                                                         | ACLKRX ext in<br>ACLKRX ext out | 2                         | 26.4 | ns   |

**Table 5-79. Switching Characteristics Over Recommended Operating Conditions for McASP3/4/5/6/7/8**  
<sup>(1)</sup> (continued)

| NO.   | PARAMETER              | DESCRIPTION                                            | MODE                                | MIN   | MAX  | UNIT |
|-------|------------------------|--------------------------------------------------------|-------------------------------------|-------|------|------|
| ASP14 | $t_d(\text{ACLK-AXR})$ | Delay time, ACLK/R/X transmit edge to AXR output valid | ACLK/R/X int                        | -1.68 | 6.97 | ns   |
|       |                        |                                                        | ACLK/R/X ext in<br>ACLK/R/X ext out | 1.07  | 25.9 | ns   |

- (1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1  
 ACLKR external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1
- (2) P = AHCLKX period in ns.
- (3) R = ACLKR/X period in ns.



**Figure 5-56. McASP Output Timing**

**NOTE**

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bitfield for each corresponding pad control register.

The pad control registers are presented in [Table 4-29](#) and described in chapter Control Module of the Device TRM.

[Table 5-80](#) through [Table 5-87](#) explain all cases with Virtual Mode Details for McASP1/2/3/4/5/6/7/8 (see [Figure 5-57](#) through [Figure 5-64](#)).

**Table 5-80. Virtual Mode Case Details for McASP1**

| No.                                                              | CASE   | CASE Description                     | Virtual Mode Settings |                           | Notes                           |
|------------------------------------------------------------------|--------|--------------------------------------|-----------------------|---------------------------|---------------------------------|
|                                                                  |        |                                      | Signals               | Virtual Mode Value        |                                 |
| IP Mode : ASYNC                                                  |        |                                      |                       |                           |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKR/FSR  | MCASP1_VIRTUAL3_ASYNC_RX  |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKR/FSR  | MCASP1_VIRTUAL3_ASYNC_RX  |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL3_ASYNC_RX  | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKR/FSR  | MCASP1_VIRTUAL1_ASYNC_TX  |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL3_ASYNC_RX  | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKR/FSR  | MCASP1_VIRTUAL1_ASYNC_TX  |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                      |                       |                           |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                   | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input              | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKX/FSX  | MCASP1_VIRTUAL2_SYNC_RX   |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                    | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKX/FSX  | MCASP1_VIRTUAL2_SYNC_RX   |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input              | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                      | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |

**Table 5-81. Virtual Mode Case Details for McASP2**

| No.                                                              | CASE   | CASE Description                        | Virtual Mode Settings |                                             | Notes                           |
|------------------------------------------------------------------|--------|-----------------------------------------|-----------------------|---------------------------------------------|---------------------------------|
|                                                                  |        |                                         | Signals               | Virtual Mode Value                          |                                 |
| IP Mode : ASYNC                                                  |        |                                         |                       |                                             |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output<br>CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) <sup>(1)</sup>    | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | Default (No Virtual Mode) <sup>(1)</sup>    |                                 |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP2_VIRTUAL1_ASYNC_RX_80M <sup>(2)</sup> |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output<br>CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode)                   | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP2_VIRTUAL2_ASYNC_RX                    |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output<br>CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL2_ASYNC_RX                    | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP2_VIRTUAL3_ASYNC_TX                    |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output<br>CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL2_ASYNC_RX                    | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP2_VIRTUAL3_ASYNC_TX                    |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                         |                       |                                             |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                      | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode)                   | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode)                   |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input                 | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL4_SYNC_RX                     | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP2_VIRTUAL4_SYNC_RX                     |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                       | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL4_SYNC_RX <sup>(1)</sup>      | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP2_VIRTUAL4_SYNC_RX <sup>(1)</sup>      |                                 |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP2_VIRTUAL5_SYNC_RX_80M <sup>(2)</sup>  |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input                 | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode)                   | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode)                   |                                 |

- (1) Used up to 50 MHz. Should also be used in a CI-FI- mixed case where AXR operate as both inputs and outputs (that is, AXR are bidirectional).
- (2) Used in 80 MHz input only mode when AXR, CLKX and FSX are all inputs.

**Table 5-82. Virtual Mode Case Details for McASP3**

| No.                                                              | CASE   | CASE Description                        | Virtual Mode Settings |                           | Notes                           |
|------------------------------------------------------------------|--------|-----------------------------------------|-----------------------|---------------------------|---------------------------------|
|                                                                  |        |                                         | Signals               | Virtual Mode Value        |                                 |
| IP Mode : ASYNC                                                  |        |                                         |                       |                           |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output<br>CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP3_VIRTUAL2_SYNC_RX   |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output<br>CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP3_VIRTUAL2_SYNC_RX   |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output<br>CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP3_VIRTUAL2_SYNC_RX   |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output<br>CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP3_VIRTUAL2_SYNC_RX   |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                         |                       |                           |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                      | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input                 | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP3_VIRTUAL2_SYNC_RX   |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                       | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP3_VIRTUAL2_SYNC_RX   |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input                 | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |

**Table 5-83. Virtual Mode Case Details for McASP4**

| No.                                                              | CASE   | CASE Description                        | Virtual Mode Settings |                           | Notes                           |
|------------------------------------------------------------------|--------|-----------------------------------------|-----------------------|---------------------------|---------------------------------|
|                                                                  |        |                                         | Signals               | Virtual Mode Value        |                                 |
| IP Mode : ASYNC                                                  |        |                                         |                       |                           |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output<br>CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP4_VIRTUAL1_SYNC_RX   |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output<br>CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP4_VIRTUAL1_SYNC_RX   |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output<br>CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP4_VIRTUAL1_SYNC_RX   |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output<br>CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP4_VIRTUAL1_SYNC_RX   |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                         |                       |                           |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                      | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input                 | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP4_VIRTUAL1_SYNC_RX   |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                       | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP4_VIRTUAL1_SYNC_RX   |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input                 | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |

**Table 5-84. Virtual Mode Case Details for McASP5**

| No.                                                              | CASE   | CASE Description                        | Virtual Mode Settings |                           | Notes                           |
|------------------------------------------------------------------|--------|-----------------------------------------|-----------------------|---------------------------|---------------------------------|
|                                                                  |        |                                         | Signals               | Virtual Mode Value        |                                 |
| IP Mode : ASYNC                                                  |        |                                         |                       |                           |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output<br>CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP5_VIRTUAL1_SYNC_RX   |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output<br>CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP5_VIRTUAL1_SYNC_RX   |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output<br>CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP5_VIRTUAL1_SYNC_RX   |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output<br>CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP5_VIRTUAL1_SYNC_RX   |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                         |                       |                           |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                      | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input                 | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP5_VIRTUAL1_SYNC_RX   |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                       | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP5_VIRTUAL1_SYNC_RX   |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input                 | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |

**Table 5-85. Virtual Mode Case Details for McASP6**

| No.                                                              | CASE   | CASE Description                        | Virtual Mode Settings |                           | Notes                           |
|------------------------------------------------------------------|--------|-----------------------------------------|-----------------------|---------------------------|---------------------------------|
|                                                                  |        |                                         | Signals               | Virtual Mode Value        |                                 |
| IP Mode : ASYNC                                                  |        |                                         |                       |                           |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output<br>CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP6_VIRTUAL1_SYNC_RX   |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output<br>CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP6_VIRTUAL1_SYNC_RX   |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output<br>CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP6_VIRTUAL1_SYNC_RX   |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output<br>CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP6_VIRTUAL1_SYNC_RX   |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                         |                       |                           |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                      | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input                 | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP6_VIRTUAL1_SYNC_RX   |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                       | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP6_VIRTUAL1_SYNC_RX   |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input                 | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |

**Table 5-86. Virtual Mode Case Details for McASP7**

| No.                                                              | CASE   | CASE Description                        | Virtual Mode Settings |                           | Notes                           |
|------------------------------------------------------------------|--------|-----------------------------------------|-----------------------|---------------------------|---------------------------------|
|                                                                  |        |                                         | Signals               | Virtual Mode Value        |                                 |
| IP Mode : ASYNC                                                  |        |                                         |                       |                           |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output<br>CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP7_VIRTUAL2_SYNC_RX   |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output<br>CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP7_VIRTUAL2_SYNC_RX   |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output<br>CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP7_VIRTUAL2_SYNC_RX   |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output<br>CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP7_VIRTUAL2_SYNC_RX   |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                         |                       |                           |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                      | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input                 | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP7_VIRTUAL2_SYNC_RX   |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                       | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX   | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP7_VIRTUAL2_SYNC_RX   |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input                 | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |

**Table 5-87. Virtual Mode Case Details for McASP8**

| No.                                                              | CASE   | CASE Description                        | Virtual Mode Settings |                           | Notes                           |
|------------------------------------------------------------------|--------|-----------------------------------------|-----------------------|---------------------------|---------------------------------|
|                                                                  |        |                                         | Signals               | Virtual Mode Value        |                                 |
| IP Mode : ASYNC                                                  |        |                                         |                       |                           |                                 |
| 1                                                                | COIFOI | CLKX / FSX: Output<br>CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-57</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP8_VIRTUAL1_SYNC_RX   |                                 |
| 2                                                                | COIFIO | CLKX / FSR: Output<br>CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-58</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP8_VIRTUAL1_SYNC_RX   |                                 |
| 3                                                                | CIOFIO | CLKR / FSR: Output<br>CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-59</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP8_VIRTUAL1_SYNC_RX   |                                 |
| 4                                                                | CIOFOI | CLKR / FSX: Output<br>CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-60</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKR/FSR  | MCASP8_VIRTUAL1_SYNC_RX   |                                 |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) |        |                                         |                       |                           |                                 |
| 5                                                                | CO-FO- | CLKX / FSX: Output                      | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-61</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |
| 6                                                                | CI-FO- | FSX: Output CLKX: Input                 | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-62</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP8_VIRTUAL1_SYNC_RX   |                                 |
| 7                                                                | CI-FI- | CLKX / FSX: Input                       | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX   | See <a href="#">Figure 5-63</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | MCASP8_VIRTUAL1_SYNC_RX   |                                 |
| 8                                                                | CO-FI- | CLKX: Output FSX: Input                 | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See <a href="#">Figure 5-64</a> |
|                                                                  |        |                                         | AXR(Inputs)/CLKX/FSX  | Default (No Virtual Mode) |                                 |

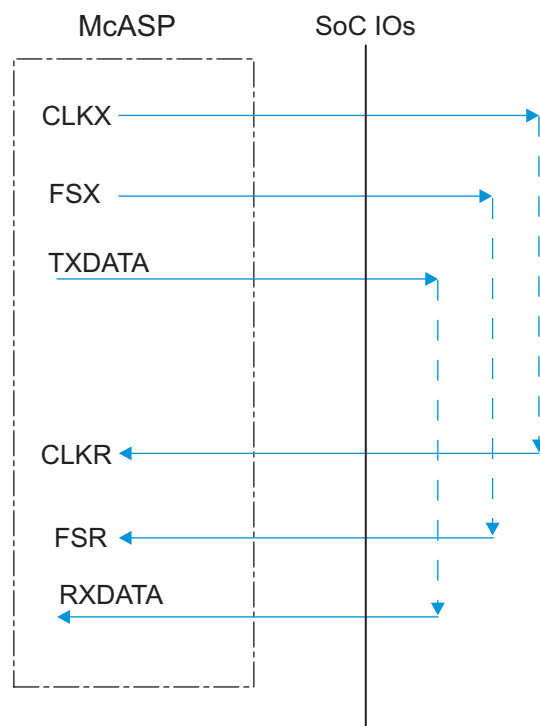


Figure 5-57. McASP1-8 COIFOI – ASYNC Mode

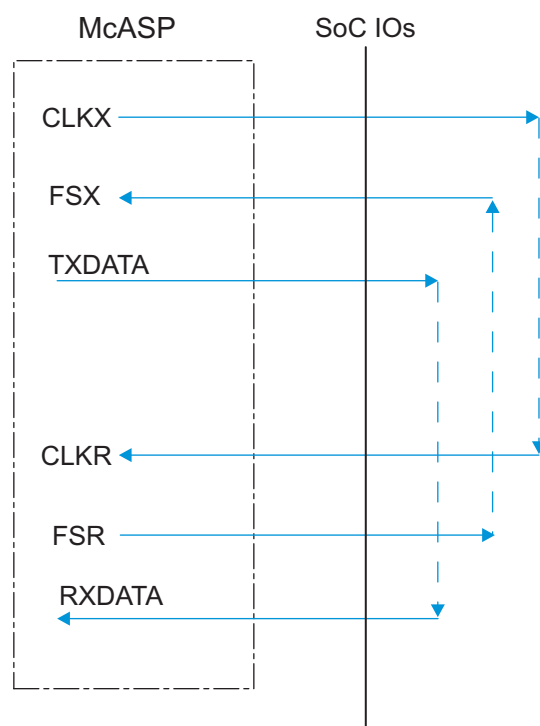
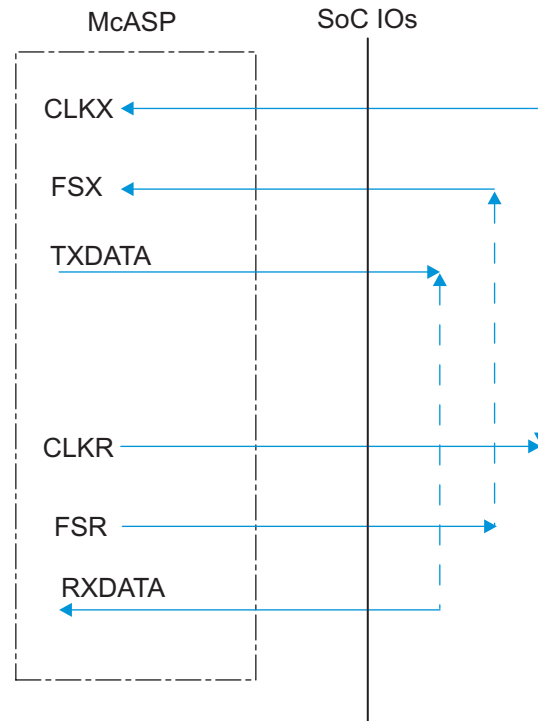
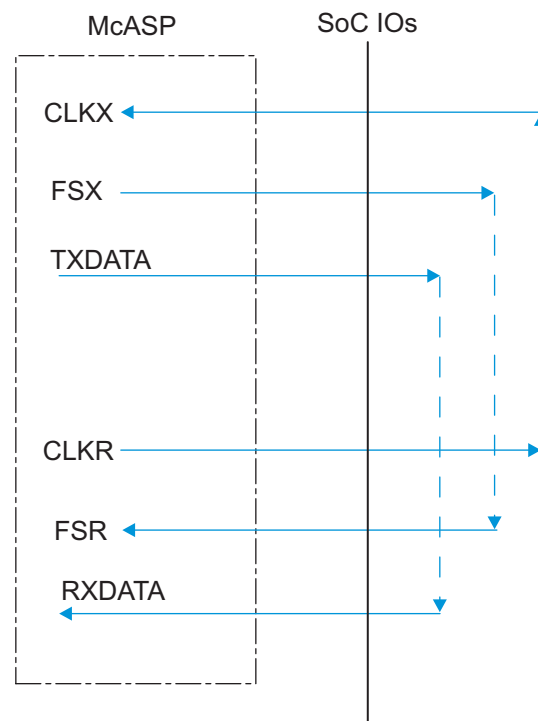


Figure 5-58. McASP1-8 COIFIO – ASYNC Mode



**Figure 5-59. McASP1-8 CIOFIO – ASYNC Mode**



**Figure 5-60. McASP1-8 CIOFOI – ASYNC Mode**

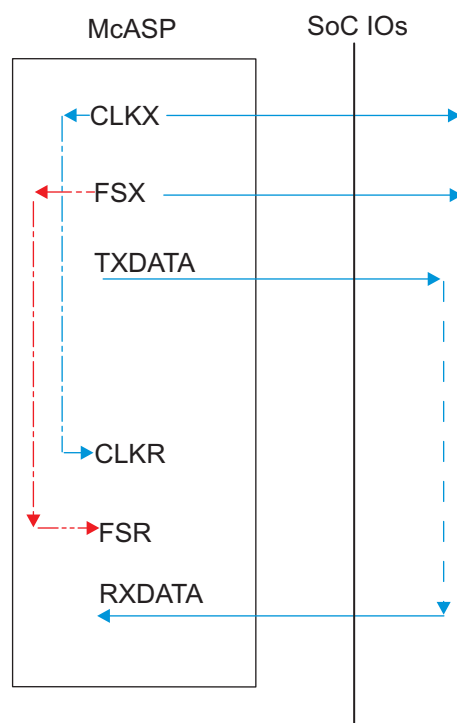


Figure 5-61. McASP1-8 CO-FO- – SYNC Mode

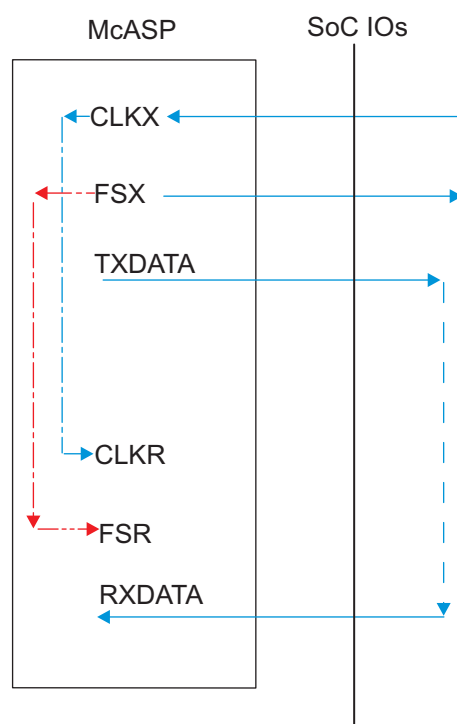
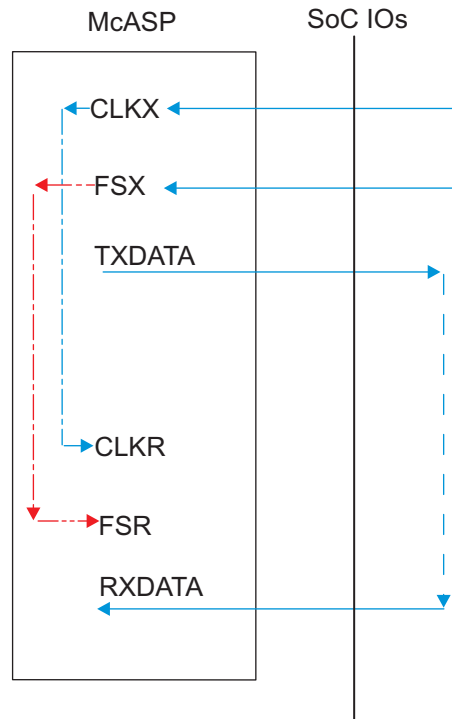
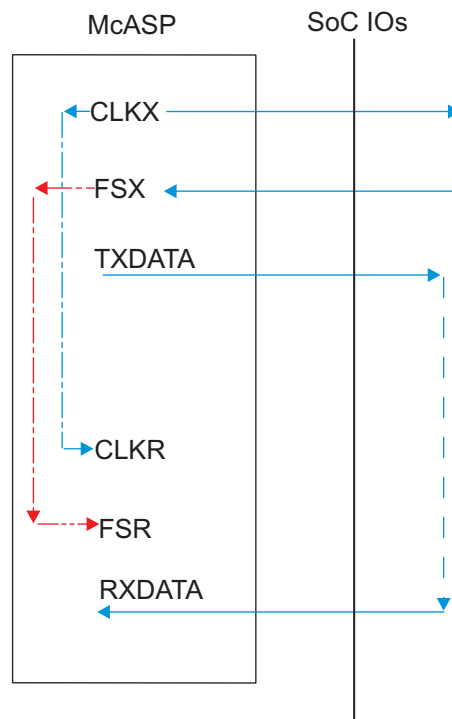


Figure 5-62. McASP1-8 CI-FO- – SYNC Mode



**Figure 5-63. McASP1-8 CI-FI- – SYNC Mode**



**Figure 5-64. McASP1-8 CO-FI- – SYNC Mode**

Virtual IO Timings Modes must be used to guarantee some IO timings for McASP1. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 5-88, Virtual Functions Mapping for McASP1](#) for a definition of the Virtual modes.

[Table 5-88](#) presents the values for DELAYMODE bitfield.

Table 5-88. Virtual Functions Mapping for McASP1

| BALL | BALL NAME    | Delay Mode Value         |                         |                          | MUXMODE[15:0] |              |             |
|------|--------------|--------------------------|-------------------------|--------------------------|---------------|--------------|-------------|
|      |              | MCASP1_VIRTUAL1_ASYNC_TX | MCASP1_VIRTUAL2_SYNC_RX | MCASP1_VIRTUAL3_ASYNC_RX | 0             | 1            | 2           |
| E21  | gpio6_14     | 11                       | 15                      | 14                       |               | mcasp1_axr8  |             |
| F20  | gpio6_15     | 11                       | 15                      | 14                       |               | mcasp1_axr9  |             |
| F21  | gpio6_16     | 11                       | 15                      | 14                       |               | mcasp1_axr10 |             |
| D18  | xref_clk0    | 0                        | 15                      | 14                       |               |              | mcasp1_axr4 |
| E17  | xref_clk1    | 0                        | 15                      | 14                       |               |              | mcasp1_axr5 |
| B26  | xref_clk2    | 5                        | 15                      | 14                       |               |              | mcasp1_axr6 |
| C23  | xref_clk3    | 5                        | 15                      | 14                       |               |              | mcasp1_axr7 |
| C14  | mcasp1_aclkx | 8                        | 15                      | 14                       | mcasp1_aclkx  |              |             |
| D14  | mcasp1_fsx   | 12                       | 15                      | 14                       | mcasp1_fsx    |              |             |
| B14  | mcasp1_aclkr | 11                       | N/A                     | 15                       | mcasp1_aclkr  |              |             |
| J14  | mcasp1_fsr   | 11                       | N/A                     | 15                       | mcasp1_fsr    |              |             |
| G12  | mcasp1_axr0  | 8                        | 15                      | 14                       | mcasp1_axr0   |              |             |
| F12  | mcasp1_axr1  | 8                        | 15                      | 14                       | mcasp1_axr1   |              |             |
| G13  | mcasp1_axr2  | 10                       | 15                      | 14                       | mcasp1_axr2   |              |             |
| J11  | mcasp1_axr3  | 10                       | 15                      | 14                       | mcasp1_axr3   |              |             |
| E12  | mcasp1_axr4  | 10                       | 15                      | 14                       | mcasp1_axr4   |              |             |
| F13  | mcasp1_axr5  | 10                       | 15                      | 14                       | mcasp1_axr5   |              |             |
| C12  | mcasp1_axr6  | 10                       | 15                      | 14                       | mcasp1_axr6   |              |             |
| D12  | mcasp1_axr7  | 10                       | 15                      | 14                       | mcasp1_axr7   |              |             |
| B12  | mcasp1_axr8  | 6                        | 15                      | 14                       | mcasp1_axr8   |              |             |
| A11  | mcasp1_axr9  | 6                        | 15                      | 14                       | mcasp1_axr9   |              |             |
| B13  | mcasp1_axr10 | 6                        | 15                      | 14                       | mcasp1_axr10  |              |             |
| A12  | mcasp1_axr11 | 6                        | 15                      | 14                       | mcasp1_axr11  |              |             |
| E14  | mcasp1_axr12 | 6                        | 15                      | 14                       | mcasp1_axr12  |              |             |
| A13  | mcasp1_axr13 | 6                        | 15                      | 14                       | mcasp1_axr13  |              |             |
| G14  | mcasp1_axr14 | 6                        | 15                      | 14                       | mcasp1_axr14  |              |             |
| F14  | mcasp1_axr15 | 6                        | 15                      | 14                       | mcasp1_axr15  |              |             |

1. NA in this table stands for Not Applicable.

Virtual IO Timings Modes must be used to guarantee some IO timings for McASP2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 5-89, Virtual Functions Mapping for McASP2](#) for a definition of the Virtual modes.

[Table 5-89](#) presents the values for DELAYMODE bitfield.

Table 5-89. Virtual Functions Mapping for McASP2

| BALL | BALL NAME    | Delay Mode Value             |                          |                          |                         |                             | MUXMODE[15:0] |              |              |
|------|--------------|------------------------------|--------------------------|--------------------------|-------------------------|-----------------------------|---------------|--------------|--------------|
|      |              | MCASP2_VIRTUAL1_ASYNC_RX_80M | MCASP2_VIRTUAL2_ASYNC_RX | MCASP2_VIRTUAL3_ASYNC_TX | MCASP2_VIRTUAL4_SYNC_RX | MCASP2_VIRTUAL5_SYNC_RX_80M | 0             | 1            | 2            |
| D18  | xref_clk0    | 10                           | 9                        | 4                        | 8                       | 6                           |               | mcasp2_axr8  |              |
| E17  | xref_clk1    | 10                           | 9                        | 4                        | 8                       | 6                           |               | mcasp2_axr9  |              |
| B26  | xref_clk2    | 13                           | 12                       | 0                        | 11                      | 10                          |               | mcasp2_axr10 |              |
| C23  | xref_clk3    | 13                           | 12                       | 0                        | 11                      | 10                          |               | mcasp2_axr11 |              |
| A19  | mcasp2_aclkx | 15                           | 14                       | 5                        | 10                      | 9                           | mcasp2_aclkx  |              |              |
| A18  | mcasp2_fsx   | 15                           | 14                       | 5                        | 10                      | 9                           | mcasp2_fsx    |              |              |
| E15  | mcasp2_aclkr | 15                           | 14                       | 10                       | N/A                     | N/A                         | mcasp2_aclkr  |              |              |
| A20  | mcasp2_fsr   | 15                           | 14                       | 10                       | N/A                     | N/A                         | mcasp2_fsr    |              |              |
| B15  | mcasp2_axr0  | 15                           | 14                       | 9                        | 13                      | 12                          | mcasp2_axr0   |              |              |
| A15  | mcasp2_axr1  | 15                           | 14                       | 9                        | 13                      | 12                          | mcasp2_axr1   |              |              |
| C15  | mcasp2_axr2  | 15                           | 14                       | 4                        | 10                      | 9                           | mcasp2_axr2   |              |              |
| A16  | mcasp2_axr3  | 15                           | 14                       | 4                        | 10                      | 9                           | mcasp2_axr3   |              |              |
| D15  | mcasp2_axr4  | 15                           | 14                       | 7                        | 13                      | 12                          | mcasp2_axr4   |              |              |
| B16  | mcasp2_axr5  | 15                           | 14                       | 7                        | 13                      | 12                          | mcasp2_axr5   |              |              |
| B17  | mcasp2_axr6  | 15                           | 14                       | 7                        | 13                      | 12                          | mcasp2_axr6   |              |              |
| A17  | mcasp2_axr7  | 15                           | 14                       | 7                        | 13                      | 12                          | mcasp2_axr7   |              |              |
| B18  | mcasp3_aclkx | 15                           | 14                       | 5                        | 10                      | 9                           |               |              | mcasp2_axr12 |
| F15  | mcasp3_fsx   | 15                           | 14                       | 4                        | 10                      | 9                           |               |              | mcasp2_axr13 |
| B19  | mcasp3_axr0  | 15                           | 14                       | 4                        | 10                      | 9                           |               |              | mcasp2_axr14 |
| C17  | mcasp3_axr1  | 15                           | 14                       | 3                        | 10                      | 8                           |               |              | mcasp2_axr15 |

1. NA in this table stands for Not Applicable.

Virtual IO Timings Modes must be used to guarantee some IO timings for McASP3/4/5/6/7/8. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 5-90, Virtual Functions Mapping for McASP3/4/5/6/7/8](#) for a definition of the Virtual modes.

[Table 5-90](#) presents the values for DELAYMODE bitfield.

Table 5-90. Virtual Functions Mapping for McASP3/4/5/6/7/8

| BALL                    | BALL NAME    | Delay Mode Value | MUXMODE[15:0] |              |              |
|-------------------------|--------------|------------------|---------------|--------------|--------------|
|                         |              |                  | 0             | 1            | 2            |
| MCASP3_VIRTUAL2_SYNC_RX |              |                  |               |              |              |
| C15                     | mcasp2_axr2  | 8                |               | mcasp3_axr2  |              |
| A16                     | mcasp2_axr3  | 8                |               | mcasp3_axr3  |              |
| B18                     | mcasp3_aclkx | 8                | mcasp3_aclkx  | mcasp3_aclkr |              |
| F15                     | mcasp3_fsx   | 8                | mcasp3_fsx    | mcasp3_fsr   |              |
| B19                     | mcasp3_axr0  | 8                | mcasp3_axr0   |              |              |
| C17                     | mcasp3_axr1  | 6                | mcasp3_axr1   |              |              |
| MCASP4_VIRTUAL1_SYNC_RX |              |                  |               |              |              |
| E12                     | mcasp1_axr4  | 13               |               | mcasp4_axr2  |              |
| F13                     | mcasp1_axr5  | 13               |               | mcasp4_axr3  |              |
| C18                     | mcasp4_aclkx | 15               | mcasp4_aclkx  | mcasp4_aclkr |              |
| A21                     | mcasp4_fsx   | 15               | mcasp4_fsx    | mcasp4_fsr   |              |
| G16                     | mcasp4_axr0  | 15               | mcasp4_axr0   |              |              |
| D17                     | mcasp4_axr1  | 15               | mcasp4_axr1   |              |              |
| MCASP5_VIRTUAL1_SYNC_RX |              |                  |               |              |              |
| C12                     | mcasp1_axr6  | 13               |               | mcasp5_axr2  |              |
| D12                     | mcasp1_axr7  | 13               |               | mcasp5_axr3  |              |
| AA3                     | mcasp5_aclkx | 15               | mcasp5_aclkx  | mcasp5_aclkr |              |
| AB9                     | mcasp5_fsx   | 15               | mcasp5_fsx    | mcasp5_fsr   |              |
| AB3                     | mcasp5_axr0  | 15               | mcasp5_axr0   |              |              |
| AA4                     | mcasp5_axr1  | 15               | mcasp5_axr1   |              |              |
| MCASP6_VIRTUAL1_SYNC_RX |              |                  |               |              |              |
| G13                     | mcasp1_axr2  | 13               |               | mcasp6_axr2  |              |
| J11                     | mcasp1_axr3  | 13               |               | mcasp6_axr3  |              |
| B12                     | mcasp1_axr8  | 10               |               | mcasp6_axr0  |              |
| A11                     | mcasp1_axr9  | 10               |               | mcasp6_axr1  |              |
| B13                     | mcasp1_axr10 | 10               |               | mcasp6_aclkx | mcasp6_aclkr |
| A12                     | mcasp1_axr11 | 10               |               | mcasp6_fsx   | mcasp6_fsr   |
| MCASP7_VIRTUAL2_SYNC_RX |              |                  |               |              |              |
| B14                     | mcasp1_aclkr | 14               |               | mcasp7_axr2  |              |
| J14                     | mcasp1_fsr   | 14               |               | mcasp7_axr3  |              |
| E14                     | mcasp1_axr12 | 10               |               | mcasp7_axr0  |              |

Table 5-90. Virtual Functions Mapping for McASP3/4/5/6/7/8 (continued)

| BALL                    | BALL NAME    | Delay Mode Value | MUXMODE[15:0] |              |              |
|-------------------------|--------------|------------------|---------------|--------------|--------------|
|                         |              |                  | 0             | 1            | 2            |
| A13                     | mcasp1_axr13 | 10               |               | mcasp7_axr1  |              |
| G14                     | mcasp1_axr14 | 10               |               | mcasp7_aclkx | mcasp7_aclkr |
| F14                     | mcasp1_axr15 | 10               |               | mcasp7_fsx   | mcasp7_fsr   |
| MCASP8_VIRTUAL1_SYNC_RX |              |                  |               |              |              |
| E15                     | mcasp2_aclkr | 13               |               | mcasp8_axr2  |              |
| A20                     | mcasp2_fsr   | 13               |               | mcasp8_axr3  |              |
| D15                     | mcasp2_axr4  | 11               |               | mcasp8_axr0  |              |
| B16                     | mcasp2_axr5  | 11               |               | mcasp8_axr1  |              |
| B17                     | mcasp2_axr6  | 11               |               | mcasp8_aclkx | mcasp8_aclkr |
| A17                     | mcasp2_axr7  | 11               |               | mcasp8_fsx   | mcasp8_fsr   |

#### 5.10.6.14 USB

SuperSpeed USB DRD Subsystem has four instances in the device providing the following functions:

- USB1: SuperSpeed (SS) USB 3.0 Dual-Role-Device (DRD) subsystem with integrated SS (USB3.0) PHY and HS/FS (USB2.0) PHY.
- USB2: High-Speed (HS) USB 2.0 Dual-Role-Device (DRD) subsystem with integrated HS/FS PHY.
- USB3: HS USB 2.0 Dual-Role-Device (DRD) subsystem with ULPI (SDR) interface to external HS/FS PHYs.
- USB4: HS USB 2.0 Dual-Role-Device (DRD) subsystem with ULPI (SDR) interface to external HS/FS PHYs.

#### NOTE

For more information, see the SuperSpeed USB DRD section of the Device TRM.

##### 5.10.6.14.1 USB1 DRD PHY

The USB1 DRD interface supports the following applications:

- USB2.0 High-Speed PHY port (1.8 V and 3.3 V): this asynchronous high-speed interface is compliant with the USB2.0 PHY standard with an internal transceiver (USB2.0 standard v2.0), for a maximum data rate of 480 Mbps.
- USB3.0 Super-Speed PHY port (1.8 V): this asynchronous differential super-speed interface is compliant with the USB3.0 RX/TX PHY standard (USB3.0 standard v1.0) for a maximum data bit rate of 5Gbps.

##### 5.10.6.14.2 USB2 PHY

The USB2 interface supports the following applications:

- USB2.0 High-Speed PHY port (1.8 V and 3.3 V): this asynchronous high-speed interface is compliant with the USB2.0 PHY standard with an internal transceiver (USB2.0 standard v2.0), for a maximum data rate of 480 Mbps.

##### 5.10.6.14.3 USB3 and USB4 DRD ULPI—SDR—Slave Mode—12-pin Mode

The USB3 and USB4 DRD interfaces support the following application:

- USB ULPI port: this synchronous interface is compliant with the USB2.0 ULPI SDR standard (UTMI+ v1.22), for alternative off-chip USB2.0 PHY interface; that is, with external transceiver with a maximum frequency of 60 MHz (synchronous slave mode, SDR, 12-pin, 8-data-bit).

#### NOTE

The Universal Serial Bus k ULPI modules are also referred as USBk where k = 3, 4.

Table 5-91, Table 5-92 and Figure 5-65 assume testing over the recommended operating conditions and electrical characteristic conditions.

**Table 5-91. Timing Requirements for ULPI SDR Slave Mode**

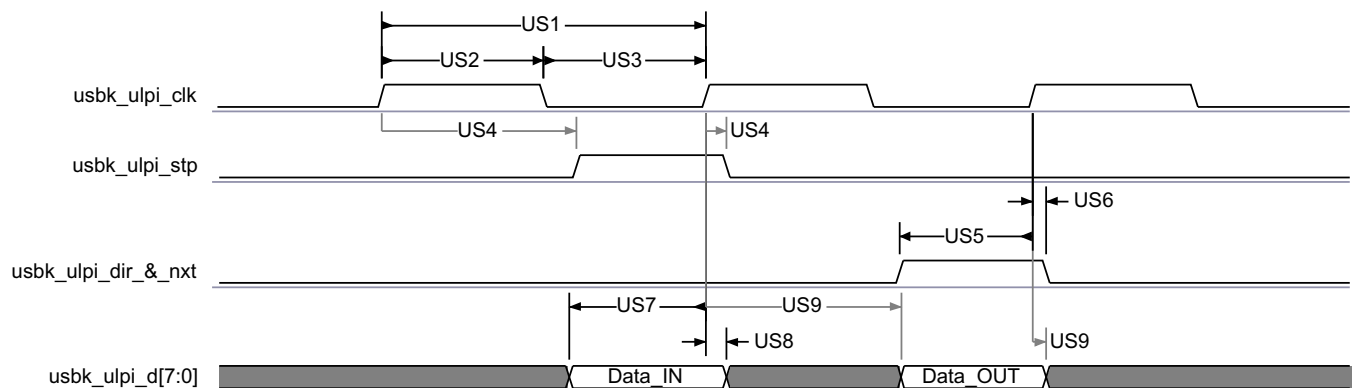
| NO. | PARAMETER            | DESCRIPTION                                                                 | MIN   | MAX | UNIT |
|-----|----------------------|-----------------------------------------------------------------------------|-------|-----|------|
| US1 | $t_{c(clk)}$         | Cycle time, usb_ulpi_clk period                                             | 16.66 |     | ns   |
| US5 | $t_{su(ctrlV-clkH)}$ | Setup time, usb_ulpi_dir/usb_ulpi_nxt valid before usb_ulpi_clk rising edge | 6.73  |     | ns   |
| US6 | $t_{h(clkH-ctrlV)}$  | Hold time, usb_ulpi_dir/usb_ulpi_nxt valid after usb_ulpi_clk rising edge   | -0.41 |     | ns   |

**Table 5-91. Timing Requirements for ULPI SDR Slave Mode (continued)**

| NO. | PARAMETER         | DESCRIPTION                                                       | MIN   | MAX | UNIT |
|-----|-------------------|-------------------------------------------------------------------|-------|-----|------|
| US7 | $t_{su}(dV-clkH)$ | Setup time, usb_ulpi_d[7:0] valid before usb_ulpi_clk rising edge | 6.73  |     | ns   |
| US8 | $t_h(clkH-dV)$    | Hold time, usb_ulpi_d[7:0] valid after usb_ulpi_clk rising edge   | -0.41 |     | ns   |

**Table 5-92. Switching Characteristics for ULPI SDR Slave Mode**

| NO. | PARAMETER        | DESCRIPTION                                                               | MIN  | MAX  | UNIT |
|-----|------------------|---------------------------------------------------------------------------|------|------|------|
| US4 | $t_d(clkH-stpV)$ | Delay time, usb_ulpi_clk rising edge high to output usb_ulpi_stp valid    | 0.44 | 8.35 | ns   |
| US9 | $t_d(clkL-dvV)$  | Delay time, usb_ulpi_clk rising edge high to output usb_ulpi_d[7:0] valid | 0.44 | 8.35 | ns   |


**Figure 5-65. HS USB3 and USB4 ULPI —SDR—Slave Mode—12-pin Mode**

In [Table 5-93](#) are presented the specific groupings of signals (IOSET) for use with USB3 and USB4 signals.

**Table 5-93. USB3 and USB4 IOSETs**

| SIGNALS       | IOSET1 |     | IOSET2 |     |
|---------------|--------|-----|--------|-----|
|               | BALL   | MUX | BALL   | MUX |
| <b>USB3</b>   |        |     |        |     |
| usb3_ulpi_d0  | AE1    | 2   | AC3    | 3   |
| usb3_ulpi_d1  | AE5    | 2   | AC9    | 3   |
| usb3_ulpi_d2  | AE3    | 2   | AC6    | 3   |
| usb3_ulpi_d3  | AF1    | 2   | AC7    | 3   |
| usb3_ulpi_d4  | AF4    | 2   | AC4    | 3   |
| usb3_ulpi_d5  | AF3    | 2   | AD4    | 3   |
| usb3_ulpi_d6  | AF6    | 2   | AB4    | 3   |
| usb3_ulpi_d7  | AF2    | 2   | AC5    | 3   |
| usb3_ulpi_nxt | AE2    | 2   | AC8    | 3   |
| usb3_ulpi_dir | AE6    | 2   | AD6    | 3   |
| usb3_ulpi_stp | AD2    | 2   | AB8    | 3   |
| usb3_ulpi_clk | AD3    | 2   | AB5    | 3   |
| <b>USB4</b>   |        |     |        |     |
| usb4_ulpi_d0  |        |     | V6     | 6   |
| usb4_ulpi_d1  |        |     | U6     | 6   |
| usb4_ulpi_d2  |        |     | U5     | 6   |
| usb4_ulpi_d3  |        |     | V5     | 6   |

**Table 5-93. USB3 and USB4 IOSETs (continued)**

| SIGNALS       | IOSET1 |     | IOSET2 |     |
|---------------|--------|-----|--------|-----|
|               | BALL   | MUX | BALL   | MUX |
| usb4_ulpi_d4  |        |     | V4     | 6   |
| usb4_ulpi_d5  |        |     | V3     | 6   |
| usb4_ulpi_d6  |        |     | Y2     | 6   |
| usb4_ulpi_d7  |        |     | W2     | 6   |
| usb4_ulpi_stp |        |     | V9     | 6   |
| usb4_ulpi_clk |        |     | W9     | 6   |
| usb4_ulpi_dir |        |     | V7     | 6   |
| usb4_ulpi_nxt |        |     | U7     | 6   |

**5.10.6.15 SATA**

The SATA RX/TX PHY interface is compliant with the SATA standard v2.6 for a maximum data rate:

- Gen2i, Gen2m, Gen2x: 3Gbps.
- Gen1i, Gen1m, Gen1x: 1.5Gbps.

**NOTE**

For more information, see the SATA Controller section of the Device TRM.

**5.10.6.16 PCIe**

The device supports connections to PCIe-compliant devices via the integrated PCIe master/slave bus interface. The PCIe module is comprised of a dual-mode PCIe core and a SerDes PHY. Each PCIe subsystem controller has support for PCIe Gen-II mode (5.0 Gbps /lane) and Gen-I mode (2.5 Gbps/lane) (Single Lane and Flexible dual lane configuration).

The device PCIe supports the following features:

- 16-bit operation @250 MHz on PIPE interface (per 16-bit lane)
- Supports 1 ports x 1 lane configuration
- Single virtual channel (VC0), single traffic class (TC0)
- Single function in end-point mode
- Automatic width and speed negotiation
- Max payload: 128 byte outbound, 256 byte inbound
- Automatic credit management
- ECRC generation and checking
- Configurable BAR filtering
- Legacy interrupt reception (RC) and generation (EP)
- MSI generation and reception
- PCI Express Active State Power Management (ASPM) state L0s and L1 (with exceptions)
- All PCI Device Power Management D-states with the exception of D3<sub>cold</sub> / L2 state

The PCIe controller on this device conforms to the PCI Express Base 3.0 Specification, revision 1.0 and the PCI Local Bus Specification, revision 3.0.

**NOTE**

For more information, see the PCIe Controller section of the Device TRM.

### 5.10.6.17 CAN

#### 5.10.6.17.1 DCAN

The device provides two DCAN interfaces for supporting distributed realtime control with a high level of security.

The DCAN interface implements the following features:

- Supports CAN protocol version 2.0 part A, B
- Bit rates up to 1 MBit/s
- 64 message objects
- Individual identifier mask for each message object
- Programmable FIFO mode for message objects
- Programmable loop-back modes for self-test operation
- Suspend mode for debug support
- Automatic bus on after Bus-Off state by a programmable 32-bit timer
- Message RAM single error correction and double error detection (SECEDED) mechanism
- Direct access to Message RAM during test mode
- Support for two interrupt lines: Level 0 and Level 1, plus separate ECC interrupt line
- Local power down and wakeup support
- Automatic message RAM initialization
- Support for DMA access

#### 5.10.6.17.2 MCAN-FD

The device supports one MCAN module connecting to the CAN network through external (for the device) transceiver for connection to the physical layer. The MCAN module supports up to 5 Mbit/s data rate and is compliant to ISO 11898-1:2015.

The MCAN-FD module implements the following features:

- Conforms with ISO 11898-1:2015
- Full CAN FD support (up to 64 data bytes)
- AUTOSAR and SAE J1939 support
- Up to 32 dedicated Transmit Buffers
- Configurable Transmit FIFO, up to 32 elements
- Configurable Transmit Queue, up to 32 elements
- Configurable Transmit Event FIFO, up to 32 elements
- Up to 64 dedicated Receive Buffers
- Two configurable Receive FIFOs, up to 64 elements each
- Up to 128 filter elements
- Internal Loopback mode for self-test
- Maskable interrupts, two interrupt lines
- Two clock domains (CAN clock/Host clock)
- Parity/ECC support - Message RAM single error correction and double error detection (SECEDED) mechanism
- Local power-down and wakeup support
- Timestamp Counter

**NOTE**

For more information, see the Serial Communication Interfaces / DCAN and MCAN sections of the Device TRM.

**NOTE**

The Controller Area Network Interface x (x = 1 to 2) is also referred to as CANx.

**NOTE**

Refer to the CAN Specification for calculations necessary to validate timing compliance. Jitter tolerance calculations must be performed to validate the implementation.

[Table 5-94](#) and [Table 5-95](#) present timing and switching characteristics for CANx Interface.

**Table 5-94. Timing Requirements for CANx Receive**

| NO. | PARAMETER               | DESCRIPTION                                      | MIN | MAX | UNIT |
|-----|-------------------------|--------------------------------------------------|-----|-----|------|
| -   | f(baud)                 | Maximum programmable baud rate                   |     | 1   | Mbps |
| -   | t <sub>d</sub> (CANnRX) | Delay time, CANnRX pin to receive shift register |     | 12  | ns   |

**Table 5-95. Switching Characteristics Over Recommended Operating Conditions for CANx Transmit**

| NO. | PARAMETER               | DESCRIPTION                                                      | MIN | MAX | UNIT |
|-----|-------------------------|------------------------------------------------------------------|-----|-----|------|
| -   | f(baud)                 | Maximum programmable baud rate                                   |     | 1   | Mbps |
| -   | t <sub>d</sub> (CANnTX) | Delay time, Transmit shift register to CANnTX pin <sup>(1)</sup> |     | 12  | ns   |

(1) These values do not include rise/fall times of the output buffer.

#### 5.10.6.18 GMAC\_SW

The three-port gigabit ethernet switch subsystem (GMAC\_SW) provides ethernet packet communication and can be configured as an ethernet switch. It provides the Gigabit Media Independent Interface (G/MII) in MII mode, Reduced Gigabit Media Independent Interface (RGMII), Reduced Media Independent Interface (RMII), and the Management Data Input/Output (MDIO) for physical layer device (PHY) management.

**NOTE**

For more information, see the Ethernet Subsystem section of the Device TRM.

**NOTE**

The Gigabit, Reduced and Media Independent Interface n (n = 0 to 1) are also referred to as MII<sub>n</sub>, RMII<sub>n</sub> and RGMII<sub>n</sub>.

**CAUTION**

The IO timings provided in this section are only valid if signals within a single IOSET are used. The IOSETs are defined in the [Table 5-100](#), [Table 5-103](#), [Table 5-108](#), and [Table 5-115](#).

**CAUTION**

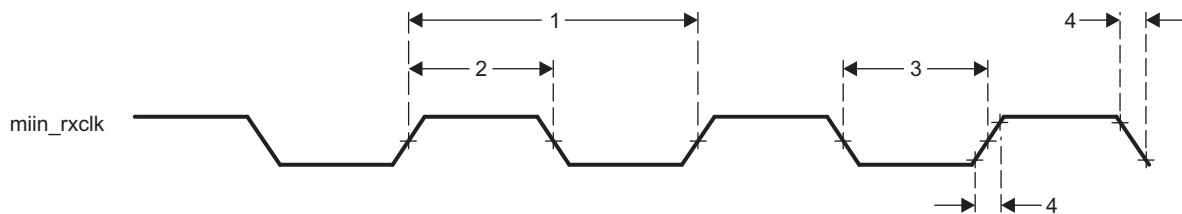
The IO Timings provided in this section are only valid for some GMAC usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

Table 5-96 and Figure 5-66 present timing requirements for MII in receive operation.

**5.10.6.18.1 GMAC MII Timings**

**Table 5-96. Timing Requirements for miin\_rxclk - MII Operation**

| NO.  | PARAMETER         | DESCRIPTION                     | SPEED    | MIN | MAX | UNIT |
|------|-------------------|---------------------------------|----------|-----|-----|------|
| MII1 | $t_{c(RX\_CLK)}$  | Cycle time, miin_rxclk          | 10 Mbps  | 400 |     | ns   |
|      |                   |                                 | 100 Mbps | 40  |     | ns   |
| MII2 | $t_{w(RX\_CLKH)}$ | Pulse duration, miin_rxclk high | 10 Mbps  | 140 | 260 | ns   |
|      |                   |                                 | 100 Mbps | 14  | 26  | ns   |
| MII3 | $t_{w(RX\_CLKL)}$ | Pulse duration, miin_rxclk low  | 10 Mbps  | 140 | 260 | ns   |
|      |                   |                                 | 100 Mbps | 14  | 26  | ns   |
| MII4 | $t_t(RX\_CLK)$    | Transition time, miin_rxclk     | 10 Mbps  |     | 3   | ns   |
|      |                   |                                 | 100 Mbps |     | 3   | ns   |

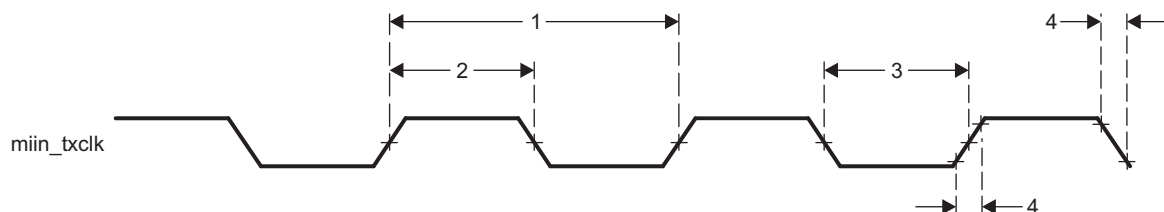


**Figure 5-66. Clock Timing (GMAC Receive) - MII Operation**

Table 5-97 and Figure 5-67 present timing requirements for MII in transmit operation.

**Table 5-97. Timing Requirements for miin\_txclk - MII Operation**

| NO.  | PARAMETER         | DESCRIPTION                     | SPEED    | MIN | MAX | UNIT |
|------|-------------------|---------------------------------|----------|-----|-----|------|
| MII1 | $t_{c(TX\_CLK)}$  | Cycle time, miin_txclk          | 10 Mbps  | 400 |     | ns   |
|      |                   |                                 | 100 Mbps | 40  |     | ns   |
| MII2 | $t_{w(TX\_CLKH)}$ | Pulse duration, miin_txclk high | 10 Mbps  | 140 | 260 | ns   |
|      |                   |                                 | 100 Mbps | 14  | 26  | ns   |
| MII3 | $t_{w(TX\_CLKL)}$ | Pulse duration, miin_txclk low  | 10 Mbps  | 140 | 260 | ns   |
|      |                   |                                 | 100 Mbps | 14  | 26  | ns   |
| MII4 | $t_t(TX\_CLK)$    | Transition time, miin_txclk     | 10 Mbps  |     | 3   | ns   |
|      |                   |                                 | 100 Mbps |     | 3   | ns   |

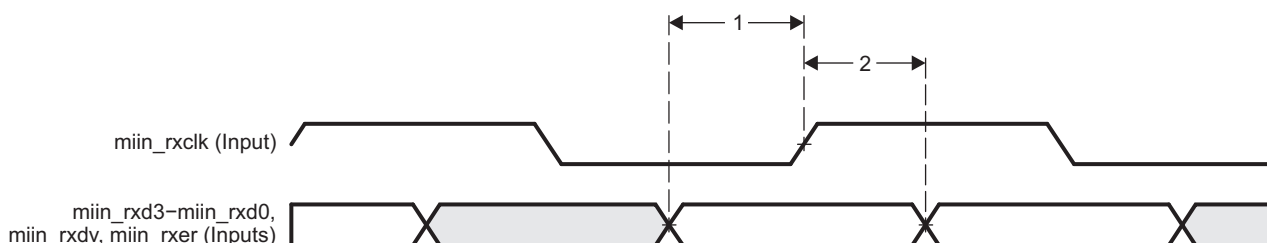


**Figure 5-67. Clock Timing (GMAC Transmit) - MII Operation**

Table 5-98 and Figure 5-68 present timing requirements for GMAC MIIn Receive 10/100Mbit/s.

**Table 5-98. Timing Requirements for GMAC MIIn Receive 10/100 Mbit/s**

| NO.  | PARAMETER                | DESCRIPTION                                                  | MIN | MAX | UNIT |
|------|--------------------------|--------------------------------------------------------------|-----|-----|------|
| MII1 | $t_{su}(RXD-RX\_CLK)$    | Setup time, receive selected signals valid before miin_rxclk | 8   |     | ns   |
|      | $t_{su}(RX\_DV-RX\_CLK)$ |                                                              |     |     |      |
|      | $t_{su}(RX\_ER-RX\_CLK)$ |                                                              |     |     |      |
| MII2 | $t_h(RX\_CLK-RXD)$       | Hold time, receive selected signals valid after miin_rxclk   | 8   |     | ns   |
|      | $t_h(RX\_CLK-RX\_DV)$    |                                                              |     |     |      |
|      | $t_h(RX\_CLK-RX\_ER)$    |                                                              |     |     |      |

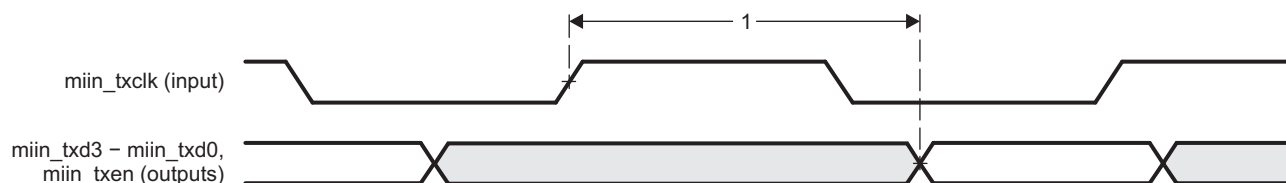


**Figure 5-68. GMAC Receive Interface Timing MIIn Operation**

Table 5-99 and Figure 5-69 present timing requirements for GMAC MIIn Transmit 10/100Mbit/s.

**Table 5-99. Switching Characteristics Over Recommended Operating Conditions for GMAC MIIn Transmit 10/100 Mbits/s**

| NO.  | PARAMETER             | DESCRIPTION                                               | MIN | MAX | UNIT |
|------|-----------------------|-----------------------------------------------------------|-----|-----|------|
| MII1 | $t_d(TX\_CLK-TXD)$    | Delay time, miin_txclk to transmit selected signals valid | 0   | 25  | ns   |
|      | $t_d(TX\_CLK-TX\_EN)$ |                                                           |     |     |      |



**Figure 5-69. GMAC Transmit Interface Timing MIIn Operation**

In Table 5-100 are presented the specific groupings of signals (IOSET) for use with GMAC MII signals.

**Table 5-100. GMAC MII IOSETs**

| SIGNALS          | IOSET5 |     | IOSET6 |     |
|------------------|--------|-----|--------|-----|
|                  | BALL   | MUX | BALL   | MUX |
| <b>GMAC MII1</b> |        |     |        |     |
| mii1_txd3        | C5     | 8   |        |     |
| mii1_txd2        | D6     | 8   |        |     |
| mii1_txd1        | B2     | 8   |        |     |
| mii1_txd0        | C4     | 8   |        |     |
| mii1_rxd3        | F5     | 8   |        |     |
| mii1_rxd2        | E4     | 8   |        |     |
| mii1_rxd1        | C1     | 8   |        |     |
| mii1_rxd0        | E6     | 8   |        |     |

**Table 5-100. GMAC MII IOSETs (continued)**

| SIGNALS          | IOSET5 |     | IOSET6 |     |
|------------------|--------|-----|--------|-----|
|                  | BALL   | MUX | BALL   | MUX |
| mii1_col         | B4     | 8   |        |     |
| mii1_rxr         | B3     | 8   |        |     |
| mii1_txr         | A3     | 8   |        |     |
| mii1_txen        | A4     | 8   |        |     |
| mii1_crs         | B5     | 8   |        |     |
| mii1_rxclk       | D5     | 8   |        |     |
| mii1_txclk       | C3     | 8   |        |     |
| mii1_rxdv        | C2     | 8   |        |     |
| <b>GMAC MII0</b> |        |     |        |     |
| mii0_txd3        |        |     | V5     | 3   |
| mii0_txd2        |        |     | V4     | 3   |
| mii0_txd1        |        |     | Y2     | 3   |
| mii0_txd0        |        |     | W2     | 3   |
| mii0_rxd3        |        |     | W9     | 3   |
| mii0_rxd2        |        |     | V9     | 3   |
| mii0_rxd1        |        |     | V6     | 3   |
| mii0_rxd0        |        |     | U6     | 3   |
| mii0_txclk       |        |     | U5     | 3   |
| mii0_txr         |        |     | U4     | 3   |
| mii0_rxr         |        |     | U7     | 3   |
| mii0_rxdv        |        |     | V2     | 3   |
| mii0_crs         |        |     | V7     | 3   |
| mii0_col         |        |     | V1     | 3   |
| mii0_rxclk       |        |     | Y1     | 3   |
| mii0_txen        |        |     | V3     | 3   |

#### 5.10.6.18.2 GMAC MDIO Interface Timings

#### CAUTION

The IO Timings provided in this section are only valid for some GMAC usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

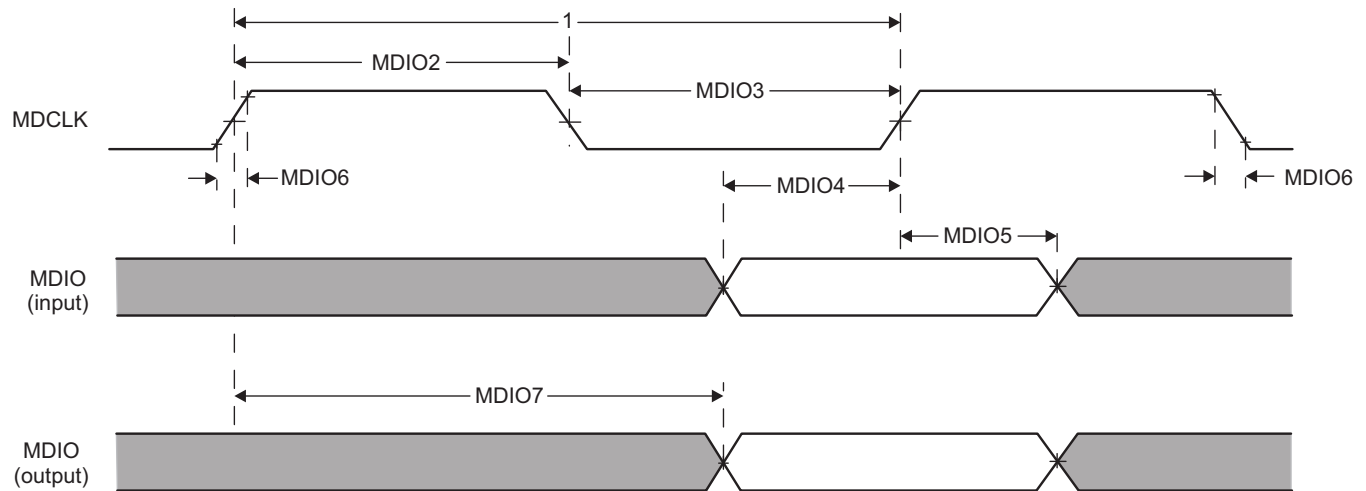
Table 5-101, Table 5-101 and Figure 5-70 present timing requirements for MDIO.

**Table 5-101. Timing Requirements for MDIO Input**

| No    | PARAMETER          | DESCRIPTION                            | MIN | MAX | UNIT |
|-------|--------------------|----------------------------------------|-----|-----|------|
| MDIO1 | $t_{c(MDC)}$       | Cycle time, MDC                        | 400 |     | ns   |
| MDIO2 | $t_{w(MDCH)}$      | Pulse Duration, MDC High               | 160 |     | ns   |
| MDIO3 | $t_{w(MDCL)}$      | Pulse Duration, MDC Low                | 160 |     | ns   |
| MDIO4 | $t_{su(MDIO-MDC)}$ | Setup time, MDIO valid before MDC High | 90  |     | ns   |
| MDIO5 | $t_{h(MDIO\_MDC)}$ | Hold time, MDIO valid from MDC High    | 0   |     | ns   |

**Table 5-102. Switching Characteristics Over Recommended Operating Conditions for MDIO Output**

| NO    | PARAMETER         | DESCRIPTION                        | MIN | MAX | UNIT |
|-------|-------------------|------------------------------------|-----|-----|------|
| MDIO6 | $t_{t(MDC)}$      | Transition time, MDC               |     | 5   | ns   |
| MDIO7 | $t_{d(MDC-MDIO)}$ | Delay time, MDC High to MDIO valid | 10  | 390 | ns   |

**Figure 5-70. GMAC MDIO Diagrams**

In [Table 5-103](#) are presented the specific groupings of signals (IOSET) for use with GMAC MDIO signals.

**Table 5-103. GMAC MDIO IOSETs**

| SIGNALS   | IOSET7 |     | IOSET8 |     | IOSET9 |     | IOSET10 |     |
|-----------|--------|-----|--------|-----|--------|-----|---------|-----|
|           | BALL   | MUX | BALL   | MUX | BALL   | MUX | BALL    | MUX |
| mdio_d    | F6     | 3   | U4     | 0   | AB4    | 1   | B20     | 5   |
| mdio_mclk | D3     | 3   | V1     | 0   | AC5    | 1   | B21     | 5   |

### 5.10.6.18.3 GMAC RMII Timings

The main reference clock REF\_CLK (RMII\_50MHZ\_CLK) of RMII interface is internally supplied from PRCM. The source of this clock could be either externally sourced from the RMII\_MHZ\_50\_CLK pin of the device or internally generated from DPLL\_GMAC output clock GMAC\_RMII\_HS\_CLK. Please see the PRCM chapter of the Device TRM for full details about RMII reference clock.

#### CAUTION

The IO Timings provided in this section are only valid for some GMAC usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

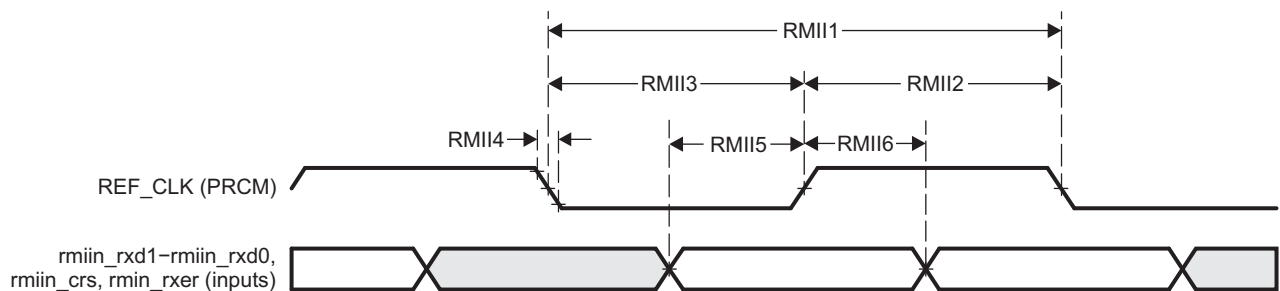
Table 5-104, Table 5-105 and Figure 5-71 present timing requirements for GMAC RMII In Receive.

**Table 5-104. Timing Requirements for GMAC REF\_CLK - RMII Operation**

| NO.   | PARAMETER          | DESCRIPTION                  | MIN | MAX | UNIT |
|-------|--------------------|------------------------------|-----|-----|------|
| RMII1 | $t_{c(REF\_CLK)}$  | Cycle time, REF_CLK          | 20  |     | ns   |
| RMII2 | $t_{w(REF\_CLKH)}$ | Pulse duration, REF_CLK high | 7   | 13  | ns   |
| RMII3 | $t_{w(REF\_CLKL)}$ | Pulse duration, REF_CLK low  | 7   | 13  | ns   |
| RMII4 | $t_{tt(REF\_CLK)}$ | Transistion time, REF_CLK    |     | 3   | ns   |

**Table 5-105. Timing Requirements for GMAC RMII In Receive**

| NO.   | PARAMETER                  | DESCRIPTION                                               | MIN | MAX | UNIT |
|-------|----------------------------|-----------------------------------------------------------|-----|-----|------|
| RMII5 | $t_{su(RXD-REF\_CLK)}$     | Setup time, receive selected signals valid before REF_CLK | 4   |     | ns   |
|       | $t_{su(CRS\_DV-REF\_CLK)}$ |                                                           |     |     |      |
|       | $t_{su(RX\_ER-REF\_CLK)}$  |                                                           |     |     |      |
| RMII6 | $t_{h(REF\_CLK-RXD)}$      | Hold time, receive selected signals valid after REF_CLK   | 2   |     | ns   |
|       | $t_{h(REF\_CLK-CRS\_DV)}$  |                                                           |     |     |      |
|       | $t_{h(REF\_CLK-RX\_ER)}$   |                                                           |     |     |      |



SPRS8xx\_GMAC\_RMII RX\_05

**Figure 5-71. GMAC Receive Interface Timing RMII In Operation**

Table 5-106, Table 5-106 and Figure 5-72 present switching characteristics for GMAC RMII In Transmit 10/100Mbit/s.

**Table 5-106. Switching Characteristics Over Recommended Operating Conditions for GMAC REF\_CLK - RMII Operation**

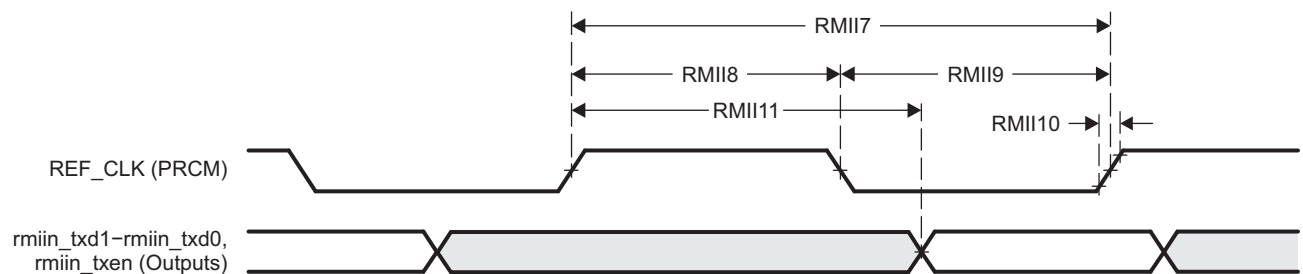
| NO.   | PARAMETER          | DESCRIPTION                  | MIN | MAX | UNIT |
|-------|--------------------|------------------------------|-----|-----|------|
| RMII7 | $t_{c(REF\_CLK)}$  | Cycle time, REF_CLK          | 20  |     | ns   |
| RMII8 | $t_{w(REF\_CLKH)}$ | Pulse duration, REF_CLK high | 7   | 13  | ns   |

**Table 5-106. Switching Characteristics Over Recommended Operating Conditions for GMAC REF\_CLK - RMII Operation (continued)**

| NO.    | PARAMETER         | DESCRIPTION                 | MIN | MAX | UNIT |
|--------|-------------------|-----------------------------|-----|-----|------|
| RMII9  | $t_{w(REF\_CLK)}$ | Pulse duration, REF_CLK low | 7   | 13  | ns   |
| RMII10 | $t_{f(REF\_CLK)}$ | Transistion time, REF_CLK   |     | 3   | ns   |

**Table 5-107. Switching Characteristics Over Recommended Operating Conditions for GMAC RMII<sub>n</sub> Transmit 10/100 Mbits/s**

| NO.    | PARAMETER               | DESCRIPTION                                                 | RMII <sub>n</sub> | MIN | MAX  | UNIT |
|--------|-------------------------|-------------------------------------------------------------|-------------------|-----|------|------|
| RMII11 | $t_d(REF\_CLK-TXD)$     | Delay time, REF_CLK high to selected transmit signals valid | RMII0             | 2   | 13.5 | ns   |
|        | $t_{dd}(REF\_CLK-TXEN)$ |                                                             |                   |     |      |      |
|        | $t_d(REF\_CLK-TXD)$     |                                                             | RMII1             | 2   | 13.8 | ns   |
|        | $t_{dd}(REF\_CLK-TXEN)$ |                                                             |                   |     |      |      |



SPRS990F\_GMAC\_RMII\_TX\_06

**Figure 5-72. GMAC Transmit Interface Timing RMII<sub>n</sub> Operation**

In [Table 5-108](#) are presented the specific groupings of signals (IOSET) for use with GMAC RMII signals.

**Table 5-108. GMAC RMII IOSETs**

| SIGNALS           | IOSET1 |     | IOSET2 |     |
|-------------------|--------|-----|--------|-----|
|                   | BALL   | MUX | BALL   | MUX |
| <b>GMAC RMII1</b> |        |     |        |     |
| RMII_MHZ_50_CLK   | U3     | 0   |        |     |
| rmi11_txd1        | V5     | 2   |        |     |
| rmi11_txd0        | V4     | 2   |        |     |
| rmi11_rxd1        | W9     | 2   |        |     |
| rmi11_rxd0        | V9     | 2   |        |     |
| rmi11_rxer        | Y1     | 2   |        |     |
| rmi11_txen        | U5     | 2   |        |     |
| rmi11_crs         | V2     | 2   |        |     |
| <b>GMAC RMII0</b> |        |     |        |     |
| RMII_MHZ_50_CLK   |        |     | U3     | 0   |
| rmi0_txd1         |        |     | Y2     | 1   |
| rmi0_txd0         |        |     | W2     | 1   |
| rmi0_rxd1         |        |     | V6     | 1   |
| rmi0_rxd0         |        |     | U6     | 1   |
| rmi0_txen         |        |     | V3     | 1   |
| rmi0_rxer         |        |     | U7     | 1   |
| rmi0_crs          |        |     | V7     | 1   |

Manual IO Timings Modes must be used to guarantee some IO timings for GMAC. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-109, Manual Functions Mapping for GMAC RMII0](#) for a definition of the Manual modes.

[Table 5-109](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-109. Manual Functions Mapping for GMAC RMII0**

| BALL | BALL NAME       | GMAC_RMII0_MANUAL1 |              | CFG REGISTER           | MUXMODE         |            |
|------|-----------------|--------------------|--------------|------------------------|-----------------|------------|
|      |                 | A_DELAY (ps)       | G_DELAY (ps) |                        | 0               | 1          |
| U3   | RMII_MHZ_50_CLK | 0                  | 0            | CFG_RMII_MHZ_50_CLK_IN | RMII_MHZ_50_CLK |            |
| U6   | rgmii0_txd0     | 500                | 500          | CFG_RGMII0_TXD0_IN     |                 | rmii0_rxd0 |
| V6   | rgmii0_txd1     | 840                | 1000         | CFG_RGMII0_TXD1_IN     |                 | rmii0_rxd1 |
| U7   | rgmii0_txd2     | 360                | 840          | CFG_RGMII0_TXD2_IN     |                 | rmii0_rxer |
| V7   | rgmii0_txd3     | 600                | 1000         | CFG_RGMII0_TXD3_IN     |                 | rmii0_crs  |

Manual IO Timings Modes must be used to guarantee some IO timings for GMAC. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-110, Manual Functions Mapping for GMAC RMII1](#) for a definition of the Manual modes.

[Table 5-110](#) list the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-110. Manual Functions Mapping for GMAC RMII1**

| BALL | BALL NAME       | GMAC_RMII1_MANUAL1 |              | CFG REGISTER           | MUXMODE         |            |
|------|-----------------|--------------------|--------------|------------------------|-----------------|------------|
|      |                 | A_DELAY (ps)       | G_DELAY (ps) |                        | 0               | 2          |
| U3   | RMII_MHZ_50_CLK | 0                  | 0            | CFG_RMII_MHZ_50_CLK_IN | RMII_MHZ_50_CLK |            |
| W9   | rgmii0_txc      | 300                | 1200         | CFG_RGMII0_TXC_IN      |                 | rmii1_rxd1 |
| V9   | rgmii0_txctl    | 300                | 1000         | CFG_RGMII0_TXCTL_IN    |                 | rmii1_rxd0 |
| V2   | uart3_rxd       | 400                | 700          | CFG_UART3_RXD_IN       |                 | rmii1_crs  |
| Y1   | uart3_txd       | 300                | 500          | CFG_UART3_TXD_IN       |                 | rmii1_rxer |

#### 5.10.6.18.4 GMAC RGMII Timings

##### CAUTION

The IO Timings provided in this section are only valid for some GMAC usage modes when the corresponding Virtual IO Timings or Manual IO Timings are configured as described in the tables found in this section.

[Table 5-111](#), [Table 5-112](#) and [Figure 5-73](#) present timing requirements for receive RGMII operation.

**Table 5-111. Timing Requirements for rgmiin\_rxc - RGMII Operation**

| NO.    | PARAMETER     | DESCRIPTION                     | SPEED     | MIN | MAX | UNIT |
|--------|---------------|---------------------------------|-----------|-----|-----|------|
| RGMII1 | $t_{c(RXC)}$  | Cycle time, rgmiin_rxc          | 10 Mbps   | 360 | 440 | ns   |
|        |               |                                 | 100 Mbps  | 36  | 44  | ns   |
|        |               |                                 | 1000 Mbps | 7.2 | 8.8 | ns   |
| RGMII2 | $t_{w(RXCH)}$ | Pulse duration, rgmiin_rxc high | 10 Mbps   | 160 | 240 | ns   |
|        |               |                                 | 100 Mbps  | 16  | 24  | ns   |
|        |               |                                 | 1000 Mbps | 3.6 | 4.4 | ns   |

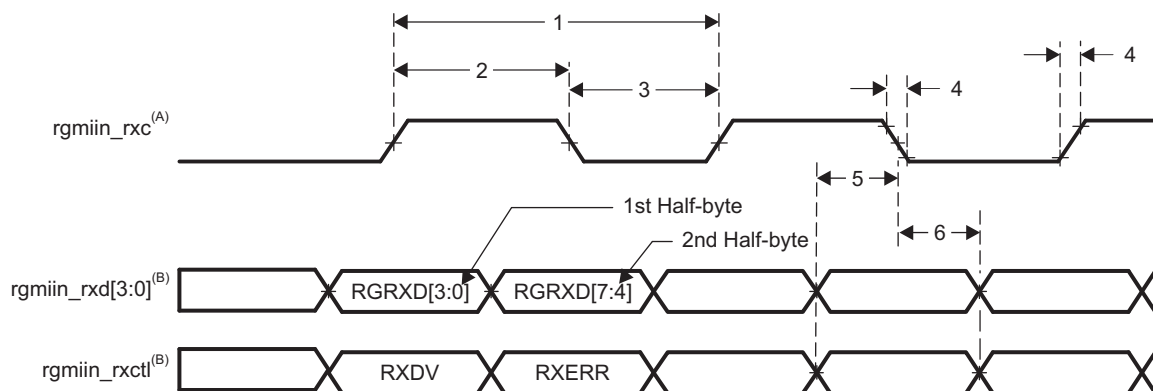
**Table 5-111. Timing Requirements for rgmiin\_rxc - RGMII In Operation (continued)**

| NO.    | PARAMETER     | DESCRIPTION                    | SPEED     | MIN | MAX  | UNIT |
|--------|---------------|--------------------------------|-----------|-----|------|------|
| RGMII3 | $t_{w(RXCL)}$ | Pulse duration, rgmiin_rxc low | 10 Mbps   | 160 | 240  | ns   |
|        |               |                                | 100 Mbps  | 16  | 24   | ns   |
|        |               |                                | 1000 Mbps | 3.6 | 4.4  | ns   |
| RGMII4 | $t_{t(RXC)}$  | Transition time, rgmiin_rxc    | 10 Mbps   |     | 0.75 | ns   |
|        |               |                                | 100 Mbps  |     | 0.75 | ns   |
|        |               |                                | 1000 Mbps |     | 0.75 | ns   |

**Table 5-112. Timing Requirements for GMAC RGMII In Input Receive for 10/100/1000 Mbps <sup>(1)</sup>**

| NO.    | PARAMETER          | DESCRIPTION                                                           | MIN | MAX | UNIT |
|--------|--------------------|-----------------------------------------------------------------------|-----|-----|------|
| RGMII5 | $t_{su(RXD-RXCH)}$ | Setup time, receive selected signals valid before rgmiin_rxc high/low | 1   |     | ns   |
| RGMII6 | $t_{h(RXCH-RXD)}$  | Hold time, receive selected signals valid after rgmiin_rxc high/low   | 1   |     | ns   |

(1) For RGMII, receive selected signals include: rgmiin\_rxd[3:0] and rgmiin\_rxctl.



- A. rgmiin\_rxc must be externally delayed relative to the data and control pins.
- B. Data and control information is received using both edges of the clocks. rgmiin\_rxd[3:0] carries data bits 3-0 on the rising edge of rgmiin\_rxc and data bits 7-4 on the falling edge of rgmiin\_rxc. Similarly, rgmiin\_rxctl carries RXDV on rising edge of rgmiin\_rxc and RXERR on falling edge of rgmiin\_rxc.

**Figure 5-73. GMAC Receive Interface Timing, RGMII In Operation**

Table 5-113, Table 5-114 and Figure 5-74 present switching characteristics for transmit - RGMII In for 10/100/1000Mbit/s.

**Table 5-113. Switching Characteristics Over Recommended Operating Conditions for rgmiin\_txctl - RGMII In Operation for 10/100/1000 Mbit/s**

| NO.    | PARAMETER     | DESCRIPTION                     | SPEED     | MIN | MAX  | UNIT |
|--------|---------------|---------------------------------|-----------|-----|------|------|
| RGMII1 | $t_{c(TXC)}$  | Cycle time, rgmiin_txc          | 10 Mbps   | 360 | 440  | ns   |
|        |               |                                 | 100 Mbps  | 36  | 44   | ns   |
|        |               |                                 | 1000 Mbps | 7.2 | 8.8  | ns   |
| RGMII2 | $t_{w(TXCH)}$ | Pulse duration, rgmiin_txc high | 10 Mbps   | 160 | 240  | ns   |
|        |               |                                 | 100 Mbps  | 16  | 24   | ns   |
|        |               |                                 | 1000 Mbps | 3.6 | 4.4  | ns   |
| RGMII3 | $t_{w(TXCL)}$ | Pulse duration, rgmiin_txc low  | 10 Mbps   | 160 | 240  | ns   |
|        |               |                                 | 100 Mbps  | 16  | 24   | ns   |
|        |               |                                 | 1000 Mbps | 3.6 | 4.4  | ns   |
| RGMII4 | $t_{t(TXC)}$  | Transition time, rgmiin_txc     | 10 Mbps   |     | 0.75 | ns   |
|        |               |                                 | 100 Mbps  |     | 0.75 | ns   |
|        |               |                                 | 1000 Mbps |     | 0.75 | ns   |

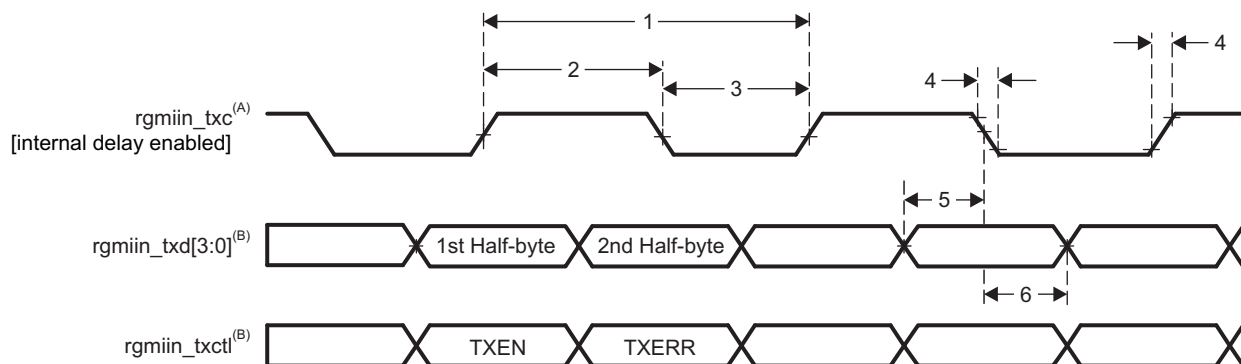
**Table 5-114. Switching Characteristics for GMAC RGMII<sub>n</sub> Output Transmit for 10/100/1000 Mbps <sup>(1)</sup>**

| NO.    | PARAMETER                        | DESCRIPTION                                                                 | MODE                                        | MIN                 | MAX | UNIT |
|--------|----------------------------------|-----------------------------------------------------------------------------|---------------------------------------------|---------------------|-----|------|
| RGMII5 | $t_{\text{osu}}(\text{TxD-TXC})$ | Output Setup time, transmit selected signals valid to rgmiin_txc high/low   | RGMII0, Internal Delay Enabled, 1000 Mbps   | 1.05 <sup>(2)</sup> |     | ns   |
|        |                                  |                                                                             | RGMII0, Internal Delay Enabled, 10/100 Mbps | 1.2                 |     | ns   |
|        |                                  |                                                                             | RGMII1, Internal Delay Enabled, 1000 Mbps   | 1.05 <sup>(3)</sup> |     | ns   |
|        |                                  |                                                                             | RGMII1, Internal Delay Enabled, 10/100 Mbps | 1.2                 |     | ns   |
| RGMII6 | $t_{\text{oh}}(\text{TXC-TXD})$  | Output Hold time, transmit selected signals valid after rgmiin_txc high/low | RGMII0, Internal Delay Enabled, 1000 Mbps   | 1.05 <sup>(2)</sup> |     | ns   |
|        |                                  |                                                                             | RGMII0, Internal Delay Enabled, 10/100 Mbps | 1.2                 |     | ns   |
|        |                                  |                                                                             | RGMII1, Internal Delay Enabled, 1000 Mbps   | 1.05 <sup>(3)</sup> |     | ns   |
|        |                                  |                                                                             | RGMII1, Internal Delay Enabled, 10/100 Mbps | 1.2                 |     | ns   |

(1) For RGMII, transmit selected signals include: rgmiin\_txd[3:0] and rgmiin\_txctl.

(2) RGMII0 1000Mbps operation requires that the 4 data pins rgmiio\_txd[3:0] and rgmiio\_txctl have their board propagation delays matched within 50pS of rgmiio\_txc.

(3) RGMII1 1000Mbps operation requires that the 4 data pins rgmii1\_txd[3:0] and rgmii1\_txctl have their board propagation delays matched within 50pS of rgmii1\_txc.



- A. TxC is delayed internally before being driven to the rgmiin\_txc pin. This internal delay is always enabled.  
 B. Data and control information is transmitted using both edges of the clocks. rgmiin\_txd[3:0] carries data bits 3-0 on the rising edge of rgmiin\_txc and data bits 7-4 on the falling edge of rgmiin\_txc. Similarly, rgmiin\_txctl carries TXEN on rising edge of rgmiin\_txc and TXERR on falling edge of rgmiin\_txc.

**Figure 5-74. GMAC Transmit Interface Timing RGMII<sub>n</sub> Operation**

In [Table 5-115](#) are presented the specific groupings of signals (IOSET) for use with GMAC RGMII signals.

**Table 5-115. GMAC RGMII IOSETs**

| SIGNALS            | IOSET3 |     | IOSET4 |     |
|--------------------|--------|-----|--------|-----|
|                    | BALL   | MUX | BALL   | MUX |
| <b>GMAC RGMII1</b> |        |     |        |     |
| rgmii1_txd3        | C3     | 3   |        |     |
| rgmii1_txd2        | C4     | 3   |        |     |
| rgmii1_txd1        | B2     | 3   |        |     |
| rgmii1_txd0        | D6     | 3   |        |     |
| rgmii1_rxd3        | B3     | 3   |        |     |
| rgmii1_rxd2        | B4     | 3   |        |     |
| rgmii1_rxd1        | B5     | 3   |        |     |

**Table 5-115. GMAC RGMII IOSETs (continued)**

| SIGNALS            | IOSET3 |     | IOSET4 |     |
|--------------------|--------|-----|--------|-----|
|                    | BALL   | MUX | BALL   | MUX |
| rgmii1_rxd0        | A4     | 3   |        |     |
| rgmii1_rxctl       | A3     | 3   |        |     |
| rgmii1_txc         | D5     | 3   |        |     |
| rgmii1_txctl       | C2     | 3   |        |     |
| rgmii1_rxc         | C5     | 3   |        |     |
| <b>GMAC RGMII0</b> |        |     |        |     |
| rgmii0_txd3        |        |     | V7     | 0   |
| rgmii0_txd2        |        |     | U7     | 0   |
| rgmii0_txd1        |        |     | V6     | 0   |
| rgmii0_txd0        |        |     | U6     | 0   |
| rgmii0_rxd3        |        |     | V4     | 0   |
| rgmii0_rxd2        |        |     | V3     | 0   |
| rgmii0_rxd1        |        |     | Y2     | 0   |
| rgmii0_rxd0        |        |     | W2     | 0   |
| rgmii0_txc         |        |     | W9     | 0   |
| rgmii0_rxctl       |        |     | V5     | 0   |
| rgmii0_rxc         |        |     | U5     | 0   |
| rgmii0_txctl       |        |     | V9     | 0   |

**NOTE**

To configure the desired Manual IO Timing Mode the user must follow the steps described in section "Manual IO Timing Modes" of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information please see the *Control Module Chapter* in the Device TRM.

Manual IO Timings Modes must be used to guarantee some IO timings for GMAC. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-116, Manual Functions Mapping for GMAC RGMII0](#) for a definition of the Manual modes.

[Table 5-117](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-116. Manual Functions Mapping for GMAC RGMII0**

| BALL | BALL NAME    | GMAC_RGMII0_MANUAL1 |              | CFG REGISTER         | MUXMODE      |
|------|--------------|---------------------|--------------|----------------------|--------------|
|      |              | A_DELAY (ps)        | G_DELAY (ps) |                      | 0            |
| U5   | rgmii0_rxc   | 451                 | 0            | CFG_RGMII0_RXC_IN    | rgmii0_rxc   |
| V5   | rgmii0_rxctl | 127                 | 1571         | CFG_RGMII0_RXCTL_IN  | rgmii0_rxctl |
| W2   | rgmii0_rxd0  | 165                 | 1178         | CFG_RGMII0_RXD0_IN   | rgmii0_rxd0  |
| Y2   | rgmii0_rxd1  | 136                 | 1302         | CFG_RGMII0_RXD1_IN   | rgmii0_rxd1  |
| V3   | rgmii0_rxd2  | 0                   | 1520         | CFG_RGMII0_RXD2_IN   | rgmii0_rxd2  |
| V4   | rgmii0_rxd3  | 28                  | 1690         | CFG_RGMII0_RXD3_IN   | rgmii0_rxd3  |
| W9   | rgmii0_txc   | 121                 | 0            | CFG_RGMII0_TXC_OUT   | rgmii0_txc   |
| V9   | rgmii0_txctl | 410                 | 0            | CFG_RGMII0_TXCTL_OUT | rgmii0_txctl |
| U6   | rgmii0_txd0  | 483                 | 0            | CFG_RGMII0_TXD0_OUT  | rgmii0_txd0  |
| V6   | rgmii0_txd1  | 335                 | 0            | CFG_RGMII0_TXD1_OUT  | rgmii0_txd1  |
| U7   | rgmii0_txd2  | 330                 | 0            | CFG_RGMII0_TXD2_OUT  | rgmii0_txd2  |

**Table 5-116. Manual Functions Mapping for GMAC RGMII0 (continued)**

| BALL | BALL NAME   | GMAC_RGMII0_MANUAL1 |              | CFG REGISTER        | MUXMODE     |
|------|-------------|---------------------|--------------|---------------------|-------------|
|      |             | A_DELAY (ps)        | G_DELAY (ps) |                     |             |
| V7   | rgmii0_txd3 | 522                 | 0            | CFG_RGMII0_TXD3_OUT | rgmii0_txd3 |

Manual IO Timings Modes must be used to guarantee some IO timings for GMAC. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-117, Manual Functions Mapping for GMAC RGMII1](#) for a definition of the Manual modes.

[Table 5-117](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-117. Manual Functions Mapping for GMAC RGMII1**

| BALL | BALL NAME | GMAC_RGMII1_MANUAL1 |              | CFG REGISTER      | MUXMODE      |
|------|-----------|---------------------|--------------|-------------------|--------------|
|      |           | A_DELAY (ps)        | G_DELAY (ps) |                   |              |
| C5   | vin2a_d18 | 417                 | 0            | CFG_VIN2A_D18_IN  | rgmii1_rxc   |
| A3   | vin2a_d19 | 156                 | 843          | CFG_VIN2A_D19_IN  | rgmii1_rxctl |
| B3   | vin2a_d20 | 223                 | 1413         | CFG_VIN2A_D20_IN  | rgmii1_rxd3  |
| B4   | vin2a_d21 | 169                 | 1415         | CFG_VIN2A_D21_IN  | rgmii1_rxd2  |
| B5   | vin2a_d22 | 43                  | 1150         | CFG_VIN2A_D22_IN  | rgmii1_rxd1  |
| A4   | vin2a_d23 | 0                   | 1210         | CFG_VIN2A_D23_IN  | rgmii1_rxd0  |
| D5   | vin2a_d12 | 147                 | 0            | CFG_VIN2A_D12_OUT | rgmii1_txc   |
| C2   | vin2a_d13 | 480                 | 0            | CFG_VIN2A_D13_OUT | rgmii1_txctl |
| C3   | vin2a_d14 | 378                 | 0            | CFG_VIN2A_D14_OUT | rgmii1_txd3  |
| C4   | vin2a_d15 | 562                 | 0            | CFG_VIN2A_D15_OUT | rgmii1_txd2  |
| B2   | vin2a_d16 | 483                 | 0            | CFG_VIN2A_D16_OUT | rgmii1_txd1  |
| D6   | vin2a_d17 | 380                 | 0            | CFG_VIN2A_D17_OUT | rgmii1_txd0  |

#### 5.10.6.19 eMMC/SD/SDIO

The Device includes the following external memory interfaces 4 MultiMedia Card/Secure Digital/Secure Digital Input Output Interface (MMC/SD/SDIO).

##### NOTE

The eMMC/SD/SDIO<sub>i</sub> (i = 1 to 4) controller is also referred to as MMC<sub>i</sub>.

##### 5.10.6.19.1 MMC1—SD Card Interface

MMC1 interface is compliant with the SD Standard v3.01 and it supports the following SD Card applications:

- Default speed, 4-bit data, SDR, half-cycle
- High speed, 4-bit data, SDR, half-cycle
- SDR12, 4-bit data, half-cycle
- SDR25, 4-bit data, half-cycle
- UHS-I SDR50, 4-bit data, half-cycle
- UHS-I SDR104, 4-bit data, half-cycle
- UHS-I DDR50, 4-bit data

##### NOTE

For more information, see the eMMC/SD/SDIO chapter of the Device TRM.

### 5.10.6.19.1.1 Default speed, 4-bit data, SDR, half-cycle

Table 5-118 and Table 5-119 present Timing requirements and Switching characteristics for MMC1 - Default Speed in receiver and transmitter mode (see Figure 5-75 and Figure 5-76)

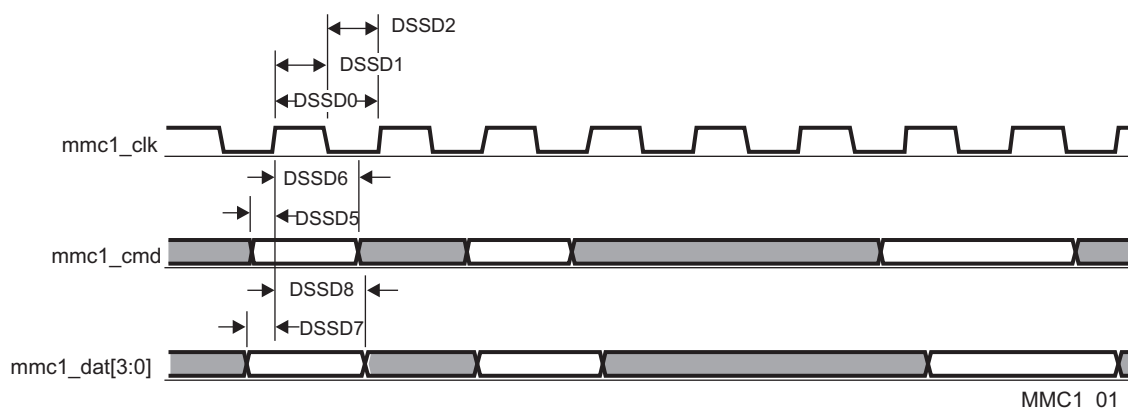
**Table 5-118. Timing Requirements for MMC1 - SD Card Default Speed Mode**

| NO.   | PARAMETER           | DESCRIPTION                                                       | MIN   | MAX | UNIT |
|-------|---------------------|-------------------------------------------------------------------|-------|-----|------|
| DSSD5 | $t_{su(cmdV-clkH)}$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge      | 5.11  |     | ns   |
| DSSD6 | $t_h(clkH-cmdV)$    | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge        | 20.46 |     | ns   |
| DSSD7 | $t_{su(dV-clkH)}$   | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge | 5.11  |     | ns   |
| DSSD8 | $t_h(clkH-dV)$      | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge   | 20.46 |     | ns   |

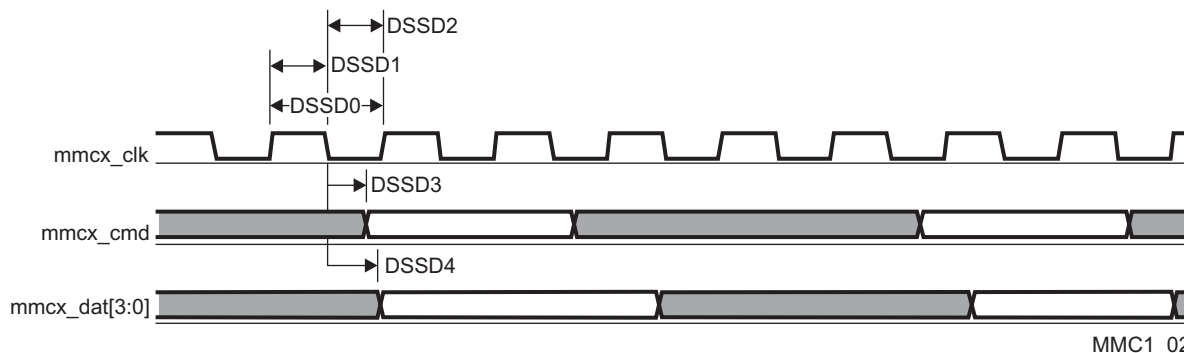
**Table 5-119. Switching Characteristics for MMC1 - SD Card Default Speed Mode**

| NO.   | PARAMETER        | DESCRIPTION                                                         | MIN                           | MAX   | UNIT |
|-------|------------------|---------------------------------------------------------------------|-------------------------------|-------|------|
| DSSD0 | fop(clk)         | Operating frequency, mmc1_clk                                       |                               | 24    | MHz  |
| DSSD1 | $t_{w(clkH)}$    | Pulse duration, mmc1_clk high                                       | 0.5P-<br>0.185 <sup>(1)</sup> |       | ns   |
| DSSD2 | $t_{w(clkL)}$    | Pulse duration, mmc1_clk low                                        | 0.5P-<br>0.185 <sup>(1)</sup> |       | ns   |
| DSSD3 | $t_d(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition      | -14.93                        | 14.93 | ns   |
| DSSD4 | $t_d(clkL-dV)$   | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -14.93                        | 14.93 | ns   |

(1) P = output mmc1\_clk period in ns



**Figure 5-75. MMC/SD/SDIO in - Default Speed - Receiver Mode**



**Figure 5-76. MMC/SD/SDIO in - Default Speed - Transmitter Mode**

### 5.10.6.19.1.2 High speed, 4-bit data, SDR, half-cycle

Table 5-120 and Table 5-121 present Timing requirements and Switching characteristics for MMC1 - High Speed in receiver and transmitter mode (see Figure 5-77 and Figure 5-78)

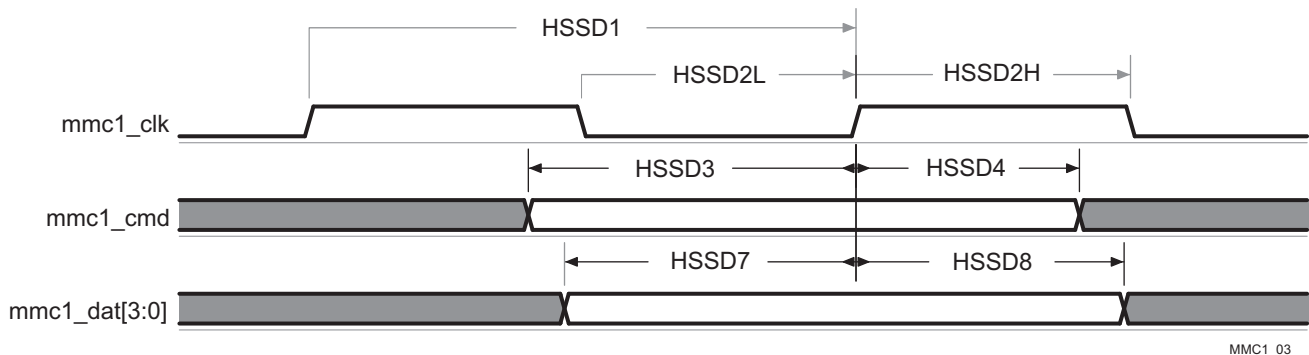
**Table 5-120. Timing Requirements for MMC1 - SD Card High Speed Mode**

| NO.   | PARAMETER           | DESCRIPTION                                                       | MIN | MAX | UNIT |
|-------|---------------------|-------------------------------------------------------------------|-----|-----|------|
| HSSD3 | $t_{su}(cmdV-clkH)$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge      | 5.3 |     | ns   |
| HSSD4 | $t_h(clkH-cmdV)$    | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge        | 2.6 |     | ns   |
| HSSD7 | $t_{su}(dV-clkH)$   | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge | 5.3 |     | ns   |
| HSSD8 | $t_h(clkH-dV)$      | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge   | 2.6 |     | ns   |

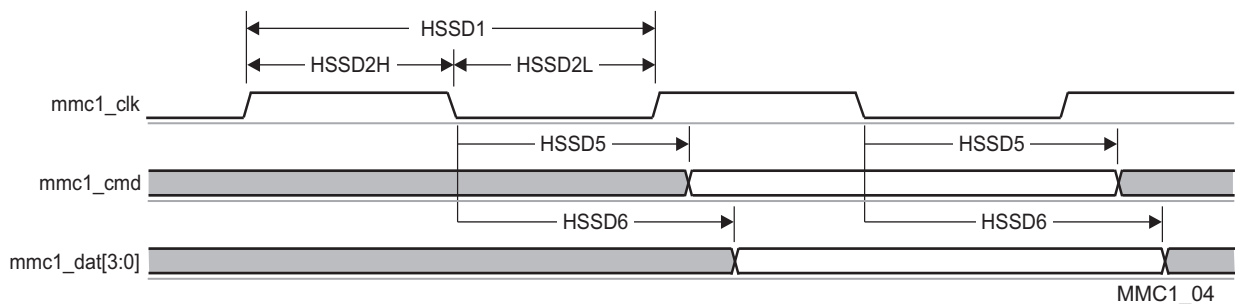
**Table 5-121. Switching Characteristics for MMC1 - SD Card High Speed Mode**

| NO.    | PARAMETER        | DESCRIPTION                                                         | MIN                           | MAX | UNIT |
|--------|------------------|---------------------------------------------------------------------|-------------------------------|-----|------|
| HSSD1  | fop(clk)         | Operating frequency, mmc1_clk                                       |                               | 48  | MHz  |
| HSSD2H | $t_w(clkH)$      | Pulse duration, mmc1_clk high                                       | 0.5P-<br>0.185 <sup>(1)</sup> |     | ns   |
| HSSD2L | $t_w(clkL)$      | Pulse duration, mmc1_clk low                                        | 0.5P-<br>0.185 <sup>(1)</sup> |     | ns   |
| HSSD5  | $t_d(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition      | -7.6                          | 3.6 | ns   |
| HSSD6  | $t_d(clkL-dV)$   | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -7.6                          | 3.6 | ns   |

(1) P = output mmc1\_clk period in ns



**Figure 5-77. MMC/SD/SDIO in - High Speed - Receiver Mode**



**Figure 5-78. MMC/SD/SDIO in - High Speed - Transmitter Mode**

### 5.10.6.19.1.3 SDR12, 4-bit data, half-cycle

Table 5-122 and Table 5-123 present Timing requirements and Switching characteristics for MMC1 - SDR12 in receiver and transmitter mode (see Figure 5-79 and Figure 5-80).

**Table 5-122. Timing Requirements for MMC1 - SD Card SDR12 Mode**

| NO.    | PARAMETER           | DESCRIPTION                                                       | MODE | MIN   | MAX | UNIT |
|--------|---------------------|-------------------------------------------------------------------|------|-------|-----|------|
| SDR125 | $t_{su}(cmdV-clkH)$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge      |      | 25.99 |     | ns   |
| SDR126 | $t_{h}(clkH-cmdV)$  | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge        |      | 1.6   |     | ns   |
| SDR127 | $t_{su}(dV-clkH)$   | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge |      | 25.99 |     | ns   |
| SDR128 | $t_{h}(clkH-dV)$    | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge   |      | 1.6   |     | ns   |

**Table 5-123. Switching Characteristics for MMC1 - SD Card SDR12 Mode**

| NO.    | PARAMETER          | DESCRIPTION                                                         | MIN                       | MAX   | UNIT |
|--------|--------------------|---------------------------------------------------------------------|---------------------------|-------|------|
| SDR120 | fop(clk)           | Operating frequency, mmc1_clk                                       |                           | 24    | MHz  |
| SDR121 | $t_{w}(clkH)$      | Pulse duration, mmc1_clk high                                       | 0.5P-0.185 <sup>(1)</sup> |       | ns   |
| SDR122 | $t_{w}(clkL)$      | Pulse duration, mmc1_clk low                                        | 0.5P-0.185 <sup>(1)</sup> |       | ns   |
| SDR123 | $t_{d}(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition      | -19.13                    | 16.93 | ns   |
| SDR124 | $t_{d}(clkL-dV)$   | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -19.13                    | 16.93 | ns   |

(1) P = output mmc1\_clk period in ns

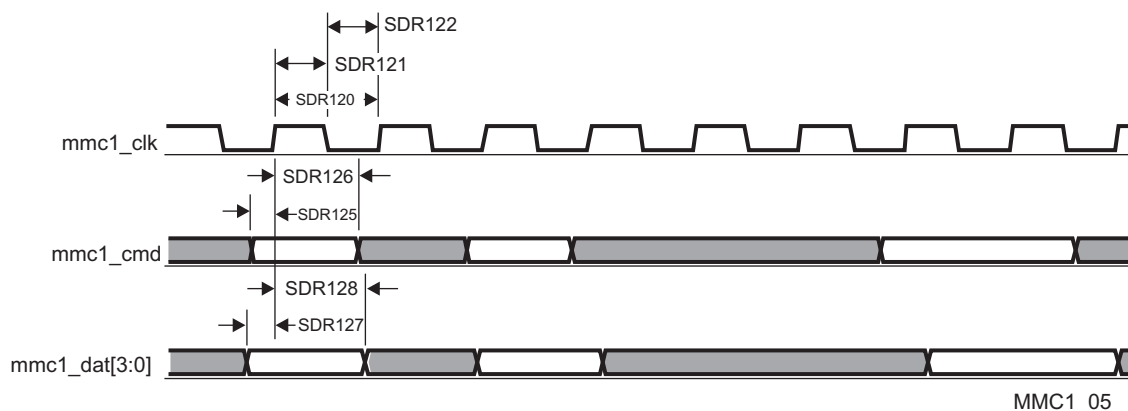
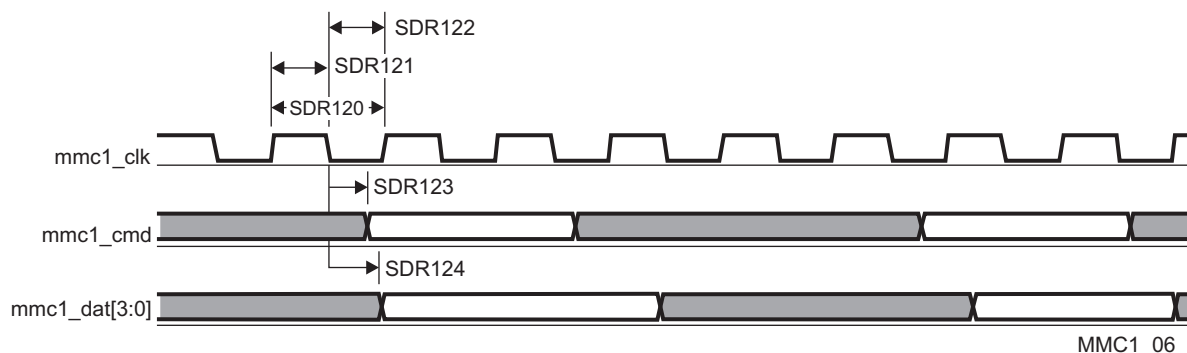
**Figure 5-79. MMC/SD/SDIO in - High Speed SDR12 - Receiver Mode****Figure 5-80. MMC/SD/SDIO in - High Speed SDR12 - Transmitter Mode****5.10.6.19.1.4 SDR25, 4-bit data, half-cycle**

Table 5-124 and Table 5-125 present Timing requirements and Switching characteristics for MMC1 - SDR25 in receiver and transmitter mode (see Figure 5-81 and Figure 5-82).

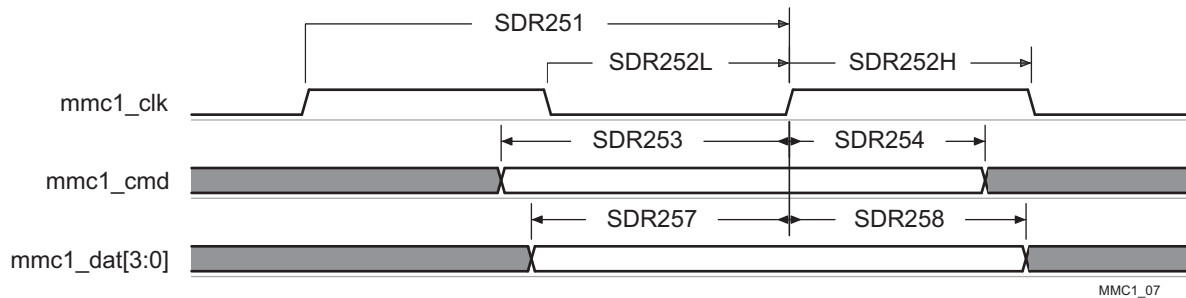
**Table 5-124. Timing Requirements for MMC1 - SD Card SDR25 Mode**

| NO.    | PARAMETER           | DESCRIPTION                                                       | MODE | MIN | MAX | UNIT |
|--------|---------------------|-------------------------------------------------------------------|------|-----|-----|------|
| SDR253 | $t_{su}(cmdV-clkH)$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge      |      | 5.3 |     | ns   |
| SDR254 | $t_h(clkH-cmdV)$    | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge        |      | 1.6 |     | ns   |
| SDR257 | $t_{su}(dV-clkH)$   | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge |      | 5.3 |     | ns   |
| SDR258 | $t_h(clkH-dV)$      | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge   |      | 1.6 |     | ns   |

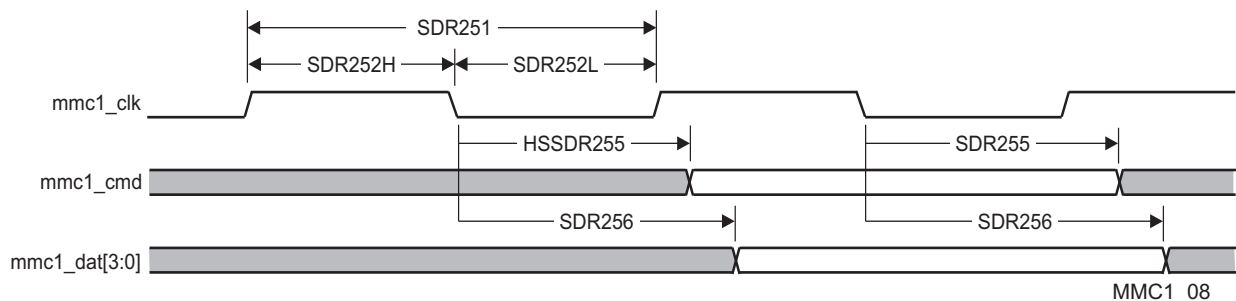
**Table 5-125. Switching Characteristics for MMC1 - SD Card SDR25 Mode**

| NO.         | PARAMETER        | DESCRIPTION                                                         | MIN                           | MAX | UNIT |
|-------------|------------------|---------------------------------------------------------------------|-------------------------------|-----|------|
| SDR251      | fop(clk)         | Operating frequency, mmc1_clk                                       |                               | 48  | MHz  |
| SDR252<br>H | $t_w(clkH)$      | Pulse duration, mmc1_clk high                                       | 0.5P-<br>0.185 <sup>(1)</sup> |     | ns   |
| SDR252L     | $t_w(clkL)$      | Pulse duration, mmc1_clk low                                        | 0.5P-<br>0.185 <sup>(1)</sup> |     | ns   |
| SDR255      | $t_d(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition      | -8.8                          | 6.6 | ns   |
| SDR256      | $t_d(clkL-dV)$   | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -8.8                          | 6.6 | ns   |

(1) P = output mmc1\_clk period in ns



**Figure 5-81. MMC/SD/SDIO in - High Speed SDR25 - Receiver Mode**



**Figure 5-82. MMC/SD/SDIO in - High Speed SDR25 - Transmitter Mode**

#### 5.10.6.19.1.5 UHS-I SDR50, 4-bit data, half-cycle

Table 5-126 and Table 5-127 present Timing requirements and Switching characteristics for MMC1 - SDR50 in receiver and transmitter mode (see Figure 5-83 and Figure 5-84).

**Table 5-126. Timing Requirements for MMC1 - SD Card SDR50 Mode**

| NO.    | PARAMETER           | DESCRIPTION                                                  | MODE | MIN  | MAX | UNIT |
|--------|---------------------|--------------------------------------------------------------|------|------|-----|------|
| SDR503 | $t_{su}(cmdV-clkH)$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge |      | 1.48 |     | ns   |

**Table 5-126. Timing Requirements for MMC1 - SD Card SDR50 Mode (continued)**

| NO.    | PARAMETER                 | DESCRIPTION                                                       | MODE | MIN  | MAX | UNIT |
|--------|---------------------------|-------------------------------------------------------------------|------|------|-----|------|
| SDR504 | $t_{h(\text{clkH-cmdV})}$ | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge        |      | 1.6  |     | ns   |
| SDR507 | $t_{su(\text{dV-clkH})}$  | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge |      | 1.48 |     | ns   |
| SDR508 | $t_{h(\text{clkH-dV})}$   | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge   |      | 1.6  |     | ns   |

**Table 5-127. Switching Characteristics for MMC1 - SD Card SDR50 Mode**

| NO.         | PARAMETER                 | DESCRIPTION                                                         | MIN                           | MAX  | UNIT |
|-------------|---------------------------|---------------------------------------------------------------------|-------------------------------|------|------|
| SDR501      | fop(clk)                  | Operating frequency, mmc1_clk                                       |                               | 96   | MHz  |
| SDR502<br>H | $t_{w(\text{clkH})}$      | Pulse duration, mmc1_clk high                                       | 0.5P-<br>0.185 <sup>(1)</sup> |      | ns   |
| SDR502L     | $t_{w(\text{clkL})}$      | Pulse duration, mmc1_clk low                                        | 0.5P-<br>0.185 <sup>(1)</sup> |      | ns   |
| SDR505      | $t_{d(\text{clkL-cmdV})}$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition      | -3.66                         | 1.46 | ns   |
| SDR506      | $t_{d(\text{clkL-dV})}$   | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -3.66                         | 1.46 | ns   |

(1) P = output mmc1\_clk period in ns

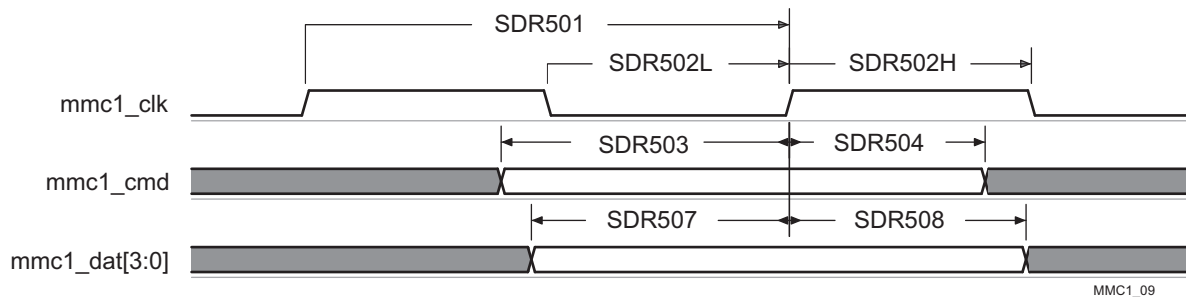
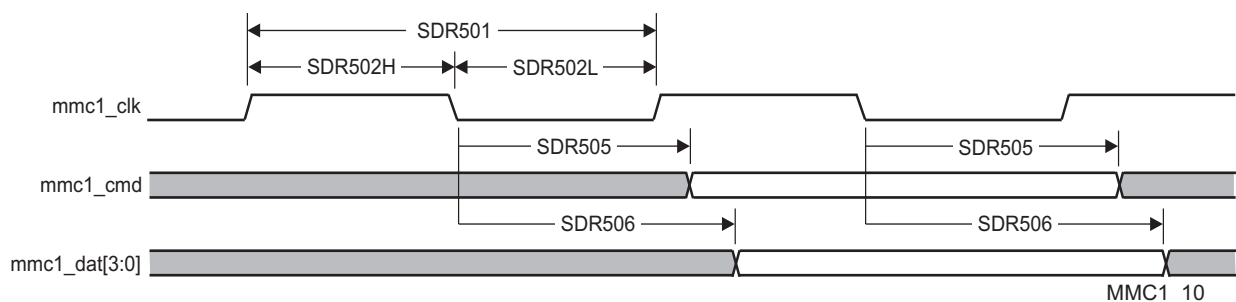
**Figure 5-83. MMC/SD/SDIO in - High Speed SDR50 - Receiver Mode****Figure 5-84. MMC/SD/SDIO in - High Speed SDR50 - Transmitter Mode****5.10.6.19.1.6 UHS-I SDR104, 4-bit data, half-cycle**

Table 5-128 presents Timing requirements and Switching characteristics for MMC1 - SDR104 in receiver and transmitter mode (see Figure 5-85 and Figure 5-86)

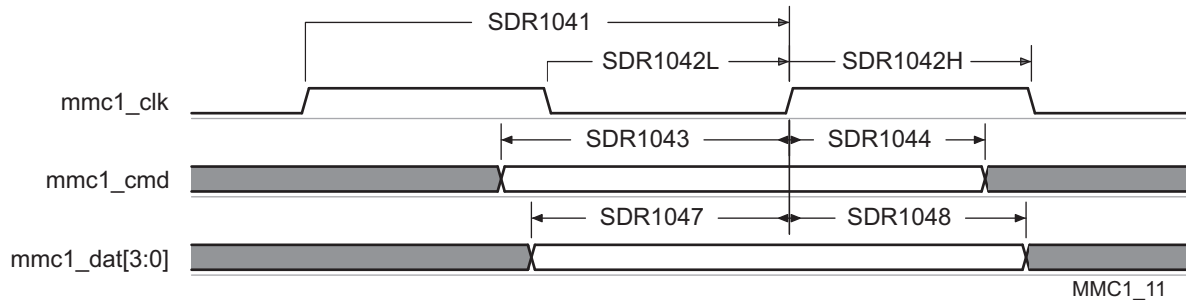
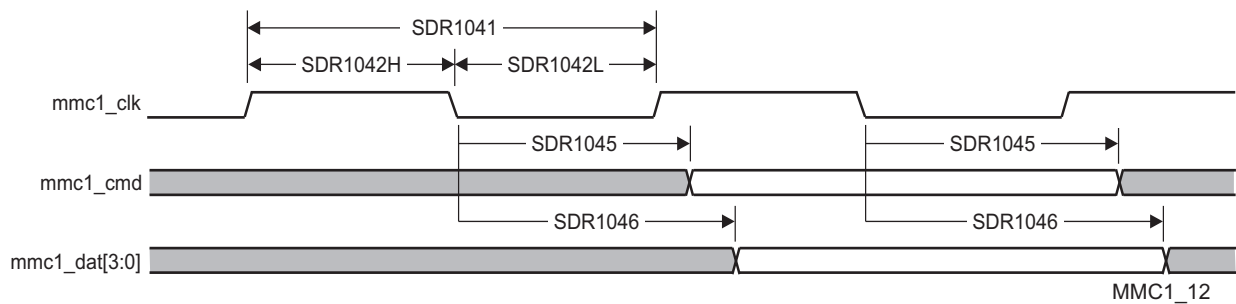
**Table 5-128. Switching Characteristics for MMC1 - SD Card SDR104 Mode**

| NO.          | PARAMETER            | DESCRIPTION                   | MIN                           | MAX | UNIT |
|--------------|----------------------|-------------------------------|-------------------------------|-----|------|
| SDR1041      | fop(clk)             | Operating frequency, mmc1_clk |                               | 192 | MHz  |
| SDR1042<br>H | $t_{w(\text{clkH})}$ | Pulse duration, mmc1_clk high | 0.5P-<br>0.185 <sup>(1)</sup> |     | ns   |

**Table 5-128. Switching Characteristics for MMC1 - SD Card SDR104 Mode (continued)**

| NO.      | PARAMETER          | DESCRIPTION                                                         | MIN                       | MAX  | UNIT |
|----------|--------------------|---------------------------------------------------------------------|---------------------------|------|------|
| SDR1042L | $t_{w(clkL)}$      | Pulse duration, mmc1_clk low                                        | 0.5P-0.185 <sup>(1)</sup> |      | ns   |
| SDR1045  | $t_{d(clkL-cmdV)}$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition      | -1.09                     | 0.49 | ns   |
| SDR1046  | $t_{d(clkL-dV)}$   | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -1.09                     | 0.49 | ns   |

(1) P = output mmc1\_clk period in ns


**Figure 5-85. MMC/SD/SDIO in - High Speed SDR104 - Receiver Mode**

**Figure 5-86. MMC/SD/SDIO in - High Speed SDR104 - Transmitter Mode**

#### 5.10.6.19.1.7 UHS-I DDR50, 4-bit data

Table 5-129 and Table 5-130 present Timing requirements and Switching characteristics for MMC1 - DDR50 in receiver and transmitter mode (see Figure 5-87 and Figure 5-88).

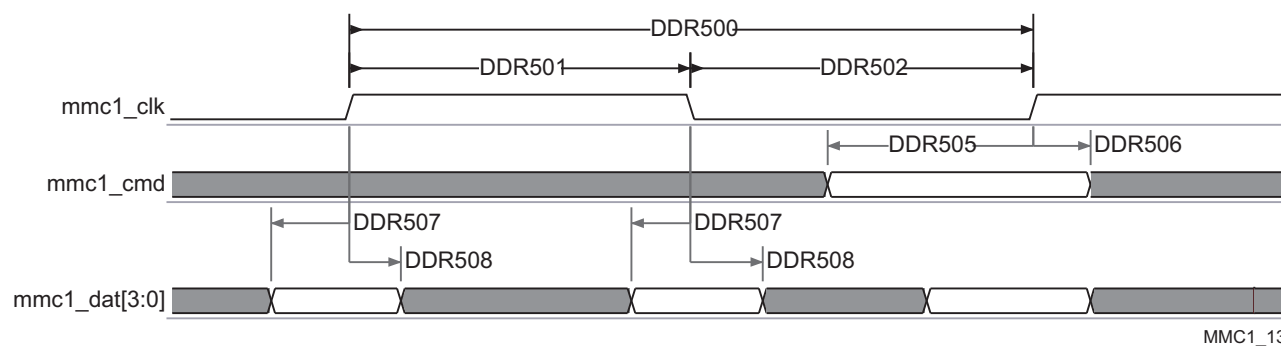
**Table 5-129. Timing Requirements for MMC1 - SD Card DDR50 Mode**

| NO.    | PARAMETER          | DESCRIPTION                                                | MODE | MIN  | MAX | UNIT |
|--------|--------------------|------------------------------------------------------------|------|------|-----|------|
| DDR505 | $t_{su(cmdV-clk)}$ | Setup time, mmc1_cmd valid before mmc1_clk transition      |      | 1.79 |     | ns   |
| DDR506 | $t_{h(clk-cmdV)}$  | Hold time, mmc1_cmd valid after mmc1_clk transition        |      | 1.6  |     | ns   |
| DDR507 | $t_{su(dV-clk)}$   | Setup time, mmc1_dat[3:0] valid before mmc1_clk transition |      | 1.79 |     | ns   |
| DDR508 | $t_{h(clk-dV)}$    | Hold time, mmc1_dat[3:0] valid after mmc1_clk transition   |      | 1.6  |     | ns   |

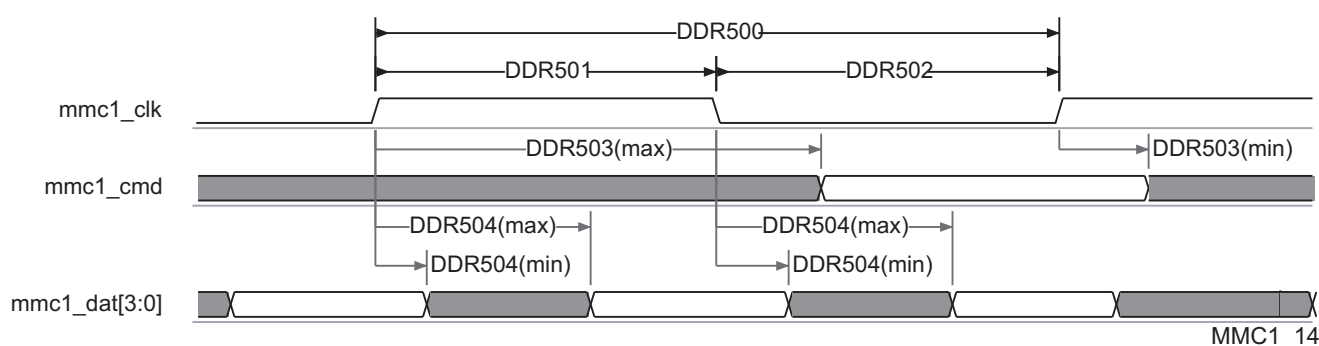
**Table 5-130. Switching Characteristics for MMC1 - SD Card DDR50 Mode**

| NO.    | PARAMETER         | DESCRIPTION                                                 | MIN                       | MAX | UNIT |
|--------|-------------------|-------------------------------------------------------------|---------------------------|-----|------|
| DDR500 | fop(clk)          | Operating frequency, mmc1_clk                               |                           | 48  | MHz  |
| DDR501 | $t_{w(clkH)}$     | Pulse duration, mmc1_clk high                               | 0.5P-0.185 <sup>(1)</sup> |     | ns   |
| DDR502 | $t_{w(clkL)}$     | Pulse duration, mmc1_clk low                                | 0.5P-0.185 <sup>(1)</sup> |     | ns   |
| DDR503 | $t_{d(clk-cmdV)}$ | Delay time, mmc1_clk transition to mmc1_cmd transition      | 1.225                     | 6.6 | ns   |
| DDR504 | $t_{d(clk-dV)}$   | Delay time, mmc1_clk transition to mmc1_dat[3:0] transition | 1.225                     | 6.6 | ns   |

(1) P = output mmc1\_clk period in ns



**Figure 5-87. SDMMC - High Speed SD - DDR - Data/Command Receive**



**Figure 5-88. SDMMC - High Speed SD - DDR - Data/Command Transmit**

#### NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bitfield for each corresponding pad control register.

The pad control registers are presented in [Table 4-29](#) and described in Device TRM, *Control Module Chapter*.

Virtual IO Timings Modes must be used to guarantee some IO timings for MMC1. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 5-131, Virtual Functions Mapping for MMC1](#) for a definition of the Virtual modes.

[Table 5-131](#) presents the values for DELAYMODE bitfield.

**Table 5-131. Virtual Functions Mapping for MMC1**

| BALL | BALL NAME | Delay Mode Value |               |               |               |               | MUXMODE[15:0] |
|------|-----------|------------------|---------------|---------------|---------------|---------------|---------------|
|      |           | MMC1_VIRTUAL1    | MMC1_VIRTUAL2 | MMC1_VIRTUAL5 | MMC1_VIRTUAL6 | MMC1_VIRTUAL7 | 0             |
| W6   | mmc1_clk  | 11               | 10            | 7             | 6             | 5             | mmc1_clk      |
| W5   | mmc1_cmd  | 11               | 10            | 7             | 6             | 5             | mmc1_cmd      |
| V5   | mmc1_dat0 | 11               | 10            | 7             | 6             | 5             | mmc1_dat0     |
| Y4   | mmc1_dat1 | 11               | 10            | 7             | 6             | 5             | mmc1_dat1     |
| AA5  | mmc1_dat2 | 11               | 10            | 7             | 6             | 5             | mmc1_dat2     |
| Y3   | mmc1_dat3 | 11               | 10            | 7             | 6             | 5             | mmc1_dat3     |

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**NOTE**

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information see the Control Module chapter in the Device TRM.

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Manual IO Timings Modes must be used to guarantee some IO timings for MMC1. See [Table 5-32](#), *Modes Summary* for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-132](#), *Manual Functions Mapping for MMC1* for a definition of the Manual modes.

[Table 5-132](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-132. Manual Functions Mapping for MMC1

| BALL | BALL NAME | MMC1_DDR_MANUAL1 |              | MMC1_SDR104_MANUAL1 |              | CFG REGISTER      | MUXMODE   |
|------|-----------|------------------|--------------|---------------------|--------------|-------------------|-----------|
|      |           | A_DELAY (ps)     | G_DELAY (ps) | A_DELAY (ps)        | G_DELAY (ps) |                   | 0         |
| W6   | mmc1_clk  | 489              | 0            | -                   | -            | CFG_MMC1_CLK_IN   | mmc1_clk  |
| W5   | mmc1_cmd  | 0                | 0            | -                   | -            | CFG_MMC1_CMD_IN   | mmc1_cmd  |
| V5   | mmc1_dat0 | 374              | 0            | -                   | -            | CFG_MMC1_DAT0_IN  | mmc1_dat0 |
| Y4   | mmc1_dat1 | 31               | 0            | -                   | -            | CFG_MMC1_DAT1_IN  | mmc1_dat1 |
| AA5  | mmc1_dat2 | 56               | 0            | -                   | -            | CFG_MMC1_DAT2_IN  | mmc1_dat2 |
| Y3   | mmc1_dat3 | 0                | 0            | -                   | -            | CFG_MMC1_DAT3_IN  | mmc1_dat3 |
| W6   | mmc1_clk  | 1355             | 0            | 892                 | 0            | CFG_MMC1_CLK_OUT  | mmc1_clk  |
| W5   | mmc1_cmd  | 0                | 0            | 0                   | 0            | CFG_MMC1_CMD_OEN  | mmc1_cmd  |
| W5   | mmc1_cmd  | 0                | 0            | 0                   | 0            | CFG_MMC1_CMD_OUT  | mmc1_cmd  |
| V5   | mmc1_dat0 | 0                | 0            | 0                   | 0            | CFG_MMC1_DAT0_OEN | mmc1_dat0 |
| V5   | mmc1_dat0 | 0                | 4            | 0                   | 0            | CFG_MMC1_DAT0_OUT | mmc1_dat0 |
| Y4   | mmc1_dat1 | 0                | 0            | 0                   | 0            | CFG_MMC1_DAT1_OEN | mmc1_dat1 |
| Y4   | mmc1_dat1 | 0                | 0            | 0                   | 0            | CFG_MMC1_DAT1_OUT | mmc1_dat1 |
| AA5  | mmc1_dat2 | 0                | 0            | 0                   | 0            | CFG_MMC1_DAT2_OEN | mmc1_dat2 |
| AA5  | mmc1_dat2 | 0                | 0            | 0                   | 0            | CFG_MMC1_DAT2_OUT | mmc1_dat2 |
| Y3   | mmc1_dat3 | 0                | 0            | 0                   | 0            | CFG_MMC1_DAT3_OEN | mmc1_dat3 |
| Y3   | mmc1_dat3 | 0                | 0            | 0                   | 0            | CFG_MMC1_DAT3_OUT | mmc1_dat3 |

#### 5.10.6.19.2 MMC2 — eMMC

MMC2 interface is compliant with the JC64 eMMC Standard v4.5 and it supports the following eMMC applications:

- Standard JC64 SDR, 8-bit data, half cycle
- High-speed JC64 SDR, 8-bit data, half cycle
- High-speed JC64 DDR, 8-bit data
- High-speed HS200 JC64 SDR, 8-bit data, half cycle

#### NOTE

For more information, see the eMMC/SD/SDIO chapter of the Device TRM.

##### 5.10.6.19.2.1 Standard JC64 SDR, 8-bit data, half cycle

Table 5-133 and Table 5-134 present Timing requirements and Switching characteristics for MMC2 - Standard SDR in receiver and Transmitter mode (see Figure 5-89 and Figure 5-90).

**Table 5-133. Timing Requirements for MMC2 - JC64 Standard SDR Mode**

| NO.   | PARAMETER           | DESCRIPTION                                                       | MIN   | MAX | UNIT |
|-------|---------------------|-------------------------------------------------------------------|-------|-----|------|
| SSDR5 | $t_{su(cmdV-clkH)}$ | Setup time, mmc2_cmd valid before mmc2_clk rising clock edge      | 13.19 |     | ns   |
| SSDR6 | $t_{h(clkH-cmdV)}$  | Hold time, mmc2_cmd valid after mmc2_clk rising clock edge        | 8.4   |     | ns   |
| SSDR7 | $t_{su(dV-clkH)}$   | Setup time, mmc2_dat[7:0] valid before mmc2_clk rising clock edge | 13.19 |     | ns   |
| SSDR8 | $t_{h(clkH-dV)}$    | Hold time, mmc2_dat[7:0] valid after mmc2_clk rising clock edge   | 8.4   |     | ns   |

**Table 5-134. Switching Characteristics for MMC2 - JC64 Standard SDR Mode**

| NO.    | PARAMETER          | DESCRIPTION                                                         | MIN                       | MAX   | UNIT |
|--------|--------------------|---------------------------------------------------------------------|---------------------------|-------|------|
| SSDR1  | $f_{op}(clk)$      | Operating frequency, mmc2_clk                                       |                           | 24    | MHz  |
| SSDR2H | $t_{w}(clkH)$      | Pulse duration, mmc2_clk high                                       | 0.5P-0.172 <sup>(1)</sup> |       | ns   |
| SSDR2L | $t_{w}(clkL)$      | Pulse duration, mmc2_clk low                                        | 0.5P-0.172 <sup>(1)</sup> |       | ns   |
| SSDR3  | $t_{d}(clkL-cmdV)$ | Delay time, mmc2_clk falling clock edge to mmc2_cmd transition      | -16.96                    | 16.96 | ns   |
| SSDR4  | $t_{d}(clkL-dV)$   | Delay time, mmc2_clk falling clock edge to mmc2_dat[7:0] transition | -16.96                    | 16.96 | ns   |

(1) P = output mmc2\_clk period in ns

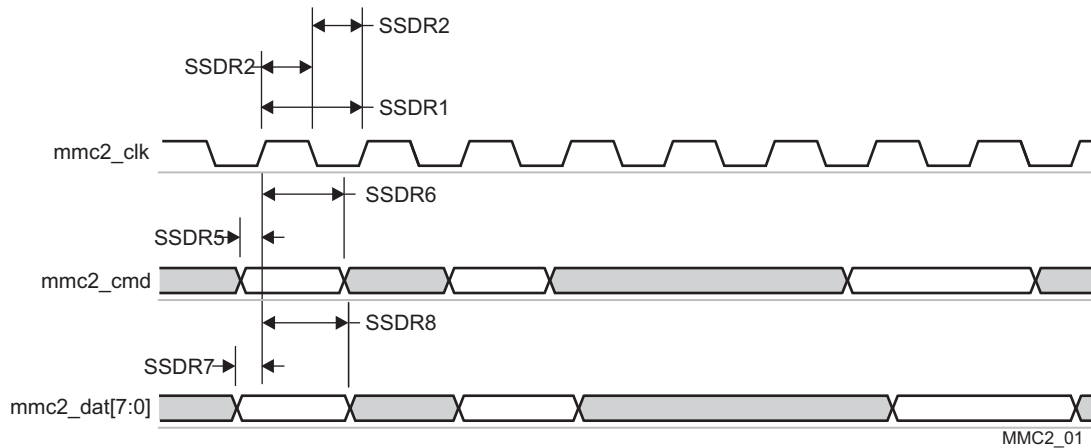
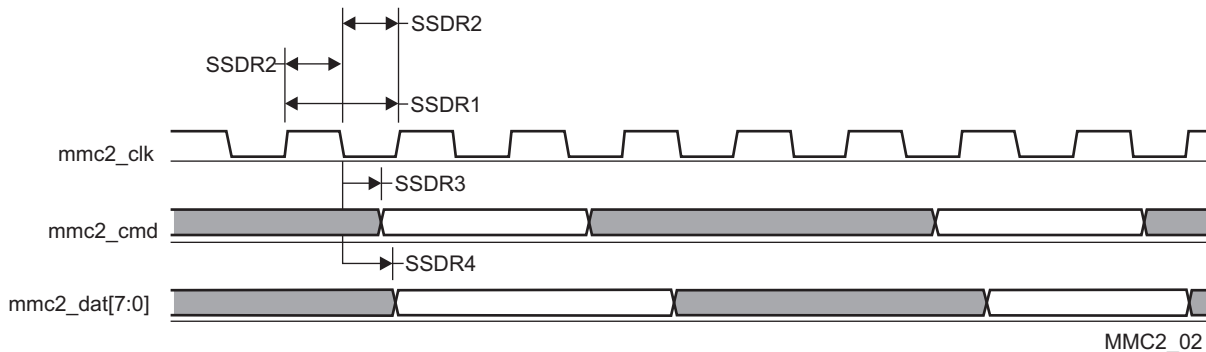
**Figure 5-89. MMC/SD/SDIO in - Standard JC64 - Receiver Mode****Figure 5-90. MMC/SD/SDIO in - Standard JC64 - Transmitter Mode****5.10.6.19.2.2 High-Speed JC64 SDR, 8-bit data, half cycle**

Table 5-135 and Table 5-136 present Timing requirements and Switching characteristics for MMC2 - High speed SDR in receiver and transmitter mode (see Figure 5-91 and Figure 5-92).

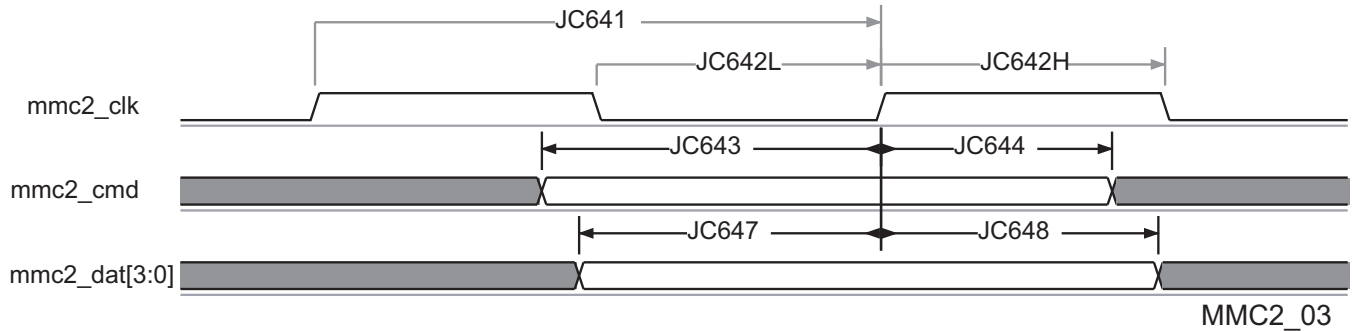
**Table 5-135. Timing Requirements for MMC2 - JC64 High-Speed SDR Mode**

| NO.   | PARAMETER           | DESCRIPTION                                                       | MIN | MAX | UNIT |
|-------|---------------------|-------------------------------------------------------------------|-----|-----|------|
| JC643 | $t_{su}(cmdV-clkH)$ | Setup time, mmc2_cmd valid before mmc2_clk rising clock edge      | 5.6 |     | ns   |
| JC644 | $t_{h}(clkH-cmdV)$  | Hold time, mmc2_cmd valid after mmc2_clk rising clock edge        | 2.6 |     | ns   |
| JC647 | $t_{su}(dV-clkH)$   | Setup time, mmc2_dat[7:0] valid before mmc2_clk rising clock edge | 5.6 |     | ns   |
| JC648 | $t_{h}(clkH-dV)$    | Hold time, mmc2_dat[7:0] valid after mmc2_clk rising clock edge   | 2.6 |     | ns   |

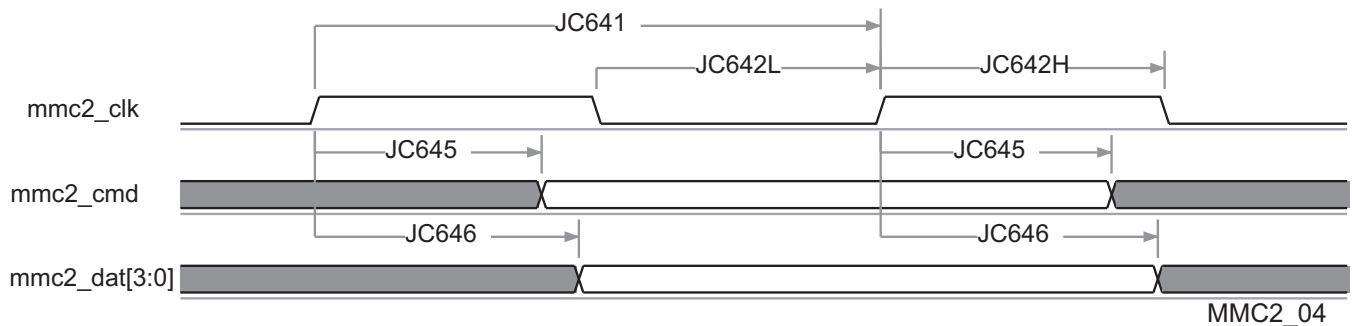
**Table 5-136. Switching Characteristics for MMC2 - JC64 High-Speed SDR Mode**

| NO.    | PARAMETER          | DESCRIPTION                                                         | MIN                           | MAX  | UNIT |
|--------|--------------------|---------------------------------------------------------------------|-------------------------------|------|------|
| JC641  | $f_{op}(clk)$      | Operating frequency, mmc2_clk                                       |                               | 48   | MHz  |
| JC642H | $t_{w}(clkH)$      | Pulse duration, mmc2_clk high                                       | 0.5P-<br>0.172 <sup>(1)</sup> |      | ns   |
| JC642L | $t_{w}(clkL)$      | Pulse duration, mmc2_clk low                                        | 0.5P-<br>0.172 <sup>(1)</sup> |      | ns   |
| JC645  | $t_{d}(clkL-cmdV)$ | Delay time, mmc2_clk falling clock edge to mmc2_cmd transition      | -6.64                         | 6.64 | ns   |
| JC646  | $t_{d}(clkL-dV)$   | Delay time, mmc2_clk falling clock edge to mmc2_dat[7:0] transition | -6.64                         | 6.64 | ns   |

(1) P = output mmc2\_clk period in ns



**Figure 5-91. MMC/SD/SDIO in - High-Speed JC64 - Receiver Mode**



**Figure 5-92. MMC/SD/SDIO in - High-Speed JC64 - Transmitter Mode**

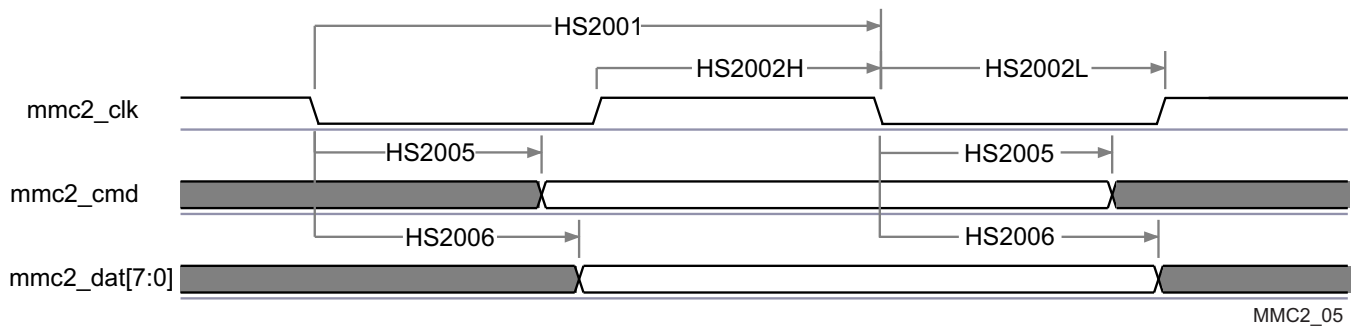
#### 5.10.6.19.2.3 High-Speed HS200 JC64 SDR, 8-bit data, half cycle

Table 5-137 presents Timing requirements and Switching characteristics for MMC2 - HS200 in receiver and transmitter mode (see Figure 5-93).

**Table 5-137. Switching Characteristics for MMC2 - JEDS84 HS200 Mode**

| NO.     | PARAMETER          | DESCRIPTION                                                         | MIN                           | MAX   | UNIT |
|---------|--------------------|---------------------------------------------------------------------|-------------------------------|-------|------|
| HS2001  | $f_{op}(clk)$      | Operating frequency, mmc2_clk                                       |                               | 192   | MHz  |
| HS2002H | $t_{w}(clkH)$      | Pulse duration, mmc2_clk high                                       | 0.5P-<br>0.172 <sup>(1)</sup> |       | ns   |
| HS2002L | $t_{w}(clkL)$      | Pulse duration, mmc2_clk low                                        | 0.5P-<br>0.172 <sup>(1)</sup> |       | ns   |
| HS2005  | $t_{d}(clkL-cmdV)$ | Delay time, mmc2_clk falling clock edge to mmc2_cmd transition      | -1.136                        | 0.536 | ns   |
| HS2006  | $t_{d}(clkL-dV)$   | Delay time, mmc2_clk falling clock edge to mmc2_dat[7:0] transition | -1.136                        | 0.536 | ns   |

(1) P = output mmc2\_clk period in ns



**Figure 5-93. eMMC in - HS200 SDR - Transmitter Mode**

#### 5.10.6.19.2.4 High-Speed JC64 DDR, 8-bit data

Table 5-138 and Table 5-139 present Timing requirements and Switching characteristics for MMC2 - High speed DDR in receiver and transmitter mode (see Figure 5-94 and Figure 5-95).

**Table 5-138. Timing Requirements for MMC2 - JC64 High-Speed DDR Mode**

| NO.  | PARAMETER          | DESCRIPTION                                                | MODE | MIN | MAX | UNIT |
|------|--------------------|------------------------------------------------------------|------|-----|-----|------|
| DDR3 | $t_{su(cmdV-clk)}$ | Setup time, mmc2_cmd valid before mmc2_clk transition      |      | 1.8 |     | ns   |
| DDR4 | $t_{h(clk-cmdV)}$  | Hold time, mmc2_cmd valid after mmc2_clk transition        |      | 1.6 |     | ns   |
| DDR7 | $t_{su(dV-clk)}$   | Setup time, mmc2_dat[7:0] valid before mmc2_clk transition |      | 1.8 |     | ns   |
| DDR8 | $t_{h(clk-dV)}$    | Hold time, mmc2_dat[7:0] valid after mmc2_clk transition   |      | 1.6 |     | ns   |

**Table 5-139. Switching Characteristics for MMC2 - JC64 High-Speed DDR Mode**

| NO.   | PARAMETER         | DESCRIPTION                                                 | MIN                       | MAX  | UNIT |
|-------|-------------------|-------------------------------------------------------------|---------------------------|------|------|
| DDR1  | $f_{op(clk)}$     | Operating frequency, mmc2_clk                               |                           | 48   | MHz  |
| DDR2H | $t_{w(clkH)}$     | Pulse duration, mmc2_clk high                               | 0.5P-0.172 <sup>(1)</sup> |      | ns   |
| DDR2L | $t_{w(clkL)}$     | Pulse duration, mmc2_clk low                                | 0.5P-0.172 <sup>(1)</sup> |      | ns   |
| DDR5  | $t_{d(clk-cmdV)}$ | Delay time, mmc2_clk transition to mmc2_cmd transition      | 2.9                       | 7.14 | ns   |
| DDR6  | $t_{d(clk-dV)}$   | Delay time, mmc2_clk transition to mmc2_dat[7:0] transition | 2.9                       | 7.14 | ns   |

(1) P = output mmc2\_clk period in ns

Table 5-140 and Table 5-141 present Timing requirements and Switching characteristics for MMC2 - High speed DDR in receiver and transmitter mode During Boot (see Figure 5-94 and Figure 5-95).

**Table 5-140. Timing Requirements for MMC2 - JC64 High-Speed DDR Mode During Boot**

| NO.  | PARAMETER          | DESCRIPTION                                                | MODE | MIN                | MAX | UNIT |
|------|--------------------|------------------------------------------------------------|------|--------------------|-----|------|
| DDR3 | $t_{su(cmdV-clk)}$ | Setup time, mmc2_cmd valid before mmc2_clk transition      | Boot | 1.8                |     | ns   |
| DDR4 | $t_{h(clk-cmdV)}$  | Hold time, mmc2_cmd valid after mmc2_clk transition        | Boot | 1.8 <sup>(1)</sup> |     | ns   |
| DDR7 | $t_{su(dV-clk)}$   | Setup time, mmc2_dat[7:0] valid before mmc2_clk transition | Boot | 1.8                |     | ns   |
| DDR8 | $t_{h(clk-dV)}$    | Hold time, mmc2_dat[7:0] valid after mmc2_clk transition   | Boot | 1.8 <sup>(1)</sup> |     | ns   |

(1) This Hold time requirement is larger than the Hold time provided by a typical eMMC component. Therefore, the trace length between the Device and eMMC component must be sufficiently long enough to ensure that the Hold time is met at the Device.

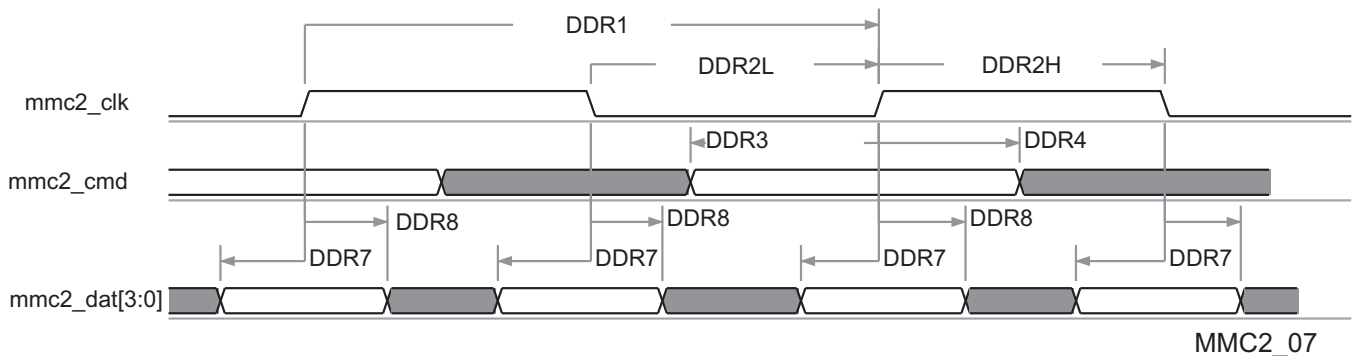
**Table 5-141. Switching Characteristics for MMC2 - JC64 High-Speed DDR Mode During Boot**

| NO.  | PARAMETER     | DESCRIPTION                   | MODE | MIN | MAX | UNIT |
|------|---------------|-------------------------------|------|-----|-----|------|
| DDR1 | $f_{op(clk)}$ | Operating frequency, mmc2_clk | Boot |     | 48  | MHz  |

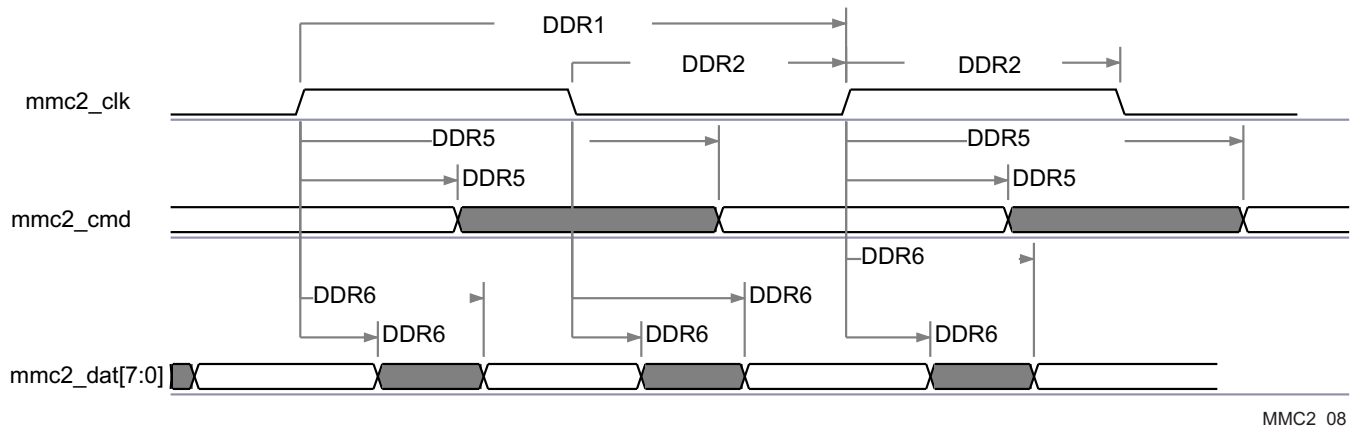
**Table 5-141. Switching Characteristics for MMC2 - JC64 High-Speed DDR Mode During Boot (continued)**

| NO.   | PARAMETER        | DESCRIPTION                                                 | MODE | MIN                           | MAX  | UNIT |
|-------|------------------|-------------------------------------------------------------|------|-------------------------------|------|------|
| DDR2H | $t_{w(ckH)}$     | Pulse duration, mmc2_clk high                               | Boot | 0.5P-<br>0.172 <sup>(1)</sup> |      | ns   |
| DDR2L | $t_{w(ckL)}$     | Pulse duration, mmc2_clk low                                | Boot | 0.5P-<br>0.172 <sup>(1)</sup> |      | ns   |
| DDR5  | $t_{d(ck-cmdV)}$ | Delay time, mmc2_clk transition to mmc2_cmd transition      | Boot | 2.9                           | 7.14 | ns   |
| DDR6  | $t_{d(ck-dV)}$   | Delay time, mmc2_clk transition to mmc2_dat[7:0] transition | Boot | 2.9                           | 7.14 | ns   |

(1) P = output mmc2\_clk period in ns



**Figure 5-94. MMC/SD/SDIO in - High-Speed DDR JC64 - Receiver Mode**



**Figure 5-95. MMC/SD/SDIO in - High-Speed DDR JC64 - Transmitter Mode**

**NOTE**

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information see the Control Module chapter in the Device TRM.

Manual IO Timings Modes must be used to guarantee some IO timings for MMC2. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-142, Manual Functions Mapping for MMC2 with Internal Loopback Clock and for HS200](#) for a definition of the Manual modes.

[Table 5-142](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-142. Manual Functions Mapping for MMC2 With Internal Loopback Clock and for HS200**

| BALL | BALL NAME | MMC2_DDR_LB_MANUAL1 |              | MMC2_STD_HS_LB_MANUAL1 |              | MMC2_HS200_MANUAL1 |              | CFG REGISTER     | MUXMODE<br>1 |
|------|-----------|---------------------|--------------|------------------------|--------------|--------------------|--------------|------------------|--------------|
|      |           | A_DELAY (ps)        | G_DELAY (ps) | A_DELAY (ps)           | G_DELAY (ps) | A_DELAY (ps)       | G_DELAY (ps) |                  |              |
| K7   | gpmc_a19  | 124                 | 0            | 850                    | 0            | -                  | -            | CFG_GPMC_A19_IN  | mmc2_dat4    |
| M7   | gpmc_a20  | 62                  | 0            | 1264                   | 0            | -                  | -            | CFG_GPMC_A20_IN  | mmc2_dat5    |
| J5   | gpmc_a21  | 0                   | 0            | 786                    | 0            | -                  | -            | CFG_GPMC_A21_IN  | mmc2_dat6    |
| K6   | gpmc_a22  | 0                   | 0            | 902                    | 0            | -                  | -            | CFG_GPMC_A22_IN  | mmc2_dat7    |
| J7   | gpmc_a23  | 645                 | 3054         | 0                      | 2764         | -                  | -            | CFG_GPMC_A23_IN  | mmc2_clk     |
| J4   | gpmc_a24  | 48                  | 0            | 1185                   | 0            | -                  | -            | CFG_GPMC_A24_IN  | mmc2_dat0    |
| J6   | gpmc_a25  | 0                   | 0            | 670                    | 0            | -                  | -            | CFG_GPMC_A25_IN  | mmc2_dat1    |
| H4   | gpmc_a26  | 0                   | 0            | 972                    | 0            | -                  | -            | CFG_GPMC_A26_IN  | mmc2_dat2    |
| H5   | gpmc_a27  | 0                   | 0            | 1116                   | 0            | -                  | -            | CFG_GPMC_A27_IN  | mmc2_dat3    |
| H6   | gpmc_cs1  | 0                   | 0            | 250                    | 0            | -                  | -            | CFG_GPMC_CS1_IN  | mmc2_cmd     |
| K7   | gpmc_a19  | 0                   | 0            | 0                      | 0            | 384                | 0            | CFG_GPMC_A19_OEN | mmc2_dat4    |
| K7   | gpmc_a19  | 135                 | 0            | 0                      | 0            | 350                | 174          | CFG_GPMC_A19_OUT | mmc2_dat4    |
| M7   | gpmc_a20  | 0                   | 0            | 0                      | 0            | 410                | 0            | CFG_GPMC_A20_OEN | mmc2_dat5    |
| M7   | gpmc_a20  | 47                  | 0            | 0                      | 0            | 335                | 0            | CFG_GPMC_A20_OUT | mmc2_dat5    |
| J5   | gpmc_a21  | 0                   | 0            | 0                      | 0            | 468                | 0            | CFG_GPMC_A21_OEN | mmc2_dat6    |
| J5   | gpmc_a21  | 101                 | 0            | 0                      | 0            | 339                | 0            | CFG_GPMC_A21_OUT | mmc2_dat6    |
| K6   | gpmc_a22  | 0                   | 0            | 0                      | 0            | 676                | 0            | CFG_GPMC_A22_OEN | mmc2_dat7    |
| K6   | gpmc_a22  | 30                  | 0            | 0                      | 0            | 219                | 0            | CFG_GPMC_A22_OUT | mmc2_dat7    |
| J7   | gpmc_a23  | 423                 | 0            | 0                      | 0            | 1062               | 154          | CFG_GPMC_A23_OUT | mmc2_clk     |
| J4   | gpmc_a24  | 0                   | 0            | 0                      | 0            | 640                | 0            | CFG_GPMC_A24_OEN | mmc2_dat0    |
| J4   | gpmc_a24  | 0                   | 0            | 0                      | 0            | 150                | 0            | CFG_GPMC_A24_OUT | mmc2_dat0    |
| J6   | gpmc_a25  | 0                   | 0            | 0                      | 0            | 356                | 0            | CFG_GPMC_A25_OEN | mmc2_dat1    |
| J6   | gpmc_a25  | 0                   | 0            | 0                      | 0            | 150                | 0            | CFG_GPMC_A25_OUT | mmc2_dat1    |
| H4   | gpmc_a26  | 0                   | 0            | 0                      | 0            | 579                | 0            | CFG_GPMC_A26_OEN | mmc2_dat2    |
| H4   | gpmc_a26  | 0                   | 0            | 0                      | 0            | 200                | 0            | CFG_GPMC_A26_OUT | mmc2_dat2    |
| H5   | gpmc_a27  | 0                   | 0            | 0                      | 0            | 435                | 0            | CFG_GPMC_A27_OEN | mmc2_dat3    |
| H5   | gpmc_a27  | 0                   | 0            | 0                      | 0            | 236                | 0            | CFG_GPMC_A27_OUT | mmc2_dat3    |
| H6   | gpmc_cs1  | 0                   | 0            | 0                      | 0            | 759                | 0            | CFG_GPMC_CS1_OEN | mmc2_cmd     |
| H6   | gpmc_cs1  | 0                   | 0            | 0                      | 0            | 372                | 0            | CFG_GPMC_CS1_OUT | mmc2_cmd     |



### 5.10.6.19.3 MMC3 and MMC4—SDIO/SD

MMC3 and MMC4 interfaces are compliant with the SDIO3.0 standard v1.0, SD Part E1 and for generic SDIO devices, it supports the following applications:

- MMC3 8-bit data and MMC4 4-bit data, SD Default speed, SDR
- MMC3 8-bit data and MMC4 4-bit data, SD High speed, SDR
- MMC3 8-bit data and MMC4 4-bit data, UHS-1 SDR12 (SD Standard v3.01), 4-bit data, SDR, half cycle
- MMC3 8-bit data and MMC4 4-bit data, UHS-I SDR25 (SD Standard v3.01), 4-bit data, SDR, half cycle
- MMC3 8-bit data, UHS-I SDR50

#### NOTE

The eMMC/SD/SDIOj (j = 3 to 4) controller is also referred to as MMCj.

#### NOTE

For more information, see the MMC/SDIO chapter of the Device TRM.

#### 5.10.6.19.3.1 MMC3 and MMC4, SD Default Speed

Figure 5-96, Figure 5-97, and Table 5-143 through Table 5-146 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD Default speed in receiver and transmitter mode.

**Table 5-143. Timing Requirements for MMC3 - Default Speed Mode <sup>(1)</sup>**

| NO. | PARAMETER           | DESCRIPTION                                                       | MIN   | MAX | UNIT |
|-----|---------------------|-------------------------------------------------------------------|-------|-----|------|
| DS5 | $t_{su(cmdV-clkH)}$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge      | 5.11  |     | ns   |
| DS6 | $t_h(clkH-cmdV)$    | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge        | 20.46 |     | ns   |
| DS7 | $t_{su(dV-clkH)}$   | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 5.11  |     | ns   |
| DS8 | $t_h(clkH-dV)$      | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge   | 20.46 |     | ns   |

(1) i in [i:0] = 7

**Table 5-144. Switching Characteristics for MMC3 - SD/SDIO Default Speed Mode <sup>(2)</sup>**

| NO. | PARAMETER        | DESCRIPTION                                                         | MIN                           | MAX   | UNIT |
|-----|------------------|---------------------------------------------------------------------|-------------------------------|-------|------|
| DS0 | fop(clk)         | Operating frequency, mmc3_clk                                       |                               | 24    | MHz  |
| DS1 | $t_w(clkH)$      | Pulse duration, mmc3_clk high                                       | 0.5P-<br>0.270 <sup>(1)</sup> |       | ns   |
| DS2 | $t_w(clkL)$      | Pulse duration, mmc3_clk low                                        | 0.5P-<br>0.270 <sup>(1)</sup> |       | ns   |
| DS3 | $t_d(clkL-cmdV)$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition      | -14.93                        | 14.93 | ns   |
| DS4 | $t_d(clkL-dV)$   | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -14.93                        | 14.93 | ns   |

(1) P = output mmc3\_clk period in ns

(2) i in [i:0] = 7

**Table 5-145. Timing Requirements for MMC4 - Default Speed Mode <sup>(1)</sup>**

| NO. | PARAMETER           | DESCRIPTION                                                       | MIN   | MAX | UNIT |
|-----|---------------------|-------------------------------------------------------------------|-------|-----|------|
| DS5 | $t_{su(cmdV-clkH)}$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge      | 5.11  |     | ns   |
| DS6 | $t_h(clkH-cmdV)$    | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge        | 20.46 |     | ns   |
| DS7 | $t_{su(dV-clkH)}$   | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 5.11  |     | ns   |
| DS8 | $t_h(clkH-dV)$      | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge   | 20.46 |     | ns   |

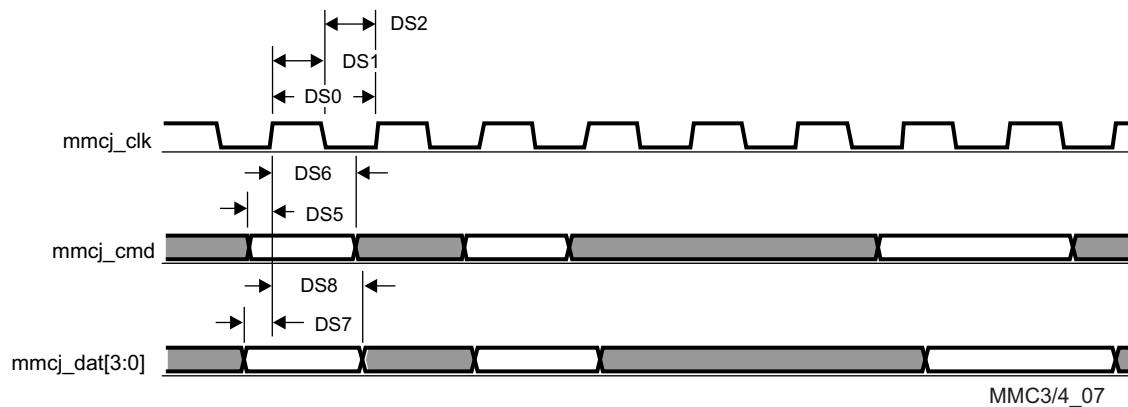
(1)  $i$  in  $[i:0] = 3$

**Table 5-146. Switching Characteristics for MMC4 - Default Speed Mode <sup>(2)</sup>**

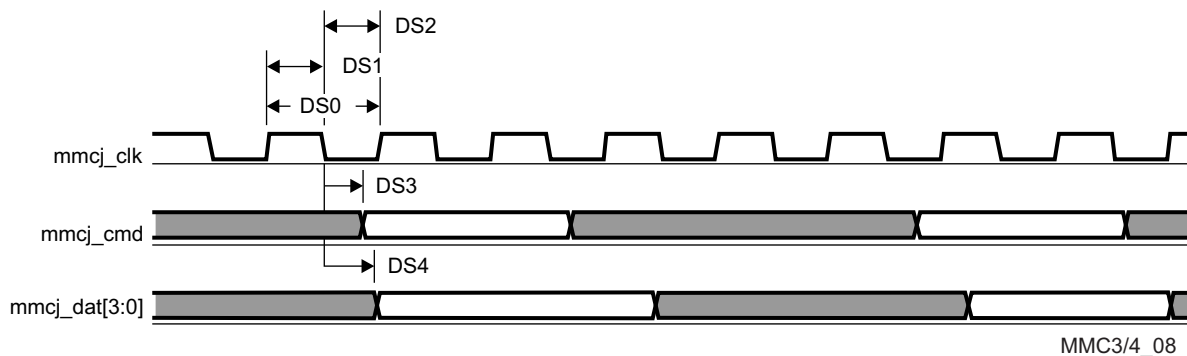
| NO. | PARAMETER                 | DESCRIPTION                                                         | MIN                           | MAX   | UNIT |
|-----|---------------------------|---------------------------------------------------------------------|-------------------------------|-------|------|
| DS0 | fop(clk)                  | Operating frequency, mmc4_clk                                       |                               | 24    | MHz  |
| DS1 | $t_{w(\text{clkH})}$      | Pulse duration, mmc4_clk high                                       | 0.5P-<br>0.270 <sup>(1)</sup> |       | ns   |
| DS2 | $t_{w(\text{clkL})}$      | Pulse duration, mmc4_clk low                                        | 0.5P-<br>0.270 <sup>(1)</sup> |       | ns   |
| DS3 | $t_{d(\text{clkL-cmdV})}$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition      | -14.93                        | 14.93 | ns   |
| DS4 | $t_{d(\text{clkL-dV})}$   | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -14.93                        | 14.93 | ns   |

(1) P = output mmc4\_clk period in ns

(2)  $i$  in  $[i:0] = 3$



**Figure 5-96. MMC/SD/SDIOj in - Default Speed - Receiver Mode**



**Figure 5-97. MMC/SD/SDIOj in - Default Speed - Transmitter Mode**

#### 5.10.6.19.3.2 MMC3 and MMC4, SD High Speed

Figure 5-98, Figure 5-99, and Table 5-147 through Table 5-150 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD and SDIO High speed in receiver and transmitter mode.

**Table 5-147. Timing Requirements for MMC3 - SD/SDIO High Speed Mode <sup>(1)</sup>**

| NO. | PARAMETER                  | DESCRIPTION                                                       | MIN | MAX | UNIT |
|-----|----------------------------|-------------------------------------------------------------------|-----|-----|------|
| HS3 | $t_{su(\text{cmdV-clkH})}$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge      | 5.3 |     | ns   |
| HS4 | $t_{h(\text{clkH-cmdV})}$  | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge        | 2.6 |     | ns   |
| HS7 | $t_{su(\text{dV-clkH})}$   | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 5.3 |     | ns   |

**Table 5-147. Timing Requirements for MMC3 - SD/SDIO High Speed Mode <sup>(1)</sup> (continued)**

| NO. | PARAMETER               | DESCRIPTION                                                     | MIN | MAX | UNIT |
|-----|-------------------------|-----------------------------------------------------------------|-----|-----|------|
| HS8 | $t_{h(\text{clkH-dV})}$ | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge | 2.6 |     | ns   |

(1) i in [i:0] = 7

**Table 5-148. Switching Characteristics for MMC3 - SD/SDIO High Speed Mode <sup>(2)</sup>**

| NO.  | PARAMETER                 | DESCRIPTION                                                         | MIN                           | MAX | UNIT |
|------|---------------------------|---------------------------------------------------------------------|-------------------------------|-----|------|
| HS1  | fop(clk)                  | Operating frequency, mmc3_clk                                       |                               | 48  | MHz  |
| HS2H | $t_{w(\text{clkH})}$      | Pulse duration, mmc3_clk high                                       | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |
| HS2L | $t_{w(\text{clkL})}$      | Pulse duration, mmc3_clk low                                        | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |
| HS5  | $t_{d(\text{clkL-cmdV})}$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition      | -7.6                          | 3.6 | ns   |
| HS6  | $t_{d(\text{clkL-dV})}$   | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -7.6                          | 3.6 | ns   |

(1) P = output mmc3\_clk period in ns

(2) i in [i:0] = 7

**Table 5-149. Timing Requirements for MMC4 - High Speed Mode <sup>(1)</sup>**

| NO. | PARAMETER                  | DESCRIPTION                                                       | MIN | MAX | UNIT |
|-----|----------------------------|-------------------------------------------------------------------|-----|-----|------|
| HS3 | $t_{su(\text{cmdV-clkH})}$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge      | 5.3 |     | ns   |
| HS4 | $t_{h(\text{clkH-cmdV})}$  | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge        | 1.6 |     | ns   |
| HS7 | $t_{su(\text{dV-clkH})}$   | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 5.3 |     | ns   |
| HS8 | $t_{h(\text{clkH-dV})}$    | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge   | 1.6 |     | ns   |

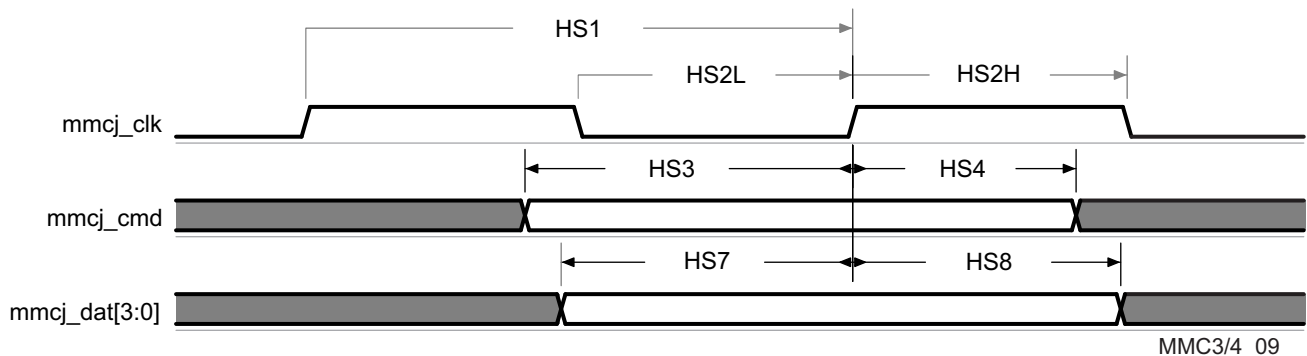
(1) i in [i:0] = 3

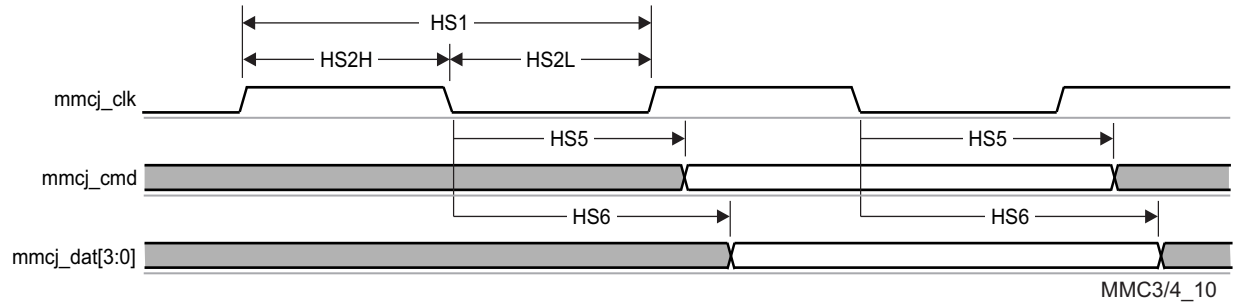
**Table 5-150. Switching Characteristics for MMC4 - High Speed Mode <sup>(2)</sup>**

| NO.  | PARAMETER                 | DESCRIPTION                                                         | MIN                           | MAX | UNIT |
|------|---------------------------|---------------------------------------------------------------------|-------------------------------|-----|------|
| HS1  | fop(clk)                  | Operating frequency, mmc4_clk                                       |                               | 48  | MHz  |
| HS2H | $t_{w(\text{clkH})}$      | Pulse duration, mmc4_clk high                                       | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |
| HS2L | $t_{w(\text{clkL})}$      | Pulse duration, mmc4_clk low                                        | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |
| HS5  | $t_{d(\text{clkL-cmdV})}$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition      | -8.8                          | 6.6 | ns   |
| HS6  | $t_{d(\text{clkL-dV})}$   | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -8.8                          | 6.6 | ns   |

(1) P = output mmc4\_clk period in ns

(2) i in [i:0] = 3

**Figure 5-98. MMC/SD/SDIOj in - High Speed - Receiver Mode**



**Figure 5-99. MMC/SD/SDIOj in - High Speed - Transmitter Mode**

#### 5.10.6.19.3.3 MMC3 and MMC4, SD and SDIO SDR12 Mode

Figure 5-100, Figure 5-101, and Table 5-151, through Table 5-154 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD and SDIO SDR12 in receiver and transmitter mode.

**Table 5-151. Timing Requirements for MMC3 - SDR12 Mode <sup>(1)</sup>**

| NO.    | PARAMETER           | DESCRIPTION                                                       | MIN   | MAX | UNIT |
|--------|---------------------|-------------------------------------------------------------------|-------|-----|------|
| SDR125 | $t_{su}(cmdV-clkH)$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge      | 25.99 |     | ns   |
| SDR126 | $t_h(clkH-cmdV)$    | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge        | 1.6   |     | ns   |
| SDR127 | $t_{su}(dV-clkH)$   | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 25.99 |     | ns   |
| SDR128 | $t_h(clkH-dV)$      | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge   | 1.6   |     | ns   |

(1) i in [i:0] = 7

**Table 5-152. Switching Characteristics for MMC3 - SDR12 Mode <sup>(2)</sup>**

| NO.    | PARAMETER        | DESCRIPTION                                                         | MIN                           | MAX   | UNIT |
|--------|------------------|---------------------------------------------------------------------|-------------------------------|-------|------|
| SDR120 | fop(clk)         | Operating frequency, mmc3_clk                                       |                               | 24    | MHz  |
| SDR121 | $t_w(clkH)$      | Pulse duration, mmc3_clk high                                       | 0.5P-<br>0.270 <sup>(1)</sup> |       | ns   |
| SDR122 | $t_w(clkL)$      | Pulse duration, mmc3_clk low                                        | 0.5P-<br>0.270 <sup>(1)</sup> |       | ns   |
| SDR123 | $t_d(clkL-cmdV)$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition      | -19.13                        | 16.93 | ns   |
| SDR124 | $t_d(clkL-dV)$   | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -19.13                        | 16.93 | ns   |

(1) P = output mmc3\_clk period in ns

(2) i in [i:0] = 7

**Table 5-153. Timing Requirements for MMC4 - SDR12 Mode <sup>(1)</sup>**

| NO.    | PARAMETER           | DESCRIPTION                                                       | MIN   | MAX | UNIT |
|--------|---------------------|-------------------------------------------------------------------|-------|-----|------|
| SDR125 | $t_{su}(cmdV-clkH)$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge      | 25.99 |     | ns   |
| SDR126 | $t_h(clkH-cmdV)$    | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge        | 1.6   |     | ns   |
| SDR127 | $t_{su}(dV-clkH)$   | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 25.99 |     | ns   |
| SDR128 | $t_h(clkH-dV)$      | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge   | 1.6   |     | ns   |

(1) j in [i:0] = 3

**Table 5-154. Switching Characteristics for MMC4 - SDR12 Mode <sup>(2)</sup>**

| NO.    | PARAMETER   | DESCRIPTION                   | MIN                           | MAX | UNIT |
|--------|-------------|-------------------------------|-------------------------------|-----|------|
| SDR120 | fop(clk)    | Operating frequency, mmc4_clk |                               | 24  | MHz  |
| SDR121 | $t_w(clkH)$ | Pulse duration, mmc4_clk high | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |
| SDR122 | $t_w(clkL)$ | Pulse duration, mmc4_clk low  | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |

**Table 5-154. Switching Characteristics for MMC4 - SDR12 Mode <sup>(2)</sup> (continued)**

| NO.    | PARAMETER                 | DESCRIPTION                                                         | MIN    | MAX   | UNIT |
|--------|---------------------------|---------------------------------------------------------------------|--------|-------|------|
| SDR125 | $t_{d(\text{clkL-cmdV})}$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition      | -19.13 | 16.93 | ns   |
| SDR126 | $t_{d(\text{clkL-dV})}$   | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -19.13 | 16.93 | ns   |

(1) P = output mmc4\_clk period in ns

(2) j in [i:0] = 3

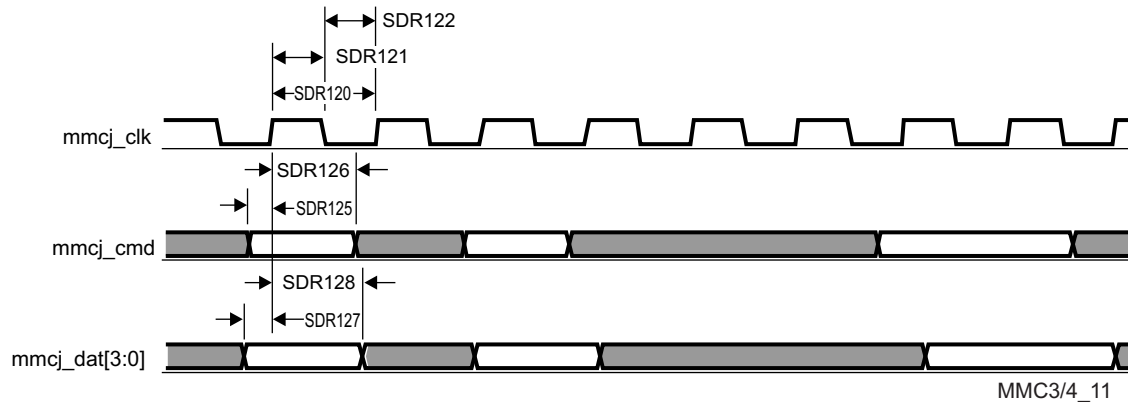
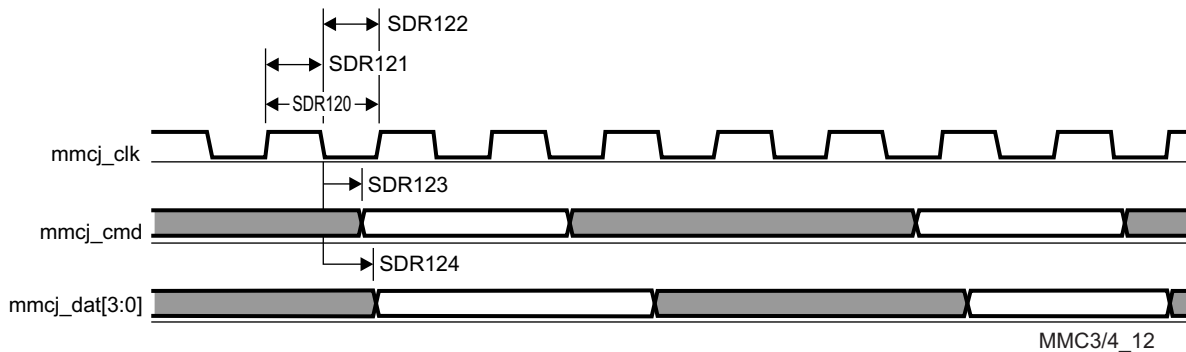
**Figure 5-100. MMC/SD/SDIOj in - SDR12 - Receiver Mode****Figure 5-101. MMC/SD/SDIOj in - SDR12 - Transmitter Mode****5.10.6.19.3.4 MMC3 and MMC4, SD SDR25 Mode**

Figure 5-102, Figure 5-103, and Table 5-155 through Table 5-158 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD and SDIO SDR25 in receiver and transmitter mode.

**Table 5-155. Timing Requirements for MMC3 - SDR25 Mode <sup>(1)</sup>**

| NO.    | PARAMETER                  | DESCRIPTION                                                       | MIN | MAX | UNIT |
|--------|----------------------------|-------------------------------------------------------------------|-----|-----|------|
| SDR253 | $t_{su(\text{cmdV-clkH})}$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge      | 5.3 |     | ns   |
| SDR254 | $t_{h(\text{clkH-cmdV})}$  | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge        | 1.6 |     | ns   |
| SDR257 | $t_{su(\text{dV-clkH})}$   | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 5.3 |     | ns   |
| SDR258 | $t_{h(\text{clkH-dV})}$    | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge   | 1.6 |     | ns   |

(1) i in [i:0] = 7

**Table 5-156. Switching Characteristics for MMC3 - SDR25 Mode <sup>(2)</sup>**

| NO.    | PARAMETER | DESCRIPTION                   | MIN | MAX | UNIT |
|--------|-----------|-------------------------------|-----|-----|------|
| SDR251 | fop(clk)  | Operating frequency, mmc3_clk |     | 48  | MHz  |

**Table 5-156. Switching Characteristics for MMC3 - SDR25 Mode <sup>(2)</sup> (continued)**

| NO.         | PARAMETER                 | DESCRIPTION                                                         | MIN                            | MAX | UNIT |
|-------------|---------------------------|---------------------------------------------------------------------|--------------------------------|-----|------|
| SDR252<br>H | $t_{w(\text{clkH})}$      | Pulse duration, mmc3_clk high                                       | 0.5P <sup>(1)</sup> -<br>0.270 |     | ns   |
| SDR252L     | $t_{w(\text{clkL})}$      | Pulse duration, mmc3_clk low                                        | 0.5P <sup>(1)</sup> -<br>0.270 |     | ns   |
| SDR255      | $t_{d(\text{clkL-cmdV})}$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition      | -8.8                           | 6.6 | ns   |
| SDR256      | $t_{d(\text{clkL-dV})}$   | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -8.8                           | 6.6 | ns   |

(1) P = output mmc3\_clk period in ns

(2) i in [i:0] = 7

**Table 5-157. Timing Requirements for MMC4 - SDR25 Mode <sup>(1)</sup>**

| NO.    | PARAMETER                  | DESCRIPTION                                                       | MIN | MAX | UNIT |
|--------|----------------------------|-------------------------------------------------------------------|-----|-----|------|
| SDR255 | $t_{su(\text{cmdV-clkH})}$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge      | 5.3 |     | ns   |
| SDR256 | $t_{h(\text{clkH-cmdV})}$  | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge        | 1.6 |     | ns   |
| SDR257 | $t_{su(\text{dV-clkH})}$   | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 5.3 |     | ns   |
| SDR258 | $t_{h(\text{clkH-dV})}$    | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge   | 1.6 |     | ns   |

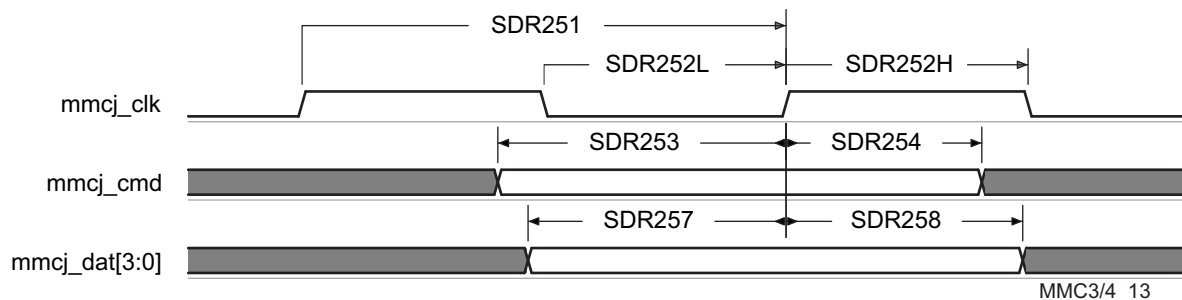
(1) i in [i:0] = 3

**Table 5-158. Switching Characteristics for MMC4 - SDR25 Mode <sup>(2)</sup>**

| NO.         | PARAMETER                 | DESCRIPTION                                                         | MIN                           | MAX | UNIT |
|-------------|---------------------------|---------------------------------------------------------------------|-------------------------------|-----|------|
| SDR251      | fop(clk)                  | Operating frequency, mmc4_clk                                       |                               | 48  | MHz  |
| SDR252<br>H | $t_{w(\text{clkH})}$      | Pulse duration, mmc4_clk high                                       | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |
| SDR252L     | $t_{w(\text{clkL})}$      | Pulse duration, mmc4_clk low                                        | 0.5P-<br>0.270 <sup>(1)</sup> |     | ns   |
| SDR255      | $t_{d(\text{clkL-cmdV})}$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition      | -8.8                          | 6.6 | ns   |
| SDR256      | $t_{d(\text{clkL-dV})}$   | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -8.8                          | 6.6 | ns   |

(1) P = output mmc4\_clk period in ns

(2) i in [i:0] = 3


**Figure 5-102. MMC/SD/SDIOj in - SDR25 - Receiver Mode**

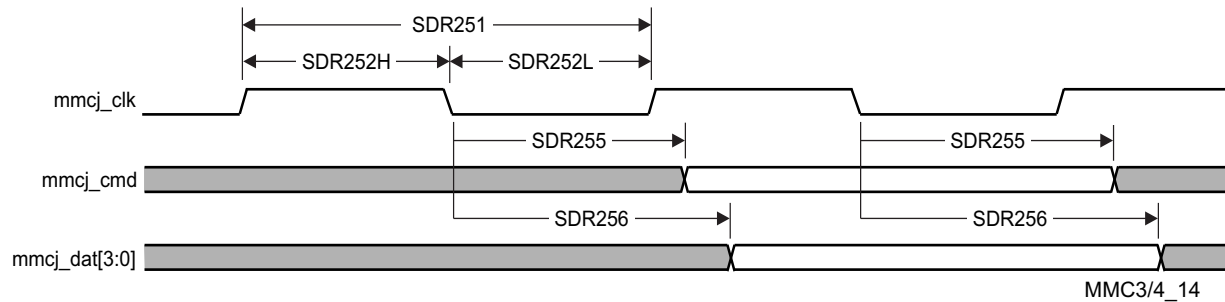


Figure 5-103. MMC/SD/SDIOj in - SDR25 - Transmitter Mode

#### 5.10.6.19.3.5 MMC3 SDIO High-Speed UHS-I SDR50 Mode, Half Cycle

Figure 5-104, Figure 5-105, Table 5-159, and Table 5-160 present Timing requirements and Switching characteristics for MMC3 - SDIO High speed SDR50 in receiver and transmitter mode.

Table 5-159. Timing Requirements for MMC3 - SDR50 Mode <sup>(1)</sup>

| NO.    | PARAMETER           | DESCRIPTION                                                       | MIN  | MAX | UNIT |
|--------|---------------------|-------------------------------------------------------------------|------|-----|------|
| SDR503 | $t_{su}(cmdV-clkH)$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge      | 1.48 |     | ns   |
| SDR504 | $t_h(clkH-cmdV)$    | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge        | 1.6  |     | ns   |
| SDR507 | $t_{su}(dV-clkH)$   | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 1.48 |     | ns   |
| SDR508 | $t_h(clkH-dV)$      | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge   | 1.6  |     | ns   |

(1) i in [i:0] = 7

Table 5-160. Switching Characteristics for MMC3 - SDR50 Mode <sup>(2)</sup>

| NO.     | PARAMETER        | DESCRIPTION                                                         | MIN                       | MAX  | UNIT |
|---------|------------------|---------------------------------------------------------------------|---------------------------|------|------|
| SDR501  | fop(clk)         | Operating frequency, mmc3_clk                                       |                           | 96   | MHz  |
| SDR502H | $t_w(clkH)$      | Pulse duration, mmc3_clk high                                       | 0.5P-0.270 <sup>(1)</sup> |      | ns   |
| SDR502L | $t_w(clkL)$      | Pulse duration, mmc3_clk low                                        | 0.5P-0.270 <sup>(1)</sup> |      | ns   |
| SDR505  | $t_d(clkL-cmdV)$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition      | -3.66                     | 1.46 | ns   |
| SDR506  | $t_d(clkL-dV)$   | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -3.66                     | 1.46 | ns   |

(1) P = output mmc3\_clk period in ns

(2) i in [i:0] = 7

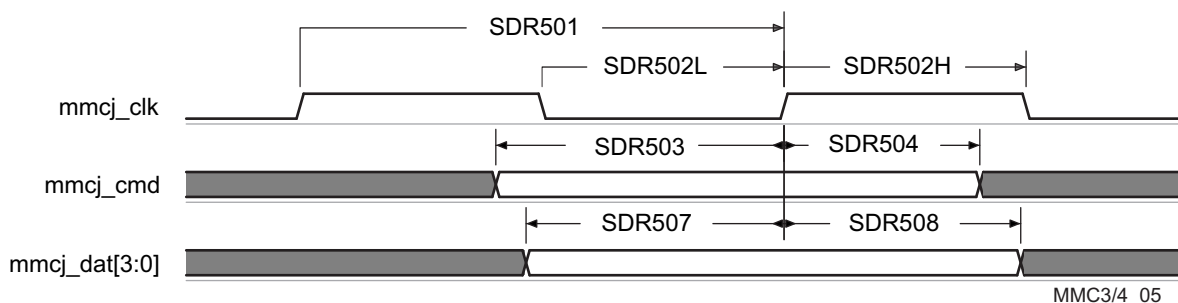


Figure 5-104. MMC/SD/SDIOj in - High Speed SDR50 - Receiver Mode

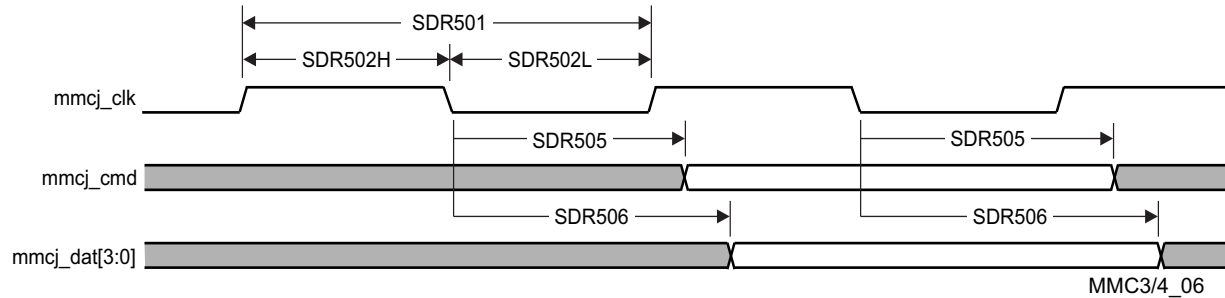


Figure 5-105. MMC/SD/SDIOj in - High Speed SDR50 - Transmitter Mode

#### NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information see the Control Module chapter in the Device TRM.

Manual IO Timings Modes must be used to guarantee some IO timings for MMC3. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-161, Manual Functions Mapping for MMC3](#) for a definition of the Manual modes.

[Table 5-161](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

Table 5-161. Manual Functions Mapping for MMC3

| BALL | BALL NAME | MMC3_MANUAL1 |              | MMC3_MANUAL2 |              | CFG REGISTER      | MUXMODE   |
|------|-----------|--------------|--------------|--------------|--------------|-------------------|-----------|
|      |           | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) |                   | 0         |
| AD4  | mmc3_clk  | 0            | 386          | 852          | 0            | CFG_MMC3_CLK_IN   | mmc3_clk  |
| AD4  | mmc3_clk  | 605          | 0            | 94           | 0            | CFG_MMC3_CLK_OUT  | mmc3_clk  |
| AC4  | mmc3_cmd  | 0            | 0            | 122          | 0            | CFG_MMC3_CMD_IN   | mmc3_cmd  |
| AC4  | mmc3_cmd  | 0            | 0            | 0            | 0            | CFG_MMC3_CMD_OEN  | mmc3_cmd  |
| AC4  | mmc3_cmd  | 0            | 0            | 0            | 0            | CFG_MMC3_CMD_OUT  | mmc3_cmd  |
| AC7  | mmc3_dat0 | 171          | 0            | 91           | 0            | CFG_MMC3_DAT0_IN  | mmc3_dat0 |
| AC7  | mmc3_dat0 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT0_OEN | mmc3_dat0 |
| AC7  | mmc3_dat0 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT0_OUT | mmc3_dat0 |
| AC6  | mmc3_dat1 | 221          | 0            | 57           | 0            | CFG_MMC3_DAT1_IN  | mmc3_dat1 |
| AC6  | mmc3_dat1 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT1_OEN | mmc3_dat1 |
| AC6  | mmc3_dat1 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT1_OUT | mmc3_dat1 |
| AC9  | mmc3_dat2 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT2_IN  | mmc3_dat2 |
| AC9  | mmc3_dat2 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT2_OEN | mmc3_dat2 |
| AC9  | mmc3_dat2 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT2_OUT | mmc3_dat2 |
| AC3  | mmc3_dat3 | 474          | 0            | 375          | 0            | CFG_MMC3_DAT3_IN  | mmc3_dat3 |
| AC3  | mmc3_dat3 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT3_OEN | mmc3_dat3 |
| AC3  | mmc3_dat3 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT3_OUT | mmc3_dat3 |
| AC8  | mmc3_dat4 | 792          | 0            | 213          | 0            | CFG_MMC3_DAT4_IN  | mmc3_dat4 |
| AC8  | mmc3_dat4 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT4_OEN | mmc3_dat4 |
| AC8  | mmc3_dat4 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT4_OUT | mmc3_dat4 |
| AD6  | mmc3_dat5 | 782          | 0            | 355          | 0            | CFG_MMC3_DAT5_IN  | mmc3_dat5 |
| AD6  | mmc3_dat5 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT5_OEN | mmc3_dat5 |
| AD6  | mmc3_dat5 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT5_OUT | mmc3_dat5 |

**Table 5-161. Manual Functions Mapping for MMC3 (continued)**

| BALL | BALL NAME | MMC3_MANUAL1 |              | MMC3_MANUAL2 |              | CFG REGISTER      | MUXMODE<br>0 |
|------|-----------|--------------|--------------|--------------|--------------|-------------------|--------------|
|      |           | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) |                   |              |
| AB8  | mmc3_dat6 | 942          | 0            | 437          | 0            | CFG_MMC3_DAT6_IN  | mmc3_dat6    |
| AB8  | mmc3_dat6 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT6_OEN | mmc3_dat6    |
| AB8  | mmc3_dat6 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT6_OUT | mmc3_dat6    |
| AB5  | mmc3_dat7 | 636          | 0            | 224          | 0            | CFG_MMC3_DAT7_IN  | mmc3_dat7    |
| AB5  | mmc3_dat7 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT7_OEN | mmc3_dat7    |
| AB5  | mmc3_dat7 | 0            | 0            | 0            | 0            | CFG_MMC3_DAT7_OUT | mmc3_dat7    |

Manual IO Timings Modes must be used to guarantee some IO timings for MMC4. See [Table 5-32, Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 5-162, Manual Functions Mapping for MMC4](#) for a definition of the Manual modes.

[Table 5-162](#) lists the A\_DELAY and G\_DELAY values needed to calculate the correct values to be set in the CFG\_x registers.

**Table 5-162. Manual Functions Mapping for MMC4**

| BALL | BALL NAME  | MMC4_MANUAL1 |              | MMC4_DS_MANUAL1 |              | CFG REGISTER       | MUXMODE<br>3 |
|------|------------|--------------|--------------|-----------------|--------------|--------------------|--------------|
|      |            | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps)    | G_DELAY (ps) |                    |              |
| E25  | uart1_ctsn | 0            | 0            | 0               | 0            | CFG_UART1_CTSN_IN  | mmc4_clk     |
| E25  | uart1_ctsn | 1147         | 0            | 0               | 0            | CFG_UART1_CTSN_OUT | mmc4_clk     |
| C27  | uart1_rtsn | 1834         | 0            | 307             | 0            | CFG_UART1_RTSN_IN  | mmc4_cmd     |
| C27  | uart1_rtsn | 0            | 0            | 0               | 0            | CFG_UART1_RTSN_OEN | mmc4_cmd     |
| C27  | uart1_rtsn | 0            | 0            | 0               | 0            | CFG_UART1_RTSN_OUT | mmc4_cmd     |
| D27  | uart2_ctsn | 2165         | 0            | 785             | 0            | CFG_UART2_CTSN_IN  | mmc4_dat2    |
| D27  | uart2_ctsn | 0            | 0            | 0               | 0            | CFG_UART2_CTSN_OEN | mmc4_dat2    |
| D27  | uart2_ctsn | 0            | 0            | 0               | 0            | CFG_UART2_CTSN_OUT | mmc4_dat2    |
| C28  | uart2_rtsn | 1929         | 64           | 613             | 0            | CFG_UART2_RTSN_IN  | mmc4_dat3    |
| C28  | uart2_rtsn | 0            | 0            | 0               | 0            | CFG_UART2_RTSN_OEN | mmc4_dat3    |
| C28  | uart2_rtsn | 0            | 0            | 0               | 0            | CFG_UART2_RTSN_OUT | mmc4_dat3    |
| D28  | uart2_rxd  | 1935         | 128          | 683             | 0            | CFG_UART2_RXD_IN   | mmc4_dat0    |
| D28  | uart2_rxd  | 0            | 0            | 0               | 0            | CFG_UART2_RXD_OEN  | mmc4_dat0    |
| D28  | uart2_rxd  | 0            | 0            | 0               | 0            | CFG_UART2_RXD_OUT  | mmc4_dat0    |
| D26  | uart2_txd  | 2172         | 44           | 835             | 0            | CFG_UART2_TXD_IN   | mmc4_dat1    |
| D26  | uart2_txd  | 0            | 0            | 0               | 0            | CFG_UART2_TXD_OEN  | mmc4_dat1    |
| D26  | uart2_txd  | 0            | 0            | 0               | 0            | CFG_UART2_TXD_OUT  | mmc4_dat1    |

### 5.10.6.20 GPIO

The general-purpose interface combines eight general-purpose input/output (GPIO) banks. Each GPIO module provides 32 dedicated general-purpose pins with input and output capabilities; thus, the general-purpose interface supports up to 247 pins.

These pins can be configured for the following applications:

- Data input (capture)/output (drive)
- Keyboard interface with a debounce cell
- Interrupt generation in active mode upon the detection of external events. Detected events are processed by two parallel independent interrupt-generation submodules to support biprocessor operations
- Wake-up request generation in idle mode upon the detection of external events

#### NOTE

For more information, see the General-Purpose Interface chapter of the Device TRM.

#### NOTE

The general-purpose input/output  $i$  ( $i = 1$  to 8) bank is also referred to as GPIOi.

### 5.10.6.21 System and Miscellaneous interfaces

The Device includes the following System and Miscellaneous interfaces:

- Sysboot Interface
- Enhanced DMA Interface
- Interrupt Controllers (INTC) Interface
- Observability Signal (OBS) Interface

### 5.10.7 Emulation and Debug Subsystem

The Device includes the following test interfaces:

- IEEE 1149.1 Standard-Test-Access Port (JTAG)
- Trace Port Interface Unit (TPIU)
- Advanced Event Triggering Interface (AET)

#### 5.10.7.1 JTAG

The JTAG (IEEE Standard 1149.1-1990 Standard-Test-Access Port and Boundary Scan Architecture) interface is used for BSDL testing and emulation of the device. The  $trstn$  pin only needs to be released when it is necessary to use a JTAG controller to debug the device or exercise the device's boundary scan functionality. For maximum reliability, the device includes an Internal Pulldown (IPD) on the  $trstn$  pin to ensure that  $trstn$  is always asserted upon power up and the device's internal emulation logic is always properly initialized. JTAG controllers from Texas Instruments actively drive  $trstn$  high. However, some third-party JTAG controllers may not drive  $trstn$  high but expect the use of a Pullup resistor on  $trstn$ . When using this type of JTAG controller, assert  $trstn$  to initialize the device after powerup and externally drive  $trstn$  high before attempting any emulation or boundary-scan operations.

The main JTAG features include:

- 32 KB embedded trace buffer (ETB)
- 5-pin system trace interface for debug
- Supports Advanced Event Triggering (AET)
- All processors can be emulated via JTAG ports
- All functions on EMU pins of the device:
  - EMU[1:0] - cross-triggering, boot mode (WIR), STM trace
  - EMU[4:2] - STM trace only (single direction)

#### 5.10.7.1.1 JTAG Electrical Data/Timing

Table 5-163, Table 5-164 and Figure 5-106 assume testing over the recommended operating conditions and electrical characteristic conditions below.

**Table 5-163. Timing Requirements for IEEE 1149.1 JTAG**

| NO. | PARAMETER   | DESCRIPTION                              | MIN   | MAX | UNIT |
|-----|-------------|------------------------------------------|-------|-----|------|
| J1  | $t_c(TCK)$  | Cycle time, TCK                          | 62.29 |     | ns   |
| J1H | $t_w(TCKH)$ | Pulse duration, TCK high (40% of $t_c$ ) | 24.92 |     | ns   |
| J1L | $t_w(TCKL)$ | Pulse duration, TCK low (40% of $t_c$ )  | 24.92 |     | ns   |

**Table 5-163. Timing Requirements for IEEE 1149.1 JTAG (continued)**

| NO. | PARAMETER         | DESCRIPTION                              | MIN   | MAX | UNIT |
|-----|-------------------|------------------------------------------|-------|-----|------|
| J3  | $t_{su}(TDI-TCK)$ | Input setup time, TDI valid to TCK high  | 6.23  |     | ns   |
|     | $t_{su}(TMS-TCK)$ | Input setup time, TMS valid to TCK high  | 6.23  |     | ns   |
| J4  | $t_h(TCK-TDI)$    | Input hold time, TDI valid from TCK high | 31.15 |     | ns   |
|     | $t_h(TCK-TMS)$    | Input hold time, TMS valid from TCK high | 31.15 |     | ns   |

**Table 5-164. Switching Characteristics Over Recommended Operating Conditions for IEEE 1149.1 JTAG**

| NO. | PARAMETER        | DESCRIPTION                      | MIN | MAX  | UNIT |
|-----|------------------|----------------------------------|-----|------|------|
| J2  | $t_d(TCKL-TDOV)$ | Delay time, TCK low to TDO valid | 0   | 30.5 | ns   |

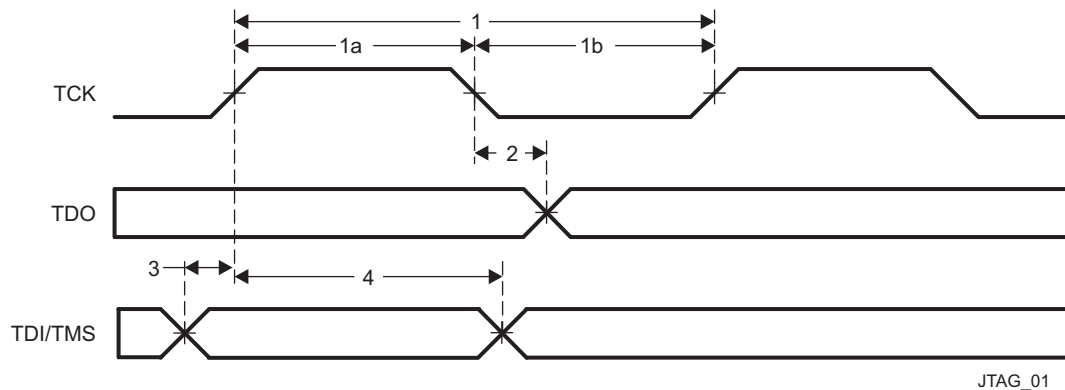
**Figure 5-106. JTAG Timing**

Table 5-165, Table 5-166 and Figure 5-107 assume testing over the recommended operating conditions and electrical characteristic conditions below.

**Table 5-165. Timing Requirements for IEEE 1149.1 JTAG With RTCK**

| NO.  | PARAMETER         | DESCRIPTION                              | MIN   | MAX | UNIT |
|------|-------------------|------------------------------------------|-------|-----|------|
| JR1  | $t_c(TCK)$        | Cycle time, TCK                          | 62.29 |     | ns   |
| JR1H | $t_w(TCKH)$       | Pulse duration, TCK high (40% of $t_c$ ) | 24.92 |     | ns   |
| JR1L | $t_w(TCKL)$       | Pulse duration, TCK low (40% of $t_c$ )  | 24.92 |     | ns   |
| JR3  | $t_{su}(TDI-TCK)$ | Input setup time, TDI valid to TCK high  | 6.23  |     | ns   |
|      | $t_{su}(TMS-TCK)$ | Input setup time, TMS valid to TCK high  | 6.23  |     | ns   |
| JR4  | $t_h(TCK-TDI)$    | Input hold time, TDI valid from TCK high | 31.15 |     | ns   |
|      | $t_h(TCK-TMS)$    | Input hold time, TMS valid from TCK high | 31.15 |     | ns   |

**Table 5-166. Switching Characteristics Over Recommended Operating Conditions for IEEE 1149.1 JTAG With RTCK**

| NO. | PARAMETER       | DESCRIPTION                                                                                                                                                                              | MIN   | MAX | UNIT |
|-----|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----|------|
| JR5 | $t_d(TCK-RTCK)$ | Delay time, TCK to RTCK with no selected subpaths (i.e. ICEPick is the only tap selected - when the Arm is in the scan chain, the delay time is a function of the Arm functional clock). | 0     | 27  | ns   |
| JR6 | $t_c(RTCK)$     | Cycle time, RTCK                                                                                                                                                                         | 62.29 |     | ns   |
| JR7 | $t_w(RTCKH)$    | Pulse duration, RTCK high (40% of $t_c$ )                                                                                                                                                | 24.92 |     | ns   |
| JR8 | $t_w(RTCKL)$    | Pulse duration, RTCK low (40% of $t_c$ )                                                                                                                                                 | 24.92 |     | ns   |

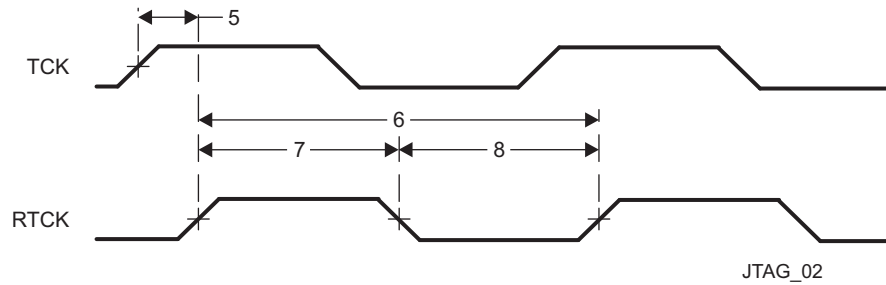


Figure 5-107. JTAG With RTCK Timing

### 5.10.7.2 Trace Port Interface Unit (TPIU)

#### CAUTION

The I/O timings provided in this section are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 5-168](#).

#### 5.10.7.2.1 TPIU PLL DDR Mode

[Table 5-167](#) and [Figure 5-108](#) assume testing over the recommended operating conditions and electrical characteristic conditions below.

Table 5-167. Switching Characteristics for TPIU

| NO.   | PARAMETER          | DESCRIPTION                                           | MIN   | MAX  | UNIT |
|-------|--------------------|-------------------------------------------------------|-------|------|------|
| TPIU1 | $t_{c(clk)}$       | Cycle time, TRACECLK period                           | 5.56  |      | ns   |
| TPIU4 | $t_{d(clk-ctlV)}$  | Skew time, TRACECLK transition to TRACECTL transition | -0.96 | 0.96 | ns   |
| TPIU5 | $t_{d(clk-dataV)}$ | Skew time, TRACECLK transition to TRACEDATA[17:0]     | -0.96 | 0.96 | ns   |

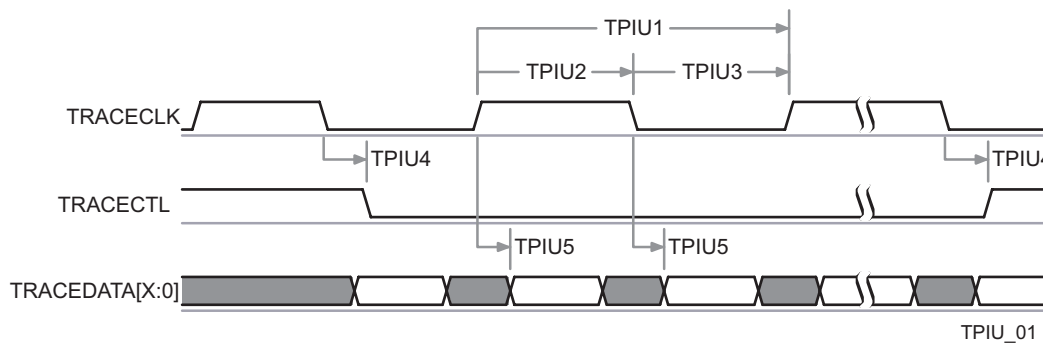


Figure 5-108. TPIU—PLL DDR Transmit Mode<sup>(1)</sup>

(1) In d[X:0], X is equal to 15 or 17.

In [Table 5-168](#) are presented the specific groupings of signals (IOSET) for use with TPIU signals.

Table 5-168. TPIU IOSETs

| SIGNALS | IOSET1 |     | IOSET2 |     |
|---------|--------|-----|--------|-----|
|         | BALL   | MUX | BALL   | MUX |
| emu0    | G21    | 0   | G21    | 0   |
| emu1    | D24    | 0   | D24    | 0   |
| emu2    | F10    | 2   | F10    | 2   |

**Table 5-168. TPIU IOSETs (continued)**

| SIGNALS | IOSET1 |     | IOSET2 |     |
|---------|--------|-----|--------|-----|
|         | BALL   | MUX | BALL   | MUX |
| emu3    | D7     | 2   | D7     | 2   |
| emu4    | A7     | 2   | A7     | 2   |
| emu5    | E1     | 5   | G11    | 2   |
| emu6    | G2     | 5   | E9     | 2   |
| emu7    | H7     | 5   | F9     | 2   |
| emu8    | G1     | 5   | F8     | 2   |
| emu9    | G6     | 5   | E7     | 2   |
| emu10   | F2     | 5   | D8     | 2   |
| emu11   | F3     | 5   | A5     | 2   |
| emu12   | D1     | 5   | C6     | 2   |
| emu13   | E2     | 5   | C8     | 2   |
| emu14   | D2     | 5   | C7     | 2   |
| emu15   | F4     | 5   | A8     | 2   |
| emu16   | C1     | 5   | C9     | 2   |
| emu17   | E4     | 5   | A9     | 2   |
| emu18   | F5     | 5   | B9     | 2   |
| emu19   | E6     | 5   | A10    | 2   |

## 6 Detailed Description

### 6.1 Description

TI's new TDA2Px System-on-Chip (SoC) is a highly optimized and scalable family of devices designed to meet the requirements of leading Advanced Driver Assistance Systems (ADAS). The TDA2Px family enables broad ADAS applications in automobiles by integrating an optimal mix of performance, low power and ADAS vision analytics processing that aims to facilitate a more autonomous and collision-free driving experience.

The TDA2Px SoC enables sophisticated embedded vision technology in automobiles by broadest range of ADAS applications including front camera, park assist, surround view and sensor fusion on a single architecture.

The TDA2Px SoC incorporates a heterogeneous, scalable architecture that includes a mix of TI's fixed and floating-point TMS320C66x digital signal processor (DSP) generation cores, Vision AccelerationPac, Arm Cortex-A15 MPCore and dual-Cortex-M4 processors. The integration of a video accelerator for decoding multiple video streams over an Ethernet AVB network, along with graphics accelerators for rendering virtual views, enable a 3D viewing experience. And the TDA2Px SoC also integrates a host of peripherals including multi-camera interfaces (both parallel and serial) for LVDS-based surround view systems, displays, CAN and GigB Ethernet AVB.

The Vision AccelerationPac for this family of products includes multiple embedded vision engines (EVEs) offloading the vision analytics functionality from the application processor while also reducing the power footprint. The Vision AccelerationPac is optimized for vision processing with a 32-bit RISC core for efficient program execution and a vector coprocessor for specialized vision processing.

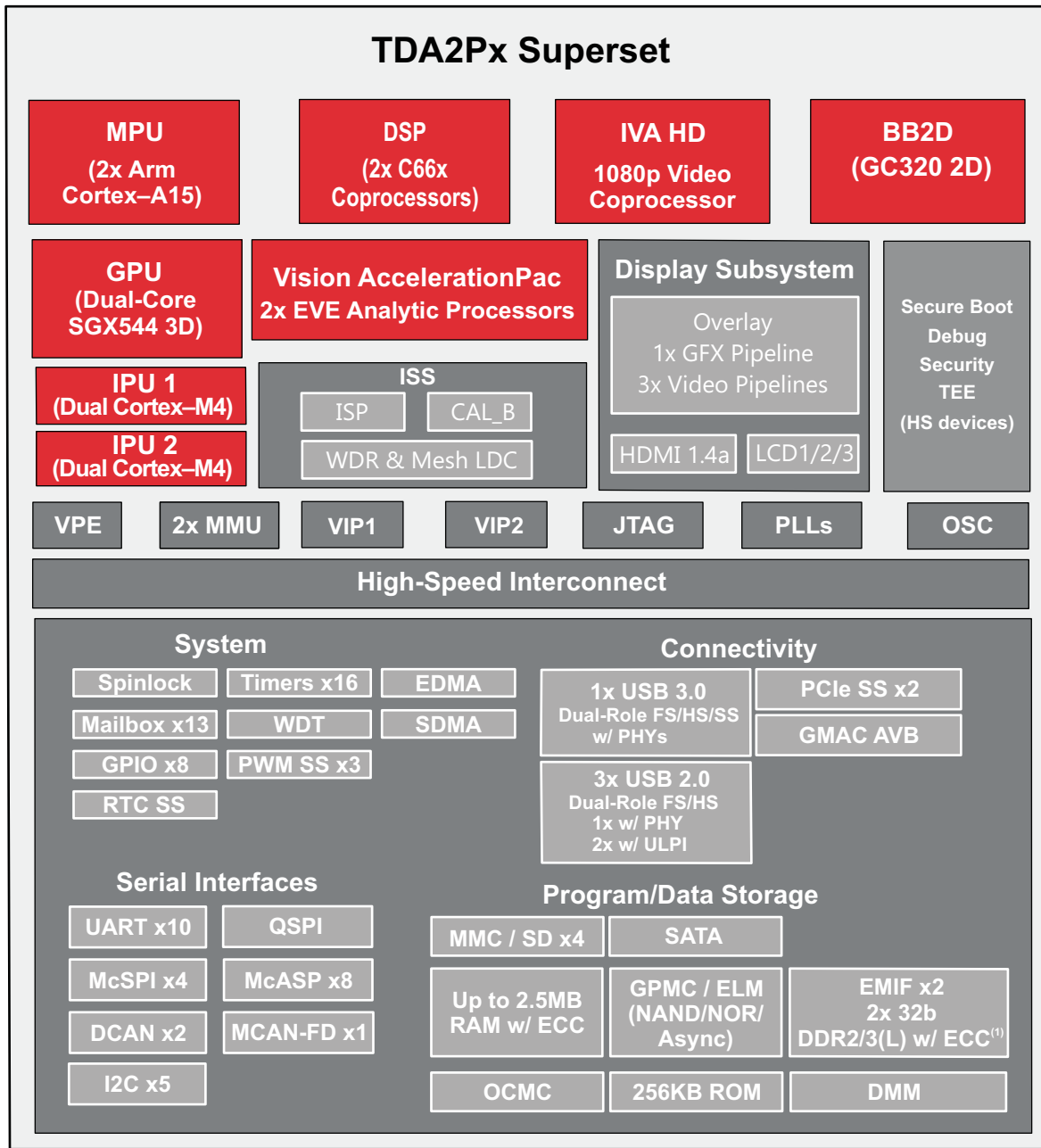
Additionally, TI provides a complete set of development tools for the Arm, DSP, and EVE coprocessor, including C compilers, a DSP assembly optimizer to simplify programming and scheduling, and a debugging interface for visibility into source code execution.

Cryptographic acceleration is available in all devices. All other supported security features, including support for secure boot, debug security and support for trusted execution environment are available on High-Security (HS) devices. For more information about HS devices, contact your TI representative.

The TDA2Px ADAS processor is qualified according to the AEC-Q100 standard.

### 6.2 Functional Block Diagram

[Figure 6-1](#) is functional block diagram for the device.



intro-001

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**Figure 6-1. TDA2Px Block Diagram**

(1) ECC is only available on EMIF1.

## 6.3 MPU

The dual Cortex®-A15 microprocessor unit (MPU) subsystem serves the applications processing role by running the high-level operating system (HLOS) and application code.

The MPU subsystem incorporates two Cortex-A15 MPU cores (MPU\_C0 and MPU\_C1), individual level 1 (L1) caches, level 2 (L2) cache (MPU\_L2CACHE) shared between them, and various other shared peripherals. To aid software development, the processor cores can be kept cache-coherent with each other and with the L2 cache.

The MPU subsystem provides a high-performance computing platform with high peak-computing performance and low memory latency.

The MPU subsystem integrates the following:

- Arm Cortex-A15 MP Core (MPU\_CLUSTER)
  - Two Cortex-A15 MPU cores (revision r2p2, SMP architecture), each of them having the following features:
    - Superscalar, dynamic multi-issue technology
      - Out-of-order (OoO) instruction dispatch and completion
      - Dynamic branch prediction with branch target buffer (BTB), global history buffer (GHB), and 48-entry return stack
      - Continuous fetch and decoding of three instructions per clock cycle
      - Dispatch of up to four instructions and completion of eight instructions per clock cycle
      - Provides optimal performance from binaries compiled for previous Arm processors
      - Five execution units handle simple instructions, branch instructions, Neon™ and floating point instructions, multiply instructions, and load and store instructions.
      - Simple instructions take two cycles from dispatch, while complex instructions take up to 11 cycles.
      - Can issue two simple instructions in a cycle
      - Can issue a load and a store instruction in the same cycle
    - Integrated Neon processing engine to include the Arm Neon Advanced SIMD (single instruction, multiple data) support for accelerated media and signal processing computation
    - Includes VFPv4-compatible hardware to support single- and double-precision add, subtract, divide, multiply and accumulate, and square root operations
    - Extensive support to accelerate virtualization using a hypervisor
    - 32-KiB L1 instruction (L1I) and 32-KiB L1 data (L1D) cache:
      - 64-byte line size
      - 2-way set associative
    - Memory management unit (MMU):
      - Two-level translation lookaside buffer (TLB) organization
        - First level is an 32-entry, fully associative micro-TLB implemented for each of instruction fetch, load, and store.
        - Second level is a unified, 4-way associative, 512-entry main TLB
      - Supports hardware TLB table-walk for backward-compatible and new 64-bit entry page table formats
      - New page table format can produce 40-bit physical addresses
      - Two-stage translation where first stage is HLOS-controlled and the second level may be controlled by a hypervisor. Second stage always uses the new page table format
  - Integrated L2 cache (MPU\_L2CACHE) and snoop control unit (SCU):
    - 2-MiB of unified (instructions and data) cache organized as 16 ways of 2048 sets of 64-byte lines
    - Redundant L1 data (cache) tags to perform snoop filtering (L1 instruction cache tags are not duplicated)
    - Operates at Cortex-A15 MPU core clock rate
    - Integrated L2 cache controller (MPU\_L2CACHE\_CTRL):
      - Sixteen 64-byte line buffers that handle evictions, line fills and snoop transfers
      - One 128-bit AMBA4 Coherent Bus (AXI4-ACE) port
      - Auto-prefetch buffer for up to 16 streams per core and detecting forward and backward strides
  - Generalized interrupt controller (GIC, also referred to as MPU\_INTIC): An interrupt controller supplied by Arm. The single GIC in the MPU\_CLUSTER routes interrupts to each of the MPU cores. The GIC supports:
    - Number of shared peripheral interrupts (SPI): 160

- Number of software generated interrupts (SGI): 16
- Number of CPU interfaces: 2
- Virtual CPU interface for virtualization support. This allows the majority of guest operating system (OS) interactions with the GIC to be handled in hardware, but with physical interrupts still requiring hypervisor intervention to assign them to the appropriate virtual machine.
- Integrated timer counter and one timer block per MPU core
- Arm CoreSight™ debug and trace modules. For more information, see chapter On-Chip Debug Support of the Device TRM.
- MPU\_AXI2OCP bridge (local interconnect):
  - Connected to Memory Adapter (MPU\_MA), which routes the non-EMIF address space transactions to MPU\_AXI2OCP
  - Single request multiple data (SRMD) protocol on L3\_MAIN port
  - Multiple targets:
    - 64-bit port to the L3\_MAIN interconnect. Interface frequency is 1/4 or 1/8 of core frequency
    - MPU\_ROM
    - Internal MPU subsystem peripheral targets, including Memory Adapter LISA Section Manager (MA\_LSM), wake-up generator (MPU\_WUGEN), watchdog timer (MPU\_WD\_TIMER), and local PRCM module (MPU\_PRCM) configuration
    - Internal AXI target, CoreSight System Trace Module (CS\_STM)
- Memory adapter (MPU\_MA): Helps decrease the latency of accesses between the MPU\_L2CACHE and the two EMIFs (EMIF0 and EMIF1) by providing a direct path between the MPU subsystem and the EMIFs:
  - Connected to 128-bit AMBA4 interface of MPU\_CLUSTER
  - Direct 128-bit interface to each of EMIF0 and EMIF1
  - Interface speed between MPU\_CLUSTER and MPU\_MA is at half-speed of MPU\_CLUSTER internal core frequency
  - Quarter-speed interface to EMIF
  - Uses firewall logic to check access rights of incoming addressess
- Local PRCM (MPU\_PRCM):
  - Handles MPU\_C0 and MPU\_C1 power domains
  - Supports SR3-APG (SmartReflex3 Automatic Power Gating) power management technology inside the MPU\_CLUSTER
  - MPU subsystem has six power domains
- Wake-up generator (MPU\_WUGEN)
  - Responsible for waking up the MPU cores
- Standby controller: Handles the power transitions inside the MPU subsystem
- Realtime (master) counter (COUNTER\_REALTIME): Produces the count used by the private timer peripherals in the MPU\_CLUSTER
- Watchdog timer (MPU\_WD\_TIMER): Used to generate a chip-level watchdog reset request to global PRCM
- On-chip boot ROM (MPU\_ROM): The MPU\_ROM size is 48-KiB, and the address range is from 0x4003 8000 to 0x4004 3FFF. For more information about booting from this memory, see chapter *Initialization* of the Device TRM.

- Interfaces:
  - 128-bit interface to each of EMIF0 and EMIF1
  - 64-bit master port to the L3\_MAIN interconnect
  - 32-bit slave port from the L4\_CFG\_EMU interconnect (debug subsystem) for configuration of the MPU subsystem debug modules
  - 32-bit slave port from the L4\_CFG interconnect for memory adapter firewall (MPU\_MA\_NTTP\_FW) configuration
  - 32-bit ATB output for transmitting debug and trace data
  - 160 peripheral interrupt inputs

For more information, see chapter *Dual Cortex-A15 MPU Subsystem* of the Device TRM.

## 6.4 DSP Subsystem

The device includes two identical instances (DSP1 and DSP2) of a digital signal processor (DSP) subsystem, based on the TI's standard TMS320C66x™ DSP CorePac core.

The TMS320C66x DSP core enhances the TMS320C674x™ core, which merges the C674x™ floating point and the C64x+™ fixed-point instruction set architectures. The C66x DSP is object-code compatible with the C64x+/C674x DSPs.

For more information on the TMS320C66x core CPU, see the *TMS320C66x DSP CPU and Instruction Set Reference Guide* ([SPRUH7](#)).

The DSP subsystem integrated in the device includes the following components:

- A TMS320C66x™ CorePac DSP core that encompasses:
  - L1 program-dedicated (L1P) cacheable memory
  - L1 data-dedicated (L1D) cacheable memory
  - L2 (program and data) cacheable memory
  - Extended Memory Controller (XMC)
  - External Memory Controller (EMC)
  - DSP CorePac located interrupt controller (INTC)
  - DSP CorePac located power-down controller (PDC)
- Dedicated enhanced data memory access engine - EDMA, to transfer data from/to memories and peripherals external to the DSP subsystems and to local DSP memory (most commonly L2 SRAM). The external DMA requests are passed through DSP system level (SYS) wakeup logic, and collected from the DSP1 / DSP2 dedicated outputs of the device DMA Events Crossbar for each of the two subsystems.
- A level 2 (L2) interconnect network (DSP NoC) to allow connectivity between different modules of the subsystem or the remainder of the device via the device L3\_MAIN interconnect.
- Two memory management units (on EDMA L2 interconnect and DSP MDMA paths) for accessing the device L3\_MAIN interconnect address space
- Dedicated system control logic (DSP\_SYSTEM) responsible for power management, clock generation, and connection to the device power, reset, and clock management (PRCM) module

The TMS320C66x Instruction Set Architecture (ISA) is the latest for the C6000 family. As with its predecessors (C64x, C64x+ and C674x), the C66x is an advanced VLIW architecture with 8 functional units (two multiplier units and six arithmetic logic units) that operate in parallel. The C66x CPU has a total of 64 general-purpose 32-bit registers.

Some features of the DSP C6000 family devices are:

- Advanced VLIW CPU with eight functional units (two multipliers and six ALUs) which:
  - Executes up to eight instructions per cycle for up to ten times the performance of typical DSPs
  - Allows designers to develop highly effective RISC-like code for fast development time

- Instruction packing
  - Gives code size equivalence for eight instructions executed serially or in parallel
  - Reduces code size, program fetches, and power consumption
- Conditional execution of most instructions
  - Reduces costly branching
  - Increases parallelism for higher sustained performance
- Efficient code execution on independent functional units
  - Industry's most efficient C compiler on DSP benchmark suite
  - Industry's first assembly optimizer for fast development and improved parallelization
- 8-/16-/32-bit/64-bit data support, providing efficient memory support for a variety of applications
- 40-bit arithmetic options which add extra precision for vocoders and other computationally intensive applications
- Saturation and normalization to provide support for key arithmetic operations
- Field manipulation and instruction extract, set, clear, and bit counting support common operation found in control and data manipulation applications.

The C66x CPU has the following additional features:

- Each multiplier can perform two  $16 \times 16$ -bit or four  $8 \times 8$  bit multiplies every clock cycle.
- Quad 8-bit and dual 16-bit instruction set extensions with data flow support
- Support for non-aligned 32-bit (word) and 64-bit (double word) memory accesses
- Special communication-specific instructions have been added to address common operations in error-correcting codes.
- Bit count and rotate hardware extends support for bit-level algorithms.
- Compact instructions: Common instructions (AND, ADD, LD, MPY) have 16-bit versions to reduce code size.
- Protected mode operation: A two-level system of privileged program execution to support higher-capability operating systems and system features such as memory protection.
- Exceptions support for error detection and program redirection to provide robust code execution
- Hardware support for modulo loop operation to reduce code size and allow interrupts during fully-pipelined code
- Each multiplier can perform  $32 \times 32$  bit multiplies
- Additional instructions to support complex multiplies allowing up to eight 16-bit multiply/add/subtracts per clock cycle

The TMS320C66x has the following key improvements to the ISA:

- 4x Multiply Accumulate improvement for both fixed and floating point
- Improvement of the floating point arithmetic
- Enhancement of the vector processing capability for fixed and floating point
- Addition of domain-specific instructions for complex arithmetic and matrix operations

**On the C66x ISA, the vector processing capability is improved by extending the width of the SIMD instructions.** The C674x DSP supports 2-way SIMD operations for 16-bit data and 4-way SIMD operations for 8-bit data. C66x enhances this capabilities with the addition of SIMD instructions for 32-bit data allowing operation on 128-bit vectors. For example the QMPY32 instruction is able to perform the element to element multiplication between two vectors of four 32-bit data each.

C66x ISA includes a set of specific instructions to handle complex arithmetic and matrix operations.

- **TMS320C66x DSP CorePac memory components:**
  - A 32-KiB L1 program memory (L1P) configurable as cache and/or SRAM:
    - When configured as a cache, the L1P is a 1-way set-associative cache with a 32-byte cache line
    - The DSP CorePac L1P memory controller provides bandwidth management, memory protection, and power-down functions
    - The L1P is capable of cache block and global coherence operations
    - The L1P controller has an Error Detection (ED) mechanism, including necessary SRAM
    - The L1P memory can be fully configured as a cache or SRAM
    - Page size for L1P memory is 2KB
  - A 32-KiB L1 data memory (L1D) with ECC, configurable as cache and / or SRAM:
    - When configured as a cache, the L1D is a 2-way set-associative cache with a 64-byte cache line
    - The DSP CorePac L1D memory controller provides bandwidth management, memory protection, and power-down functions
    - The L1D memory can be fully configured as a cache or SRAM
    - No support for error correction or detection
    - Page size for L1D memory is 2KB
  - A 288-KiB (program and data) L2 memory, only part of which is cacheable:
    - When configured as a cache, the L2 memory is a 4-way set associative cache with a 128-byte cache line
    - Only 256 KiB of L2 memory can be configured as cache or SRAM
    - 32 KiB of the L2 memory is always mapped as SRAM
    - The L2 memory controller has an Error Correction Code (ECC) and ED mechanism, including necessary SRAM
    - The L2 memory controller supports hardware prefetching and also provides bandwidth management, memory protection, and power-down functions.
    - Page size for L2 memory is 16KB
- The **External Memory Controller (EMC)** is a bridge from the C66x CorePac to the rest of the DSP subsystem and device. It has :
  - a 32-bit configuration port (CFG) providing access to local subsystem resources (like DSP\_EDMA, DSP\_SYSTEM, and so forth) or to L3\_MAIN resources accessible via the CFG address range.
  - a 128-bit slave-DMA port (SDMA) which provides accesses of system masters outside the DSP subsystem to resources inside the DSP subsystem or C66x DSP CorePac memories, i.e. when the DSP subsystem is the slave in a transaction.
- The **Extended Memory Controller (XMC)** processes requests from the L2 Cache Controller (which are a result of CPU instruction fetches, load/store commands, cache operations) to device resources via the C66x DSP CorePac 128-bit master DMA (MDMA) port:
  - Memory protection for addresses outside C66x DSP CorePac generated over device L3\_MAIN on the MDMA port
  - Prefetch, multi-in-flight requests
- A DSP local **Interrupt Controller (INTC)** in the DSP C66x CorePac, interfaces the system events to the DSP C66x core CPU interrupt and exceptions inputs. Each DSP subsystem C66x CorePac interrupt controller supports up to 128 system events of which 64 interrupts are external to DSP subsystems, collected from the DSP1 /DSP2 dedicated outputs of the device Interrupt Crossbar.

- **Local Enhanced Direct Memory Access (EDMA) controller features:**
  - Channel controller (CC) : 64-channel, 128 PaRAM, 2 Queues
  - 2 x Third-party Transfer Controllers (TPTC0 and TPTC1):
    - Each TC has a 128-bit read port and a 128-bit write port
    - 2KiB FIFOs on each TPTC
  - 1-dimensional/2-dimensional (1D/2D) addressing
  - Chaining capability
- **DSP subsystem integrated MMUs:**
  - Two MMUs are integrated:
    - The MMU0 is located between DSP MDMA master port and the device L3\_MAIN interconnect and can be optionally bypassed
    - The MMU1 is located between the EDMA master port and the device L3\_MAIN interconnect
- A DSP local **Power-Down Controller (PDC)** is responsible to power-down various parts of the DSP C66x CorePac, or the entire DSP C66x CorePac.
- The DSP subsystem **System Control logic** provides:
  - Slave idle and master standby protocols with device PRCM for powerdown
  - OCP Disconnect handshake for init and target busses
  - Asynchronous reset
  - Power-down modes:
    - "Clockstop" mode featuring wake-up on interrupt event. The DMA event wake-up is managed in software.
- The device DSP subsystems are supplied by a PRCM DPLL, but each DSP1/2 **has integrated its own PLL module** outside the C66x CorePac for clock gating and division.
- **The device DSP subsystem has following port instances** to connect to remaining part of the device. See also :
  - A 128-bit initiator (DSP MDMA master) port for MDMA/Cache requests
  - A 128-bit initiator (DSP EDMA master) port for EDMA requests
  - A 32-bit initiator (DSP CFG master) port for configuration requests
  - A 128-bit target (DSP slave) port for requests to DSP memories and various peripherals
- **C66x DSP subsystem (DSPSS) safety aspects:**
  - Above mentioned memory ECC/ED mechanisms
  - MMUs enable mapping of only the necessary application space to the processor
  - Memory Protection Units internal to the DSPSS (in L1P, L1D and L2 memory controllers) and external to DSPSS (firewalls) to help define legal accesses and raise exceptions on illegal accesses
  - Exceptions: Memory errors, various DSP errors, MMU errors and some system errors are detected and cause exceptions. The exceptions could be handled by the DSP or by a designated safety processor at the chip level. Note that it may not be possible for the safety processor to completely handle some exceptions

#### Unsupported features on the C66x DSP core for the device are:

- The Extended Memory Controller MPAX (memory protection and address extension) 36-bit addressing is NOT supported

#### Known DSP subsystem powermode restrictions for the device are:

- "Full logic / RAM retention" mode featuring wake-up on both interrupt or DMA event (logic in "always on" domain). Only OFF mode is supported by DSP subsystem, **requiring full boot**.

For more information about C66x debug/trace support, see chapter *On-Chip Debug Support* of the Device TRM.

## 6.5 ISS

The imaging subsystem (ISS) deals with the processing of pixel data coming from external image sensor or data from memory (image format encoding and decoding can be done to and from memory). ISS is tightly coupled with a low-interrupt latency microprocessor subsystem (Cortex-M4 IPU), which runs a real-time operating system (OS) to reach optimal performance, and can quickly change the ISS configuration during frame blanking periods and run some sequencing tasks.

ISS is a key component for Rear View Camera, Front View Stereo Camera, and Surround View Camera applications.

ISS targets the following major use cases:

- Video / Preview
  - Up to 1080p60
  - Up to 2x 1080p30
- Stereo Video / Preview
  - Up to 2x 1080p30
- Multi-camera use cases, with capability of up to 4 simultaneous cameras (ISP is time shared)

ISS offers the following main features:

- ISS interfaces:
  - One Camera Adapter Layer (CAL) module supporting DMA function for data read from system memory
  - 128-bit data interface to L3\_MAIN system interconnect
- Image Signal Processor (ISP):
  - Memory-to-memory processing
  - Up to 532 MPix/s throughput
  - Statistic data collection
  - Image pipe interface (IPIPEIF) front-end RAW data processing
  - IPIPE back-end RGB and YUV data processing
  - High-ISO video noise filtering (NSF3V)
  - Global and local contrast enhancement accelerator (GLBCE)
  - Two image continuous real-time resizers (RSZ)
  - Chroma noise filter (CNF)
- Still Image Coprocessor (SIMCOP):
  - Memory-to-memory operation
  - Warping accelerator (LDC)
  - Temporal video noise filter (VTNF)
  - Direct memory access (DMA) controller
  - Hardware sequencer
  - Mesh based lens distortion and perspective correction

For more information, see chapter *Imaging Subsystem* of the Device TRM.

## 6.6 IVA

The IVA supports resolutions up to 1080 p/i with full performance of 60 fps (or 120 fields), achievable for encode or decode only (not for simultaneous encode and decode).

The IVA subsystem is composed of:

- A primary sequencer, including its memories and an imaging controller: ICONT1
- A video direct memory access (VDMA) processor, which can be used as a secondary sequencer: ICONT2

- A VDMA engine: DMA\_IVA
- An entropy codec: ECD3
- A motion compensation engine: MC3
- A transform and quantization calculation engine: CALC3
- A loop filter acceleration engine: ILF3
- A motion estimation acceleration engine: IME3
- An intraprediction estimation engine: IPE3
- Shared level 2 (L2) interface and memory
- Local interconnect (L4\_IVA)
- A message interface for communication between SYNCBOXes
- Mailbox
- A debug module for trace event and software instrumentation: SMSET

For more information, see chapter *IVA Subsystem* of the Device TRM.

## 6.7 EVE

The embedded vision engine (EVE) module is a programmable imaging and vision processing engine, intended for use in devices that serve customer electronics imaging and vision applications. Its programmability meets late-in-development or post-silicon processing requirements, and lets third parties or customers add differentiating features in imaging and vision products.

The device includes two instances of the EVE engine. A single EVE module consists of an ARP32 scalar core, a vector coprocessor (VCOP) vector core, and an Enhanced DMA (EDMA3) controller.

The EVE engine includes the following main features:

- Two 128-bit interconnect initiator ports used for:
  - Paging between system-level memory (L3 SRAM/DDR) and EVE memory (primarily IBUF, WBUF)
  - ARP32 program fetches to system memory (through program cache)
  - ARP32 load or store requests to system memory
  - ARP32 program cache-related read requests, including prefetch/preload requests
- 128-bit interconnect target port used for system-level host or DMA access to EVE memory or MMR space
- Scalar core (ARP32) with the following features:
  - 32KB program cache (direct mapped and prefetch)
  - 32KB data memory (DMEM)
- Vector core (VCOP):
  - 32KB working buffer (WBUF)
  - 16KB image buffer low copy A (IBUFLA)
  - 16KB image buffer low copy B (IBUFLB)
  - 16KB image buffer high copy A (IBUFHA)
  - 16KB image buffer high copy B (IBUFHB)
- EDMA channel controller (EDMACC): 128 PaRAM entries, 2 Queues
- EDMA transfer controllers: two instances, 2k FIFO each
- Memory Management Units (MMUs):
  - 32-entry TLB per MMU
  - Page walking with hardware
  - EDMA accesses and ARP32 program or data accesses to system memory space
  - Can limit EVE accesses to desired subset of system addresses
- Configuration interconnect for MMR and debug accesses

- High-performance interconnect for high throughput and high concurrency data transfers between connected endpoints
- Multiple interrupts for interrupt mapping, DMA event mapping, and interprocessor handshaking
- Support for slave idle and master standby protocols for clock gating
- No support for retention and memory array off modes
- Error detection on all memories:
  - Single bit error detect on DMEM, WBUF, IBUFLA, IBUFLB, IBUFHA, and IBUFHB
  - Double bit error detect on program cache
- Invalid instruction detection in the two processor units (ARP32 and VCOP)
- Debug support:
  - Subsystem Counter Timer Module (SCTM) for counting and measuring of VCOP, EVE program cache, and EDMA performance-related state
  - Software Messaging System Event Trace (SMSET) for trace of software messages and hardware events
  - ARP32 debug support: State visibility, breakpoint, run control, cross-triggering
  - VCOP debug support: State visibility and run control
- Interprocessor communication: Internal Mailbox for DSP/EVE communication

For more information, see chapter *Embedded Vision Engine (EVE)* of the Device TRM.

## 6.8 IPU

Each IPU subsystem contains two Arm® Cortex-M4 processors (IPUx\_C0 and IPUx\_C1) that share a common level 1 (L1) cache (called unicache [IPUx\_UNICACHE]). The two Cortex-M4 cores are completely homogeneous to one another. Any task possible using one Cortex-M4 core is also possible using the other Cortex-M4 core. It is software responsibility to distribute the various tasks between each Cortex-M4 core for optimal performance.

The key features of the IPU subsystem are:

- Two Arm Cortex-M4 microprocessors (IPUx\_C0 and IPUx\_C1):
  - Armv7-M and Thumb®-2 instruction set architecture (ISA)
  - Armv6 SIMD and digital signal processor (DSP) extensions
  - Single-cycle MAC
  - Integrated nested vector interrupt controller (NVIC) (also called IPUx\_Cx\_INTC, where x = 0, 1)
  - Integrated bus matrix
  - Registers:
    - Thirteen general-purpose 32-bit registers
    - Link register (LR)
    - Program counter (PC)
    - Program status register, xPSR
    - Two banked SP registers
  - Integrated power management
  - Extensive debug capabilities
- Unicache interface:
  - Instruction and data interface
  - Supports paralleled accesses
- Level 2 (L2) master interface (MIF) splitter for access to memory or configuration port
- Configuration port: Used for unicache maintenance and unicache memory management unit (IPUx\_UNICACHE\_MMU) configuration

- Unicache:
  - 32 KiB divided into 16 banks
  - 4-way
  - Cache configuration lock/freeze/preload
  - Internal MMU:
    - 16-entry region-based address translation
    - Read/write control and access type control
    - Execute Never (XN) MMU protection policy
    - Little-endian format
- Subsystem counter timer module (IPUx\_UNICACHE\_SCTM, or just SCTM)
- On-chip ROM (IPUx\_ROM) and banked RAM (IPUx\_RAM) memory
- Emulation/debug: Emulation feature embedded in Cortex-M4
- L2 MMU (IPUx\_MMU): 32 entries with table walking logic
- Wake-up generator (IPUx\_WUGEN): Generates wake-up request from external interrupts
- Power management:
  - Local power-management control: Configurable through the IPUx\_WUGEN registers.
  - Three sleep modes supported, controlled by the local power-management module.
  - IPUx is clock-gated in all sleep modes.
  - IPUx\_Cx\_INTC interrupt interface stays awake.

For more information, see chapter *Dual Cortex-M4 IPU Subsystem* of the Device TRM.

## 6.9 VPE

VPE Features:

- Supports memory to memory operations only.
- VPE consist of a single memory to memory path which can perform the following operations:
  - Read of raster or tiled YUV420 coplanar, YUV422 coplanar or YUV422 interleaved video
  - Deinterlacing of the input video using a 4 field motion based algorithm
  - Scaling of the input video up to 1080p (1920x1080) resolution
  - Write of the resulting video in YUV420 coplanar (raster or tiled), YUV422 coplanar (raster or tiled), YUV422 interleaved (raster or tiled), YUV444 single plane (raster only) or RGB888 (raster only)
  - Deinterlacing up to two 1080i video sources.
  - The single data path performs operations in the following order
    - Chroma Upsampling from 420 to 422 (if needed)
    - Deinterlacing of 422 video from interlaced to progressive (if needed)
    - Scaling of 422 video after deinterlace
    - Conversion of 422 video to 420, 444 or RGB (if needed)
  - VC-1 Range Mapping and Range Reduction support on input video before Chroma Upsampling (if needed)
- Chroma Upsampling Features
  - 4 line Catmull-Rom based implementation
  - Programmable coefficients for interlaced or progressive conversion. Separate coefficients can be provided for top and bottom fields

- Deinterlacer Features
  - 8-bit, YCbCr 4:2:2
  - Motion-adaptive deinterlacing (MDT)
    - Motion detection is based on Luma only
    - 4-field data is used
    - Motion values adaptive to the frequency of luma texture
  - Edge-Directed Interpolation (EDI)
    - Edge detection using luma pixels in a 2x7 window
    - Seven edge vectors: -1.5, -1, -0.5, 0, 0.5, 1, 1.5
    - Edge-directed chroma interpolation
    - Soft-switch between edge directed interpolation and vertical interpolation depending on the confidence factor
  - Film Mode Detection (FMD)
    - 3-2 pull down detection
    - 2-2 pull down detection
    - Hysteresis controls how fast FMD can enter/exit film mode (software function)
    - Bad Edit Detection (BED)
  - Progressive Input
    - For Progressive Input, the module passes input to output. No internal processing is performed. This is essentially a bypass mode
  - Interlace Bypass
    - For Interlace Input, the module can pass the inputs data directly to the outputs in a bypass configuration. No internal processing is performed
- Scaler Features
  - Vertical and horizontal up/down scaling
    - Polyphase filter upscaling
  - Running average vertical down scaling for memory optimization
  - Decimation and polyphase filtering for horizontal scaling
  - Non-linear scaling for stretched/compressed left and right sides
  - Input image trimmer for pan/scan support
  - Pre-scaling peaking filter for enhanced sharpness
  - Scale field as frame
  - Interlacing of scaled output
  - Full 1080p input and output support
  - YCbCr422 input and output
  - Minimum horizontal scaling ratio = 1/8x
  - Maximum horizontal scaling ratio – limited by output line buffer (2014 pixels)
  - Scaling filter Coefficient memory download
- Chroma Downsampler Features
  - Simple two-line averager capable of converting from YUV422 to YUV420 space
- 422 to 444 Features
  - Catmull-Rom based filter
  - 4 pixel, fixed coefficient
- Color Space Converter Features
  - Fully programmable 3x3 matrix multiplier with offset control

For more information, see chapter *Video Processing Engine* of the Device TRM.

## 6.10 GPU

The 3D graphics processing unit (GPU) accelerates 2-dimensional (2D) and 3-dimensional (3D) graphics and compute applications. It is based on the POWERVR® SGX544-MP2 core from Imagination Technologies. The SGX544-MP2 core is a multicore (dual-core) evolution of the POWERVR SGX544 GPU.

SGX is a new generation of programmable POWERVR graphics and video IP cores. The POWERVR SGX is a scalable architecture which efficiently processes a number of differing multimedia data types concurrently:

- Pixel Data
- Vertex Data
- General Purpose Processing

The dual core GPU splits geometry and pixel rendering among the cores to improve performance proportional to the number of cores.

GPU Features:

- Multicore GPU architecture:
  - 2 × SGX544 cores
  - Shared system level cache of 128 KiB (64 KiB per SGX-544 core)
- Tile-based deferred rendering architecture:
  - Reduces external bandwidth to SDRAM
- Universal Scalable Shader Engine (USSE™):
  - Multithreaded engine incorporating vertex and pixel shader functionality
  - Automatic load balancing of vertex and pixel processing tasks
- Present and texture load accelerator (PTLA):
  - Enables to move, rotate, twiddle, and scale texture surfaces
  - Supports RGB, ARGB, YUV4:2:2, and YUV4:2:0 surface formats
  - Supports bilinear upscale
  - Supports source color key
- Fully virtualized memory addressing for operating system (OS) in a unified memory architecture:
  - Memory management unit (MMU)
  - Up to 4-GiB virtual address space

For more information, see chapter *3D Graphics Accelerator* of the Device TRM.

## 6.11 Memory Subsystem

### 6.11.1 EMIF

The EMIF module provides connectivity between DDR memory types and manages data bus read/write accesses between external memory and device subsystems which have master access to the L3\_MAIN interconnect and DMA capability.

The EMIF module has the following capabilities:

- Supports JEDEC standard-compliant DDR3/DDR3L-SDRAM memory types
- 2-GiB SDRAM address range over one chip-select. This range is configurable through the dynamic memory manager (DMM) module
- Supports SDRAM devices with one, two, four or eight internal banks
- Supports SDRAM devices with single or dual die packages
- Data bus widths:
  - 128-bit L3\_MAIN (system) interconnect data bus width
  - 128-bit port for direct connection with MPU subsystem
  - 32-bit SDRAM data bus width
  - 16-bit SDRAM data bus width used in narrow mode
- Supported CAS latencies:
  - DDR3: 5, 6, 7, 8, 9, 10 and 11
- Supports 256-, 512-, 1024-, and 2048-word page sizes
- Supported burst length: 8
- Supports sequential burst type
- SDRAM auto initialization from reset or configuration change
- Supports self refresh and power-down modes for low power
- Partial array self-refresh mode for low power.
- Output impedance (ZQ) calibration for DDR3
- Supports on-die termination (ODT) DDR3
- Supports prioritized refresh
- Programmable SDRAM refresh rate and backlog counter
- Programmable SDRAM timing parameters
- Write and read leveling/calibration and data eye training for DDR3

The EMIF module does not support:

- Burst chop for DDR3
- Interleave burst type
- Auto precharge because of better Bank Interleaving performance
- DLL disabling from EMIF side
- SDRAM devices with more than one die, or topologies which require more than one chip select on a single EMIF channel

For more information, see section *EMIF Controller* in chapter *Memory Subsystem* of the Device TRM.

### 6.11.2 GPMC

The General Purpose Memory Controller (GPMC) is an external memory controller of the device. Its data access engine provides a flexible programming model for communication with all standard memories.

The GPMC supports the following various access types:

- Asynchronous read/write access
- Asynchronous read page access (4, 8, and 16 Word16)

- Synchronous read/write access
- Synchronous read/write burst access without wrap capability (4, 8 and 16 Word16)
- Synchronous read/write burst access with wrap capability (4, 8 and 16 Word16)
- Address-data-multiplexed (AD) access
- Address-address-data (AAD) multiplexed access
- Little- and big-endian access

The GPMC can communicate with a wide range of external devices:

- External asynchronous or synchronous 8-bit wide memory or device (non burst device)
- External asynchronous or synchronous 16-bit wide memory or device
- External 16-bit non-multiplexed NOR flash device
- External 16-bit address and data multiplexed NOR Flash device
- External 8-bit and 16-bit NAND flash device
- External 16-bit pseudo-SRAM (pSRAM) device

The main features of the GPMC are:

- 8- or 16-bit-wide data path to external memory device
- Supports up to eight CS regions of programmable size and programmable base addresses in a total address space of 1 GiB
- Supports transactions controlled by a firewall
- On-the-fly error code detection using the Bose-Chaudhuri-Hocquenghem (BCH) ( $t = 4, 8, \text{ or } 16$ ) or Hamming code to improve the reliability of NAND with a minimum effect on software (NAND flash with 512-byte page size or greater)
- Fully pipelined operation for optimal memory bandwidth use
- The clock to the external memory is provided from GPMC functional clock divided by 1, 2, 3, or 4
- Supports programmable autoclock gating when no access is detected
- Independent and programmable control signal timing parameters for setup and hold time on a per-chip basis. Parameters are set according to the memory device timing parameters, with a timing granularity of one GPMC functional clock cycle.
- Flexible internal access time control (WAIT state) and flexible handshake mode using external WAIT pin monitoring
- Support bus keeping
- Support bus turnaround
- Prefetch and write posting engine associated with to achieve full performance from the NAND device with minimum effect on NOR/SRAM concurrent access

For more information, see section *General-Purpose Memory Controller* in chapter *Memory Subsystem* of the Device TRM.

### 6.11.3 ELM

In the case of NAND modules with no internal correction capability, sometimes referred to as bare NAND, the correction process can be delegated to the error location module (ELM) used in conjunction with the GPMC.

The ELM supports the following features:

- 4, 8, and 16 bits per 512-byte block error location based on BCH algorithm
- Eight simultaneous processing contexts
- Page-based and continuous modes

- Interrupt generation when error location process completes:
  - When the full page has been processed in page mode
  - For each syndrome polynomial (checksum-like information) in continuous mode

For more information, see section *Error Location Module* in chapter *Memory Subsystem* of the Device TRM.

#### 6.11.4 OCMC

There is one on-chip memory controller (OCMC) in the device.

The OCM Controller supports the following features:

- L3\_MAIN data interface:
  - Used for maximum throughput performance
  - 128-bit data bus width
  - Burst supported
- L4 interface (OCMC\_RAM only):
  - Used for access to configuration registers
  - 32-bit data bus width
  - Only single accesses supported
  - The L4 associated OCMC clock is two times lower than the L3 associated OCMC clock
- Error correction and detection:
  - Single error correction and dual error detection
  - 9-bit Hamming error correction code (ECC) calculated on 128-bit data word which is concatenated with memory address bits
  - Hamming distance of 4
  - Enable/Disable mode control through a dedicated register
  - Single bit error correction on a read transaction
  - Exclusion of repeated addresses from correctable error address trace history
  - ECC valid for all write transactions to an enabled region
  - Sub-128-bit writes supported via read modify write
- ECC Error Status Reporting:
  - Trace history buffer (FIFO) with depth of 4 for corrected error address
  - Trace history buffer with depth of 4 for non correctable error address and also including double error detection
  - Interrupt generation for correctable and uncorrectable detected errors
- ECC Diagnostics Configuration:
  - Counters for single error correction (SEC), double error detection (DED) and address error events (AEE)
  - Programmable threshold registers for exceptions associated with SEC, DED and AEE counters
  - Register control for enabling and disabling of diagnostics
  - Configuration registers and ECC status accessible through L4 interconnect
- Circular buffer for sliced based VIP frame transfers:
  - Up to 12 programmable circular buffers mapped with unique virtual frame addresses
  - On the fly (with no additional latency) address translation from virtual to OCMC circular buffer memory space
  - Virtual frame size up to 8 MiB and circular buffer size up to 1 MiB
  - Error handling and reporting of illegal CBUF addressing
  - Underflow and Overflow status reporting and error handling
  - Last access read/write address history

- Two Interrupt outputs configured independently to service either ECC or CBUF interrupt events

The OCM controller does not have a memory protection logic and does not support endianness conversion.

For more information, see section *On-Chip Memory (OCM) Subsystem* in chapter *Memory Subsystem* of the Device TRM.

## 6.12 Interprocessor Communication

### 6.12.1 Mailbox

Communication between the on-chip processors of the device uses a queued mailbox-interrupt mechanism.

The queued mailbox-interrupt mechanism allows the software to establish a communication channel between two processors through a set of registers and associated interrupt signals by sending and receiving messages (mailboxes).

The device implements the following mailbox types:

- System mailbox:
  - Number of instances: 13
  - Used for communication between: MPU, DSP1, IPU1, and IPU2 subsystems
  - Reference name: MAILBOX(1..13)
- IVA mailbox:
  - Number of instances: 1
  - Used for communication between: IVA local user (ICONT1, or ICONT2) and three external users (selected among MPU, DSP1, IPU1, and IPU2 subsystems)
  - Reference name: IVA\_MBOX

Each mailbox module supports the following features:

- Parameters configurable at design time
  - Number of users
  - Number of mailbox message queues
  - Number of messages (FIFO depth) for each message queue
- 32-bit message width
- Message reception and queue-not-full notification using interrupts
- Support of 16-/32-bit addressing scheme
- Power management support

For more information, see chapter *Mailbox* of the Device TRM.

### 6.12.2 Spinlock

The Spinlock module provides hardware assistance for synchronizing the processes running on multiple processors in the device:

- Dual Cortex®-A15 microprocessor unit (MPU) subsystem
- Digital signal processor (DSP) subsystems – DSP1 and DSP2
- Dual Cortex-M4 image processing unit (IPU) subsystems – IPU1 and IPU2

The Spinlock module implements 256 spinlocks (or hardware semaphores), which provide an efficient way to perform a lock operation of a device resource using a single read-access, avoiding the need of a readmodify- write bus transfer that the programmable cores are not capable of.

For more information, see chapter *Spinlock* of the Device TRM.

## 6.13 Interrupt Controller

The device has a large number of interrupts to service the needs of its many peripherals and subsystems. The MPU, DSP (x2), and IPU (x2) subsystems are capable of servicing these interrupts via their integrated interrupt controllers. In addition, each processor's interrupt controller is preceded by an Interrupt Controller Crossbar (IRQ\_CROSSBAR) that provides flexibility in mapping the device interrupts to processor interrupt inputs. For more information about IRQ crossbar, see chapter *Control Module* of the Device TRM.

### Dual Cortex®-A15 MPU Subsystem Interrupt Controller (MPU\_INTC)

The MPU\_INTC module (also called Generalized Interrupt Controller [GIC]) is a single functional unit that is integrated in the Arm® Cortex-A15 multiprocessor core (MPCore) alongside Cortex-A15 processors. It provides:

- 160 hardware interrupt inputs
- Generation of interrupts by software
- Prioritization of interrupts
- Masking of any interrupts
- Distribution of the interrupts to the target Cortex-A15 processor(s)
- Tracking the status of interrupts

Each Cortex-A15 processor supports three main groups of interrupt sources, with each interrupt source having a unique ID:

- *Software Generated Interrupts (SGIs)*: SGIs are generated by writing to the Cortex-A15 Software Generated Interrupt Register (GICD\_SGIR). A maximum of 16 SGIs (ID0–ID15) can be generated for each CPU interface. An SGI has edge-triggered properties. The software triggering of the interrupt is equivalent to the edge transition of the interrupt signal on a peripheral input.
- *Private Peripheral Interrupts (PPIs)*: A PPI is an interrupt generated by a peripheral that is specific to a single processor. Although interrupts ID16–ID31 are dedicated to PPIs in general, only seven PPIs are actually used for each CPU interface (ID25–ID31). Interrupts ID16–ID24 are reserved (not used).
- *Shared Peripheral Interrupts (SPIs)*: SPIs are triggered by events generated on associated interrupt input lines. In this device, the GIC is configured to support 160 SPIs corresponding to its external IRQS[159:0] signals.

For detailed information about this module and description of SGIs and PPIs, see the Arm *Cortex-A15 MP Core Technical Reference Manual* (available at [infocenter.arm.com/help/index.jsp](http://infocenter.arm.com/help/index.jsp)).

### C66x DSP Subsystem Interrupt Controller (DSPx\_INTC, where x = 1, 2)

There are two Digital Signal Processing (DSP) subsystems in the device - DSP1, and DSP2. Each DSP subsystem integrates an interrupt controller - DSPx\_INTC, which interfaces the system events to the C66x core interrupt and exceptions inputs. It combines up to 128 interrupts into 12 prioritized interrupts presented to the C66x CPU.

For detailed information about this module, see chapter *DSP Subsystems* of the Device TRM.

### Dual Cortex-M4 IPU Subsystem Interrupt Controller (IPUx\_Cx\_INTC, where x = 1, 2)

There are two Image Processing Unit (IPU) subsystems in the device - IPU1, and IPU2. Each IPU subsystem integrates two Arm Cortex-M4 cores.

A Nested Vectored Interrupt Controller (NVIC) is integrated within each Cortex-M4. The interrupt mapping is the same (per IPU) for the two cores to facilitate parallel processing. The NVIC supports:

- 64 external interrupts (in addition to 16 Cortex-M4 internal interrupts), which are dynamically prioritized with 16 levels of priority defined for each core
- Low-latency exception and interrupt handling
- Prioritization and handling of exceptions
- Control of the local power management
- Debug accesses to the processor core

For detailed information about this module, refer to *Arm Cortex-M4 Technical Reference Manual* (available at [infocenter.arm.com/help/index.jsp](http://infocenter.arm.com/help/index.jsp)).

## 6.14 EDMA

The primary purpose of the Enhanced Direct Memory Access (EDMA) controller is to service user-programmed data transfers between two memory-mapped slave endpoints on the device.

Typical usage of the EDMA controller includes:

- Servicing software-driven paging transfers (for example, data movement between external memory [such as SDRAM] and internal memory [such as DSP L2 SRAM])
- Servicing event-driven peripherals, such as a serial port
- Performing sorting or sub-frame extraction of various data structures
- Offloading data transfers from the main device CPUs, such as the C66x DSP CorePac or the Arm CorePac

The EDMA controller consists of two major principle blocks:

- EDMA Channel Controller
- EDMA Transfer Controller(s)

The EDMA Channel Controller (EDMACC) serves as the user interface for the EDMA controller. The EDMACC includes parameter RAM (PaRAM), channel control registers, and interrupt control registers. The EDMACC serves to prioritize incoming software requests or events from peripherals and submits transfer requests (TR) to the EDMA transfer controller.

The EDMA Transfer Controller (EDMATC) is responsible for data movement. The transfer request packets (TRP) submitted by the EDMACC contain the transfer context, based on which the transfer controller issues read/write commands to the source and destination addresses programmed for a given transfer.

There are two EDMA controllers present on this device:

- EDMA\_0, integrating:
  - 1 Channel Controller, referenced as: EDMACC\_0
  - 2 Transfer Controllers, referenced as: EDMACC\_0\_TC\_0 (or EDMATC\_0) and EDMACC\_0\_TC\_1 (or EDMATC\_1)
- EDMA\_1, integrating:
  - 1 Channel Controller, referenced as: EDMACC\_1
  - 2 Transfer Controllers, referenced as: EDMACC\_1\_TC\_0 (or EDMATC\_2) and EDMACC\_1\_TC\_1 (or EDMATC\_3)

The two EDMA channel controllers (EDMACC\_0 and EDMACC\_1) are functionally identical. For simplification, the unified name EDMACC shall be regularly used throughout this chapter when referring to EDMA Channel Controllers functionality and features.

The four EDMA transfer controllers (EDMACC\_0\_TC\_0, EDMACC\_0\_TC\_1, EDMACC\_1\_TC\_0 and EDMACC\_1\_TC\_1) are functionally identical. For simplification, the unified name EDMATC shall be regularly used throughout this chapter when referring to EDMA Transfer Controllers functionality and features.

Each EDMACC has the following features:

- Fully orthogonal transfer description
  - 3 transfer dimensions:
    - Array (multiple bytes)
    - Frame (multiple arrays)
    - Block (multiple frames)
  - Single event can trigger transfer of array, frame, or entire block
  - Independent indexes on source and destination

- Flexible transfer definition
  - Increment or constant addressing modes
  - Linking mechanism allows automatic PaRAM set update
  - Chaining allows multiple transfers to execute with one event
- 64 DMA channels
  - Channels triggered by either:
    - Event synchronization
    - Manual synchronization (CPU write to event set register)
    - Chain synchronization (completion of one transfer triggers another transfer)
  - Support for programmable DMA Channel to PaRAM mapping
- 8 Quick DMA (QDMA) channels
  - QDMA channels are triggered automatically upon writing to PaRAM set entry
  - Support for programmable QDMA channel to PaRAM mapping
- 512 PaRAM sets
  - Each PaRAM set can be used for a DMA channel, QDMA channel, or link set
- 2 transfer controllers/event queues
  - 16 event entries per event queue
- Interrupt generation based on:
  - Transfer completion
  - Error conditions
- Debug visibility
  - Queue water marking/threshold
  - Error and status recording to facilitate debug
- Memory protection support
  - Proxied memory protection for TR submission
  - Active memory protection for accesses to PaRAM and registers

Each EDMATC has the following features:

- Supports 2-dimensional (2D) transfers with independent indexes on source and destination (EDMACC manages the 3rd dimension)
- Up to 4 in-flight transfer requests (TR)
- Programmable priority levels
- Support for increment or constant addressing mode transfers
- Interrupt and error support
- Supports only little-endian operation in this device
- Memory mapped register (MMR) bit fields are fixed position in 32-bit MMR

For more information, see section *Enhanced DMA* in chapter *DMA Controllers* of the Device TRM.

## 6.15 Peripherals

### 6.15.1 VIP

The VIP module provides video capture functions for the device. VIP incorporates a multi-channel raw video parser, various video processing blocks, and a flexible Video Port Direct Memory Access (VPDMA) engine to store incoming video in various formats. The device uses three instantiations of the VIP module giving the ability of capturing up to six video streams.

A VIP module includes the following main features:

- Two independently configurable external video input capture slices (Slice 0 and Slice 1) each of which has two video input ports, Port A and Port B, where Port A can be configured as a 24/16/8-bit port, and Port B is a fixed 8-bit port.
- Each video Port A can be operated as a port with clock independent input channels (with interleaved or separated Y/C data input). Embedded sync and external sync modes are supported for all input configurations.
- Support for a single external asynchronous pixel clock, up to 165MHz per port.
- Pixel Clock Input Domain Port A supports up to one 24-bit input data bus, including BT.1120 style embedded sync for 16-bit and 24-bit data.
- Embedded Sync data interface mode supports single or multiplexed sources
- Discrete Sync data interface mode supports only single source input
- 24-bit data input plus discrete syncs can be configured to include:
  - 8-bit YUV422 (Y and U/V time interleaved)
  - 16-bit YUV422 (CbY and CrY time interleaved)
  - 24-bit YUV444
  - 16-bit RGB565
  - 24-bit RGB888
  - 12/16-bit RAW Capture
  - 24-bit RAW capture
- Discrete sync modes include:
  - VSYNC + HSYNC (FID determined by FID signal pin or HSYNC/VSYNC skew)
  - VSYNC + ACTVID + FID
  - VBLANK + ACTVID (ACTVID toggles in VBLANK) + FID
  - VBLANK + ACTVID (no ACTVID toggles in VBLANK) + FID
- VBLANK + ACTVID (no ACTVID toggles in VBLANK) + FID
  - Embedded syncs only
  - Pixel (2x or 4x) or Line multiplexed modes supported
  - Performs demultiplexing and basic error checking
  - Supports maximum of 9 channels in Line Mux (8 normal + 1 split line)
- Ancillary data capture support
  - For 16-bit or 24-bit input, ancillary data may be extracted from any single channel
  - For 8-bit time interleaved input, ancillary data can be chosen from the Luma channel, the Chroma channel, or both channels
  - Horizontal blanking interval data capture only supported when using discrete syncs (VSYNC + HSYNC or VSYNC + HBLANK)
  - Ancillary data extraction supported on multichannel capture as well as single source streams

- Format conversion and scaling
  - Programmable color space conversion
  - YUV422 to YUV444 conversion
  - YUV444 to YUV422 conversion
  - YUV422 to YUV420 conversion
  - YUV444 Source: YUV444 to YUV444, YUV444 to RGB888, YUV444 to YUV422, YUV444 to YUV420
  - RGB888 Source: RGB888 to RGB888, RGB888 to YUV444, RGB888 to YUV422, RGB888 to YUV420
  - YUV422 Source: YUV422 to YUV422, YUV422 to YUV420, YUV422 to YUV444, YUV422 to RGB888
  - Supports RAW to RAW (no processing)
  - Scaling and format conversions do not work for multiplexed input
- Supports up to 2047 pixels wide input - when scaling is engaged
- Supports up to 3840 pixels wide input - when only chroma up/down sampling is engaged, without scaling
- Supports up to 4095 pixels wide input - without scaling and chroma up/down sampling
- The maximum supported input resolution is further limited by:
  - Pixel clock and feature-dependent constraints
  - For RGB24-bit format (RAW data), the maximum frame width is limited to 2730 pixels

A VPDMA module includes the following main features:

- VPDMA output buffer size restriction feature, which ensures that writes do not exceed allocated memory buffer size
- Support for Tiled (2D) and raster addressing without bandwidth penalty
- Dual clients per channel allows for capture of scaled and nonscaled versions of the data stream (nonmultiplexed mode only)
- Start on new frame capability
- Interrupt every X number of frames
- Interrupt every X lines (syncd to frame start)

For more information, see chapter *Video Input Port* of the Device TRM.

### 6.15.2 DSS

Display Port Interfaces (DPI) is available in DSS named DPI Video Output (VOUT).

VOUT interface consists of:

- 24-bit data bus (data[23:0])
- Horizontal synchronization signal (HSYNC)
- Vertical synchronization signal (VSYNC)
- Data enable (DE)
- Field ID (FID)
- Pixel clock (CLK)

For more information, see section *Display Subsystem* of the Device TRM.

### 6.15.3 Timers

The device has 16 general-purpose (GP) timers (TIMER1 - TIMER16), two watchdog timers, and a 32-kHz synchronized timer (COUNTER\_32K) that have the following features:

- Dedicated input trigger for capture mode and dedicated output trigger/pulse width modulation (PWM) signal

- Interrupts generated on overflow, compare, and capture
- Free-running 32-bit upward counter
- Supported modes:
  - Compare and capture modes
  - Auto-reload mode
  - Start-stop mode
- On-the-fly read/write register (while counting)

The device has two system watchdog timer (WD\_TIMER1 and WD\_TIMER2) that have the following features:

- Free-running 32-bit upward counter
- On-the-fly read/write register (while counting)
- Reset upon occurrence of a timer overflow condition

The device includes one instance of the 32-bit watchdog timer: WD\_TIMER2, also called the MPU watchdog timer.

The watchdog timer is used to provide a recovery mechanism for the device in the event of a fault condition, such as a non-exiting code loop.

For more information, see section *General-Purpose Timers* in chapter *Timers* of the Device TRM.

#### 6.15.4 I2C

The device contains five multimaster high-speed (HS) inter-integrated circuit (I<sup>2</sup>C) controllers (I2Ci modules, where  $i = 1, 2, 3, 4, 5$ ) each of which provides an interface between a local host (LH), such as a digital signal processor (DSP), and any I<sup>2</sup>C-bus-compatible device that connects through the I<sup>2</sup>C serial bus. External components attached to the I<sup>2</sup>C bus can serially transmit and receive up to 8 bits of data to and from the LH device through the 2-wire I<sup>2</sup>C interface.

Each multimaster HS I<sup>2</sup>C controller can be configured to act like a slave or master I<sup>2</sup>C-compatible device.

I2C1 and I2C2 controllers have dedicated I2C compliant open drain buffers, and support Fast mode (up to 400Kbps). I2C3, I2C4 and I2C5 controllers are multiplexed with standard LVCMOS IO and connected to emulate open drain. I<sup>2</sup>C emulation is achieved by configuring the LVCMOS buffers to output Hi-Z instead of driving high when transmitting logic 1. These controllers support HS mode (up to 3.4Mbps).

For more information, see section *Multimaster High-Speed I2C Controller (I2C)* in chapter *Serial Communication Interfaces* of the Device TRM.

#### 6.15.5 UART

The UART is a simple L4 slave peripheral that utilizes the DMA\_SYSTEM or EDMA for data transfer or IRQ polling via CPU. There are 10 UART modules in the device. Only one UART supports IrDA features. Each UART can be used for configuration and data exchange with a number of external peripheral devices or interprocessor communication between devices.

##### 6.15.5.1 UART Features

The UARTi (where  $i = 1$  to 10) include the following features:

- 16C750 compatibility
- 64-byte FIFO buffer for receiver and 64-byte FIFO for transmitter
- Programmable interrupt trigger levels for FIFOs
- Baud generation based on programmable divisors N (where  $N = 1 \dots 16,384$ ) operating from a fixed functional clock of 48 MHz or 192 MHz

Oversampling is programmed by software as 16 or 13. Thus, the baud rate computation is one of two options:

- Baud rate = (functional clock / 16) / N
- Baud rate = (functional clock / 13) / N
- This software programming mode enables higher baud rates with the same error amount without changing the clock source
- Break character detection and generation
- Configurable data format:
  - Data bit: 5, 6, 7, or 8 bits
  - Parity bit: Even, odd, none
  - Stop-bit: 1, 1.5, 2 bit(s)
- Flow control: Hardware (RTS/CTS) or software (XON/XOFF)
- The 48 MHz functional clock option allows baud rates up to 3.6Mbps
- The 192 MHz functional clock option allows baud rates up to 12Mbps
- UART1 module has extended modem control signals (DCD, RI, DTR, DSR)
- UART3 supports IrDA

#### 6.15.5.2 IrDA Features

UART3 supports the following IrDA key features:

- Support of IrDA 1.4 slow infrared (SIR), medium infrared (MIR), and fast infrared (FIR) communications:
  - Frame formatting: Addition of variable beginning-of-frame (xBOF) characters and end-of-frame (EOF) characters
  - Uplink/downlink cyclic redundancy check (CRC) generation/detection
  - Asynchronous transparency (automatic insertion of break character)
  - Eight-entry status FIFO (with selectable trigger levels) to monitor frame length and frame errors
  - Framing error, CRC error, illegal symbol (FIR), and abort pattern (SIR, MIR) detection

#### 6.15.5.3 CIR Features

The CIR mode uses a variable pulse-width modulation (PWM) technique (based on multiples of a programmable  $t$  period) to encompass the various formats of infrared encoding for remote-control applications. The CIR logic transmits data packets based on a user-definable frame structure and packet content.

The CIR (UART3 only) includes the following features to provide CIR support for remote-control applications:

- Transmit mode only (receive mode is not supported)
- Free data format (supports any remote-control private standards)
- Selectable bit rate
- Configurable carrier frequency
- 1/2, 5/12, 1/3, or 1/4 carrier duty cycle

For more information, see section *UART/IrDA/CIR* in chapter *Serial Communication Interfaces* of the Device TRM.

#### 6.15.6 McSPI

The McSPI is a master/slave synchronous serial bus. There are four separate McSPI modules (McSPI1, McSPI2, McSPI3, and McSPI4) in the device. All these four modules support up to four external devices (four chip selects) and are able to work as both master and slave.

The McSPI modules include the following main features:

- Serial clock with programmable frequency, polarity, and phase for each channel

- Wide selection of McSPI word lengths, ranging from 4 to 32 bits
- Up to four master channels, or single channel in slave mode
- Master multichannel mode:
  - Full duplex/half duplex
  - Transmit-only/receive-only/transmit-and-receive modes
  - Flexible input/output (I/O) port controls per channel
  - Programmable clock granularity
  - McSPI configuration per channel. This means, clock definition, polarity enabling and word width
- Single interrupt line for multiple interrupt source events
- Power management through wake-up capabilities
- Enable the addition of a programmable start-bit for McSPI transfer per channel (start-bit mode)
- Supports start-bit write command
- Supports start-bit pause and break sequence
- Programmable timing control between chip select and external clock generation
- Built-in FIFO available for a single channel

For more information, see section *Multichannel Serial Peripheral Interface* in chapter *Serial Communication Interfaces* of the Device TRM.

### 6.15.7 QSPI

The quad serial peripheral interface (QSPI™) module is a kind of SPI module that allows single, dual, or quad read access to external SPI devices. This module has a memory mapped register interface, which provides a direct interface for accessing data from external SPI devices and thus simplifying software requirements. The QSPI works as a master only.

The QSPI supports the following features:

- General SPI features:
  - Programmable clock divider
  - Six pin interface
  - Programmable length (from 1 to 128 bits) of the words transferred
  - Programmable number (from 1 to 4096) of the words transferred
  - 4 external chip-select signals
  - Support for 3-, 4-, or 6-pin SPI interface
  - Optional interrupt generation on word or frame (number of words) completion
  - Programmable delay between chip select activation and output data from 0 to 3 QSPI clock cycles
  - Programmable signal polarities
  - Programmable active clock edge
  - Software-controllable interface allowing for any type of SPI transfer
  - Control through L3\_MAIN configuration port
- Serial flash interface (SFI) features:
  - Serial flash read/write interface
  - Additional registers for defining read and write commands to the external serial flash device
  - 1 to 4 address bytes
  - Fast read support, where fast read requires dummy bytes after address bytes; 0 to 3 dummy bytes can be configured.
  - Dual read support
  - Quad read support
  - Little-endian support only
  - Linear increment addressing mode only

The QSPI supports only dual and quad reads. Dual or quad writes are not supported. In addition, there is no "pass through" mode supported where the data present on the QSPI input is sent to its output.

For more information, see section *Quad Serial Peripheral Interface* in chapter *Serial Communication Interfaces* of the Device TRM.

### 6.15.8 McASP

The McASP functions as a general-purpose audio serial port optimized to the requirements of various audio applications. The McASP module can operate in both transmit and receive modes. The McASP is useful for time-division multiplexed (TDM) stream, Inter-IC Sound (I2S) protocols reception and transmission as well as for an intercomponent digital audio interface transmission (DIT). The McASP has the flexibility to gluelessly connect to a Sony/Philips digital interface (S/PDIF) transmit physical layer component.

Although intercomponent digital audio interface reception (DIR) mode (i.e. S/PDIF stream receiving) is not natively supported by the McASP module, a specific TDM mode implementation for the McASP receivers allows an easy connection to external DIR components (for example, S/PDIF to I2S format converters).

The device have integrated 8 McASP modules (McASP1-McASP8) with:

- McASP1 and McASP2 supporting 16 channels with independent TX/RX clock/sync domain
- McASP3 through McASP8 modules supporting 4 channels with independent TX/RX clock/sync domain

For more information, see section *Multichannel Audio Serial Port* in chapter *Serial Communication Interfaces* of the Device TRM.

### 6.15.9 USB

SuperSpeed USB DRD Subsystem has three instances in the device providing the following functions:

- USB1: SuperSpeed (SS) USB 3.0 Dual-Role-Device (DRD) subsystem with integrated SS (USB3.0) PHY and HS/FS (USB2.0) PHY
- USB2: High-Speed (HS) USB 2.0 Dual-Role-Device (DRD) subsystem with integrated HS/FS PHY

SuperSpeed USB DRD Subsystem has the following features:

- Dual-role-device (DRD) capability:
  - Supports USB Peripheral (or Device) mode at speeds SS (5Gbps)(USB1 only), HS (480 Mbps), and FS (12 Mbps)
  - Supports USB Host mode at speeds SS (5Gbps)(USB1 only), HS (480 Mbps), FS (12 Mbps), and LS (1.5 Mbps)
  - USB static peripheral operation
  - USB static host operation
  - Flexible stream allocation
  - Stream priority
  - External Buffer Control
- Each instance contains single xHCI controller with the following features:
  - Internal DMA controller
  - Descriptor caching and data prefetching
  - Interrupt moderation and blocking
  - Power management USB3.0 states for U0, U1, U2, and U3
  - Dynamic FIFO memory allocation for all endpoints
  - Supports all modes of transfers (control, bulk, interrupt, and isochronous)
  - Supports high bandwidth ISO mode
- Connects to an external charge pump for VBUS 5 V generation
- USB-HS PHY (USB2PHY1 and USB2PHY2 for USB1 and USB2, respectively): contain the USB functions, drivers, receivers, and pads for correct D+/D– signalling

For more information, see section *SuperSpeed USB DRD* in chapter *Serial Communication Interfaces* of the Device TRM.

### 6.15.10 SATA

The SATA host controller handles data interactions between a local host system memory and a SATA mass storage device with minimal local host (LH) intervention.

In contrast to the parallel 16-bit - ATA (PATA) interface, the SATA interface takes advantage of serial data transmission/reception over a differential pair of conductors. SATA uses the command set from the ATA/ATAPI-6 standard augmented with native command queuing (NCQ) commands optimized for the serialized interface.

The device has one embedded SATA host bus adapter (HBA) controller with a single port.

For more information, see section *SATA Controller* in chapter *Serial Communication Interface* of the Device TRM.

### 6.15.11 PCIe

The Peripheral Component Interconnect Express (PCIe) module is a multi-lane I/O interconnect that provides low pin-count, high reliability, and high-speed data transfer at rates of up to 5.0 Gbps per lane, per direction, for serial links on backplanes and printed wiring boards. It is a 3-rd Generation I/O Interconnect technology succeeding PCI and ISA bus that is designed to be used as a general-purpose serial I/O interconnect. It is also used as a bridge to other interconnects like USB2/3.0, GbE MAC, and so forth.

The PCI Express standard predecessor - PCI, is a parallel bus architecture that is increasingly difficult to scale-up in bandwidth, which is usually performed by increasing the number of data signal lines. The PCIe architecture was developed to help minimize I/O bus bottlenecks within systems and to provide the necessary bandwidth for high-speed, chip-to-chip, and board-to-board communications within a system. It is designed to replace the PCI-based shared, parallel bus signaling technology that is approaching its practical performance limits while simplifying the interface design.

The device instantiates two PCIe subsystems (PCIe\_SS1 and PCIe\_SS2). The PCIe controller is capable to operate either in Root Complex (RC) or in End Point (EP) PCIe mode. The device PCIe\_SS1 controller supports up to two 16-bit data lanes on its PIPE port. The device PCIe\_SS2 controller supports only one 16-bit data lane on its PIPE port.

When the PCIe\_SS1 controller PIPE port is configured to operate in a single-lane mode, it operates on a single pair of PCIe PHY serializer and deserializer - PCIe1\_PHY\_TX/PCIe1\_PHY\_RX. When PCIe\_SS1 PIPE is configured to operate in dual-lane mode, it operates on two pairs of PCIe PHY serializer and deserializer - PCIe1\_PHY\_TX/PCIe1\_PHY\_RX and PCIe2\_PHY\_TX/PCIe2\_PHY\_RX, respectively. The single-lane PCIe\_SS2 controller PIPE port (if enabled) can operate only on the PCIe2\_PHY\_TX/PCIe2\_PHY\_RX pair. Hereby, if PCIe\_SS2 controller is used, the PCIe\_SS1 can operate only in a single-lane mode on the PCIe1\_PHY\_TX/PCIe1\_PHY\_RX. In addition, PCIe PHY subsystem encompasses a PCIe PCS (physical coding sublayer), a PCIe power management logic, APLL, a DPLL reference clock generator and an APLL clock low-jitter buffer.

- The PCIe Controller implements the transport and link layers of the PCIe interface protocol.
- PCIe PCS (a physical coding sublayer component) converts a 8-bit portion of parallel data over a PCIe lane to a 10-bit parallel data to adapt the process of serialization and deserialization in the TX/RX PHYs to various requirements. At the same time it transforms the transmission rate to maintain the PCIe Gen2 bandwidth (5 Gbps) on both sides (PCIe controller and PHY).
- A multiplexer logic which adds flexibility to connect a PCIe controller hardware mapped PCS logic output to a single (for the single-lane PCIe\_SS2 controller) or to a couple (for the 2-lane PCIe\_SS1 controller) of PHY ports at a time

- Physical layer (PHY) serializer/deserializer components with associated power control logic, building the so called PMA (physical media attachment) part of the PCIe\_PHY transceiver, as follows:
  - PCIe physical port 0 associated serializer (TX) - PCIe1\_PHY\_TX and deserializer (RX) - PCIe1\_PHY\_RX
  - PCIe physical port 1 associated serializer (TX) - PCIe2\_PHY\_TX and deserializer (RX) - PCIe2\_PHY\_RX
- DPLL\_PCIE\_REF is a DPLL clock source, controlled from the device PRCM, that provides a 100-MHz clock to the PCIe PHY serializer/deserializer components reference clock inputs.
- Both the PCIe\_SS1 and PCIe\_SS2 share the same APLL (APLLPCIE) which by default multiplies the DPLL\_PCIE\_REF (typically 100 MHz or 20 MHz) clock to 2.5 GHz.
- The APLLPCIE low-jitter buffer (ACSPCIE) and additional logic takes care to provide the PCIe APLL reference input clock.

PCIe module supports the following features:

- PCI Local Bus Specification revision 3.0
- PCI Express Base 3.0 Specification, revision 1.0.

**At system level the device supports PCI express interface in the following configurations:**

- Each PCIe subsystem controller has support for PCIe Gen2 mode (5.0 Gbps per lane) and Gen1 mode (2.5 Gbps per lane).
- One PCIe (PCIe\_SS1) operates as Gen2 2-lanes supporting in either root-complex (RC) or end-point EP.
- Two PCIe (PCIe\_SS1 and PCIe\_SS2) operates Gen2 1-lane supporting either RC or EP with the possibility of one operating in Gen1 and one in Gen2.
- PCIe\_SS1 can be configured to operate in either 2-Lane (dual lane) or 1-Lane (single lane) mode, as follows:
  - Single Lane - lane 0 mapped to the PCIe port 0 of the device
  - Flexible dual lane configuration - lanes 0 and 1 can be swapped on the two PCIe ports
- PCIe\_SS2 can only operate in 1-Lane mode, as follows:
  - Single Lane - lane 0 mapped to the device PCIe port 1

When PCIe\_SS1 is configured to operate in dual-lane mode, PCIe\_SS2 is in-operable as both PCIe1\_PHY\_RX/TX and PCIe2\_PHY\_RX/TX are assigned to PCIe\_SS1, and thereby NOT available to PCIe\_SS2.

**The main features of a device PCIe controller are:**

- 16-bit operation at 250 MHz on PIPE interface (per 16-bit lane)
- One master port on the L3\_MAIN supporting 32-bit address and 64-bit data bus.
- PCIe\_SS1 master port dedicated MMU (device MMU2) on L3\_MAIN path, to which PCIe traffic can be optionally mapped.
- One slave port on the L3\_MAIN supporting 29-bit address and 64-bit data bus.
- Maximum outbound payload size of 64 Bytes (the L3 Interconnect PCIe1/2 target ports split bursts of size >64 Bytes to the into multiple 64 Byte bursts)
- Maximum inbound payload size of 256 Bytes (internally converted to 128 Byte - bursts)
- No remote read request size limit: implicit support for 4 KiB-size and greater
- Support of EP legacy mode
- Support of inbound I/O accesses in EP legacy mode
- PIPE interface features fixed-width (16-bit data per lane) and dynamic frequency to switch between PCIe Gen1 and Gen2.
- Ultra-low transmit and receive latency
- Automatic Lane reversal as specified in the PCI Express Base 3.0 Specification, revision 1.0 (transmit and receive)

- Polarity inversion on receive
- Single Virtual Channel (VC0) and Single Traffic Class (TC0)
- Single Function in End point mode
- Automatic credit management
- ECRC generation and checking
- All PCI Device Power Management D-states with the exception of D3<sub>cold</sub>/L2 state
- PCI Express Active State Power Management (ASPM) state L0s and L1 (with exceptions)
- PCI Express Link Power Management states except for L2 state
- PCI Express Advanced Error Reporting (AER)
- PCI Express messages for both transmit and receive
- Filtering for Posted, Non-Posted, and Completion traffic
- Configurable BAR filtering, I/O filtering, configuration filtering and completion lookup/timeout
- Access to configuration space registers and external application memory mapped registers through ECAM mechanism.
- Legacy PCI Interrupts reception (RC) and generation (EP)
- 2 x hardware interrupts per PCIe\_SS1 and PCIe\_SS2 controller mapped via the device Interrupt Crossbar (IRQ\_CROSSBAR) to multiple device host (MPU, DSP, and so forth) interrupt controllers in the device
- MSIs generation and reception
- PCIe\_PHY Loopback in RC mode

For more information, see section *PCIe Controller* in chapter *Serial Communication Interfaces* of the Device TRM.

### 6.15.12 CAN

The Controller Area Network (CAN) is a serial communications protocol which efficiently supports distributed real-time applications. CAN has high immunity to electrical interference and the ability to self-diagnose and repair data errors. In a CAN network, many short messages are broadcast to the entire network, which provides for data consistency in every node of the system.

The device provides two DCAN interfaces for supporting distributed realtime control with a high level of security. The DCAN interfaces implement the following features:

- Support one CAN 2.0B Protocol
- Support one CAN 2.0B Protocol with available FD (Flexible Data Rate) functionality
- Bit rates up to 1 MBit/s
- 64 message objects
- Individual identifier mask for each message object
- Programmable FIFO mode for message objects
- Programmable loop-back modes for self-test operation
- Suspend mode for debug support
- Software module reset
- Automatic bus on after Bus-Off state by a programmable 32-bit timer
- Direct access to Message RAM during test mode
- CAN Rx/Tx pins are configurable as general-purpose IO pins
- Two interrupt lines (plus additional parity-error interrupts line)
- RAM initialization
- DMA support

For more information, see section *DCAN* in chapter *Serial Communication Interfaces* of the Device TRM.

### 6.15.13 GMAC\_SW

The three-port gigabit ethernet switch subsystem (GMAC\_SW) provides ethernet packet communication and can be configured as an ethernet switch. It provides the gigabit media independent interface (G/MII) in MII mode, reduced gigabit media independent interface (RGMII), reduced media independent interface (RMII), and the management data input output (MDIO) for physical layer device (PHY) management.

The GMAC\_SW subsystem provides the following features:

- Two Ethernet ports (port 1 and port 2) with selectable RGMII, RMII, and G/MII (in MII mode only) interfaces plus internal Communications Port Programming Interface (CPPI 3.1) on port 0
- Synchronous 10/100/1000 Mbit operation
- Wire rate switching (802.1d)
- Non-blocking switch fabric
- Flexible logical FIFO-based packet buffer structure
- Four priority level Quality Of Service (QOS) support (802.1p)
- CPPI 3.1 compliant DMA controllers
- Support for Audio/Video Bridging (P802.1Qav/D6.0)
- Support for IEEE 1588 Clock Synchronization (2008 Annex D and Annex F)
  - Timing FIFO and time stamping logic embedded in the subsystem
- Device Level Ring (DLR) Support
- Energy Efficient Ethernet (EEE) support (802.3az)
- Flow Control Support (802.3x)
- Address Lookup Engine (ALE)
  - 1024 total address entries plus VLANs
  - Wire rate lookup
  - Host controlled time-based aging
  - Multiple spanning tree support (spanning tree per VLAN)
  - L2 address lock and L2 filtering support
  - MAC authentication (802.1x)
  - Receive-based or destination-based multicast and broadcast rate limits
  - MAC address blocking
  - Source port locking
  - OUI (Vendor ID) host accept/deny feature
  - Remapping of priority level of VLAN or ports
- VLAN support
  - 802.1Q compliant
    - Auto add port VLAN for untagged frames on ingress
    - Auto VLAN removal on egress and auto pad to minimum frame size
- Ethernet Statistics:
  - EtherStats and 802.3Stats Remote network Monitoring (RMON) statistics gathering (shared)
  - Programmable statistics interrupt mask when a statistic is above one half its 32-bit value
- Flow Control Support (802.3x)
- Digital loopback and FIFO loopback modes supported
- Maximum frame size 2016 bytes (2020 with VLAN)
- 8k (2048 × 32) internal CPPI buffer descriptor memory
- Management Data Input/Output (MDIO) module for PHY Management
- Programmable interrupt control with selected interrupt pacing
- Emulation support

- Programmable Transmit Inter Packet Gap (IPG)
- Reset isolation (switch function remains active even in case of all device resets except for POR pin reset and ICEPICK cold reset)
- Full duplex mode supported in 10/100/1000 Mbps. Half-duplex mode supported only in 10/100 Mbps.
- IEEE 802.3 gigabit Ethernet conformant

For more information, see section *Gigabit Ethernet Switch (GMAC\_SW)* in chapter *Serial Communication Interfaces* of the Device TRM.

#### 6.15.14 eMMC/SD/SDIO

The eMMC/SD/SDIO host controller provides an interface between a local host (LH) such as a microprocessor unit (MPU) or digital signal processor (DSP) and either eMMC, SD® memory cards, or SDIO cards and handles eMMC/SD/SDIO transactions with minimal LH intervention.

Optionally, the controller is connected to the L3\_MAIN interconnect to have a direct access to system memory. It also supports two direct memory access (DMA) slave channels or a DMA master access (in this case, slave DMA channels are deactivated) depending on its integration.

The eMMC/SD/SDIO host controller deals with eMMC/SD/SDIO protocol at transmission level, data packing, adding cyclic redundancy checks (CRCs), start/end bit, and checking for syntactical correctness.

The application interface can send every eMMC/SD/SDIO command and poll for the status of the adapter or wait for an interrupt request, which is sent back in case of exceptions or to warn of end of operation.

The application interface can read card responses or flag registers. It can also mask individual interrupt sources. All these operations can be performed by reading and writing control registers. The eMMC/SD/SDIO host controller also supports two DMA channels.

There are four eMMC/SD/SDIO host controllers inside the device. gives an overview of the eMMC/SD/SDIOi (i = 1 to 4) controllers.

Each controller has the following data width:

- eMMC/SD/SDIO1 - 4-bit wide data bus
- eMMC/SD/SDIO2 - 8-bit wide data bus
- eMMC/SD/SDIO3 - 8-bit wide data bus
- eMMC/SD/SDIO4 - 4-bit wide data bus

The eMMC/SD/SDIOi controller is also referred to as MMCi.

Compliance with standards:

- Full compliance with MMC/eMMC command/response sets as defined in the JC64 MMC/eMMC Standard Specification, v4.5.
- Full compliance with SD command/response sets as defined in the SD Physical Layer Specification v3.01
- Full compliance with SDIO command/response sets and interrupt/read-wait suspend-resume operations as defined in the SD part E1 Specification v3.00
- Full compliance with SD Host Controller Standard Specification sets as defined in the SD card Specification Part A2 v3.00

Main features of the eMMC/SD/SDIO host controllers:

- Flexible architecture allowing support for new command structure
- 32-bit wide access bus to maximize bus throughput
- Designed for low power
- Programmable clock generation
- Dedicated DLL to support SDR104 mode (MMC1 only)
- Dedicated DLL to support HS200 mode (MMC2 only)

- Card insertion/removal detection and write protect detection
- L4 slave interface supports:
  - 32-bit data bus width
  - 8/16/32 bit access supported
  - 9-bit address bus width
  - Streaming burst supported only with burst length up to 7
  - WNP supported
- L3 initiator interface Supports:
  - 32-bit data bus width
  - 8/16/32 bit access supported
  - 32-bit address bus width
  - Burst supported
- Built-in 1024-byte buffer for read or write
- Two DMA channels, one interrupt line
- Support JC 64 v4.4.1 boot mode operations
- Support SDA 3.00 Part A2 programming model
- Support SDA 3.00 Part A2 DMA feature (ADMA2)
- Supported data transfer rates:
  - MMCi supports the following SD v3.0 data transfer rates:
    - DS mode (3.3V I/Os): up to 12 MBps (24 MHz clock)
    - HS mode (3.3V I/Os): up to 24 MBps (48 MHz clock)
    - SDR12 (1.8V I/Os): up to 12 MBps (24 MHz clock)
    - SDR25 (1.8V I/Os): up to 24 MBps (48 MHz clock)
    - SDR50 (1.8V I/Os): up to 48 MBps (96 MHz clock) - MMC1 and MMC3 only
    - DDR50 (1.8V I/Os): up to 48 MBps (48 MHz clock) - MMC1 only
    - SDR104 (1.8V I/Os) cards can be supported up to 192 MHz clock (96 MBps max) - MMC1 only
  - MMCi supports the Default SD mode 1-bit data transfer up to 24Mbps (3MBps)
  - Only MMC2 supports also the following JC64 v4.5 data transfer rates:
    - Up to 192 MBps in eMMC mode, 8-bit SDR mode (192 MHz clock frequency)
    - Up to 96 MBps in eMMC mode, 8-bit DDR mode (48 MHz clock frequency)
- All eMMC/SD/SDIO controllers are connected to 1.8V/3.3V compatible I/Os to support 1.8V/3.3V signaling

#### NOTE

eMMC functionality is supported fully by MMC2 only. The other MMC modules are capable of eMMC functionality, but are not timing-optimized for eMMC.

The differences between the eMMC/SD/SDIO host controllers and a standard SD host controller defined by the *SD Card Specification, Part A2, SD Host Controller Standard Specification*, v3.0 are:

- The clock divider in the eMMC/SD/SDIO host controller supports a wider range of frequency than specified in the *SD Memory Card Specifications*, v3.0. The eMMC/SD/SDIO host controller supports odd and even clock ratio.
- The eMMC/SD/SDIO host controller supports configurable busy time-out.
- ADMA2 64-bit mode is not supported.
- There is no external LED control.

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**NOTE**

Only even ratios are supported in DDR mode.

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For more information, see chapter *eMMC/SD/SDIO* of the Device TRM.

### 6.15.15 GPIO

The general-purpose interface combines eight general-purpose input/output (GPIO) banks.

Each GPIO module provides 32 dedicated general-purpose pins with input and output capabilities; thus, the general-purpose interface supports up to 247 pins.

These pins can be configured for the following applications:

- Data input (capture)/output (drive)
  - Keyboard interface with a debounce cell
  - Interrupt generation in active mode upon the detection of external events. Detected events are processed by two parallel independent interrupt-generation submodules to support biprocessor operations
  - Wake-up request generation in idle mode upon the detection of external events
- 

**NOTE**

The general-purpose input/output *i* (*i* = 1 to 8) bank is also referred to as GPIO*i*.

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For more information, see chapter *General-Purpose Interface* of the Device TRM.

### 6.15.16 ePWM

An effective PWM peripheral must be able to generate complex pulse width waveforms with minimal CPU overhead or intervention. It needs to be highly programmable and very flexible while being easy to understand and use. The ePWM unit described here addresses these requirements by allocating all needed timing and control resources on a per PWM channel basis. Cross coupling or sharing of resources has been avoided; instead, the ePWM is built up from smaller single channel modules with separate resources and that can operate together as required to form a system. This modular approach results in an orthogonal architecture and provides a more transparent view of the peripheral structure, helping users to understand its operation quickly.

Each ePWM module supports the following features:

- Dedicated 16-bit time-base counter with period and frequency control
- Two PWM outputs (EPWMxA and EPWMxB) that can be used in the following configurations:
  - Two independent PWM outputs with single-edge operation
  - Two independent PWM outputs with dual-edge symmetric operation
  - One independent PWM output with dual-edge asymmetric operation
- Asynchronous override control of PWM signals through software.
- Programmable phase-control support for lag or lead operation relative to other ePWM modules.
- Hardware-locked (synchronized) phase relationship on a cycle-by-cycle basis.
- Dead-band generation with independent rising and falling edge delay control.
- Programmable trip zone allocation of both cycle-by-cycle trip and one-shot trip on fault conditions.
- A trip condition can force either high, low, or high-impedance state logic levels at PWM outputs.
- Programmable event prescaling minimizes CPU overhead on interrupts.
- PWM chopping by high-frequency carrier signal, useful for pulse transformer gate drives.

For more information, see section *Enhanced PWM (ePWM) Module* in chapter *Pulse-Width Modulation Subsystem* of the Device TRM.

### 6.15.17 eCAP

Uses for eCAP include:

- Sample rate measurements of audio inputs
- Speed measurements of rotating machinery (for example, toothed sprockets sensed via Hall sensors)
- Elapsed time measurements between position sensor pulses
- 4 stage sequencer (Mod4 counter) which is synchronized to external events (ECAPx pin edges)
- Period and duty cycle measurements of pulse train signals
- Decoding current or voltage amplitude derived from duty cycle encoded current/voltage sensors

The eCAP module includes the following features:

- 32-bit time base counter
- 4-event time-stamp registers (each 32 bits)
- Edge polarity selection for up to four sequenced time-stamp capture events
- Interrupt on either of the four events
- Single shot capture of up to four event time-stamps
- Continuous mode capture of time-stamps in a four-deep circular buffer
- Absolute time-stamp capture
- Difference (Delta) mode time-stamp capture
- All above resources dedicated to a single input pin
- When not used in capture mode, the ECAP module can be configured as a single channel PWM output

For more information, see section *Enhanced Capture (eCAP) Module* in chapter *Pulse-Width Modulation Subsystem* of the Device TRM.

### 6.15.18 eQEP

A single track of slots patterns the periphery of an incremental encoder disk. These slots create an alternating pattern of dark and light lines. The disk count is defined as the number of dark/light line pairs that occur per revolution (lines per revolution). As a rule, a second track is added to generate a signal that occurs once per revolution (index signal: QEPI), which can be used to indicate an absolute position. Encoder manufacturers identify the index pulse using different terms such as index, marker, home position, and zero reference.

To derive direction information, the lines on the disk are read out by two different photo-elements that "look" at the disk pattern with a mechanical shift of 1/4 the pitch of a line pair between them. This shift is realized with a reticle or mask that restricts the view of the photo-element to the desired part of the disk lines. As the disk rotates, the two photo-elements generate signals that are shifted 90 degrees out of phase from each other. These are commonly called the quadrature QEPA and QEPB signals. The clockwise direction for most encoders is defined as the QEPA channel going positive before the QEPB channel.

The encoder wheel typically makes one revolution for every revolution of the motor or the wheel may be at a geared rotation ratio with respect to the motor. Therefore, the frequency of the digital signal coming from the QEPA and QEPB outputs varies proportionally with the velocity of the motor. For example, a 2000-line encoder directly coupled to a motor running at 5000 revolutions per minute (rpm) results in a frequency of 166.6 kHz, so by measuring the frequency of either the QEPA or QEPB output, the processor can determine the velocity of the motor.

For more information, see section *Enhanced Quadrature Encoder Pulse (eQEP) Module* in chapter *Pulse-Width Modulation Subsystem* of the Device TRM.

## 6.16 On-Chip Debug

Debugging a system that contains an embedded processor involves an environment that connects high-level debugging software running on a host computer to a low-level debug interface supported by the target device. Between these levels, a debug and trace controller (DTC) facilitates communication between the host debugger and the debug support logic on the target chip.

The DTC is a combination of hardware and software that connects the host debugger to the target system. The DTC uses one or more hardware interfaces and/or protocols to convert actions dictated by the debugger user to JTAG commands and scans that execute the core hardware.

The debug software and hardware components let the user control multiple central processing unit (CPU) cores embedded in the device in a global or local manner. This environment provides:

- Synchronized global starting and stopping of multiple processors
- Starting and stopping of an individual processor
- Each processor can generate triggers that can be used to alter the execution flow of other processors

System topics include but are not limited to:

- System clocking and power-down issues
- Interconnection of multiple devices
- Trigger channels

For more information, see chapter *On-chip Debug* of the Device TRM.

The device deploys Texas Instrument's CTools debug technology for on-chip debug and trace support. It provides the following features:

- External debug interfaces:
  - Primary debug interface - IEEE1149.1 (JTAG) or IEEE1149.7 (complementary superset of JTAG)
    - Used for debugger connection
    - Default mode is IEEE1149.1 but debugger can switch to IEEE1149.7 via an IEEE1149.7 adapter module
    - Controls ICEPick™ (generic test access port [TAP] for dynamic TAP insertion) to allow the debugger to access several debug resources through its secondary (output) JTAG ports (for more information, see *ICEPick Secondary TAPs* section of the Device TRM).
  - Debug (trace) port
    - Can be used to export processor or system trace off-chip (to an external trace receiver)
    - Can be used for cross-triggering with an external device
    - Configured through debug resources manager (DRM) module instantiated in the debug subsystem
    - For more information about debug (trace) port, see *Debug (Trace) Port* and *Concurrent Debug Modes* sections of the Device TRM.
- JTAG based processor debug on:
  - Cortex-A15 in MPU
  - C66x in DSP1
  - Cortex-M4 (x2) in IPU1, IPU2
  - Arm968 (x2) in IVA
- Dynamic TAP insertion
  - Controlled by ICEPick
  - For more information, see , *Dynamic TAP Insertion*.
- Power and clock management
  - Debugger can get the status of the power domain associated to each TAP.
  - Debugger may prevent the application software switching off the power domain.
  - Application power management behavior can be preserved during debug across power transitions.
  - For more information, see *Power and Clock Management* section of the Device TRM.

- Reset management
  - Debugger can configure ICEPick to assert, block, or extend the reset of a given subsystem.
  - For more information, see *Reset Management* section of the Device TRM.
- Cross-triggering
  - Provides a way to propagate debug (trigger) events from one processor, subsystem, or module to another:
    - Subsystem A can be programmed to generate a debug event, which can then be exported as a global trigger across the device.
    - Subsystem B can be programmed to be sensitive to the trigger line input and to generate an action on trigger detection.
  - Two global trigger lines are implemented
  - Device-level cross-triggering is handled by the XTRIG (TI cross-trigger) module implemented in the debug subsystem
  - Various Arm® CoreSight™ cross-trigger modules implemented to provide support for CoreSight triggers distribution
    - CoreSight Cross-Trigger Interface (CS\_CTI) modules
    - CoreSight Cross-Trigger Matrix (CS\_CTM) modules
  - For more information about cross-triggering, see *Cross-Triggering* section of the Device TRM.
- Suspend
  - Provides a way to stop a closely coupled hardware process running on a peripheral module when the host processor enters debug state
  - For more information about suspend, see *Suspend* section of the Device TRM.
- MPU watchpoint
  - Embedded in MPU subsystem
  - Provides visibility on MPU to EMIF direct paths
  - For more information, see *MPU Memory Adaptor (MPU\_MA) Watchpoint* section of the Device TRM.
- Processor trace
  - Cortex-A15 (MPU) and C66x (DSP) processor trace is supported
  - Program trace only for MPU (no data trace)
  - MPU trace supported by a CoreSight Program Trace Macrocell (CS\_PTM) module
  - Three exclusive trace sinks:
    - CoreSight Trace Port Interface Unit (CS\_TPIU) – trace export to an external trace receiver
    - CTools Trace Buffer Router (CT\_TBR) in system bridge mode – trace export through USB
    - CT\_TBR in buffer mode – trace history store into on-chip trace buffer
  - For more information, see *Processor Trace* section of the Device TRM.

- System instrumentation (trace)
  - Supported by a CTools System Trace Module (CT\_STM), implementing MIPI System Trace Protocol (STP) (rev 2.0)
  - Real-time software trace
    - MPU software instrumentation through CoreSight STM (CS\_STM) (STP2.0)
    - System-on-chip (SoC) software instrumentation through CT\_STM (STP2.0)
  - OCP watchpoint (OCP\_WP\_NOC)
    - OCP target traffic monitoring: OCP\_WP\_NOC can be configured to generate a trigger upon watchpoint match (that is, when target transaction attributes match the user-defined attributes).
    - SoC events trace
    - DMA transfer profiling
  - Statistics collector (performance probes)
    - Computes traffic statistics within a user-defined window and periodically reports to the user through the CT\_STM interface
    - Embedded in the L3\_MAIN interconnect
    - 10 instances:
      - 1 instance dedicated to target (SDRAM) load monitoring
      - 9 instances dedicated to master latency monitoring
  - IVA instrumentation (hardware accelerator [HWA] profiling)
    - Supported through a software message and system trace event (SMSET) module embedded in the IVA subsystem
  - Power-management events profiling (PM instrumentation [PMI])
    - Monitoring major power-management events. The PM state changes are handled as generic events and encapsulated in STP messages.
  - Clock-management events profiling (CM instrumentation [CMI])
    - Monitoring major clock management events. The CM state changes are handled as generic events and encapsulated in STP messages.
    - Two instances, one per CM
      - CM1 Instrumentation (CMI1) module mapped in the PD\_CORE\_AON power domain
      - CM2 Instrumentation (CMI2) module mapped in the PD\_CORE power domain
  - For more information, see *System Instrumentation* section of the Device TRM.
- Performance monitoring
  - Supported by subsystem counter timer module (SCTM) for IPU
  - Supported by performance monitoring unit (PMU) for MPU subsystem

For more information, see chapter *On-Chip Debug Support* of the Device TRM.

## 7 Applications, Implementation, and Layout

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test design implementation to confirm system functionality.

### 7.1 Introduction

This chapter is intended to communicate, guide and illustrate a PCB design strategy resulting in a PCB that can support TI's latest Application Processor. This Processor is a high-performance processor designed for automotive Infotainment and Advanced Driver Assistance Systems based on enhanced OMAP™ architecture integrated on a 28-nm CMOS process technology.

These guidelines first focus on designing a robust Power Delivery Network (PDN) which is essential to achieve the desirable high performance processing available on Device. The general principles and step-by-step approach for implementing good power integrity (PI) with specific requirements will be described for the key Device power domains.

TI strongly believes that simulating a PCB's proposed PDN is required for first pass PCB design success. Key Device processor high-current power domains need to be evaluated for Power Rail IR Drop, Decoupling Capacitor Loop-Inductance and Power Rail Target Impedance. Only then can a PCB's PDN performance be truly accessed by comparing these model PI parameters vs. TI's recommended values. Ultimately for any high-volume product, TI recommends conducting a "Processor PDN Validation" test on prototype PCBs across processor "split lots" to verify PDN robustness meets desired performance goals for each customer's worst-case scenario. Please contact your TI representative to receive guidance on PDN PI modeling and validation testing.

Likewise, the methodology and requirements needed to route Device high-speed, differential interfaces (i.e. USB2.0, USB3.0, HDMI, PCI, SATA), single-ended interfaces (i.e. DDR2/DDR3, QSPI) and general purpose interfaces using LVCMOS drivers that meet timing requirements while minimizing signal integrity (SI) distortions on the PCB's signaling traces. Signal trace lengths and flight times are aligned with FR-4 standard specification for PCBs.

Several different PCB layout stack-up examples have been presented to illustrate a typical number of layers, signal assignments and controlled impedance requirements. Different Device interface signals demand more or less complexity for routing and controlled impedance stack-ups. Optimizing the PCB's PDN stack-up needs with all of these different types of signal interfaces will ultimately determine the final layer count and layer assignments in each customer's PCB design.

This guideline must be used as a supplement in complement to TI's Application Processor, Power Management IC (PMIC) and Audio Companion components along with other TI component technical documentation (i.e. Technical Reference Manual, Data Manual, Data Sheets, Silicon Errata, Pin-Out Spreadsheet, Application Notes, etc.).

### NOTE

Notwithstanding any provision to the contrary, TI makes no warranty expressed, implied, or statutory, including any implied warranty of merchantability of fitness for a specific purpose, for customer boards. The data described in this appendix are intended as guidelines only.

### NOTE

These PCB guidelines are in a draft maturity and consequently, are subject to change depending on design verification testing conducted during IC development and validation. Note also that any references to Application Processor's ballout or pin muxing are subject to change following the processor's ballout maturity.

## 7.1.1 Initial Requirements and Guidelines

Unless otherwise specified, the characteristic impedance for single-ended interfaces is recommended to be between 35  $\Omega$  and 65  $\Omega$  to minimize the overshoot or undershoot on far-end loads.

Characteristic impedance for differential interfaces must be routed as differential traces on the same layer. The trace width and spacing must be chosen to yield the recommended differential impedance. For more information see [Section 7.5.1](#).

The PDN must be optimized for low trace resistance and low trace inductance for all high-current power nets from PMIC to the device.

An external interface using a connector must be protected following the IEC61000-4-2 level 4 system ESD.

## 7.2 Power Optimizations

This section describes the necessary steps for designing a robust Power Distribution Network (PDN):

- [Section 7.2.1, Step 1](#): PCB Stack-up
- [Section 7.2.2, Step 2](#): Physical Placement
- [Section 7.2.3, Step 3](#): Static Analysis
- [Section 7.2.4, Step 4](#): Frequency Analysis

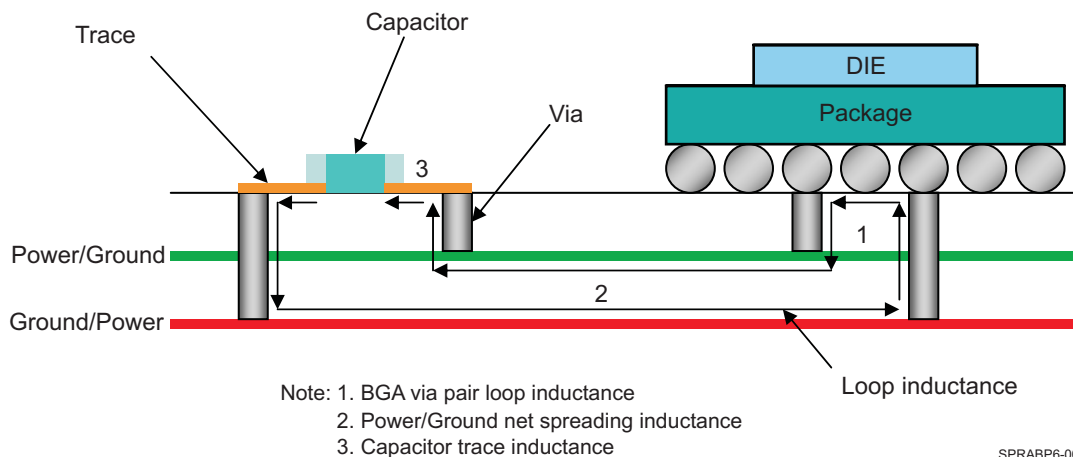
### 7.2.1 Step 1: PCB Stack-up

The PCB stack-up (layer assignment) is an important factor in determining the optimal performance of the power distribution system. An optimized PCB stack-up for higher power integrity performance can be achieved by following these recommendations:

- Power and ground plane pairs must be closely coupled together. The capacitance formed between the planes can decouple the power supply at high frequencies. Whenever possible, the power and ground planes must be solid to provide continuous return path for return current.
- Use a thin dielectric between the power and ground plane pair. Capacitance is inversely proportional to the separation of the plane pair. Minimizing the separation distance (the dielectric thickness) maximizes the capacitance.
- Optimize the power and ground plane pair carrying high current supplies to key component power domains as close as possible to the same surface where these components are placed (see [Figure 7-1](#)). This will help to minimize "loop inductance" encountered between supply decoupling capacitors and component supply inputs and between power and ground plane pairs.

### NOTE

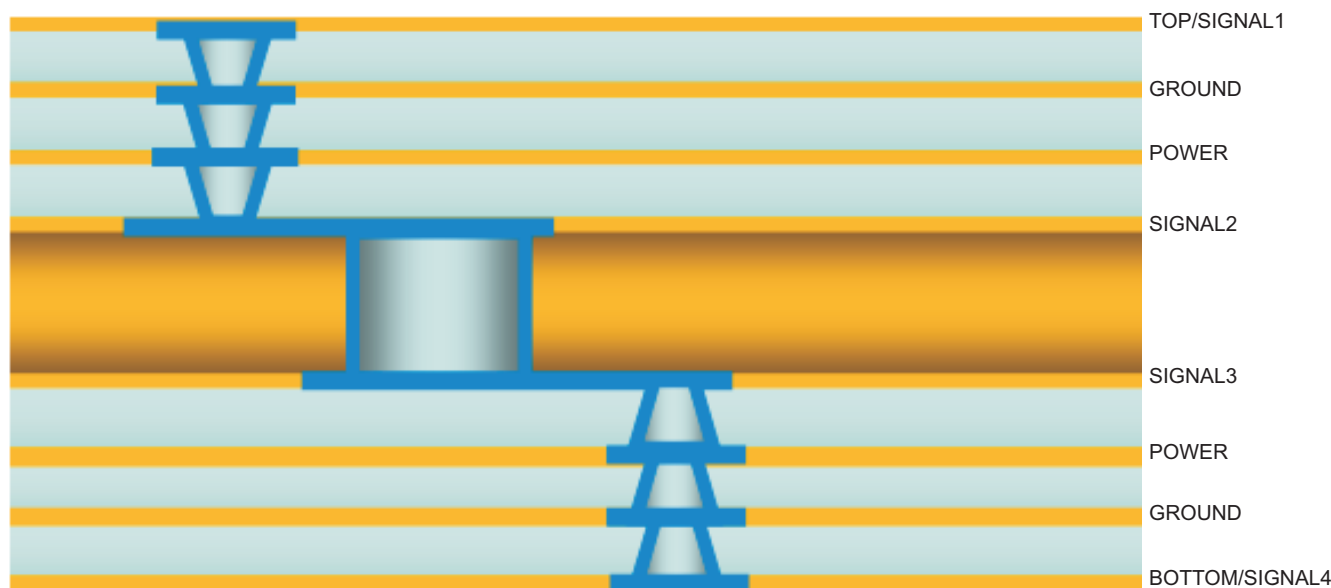
1-2oz Cu weight for power / ground plane is preferred to enable better PCB heat spreading, helping to reduce Processor junction temperatures. In addition, it is preferable to have the power / ground planes be adjacent to the PCB surface on which the Processor is mounted.



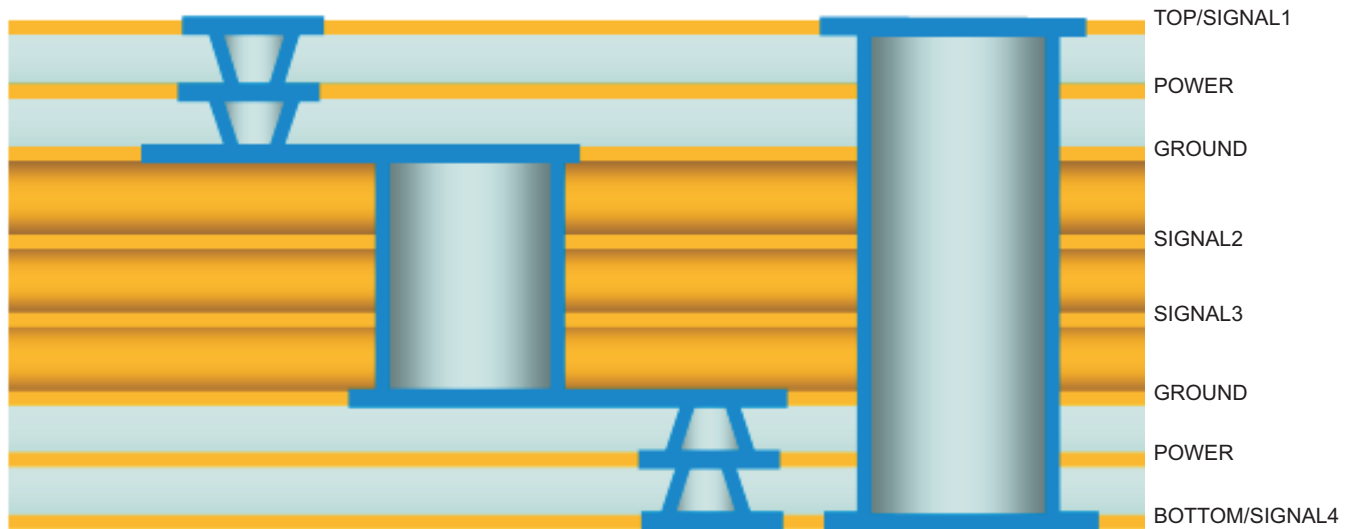
**Figure 7-1. Minimize Loop Inductance With Proper Layer Assignment**

The placement of power and ground planes in the PCB stackup (determined by layer assignment) has a significant impact on the parasitic inductances of power current path as shown in [Figure 7-1](#). For this reason, it is recommended to consider layer order in the early stages of the PCB PDN design cycle, putting high-priority supplies in the top half of the stackup (assuming high load and priority components are mounted on the top-side of PCB) and low-priority supplies in the bottom half of the stackup as shown in the examples below (vias have parasitic inductances which impact the bottom layers more, so it is advised to put the sensitive and high-priority power supplies on the top/same layers).

Two PCB stack-ups with layer assignments and via types that can enable an optimize PDN are shown in [Figure 7-2](#) and [Figure 7-3](#).



**Figure 7-2. Layer PCB With High Density Interconnect (HDI) Vias**



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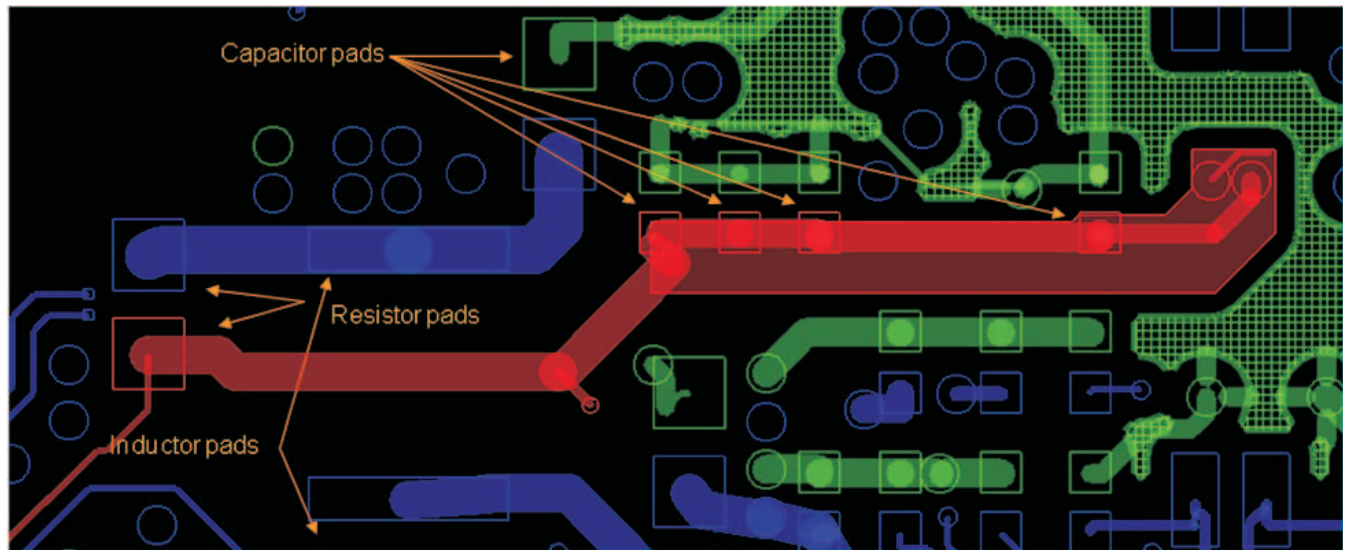
**Figure 7-3. Layer PCB With Plated Through Holes (PTH) Vias**

### 7.2.2 Step 2: Physical Placement

A critical step in designing an optimized PDN is that proper care must be taken to making sure that the initial floor planning of the PCB layout is done with good power integrity design guidelines in mind. The following points are important for optimizing a PCB's PDN:

- Minimizing the physical distance between power sources and key high load components is the first step toward optimization. Placing source and load components on the same side of the PCB is desirable. This will minimize via inductance impact for high current loads and steps
- External trace routing between components must be as wide as possible. The wider the traces, the lower the DC resistance and consequently the lower the static IR drop.
- Whenever possible for the internal layers (routing and plane), wide traces and copper area fills are preferred for PDN layout. The routing of power nets in plane provide for more interplane capacitance and improved high frequency performance of the PDN.
- Whenever possible, use a via to component pin/pad ratio of 1:1 or better (i.e. especially decoupling capacitors, power inductors and current sensing resistors). Do not share vias among multiple capacitors for connecting power supply and ground planes.
- Placement of vias must be as close as possible or even within a component's solder pad if the PCB technology you are using provides this capability.

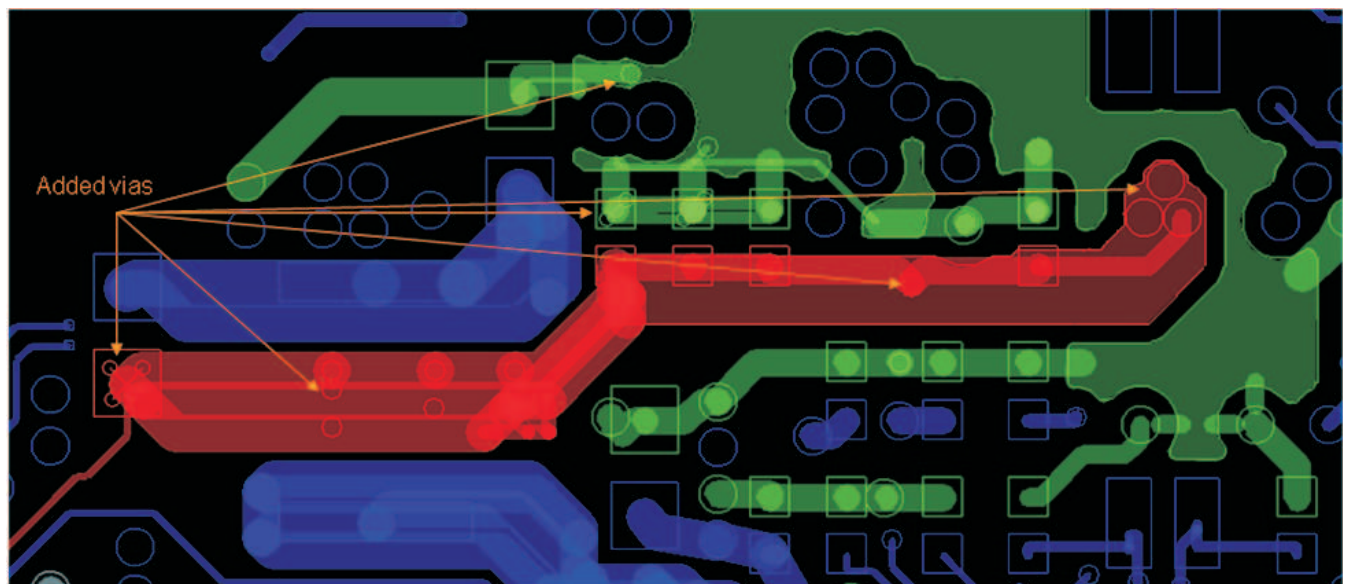
Figure 7-4 shows an example of acceptable width for power net routing but with poor via placement.



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**Figure 7-4. Poor Via Assignment for PDN**

Figure 7-5 shows an improved power net routing with better via assignment and placement, respectively.



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**Figure 7-5. Improved Via Assignment for PDN**

- To avoid any “ampacity” issue – maximum current-carrying capacity of each transitional via should be evaluated to determine the appropriate number of vias required to connect components.

Figure 7-6 and Figure 7-7 show examples of “via starvation” on a power net transitioning from top routing layer to internal layers and the improved layout, respectively. Adding vias to bring the “via-to-pad” ratio to 1:1 will improve PDN performance.



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One via for 5 capacitor pads is NOT good practice

**Figure 7-6. Via Starvation**

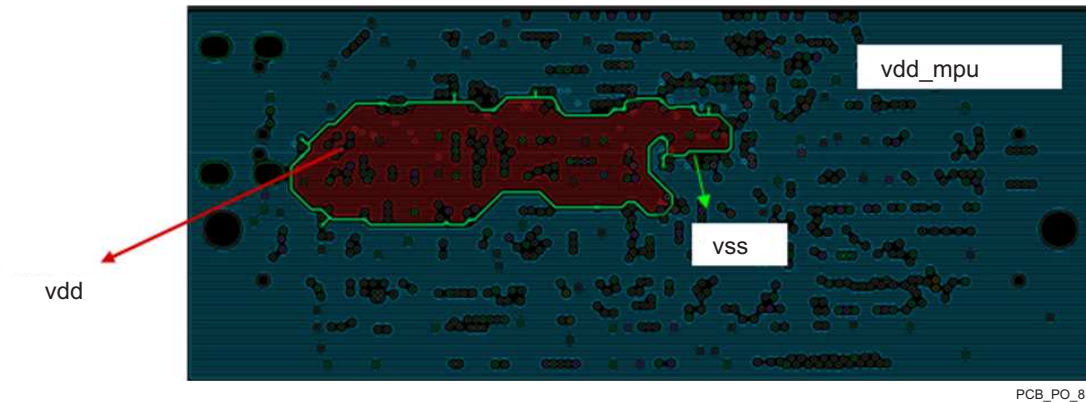


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Added vias

**Figure 7-7. Improved Layout With More Transitional Vias**

- For noise sensitive power supplies (i.e. Phase Lock-Loops, analog signals like audio and video), a Gnd shield can be used to isolate coplanar supplies that may have high step currents or high frequency switching transitions from coupling into low-noise supplies.



**Figure 7-8. Coplanar Shielding of Power Net Using Ground Guard-band**

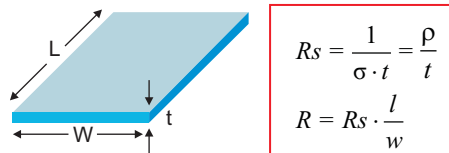
### 7.2.3 Step 3: Static Analysis

Delivering reliable power to circuits is always of critical importance because voltage drops (also known as IR drops) can happen at every level within an electronic system, on-chip, within a package, and across the board. Robust system performance can only be ensured by understanding how the system elements will perform under typical stressful Use Cases. Therefore, it is a good practice to perform a Static or DC Analysis.

Static or DC analysis and design methodology results in a PDN design that minimizes voltage or IR drops across power and ground planes, traces and vias. This ensures the application processor's internal transistors will be operating within their specified voltage ranges for proper functionality. The amount of IR drop that will be encountered is based upon amount power drawn for a desired Use Case and PCB trace (widths, geometry and number of parallel traces) and via (size, type and number) characteristics.

Components that are distant from their power source are particularly susceptible to IR drop. Designs that rely on battery power must minimize voltage drops to avoid unacceptable power loss that can negatively impact system performance. Early assessments a PDN's static (DC) performance helps to determine basic power distribution parameters such as best system input power point, optimal PCB layer stackup, and copper area needed for load currents.

The resistance  $R_s$  of a plane conductor for a unit length and unit width is called the **surface resistivity** (ohms per square).



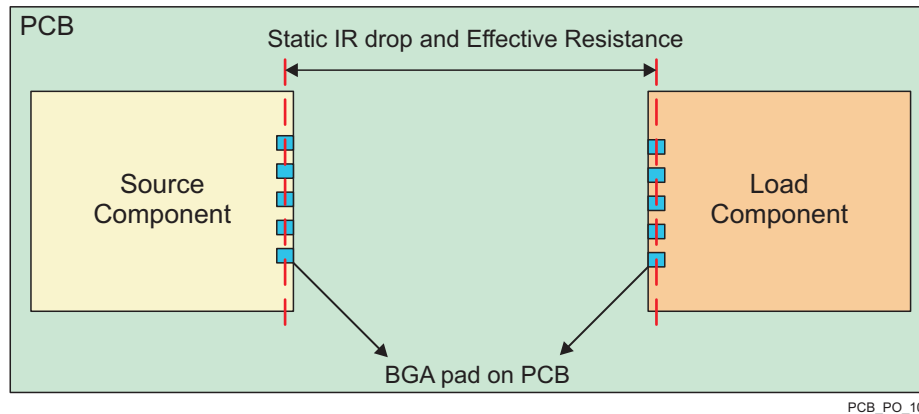
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**Figure 7-9. Depiction of Sheet Resistivity and Resistance**

Ohm's Law ( $V = I \times R$ ) relates conduction current to voltage drop. At DC, the relation coefficient is a constant and represents the resistance of the conductor. Even current carrying conductors will dissipate power at high currents even though their resistance may be very small. Both voltage drop and power dissipation are proportional to the resistance of the conductor.

Figure 7-10 shows a PCB-level static IR drop budget defined between the power management device (PMIC) pins and the application processor's balls when the PMIC is supplying power.

- It is highly recommended to physically place the PMIC as close as possible to the processor and on the same side. The orientation of the PMIC vs. processor should be aligned to minimize distance for the highest current rail.



**Figure 7-10. Static IR Drop Budget for PCB Only**

The system-level IR drop budget is made up of three portions: on-chip, package, and PCB board. Static IR or DC analysis/design methodology consists of designing the PDN such that the voltage drop (under DC operating conditions) across power and ground pads of the transistors of the application processor device is within a specified value of the nominal voltage for proper functionality of the device.

A PCB system-level voltage drop budget for proper device functionality is typically 1.5 % of nominal voltage. For a 1.35-V supply, this would be  $\leq 20$  mV.

To accurately analyze PCB static IR drop, the actual geometry of the PDN must be modeled properly and simulated to accurately characterize long distribution paths, copper weight impacts, electro-migration violations of current-carrying vias, and “Swiss-cheese” effects via placement has on power rails. It is recommended to perform the following analyses:

- Lumped resistance/IR drop analysis
- Distributed resistance/IR drop analysis

#### NOTE

The PMIC companion device supporting Processor has been designed with voltage sensing feedback loop capabilities that enable a remote sense of the SMPS output voltage at the point of use.

The NOTE above means the SMPS feedback signals and returns must be routed across PCB and connected to the Device input power ball for which a particular SMPS is supplying power. This feedback loop provides compensation for some of the voltage drop encountered across the PDN within limits. As such, the effective resistance of the PDN within this loop should be determined in order to optimize voltage compensation loop performance. The resistance of two PDN segments are of interest: one from the power inductor/bulk power filtering capacitor node to the Processor's input power and second is the entire PDN route from SMPS output pin/ball to the Processor input power.

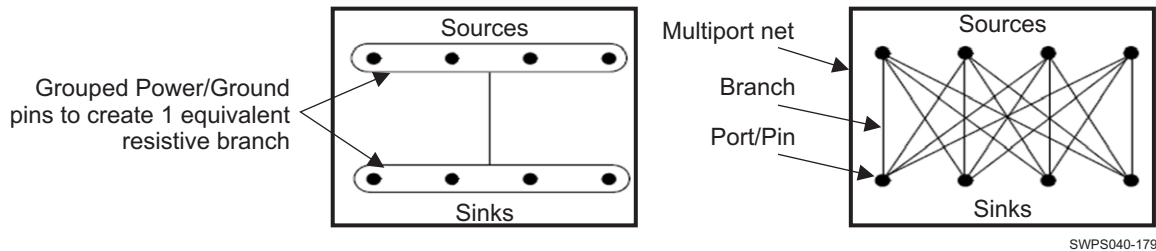
In the following sections each methodology is described in detail and an example has been provided of analysis flow that can be used by the PCB designer to validate compliance to the requirements on their PCB PDN design.

### 7.2.3.1 PDN Resistance and IR Drop

Lumped methodology consists of grouping all of the power pins on both the PMIC (voltage source) and processor (current sink) devices. Then the PMIC source is set to an expected Use Case voltage level and the processor load has its Use Case current sink value set as well. Now the lumped/effective resistance for the power rail trace/plane routes can be determine based upon the actual layout's power rail etch wide, shape, length, via count and placement [Figure 7-11](#) illustrates the pin-grouping/lumped concept.

The lumped methodology consists of importing the PCB layout database (from Cadence Allegro tool or any other layout design tool) into the static IR drop modeling and simulation tool of preference for the PCB designer. This is followed by applying the correct PCB stack-up information (thickness, material properties) of the PCB dielectric and metallization layers. The material properties of dielectric consist of permittivity (Dk) and loss tangent (Df).

For the conductor layers, the correct conductivity needs to be programmed into the simulation tool. This is followed by pin-grouping of the power and ground nets, and applying appropriate voltage/current sources. The current and voltage information can be obtained from the power and voltage specifications of the device under different operating conditions / Use Cases.



**Figure 7-11. Pin-grouping concept: Lumped and Distributed Methodologies**

#### 7.2.4 Step 4: Frequency Analysis

Delivering low noise voltage sources are very important to allowing a system to operate at the lowest possible Operational Performance Point (OPP) for any one Use Case. An OPP is a combination of the supply voltage level and clocking rate for key internal processor domains. A SCH and PCB designed to provide low noise voltage supplies will then enable the processor to enter optimal OPPs for each Use Case that in turn will minimize power dissipation and junction temperatures on-die. Therefore, it is a good engineering practice to perform a Frequency Analysis over the key power domains.

Frequency analysis and design methodology results in a PDN design that minimizes transient noise voltages at the processor's input power balls. This allows the processor's internal transistors to operate near the minimum specified operating supply voltage levels. To accomplish this one must evaluate how a voltage supply will change due to impedance variations over frequency. This analysis will focus on the decoupling capacitor network (VDD\_xxx and VSS/Gnd rails) at the load. Sufficient capacitance with a distribution of self-resonant points will provide for an overall lower impedance vs frequency response for each power domain.

Decoupling components that are distant from their load's input power are susceptible to encountering spreading loop inductance from the PCB design. Early analysis of each key power domain's frequency response helps to determine basic decoupling capacitor placement, optimal footprint, layer assignment, and types needed for minimizing supply voltage noise/fluctuations due to switching and load current transients.

#### NOTE

Evaluation of loop inductance values for decoupling capacitors placed ~300 mils closer to the load's input power balls has shown an 18 % reduction in loop inductance due to reduced distance.

- Decoupling capacitors must be carefully placed in order to minimize loop inductance impact on supply voltage transients. A real capacitor has characteristics not only of capacitance but also inductance and resistance.

Figure 7-12 shows the parasitic model of a real capacitor. A real capacitor must be treated as an RLC circuit with effective series resistance (ESR) and effective series inductance (ESL).



**Figure 7-12. Characteristics of a Real Capacitor With ESL and ESR**

The magnitude of the impedance of this series model is given as:

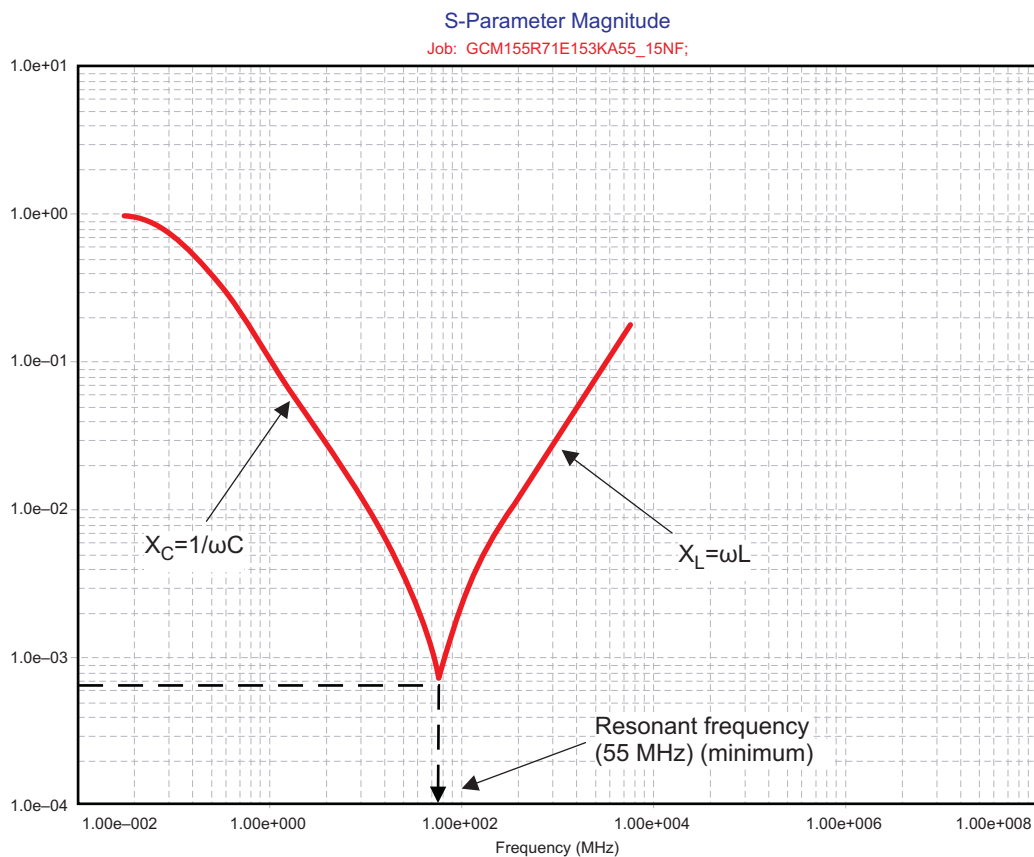
$$|Z| = \sqrt{ESR^2 + \left( \omega ESL - \frac{1}{\omega C} \right)^2}$$

where :  $\omega = 2\pi f$

SWPS040-e002

**Figure 7-13. Series Model Impedance Equation**

Figure 7-14 shows the resonant frequency response of a typical capacitor with a self-resonant frequency of 55 MHz. The impedance of the capacitor is a combination of its series resistance and reactive capacitance and inductance as shown in the equation above.



**Figure 7-14. Typical Impedance Profile of a Capacitor**

Because a capacitor has series inductance and resistance that impacts its effectiveness, it is important that the following recommendations are adopted in placing capacitors on the PDN.

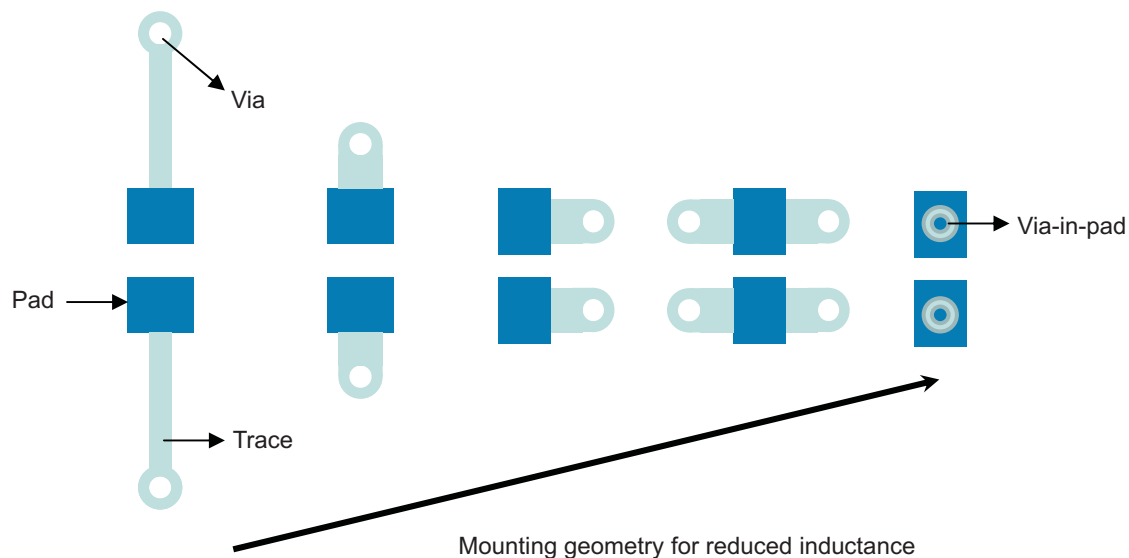
Wherever possible, mount the capacitor with the geometry that minimizes the mounting inductance and resistance. This was shown earlier in Figure 7-1. The capacitor mounting inductance and resistance values include the inductance and resistance of the pads, trace, and vias. Whenever possible, use footprints that have the lowest inductance configuration as shown in Figure 7-15

The length of a trace used to connect a capacitor has a big impact on parasitic inductance and resistance of the mounting. This trace must be as short and as wide as possible. Wherever possible, minimize distance to supply and Gnd vias by locating vias nearby or within the capacitor's solder pad landing. Further improvements can be made to the mounting by placing vias to the side of capacitor lands or doubling the number of vias as shown in Figure 7-15. If the PCB manufacturing processes allow it and if cost-effective, via-in-pad (VIP) geometries are strongly recommended.

In addition to mounting inductance and resistance associated with placing a capacitor on the PCB, the effectiveness of a decoupling capacitor also depends on the spreading inductance and resistance that the capacitor sees with respect to the load. The spreading inductance and resistance is strongly dependent on the layer assignment in the PCB stack-up. Therefore, try to minimize X, Y and Z dimensions where the Z is due to PCB thickness (as shown in Figure 7-2).

From left (highest inductance) to right (lowest inductance) the capacitor footprint types shown in Figure 7-15 are known as:

- 2-via, Skinny End Exit (2vSEE)
- 2-via, Wide End Exit (2vWEE)
- 2-via, Wide Side Exit (2vWSE)
- 4-via, Wide Side Exit (4vWSE)
- 2-via, In-Pad (2vIP)



SWPS040-177

**Figure 7-15. Capacitor Placement Geometry for Improved Mounting Inductance**

#### NOTE

Evaluation of loop inductance values for decoupling capacitor footprints 2vSEE (worst case) vs 4vWSE (2nd best) has shown a 30 % reduction in inductance when 4vWSE footprint was used in place of 2vSEE.

#### Decoupling Capacitor (Dcap) Strategy:

1. Use lowest inductance footprint and trace connection scheme possible for given PCB technology and layout area in order to minimize Dcap loop inductance to power pin as much as possible (see Figure 7-15).
2. Place Dcaps on “same-side” as component within their power plane outline to minimize “decoupling loop inductance”. Target distance to power pin should be less than ~500 mils depending upon PCB layout characteristics (plane's layer assignment and solid nature). Use PI modeling CAD tool to verify

minimum inductance for top vs bottom-side placement.

3. Place Dcaps on “opposite-side” as component within their power plane outline if “same-side” is not feasible or if distance to power pin is greater than ~500 mils for top-side location. Use PI modeling CAD tool to verify minimum inductance for top vs bottom-side placement.
4. Use minimum 10mil trace width for all voltage and gnd planes connections (i.e. Dcap pads, component power pins, etc.).
5. Place all voltage and gnd plane vias “as close as possible” to point of use (i.e. Dcap pads, component power pins, etc.).
6. Use a “Power/Gnd pad/pin to via” ratio of 1:1 whenever possible. Do not exceed 2:1 ratio for small number of vias within restricted PCB areas (i.e. underneath BGA components).

Frequency analysis for the MPU power domain has yielded the vdd\_mpu Impedance vs Frequency response shown in [Section 7.3.8.2](#), vdd\_mpu Example Analysis. As the example shows the overall MPU PDN  $R_{eff}$  meets the maximum recommended PDN resistance of 10 mΩ.

## 7.2.5 System ESD Generic Guidelines

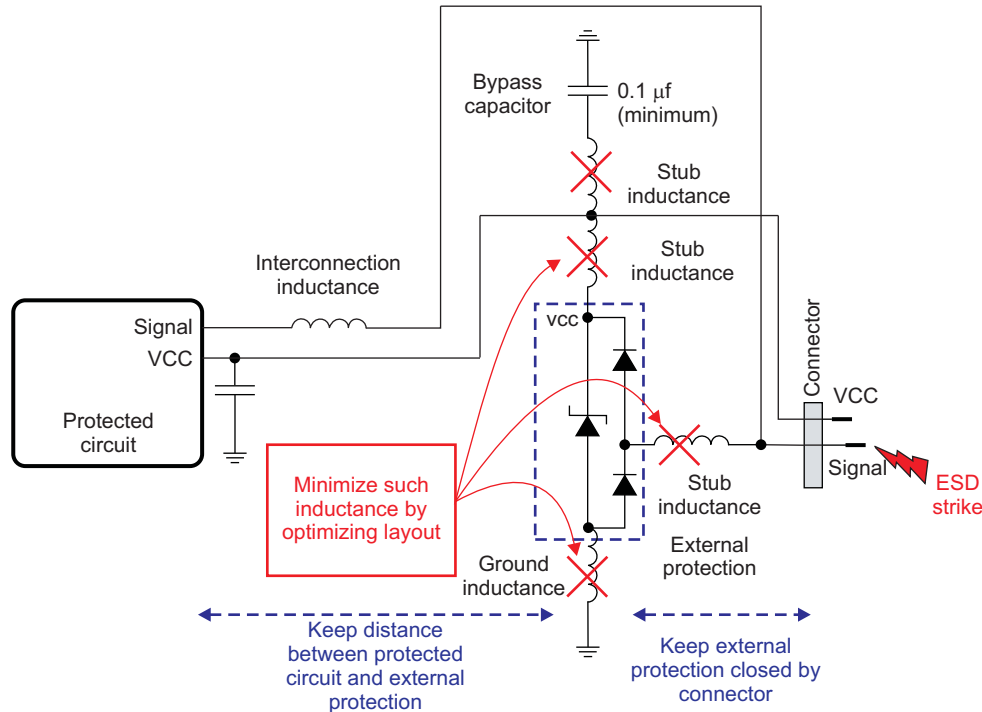
### 7.2.5.1 System ESD Generic PCB Guideline

Protection devices must be placed close to the ESD source which means close to the connector. This allows the device to subtract the energy associated with an ESD strike before it reaches the internal circuitry of the application board.

To help minimize the residual voltage pulse that will be built-up at the protection device due to its nonzero turn-on impedance, it is mandatory to route the ESD device with minimum stub length so that the low-resistive, low-inductive path from the signal to the ground is granted and not increasing the impedance between signal and ground.

For ESD protection array being railed to a power supply when no decoupling capacitor is available in close vicinity, consider using a decoupling capacitor ( $\geq 0.1 \mu\text{F}$ ) tight to the VCC pin of the ESD protection. A positive strike will be partially diverted to this capacitance resulting in a lower residual voltage pulse.

Ensure that there is sufficient metallization for the supply of signals at the interconnect side (VCC and GND in [Figure 7-16](#)) from connector to external protection because the interconnect may see between 15-A to 30-A current in a short period of time during the ESD event.



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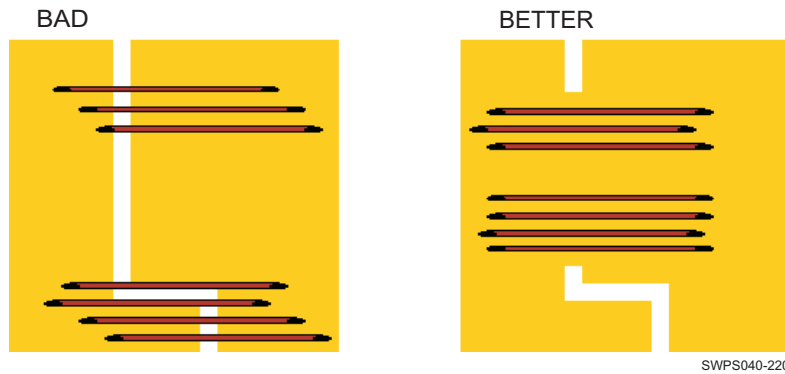
**Figure 7-16. Placement Recommendation for an ESD External Protection**

#### NOTE

To ensure normal behavior of the ESD protection (unwanted leakage), it is better to ground the ESD protection to the board ground rather than any local ground (example isolated shield or audio ground).

#### 7.2.5.2 Miscellaneous EMC Guidelines to Mitigate ESD Immunity

- Avoid running critical signal traces (clocks, resets, interrupts, control signals, and so forth) near PCB edges.
- Add high frequency filtering: Decoupling capacitors close to the receivers rather than close to the drivers to minimize ESD coupling.
- Put a ground (guard) ring around the entire periphery of the PCB to act as a lightning rod.
- Connect the guard ring to the PCB ground plane to provide a low impedance path for ESD-coupled current on the ring.
- Fill unused portions of the PCB with ground plane.
- Minimize circuit loops between power and ground by using multilayer PCB with dedicated power and ground planes.
- Shield long line length (strip lines) to minimize radiated ESD.
- Avoid running traces over split ground planes. It is better to use a bridge connecting the two planes in one area.



**Figure 7-17. Trace Examples**

- Always route signal traces and their associated ground returns as close to one another as possible to minimize the loop area enclosed by current flow:
  - At high frequencies current follows the path of least inductance.
  - At low frequencies current flows through the path of least resistance.

## 7.2.6 EMI / EMC Issues Prevention

All high-speed digital integrated circuits can be sources of unwanted radiation, which can affect nearby sensitive circuitry and cause the final product to have radiated emissions levels above the limits allowed by the EMC regulations if some preventative steps are not taken.

Likewise, analog and digital circuits can be susceptible to interference from the outside world and picked up by the circuitry interconnections.

To minimize the potential for EMI/EMC issues, the following guidelines are recommended to be followed.

### 7.2.6.1 Signal Bandwidth

To evaluate the frequency of a digital signal, an estimated rule of thumb is to consider its bandwidth  $f_{BW}$  with respect to its rise time,  $t_R$ :

$$f_{BW} \approx 0.35 / t_R$$

This frequency actually corresponds to the break point in the signal spectrum, where the harmonics start to decay at 40 dB per decade instead of 20 dB per decade.

### 7.2.6.2 Signal Routing

#### 7.2.6.2.1 Signal Routing—Sensitive Signals and Shielding

Keep radio frequency (RF) sensitive circuitry (like GPS receivers, GSM/WCDMA, Bluetooth/WLAN transceivers, frequency modulation (FM) radio) away from high-speed ICs (the device, power and audio manager, chargers, memories, and so forth) and ideally on the opposite side of the PCB. For improved protection it is recommended to place these emission sources in a shield can. If the shield can have a removable lid (two-piece shield), ensure there is low contact impedance between the fence and the lid. Leave some space between the lid and the components under it to limit the high-frequency currents induced in the lid. Limit the shield size to put any potential shield resonances above the frequencies of interest; see [Figure 7-14](#), *Typical Impedance Profile of a Capacitor*.

#### 7.2.6.2.2 Signal Routing—Outer Layer Routing

In case there is a need to use the outer layers for routing outside of shielded areas, it is recommended to route only static signals and ensure that these static signals do not carry any high-frequency components (due to parasitic coupling with other signals). In case of long traces, make provision for a bypass capacitor near the signal source.

Routing of high-frequency clock signals on outer layers, even for a short distance, is discouraged, because their emissions energy is concentrated at the discrete harmonics and can become significant even with poor radiators.

Coplanar shielding of traces on outer layers (placing ground near the sides of a track along its length) is effective only if the distance between the trace sides and the ground is smaller than the trace height above the ground reference plane. For modern multilayer PCBs this is often not possible, so coplanar shielding will not be effective. Do not route high-frequency traces near the periphery of the PCB, as the lack of a ground reference near the trace edges can increase EMI: see [Section 7.2.6.3, Ground Guidelines](#).

### 7.2.6.3 Ground Guidelines

#### 7.2.6.3.1 PCB Outer Layers

Ideally the areas on the top and bottom layers of the PCB that are not enclosed by a shield should be filled with ground after the routing is completed and connected with an adequate number of vias to the ground on the inner ground planes.

#### 7.2.6.3.2 Metallic Frames

Ensure that all metallic parts are well connected to the PCB ground (like LCD screens metallic frames, antennas reference planes, connector cages, flex cables grounds, and so forth). If using flex PCB ribbon cables to bring high-frequency signals off the PCB, ensure they are adequately shielded (coaxial cables or flex ribbons with a solid reference ground).

#### 7.2.6.3.3 Connectors

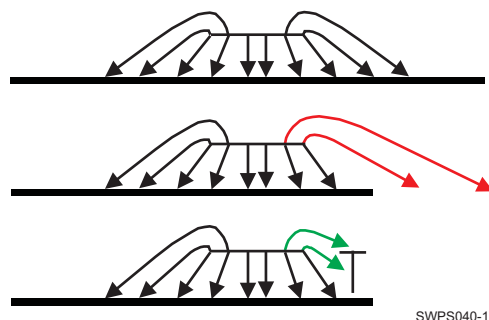
For high-frequency signals going to connectors choose a fully shielded connector, if possible (for example, SD card connectors). For signals going to external connectors or which are routed over long distances, it is recommended to reduce their bandwidth by using low-pass filters (resistor, capacitor (RC) combinations or lossy ferrite inductors). These filters will help to prevent emissions from the board and can also improve the immunity from external disturbances.

#### 7.2.6.3.4 Guard Ring on PCB Edges

The major advantage of a multilayer PCB with ground-plane is the ground return path below each and every signal or power trace.

As shown in [Figure 7-18](#) the field lines of the signal return to PCB ground as long as an infinite ground is available.

Traces near the PCB-edges do not have this infinite ground and therefore may radiate more than the others. Thus, signals (clocks) or power traces (core power) identified to be critical must not be routed in the vicinity of PCB edges, or, if not avoidable, must be accompanied by a guard ring on the PCB edge.



**Figure 7-18. Field Lines of a Signal Above Ground**



**Figure 7-19. Guard Ring Routing**

The intention of the guard ring is that HF-energy, that otherwise would have been emitted from the PCB edge, is reflected back into the board where it partially will be absorbed. For this purpose ground traces on the borders of all layers (including power layer) must be applied as shown in [Figure 7-19](#).

As these traces must have the same (HF-) potential as the ground plane they must be connected to the ground plane at least every 10 mm.

#### **7.2.6.3.5 Analog and Digital Ground**

For the optimum solution, the AGND and the DGND planes must be connected together at the power supply source in a same point. This ensures that both planes are at the same potential, while the transfer of noise from the digital to the analog domain is minimized.

### **7.3 Core Power Domains**

This section provides boundary conditions and theoretical background to be applied as a guide for optimizing a PCB design. The decoupling capacitor and PDN characteristics tables shown below give recommended capacitors and PCB parameters to be followed for schematic and PCB designs. Board designs that meet the static and dynamic PDN characteristics shown in tables below will be aligned to the expected PDN performance needed to optimize SoC performance.

#### **7.3.1 General Constraints and Theory**

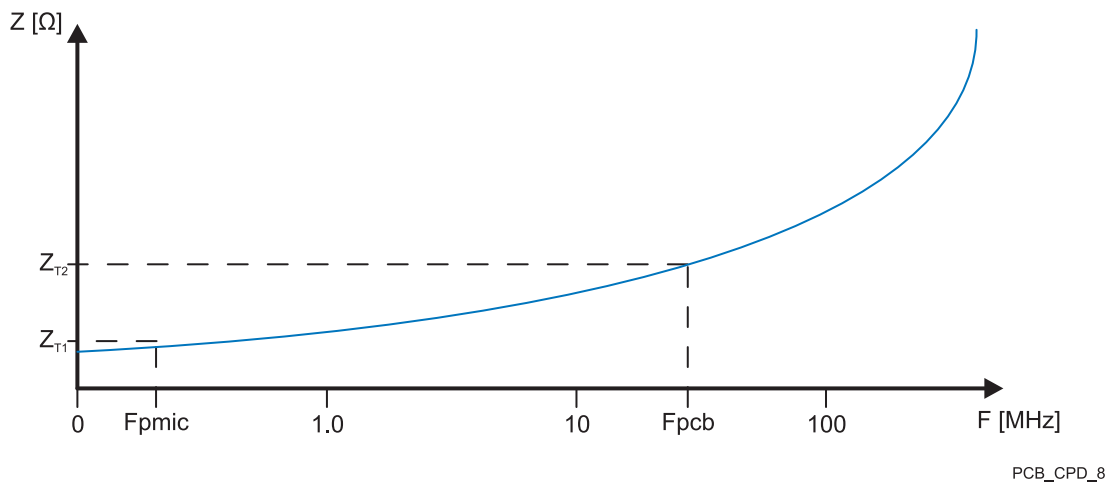
- Max PCB static/DC voltage drop (IRd) budget can be relaxed to **7.5 % of supply voltage** when using PMICs **with remote sensing at the load** as measured from PMIC's power inductor and filter capacitor node to Device's supply input including any ground return losses. TI highly recommends remote sensing.
- Max PCB static/DC voltage drop (IRd) budget of **1.5 % of supply voltage** when using PMICs **without remote sensing** as measured from PMIC's power inductor and filter capacitor node to Processor input including any ground return losses.
- PMIC component DM and guidelines should be referenced for the following:
  - Routing remote feedback sensing to optimize per each SMPS's implementation
  - Selecting power filtering capacitor values and PCB placement.
- Max Effective Resistance (R<sub>eff</sub>) budget can range from **4 mΩ – 100 mΩ** for key Device power rails not including ground returns depending upon maximum load currents and maximum DC voltage drop budget (as discussed above).
- Max Device supply input voltage difference budget of **5 mV** under max current loading shall be maintained across all balls connected to a common power rail. This represents any voltage difference that may exist between a remote sense point to any power input.
- Max PCB Loop Inductance (LL) budget between Device's power inputs and local bulk and high frequency decoupling capacitors including ground returns should range from **0.4 nH – 2.5 nH depending upon maximum transient load currents**.

- Max PCB dynamic/AC peak-to-peak transient noise voltage budgets between PMIC and Device including ground returns are as follows:
  - **+/-3 % of nominal supply voltage** for frequencies below the PMIC bandwidth (typ F<sub>pmic</sub> ~ 200 kHz)
  - **+/-5 % of nominal supply voltage** for frequencies between F<sub>pmic</sub> to F<sub>pcb</sub> (typ 20 MHz – 100 MHz)
- Max PCB Impedance (Z) vs Frequency (F) budget between Device's power inputs and PMIC's output power filter node including ground return is determined by applying the Frequency Domain Target Impedance Method to determine the PCB's maximum frequency of interest (F<sub>pcb</sub>). Ideally a properly designed and decoupled PDN will exhibit smoothly increasing Z vs. F curve. There are 2 general regions of interest as can be seen in [Figure 7-20](#).
  - 1<sup>st</sup> area is from DC (0 Hz) up to F<sub>pmic</sub> (typ a few 100 kHz) where a PMIC's transient response characteristic (i.e. Switching Freq, Compensation Loop BW) dominate. A PDN's Z is typically very low due to power filtering and bulk capacitor values when PDN has very low trace resistance (i.e. good Reff performance). The goal is to maintain a smoothly increasing Z that is less than Z<sub>t1</sub> over this low frequency range. This will ensure that a max transient current event will not cause a voltage drop more than the PMIC's current step response can support (typ 3 %).
  - 2<sup>nd</sup> area is from F<sub>pmic</sub> up to F<sub>pcb</sub> (typ 20 MHz – 100 MHz) where a PCB's inherent characteristics (i.e. parasitic capacitance, planar spreading inductances) dominate. A PDN's Z will naturally increase with frequency. At frequencies between F<sub>pmic</sub> up to F<sub>pcb</sub>, the goal is to maintain a smoothly increasing Z to be less than Z<sub>t2</sub>. This will ensure that the high frequency content of a max transient current event will not cause a voltage drop to be more than 5 % of the min supply voltage.

$$Z_T = \frac{\text{Max Voltage Rail Drop}^{\text{Note1}}}{\text{Max Transient Current}^{\text{Note2}}}$$

$$Z_{T1} = \frac{(\text{Min Voltage}) \times (\text{PMIC's Step Response})}{(\sim 50\% \text{ of Max DC Current})} = \frac{V_{\text{min}} \times 3\%(\text{typ})}{I_{\text{max}} \times \sim 50\%}$$

$$Z_{T2} = \frac{(\text{Min Voltage}) \times (\text{High-Freq Transient Noise})}{(\sim 50\% \text{ of Max DC Current})} = \frac{V_{\text{min}} \times 5\%(\text{typ})}{I_{\text{max}} \times \sim 50\%}$$



**Figure 7-20. PDN's Target impedance**

1. Voltage Rail Drop includes regulation accuracy, voltage distribution drops, and all dynamic events such as transient noise, AC ripple, voltage dips etc.
2. Typical max transient current is defined as 50 % of max current draw possible.

### 7.3.2 Voltage Decoupling

Recommended power supply decoupling capacitors main characteristics for commercial products whose ambient temperature is not to exceed +85°C are shown in table below:

**Table 7-1. Commercial Applications Recommended Decoupling Capacitors Characteristics<sup>(1)(2)(3)</sup>**

| Value  | Voltage [V] | Package | Stability | Dielectric | Capacitance Tolerance | Temp Range [°C] | Temp Sensitivity [%] | REFERENCE          |
|--------|-------------|---------|-----------|------------|-----------------------|-----------------|----------------------|--------------------|
| 22 μF  | 6,3         | 0603    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM188R60J226MEA0L |
| 10 μF  | 4,0         | 0402    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM155R60G106ME44  |
| 4.7 μF | 6,3         | 0402    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM155R60J475ME95  |
| 2.2 μF | 6,3         | 0402    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM155R60J225ME95  |
| 1 μF   | 6,3         | 0201    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM033R60J105MEA2  |

**Table 7-1. Commercial Applications Recommended Decoupling Capacitors Characteristics<sup>(1)(2)(3)</sup> (continued)**

| Value  | Voltage [V] | Package | Stability | Dielectric | Capacitance Tolerance | Temp Range [°C] | Temp Sensitivity [%] | REFERENCE         |
|--------|-------------|---------|-----------|------------|-----------------------|-----------------|----------------------|-------------------|
| 470 nF | 6,3         | 0201    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM033R60G474ME90 |
| 220 nF | 6,3         | 0201    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM033R60J224ME90 |
| 100 nF | 6,3         | 0201    | Class 2   | X5R        | - / + 20 %            | -55 to + 85     | - / + 15             | GRM033R60J104ME19 |

- (1) Minimum value for each PCB capacitor: 100 nF.
- (2) Among the different capacitors, 470 nF is recommended (not required) to filter at 5-MHz to 10-MHz frequency range.
- (3) In comparison with the EIA Class 1 dielectrics, Class 2 dielectric capacitors tend to have severe temperature drift, high dependence of capacitance on applied voltage, high voltage coefficient of dissipation factor, high frequency coefficient of dissipation, and problems with aging due to gradual change of crystal structure. Aging causes gradual exponential loss of capacitance and decrease of dissipation factor.

Recommended power supply decoupling capacitors main characteristics for automotive products are shown in table below:

**Table 7-2. Automotive Applications Recommended Decoupling Capacitors Characteristics <sup>(1)(2)</sup>**

| Value  | Voltage [V] | Package | Stability | Dielectric | Capacitance Tolerance | Temp Range [°C] | Temp Sensitivity [%] | REFERENCE         |
|--------|-------------|---------|-----------|------------|-----------------------|-----------------|----------------------|-------------------|
| 22 µF  | 6,3         | 1206    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM31CR70J226ME23 |
| 10 µF  | 6,3         | 0805    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM21BR70J106ME22 |
| 4.7 µF | 10          | 0805    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM21BC71A475MA73 |
| 2.2 µF | 6,3         | 0603    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM188R70J225ME22 |
| 1 µF   | 16          | 0603    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM188R71C105MA64 |
| 470 nF | 16          | 0603    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM188R71C474MA55 |
| 220 nF | 25          | 0603    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM188L81C224MA37 |
| 100 nF | 16          | 0402    | Class 2   | X7R        | - / + 20 %            | -55 to + 125    | - / + 15             | GCM155R71C104MA55 |

- (1) Minimum value for each PCB capacitor: 100 nF.
- (2) Among the different capacitors, 470 nF is recommended (not required) to filter at 5-MHz to 10-MHz frequency range.

### 7.3.3 Static PDN Analysis

One power net parameter derived from a PCB's PDN static analysis is the Effective Resistance (Reff). This is the total PCB power net routing resistance that is the sum of all the individual power net segments used to deliver a supply voltage to the point of load and includes any series resistive elements (i.e. current sensing resistor) that may be installed between the PMIC outputs and Processor inputs

### 7.3.4 Dynamic PDN Analysis

Three power net parameters derived from a PCB's PDN dynamic analysis are the Loop Inductance (LL), Impedance (Z) and PCB Frequency of Interest (Fpcb).

- LL values shown are the recommended max PCB trace inductance between a decoupling capacitor's power supply and ground reference terminals when viewed from the decoupling capacitor with a "theoretical shorted" applied across the Processor's supply inputs to ground reference.
- Z values shown are the recommended max PCB trace impedances allowed between Fpmic up to Fpcb frequency range that limits transient noise drops to no more than 5 % of min supply voltage during max transient current events.
- Fpcb (Frequency of Interest) is defined to be a power rail's max frequency after which adding a reasonable number of decoupling capacitors no longer significantly reduces the power rail impedance below the desired impedance target (Zt2). This is due to the dominance of the PCB's parasitic planar spreading and internal package inductances.

**Table 7-3. Recommended PDN Characteristics and EVM Decoupling Capacitors** <sup>(1)(2)(3)(4)(5)</sup>

| PDN Analysis:      | Static                                      | Dynamic                     |                                         |                                   | EVM Decoupling Capacitor Scheme per Supply <sup>(6)</sup> |           |           |     |           |           |          |       |
|--------------------|---------------------------------------------|-----------------------------|-----------------------------------------|-----------------------------------|-----------------------------------------------------------|-----------|-----------|-----|-----------|-----------|----------|-------|
| Supply             | Max R <sub>eff</sub> <sup>(7)</sup><br>[mΩ] | Max Dec.<br>Cap. LL<br>[nH] | Max<br>Impedance <sup>(8)</sup><br>[mΩ] | Frequency<br>of Interest<br>[MHz] | 100<br>nF                                                 | 220<br>nF | 470<br>nF | 1μF | 2.2<br>μF | 4.7<br>μF | 10<br>μF | 22 μF |
| vdd_mpu            | 18                                          | 2                           | 57                                      | 20                                | 12                                                        | 2         | 2         | 3   | 1         | 1         |          | 1     |
| vdd_dspeve         | 22                                          | 2.5                         | 54                                      | 20                                | 8                                                         | 1         | 1         | 2   | 1         | 1         | 1        |       |
| vdd                | 32                                          | 2                           | 87                                      | 50                                | 6                                                         | 1         | 1         | 1   | 1         | 1         |          |       |
| vdd_gpu            | 22                                          | 2.5                         | 207                                     | 50                                | 6                                                         | 1         | 1         | 1   | 1         | 1         |          |       |
| vdd_iva            | 48                                          | 2                           | 800                                     | 100                               | 5                                                         |           | 1         |     |           | 1         |          |       |
| vdds_ddr1          | 18                                          | 2.5                         | 200                                     | 100                               | 8                                                         | 4         |           | 2   |           | 2         |          | 1     |
| vdds_ddr2          | 18                                          | 2.5                         | 200                                     | 100                               | 8                                                         | 4         |           | 2   |           | 2         |          | 1     |
| cap_vbblldo_dspeve | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vbblldo_gpu    | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vbblldo_iva    | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vbblldo_mpu    | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_core1   | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_core2   | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_core3   | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_core4   | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_core5   | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_dspeve1 | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_dspeve2 | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_gpu     | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_iva     | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_mpu1    | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |
| cap_vddram_mpu2    | N/A                                         | 6                           | N/A                                     | N/A                               |                                                           |           |           | 1   |           |           |          |       |

(1) For more information on peak-to-peak noise values, see the Recommended Operating Conditions table of the Specifications chapter.

(2) ESL must be as low as possible and must not exceed 0.5 nH.

(3) The PDN (Power Delivery Network) impedance characteristics are defined versus the device activity (that runs at different frequency) based on the Recommended Operating Conditions table of the Specifications chapter.

(4) The static drop requirement drives the maximum acceptable PCB resistance between the PMIC or the external SMPS and the processor power balls.

(5) Assuming that the external SMPS (power IC) feedback sense is taken close to processor power balls.

(6) Decoupling capacitor (Dcap) scheme optimized for EVM PCB design. Each PCB design could have a different optimal Dcap scheme depending upon stackup, routing, placement and Dcap footprint to via connections.

(7) Maximum R<sub>eff</sub> from SMPS to Processor.

(8) Maximum impedance value at the Frequency of Interest and below.

#### NOTE

For power IC which can support more than 10 μF close to processor, a bulk capacitor of at least 22 μF is strongly recommended for VDD\_MPU power domains.

### 7.3.5 Power Supply Mapping

TPS65917 and LP87565 are the Power Management ICs (PMICs) that are used on the TI EVM. TI recommends use of these PMICs on customer designs for the following reasons:

- TI has validated their use with the Device
- Board level margins including transient response and output accuracy are analyzed and optimized for the entire system
- Support for power sequencing requirements (refer to [Section 5.10.3 Power Supply Sequences](#))

- Support for Adaptive Voltage Scaling (AVS) Class 0 requirements, including TI provided software

Other PMIC combinations have been analyzed and are recommended by TI in order to optimize for particular use cases. These options require additional analysis and validation to be performed by the customer. Contact your TI representative for additional details. In all cases, the customer's specific use case power estimate should be analyzed, and confirmed to be supported for any chosen implementation.

If multiple SoC voltage domains are allowed to be combined into a common board power rail, the most stringent recommended PDN guidelines ([Table 7-3](#)) should be applied to the common power rail.

It is possible that some voltage domains on the device are unused in some systems. In such cases, to ensure device reliability, it is still required that the supply pins for the specific voltage domains are connected to some core power supply output.

These unused supplies though can be combined with any of the core supplies that are used (active) in the system. For example: if IVA and GPU domains are not used, they can be combined with the CORE domain, thereby having a single power supply driving the combined CORE, IVA and GPU domains.

For the combined rail, the following relaxations do apply:

- The AVS voltage of active rail in the combined rail needs to be used to set the power supply
- The decoupling capacitance should be set according to the active rail in the combined rail

### 7.3.6 DPLL Voltage Requirement

The voltage input to the DPLLs has a low noise requirement. Board designs should supply these voltage inputs with a low noise LDO to ensure they are isolated from any potential digital switching noise. The TPS65917 and TPS659039 PMIC LDOLN outputs are specifically designed to meet this low noise requirement.

#### NOTE

For more information about Input Voltage Sources, see [Section 5.10.4.4, DPLLs, DLLs Specifications](#).

present the voltage inputs that supply the DPLLs.

**Table 7-4. Input Voltage Power Supplies for the DPLLs**

| POWER SUPPLY   | DPLLs                                                                    |
|----------------|--------------------------------------------------------------------------|
| vdda_abe_per   | DPLL_PER, DPLL_ABE and PER HSDIVIDER analog power supply                 |
| vdda_ddr       | DPLL_DDR and DDR HSDIVIDER analog power supply                           |
| vdda_debug     | DPLL_DEBUG analog power supply                                           |
| vdda_dsp_eve   | DPLL_DSP and DPLL_EVE analog power supply                                |
| vdda_gmac_core | DPLL_CORE and HSDIVIDER analog power supply                              |
| vdda_gpu       | DPLL_GPU analog power supply                                             |
| vdda_iva       | DPLL_IVA analog power supply                                             |
| vdda_video     | DPLL_VIDEO1 and DPLL_VIDEO2 analog power supply                          |
| vdda_mpu       | DPLL_MPU analog power supply                                             |
| vdda_osc       | not DPLL input but is required to be supplied by low noise input voltage |

### 7.3.7 Loss of Input Power Event

A few key PDN design items needed to enable a controlled and compliant SoC power down sequence for a "Loss of Input Power" event are:

- “Loss of Input Power” early warning.
  - TI EVM and Reference Design Study SCHs and PDNs achieve this by using the First Stage Converter’s (i.e. LM536033-Q1) Power Good status output to enable and disable the Second Stage PMIC devices (i.e. TPS65917/919, LP8733, and LP8732). If a different First Stage Converter is used, care must be taken to ensure an adequate “PG\_Status” or “Vbatt\_Status” signal is provided that can disable Second Stage PMIC to begin a controlled and compliant SoC power down sequence. The total elapsed time from asserting “PG\_Status” low until SoC’s PMIC input voltage reaches minimum level of 2.75 V should be minimum of 1.5 ms and 2 ms preferred.
- Maximize discharge time of First Stage Vout (VSYS\_3V3 power rail = input voltage to SoC PMIC).
  - TI EVM and Reference Design Study SCHs and PDNs achieve this by opening an in-line load switch immediately upon “PG\_Status” low assertion in order to remove the SoC’s 3.3 V IO load current from VSYS\_3V3. This will extend the VSYS\_3V3 power rail’s discharge time in order to maximize elapsed time for allowing SoC PMIC to execute a controlled and compliant power down sequence. Care should be taken to either disable or isolate any additional peripheral components that may be loading the VSYS\_3V3 rail as well.
- Sufficient bulk decoupling capacitance on the First Stage Vout (VSYS\_3V3 per PDN) that allows for desired 1.5 – 2 ms elapsed time as described above.
  - TI EVM and Reference Design Study SCHs and PDNs achieve this by using 200  $\mu$ F of total capacitance on VSYS\_3V3. The First Stage Converter (i.e. LM536033-Q1) can typically drive a max of 400  $\mu$ F to help extend VSYS\_3V3 discharge time for a compliant SoC power down sequence.
- Optimizing the Second Stage SoC PMIC’s OTP settings that determines SoC power up and down sequences and total elapsed time needed for a controlled sequence.
  - TI EVM and Reference Design Study SCHs and PDNs achieve this by using optimized OTPs per the SCH and components used. The definition of these OTPs is captured in the detailed timing diagrams for both power up and down sequences. The PDN diagram typically shows a recommended PMIC OTP ID based upon the SoC and DDR memory types.

### 7.3.8 Example PCB Design

The following sections describe an example PCB design and its resulting PDN performance for the vdd\_mpu key processor power domain.

#### 7.3.8.1 Example Stack-up

Layer Assignments:

- Layer Top: Signal and Segmented Power Plane
  - Processor and PMIC components placed on Top-side
- Layer 2: Gnd Plane1
- Layer 3: Signals
- Layer n: Power Plane1
- Layer n+1: Power Plane 2
- Layer n+2: Signal
- Layer n+3: Gnd Plane2
- Layer Bottom: Signal and Segmented Power Planes
  - Decoupling caps, etc.

Via Technology: Through-hole

Copper Weight:

- ½ oz for all signal layers.
- 1-2oz for all power plane for improved PCB heat spreading.
- Total PCB Thickness 0.080 inches.

### 7.3.8.2 vdd\_mpu Example Analysis

Maximum acceptable PCB resistance ( $R_{\text{eff}}$ ) between the PMIC and Processor input power balls should not exceed 10 m $\Omega$ .

Maximum decoupling capacitance loop inductance (LL) between Processor input power balls and decoupling capacitances should not exceed 2.0 nH (ESL NOT included)

Impedance target for key frequency of interest between Processor input power balls and PMIC's SMPS output power balls should not exceed 57 m $\Omega$  at 20 MHz.

**Table 7-5. Example PCB vdd\_mpu PI Analysis Summary**

| Parameter                                                               | Recommendation           | Example PCB              |
|-------------------------------------------------------------------------|--------------------------|--------------------------|
| Processor OPP                                                           | High                     |                          |
| Clocking Rate                                                           | 1.5 GHz                  |                          |
| Voltage Level                                                           | 1.22 V                   | 1.22 V                   |
| Max Current Draw                                                        | 5.12 A                   | 5.12 A                   |
| Max Effective Resistance: Power Inductor Segment Total $R_{\text{eff}}$ | 10 m $\Omega$            | 9.0 m $\Omega$           |
| Max Loop Inductance                                                     | 2.0 nH                   | 1.0 nH – 1.4 nH          |
| Impedance Target                                                        | 57 m $\Omega$ F < 20 MHz | 57 m $\Omega$ F < 20 MHz |

Figure 7-21, Figure 7-22, Figure 7-23, and Figure 7-24 show a PCB layout example and the resulting PI analysis results.

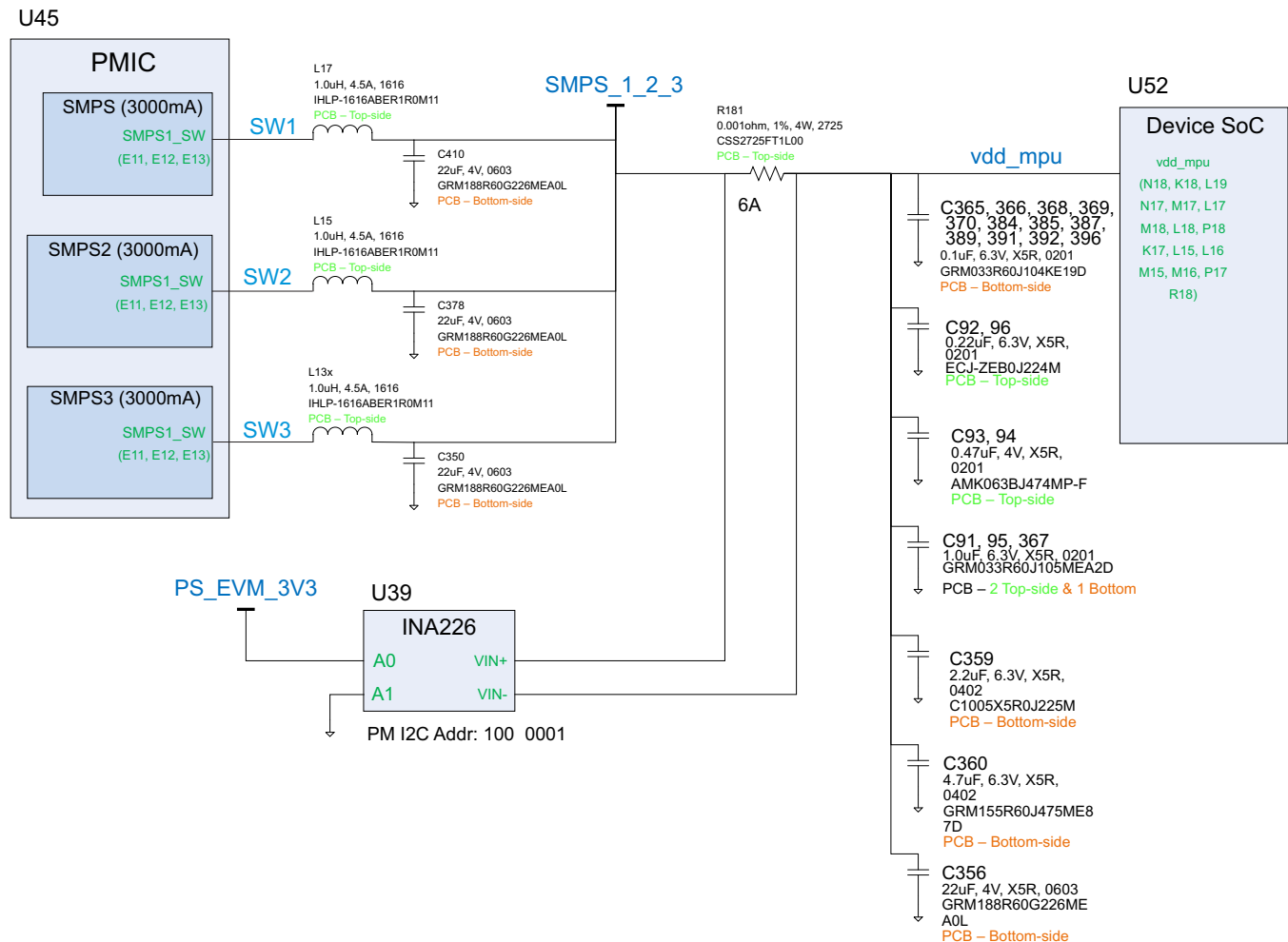


Figure 7-21. vdd\_mpu Simplified SCH Diagram

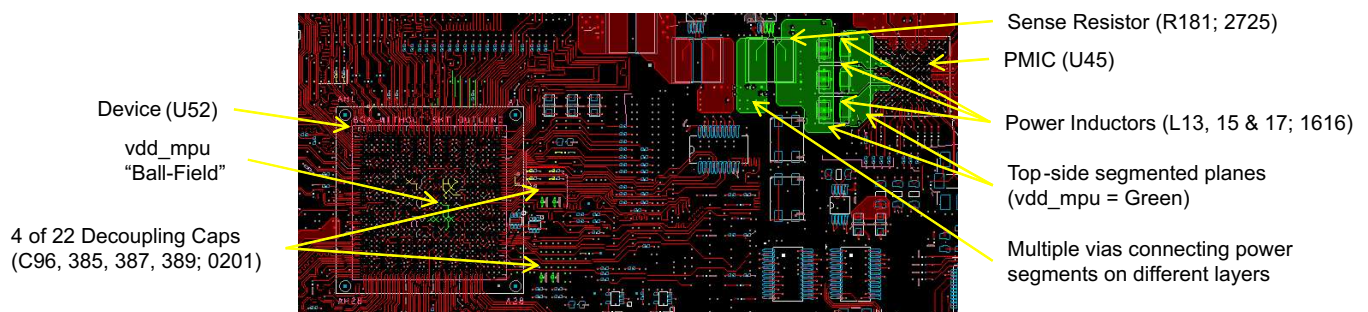


Figure 7-22. vdd\_mpu routing [Top Layer]

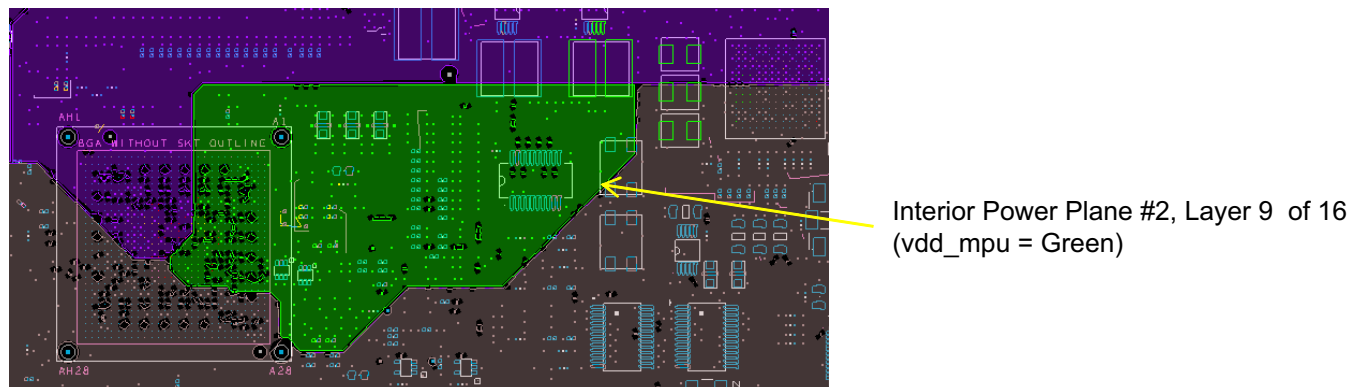
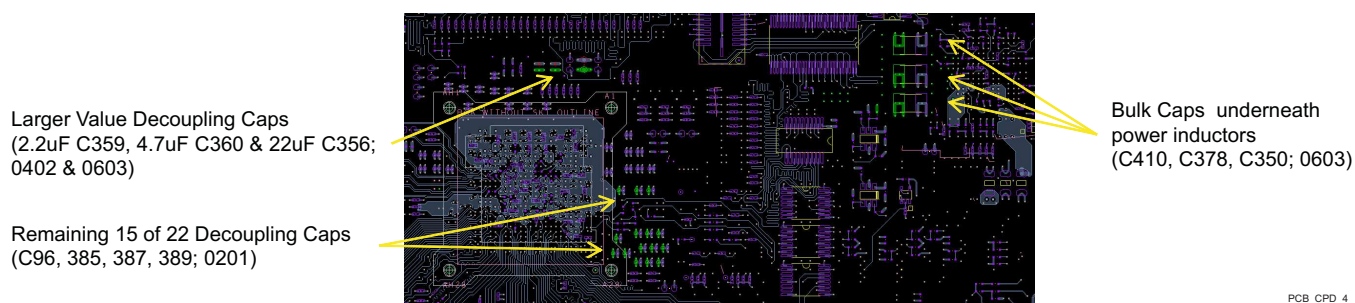


Figure 7-23. vdd\_mpu routing [Internal Power Plane #2]



PCB\_CPD\_4

Figure 7-24. vdd\_mpu routing and cap placements [Bottom Layer]

Table 7-6. PCB Etch Resistance Breakdown - From PMIC Source to Device Load

| Net[from]                        | Component [from]: | Net[to]    | Component [to]: | Etch Resistance ( $\Omega$ ) | % of Total Etch Resistance |
|----------------------------------|-------------------|------------|-----------------|------------------------------|----------------------------|
| SW1                              | L17               | SW1        | U45             | 0,001038                     | 13 %                       |
| SW2                              | L15               | SW2        | U45             | 0,000898                     | 12 %                       |
| SW3                              | L13               | SW3        | U45             | 0,000861                     | 11 %                       |
| SW1                              | L17               | SMPS_1_2_3 | R181            | 0,000696                     | 9 %                        |
| SW2                              | L15               | SMPS_1_2_3 | R181            | 0,000541                     | 7 %                        |
| SW3                              | L13               | SMPS_1_2_3 | R181            | 0,000526                     | 7 %                        |
| vdd_mpu                          | R181              | vdd_mpu    | U52             | 0,006311                     | 78 %                       |
| vdd_mpu                          | R181              | vdd_mpu    | U52             | 0,006311                     | 81 %                       |
| vdd_mpu                          | R181              | vdd_mpu    | U52             | 0,006311                     | 82 %                       |
| Total Etch Resistance from SW1 = |                   |            |                 | 0,008045                     | 100 %                      |
| Total Etch Resistance from SW2 = |                   |            |                 | 0,00775                      | 100 %                      |
| Total Etch Resistance from SW3 = |                   |            |                 | 0,007698                     | 100 %                      |
| Max Value =                      |                   |            |                 | 0,008045                     |                            |

Table 7-7. PCB Etch Resistance Breakdown - From Power Inductor to Device Load

| Net[from]  | Component [from]: | Net[to]    | Component [to]: | Etch Resistance ( $\Omega$ ) | % of Total Etch Resistance |
|------------|-------------------|------------|-----------------|------------------------------|----------------------------|
| SMPS_1_2_3 | L17               | SMPS_1_2_3 | R181            | 0,000696                     | 10 %                       |
| SMPS_1_2_3 | L15               | SMPS_1_2_3 | R181            | 0,000541                     | 8 %                        |
| SMPS_1_2_3 | L13               | SMPS_1_2_3 | R181            | 0,000526                     | 8 %                        |

**Table 7-7. PCB Etch Resistance Breakdown - From Power Inductor to Device Load (continued)**

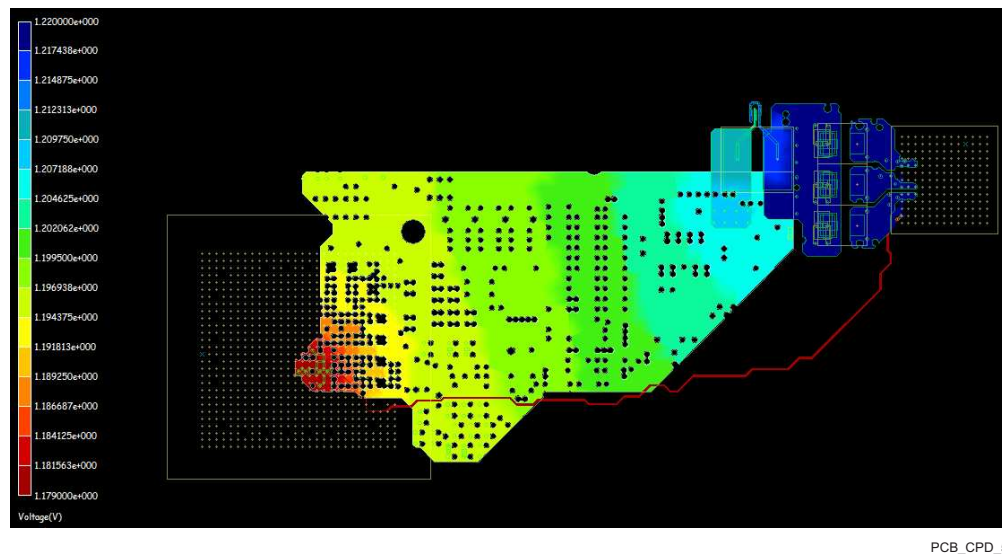
| Net[from]               | Component [from]: | Net[to] | Component [to]: | Etch Resistance ( $\Omega$ ) | % of Total Etch Resistance |
|-------------------------|-------------------|---------|-----------------|------------------------------|----------------------------|
| vdd_mpu                 | R181              | vdd_mpu | U52             | 0,006311                     | 90 %                       |
| vdd_mpu                 | R181              | vdd_mpu | U52             | 0,006311                     | 92 %                       |
| vdd_mpu                 | R181              | vdd_mpu | U52             | 0,006311                     | 92 %                       |
| Total Etch Resistance = |                   |         |                 | 0,007007                     | 100 %                      |
| Total Etch Resistance = |                   |         |                 | 0,006852                     | 100 %                      |
| Total Etch Resistance = |                   |         |                 | 0,006837                     | 100 %                      |
| Max Value =             |                   |         |                 | 0,007007                     |                            |

**Table 7-8. PDN Effective Resistance - From PMIC Source to Device Load**

| PDN Elements                            | PDN Effective Resistance ( $\Omega$ ) | % of Total Etch Resistance |
|-----------------------------------------|---------------------------------------|----------------------------|
| Etch                                    | 0,008045                              | 89 %                       |
| Inductor                                | 0                                     | 0 %                        |
| Sense Resistor                          | 0,001                                 | 11 %                       |
| Max PDN Effectiv Resistance from Source | 0,009045                              | 100 %                      |

IR Drop: vdd\_mpu (PCB RevJan14, Sentinel PSI)

- Source Conditions: 1.22 V @ 5,12 A
- Recommended  $R_{\text{eff}} < 10 \text{ m}\Omega$
- $R_{\text{eff}} = \text{Total Trace Resistance} + \text{Sence Resistor} = 8,0 \text{ 4m}\Omega + 1 \text{ m}\Omega = 9,04 \text{ m}\Omega$
- Voltage / IR Drop: 1,22 - 1,179 = 52,6 mV



**Figure 7-25. vdd\_mpu Voltage/IR Drop [All Layers]**

Dynamic analysis of this PCB design for the MPU power domain determined the vdd\_mpu decoupling capacitor loop inductance and impedance vs frequency analysis shown below. As you can see, the loop inductance values ranged from 1.0 nH to 1.4 nH and were less than maximum 2.0 nH recommended.

**NOTE**

Comparing loop inductances for capacitors at different distances from the processor's input power balls shows an 18 % reduction for caps placed closer. This was derived by averaging the inductances for the 3 caps with distances over 800 mils (Avg LL = 1.33 nH) vs the 3 caps with distances less than 600 mils (Avg LL = 1.096 nH).

**Table 7-9. Rail - vdd\_mpu**

| Cap Ref Des | Model Port # | Loop Inductance [nH] | Footprint Types | PCB Side | Distance to Ball-Field [mils] | Value [μF] | Size |
|-------------|--------------|----------------------|-----------------|----------|-------------------------------|------------|------|
| C356        | 1            | 1,4                  | 4vWSE           | Bottom   | 897                           | 22         | 0603 |
| C359        | 2            | 1,26                 | 4vWSE           | Bottom   | 855                           | 2,2        | 0402 |
| C360        | 3            | 1,33                 | 4vWSE           | Bottom   | 850                           | 4,7        | 0402 |
| C365        | 4            | 1,14                 | 4vWSE           | Bottom   | 817                           | 0,1        | 0201 |
| C366        | 5            | 1,13                 | 4vWSE           | Bottom   | 755                           | 0,1        | 0201 |
| C367        | 6            | 1,07                 | 4vWSE           | Bottom   | 758                           | 1          | 0201 |
| C368        | 7            | 1,12                 | 4vWSE           | Bottom   | 811                           | 0,1        | 0201 |
| C369        | 8            | 1,06                 | 4vWSE           | Bottom   | 690                           | 0,1        | 0201 |
| C370        | 9            | 1,12                 | 4vWSE           | Bottom   | 680                           | 0,1        | 0201 |
| C384        | 10           | 1,04                 | 4vWSE           | Bottom   | 686                           | 0,1        | 0201 |
| C385        | 11           | 1,07                 | 4vWSE           | Top      | 686                           | 0,1        | 0201 |
| C387        | 12           | 1,16                 | 4vWSE           | Top      | 755                           | 0,1        | 0201 |
| C389        | 13           | 1,18                 | 4vWSE           | Top      | 693                           | 0,1        | 0201 |
| C391        | 14           | 1,14                 | 4vWSE           | Bottom   | 693                           | 0,1        | 0201 |
| C392        | 15           | 1,18                 | 4vWSE           | Bottom   | 542                           | 0,1        | 0201 |
| C396        | 16           | 1,11                 | 4vWSE           | Bottom   | 745                           | 0,1        | 0201 |
| C91         | 17           | 1,1                  | 4vWSE           | Bottom   | 515                           | 1          | 0201 |
| C92         | 18           | 1,09                 | 4vWSE           | Bottom   | 622                           | 0,22       | 0201 |
| C93         | 19           | 1,01                 | 4vWSE           | Bottom   | 504                           | 0,47       | 0201 |
| C94         | 20           | 1,13                 | 4vWSE           | Bottom   | 604                           | 0,47       | 0201 |
| C95         | 21           | 1,04                 | 4vWSE           | Bottom   | 612                           | 1          | 0201 |
| C96         | 22           | 1,08                 | 4vWSE           | Top      | 612                           | 0,22       | 0201 |

Loop Inductance range: 1,01 - 1,40 nH

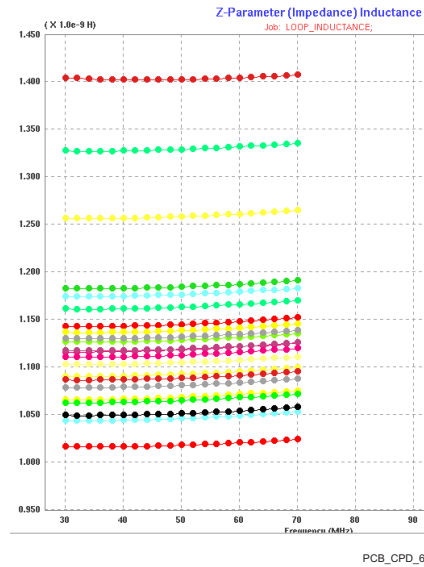


Figure 7-26. vdd\_mpu Decoupling Cap Loop Inductances

Figure 7-27 shows vdd\_mpu Impedance vs Frequency characteristics.

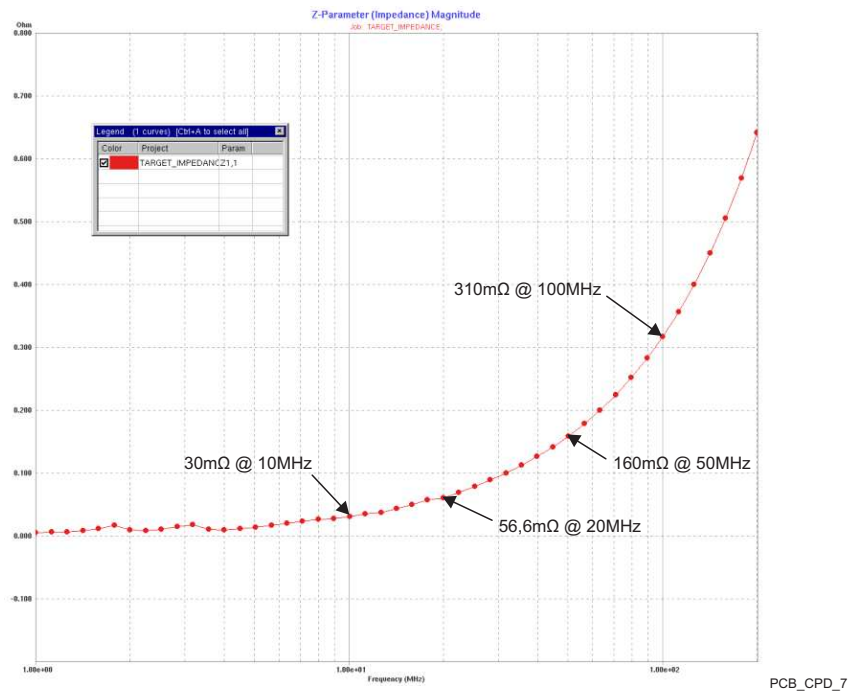


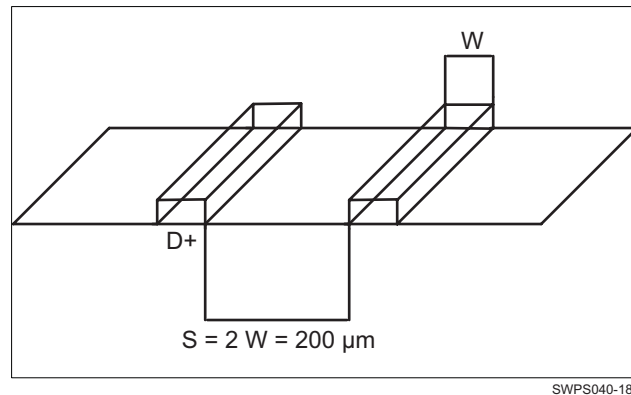
Figure 7-27. vdd\_mpu Impedance vs Frequency

## 7.4 Single-Ended Interfaces

### 7.4.1 General Routing Guidelines

The following paragraphs detail the routing guidelines that must be observed when routing the various functional LVCMOS interfaces.

- Line spacing:
  - For a line width equal to  $W$ , the spacing between two lines must be  $2W$ , at least. This minimizes the crosstalk between switching signals between the different lines. On the PCB, this is not achievable everywhere (for example, when breaking signals out from the device package), but it is recommended to follow this rule as much as possible. When violating this guideline, minimize the length of the traces running parallel to each other (see [Figure 7-28](#)).



**Figure 7-28. Ground Guard Illustration**

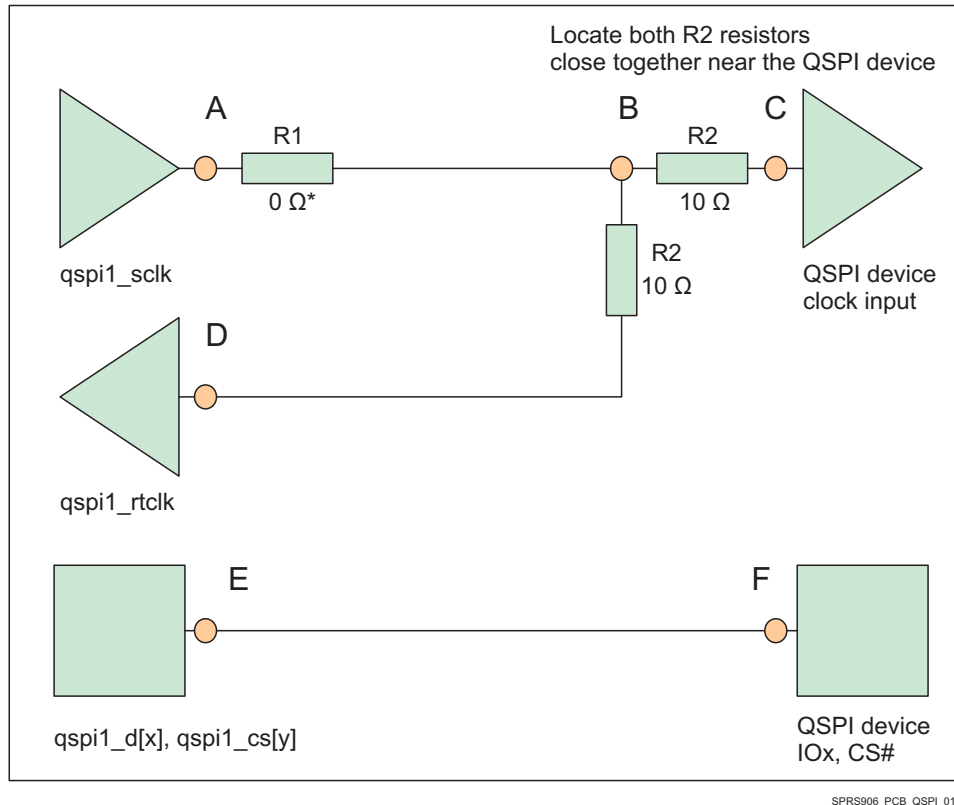
- Length matching (unless otherwise specified):
  - For bus or traces at frequencies less than 10 MHz, the trace length matching (maximum length difference between the longest and the shortest lines) must be less than 25 mm.
  - For bus or traces at frequencies greater than 10 MHz, the trace length matching (maximum length difference between the longest and the shortest lines) must be less than 2.5 mm.
- Characteristic impedance
  - Unless otherwise specified, the characteristic impedance for single-ended interfaces is recommended to be between 35-Ω and 65-Ω.
- Multiple peripheral support
  - For interfaces where multiple peripherals have to be supported in the star topology, the length of each branch has to be balanced. Before closing the PCB design, it is highly recommended to verify signal integrity based on simulations including actual PCB extraction.

#### 7.4.2 QSPI Board Design and Layout Guidelines

The following section details the routing guidelines that must be observed when routing the QSPI interfaces.

- The `qspi1_sclk` output signal must be looped back into the `qspi1_rtclk` input.
- The signal propagation delay from the `qspi1_sclk` ball to the QSPI device CLK input pin (A to C) must be approximately equal to the signal propagation delay from the QSPI device CLK pin to the `qspi1_rtclk` ball (C to D).
- The signal propagation delay from the QSPI device CLK pin to the `qspi1_rtclk` ball (C to D) must be approximately equal to the signal propagation delay of the control and data signals between the QSPI device and the SoC device (E to F, or F to E).
- The signal propagation delay from the `qspi1_sclk` signal to the series terminators ( $R2 = 10\ \Omega$ ) near the QSPI device must be  $< 450\ \text{pS}$  ( $\sim 7\ \text{cm}$  as stripline or  $\sim 8\ \text{cm}$  as microstrip)
- 50 Ω PCB routing is recommended along with series terminations, as shown in [Figure 7-29](#).

- Propagation delays and matching:
  - A to C = C to D = E to F.
  - Matching skew: < 60 pS
  - A to B < 450 pS
  - B to C = as small as possible (< 60 pS)



**Figure 7-29. QSPI Interface High Level Schematic**

**NOTE**

\*0 Ω resistor (R1), located as close as possible to the qspi1\_sclk pin, is placeholder for fine-tuning if needed.

## 7.5 Differential Interfaces

### 7.5.1 General Routing Guidelines

To maximize signal integrity, proper routing techniques for differential signals are important for high-speed designs. The following general routing guidelines describe the routing guidelines for differential lanes and differential signals.

- As much as possible, no other high-frequency signals must be routed in close proximity to the differential pair.
- Must be routed as differential traces on the same layer. The trace width and spacing must be chosen to yield the differential impedance value recommended.
- Minimize external components on differential lanes (like external ESD, probe points).
- Through-hole pins are not recommended.
- Differential lanes mustn't cross image planes (ground planes).
- No sharp bend on differential lanes.

- Number of vias on the differential pairs must be minimized, and identical on each line of the differential pair. In case of multiple differential lanes in the same interface, all lines should have the same number of vias.
- Shielded routing is to be promoted as much as possible (for instance, signals must be routed on internal layers that are inside power and/or ground planes).

## 7.5.2 USB 2.0 Board Design and Layout Guidelines

This section discusses schematic guidelines when designing a universal serial bus (USB) system.

### 7.5.2.1 Background

Clock frequencies generate the main source of energy in a USB design. The USB differential DP/DM pairs operate in high-speed mode at 480 Mbps. System clocks can operate at 12 MHz, 48 MHz, and 60 MHz. The USB cable can behave as a monopole antenna; take care to prevent RF currents from coupling onto the cable.

When designing a USB board, the signals of most interest are:

- Device interface signals: Clocks and other signal/data lines that run between devices on the PCB.
- Power going into and out of the cable: The USB connector socket pin 1 (VBUS ) may be heavily filtered and need only pass low frequency signals of less than ~100 kHz. The USB socket pin 4 (analog ground) must be able to return the current during data transmission, and must be filtered sparingly.
- Differential twisted pair signals going out on cable, DP and DM: Depending upon the data transfer rate, these device terminals can have signals with fundamental frequencies of 240 MHz (high speed), 6 MHz (full speed), and 750 kHz (low speed).
- External crystal circuit (device terminals XI and X0): 12 MHz, 19.2 MHz, 24 MHz, and 48 MHz fundamental. When using an external crystal as a reference clock, a 24 MHz and higher crystal is highly recommended.

### 7.5.2.2 USB PHY Layout Guide

The following sections describe in detail the specific guidelines for USB PHY Layout.

#### 7.5.2.2.1 General Routing and Placement

Use the following routing and placement guidelines when laying out a new design for the USB physical layer (PHY). These guidelines help minimize signal quality and electromagnetic interference (EMI) problems on a four-or-more layer evaluation module (EVM).

- Place the USB PHY and major components on the un-routed board first. For more details, see [Section 7.5.2.2.3](#).
- Route the high-speed clock and high-speed USB differential signals with minimum trace lengths.
- Route the high-speed USB signals on the plane closest to the ground plane, whenever possible.
- Route the high-speed USB signals using a minimum of vias and corners. This reduces signal reflections and impedance changes.
- When it becomes necessary to turn 90°, use two 45° turns or an arc instead of making a single 90° turn. This reduces reflections on the signal traces by minimizing impedance discontinuities.
- Do not route USB traces under or near crystals, oscillators, clock signal generators, switching regulators, mounting holes, magnetic devices or IC's that use or duplicate clock signals.
- Avoid stubs on the high-speed USB signals because they cause signal reflections. If a stub is unavoidable, then the stub should be less than 200 mils.
- Route all high-speed USB signal traces over continuous planes ( $V_{CC}$  or GND), with no interruptions. Avoid crossing over anti-etch, commonly found with plane splits.

### 7.5.2.2.2 Specific Guidelines for USB PHY Layout

The following sections describe in detail the specific guidelines for USB PHY Layout.

#### 7.5.2.2.2.1 Analog, PLL, and Digital Power Supply Filtering

To minimize EMI emissions, add decoupling capacitors with a ferrite bead at power supply terminals for the analog, phase-locked loop (PLL), and digital portions of the chip. Place this array as close to the chip as possible to minimize the inductance of the line and noise contributions to the system. An analog and digital supply example is shown in [Figure 7-30](#). In case of multiple power supply pins with the same function, tie them up to a single low-impedance point in the board and then add the decoupling capacitors, in addition to the ferrite bead. This array of caps and ferrite bead improve EMI and jitter performance. Take both EMI and jitter into account before altering the configuration.

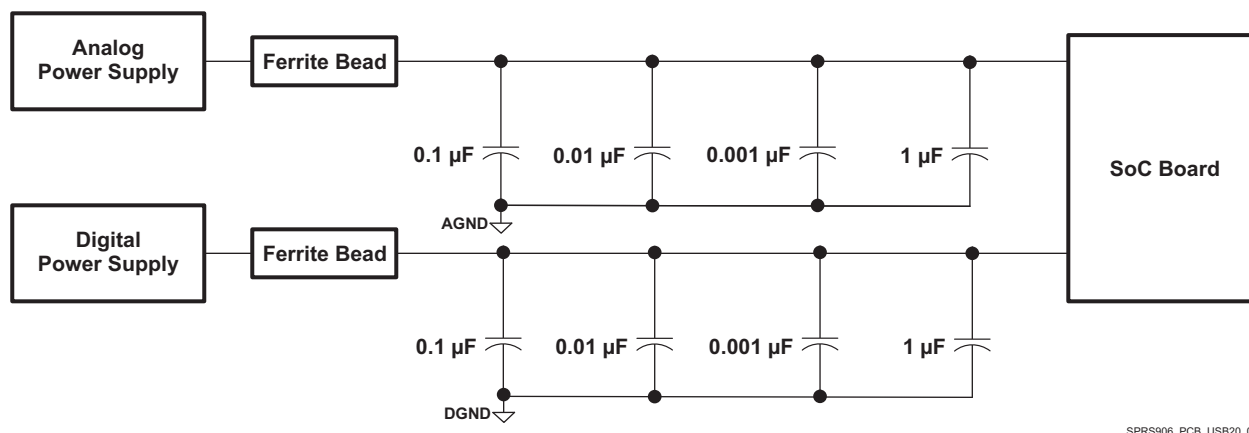


Figure 7-30. Suggested Array Capacitors and a Ferrite Bead to Minimize EMI

Consider the recommendations listed below to achieve proper ESD/EMI performance:

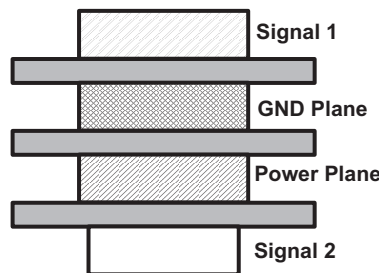
- Use a 0.01  $\mu\text{F}$  cap on each cable power VBUS line to chassis GND close to the USB connector pin.
- Use a 0.01  $\mu\text{F}$  cap on each cable ground line to chassis GND next to the USB connector pin.
- If voltage regulators are used, place a 0.01  $\mu\text{F}$  cap on both input and output. This is to increase the immunity to ESD and reduce EMI. For other requirements, see the device-specific datasheet.

#### 7.5.2.2.2.2 Analog, Digital, and PLL Partitioning

If separate power planes are used, they must be tied together at one point through a low-impedance bridge or preferably through a ferrite bead. Care must be taken to capacitively decouple each power rail close to the device. The analog ground, digital ground, and PLL ground must be tied together to the low-impedance circuit board ground plane.

#### 7.5.2.2.2.3 Board Stackup

Because of the high frequencies associated with the USB, a printed circuit board with at least four layers is recommended; two signal layers separated by a ground and power layer as shown in [Figure 7-31](#).



**Figure 7-31. Four-Layer Board Stack-Up**

The majority of signal traces should run on a single layer, preferably SIGNAL1. Immediately next to this layer should be the GND plane, which is solid with no cuts. Avoid running signal traces across a split in the ground or power plane. When running across split planes is unavoidable, sufficient decoupling must be used. Minimizing the number of signal vias reduces EMI by reducing inductance at high frequencies.

#### 7.5.2.2.2.4 Cable Connector Socket

Short the cable connector sockets directly to a small chassis ground plane (*GND strap*) that exists immediately underneath the connector sockets. This shorts EMI (and ESD) directly to the chassis ground before it gets onto the USB cable. This etch plane should be as large as possible, but all the conductors coming off connector pins 1 through 6 must have the board signal GND plane run under. If needed, scoop out the chassis GND strap etch to allow for the signal ground to extend under the connector pins. Note that the etches coming from pins 1 and 4 (VBUS power and GND) should be wide and via-ed to their respective planes as soon as possible, respecting the filtering that may be in place between the connector pin and the plane. See [Figure 7-32](#) for a schematic example.

Place a ferrite in series with the cable shield pins near the USB connector socket to keep EMI from getting onto the cable shield. The ferrite bead between the cable shield and ground may be valued between 10  $\Omega$  and 50  $\Omega$  at 100 MHz; it should be resistive to approximately 1 GHz. To keep EMI from getting onto the cable bus power wire (a very large antenna) a ferrite may be placed in series with cable bus power, VBUS, near the USB connector pin 1. The ferrite bead between connector pin 1 and bus power may be valued between 47  $\Omega$  and approximately 1000  $\Omega$  at 100 MHz. It should continue being resistive out to approximately 1 GHz, as shown in [Figure 7-32](#).

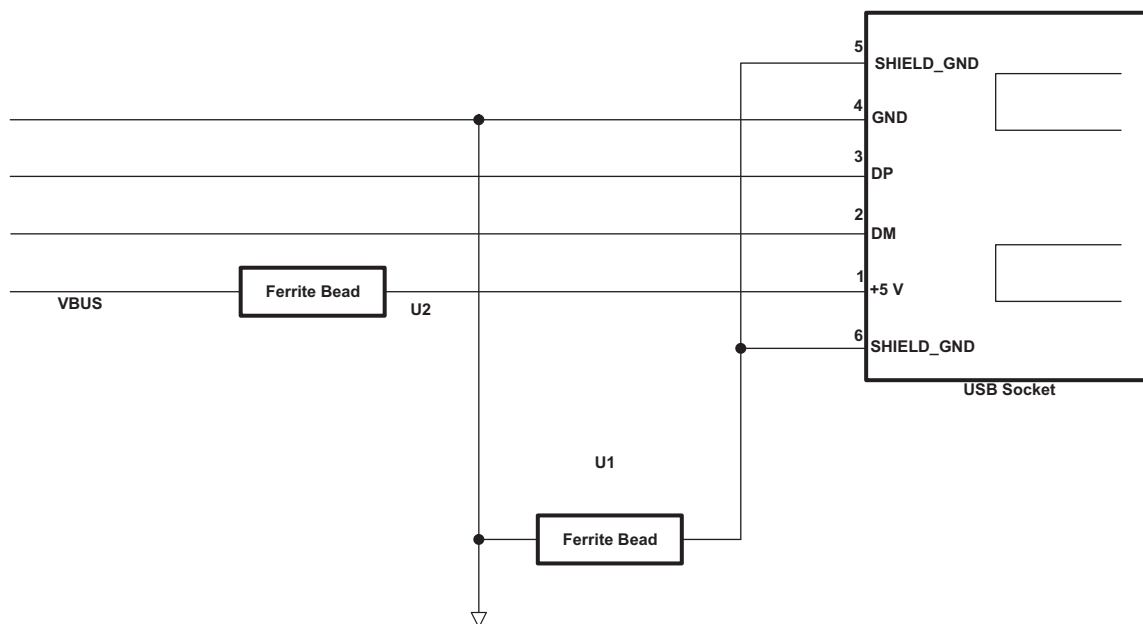


Figure 7-32. USB Connector

#### 7.5.2.2.2.5 Clock Routings

To address the system clock emissions between devices, place a  $\sim 10\ \Omega$  to  $130\ \Omega$  resistor in series with the clock signal. Use a trial and error method of looking at the shape of the clock waveform on a high-speed oscilloscope and of tuning the value of the resistance to minimize waveform distortion. The value on this resistor should be as small as possible to get the desired effect. Place the resistor close to the device generating the clock signal. If an external crystal is used, follow the guidelines detailed in the *Selection and Specification of Crystals for Texas Instruments USB 2.0 Devices* (SLLA122).

When routing the clock traces from one device to another, try to use the 3W spacing rule. The distance from the center of the clock trace to the center of any adjacent signal trace should be at least three times the width of the clock trace. Many clocks, including slow frequency clocks, can have fast rise and fall times. Using the 3W rule cuts down on crosstalk between traces. In general, leave space between each of the traces running parallel between the devices. Avoid using right angles when routing traces to minimize the routing distance and impedance discontinuities. For further protection from crosstalk, run guard traces beside the clock signals (GND pin to GND pin), if possible. This lessens clock signal coupling, as shown in Figure 7-33.

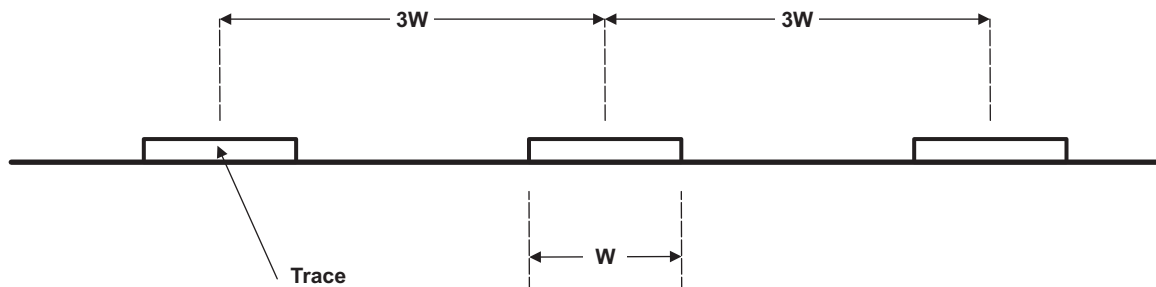
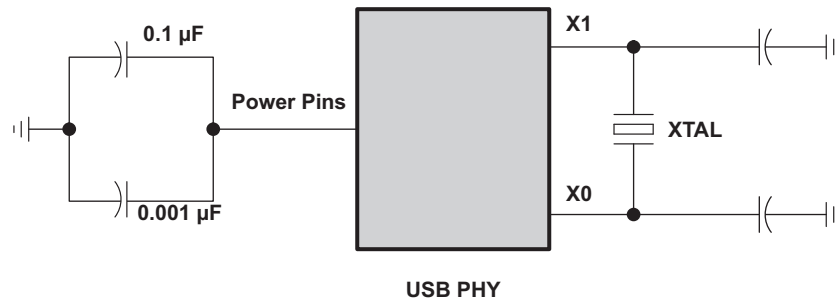


Figure 7-33. 3W Spacing Rule

#### 7.5.2.2.2.6 Crystals/Oscillator

Keep the crystal and its load capacitors close to the USB PHY pins, XI and XO (see [Figure 7-34](#)). Note that frequencies from power sources or large capacitors can cause modulations within the clock and should not be placed near the crystal. In these instances, errors such as dropped packets occur. A placeholder for a resistor, in parallel with the crystal, can be incorporated in the design to assist oscillator startup.

Power is proportional to the current squared. The current is  $I = C \cdot dv/dt$ , because  $dv/dt$  is a function of the PHY, current is proportional to the capacitive load. Cutting the load to 1/2 decreases the current by 1/2 and the power to 1/4 of the original value. For more details on crystal selection, see the *Selection and Specification of Crystals for Texas Instruments USB 2.0 Devices* ([SLLA122](#)).



**Figure 7-34. Power Supply and Clock Connection to the USB PHY**

#### 7.5.2.2.2.7 DP/DM Trace

Place the USB PHY as close as possible to the USB 2.0 connector. The signal swing during high-speed operation on the DP/DM lines is relatively small ( $400 \text{ mV} \pm 10 \%$ ), so any differential noise picked up on the twisted pair can affect the received signal. When the DP/DM traces do not have any shielding, the traces tend to behave like an antenna and picks up noise generated by the surrounding components in the environment. To minimize the effect of this behavior:

- DP/DM traces should always be matched lengths and must be no more than 4 inches in length; otherwise, the eye opening may be degraded (see [Figure 7-35](#)).
- Route DP/DM traces close together for noise rejection on differential signals, parallel to each other and within two mils in length of each other. The measurement for trace length must be started from device's balls.
- A high-speed USB connection is made through a shielded, twisted pair cable with a differential characteristic impedance of  $90 \Omega \pm 15 \%$ . In layout, the impedance of DP and DM should each be  $45 \Omega \pm 10 \%$ .
- DP/DM traces should not have any extra components to maintain signal integrity. For example, traces cannot be routed to two USB connectors.

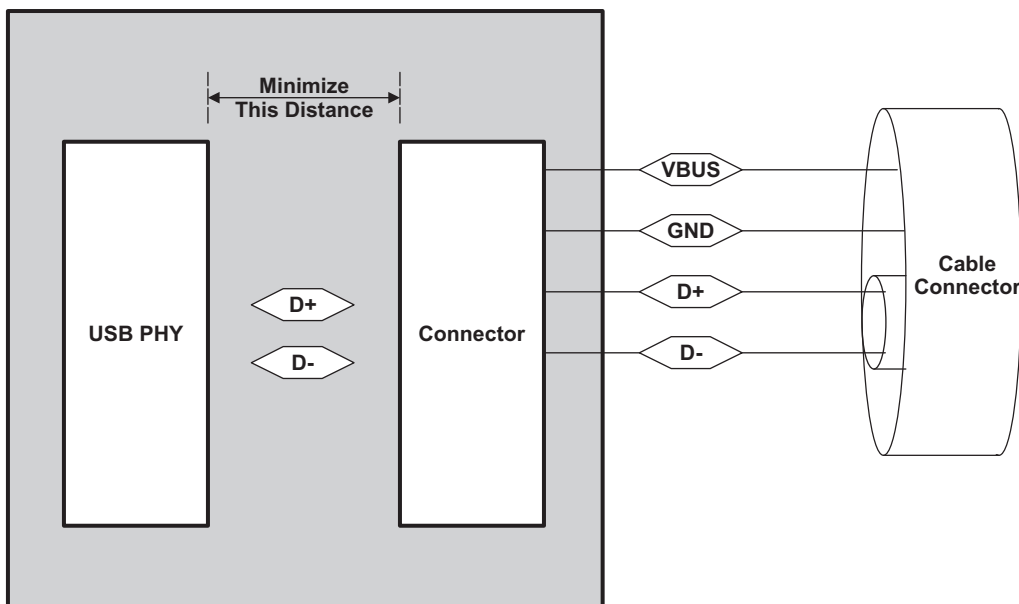


Figure 7-35. USB PHY Connector and Cable Connector

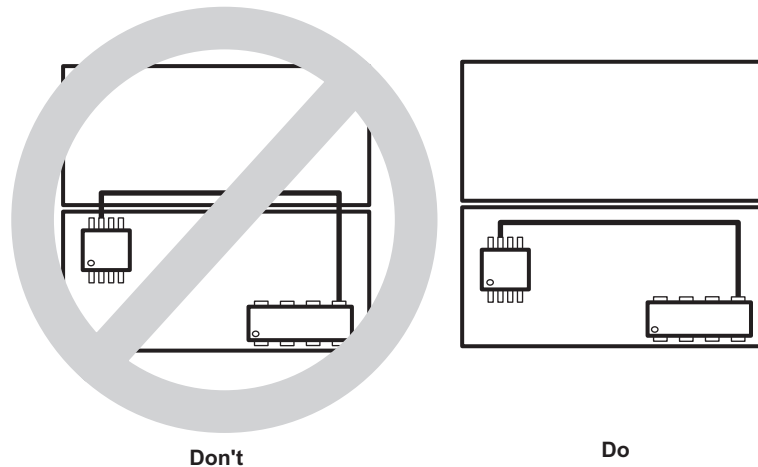
#### 7.5.2.2.2.8 DP/DM Vias

When a via must be used, increase the clearance size around it to minimize its capacitance. Each via introduces discontinuities in the signal's transmission line and increases the chance of picking up interference from the other layers of the board. Be careful when designing test points on twisted pair lines; through-hole pins are not recommended.

#### 7.5.2.2.2.9 Image Planes

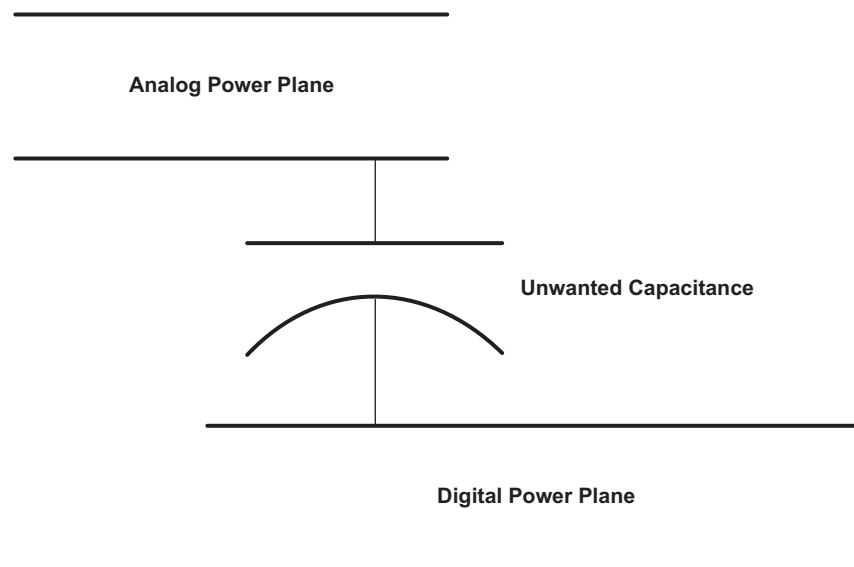
An image plane is a layer of copper (voltage plane or ground plane), physically adjacent to a signal routing plane. Use of image planes provides a low impedance, shortest possible return path for RF currents. For a USB board, the best image plane is the ground plane because it can be used for both analog and digital circuits.

- Do not route traces so they cross from one plane to the other. This can cause a broken RF return path resulting in an EMI radiating loop as shown in [Figure 7-36](#). This is important for higher frequency or repetitive signals. Therefore, on a multi-layer board, it is best to run all clock signals on the signal plane above a solid ground plane.
- Avoid crossing the image power or ground plane boundaries with high-speed clock signal traces immediately above or below the separated planes. This also holds true for the twisted pair signals (DP, DM). Any unused area of the top and bottom signal layers of the PCB can be filled with copper that is connected to the ground plane through vias.



**Figure 7-36. Do Not Cross Plane Boundaries**

- Do not overlap planes that do not reference each other. For example, do not overlap a digital power plane with an analog power plane as this produces a capacitance between the overlapping areas that could pass RF emissions from one plane to the other, as shown in [Figure 7-37](#).



**Figure 7-37. Do Not Overlap Planes**

- Avoid image plane violations. Traces that route over a slot in an image plane results in a possible RF return loop, as shown in [Figure 7-38](#).

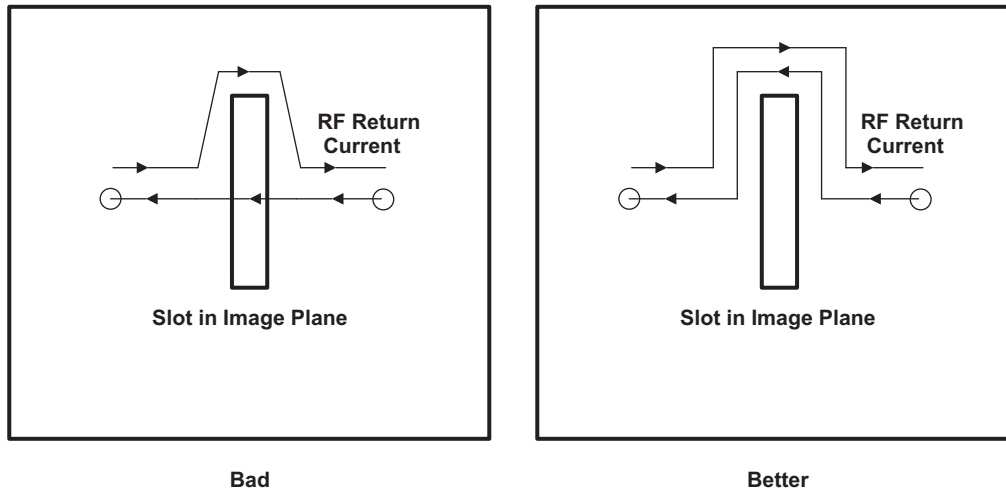


Figure 7-38. Do Not Violate Image Planes

#### 7.5.2.2.10 JTAG Interface

For test and debug of the USB PHY only, an IEEE Standard 1149.1-1990, IEEE Standard Test Access Port and Boundary-Scan Architecture (JTAG) and Serial Test and Configuration Interface (STCI) may be available on the System-on-Chip (SoC). If available, keep the USB PHY JTAG interface less than six inches; keeping this distance short reduces noise coupling from other devices and signal loss due to resistance.

#### 7.5.2.2.11 Power Regulators

Switching power regulators are a source of noise and can cause noise coupling if placed close to sensitive areas on a circuit board. Therefore, the switching power regulator should be kept away from the DP/DM signals, the external clock crystal (or clock oscillator), and the USB PHY.

### 7.5.2.3 Electrostatic Discharge (ESD)

International Electronic Commission (IEC) 61000-4-xx is a set of about 25 testing specifications from the IEC. IEC ESD Stressing is done both un-powered and with power applied, and with the device functioning. There must be no physical damage, and the device must keep working normally after the conclusion of the stressing. Typically, equipment has to pass IEC stressing at 8 kV contact and 15 kV air discharge, or higher. To market products/systems in the European community, all products/systems must be CE compliant and have the CE Mark. To obtain the CE Mark, all products/systems need to go through and pass IEC standard requirements; for ESD, it is 61000-4-2. 61000-4-2 requires that the products/systems pass contact discharge at 8 kV and air discharge at 15 kV. When performing an IEC ESD Stressing, only pins accessible to the *outside world* need to pass the test. The system into which the integrated circuit (IC) is placed makes a difference in how well the IC does. For example:

- Cable between the zap point and the IC attenuate the high frequencies in the waveform.
- Series inductance on the PCB board attenuates the high frequencies.
- Unless the capacitor's ground connection is inductive, capacitance to ground shunts away high frequencies.

#### 7.5.2.3.1 IEC ESD Stressing Test

The following sections describe in detail the IEC ESD Stressing Test modes and test types.

##### 7.5.2.3.1.1 Test Mode

The IEC ESD Stressing test is done through two modes: contact discharge mode and air discharge mode.

For the contact discharge test mode, the preferred way is direct contact applied to the conductive surfaces of the equipment under test (EUT). In the case of the USB system, the conductive surface is the outer casing of the USB connector. The electrode of the ESD generator is held in contact with the EUT or a coupling plane prior to discharge. The arc formation is created under controlled conditions, inside a relay, resulting in repeatable waveforms; however, this arc does not accurately recreate the characteristic unique to the arc of an actual ESD event.

#### **7.5.2.3.1.2 Air Discharge Mode**

The air discharge usually applies to a non-conductive surface of the EUT. Instead of a direct contact with the EUT, the charged electrode of the ESD generator is brought close to the EUT, and a spark in the air to the EUT actuates the discharge. Compared to the contact discharge mode, the air discharge is more realistic to the actual ESD occurrence. However, due to the variations of the arc length, it may not be able to produce repeatable waveform.

#### **7.5.2.3.1.3 Test Type**

The IEC ESD Stressing test has two test types: direct discharge and indirect discharge. Direct discharge is applied directly to the surface or the structure of the EUT. It includes both contact discharge and air discharge modes. Indirect discharge applies to a coupling plane in the vicinity of the EUT. The indirect discharge is used to simulate personal discharge to objects which are adjacent to the EUT. It includes contact discharge mode only.

#### **7.5.2.3.2 TI Component Level IEC ESD Test**

TI Component Level IEC ESD Test tests only the IC terminals that are exposed in system level applications. It can be used to determine the robustness of on-chip protection and the latch-up immunity. The IC can only pass the TI Component Level IEC ESD test when there is no latch-up and IC is fully functional after the test.

#### **7.5.2.3.3 Construction of a Custom USB Connector**

A standard USB connector, either type A or type B, provides good ESD protection. However, if a custom USB connector is desired, the following guidelines should be observed to ensure good ESD protection.

- There should be an easily accessible shield plate next to the connector for air-discharge mode purpose.
- Tie the outer shield of the connector to GND. When a cable is inserted into the connector, the shield of the cable should first make contact with the outer shield.
- If the connector includes power and GND, the lead of power and GND need to be longer than the leads of signal.
- The connector needs to have a key to ensure proper insertion of the cable.
- See the standard USB connector for reference.

#### 7.5.2.3.4 ESD Protection System Design Consideration

ESD protection system design consideration is covered in [Section 7.5.2.2](#) of this document. The following are additional considerations for ESD protection in a system.

- Metallic shielding for both ESD and EMI
- Chassis GND isolation from the board GND
- Air gap designed on board to absorb ESD energy
- Clamping diodes to absorb ESD energy
- Capacitors to divert ESD energy
- The use of external ESD components on the DP/DM lines may affect signal quality and are not recommended.

#### 7.5.2.4 References

- *USB 2.0 Specification*, Intel, 2000, <http://www.usb.org/developers/docs/>
- *High Speed USB Platform Design Guidelines*, Intel, 2000, [http://www.intel.com/technology/usb/download/usb2dg\\_R1\\_0.pdf](http://www.intel.com/technology/usb/download/usb2dg_R1_0.pdf)
- *Selection and Specification of Crystals for Texas Instruments USB 2.0 Devices* ([SLLA122](#))

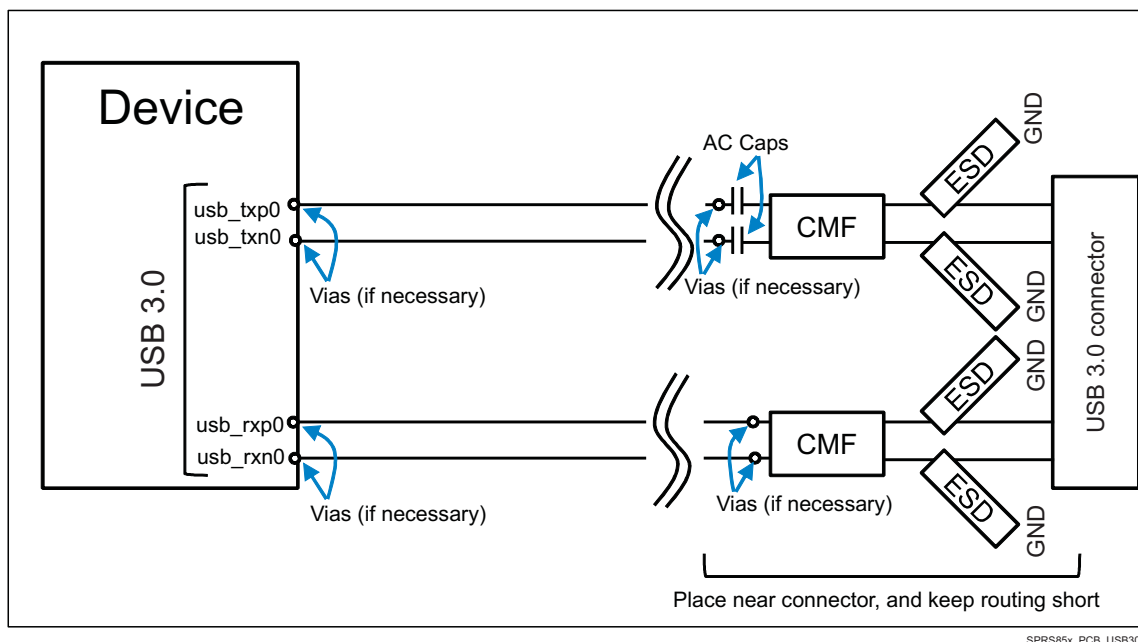
### 7.5.3 USB 3.0 Board Design and Layout Guidelines

This section provides the timing specification for the USB3.0 (USB1 in the device) interface as a PCB design and manufacturing specification. The design rules constrain PCB trace length, PCB trace skew, signal integrity, cross-talk, and signal timing. TI has performed the simulation and system design work to ensure the USB3.0 interface requirements are met. The design rules stated within this document are targeted at DEVICE mode electrical compliance. HOST mode and/or systems that do not include the 3m USB cable and far-end 11-inch PCB trace required by DEVICE mode compliance testing may not need the complete list of optimizations shown in this document; however, applying these optimizations to HOST mode systems will lead to optimal DEVICE mode performance.

#### 7.5.3.1 USB 3.0 interface introduction

The USB 3.0 has two unidirectional differential pairs: TXp/TXn pair and RXp/RXn pair. AC coupling caps are needed on the board for TX traces.

[Figure 7-39](#) present high level schematic diagram for USB 3.0 interface.



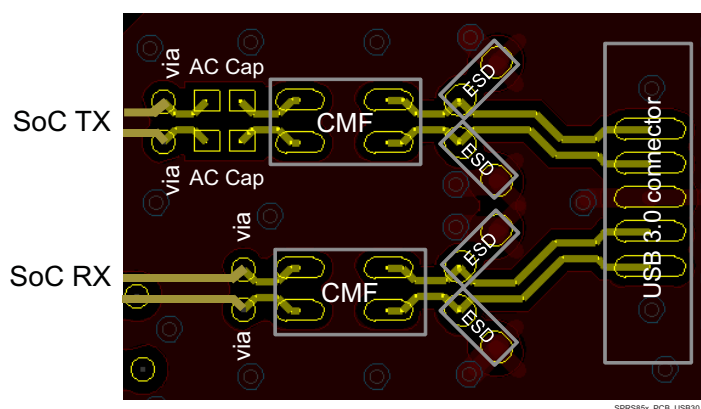
**Figure 7-39. USB 3.0 Interface High Level Schematic**

**NOTE**

ESD components should be on a PCB layer next to a system GND plane layer so the inductance of the via to GND will be minimal.

If vias are used, place the vias near the AC Caps or CMFs and under the SoC BGA, if necessary.

Figure 7-40 present placement diagram for USB 3.0 interface.



**Figure 7-40. USB 3.0 placement diagram**

**Table 7-10. USB1 Component Reference**

| INTERFACE | COMPONENT | SUPPLIER | PART NUMBER                 |
|-----------|-----------|----------|-----------------------------|
| USB3 PHY  | ESD       | TI       | TPD1E05U06                  |
|           | CMF       | Murata   | DLW21SN900HQ2               |
|           | C         | -        | 100 nF (typical size: 0201) |

### 7.5.3.2 USB 3.0 General routing rules

Some general routing guidelines regarding USB 3.0:

- Avoid crossing splits reference plane(s).
- Shorter trace length is preferred.
- Minimize the via usage and layer transition
- Keep large spacing between TX and RX pairs.
- Intra-lane delay mismatch between DP and DM less than 1ps. Same for RXp and RXn.
- Distance between common mode filter (CMF) and ESD protection device should be as short as possible
- Distance between ESD protection device and USB connector should be as short as possible.
- Distance between AC capacitors (TX only) and CMF should be as short as possible.
- USB 3.0 signals should always be routed over an adjacent ground plane.

Table 7-11 and Table 7-12 present routing specification and recommendations for USB1 in the device.

**Table 7-11. USB1 Routing Specifications**

| PARAMETER                                                                                                                         | MIN  | TYP  | MAX  | UNIT     |
|-----------------------------------------------------------------------------------------------------------------------------------|------|------|------|----------|
| Device balls to USB 3.0 connector trace length                                                                                    |      |      | 3500 | Mils     |
| Skew within a differential pair                                                                                                   |      | 3    | 6    | Mils     |
| Number of stubs allowed on TX/RX traces                                                                                           |      |      | 0    | Stubs    |
| TX/RX pair differential impedance                                                                                                 | 83   | 90   | 97   | $\Omega$ |
| Number of vias on each TX/RX trace <sup>(1)</sup>                                                                                 |      |      | 2    | Vias     |
| Differential pair to any other trace spacing <sup>(2)</sup><br><sup>(3)</sup> <sup>(4)</sup>                                      | 2xDS | 3xDS |      |          |
| Number of ground plane cuts allowed within USB3 routing region (except for specific ground carving as explained in this document) |      |      | 0    | Cuts     |
| Number of layers between USB3.0 routing region and reference ground plane                                                         |      |      | 0    | Layers   |
| PCB trace width                                                                                                                   |      | 6    |      | Mils     |
| PCB BGA escape via pad size                                                                                                       |      | 18   |      | Mils     |
| PCB BGA escape via hole size                                                                                                      |      | 10   |      | Mils     |

(1) Vias must be used in pairs and spaced equally along a signal path.

(2) DS = differential spacing of the traces.

(3) Exceptions may be necessary in the SoC package BGA area.

(4) GND guard-bands on the same layer may be closer, but should not be allowed to affect the impedance of the differential pair routing. GND guard-bands to isolate USB3.0 differential pairs from all other signals are recommended.

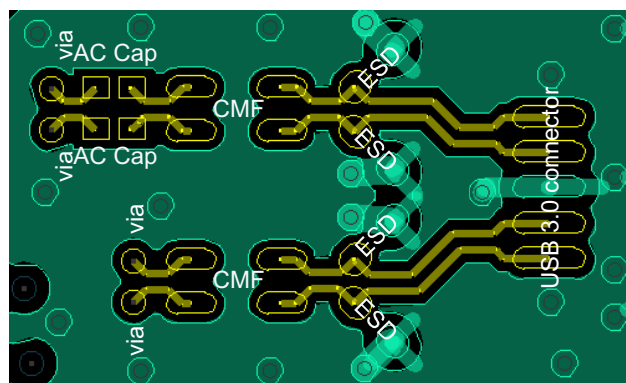
**Table 7-12. USB1 Routing Recommendations**

| Item            | Description                                                                        | Reason                                             |
|-----------------|------------------------------------------------------------------------------------|----------------------------------------------------|
| ESD location    | Place ESD component on same layer as connector (no via or stub to ESD component)   | Eliminate reflection loss from via and stub to ESD |
| ESD part number | TPD1E05U06                                                                         | Minimize capacitance (0.42 pF)                     |
| CMF part number | DLW21SN900HQ2                                                                      | Manufacturer's recommended device                  |
| Connector       | Use USB3.0 connector with supporting s-parameter model                             | Enable full signal chain simulation                |
| Carve Ground    | Carve GND underneath AC Caps, ESD, CMF, and connector                              | Minimize capacitance under ESD and CMF             |
| Round pads      | Minimize pad size and round the corners of the pads for the ESD and CMF components | Minimize capacitance                               |

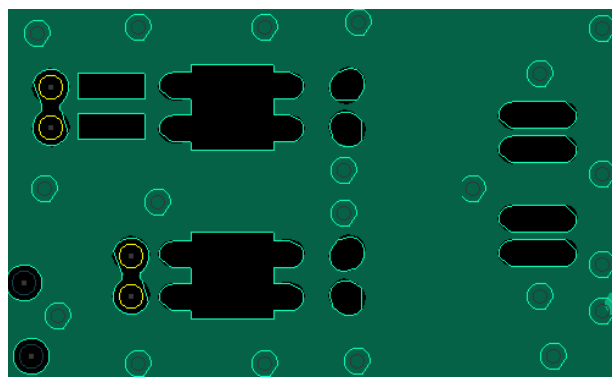
**Table 7-12. USB1 Routing Recommendations (continued)**

| Item | Description                                                                                                                                                                                 | Reason                                                 |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Vias | Max 2 vias per signal trace. If vias are required, place vias close to the AC Caps and CMFs. Vias under the SoC grid array may be used if necessary to route signals away from BGA pattern. | Vias significantly degrade signal integrity at 2.5 GHz |

Figure 7-41 presents an example layout, demonstrating the “carve GND” concept.



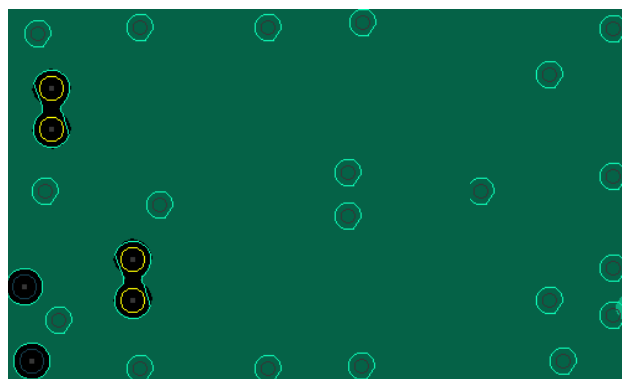
**Top Layer:** Routing from SoC through AC Caps, CMF, and ESD to connector.



**Layer2, GND:** Gaps carved in GND underneath AC Caps, CMF, ESD, and connector.



**Layer3, Signal:** Implement as keep-out zone underneath carved GND areas.



**Layer4, GND Plane** underneath AC Caps, CMF, ESD, and connector.

SPRS85x\_PCB\_USB30\_3

**Figure 7-41. USB 3.0 Example “carve GND” layout**

## 7.5.4 HDMI Board Design and Layout Guidelines

This section provides the timing specification for the HDMI interface as a PCB design and manufacturing specification. The design rules constrain PCB trace length, PCB trace skew, signal integrity, cross-talk, and signal timing. TI has performed the simulation and system design work to ensure the HDMI interface requirements are met. The design rules stated within this document are targeted at resolutions less than or equal to 1080p60 with 8-bit color; deep color (10-bit) requires further signal integrity optimization.

### 7.5.4.1 HDMI Interface Schematic

The HDMI bus is separated into three main sections (HDMI Ethernet and the optional Audio Return Channel are not specifically supported by this Device):

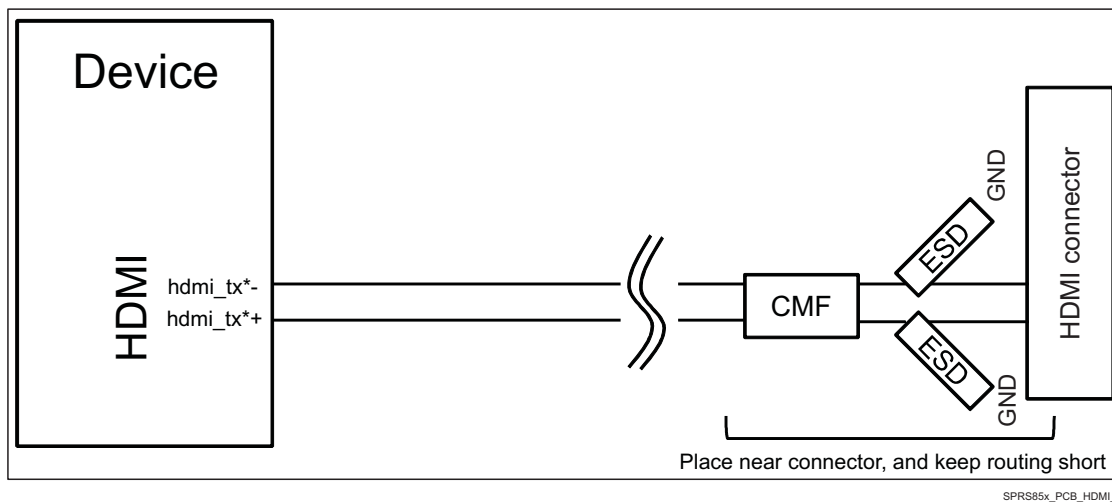
1. Transition Minimized Differential Signaling (TMDS) high speed digital video interface

2. Display Data Channel (I2C bus for configuration and status exchange between two devices)
3. Consumer Electronics Control (optional) for remote control of connected devices.

The DDC and CEC are low speed interfaces, so nothing special is required for PCB layout of these signals.

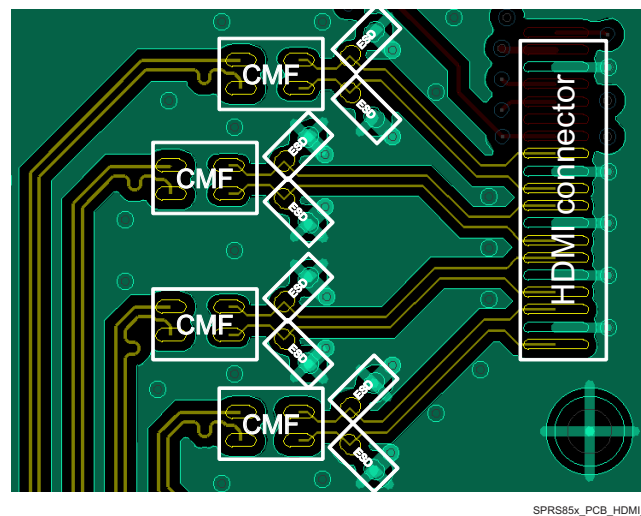
The TMDS channels are high speed differential pairs and therefore require the most care in layout. Specifications for TMDS layout are below.

Figure 7-42 shows the HDMI interface schematic.



**Figure 7-42. HDMI Interface High Level Schematic**

Figure 7-43 presents placement diagram for HDMI interface.



**Figure 7-43. HDMI Placement Diagram**

**Table 7-13. HDMI Component Reference**

| INTERFACE | DEVICE | SUPPLIER | PART NUMBER   |
|-----------|--------|----------|---------------|
| HDMI      | ESD    | TI       | TPD1E05U06    |
|           | CMF    | Murata   | DLW21SN900HQ2 |

### 7.5.4.2 TMDs General Routing Guidelines

The TMDs signals are high speed differential pairs. Care must be taken in the PCB layout of these signals to ensure good signal integrity.

The TMDs differential signal traces must be routed to achieve 100  $\Omega$  (+/- 10 %) differential impedance and 60  $\Omega$  (+/-10 %) single ended impedance. Single ended impedance control is required because differential signals can't be closely coupled on PCBs and therefore single ended impedance becomes important.

These impedances are impacted by trace width, trace spacing, distance to reference planes, and dielectric material. Verify with a PCB design tool that the trace geometry for both data signal pairs results in as close to 60  $\Omega$  impedance traces as possible. For best accuracy, work with your PCB fabricator to ensure this impedance is met.

In general, closely coupled differential signal traces are not an advantage on PCBs. When differential signals are closely coupled, tight spacing and width control is necessary. Very small width and spacing variations affect impedance dramatically, so tight impedance control can be more problematic to maintain in production.

Loosely coupled PCB differential signals make impedance control much easier. Wider traces and spacing make obstacle avoidance easier, and trace width variations don't affect impedance as much, therefore it's easier to maintain accurate impedance over the length of the signal. The wider traces also show reduced skin effect and therefore often result in better signal integrity.

Some general routing guidelines regarding TMDs:

- Avoid crossing splits reference plane(s).
- Shorter trace length is preferred.
- Distance between common mode filter (CMF) and ESD protection device should be as short as possible
- Distance between ESD protection device and HDMI connector should be as short as possible.

Table 7-14 shows the routing specifications for the TMDs signals.

**Table 7-14. TMDs Routing Specifications**

| PARAMETER                                                                                                                         | MIN  | TYP  | MAX  | UNIT     |
|-----------------------------------------------------------------------------------------------------------------------------------|------|------|------|----------|
| Device balls to HDMI header trace length                                                                                          |      |      | 4000 | Mils     |
| Skew within a differential pair                                                                                                   |      | 3    | 5    | Mils     |
| Number of stubs allowed on TMDs traces                                                                                            |      |      | 0    | stubs    |
| TMDs pair differential impedance                                                                                                  | 90   | 100  | 110  | $\Omega$ |
| TMDs single-ended impedance                                                                                                       | 54   | 60   | 66   | $\Omega$ |
| Number of vias on each TMDs trace                                                                                                 |      |      | 0    | Vias     |
| TMDs differential pair to any other trace spacing <sup>(1)</sup> <sup>(2)</sup> <sup>(3)</sup>                                    | 2×DS | 3×DS |      | Mils     |
| Number of ground plane cuts allowed within HDMI routing region (except for specific ground carving as explained in this document) |      |      | 0    | Cuts     |
| Number of layers between HDMI routing region and reference ground plane                                                           |      |      | 0    | Layers   |
| PCB trace width                                                                                                                   |      | 4.4  |      | Mils     |

(1) DS = differential spacing of the traces.

(2) Exceptions may be necessary in the SoC package BGA area.

(3) GND guard-bands may be closer, but should not be allowed to affect the impedance of the differential pair routing. GND guard-bands to isolate HDMI differential pairs from all other signals is recommended.

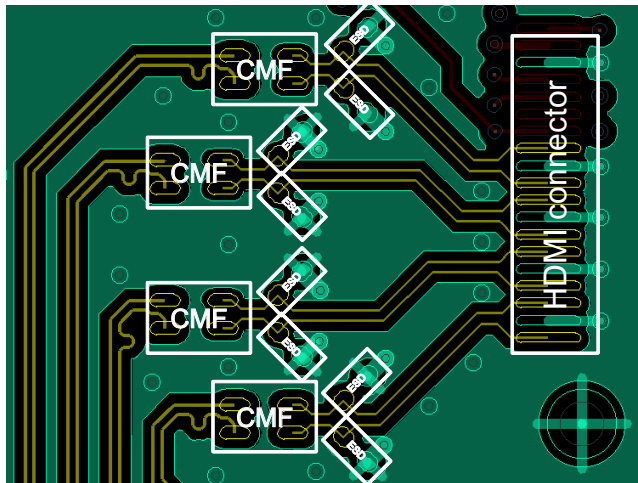
**Table 7-15. TMDs Routing Recommendations**

| Item            | Description | Reason                         |
|-----------------|-------------|--------------------------------|
| ESD part number | TPD1E05U06  | Minimize capacitance (0.42 pF) |

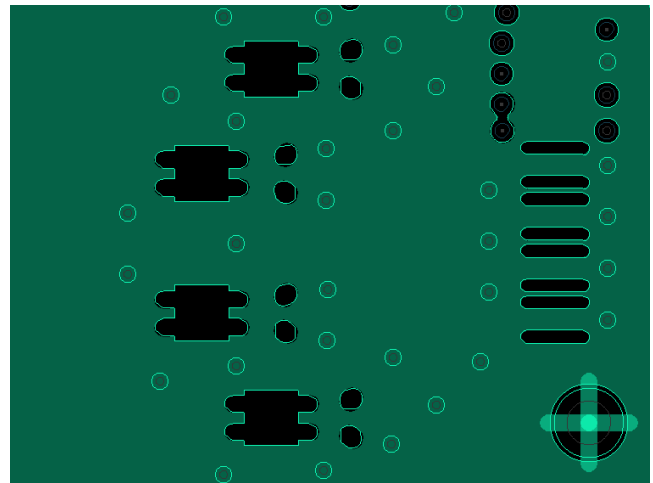
**Table 7-15. TDMS Routing Recommendations (continued)**

| Item          | Description                                                                      | Reason                                 |
|---------------|----------------------------------------------------------------------------------|----------------------------------------|
| Carve Ground  | Carve GND underneath ESD and CMF                                                 | Minimize capacitance under ESD and CMF |
| Round pads    | Reduce pad size and round the corners of the pads for the ESD and CMF components | Minimize capacitance                   |
| Routing layer | Route all signals only on the same layer as SoC                                  | Minimize reflection loss               |

Figure 7-44 presents an example layout, demonstrating the “carve GND” concept.



**Top Layer:** Routing from SoC through CMF, and ESD to connector.



**Layer2, GND:** Gaps carved in GND underneath, CMF, ESD, and connector.

SPRS95x\_PCB\_HDMI\_3

**Figure 7-44. HDMI Example “carve GND” layout**

#### 7.5.4.3 TPD5S115

The TPD5S115 is an integrated HDMI companion chip solution. The device provides a regulated 5 V output (5VOUT) for sourcing the HDMI power line. The TPD5S115 exceeds the IEC61000-4-2 (Level 4) ESD protection level.

#### 7.5.4.4 HDMI ESD Protection Device (Required)

Interfaces that connect to a cable such as HDMI generally require more ESD protection than can be built into the processor's outputs. Therefore this HDMI interface requires the use of an ESD protection chip to provide adequate ESD.

When selecting an ESD protection chip, choose the lowest capacitance ESD protection available to minimize signal degradation. In no case should the ESD protection circuit capacitance be more than 5pF.

TI manufactures these devices that provide ESD protection for HDMI signals such as the TPDxE05U06. For more information see the [www.ti.com](http://www.ti.com) website.

#### 7.5.4.5 PCB Stackup Specifications

Table 7-16 shows the stackup and feature sizes required for HDMI.

**Table 7-16. HDMI PCB Stackup Specifications**

| PARAMETER                | MIN | TYP | MAX | UNIT   |
|--------------------------|-----|-----|-----|--------|
| PCB Routing/Plane Layers | 4   | 6   | -   | Layers |

**Table 7-16. HDMI PCB Stackup Specifications (continued)**

| PARAMETER                                                               | MIN | TYP | MAX | UNIT   |
|-------------------------------------------------------------------------|-----|-----|-----|--------|
| Signal Routing Layers                                                   | 2   | 3   | -   | Layers |
| Number of ground plane cuts allowed within HDMI routing region          | -   | -   | 0   | Cuts   |
| Number of layers between HDMI routing region and reference ground plane | -   | -   | 0   | Layers |
| PCB Trace width                                                         |     | 4   |     | Mils   |

#### 7.5.4.6 Grounding

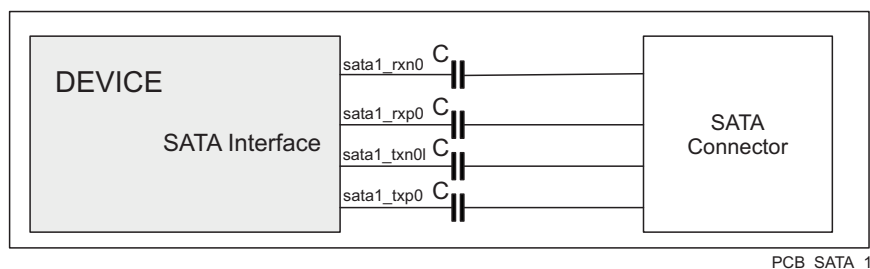
Each TMDS channel has its own shield pin and they should be grounded to provide a return current path for the TMDS signal.

### 7.5.5 SATA Board Design and Layout Guidelines

The device provides one SATA port. This section provides the timing specification for the SATA interface as a PCB design and manufacturing specification. The design rules constrain PCB trace length, PCB trace skew, signal integrity, cross-talk, and signal timing. TI has performed the simulation and system design work to ensure the SATA interface requirements are met.

#### 7.5.5.1 SATA Interface Schematic

Figure 7-45 shows the data portion of the SATA interface schematic.

**Figure 7-45. SATA Interface High Level Schematic**

#### NOTE

AC coupling capacitors (C) are required on the receive and transmit data pairs. Table 7-17 shows the requirements for these capacitors.

**Table 7-17. SATA AC Coupling Capacitors Requirements**

| PARAMETER                               | MIN | TYP  | MAX  | UNIT                  |
|-----------------------------------------|-----|------|------|-----------------------|
| SATA AC coupling capacitor value        | 0.3 | 10   | 12   | nF                    |
| SATA AC coupling capacitor package size |     | 0402 | 0603 | EIA <sup>(1)(2)</sup> |

(1) EIA LxW units, i.e., a 0402 is a 40×20 mils surface mount capacitor.

(2) The physical size of the capacitor should be as small as practical. Use the same size on both lines in each pair placed side by side.

#### 7.5.5.2 Compatible SATA Components and Modes

Table 7-18 shows the compatible SATA components and supported modes. Note that the only supported configuration is an internal cable from the processor host to the SATA device.

**Table 7-18. Compatible SATA Components and Modes**

| PARAMETER      | MIN | MAX | UNIT | SUPPORTED |
|----------------|-----|-----|------|-----------|
| Transfer Rates | 1.5 | 3   | Gbps |           |
| Internal Cable | -   | -   | -    | YES       |

### 7.5.5.3 PCB Stackup Specifications

Table 7-19 shows the stackup and feature sizes required for these types of SATA connections.

**Table 7-19. SATA PCB Stackup Specifications**

| PARAMETER                                                      | MIN | TYP | MAX | UNIT   |
|----------------------------------------------------------------|-----|-----|-----|--------|
| Number of ground plane cuts allowed within SATA routing region | -   | -   | 0   | Cuts   |
| Number of layers between SATA routing area and reference plane | -   | -   | 0   | Layers |
| PCB Routing clearance                                          |     | 4   |     | Mils   |
| PCB Trace width                                                |     | 4   |     | Mils   |

### 7.5.5.4 Routing Specifications

The SATA data signal traces must be routed to achieve 100  $\Omega$  (+/-10 %) differential impedance and 60  $\Omega$  (+/-10 %) single ended impedance. The signal ended impedance is required because differential signals can't be closely coupled on PCBs and therefore single ended impedance becomes important. 60  $\Omega$  is chosen for the single ended impedance to minimize problems caused by too low an impedance.

These impedances are impacted by trace width, trace spacing, distance to reference planes, and dielectric material. Verify with a PCB design tool that the trace geometry for both data signal pairs results in as close to 100  $\Omega$  differential and 60  $\Omega$  single ended impedance traces as possible. For best accuracy, work with your PCB fabricator to ensure this impedance is met.

Table 7-20 shows the routing specifications for the SATA data signals.

**Table 7-20. SATA Routing Specifications**

| PARAMETER                                                 | MIN                 | TYP | MAX                 | UNIT     |
|-----------------------------------------------------------|---------------------|-----|---------------------|----------|
| SATA signal trace length (device balls to SATA connector) |                     |     | 3050 <sup>(1)</sup> | Mils     |
| Differential pair trace skew matching                     |                     |     | 5                   | Mils     |
| Number of stubs allowed on SATA traces <sup>(2)</sup>     |                     |     | 0                   | stubs    |
| TX/RX pair differential impedance                         | 90                  | 100 | 110                 | $\Omega$ |
| TX/RX single-ended impedance                              | 54                  | 60  | 66                  | $\Omega$ |
| Number of vias on each SATA trace                         |                     |     | 0                   | Vias     |
| SATA differential pair to any other trace spacing         | 2×DS <sup>(3)</sup> |     |                     |          |

(1) Beyond this, signal integrity may suffer.

(2) Inline pads may be used for probing.

(3) DS = differential spacing of the SATA traces.

**Table 7-21. SATA Routing Recommendations**

| Item            | Description | Reason                                     |
|-----------------|-------------|--------------------------------------------|
| ESD part number | None        | ESD suppression generally not used on SATA |

## 7.5.6 PCIe Board Design and Layout Guidelines

The PCIe interface on the device provides support for a 5.0 Gbps lane with polarity inversion.

### 7.5.6.1 PCIe Connections and Interface Compliance

The PCIe interface on the device is compliant with the PCIe revision 3.0 specification. Please refer to the PCIe specifications for all connections that are described in it. Those recommendations are more descriptive and exhaustive than what is possible here.

The use of PCIe compatible bridges and switches is allowed for interfacing with more than one other processor or PCIe device.

#### 7.5.6.1.1 Coupling Capacitors

AC coupling capacitors are required on the transmit data pair. [Table 7-22](#) shows the requirements for these capacitors.

**Table 7-22. PCIe AC Coupling Capacitors Requirements**

| PARAMETER                               | MIN | TYP  | MAX  | UNIT                  |
|-----------------------------------------|-----|------|------|-----------------------|
| PCIe AC coupling capacitor value        | 90  | 100  | 110  | nF                    |
| PCIe AC coupling capacitor package size |     | 0402 | 0603 | EIA <sup>(1)(2)</sup> |

(1) EIA LxW units, i.e., a 0402 is a 40×20 mils surface mount capacitor.

(2) The physical size of the capacitor should be as small as practical. Use the same size on both lines in each pair placed side by side.

#### 7.5.6.1.2 Polarity Inversion

The PCIe specification requires polarity inversion support. This means for layout purposes, polarity is unimportant because each signal can change its polarity on die inside the chip. This means polarity within a lane is unimportant for layout.

### 7.5.6.2 Non-standard PCIe connections

The following sections contain suggestions for any PCIe connection that is NOT described in the official PCIe specification, such as an on-board Device to Device or Device to other PCIe compliant processor connection.

#### 7.5.6.2.1 PCB Stackup Specifications

[Table 7-23](#) shows the stackup and feature sizes required for these types of PCIe connections.

**Table 7-23. PCIe PCB Stackup Specifications**

| PARAMETER                                                                     | MIN | TYP | MAX | UNIT   |
|-------------------------------------------------------------------------------|-----|-----|-----|--------|
| Number of ground plane cuts allowed within PCIe routing region                | -   | -   | 0   | Cuts   |
| Number of layers between PCIe routing area and reference plane <sup>(1)</sup> | -   | -   | 0   | Layers |
| PCB Routing clearance                                                         |     | 4   |     | Mils   |
| PCB Trace width                                                               |     | 4   |     | Mils   |

(1) A reference plane may be a ground plane or the power plane referencing the PCIe signals.

### 7.5.6.2.2 Routing Specifications

#### 7.5.6.2.2.1 Impedance

The PCIe data signal traces must be routed to achieve 100-Ω ( $\pm 10\%$ ) differential impedance and 60-Ω ( $\pm 10\%$ ) single-ended impedance. The single-ended impedance is required because differential signals are extremely difficult to closely couple on PCBs and, therefore, single-ended impedance becomes important. These requirements are the same as those recommended in the PCIe Motherboard Checklist 1.0 document, available from PCI-SIG ([www.pcisig.com](http://www.pcisig.com)).

These impedances are impacted by trace width, trace spacing, distance between signals and referencing planes, and dielectric material. Verify with a PCB design tool that the trace geometry for both data signal pairs result in as close to 100-Ω differential impedance and 60-Ω single-ended impedance as possible. For best accuracy, work with your PCB fabricator to ensure this impedance is met. See [Table 7-24](#) below.

#### 7.5.6.2.2.2 Differential Coupling

In general, closely coupled differential signal traces are not an advantage on PCBs. When differential signals are closely coupled, tight spacing and width control is necessary. Very small width and spacing variations affect impedance dramatically, so tight impedance control can be more problematic to maintain in production. For PCBs with very tight space limitations (which are usually small) this can work, but for most PCBs, the loosely coupled option is probably best.

Loosely coupled PCB differential signals make impedance control much easier. Wider traces and spacing make obstacle avoidance easier (because each trace is not so fixed in position relative to the other), and trace width variations don't affect impedance as much, therefore it's easier to maintain an accurate impedance over the length of the signal. For longer routes, the wider traces also show reduced skin effect and therefore often result in better signal integrity with a larger eye diagram opening.

[Table 7-24](#) shows the routing specifications for the PCIe data signals.

**Table 7-24. PCI-E Routing Specifications**

| PARAMETER                                                 | MIN                 | TYP | MAX                 | UNIT  |
|-----------------------------------------------------------|---------------------|-----|---------------------|-------|
| PCIe signal trace length (device balls to PCIe connector) |                     |     | 4700 <sup>(1)</sup> | Mills |
| Differential pair trace matching                          |                     |     | 5 <sup>(2)</sup>    | Mils  |
| Number of stubs allowed on PCIe traces <sup>(3)</sup>     |                     |     | 0                   | stubs |
| TX/RX pair differential impedance                         | 90                  | 100 | 110                 | Ω     |
| TX/RX single-ended impedance                              | 54                  | 60  | 66                  | Ω     |
| Pad size of vias on PCIe trace                            |                     |     | 25 <sup>(4)</sup>   | Mils  |
| Hole size of vias on PCIe trace                           |                     |     | 14                  | Mils  |
| Number of vias on each PCIe trace                         |                     |     | 0                   | Vias  |
| PCIe differential pair to any other trace spacing         | 2×DS <sup>(5)</sup> |     |                     |       |

(1) Beyond this, signal integrity may suffer.

(2) For example, RXP0 within 5 Mils of RXN0.

(3) Inline pads may be used for probing.

(4) 35-Mil antipad maximum recommended.

(5) DS = differential spacing of the PCIe traces.

**Table 7-25. PCI-E Routing Recommendations**

| Item            | Description | Reason                                     |
|-----------------|-------------|--------------------------------------------|
| ESD part number | None        | ESD suppression generally not used on PCIe |

### 7.5.6.2.2.3 Pair Length Matching

Each signal in the differential pair should be matched to within 5 mils of its matching differential signal. Length matching should be done as close to the mismatch as possible.

### 7.5.6.3 LJCB\_REFN/P Connections

A Common Refclk Rx Architecture is required to be used for the device PCIe interface. Specifically, two modes of Common Refclk Rx Architecture are supported:

- **External REFCLK Mode:** An common external 100 MHz clock source is distributed to both the Device and the link partner
- **Output REFCLK Mode:** A 100 MHz HCSL clock source is output by the device and used by the link partner

In **External REFCLK Mode**, a high-quality, low-jitter, differential HCSL 100 MHz clock source compliant to the PCIe REFCLK AC Specifications should be provided on the Device's `ljcb_clkn` / `ljcb_clkp` inputs. Alternatively, an LVDS clock source can be used with the following additional requirements:

- External AC coupling capacitors described in [Table 7-26](#) should be populated at the `ljcb_clkn` / `ljcb_clkp` inputs.
- All termination requirements (ex. parallel 100  $\Omega$  termination) from the clock source manufacturer should be followed.

In **Output REFCLK Mode**, the 100 MHz clock from the Device's `DPLL_PCIE_REF` should be output on the Device's `ljcb_clkn` / `ljcb_clkp` pins and used as the HCSL REFCLK by the link partner. External near-side termination to ground described in [Table 7-27](#) is required on both of the `ljcb_clkn` / `ljcb_clkp` outputs in this mode.

**Table 7-26. LJCB\_REFN/P Requirements in External LVDS REFCLK Mode**

| PARAMETER                                                                          | MIN | TYP  | MAX  | UNIT                  |
|------------------------------------------------------------------------------------|-----|------|------|-----------------------|
| <code>ljcb_clkn</code> / <code>ljcb_clkp</code> AC coupling capacitor value        |     | 100  |      | nF                    |
| <code>ljcb_clkn</code> / <code>ljcb_clkp</code> AC coupling capacitor package size |     | 0402 | 0603 | EIA <sup>(1)(2)</sup> |

(1) EIA LxW units, i.e., a 0402 is a 40×20 mils surface mount capacitor.

(2) The physical size of the capacitor should be as small as practical. Use the same size on both lines in each pair placed side by side.

**Table 7-27. LJCB\_REFN/P Requirements in Output REFCLK Mode**

| PARAMETER                                                                             | MIN  | TYP | MAX  | UNIT     |
|---------------------------------------------------------------------------------------|------|-----|------|----------|
| <code>ljcb_clkn</code> / <code>ljcb_clkp</code> near-side termination to ground value | 47.5 | 50  | 52.5 | $\Omega$ |

## 7.6 Clock Routing Guidelines

### 7.6.1 32-kHz Oscillator Routing

When designing the printed-circuit board:

- Keep the crystal as close as possible to the crystal pins X1 and X2.
- Keep the trace lengths short and small to reduce capacitor loading and prevent unwanted noise pickup.
- Place a guard ring around the crystal and tie the ring to ground to help isolate the crystal from unwanted noise pickup.
- Keep all signals out from beneath the crystal and the X1 and X2 pins to prevent noise coupling.

- Finally, an additional local ground plane on an adjacent PCB layer can be added under the crystal to shield it from unwanted pickup from traces on other layers of the board. This plane must be isolated from the regular PCB ground plane and tied to the GND pin of the RTC. The plane must not be any larger than the perimeter of the guard ring. Make sure that this ground plane does not contribute to significant capacitance (a few pF) between the signal line and ground on the connections that run from X1 and X2 to the crystal.

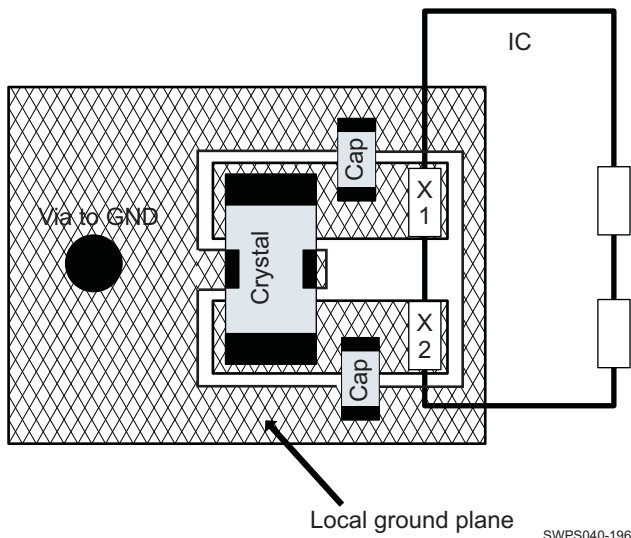


Figure 7-46. Slow Clock PCB Requirements

## 7.6.2 Oscillator Ground Connection

Although the impedance of a ground plane is low it is, of course, not zero. Therefore, any noise current in the ground plane causes a voltage drop in the ground. Figure 7-47 shows the grounding scheme for slow (low frequency) clock generated from the internal oscillator.

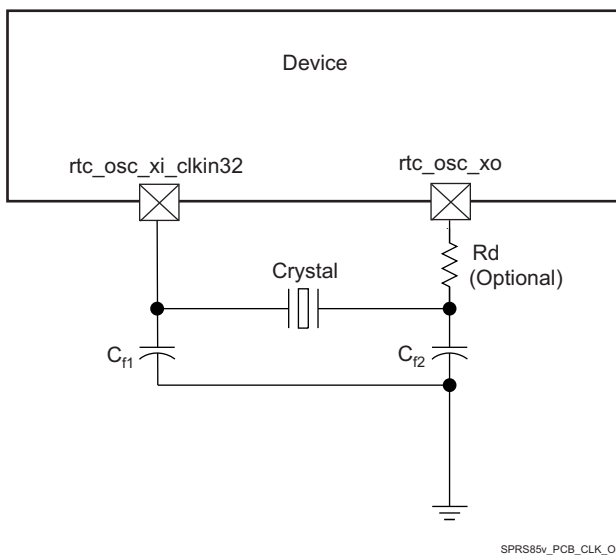
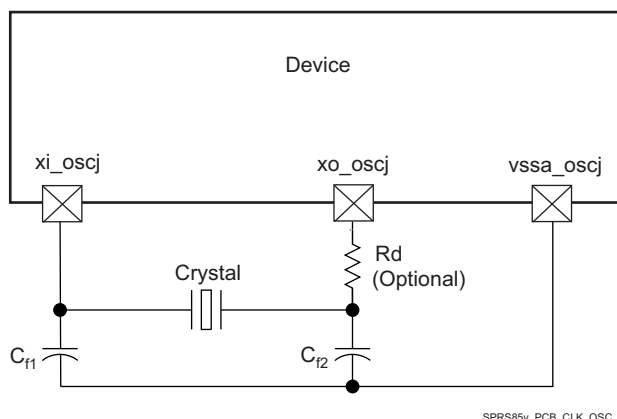


Figure 7-47. Grounding Scheme for Low-Frequency Clock

Figure 7-48 shows the grounding scheme for high-frequency clock.



(1)  $j$  in  $\_osc = 0$  or  $1$

**Figure 7-48. Grounding Scheme for High-Frequency Clock**

## 7.7 DDR2/DDR3 Board Design and Layout Guidelines

### 7.7.1 DDR2/DDR3 General Board Layout Guidelines

To help ensure good signaling performance, consider the following board design guidelines:

- Avoid crossing splits in the power plane.
- Minimize Vref noise.
- Use the widest trace that is practical between decoupling capacitors and memory module.
- Maintain a single reference.
- Minimize ISI by keeping impedances matched.
- Minimize crosstalk by isolating sensitive bits, such as strobes, and avoiding return path discontinuities.
- Use proper low-pass filtering on the Vref pins.
- Keep the stub length as short as possible.
- Add additional spacing for on-clock and strobe nets to eliminate crosstalk.
- Maintain a common ground reference for all bypass and decoupling capacitors.
- Take into account the differences in propagation delays between microstrip and stripline nets when evaluating timing constraints.

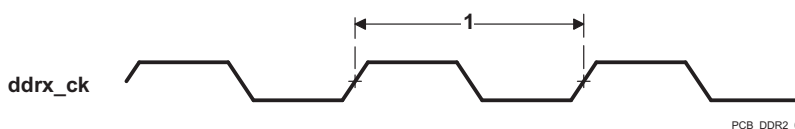
### 7.7.2 DDR2 Board Design and Layout Guidelines

#### 7.7.2.1 Board Designs

TI only supports board designs that follow the guidelines outlined in this document. The switching characteristics and the timing diagram for the DDR2 memory controller are shown in [Table 7-28](#) and [Figure 7-49](#).

**Table 7-28. Switching Characteristics Over Recommended Operating Conditions for DDR2 Memory Controller**

| NO.   | PARAMETER              | DESCRIPTION         | MIN | MAX | UNIT |
|-------|------------------------|---------------------|-----|-----|------|
| DDR21 | $t_c(\text{DDR\_CLK})$ | Cycle time, DDR_CLK | 2.5 | 8   | ns   |



**Figure 7-49. DDR2 Memory Controller Clock Timing**

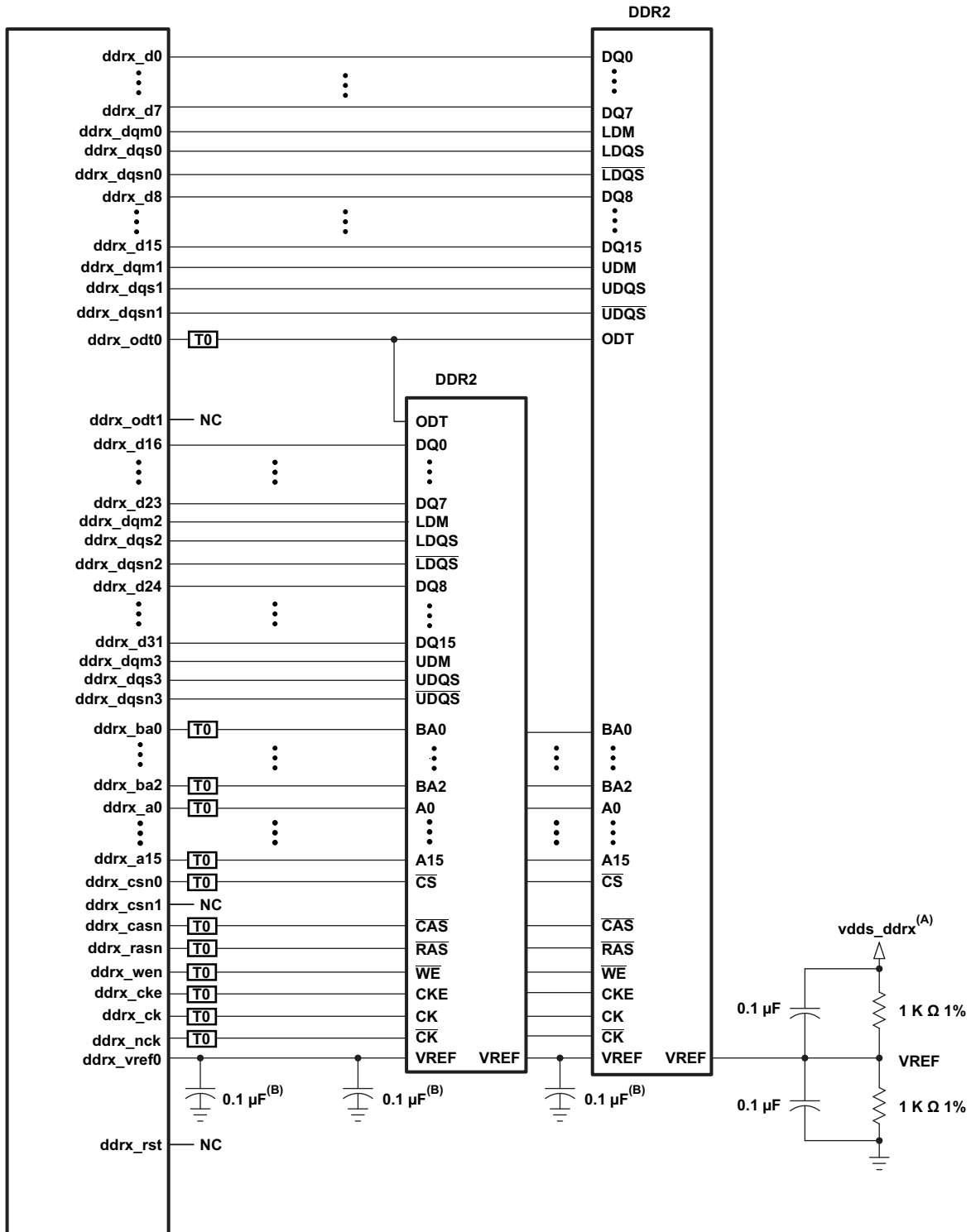
### 7.7.2.2 DDR2 Interface

This section provides the timing specification for the DDR2 interface as a PCB design and manufacturing specification. The design rules constrain PCB trace length, PCB trace skew, signal integrity, cross-talk, and signal timing. These rules, when followed, result in a reliable DDR2 memory system without the need for a complex timing closure process. For more information regarding the guidelines for using this DDR2 specification, see the *Understanding TI's PCB Routing Rule-Based DDR Timing Specification* Application Report (Literature Number: [SPRAAV0](#)).

#### 7.7.2.2.1 DDR2 Interface Schematic

[Figure 7-50](#) shows the DDR2 interface schematic for a x32 DDR2 memory system. In [Figure 7-51](#) the x16 DDR2 system schematic is identical except that the high-word DDR2 device is deleted.

When not using all or part of a DDR2 interface, the proper method of handling the unused pins is to tie off the `ddrx_dqsi` pins to ground via a 1k-Ω resistor and to tie off the `ddrx_dqsn` pins to the corresponding `vdds_ddrx` supply via a 1k-Ω resistor. This needs to be done for each byte not used. The `vdds_ddrx` and `ddrx_vref0` power supply pins need to be connected to their respective power supplies even if DDRx is not being used. All other DDR interface pins can be left unconnected. Note that the supported modes for use of the DDR EMIF are 32-bits wide, 16-bits wide, or not used.

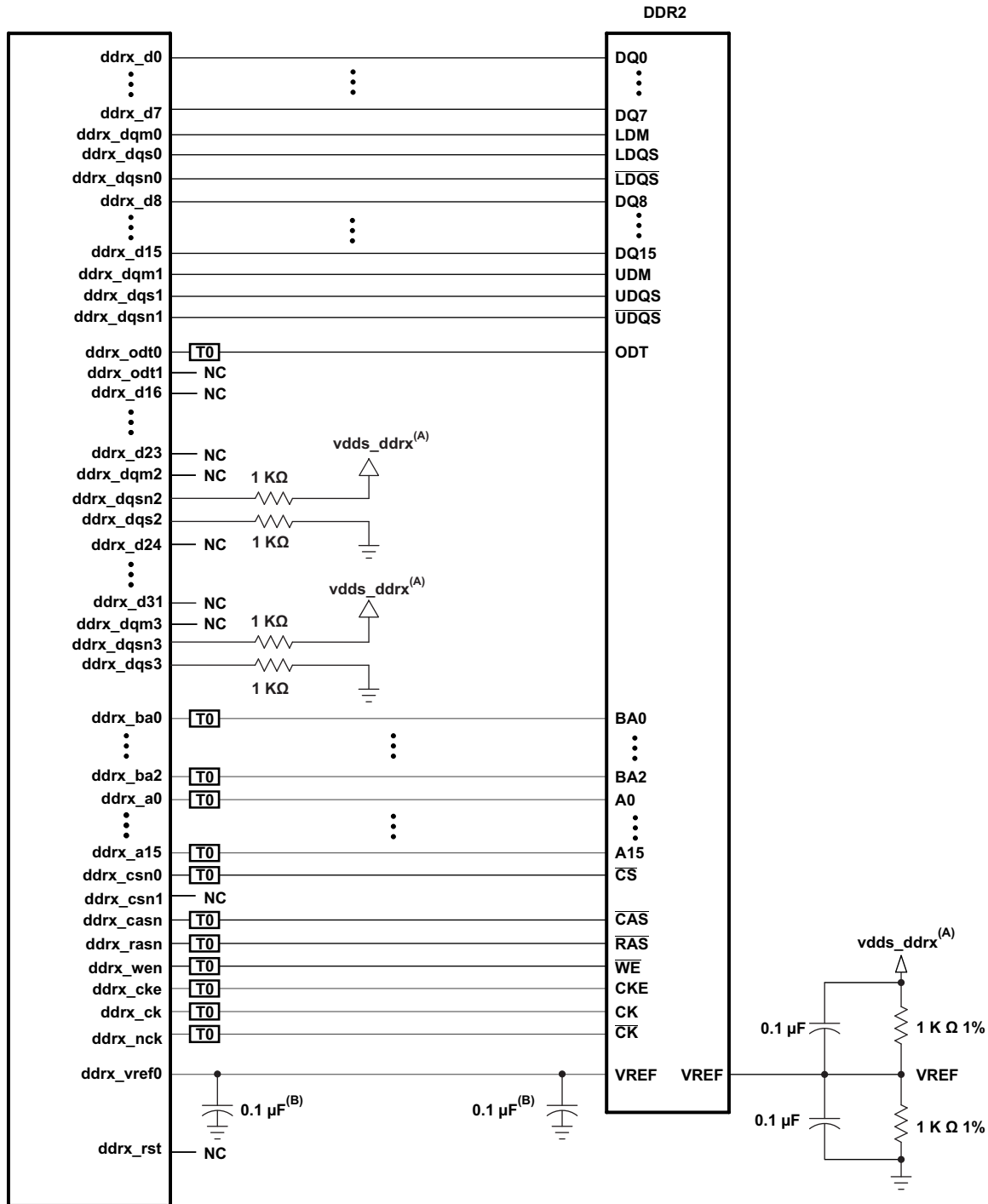


**T0** Termination is required. See terminator comments.

PCB\_DDR2\_1

- A. vdds\_ddrx is the power supply for the DDR2 memories and the Device DDR2 interface.
- B. One of these capacitors can be eliminated if the divider and its capacitors are placed near a VREF pin.

**Figure 7-50. 32-Bit DDR2 High-Level Schematic**



**T0** Termination is required. See terminator comments.

PCB\_DDR2\_2

- A. vdds\_ddrx is the power supply for the DDR2 memories and the Device DDR2 interface.
- B. One of these capacitors can be eliminated if the divider and its capacitors are placed near a VREF pin.

**Figure 7-51. 16-Bit DDR2 High-Level Schematic**

### 7.7.2.2.2 Compatible JEDEC DDR2 Devices

Table 7-29 shows the parameters of the JEDEC DDR2 devices that are compatible with this interface. Generally, the DDR2 interface is compatible with x16 DDR2-800 speed grade DDR2 devices.

**Table 7-29. Compatible JEDEC DDR2 Devices (Per Interface)**

| NO.  | PARAMETER                                    | MIN      | MAX | UNIT    |
|------|----------------------------------------------|----------|-----|---------|
| CJ21 | JEDEC DDR2 device speed grade <sup>(1)</sup> | DDR2-800 |     |         |
| CJ22 | JEDEC DDR2 device bit width                  | x16      | x16 | Bits    |
| CJ23 | JEDEC DDR2 device count <sup>(2)</sup>       | 1        | 2   | Devices |
| CJ24 | JEDEC DDR2 device ball count <sup>(3)</sup>  | 84       | 92  | Balls   |

(1) Higher DDR2 speed grades are supported due to inherent JEDEC DDR2 backwards compatibility.

(2) One DDR2 device is used for a 16-bit DDR2 memory system. Two DDR2 devices are used for a 32-bit DDR2 memory system.

(3) The 92-ball devices are retained for legacy support. New designs will migrate to 84-ball DDR2 devices. Electrically, the 92- and 84-ball DDR2 devices are the same.

### 7.7.2.2.3 PCB Stackup

The minimum stackup required for routing the Device is a six-layer stackup as shown in Table 7-30. Additional layers may be added to the PCB stackup to accommodate other circuitry or to reduce the size of the PCB footprint.

**Table 7-30. Minimum PCB Stackup**

| LAYER | TYPE   | DESCRIPTION                    |
|-------|--------|--------------------------------|
| 1     | Signal | Top routing mostly horizontal  |
| 2     | Plane  | Ground                         |
| 3     | Plane  | Power                          |
| 4     | Signal | Internal routing               |
| 5     | Plane  | Ground                         |
| 6     | Signal | Bottom routing mostly vertical |

Complete stackup specifications are provided in [Table 7-31](#).

**Table 7-31. PCB Stackup Specifications**

| NO.   | PARAMETER                                                                          | MIN | TYP | MAX | UNIT |
|-------|------------------------------------------------------------------------------------|-----|-----|-----|------|
| PS21  | PCB routing/plane layers                                                           | 6   |     |     |      |
| PS22  | Signal routing layers                                                              | 3   |     |     |      |
| PS23  | Full ground reference layers under DDR2 routing region <sup>(1)</sup>              | 1   |     |     |      |
| PS24  | Full vdds_ddrx power reference layers under the DDR2 routing region <sup>(1)</sup> | 1   |     |     |      |
| PS25  | Number of reference plane cuts allowed within DDR routing region <sup>(2)</sup>    |     |     | 0   |      |
| PS26  | Number of layers between DDR2 routing layer and reference plane <sup>(3)</sup>     |     |     | 0   |      |
| PS27  | PCB routing feature size                                                           |     | 4   |     | Mils |
| PS28  | PCB trace width, w                                                                 |     | 4   |     | Mils |
| PS29  | Single-ended impedance, Zo                                                         | 50  |     | 75  | Ω    |
| PS210 | Impedance control <sup>(5)</sup>                                                   | Z-5 | Z   | Z+5 | Ω    |

(1) Ground reference layers are preferred over power reference layers. Be sure to include bypass caps to accommodate reference layer return current as the trace routes switch routing layers. A full ground reference layer should be placed adjacent to each DDR routing layer in PCB stack up.

(2) No traces should cross reference plane cuts within the DDR routing region. High-speed signal traces crossing reference plane cuts create large return current paths which can lead to excessive crosstalk and EMI radiation.

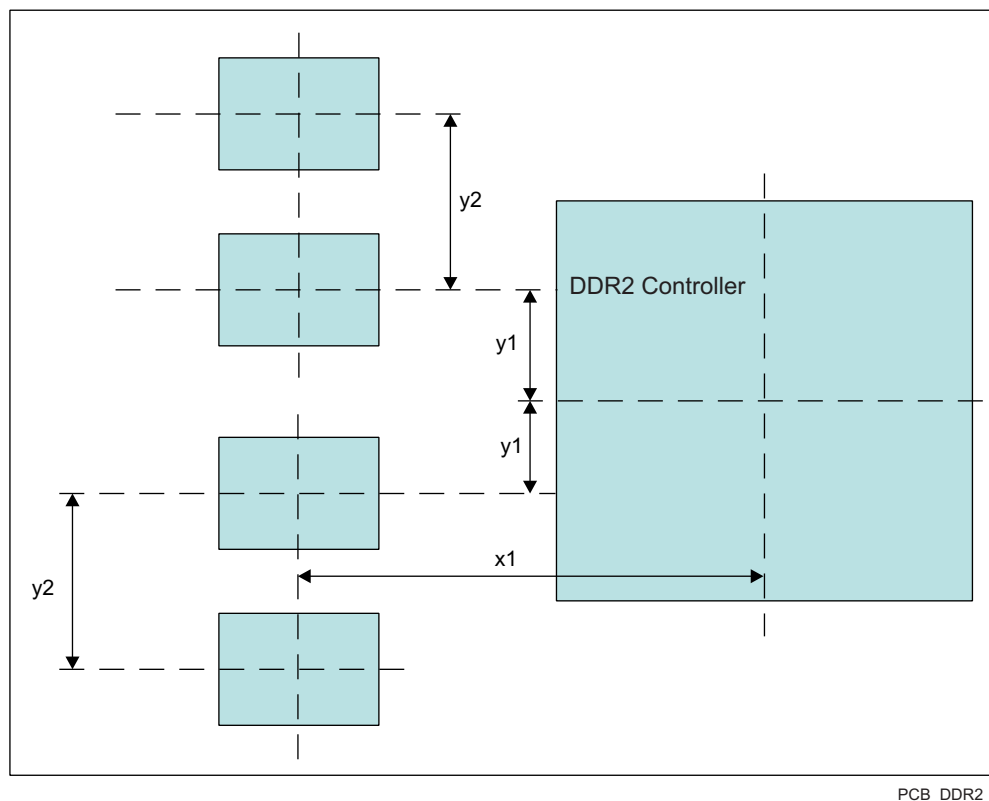
(3) Reference planes are to be directly adjacent to the signal plane to minimize the size of the return current loop.

(4) An 18-mil pad assumes Via Channel is the most economical BGA escape. A 20-mil pad may be used if additional layers are available for power routing. An 18-mil pad is required for minimum layer count escape.

(5) Z is the nominal singled-ended impedance selected for the PCB specified by PS29.

#### 7.7.2.2.4 Placement

Figure 7-52 shows the required placement for the Device as well as the DDR2 devices. The dimensions for this figure are defined in Table 7-32. The placement does not restrict the side of the PCB on which the devices are mounted. The ultimate purpose of the placement is to limit the maximum trace lengths and allow for proper routing space. For a 16-bit DDR memory system, the high-word DDR2 device is omitted from the placement.



**Figure 7-52. Device and DDR2 Device Placement**

**Table 7-32. Placement Specifications DDR2**

| NO.   | PARAMETER                                                                | MIN | MAX  | UNIT |
|-------|--------------------------------------------------------------------------|-----|------|------|
| KOD21 | X1                                                                       |     | 2000 | Mils |
| KOD22 | Y1                                                                       |     | 500  | Mils |
| KOD23 | Y2                                                                       |     | 1300 | Mils |
| KOD24 | DDR2 keepout region <sup>(1)</sup>                                       |     |      |      |
| KOD25 | Clearance from non-DDR2 signal to DDR2 keepout region <sup>(2) (3)</sup> | 4   |      | W    |

(1) DDR2 keepout region to encompass entire DDR2 routing area.

(2) Non-DDR2 signals allowed within DDR2 keepout region provided they are separated from DDR2 routing layers by a ground plane.

(3) If a device has more than one DDR2 controller, the signals from the other controller(s) are considered non-DDR2 and should be separated by this specification.

#### 7.7.2.2.5 DDR2 Keepout Region

The region of the PCB used for the DDR2 circuitry must be isolated from other signals. The DDR2 keepout region is defined for this purpose and is shown in [Figure 7-53](#). The size of this region varies with the placement and DDR routing. Additional clearances required for the keepout region are shown in [Table 7-32](#).

The region shown in [Table 7-32](#) should encompass all the DDR2 circuitry and varies depending on placement. Non-DDR2 signals should not be routed on the DDR signal layers within the DDR2 keepout region. Non-DDR2 signals may be routed in the region, provided they are routed on layers separated from DDR2 signal layers by a ground layer. No breaks should be allowed in the reference ground layers in this region. In addition, the vdds\_ddrx power plane should cover the entire keepout region. Routes for the two DDR interfaces must be separated by at least 4x; the more separation, the better.

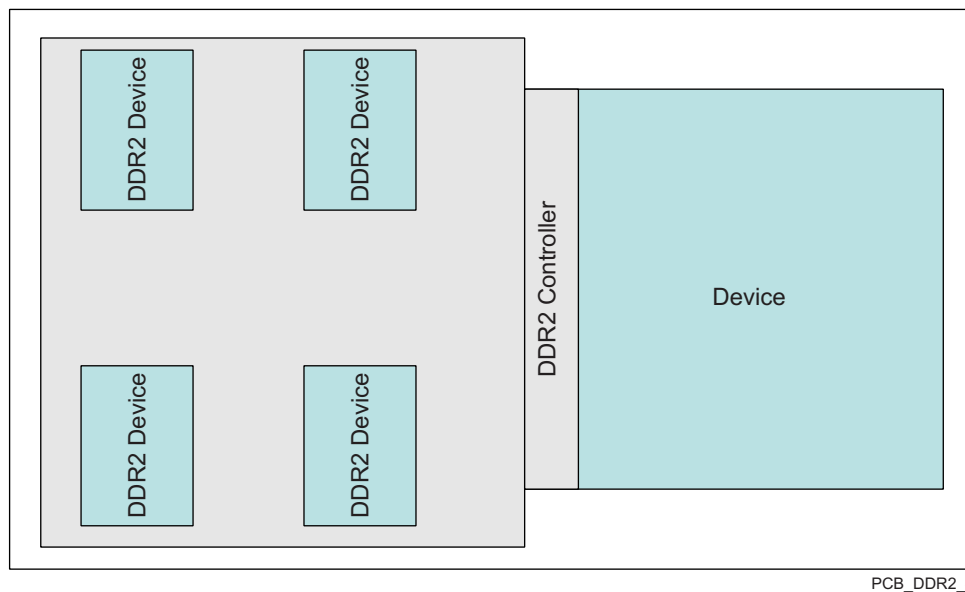


Figure 7-53. DDR2 Keepout Region

#### 7.7.2.2.6 Bulk Bypass Capacitors

Bulk bypass capacitors are required for moderate speed bypassing of the DDR2 and other circuitry. [Table 7-33](#) contains the minimum numbers and capacitance required for the bulk bypass capacitors. Note that this table only covers the bypass needs of the DDR2 interfaces and DDR2 device. Additional bulk bypass capacitance may be needed for other circuitry.

Table 7-33. Bulk Bypass Capacitors

| NO.  | PARAMETER                                                                     | MIN | TYP | MAX | UNIT          |
|------|-------------------------------------------------------------------------------|-----|-----|-----|---------------|
| BC21 | vdds_ddrx bulk bypass capacitor ( $\geq 1 \mu\text{F}$ ) count <sup>(1)</sup> |     | 1   |     | Devices       |
| BC22 | vdds_ddrx bulk bypass total capacitance                                       |     | 22  |     | $\mu\text{F}$ |

(1) These devices should be placed near the devices they are bypassing, but preference should be given to the placement of the high-speed (HS) bypass capacitors and DDR2 signal routing.

#### 7.7.2.2.7 High-Speed Bypass Capacitors

TI recommends that a PDN/power integrity analysis is performed to ensure that capacitor selection and placement is optimal for a given implementation. This section provides guidelines that can serve as a good starting point.

High-speed (HS) bypass capacitors are critical for proper DDR2 interface operation. It is particularly important to minimize the parasitic series inductance of the HS bypass capacitors, processor/DDR power, and processor/DDR ground connections. [Table 7-34](#) contains the specification for the HS bypass capacitors as well as for the power connections on the PCB. Generally speaking, it is good to:

1. Fit as many HS bypass capacitors as possible.
2. HS bypass capacitor value is  $< 1 \mu\text{F}$
3. Minimize the distance from the bypass cap to the pins/balls being bypassed.
4. Use the smallest physical sized capacitors possible with the highest capacitance readily available.
5. Connect the bypass capacitor pads to their vias using the widest traces possible and using the largest hole size via possible.
6. Minimize via sharing. Note the limites on via sharing shown in [Table 7-34](#).

**Table 7-34. High-Speed Bypass Capacitors**

| NO.   | PARAMETER                                                                                     | MIN                                               | TYP                | MAX                 | UNIT          |
|-------|-----------------------------------------------------------------------------------------------|---------------------------------------------------|--------------------|---------------------|---------------|
| HS21  | HS bypass capacitor package size <sup>(1)</sup>                                               |                                                   | 0201               | 0402                | 10 Mils       |
| HS22  | Distance, HS bypass capacitor to processor being bypassed <sup>(2)(3)(4)</sup>                |                                                   |                    | 400 <sup>(12)</sup> | Mils          |
| HS23  | processor HS bypass capacitor count <sup>(12)</sup>                                           | See <a href="#">Table 7-3</a> and <sup>(11)</sup> |                    |                     | Devices       |
| HS24  | processor HS bypass capacitor total capacitance per vdds_ddrx rail <sup>(12)</sup>            | See <a href="#">Table 7-3</a> and <sup>(11)</sup> |                    |                     | $\mu\text{F}$ |
| HS25  | Number of connection vias for each device power/ground ball per vdds_ddrx rail <sup>(5)</sup> | 1                                                 |                    |                     | Vias          |
| HS26  | Trace length from device power/ground ball to connection via <sup>(2)</sup>                   |                                                   | 35                 | 70                  | Mils          |
| HS27  | Distance, HS bypass capacitor to DDR device being bypassed <sup>(6)</sup>                     |                                                   |                    | 150                 | Mils          |
| HS28  | Number of connection vias for each HS capacitor <sup>(8)(9)</sup>                             |                                                   | 4 <sup>(14)</sup>  |                     | Vias          |
| HS29  | DDR2 device HS bypass capacitor count <sup>(7)</sup>                                          |                                                   | 12 <sup>(13)</sup> |                     | Devices       |
| HS210 | DDR2 device HS bypass capacitor total capacitance <sup>(7)</sup>                              | 0.85                                              |                    |                     | $\mu\text{F}$ |
| HS211 | Trace length from bypass capacitor connect to connection via <sup>(2)(9)</sup>                |                                                   | 35                 | 100                 | Mils          |
| HS212 | Number of connection vias for each DDR2 device power/ground ball <sup>(10)</sup>              | 1                                                 |                    |                     | Vias          |
| HS213 | Trace length from DDR2 device power/ground ball to connection via <sup>(2)(8)</sup>           |                                                   | 35                 | 60                  | Mils          |

(1) LxW, 10-mil units, that is, a 0402 is a 40×20-mil surface-mount capacitor.

(2) Closer/shorter is better.

(3) Measured from the nearest processor power/ground ball to the center of the capacitor package.

(4) Three of these capacitors should be located underneath the processor, between the cluster of vdds\_ddrx balls and ground balls, between the DDR interfaces on the package.

(5) See the Via Channel™ escape for the processor package.

(6) Measured from the DDR2 device power/ground ball to the center of the capacitor package.

(7) Per DDR2 device.

(8) An additional HS bypass capacitor can share the connection vias only if it is mounted on the opposite side of the board. No sharing of vias is permitted on the same side of the board.

(9) An HS bypass capacitor may share a via with a DDR device mounted on the same side of the PCB. A wide trace should be used for the connection and the length from the capacitor pad to the DDR device pad should be less than 150 mils.

(10) Up to a total of two pairs of DDR power/ground balls may share a via.

(11) The capacitor recommendations in this data manual reflect only the needs of this processor. Please see the memory vendor's guidelines for determining the appropriate decoupling capacitor arrangement for the memory device itself.

(12) For more information, see [Section 7.3, Core Power Domains](#).

(13) For more information refer to DDR2 specification.

(14) Preferred configuration is 4 vias: 2 to power and 2 to ground.

### 7.7.2.2.8 Net Classes

Table 7-35 lists the clock net classes for the DDR2 interface. Table 7-36 lists the signal net classes, and associated clock net classes, for the signals in the DDR2 interface. These net classes are used for the termination and routing rules that follow.

**Table 7-35. Clock Net Class Definitions**

| CLOCK NET CLASS     | PIN NAMES              |
|---------------------|------------------------|
| CK                  | ddrx_ck / ddrx_nck     |
| DQS0                | ddrx_dqs0 / ddrx_dqsn0 |
| DQS1                | ddrx_dqs1 / ddrx_dqsn1 |
| DQS2 <sup>(1)</sup> | ddrx_dqs2 / ddrx_dqsn2 |
| DQS3 <sup>(1)</sup> | ddrx_dqs3 / ddrx_dqsn3 |

(1) Only used on 32-bit wide DDR2 memory systems.

**Table 7-36. Signal Net Class Definitions**

| SIGNAL NET CLASS   | ASSOCIATED CLOCK NET CLASS | PIN NAMES                                                                                 |
|--------------------|----------------------------|-------------------------------------------------------------------------------------------|
| ADDR_CTRL          | CK                         | ddrx_ba[2:0], ddrx_a[14:0], ddrx_csnj, ddrx_casn, ddrx_rasn, ddrx_wen, ddrx_cke, ddrx_odt |
| DQ0                | DQS0                       | ddrx_d[7:0], ddrx_dqm0                                                                    |
| DQ1                | DQS1                       | ddrx_d[15:8], ddrx_dqm1                                                                   |
| DQ2 <sup>(1)</sup> | DQS2                       | ddrx_d[23:16], ddrx_dqm2                                                                  |
| DQ3 <sup>(1)</sup> | DQS3                       | ddrx_d[31:24], ddrx_dqm3                                                                  |

(1) Only used on 32-bit wide DDR2 memory systems.

### 7.7.2.2.9 DDR2 Signal Termination

Signal terminators are required in CK and ADDR\_CTRL net classes. Serial terminators may be used on data lines to reduce EMI risk; however, serial terminations are the only type permitted. ODTs are integrated on the data byte net classes. They should be enabled to ensure signal integrity. Table 7-37 shows the specifications for the series terminators.

**Table 7-37. DDR2 Signal Terminations**

| NO.  | PARAMETER                                                 | MIN | TYP | MAX            | UNIT     |
|------|-----------------------------------------------------------|-----|-----|----------------|----------|
| ST21 | CK net class <sup>(1)(2)</sup>                            | 0   |     | 10             | $\Omega$ |
| ST22 | ADDR_CTRL net class <sup>(1)(2)(3)(4)</sup>               | 0   | 22  | Z <sub>0</sub> | $\Omega$ |
| ST23 | Data byte net classes (DQS0-DQS3, DQ0-DQ3) <sup>(5)</sup> | 0   |     | Z <sub>0</sub> | $\Omega$ |

(1) Only series termination is permitted, parallel or SST specifically disallowed on board.

(2) Only required for EMI reduction.

(3) Terminator values larger than typical only recommended to address EMI issues.

(4) Termination value should be uniform across net class.

(5) No external terminations allowed for data byte net classes. ODT is to be used.

### 7.7.2.2.10 VREF Routing

VREF (ddrx\_vref0) is used as a reference by the input buffers of the DDR2 memories as well as the processor. VREF is intended to be half the DDR2 power supply voltage and should be created using a resistive divider as shown in Figure 7-51. Other methods of creating VREF are not recommended. Figure 7-54 shows the layout guidelines for VREF.

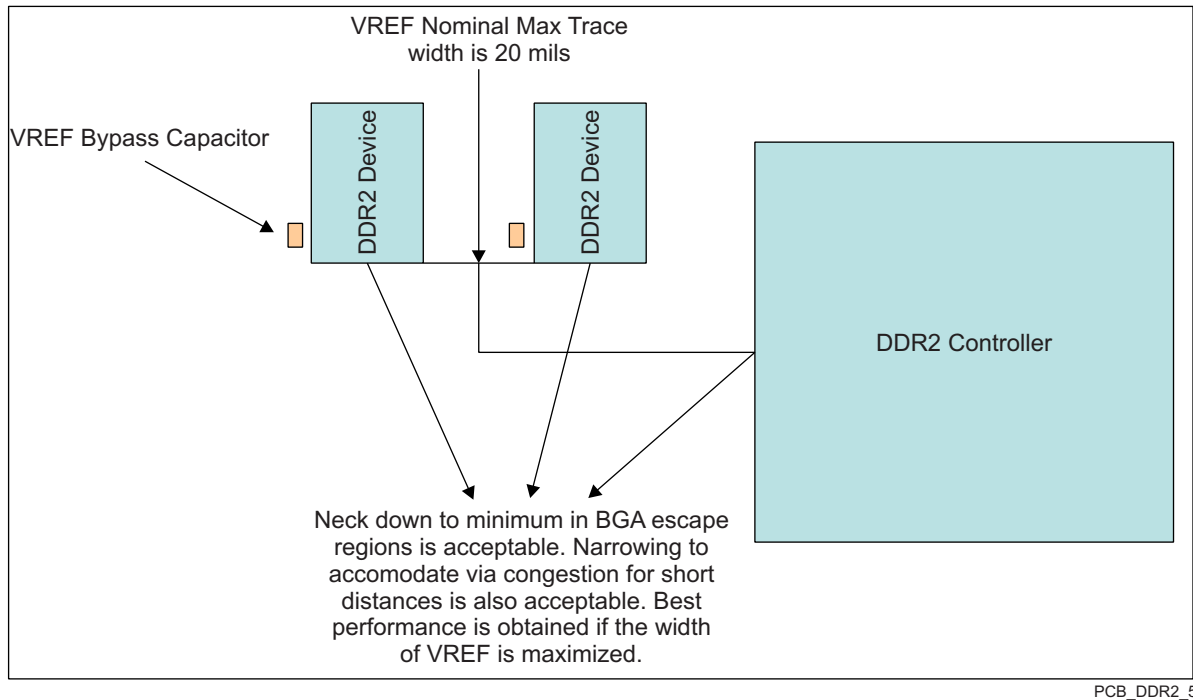


Figure 7-54. VREF Routing and Topology

### 7.7.2.3 DDR2 CK and ADDR\_CTRL Routing

Figure 7-55 shows the topology of the routing for the CK and ADDR\_CTRL net classes. The route is a balanced  $T$  as it is intended that the length of segments B and C be equal. In addition, the length of A = (A' + A'') should be maximized.

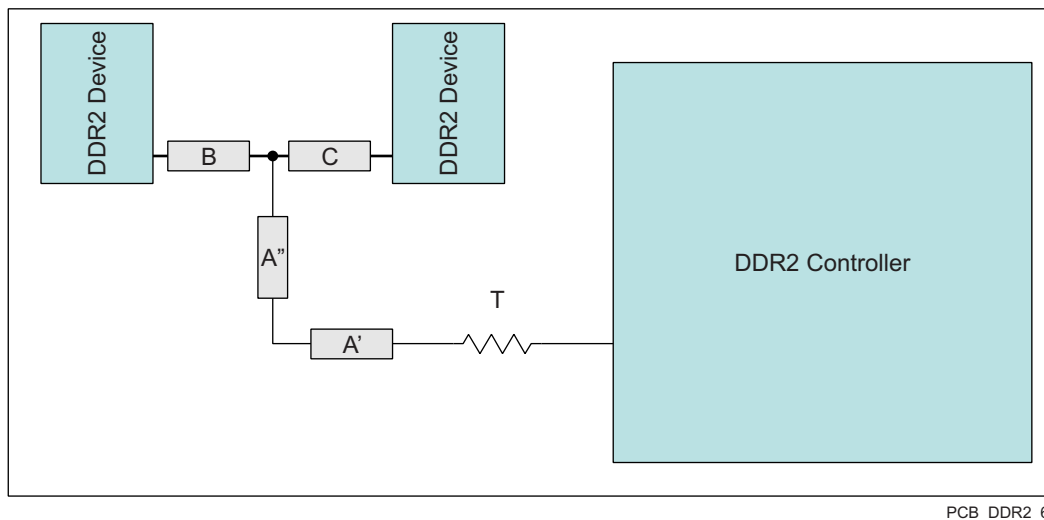


Figure 7-55. CK and ADDR\_CTRL Routing and Topology

Table 7-38. CK and ADDR\_CTRL Routing Specification <sup>(1)</sup>

| NO.   | PARAMETER                                     | MIN | MAX | UNIT |
|-------|-----------------------------------------------|-----|-----|------|
| RSC21 | Center-to-center ddrx_ck - ddrx_nck spacing   |     | 2w  |      |
| RSC22 | ddrx_ck / ddrx_nck skew <sup>(1)</sup>        |     | 5   | ps   |
| RSC23 | CK A-to-B/A-to-C skew mismatch <sup>(2)</sup> |     | 10  | ps   |

**Table 7-38. CK and ADDR\_CTRL Routing Specification <sup>(1)</sup> (continued)**

| NO.    | PARAMETER                                                                  | MIN | MAX | UNIT |
|--------|----------------------------------------------------------------------------|-----|-----|------|
| RSC24  | CK B-to-C skew mismatch                                                    |     | 10  | ps   |
| RSC25  | Center-to-center CK to other DDR2 trace spacing <sup>(3)</sup>             | 4w  |     |      |
| RSC26  | CK/ADDR_CTRL trace length <sup>(4)</sup>                                   |     | 680 | ps   |
| RSC27  | ADDR_CTRL-to-CK skew mismatch                                              |     | 25  | ps   |
| RSC28  | ADDR_CTRL-to-ADDR_CTRL skew mismatch                                       |     | 25  | ps   |
| RSC29  | Center-to-center ADDR_CTRL to other DDR2 trace spacing <sup>(3)</sup>      | 4w  |     |      |
| RSC210 | Center-to-center ADDR_CTRL to other ADDR_CTRL trace spacing <sup>(3)</sup> | 3w  |     |      |
| RSC211 | ADDR_CTRL A-to-B/A-to-C skew mismatch <sup>(2)</sup>                       |     | 25  | ps   |
| RSC212 | ADDR_CTRL B-to-C skew mismatch                                             |     | 25  | ps   |

(1) The length of segment A = A' + A'' as shown in [Figure 7-55](#).

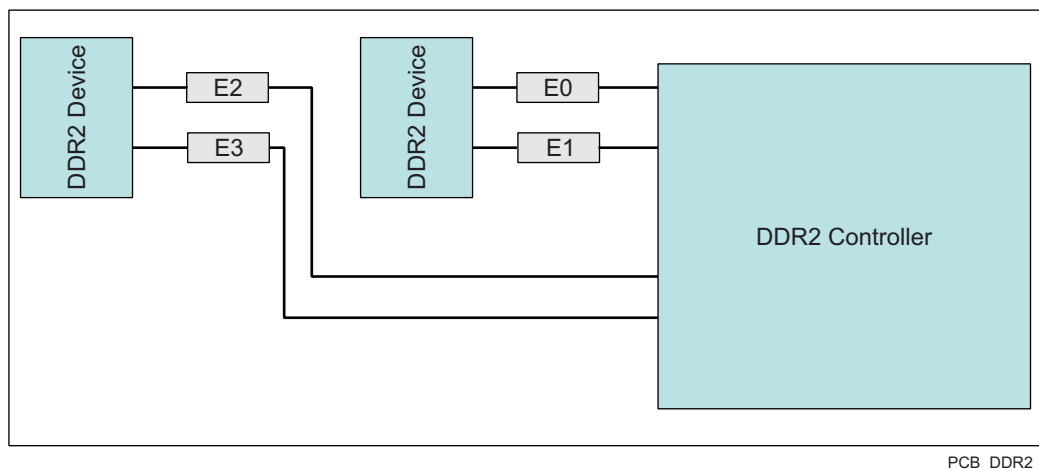
(2) Series terminator, if used, should be located closest to the Device.

(3) Center-to-center spacing is allowed to fall to minimum 2w for up to 500 mils of routed length to accommodate BGA escape and routing congestion.

(4) This is the longest routing length of the CK and ADDR\_CTRL net classes.

(5) Length of A should be maximized.

[Figure 7-56](#) shows the topology and routing for the DQS and DQ net classes; the routes are point to point. Skew matching across bytes is not needed nor recommended.


**Figure 7-56. DQS and DQ Routing and Topology**
**Table 7-39. DQS and DQ Routing Specification**

| NO.     | PARAMETER                                                          | MIN | MAX | UNIT |
|---------|--------------------------------------------------------------------|-----|-----|------|
| RSDQ21  | Center-to-center DQS-DQSn spacing in E0 E1 E2 E3                   | 2w  |     |      |
| RSDQ22  | DQS-DQSn skew in E0 E1 E2 E3                                       |     | 5   | ps   |
| RSDQ23  | Center-to-center DQS to other DDR2 trace spacing <sup>(1)</sup>    | 4w  |     |      |
| RSDQ24  | DQS/DQ trace length <sup>(2)(3)(4)</sup>                           |     | 325 | ps   |
| RSDQ25  | DQ-to-DQS skew mismatch <sup>(2)(3)(4)</sup>                       |     | 10  | ps   |
| RSDQ26  | DQ-to-DQ skew mismatch <sup>(2)(3)(4)</sup>                        |     | 10  | ps   |
| RSDQ27  | DQ-to-DQ/DQS via count mismatch <sup>(2)(3)(4)</sup>               |     | 1   | Vias |
| RSDQ28  | Center-to-center DQ to other DDR2 trace spacing <sup>(1)(5)</sup>  | 4w  |     |      |
| RSDQ29  | Center-to-center DQ to other DQ trace spacing <sup>(1)(6)(7)</sup> | 3w  |     |      |
| RSDQ210 | DQ/DQS E skew mismatch <sup>(2)(3)(4)</sup>                        |     | 25  | ps   |

- (1) Center-to-center spacing is allowed to fall to minimum 2w for up to 500 mils of routed length to accommodate BGA escape and routing congestion.
- (2) A 16-bit DDR memory system has two sets of data net classes; one for data byte 0, and one for data byte 1, each with an associated DQS (2 DQSs) per DDR EMIF used.
- (3) A 32-bit DDR memory system has four sets of data net classes; one each for data bytes 0 through 3, and each associated with a DQS (4 DQSs) per DDR EMIF used.
- (4) There is no need, and it is not recommended, to skew match across data bytes; that is, from DQS0 and data byte 0 to DQS1 and data byte 1.
- (5) DQs from other DQS domains are considered *other DDR2 trace*.
- (6) DQs from other data bytes are considered *other DDR2 trace*.
- (7) This is the longest routing distance of each of the DQS and DQ net classes.

### 7.7.3 DDR3 Board Design and Layout Guidelines

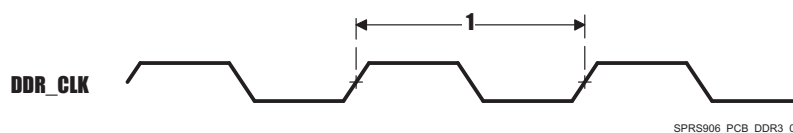
#### 7.7.3.1 Board Designs

TI only supports board designs using DDR3 memory that follow the guidelines in this document. The switching characteristics and timing diagram for the DDR3 memory controller are shown in [Table 7-40](#) and [Figure 7-57](#).

**Table 7-40. Switching Characteristics Over Recommended Operating Conditions for DDR3 Memory Controller**

| NO. | PARAMETER         |                     | MIN | MAX                | UNIT |
|-----|-------------------|---------------------|-----|--------------------|------|
| 1   | $t_{c(DDR\_CLK)}$ | Cycle time, DDR_CLK | 1.5 | 2.5 <sup>(1)</sup> | ns   |

- (1) This is the absolute maximum the clock period can be. Actual maximum clock period may be limited by DDR3 speed grade and operating frequency (see the DDR3 memory device data sheet).



**Figure 7-57. DDR3 Memory Controller Clock Timing**

#### 7.7.3.2 DDR3 EMIF

The processor contains one DDR3 EMIF.

#### 7.7.3.3 DDR3 Device Combinations

Because there are several possible combinations of device counts and single- or dual-side mounting, [Table 7-41](#) summarizes the supported device configurations.

**Table 7-41. Supported DDR3 Device Combinations**

| NUMBER OF DDR3 DEVICES | DDR3 DEVICE WIDTH (BITS) | MIRRORED?        | DDR3 EMIF WIDTH (BITS) |
|------------------------|--------------------------|------------------|------------------------|
| 1                      | 16                       | N                | 16                     |
| 2                      | 8                        | Y <sup>(1)</sup> | 16                     |
| 2                      | 16                       | N                | 32                     |
| 2                      | 16                       | Y <sup>(1)</sup> | 32                     |
| 3                      | 16                       | N <sup>(3)</sup> | 32                     |
| 4                      | 8                        | N                | 32                     |
| 4                      | 8                        | Y <sup>(2)</sup> | 32                     |
| 5                      | 8                        | N <sup>(3)</sup> | 32                     |

- (1) Two DDR3 devices are mirrored when one device is placed on the top of the board and the second device is placed on the bottom of the board.
- (2) This is two mirrored pairs of DDR3 devices.
- (3) Three or five DDR3 device combination is not available on this device, but combination types are retained for consistency with the DRA7xx family of devices.

### 7.7.3.4 DDR3 Interface Schematic

#### 7.7.3.4.1 32-Bit DDR3 Interface

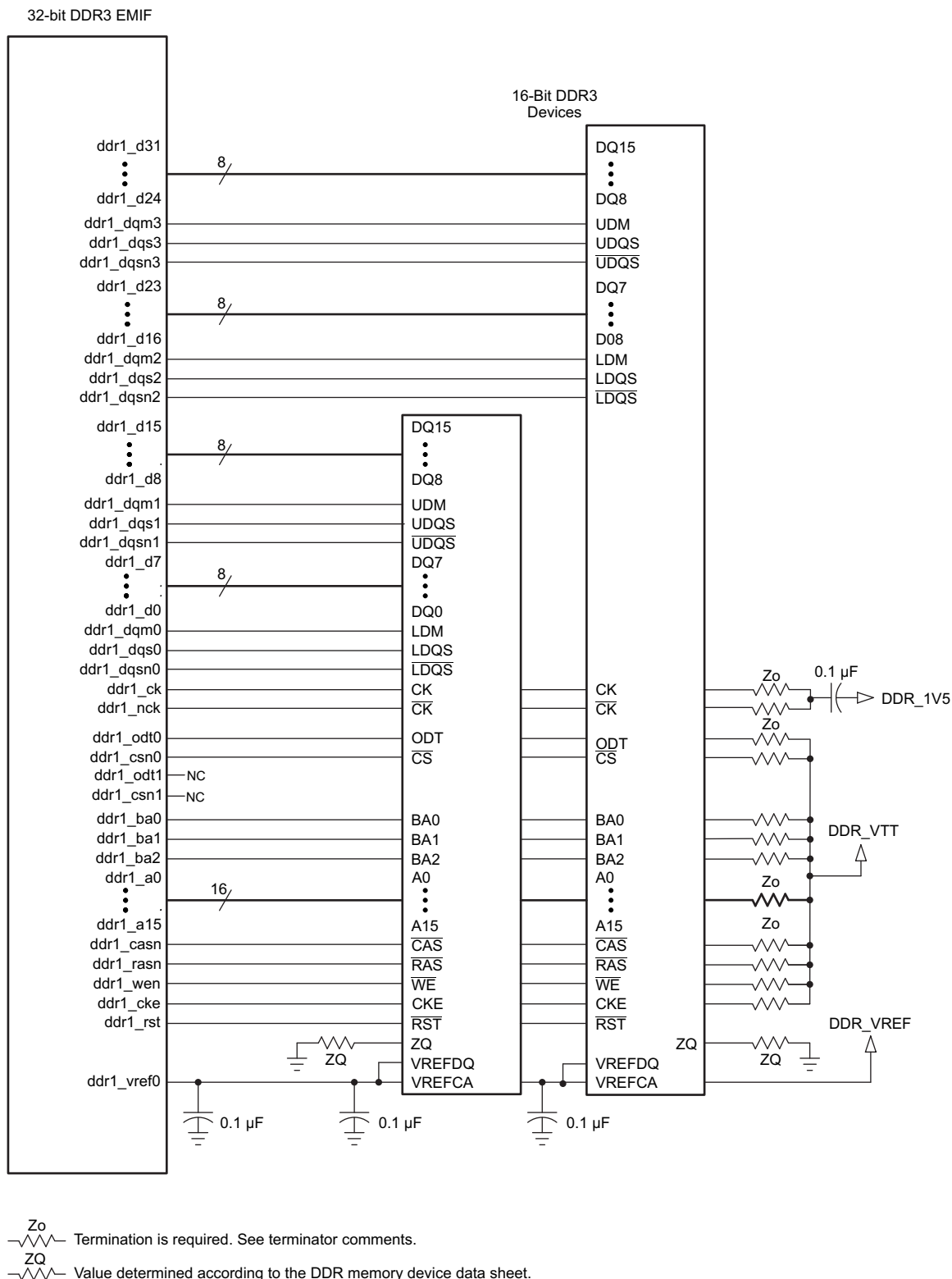
The DDR3 interface schematic varies, depending upon the width of the DDR3 devices used and the width of the bus used (16 or 32 bits). General connectivity is straightforward and very similar. 16-bit DDR devices look like two 8-bit devices. [Figure 7-58](#) and [Figure 7-59](#) show the schematic connections for 32-bit interfaces using ×16 devices.

#### 7.7.3.4.2 16-Bit DDR3 Interface

Note that the 16-bit wide interface schematic is practically identical to the 32-bit interface (see [Figure 7-58](#) and [Figure 7-59](#)); only the high-word DDR memories are removed and the unused DQS inputs are tied off.

When not using all or part of a DDR interface, the proper method of handling the unused pins is to tie off the `ddrx_dqsi` pins to ground via a 1-kΩ resistor and to tie off the `ddrx_dqsn` pins to the corresponding `vdds_ddrx` supply via a 1-kΩ resistor. This needs to be done for each byte not used. Although these signals have internal pullups and pulldowns, external pullups and pulldowns provide additional protection against external electrical noise causing activity on the signals.

The `vdds_ddrx` and `ddrx_vref0` power supply pins need to be connected to their respective power supplies even if `ddrx` is not being used. All other DDR interface pins can be left unconnected. Note that the supported modes for use of the DDR EMIF are 32-bits wide, 16-bits wide, or not used.



SPRS906\_PCB\_DDR3\_02

Figure 7-58. 32-Bit, One-Bank DDR3 Interface Schematic Using Two 16-Bit DDR3 Devices

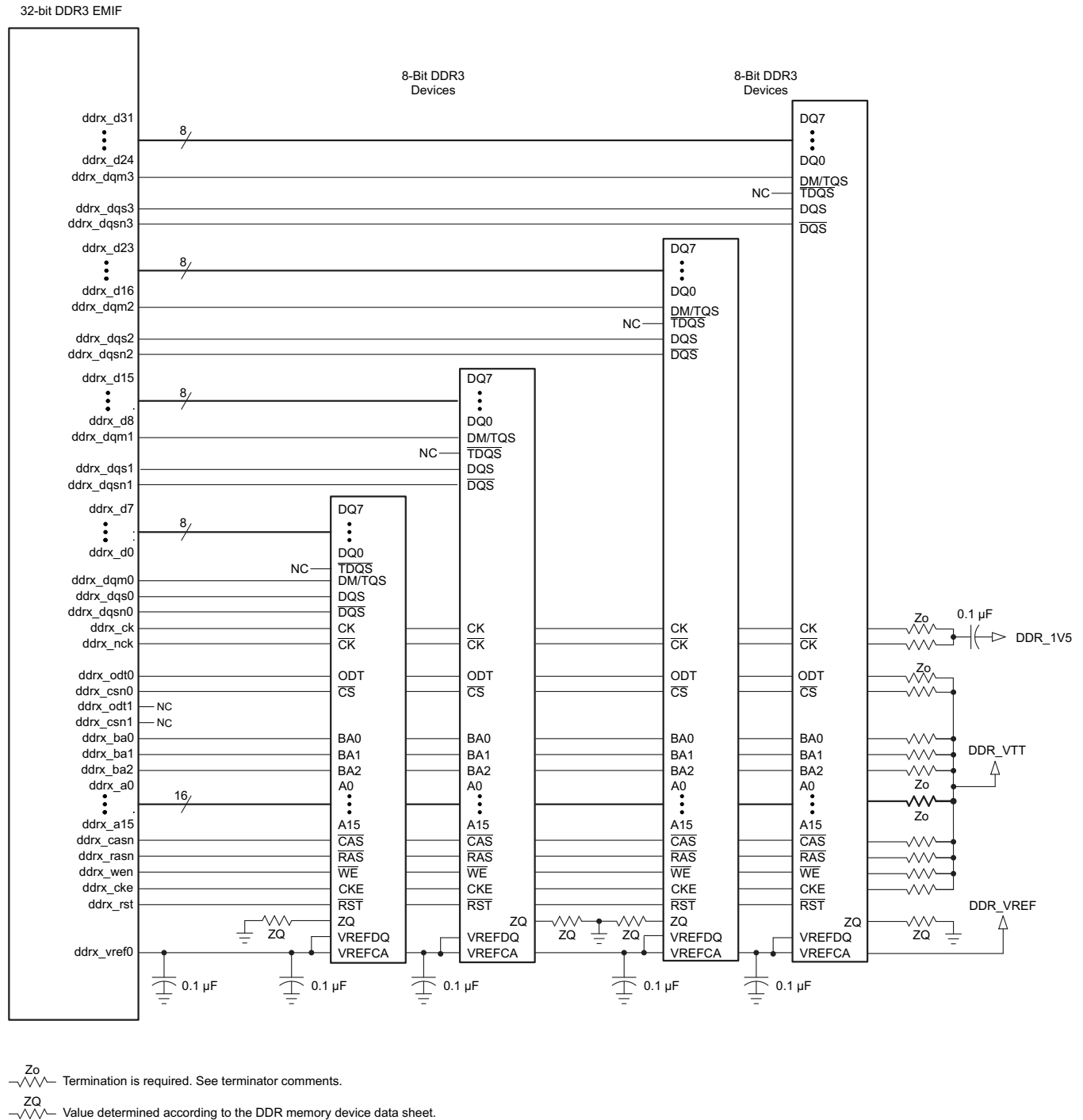


Figure 7-59. 32-Bit, One-Bank DDR3 Interface Schematic Using Four 8-Bit DDR3 Devices

### 7.7.3.5 Compatible JEDEC DDR3 Devices

Table 7-42 shows the parameters of the JEDEC DDR3 devices that are compatible with this interface. Generally, the DDR3 interface is compatible with DDR3-1333 devices in the x8 or x16 widths.

**Table 7-42. Compatible JEDEC DDR3 Devices (Per Interface)**

| N O. | PARAMETER                                    | CONDITION                          | MIN       | MAX       | UNIT    |
|------|----------------------------------------------|------------------------------------|-----------|-----------|---------|
| 1    | JEDEC DDR3 device speed grade <sup>(1)</sup> | DDR clock rate = 400 MHz           | DDR3-800  | DDR3-1600 |         |
|      |                                              | 400 MHz < DDR clock rate ≤ 533 MHz | DDR3-1066 | DDR3-1600 |         |
|      |                                              | 533 MHz < DDR clock rate ≤ 667 MHz | DDR3-1333 | DDR3-1600 |         |
| 2    | JEDEC DDR3 device bit width                  |                                    | x8        | x16       | Bits    |
| 3    | JEDEC DDR3 device count <sup>(2)</sup>       |                                    | 2         | 4         | Devices |

(1) Refer to Table 7-40, Switching Characteristics Over Recommended Operating Conditions for DDR3 Memory Controller for the range of supported DDR clock rates.

(2) For valid DDR3 device configurations and device counts, see Section 7.7.3.4, Figure 7-58, and Figure 7-59.

### 7.7.3.6 PCB Stackup

The minimum stackup for routing the DDR3 interface is a six-layer stack up as shown in Table 7-43. Additional layers may be added to the PCB stackup to accommodate other circuitry, enhance SI/EMI performance, or to reduce the size of the PCB footprint. Complete stackup specifications are provided in Table 7-44.

**Table 7-43. Six-Layer PCB Stackup Suggestion**

| LAYER | TYPE   | DESCRIPTION                           |
|-------|--------|---------------------------------------|
| 1     | Signal | Top routing mostly vertical           |
| 2     | Plane  | Ground                                |
| 3     | Plane  | Split power plane                     |
| 4     | Plane  | Split power plane or Internal routing |
| 5     | Plane  | Ground                                |
| 6     | Signal | Bottom routing mostly horizontal      |

**Table 7-44. PCB Stackup Specifications**

| NO.  | PARAMETER                                                                       | MIN | TYP | MAX | UNIT |
|------|---------------------------------------------------------------------------------|-----|-----|-----|------|
| PS1  | PCB routing/plane layers                                                        | 6   |     |     |      |
| PS2  | Signal routing layers                                                           | 3   |     |     |      |
| PS3  | Full ground reference layers under DDR3 routing region <sup>(1)</sup>           | 1   |     |     |      |
| PS4  | Full 1.5-V power reference layers under the DDR3 routing region <sup>(1)</sup>  | 1   |     |     |      |
| PS5  | Number of reference plane cuts allowed within DDR routing region <sup>(2)</sup> |     |     | 0   |      |
| PS6  | Number of layers between DDR3 routing layer and reference plane <sup>(3)</sup>  |     |     | 0   |      |
| PS7  | PCB routing feature size                                                        |     | 4   |     | Mils |
| PS8  | PCB trace width, w                                                              |     | 4   |     | Mils |
| PS9  | Single-ended impedance, Z <sub>0</sub>                                          | 50  |     | 75  | Ω    |
| PS10 | Impedance control <sup>(5)</sup>                                                | Z-5 | Z   | Z+5 | Ω    |

(1) Ground reference layers are preferred over power reference layers. Be sure to include bypass caps to accommodate reference layer return current as the trace routes switch routing layers.

(2) No traces should cross reference plane cuts within the DDR routing region. High-speed signal traces crossing reference plane cuts create large return current paths which can lead to excessive crosstalk and EMI radiation.

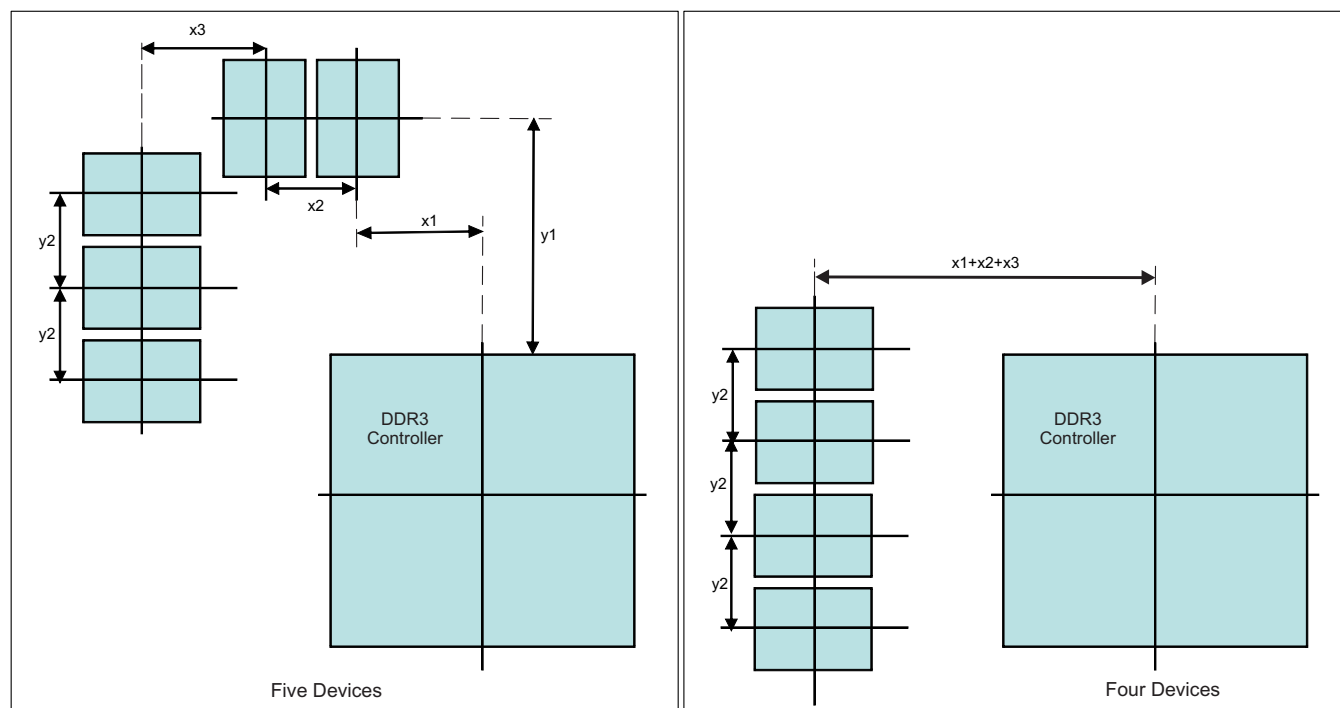
(3) Reference planes are to be directly adjacent to the signal plane to minimize the size of the return current loop.

(4) An 18-mil pad assumes Via Channel is the most economical BGA escape. A 20-mil pad may be used if additional layers are available for power routing. An 18-mil pad is required for minimum layer count escape.

(5) Z is the nominal singled-ended impedance selected for the PCB specified by PS9.

### 7.7.3.7 Placement

Figure 7-60 shows the required placement for the processor as well as the DDR3 devices. The dimensions for this figure are defined in Table 7-45. The placement does not restrict the side of the PCB on which the devices are mounted. The ultimate purpose of the placement is to limit the maximum trace lengths and allow for proper routing space. For a 16-bit DDR memory system, the high-word DDR3 devices are omitted from the placement.



**Figure 7-60. Placement Specifications**

SPRS990F\_PCB\_DDR3\_04

**Table 7-45. Placement Specifications DDR3**

| NO.   | PARAMETER                                                                | MIN | MAX  | UNIT |
|-------|--------------------------------------------------------------------------|-----|------|------|
| KOD31 | X1                                                                       |     | 500  | Mils |
| KOD32 | X2                                                                       |     | 600  | Mils |
| KOD33 | X3                                                                       |     | 600  | Mils |
| KOD34 | Y1                                                                       |     | 1800 | Mils |
| KOD35 | Y2                                                                       |     | 600  | Mils |
| KOD36 | DDR3 keepout region <sup>(1)</sup>                                       |     |      |      |
| KOD37 | Clearance from non-DDR3 signal to DDR3 keepout region <sup>(2) (3)</sup> | 4   |      | W    |

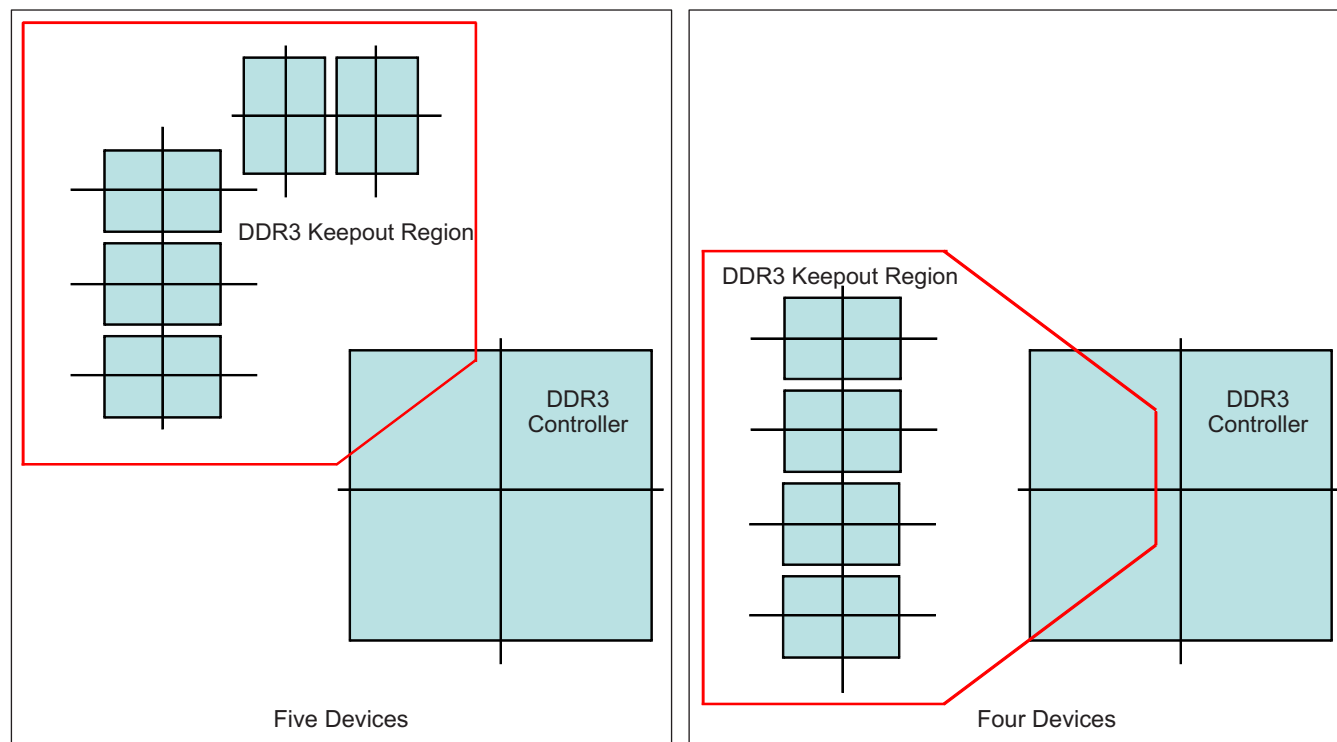
(1) DDR3 keepout region to encompass entire DDR3 routing area.

(2) Non-DDR3 signals allowed within DDR3 keepout region provided they are separated from DDR3 routing layers by a ground plane.

(3) If a device has more than one DDR controller, the signals from the other controller(s) are considered non-DDR3 and should be separated by this specification.

### 7.7.3.8 DDR3 Keepout Region

The region of the PCB used for DDR3 circuitry must be isolated from other signals. The DDR3 keepout region is defined for this purpose and is shown in [Figure 7-61](#). The size of this region varies with the placement and DDR routing. Additional clearances required for the keepout region are shown in [Table 7-45](#). Non-DDR3 signals should not be routed on the DDR signal layers within the DDR3 keepout region. Non-DDR3 signals may be routed in the region, provided they are routed on layers separated from the DDR signal layers by a ground layer. No breaks should be allowed in the reference ground layers in this region. In addition, the 1.5-V DDR3 power plane should cover the entire keepout region. Also note that the two signals from the DDR3 controller should be separated from each other by the specification in [Table 7-45](#) (see [KOD37](#)).



SPRS906\_PCB\_DDR3\_05

**Figure 7-61. DDR3 Keepout Region**

### 7.7.3.9 Bulk Bypass Capacitors

Bulk bypass capacitors are required for moderate speed bypassing of the DDR3 and other circuitry. [Table 7-46](#) contains the minimum numbers and capacitance required for the bulk bypass capacitors. Note that this table only covers the bypass needs of the DDR3 controllers and DDR3 devices. Additional bulk bypass capacitance may be needed for other circuitry.

**Table 7-46. Bulk Bypass Capacitors**

| NO. | PARAMETER                                            | MIN | MAX | UNIT    |
|-----|------------------------------------------------------|-----|-----|---------|
| 1   | vdds_ddrx bulk bypass capacitor count <sup>(1)</sup> | 1   |     | Devices |
| 2   | vdds_ddrx bulk bypass total capacitance              | 22  |     | μF      |

(1) These devices should be placed near the devices they are bypassing, but preference should be given to the placement of the high-speed (HS) bypass capacitors and DDR3 signal routing.

### 7.7.3.10 High-Speed Bypass Capacitors

High-speed (HS) bypass capacitors are critical for proper DDR3 interface operation. It is particularly important to minimize the parasitic series inductance of the HS bypass capacitors, processor/DDR power, and processor/DDR ground connections. [Table 7-47](#) contains the specification for the HS bypass capacitors as well as for the power connections on the PCB. Generally speaking, it is good to:

1. Fit as many HS bypass capacitors as possible.
2. Minimize the distance from the bypass cap to the pins/balls being bypassed.
3. Use the smallest physical sized capacitors possible with the highest capacitance readily available.
4. Connect the bypass capacitor pads to their vias using the widest traces possible and using the largest hole size via possible.
5. Minimize via sharing. Note the limites on via sharing shown in [Table 7-47](#).

**Table 7-47. High-Speed Bypass Capacitors**

| NO. | PARAMETER                                                                           | MIN                                               | TYP  | MAX  | UNIT    |
|-----|-------------------------------------------------------------------------------------|---------------------------------------------------|------|------|---------|
| 1   | HS bypass capacitor package size <sup>(1)</sup>                                     |                                                   | 0201 | 0402 | 10 Mils |
| 2   | Distance, HS bypass capacitor to processor being bypassed <sup>(2)(3)(4)</sup>      |                                                   |      | 400  | Mils    |
| 3   | Processor HS bypass capacitor count per vdds_ddrx rail <sup>(12)</sup>              | See <a href="#">Table 7-3</a> and <sup>(11)</sup> |      |      | Devices |
| 4   | Processor HS bypass capacitor total capacitance per vdds_ddrx rail <sup>(12)</sup>  | See <a href="#">Table 7-3</a> and <sup>(11)</sup> |      |      | μF      |
| 5   | Number of connection vias for each device power/ground ball <sup>(5)</sup>          |                                                   |      |      | Vias    |
| 6   | Trace length from device power/ground ball to connection via <sup>(2)</sup>         |                                                   | 35   | 70   | Mils    |
| 7   | Distance, HS bypass capacitor to DDR device being bypassed <sup>(6)</sup>           |                                                   |      | 150  | Mils    |
| 8   | DDR3 device HS bypass capacitor count <sup>(7)</sup>                                | 12                                                |      |      | Devices |
| 9   | DDR3 device HS bypass capacitor total capacitance <sup>(7)</sup>                    | 0.85                                              |      |      | μF      |
| 10  | Number of connection vias for each HS capacitor <sup>(8)(9)</sup>                   | 2                                                 |      |      | Vias    |
| 11  | Trace length from bypass capacitor connect to connection via <sup>(2)(9)</sup>      |                                                   | 35   | 100  | Mils    |
| 12  | Number of connection vias for each DDR3 device power/ground ball <sup>(10)</sup>    | 1                                                 |      |      | Vias    |
| 13  | Trace length from DDR3 device power/ground ball to connection via <sup>(2)(8)</sup> |                                                   | 35   | 60   | Mils    |

(1) LxW, 10-mil units, that is, a 0402 is a 40×20-mil surface-mount capacitor.

(2) Closer/shorter is better.

(3) Measured from the nearest processor power/ground ball to the center of the capacitor package.

(4) Three of these capacitors should be located underneath the processor, between the cluster of DDR\_1V5 balls and ground balls, between the DDR interfaces on the package.

(5) See the Via Channel™ escape for the processor package.

(6) Measured from the DDR3 device power/ground ball to the center of the capacitor package.

(7) Per DDR3 device.

(8) An additional HS bypass capacitor can share the connection vias only if it is mounted on the opposite side of the board. No sharing of vias is permitted on the same side of the board.

- (9) An HS bypass capacitor may share a via with a DDR device mounted on the same side of the PCB. A wide trace should be used for the connection and the length from the capacitor pad to the DDR device pad should be less than 150 mils.
- (10) Up to a total of two pairs of DDR power/ground balls may share a via.
- (11) The capacitor recommendations in this Data Manual reflect only the needs of this processor. Please see the memory vendor's guidelines for determining the appropriate decoupling capacitor arrangement for the memory device itself.
- (12) For more information, see [Section 7.3](#), *Core Power Domains*.

#### 7.7.3.10.1 Return Current Bypass Capacitors

Use additional bypass capacitors if the return current reference plane changes due to DDR3 signals hopping from one signal layer to another. The bypass capacitor here provides a path for the return current to hop planes along with the signal. As many of these return current bypass capacitors should be used as possible. Because these are returns for signal current, the signal via size may be used for these capacitors.

#### 7.7.3.11 Net Classes

[Table 7-48](#) lists the clock net classes for the DDR3 interface. [Table 7-49](#) lists the signal net classes, and associated clock net classes, for signals in the DDR3 interface. These net classes are used for the termination and routing rules that follow.

**Table 7-48. Clock Net Class Definitions**

| CLOCK NET CLASS     | processor PIN NAMES    |
|---------------------|------------------------|
| CK                  | ddrx_ck/ddrx_nck       |
| DQS0                | ddrx_dqs0 / ddrx_dqsn0 |
| DQS1                | ddrx_dqs1 / ddrx_dqsn1 |
| DQS2 <sup>(1)</sup> | ddrx_dqs2 / ddrx_dqsn2 |
| DQS3 <sup>(1)</sup> | ddrx_dqs3 / ddrx_dqsn3 |

(1) Only used on 32-bit wide DDR3 memory systems.

**Table 7-49. Signal Net Class Definitions**

| SIGNAL NET CLASS   | ASSOCIATED CLOCK NET CLASS | processor PIN NAMES                                                                       |
|--------------------|----------------------------|-------------------------------------------------------------------------------------------|
| ADDR_CTRL          | CK                         | ddrx_ba[2:0], ddrx_a[14:0], ddrx_csnj, ddrx_casn, ddrx_rasn, ddrx_wen, ddrx_cke, ddrx_odt |
| DQ0                | DQS0                       | ddrx_d[7:0], ddrx_dqm0                                                                    |
| DQ1                | DQS1                       | ddrx_d[15:8], ddrx_dqm1                                                                   |
| DQ2 <sup>(1)</sup> | DQS2                       | ddrx_d[23:16], ddrx_dqm2                                                                  |
| DQ3 <sup>(1)</sup> | DQS3                       | ddrx_d[31:24], ddrx_dqm3                                                                  |

(1) Only used on 32-bit wide DDR3 memory systems.

#### 7.7.3.12 DDR3 Signal Termination

Signal terminators are required for the CK and ADDR\_CTRL net classes. The data lines are terminated by ODT and, thus, the PCB traces should be unterminated. Detailed termination specifications are covered in the routing rules in the following sections.

#### 7.7.3.13 VREF\_DDR Routing

ddrx\_vref0 (VREF) is used as a reference by the input buffers of the DDR3 memories as well as the processor. VREF is intended to be half the DDR3 power supply voltage and is typically generated with the DDR3 VDD5 and VTT power supply. It should be routed as a nominal 20-mil wide trace with 0.1  $\mu$ F bypass capacitors near each device connection. Narrowing of VREF is allowed to accommodate routing congestion.

### 7.7.3.14 VTT

Like VREF, the nominal value of the VTT supply is half the DDR3 supply voltage. Unlike VREF, VTT is expected to source and sink current, specifically the termination current for the ADDR\_CTRL net class Thevenin terminators. VTT is needed at the end of the address bus and it should be routed as a power bus sub-plane. VTT should be bypassed near the terminator resistors.

### 7.7.3.15 CK and ADDR\_CTRL Topologies and Routing Definition

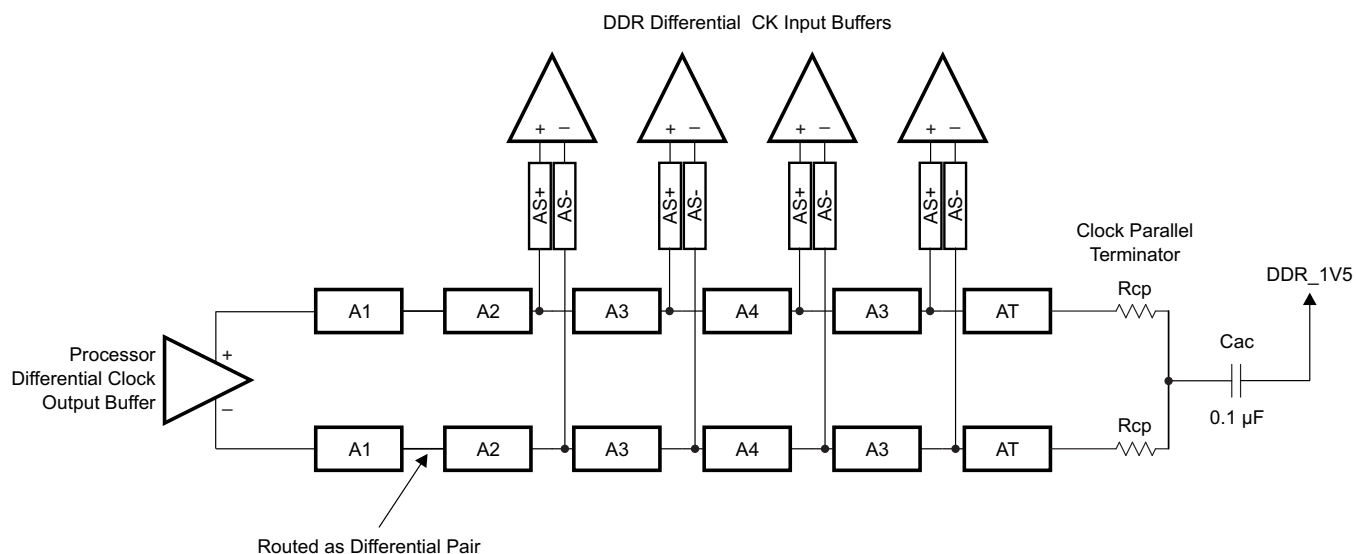
The CK and ADDR\_CTRL net classes are routed similarly and are length matched to minimize skew between them. CK is a bit more complicated because it runs at a higher transition rate and is differential. The following subsections show the topology and routing for various DDR3 configurations for CK and ADDR\_CTRL. The figures in the following subsections define the terms for the routing specification detailed in [Table 7-50](#).

#### 7.7.3.15.1 Four DDR3 Devices

Four DDR3 devices are supported on the DDR EMIF consisting of four x8 DDR3 devices arranged as one bank (CS). These four devices may be mounted on a single side of the PCB, or may be mirrored in two pairs to save board space at a cost of increased routing complexity and parts on the backside of the PCB.

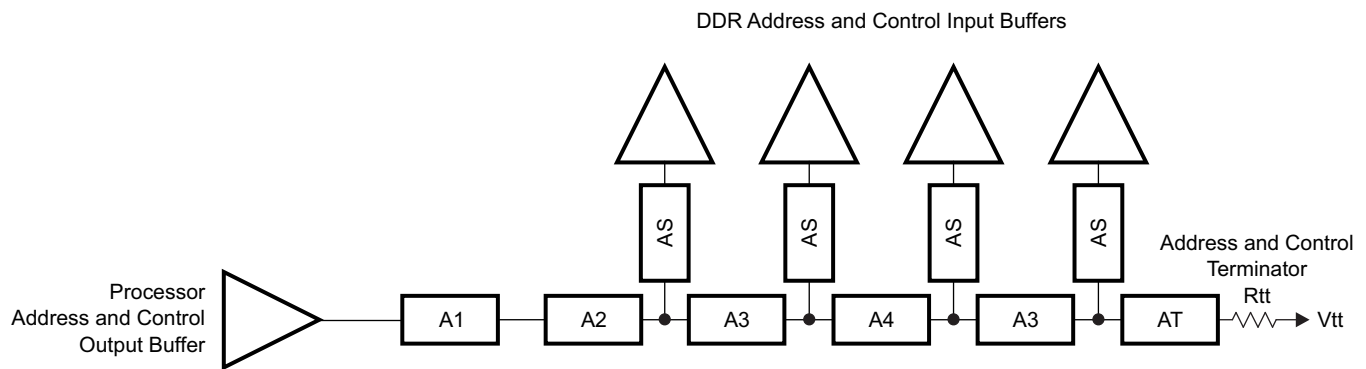
##### 7.7.3.15.1.1 CK and ADDR\_CTRL Topologies, Four DDR3 Devices

[Figure 7-62](#) shows the topology of the CK net classes and [Figure 7-63](#) shows the topology for the corresponding ADDR\_CTRL net classes.



SPRS906\_PCB\_DDR3\_06

Figure 7-62. CK Topology for Four x8 DDR3 Devices

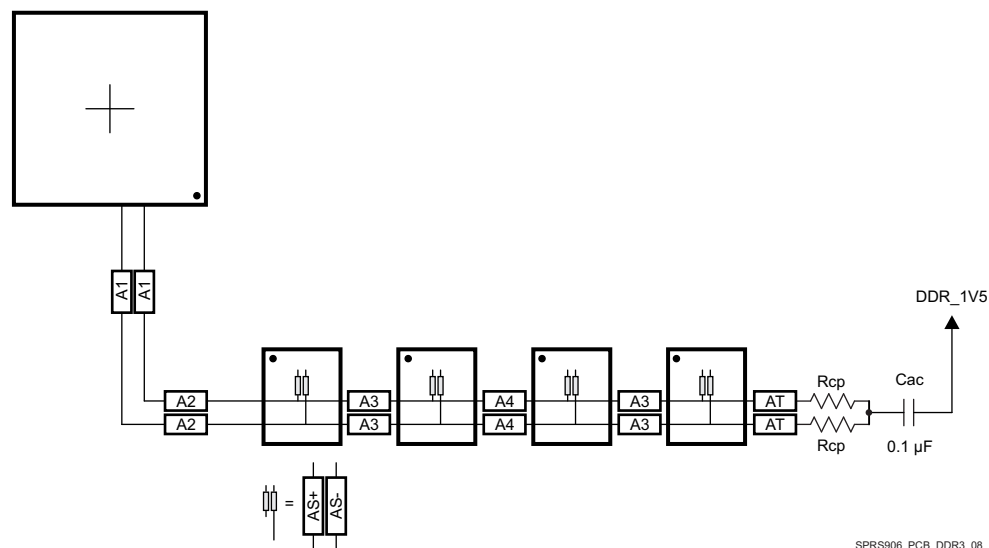


SPRS906\_PCB\_DDR3\_07

**Figure 7-63. ADDR\_CTRL Topology for Four x8 DDR3 Devices**

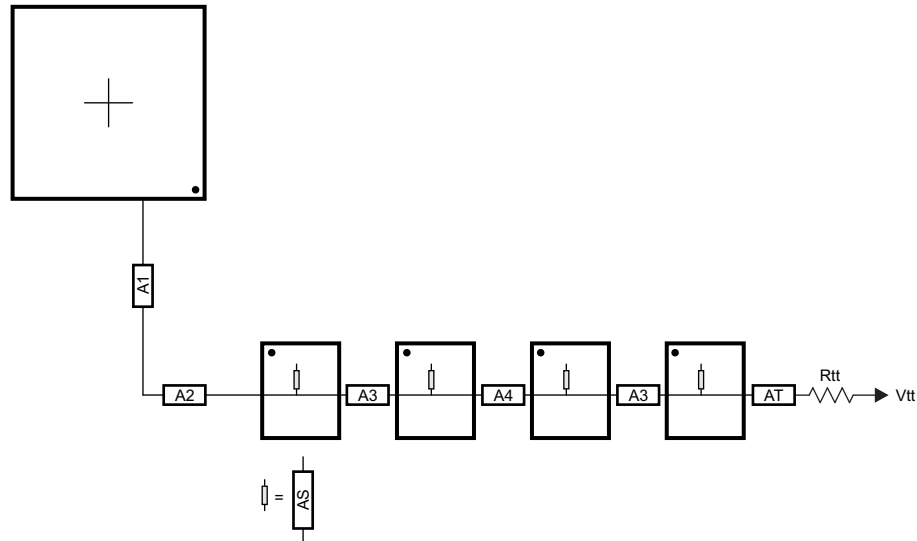
#### 7.7.3.15.1.2 CK and ADDR\_CTRL Routing, Four DDR3 Devices

Figure 7-64 shows the CK routing for four DDR3 devices placed on the same side of the PCB. Figure 7-65 shows the corresponding ADDR\_CTRL routing.



SPRS906\_PCB\_DDR3\_08

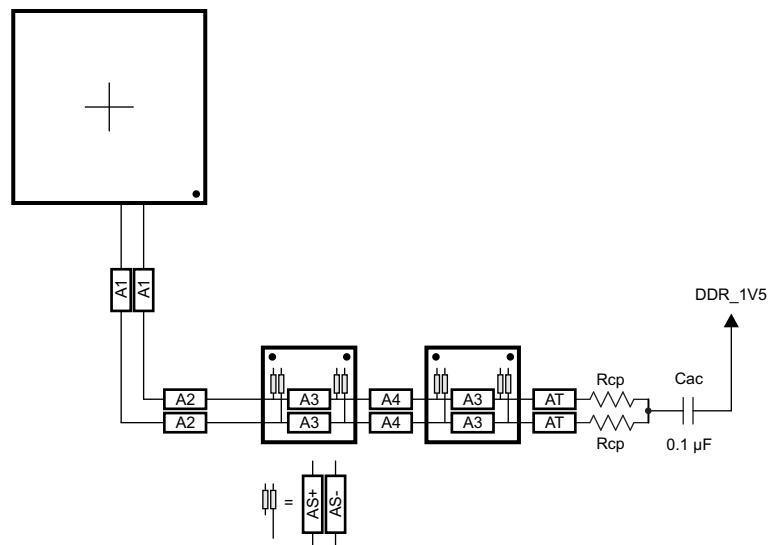
**Figure 7-64. CK Routing for Four Single-Side DDR3 Devices**



SPRS906\_PCB\_DDR3\_09

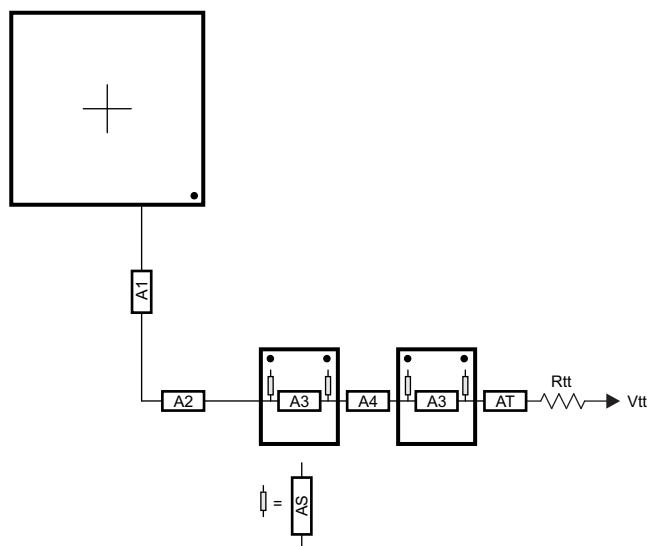
**Figure 7-65. ADDR\_CTRL Routing for Four Single-Side DDR3 Devices**

To save PCB space, the four DDR3 memories may be mounted as two mirrored pairs at a cost of increased routing and assembly complexity. [Figure 7-66](#) and [Figure 7-67](#) show the routing for CK and ADDR\_CTRL, respectively, for four DDR3 devices mirrored in a two-pair configuration.



SPRS906\_PCB\_DDR3\_10

**Figure 7-66. CK Routing for Four Mirrored DDR3 Devices**



SPRS906\_PCB\_DDR3\_11

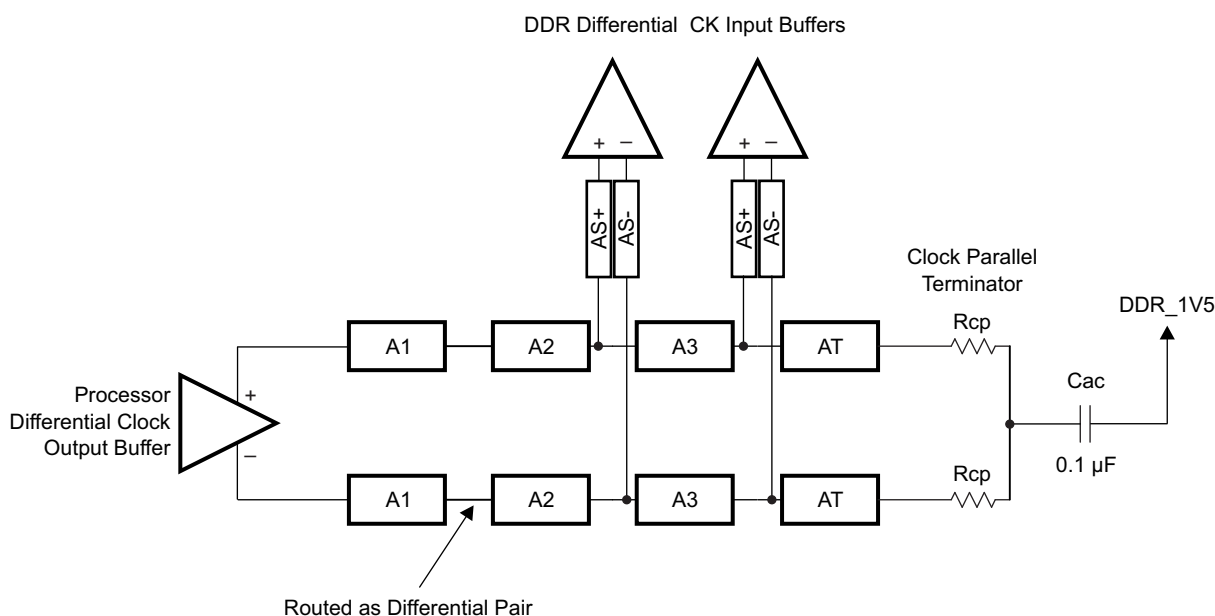
**Figure 7-67. ADDR\_CTRL Routing for Four Mirrored DDR3 Devices**

### 7.7.3.15.2 Two DDR3 Devices

Two DDR3 devices are supported on the DDR EMIF consisting of two x8 DDR3 devices arranged as one bank (CS), 16 bits wide, or two x16 DDR3 devices arranged as one bank (CS), 32 bits wide. These two devices may be mounted on a single side of the PCB, or may be mirrored in a pair to save board space at a cost of increased routing complexity and parts on the backside of the PCB.

#### 7.7.3.15.2.1 CK and ADDR\_CTRL Topologies, Two DDR3 Devices

Figure 7-68 shows the topology of the CK net classes and Figure 7-69 shows the topology for the corresponding ADDR\_CTRL net classes.



SPRS906\_PCB\_DDR3\_12

**Figure 7-68. CK Topology for Two DDR3 Devices**

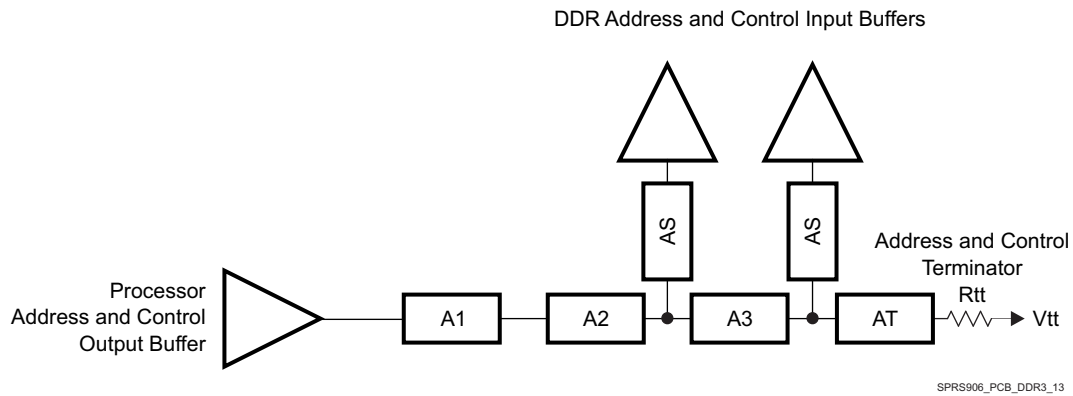


Figure 7-69. ADDR\_CTRL Topology for Two DDR3 Devices

#### 7.7.3.15.2.2 CK and ADDR\_CTRL Routing, Two DDR3 Devices

Figure 7-70 shows the CK routing for two DDR3 devices placed on the same side of the PCB. Figure 7-71 shows the corresponding ADDR\_CTRL routing.

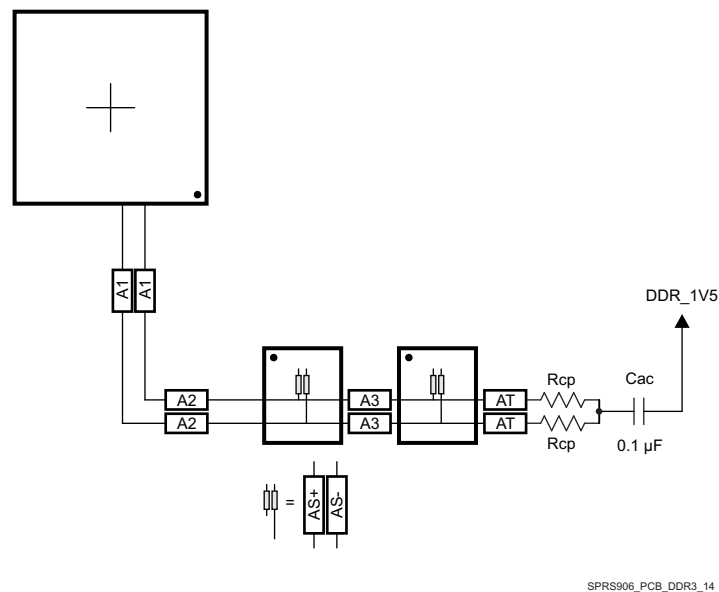
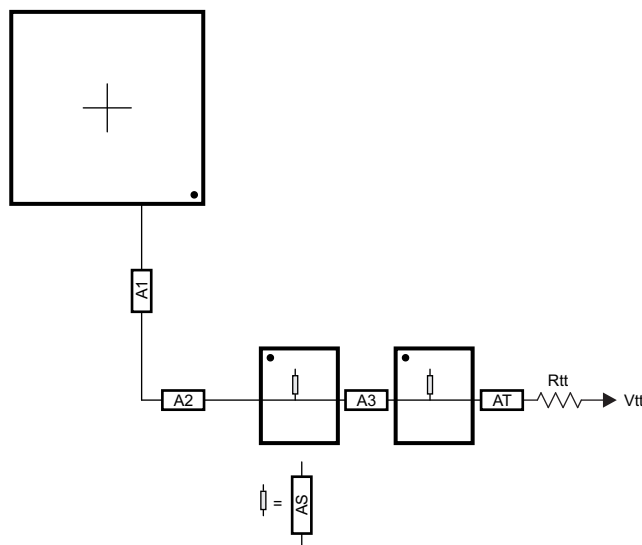


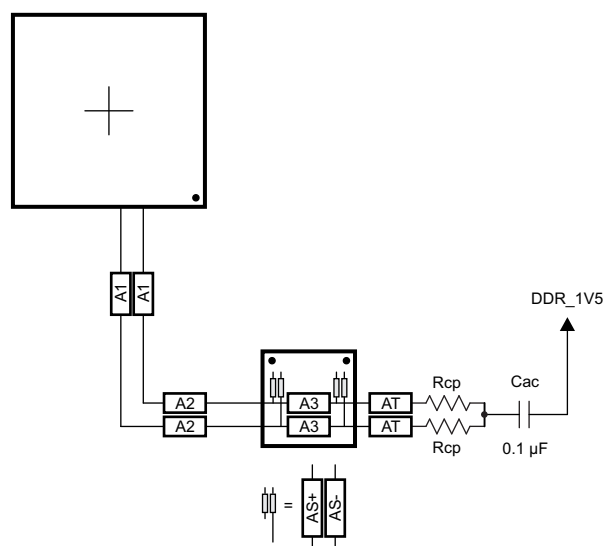
Figure 7-70. CK Routing for Two Single-Side DDR3 Devices



SPRS906\_PCB\_DDR3\_15

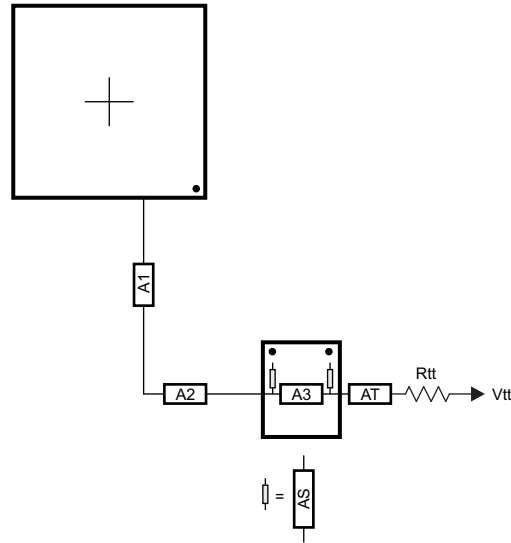
**Figure 7-71. ADDR\_CTRL Routing for Two Single-Side DDR3 Devices**

To save PCB space, the two DDR3 memories may be mounted as a mirrored pair at a cost of increased routing and assembly complexity. [Figure 7-72](#) and [Figure 7-73](#) show the routing for CK and ADDR\_CTRL, respectively, for two DDR3 devices mirrored in a single-pair configuration.



SPRS906\_PCB\_DDR3\_16

**Figure 7-72. CK Routing for Two Mirrored DDR3 Devices**



SPRS906\_PCB\_DDR3\_17

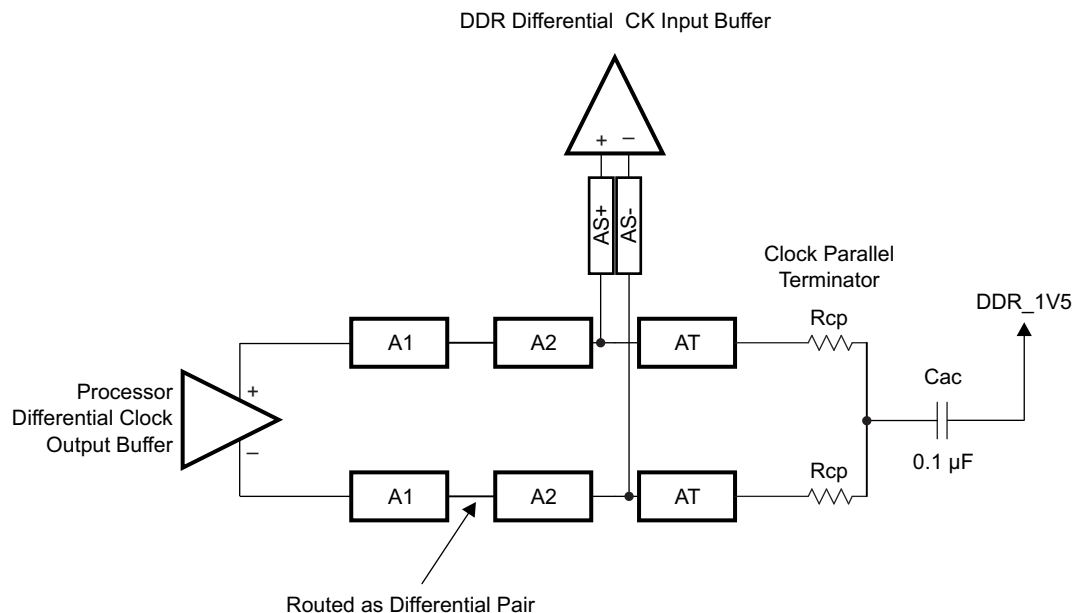
Figure 7-73. ADDR\_CTRL Routing for Two Mirrored DDR3 Devices

### 7.7.3.15.3 One DDR3 Device

A single DDR3 device is supported on the DDR EMIF consisting of one x16 DDR3 device arranged as one bank (CS), 16 bits wide.

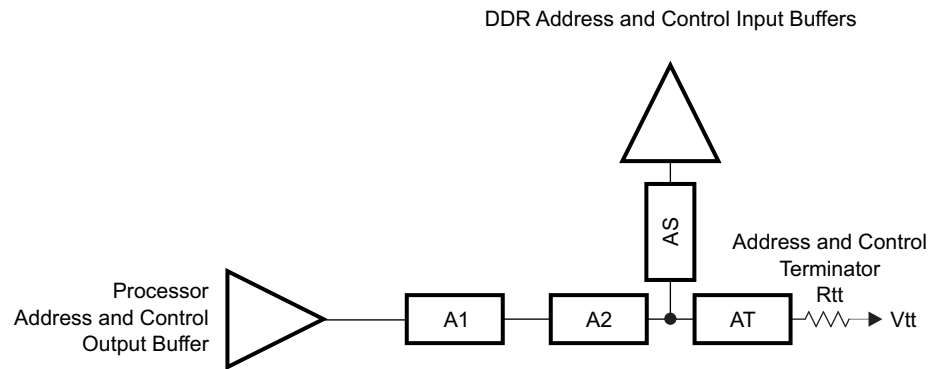
#### 7.7.3.15.3.1 CK and ADDR\_CTRL Topologies, One DDR3 Device

Figure 7-74 shows the topology of the CK net classes and Figure 7-75 shows the topology for the corresponding ADDR\_CTRL net classes.



SPRS906\_PCB\_DDR3\_18

Figure 7-74. CK Topology for One DDR3 Device

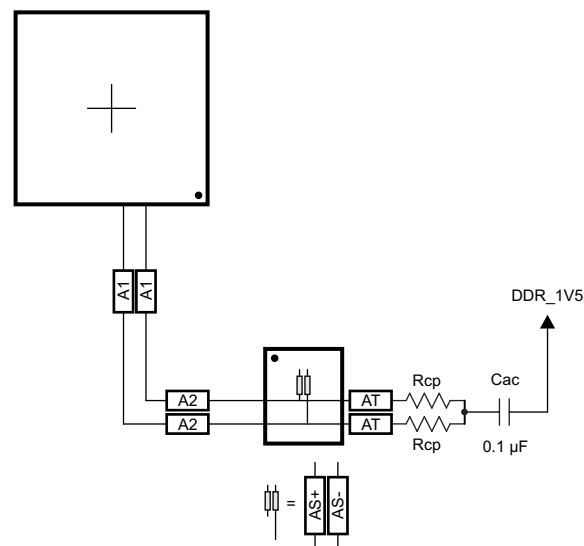


SPRS906\_PCB\_DDR3\_19

**Figure 7-75. ADDR\_CTRL Topology for One DDR3 Device**

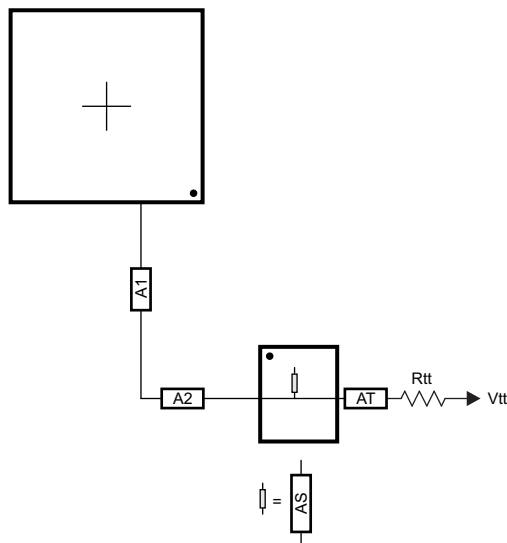
#### 7.7.3.15.3.2 CK and ADDR/CTRL Routing, One DDR3 Device

Figure 7-76 shows the CK routing for one DDR3 device placed on the same side of the PCB. Figure 7-77 shows the corresponding ADDR\_CTRL routing.



SPRS906\_PCB\_DDR3\_20

**Figure 7-76. CK Routing for One DDR3 Device**



SPRS906\_PCB\_DDR3\_21

Figure 7-77. ADDR\_CTRL Routing for One DDR3 Device

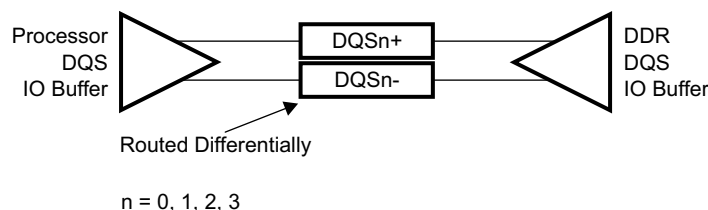
#### 7.7.3.16 Data Topologies and Routing Definition

No matter the number of DDR3 devices used, the data line topology is always point to point, so its definition is simple.

Care should be taken to minimize layer transitions during routing. If a layer transition is necessary, it is better to transition to a layer using the same reference plane. If this cannot be accommodated, ensure there are nearby ground vias to allow the return currents to transition between reference planes if both reference planes are ground or vdds\_ddr. Ensure there are nearby bypass capacitors to allow the return currents to transition between reference planes if one of the reference planes is ground. The goal is to minimize the size of the return current loops.

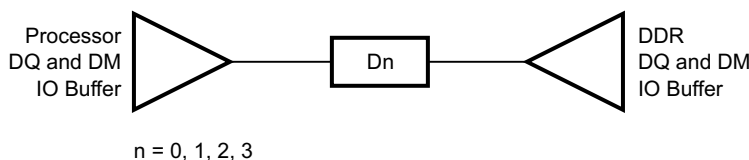
##### 7.7.3.16.1 DQS and DQ/DM Topologies, Any Number of Allowed DDR3 Devices

DQS lines are point-to-point differential, and DQ/DM lines are point-to-point singled ended. [Figure 7-78](#) and [Figure 7-79](#) show these topologies.



SPRS906\_PCB\_DDR3\_22

Figure 7-78. DQS Topology

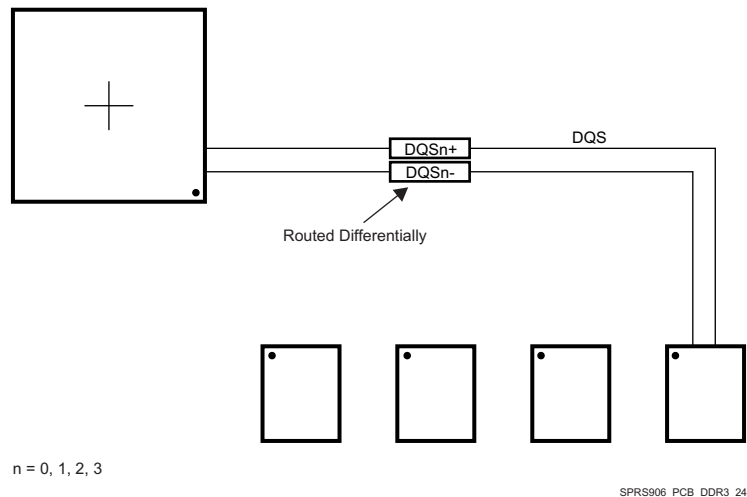


SPRS906\_PCB\_DDR3\_23

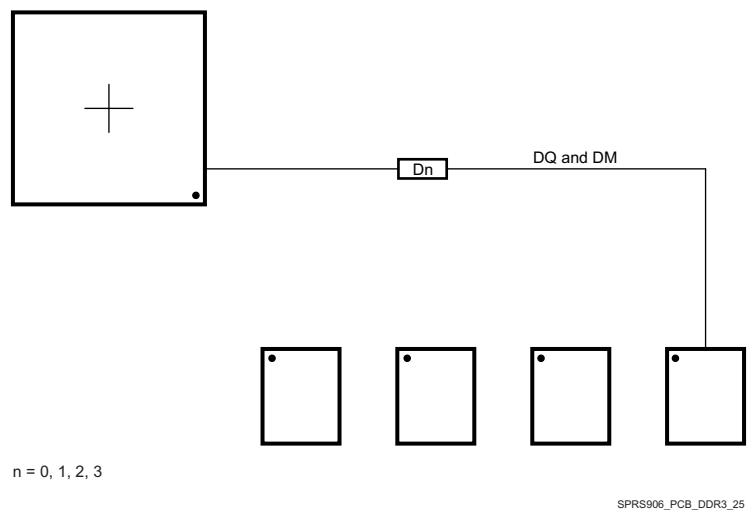
Figure 7-79. DQ/DM Topology

### 7.7.3.16.2 DQS and DQ/DM Routing, Any Number of Allowed DDR3 Devices

Figure 7-80 and Figure 7-81 show the DQS and DQ/DM routing.



**Figure 7-80. DQS Routing With Any Number of Allowed DDR3 Devices**



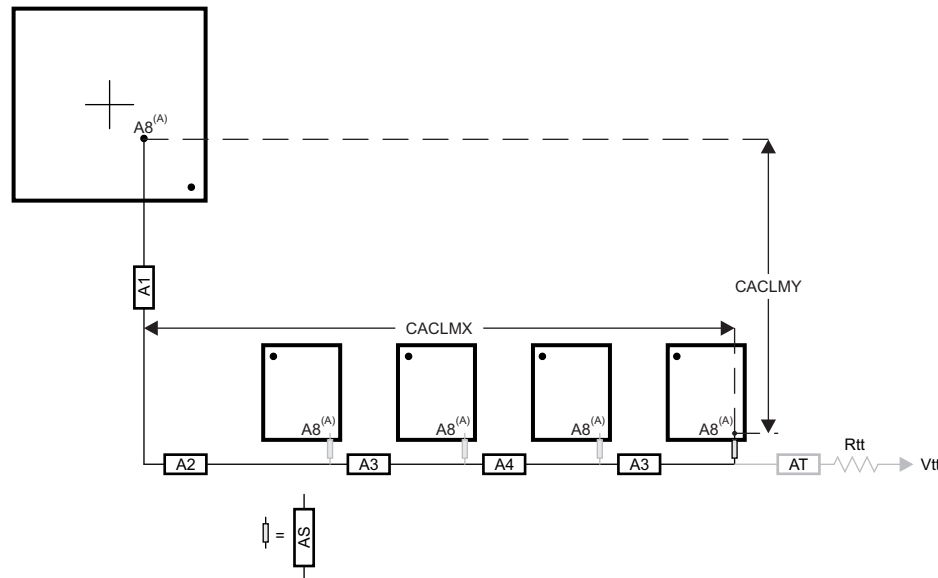
**Figure 7-81. DQ/DM Routing With Any Number of Allowed DDR3 Devices**

### 7.7.3.17 Routing Specification

#### 7.7.3.17.1 CK and ADDR\_CTRL Routing Specification

Skew within the CK and ADDR\_CTRL net classes directly reduces setup and hold margin and, thus, this skew must be controlled. The only way to practically match lengths on a PCB is to lengthen the shorter traces up to the length of the longest net in the net class and its associated clock. A metric to establish this maximum length is Manhattan distance. The Manhattan distance between two points on a PCB is the length between the points when connecting them only with horizontal or vertical segments. A reasonable trace route length is to within a percentage of its Manhattan distance. CACLM is defined as Clock Address Control Longest Manhattan distance.

Given the clock and address pin locations on the processor and the DDR3 memories, the maximum possible Manhattan distance can be determined given the placement. [Figure 7-82](#) and [Figure 7-83](#) show this distance for four loads and two loads, respectively. It is from this distance that the specifications on the lengths of the transmission lines for the address bus are determined. CACLM is determined similarly for other address bus configurations; that is, it is based on the longest net of the CK/ADDR\_CTRL net class. For CK and ADDR\_CTRL routing, these specifications are contained in [Table 7-50](#).



SPRS906\_PCB\_DDR3\_26

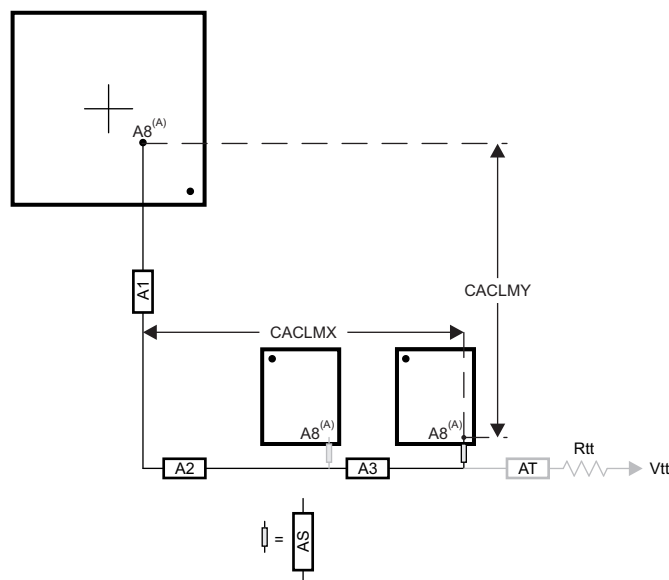
- A. It is very likely that the longest CK/ADDR\_CTRL Manhattan distance will be for Address Input 8 (A8) on the DDR3 memories. CACLM is based on the longest Manhattan distance due to the device placement. Verify the net class that satisfies this criteria and use as the baseline for CK/ADDR\_CTRL skew matching and length control.

The length of shorter CK/ADDR\_CTRL stubs as well as the length of the terminator stub are not included in this length calculation. Non-included lengths are grayed out in the figure.

Assuming A8 is the longest, CALM = CACLMY + CACLMX + 300 mils.

The extra 300 mils allows for routing down lower than the DDR3 memories and returning up to reach A8.

**Figure 7-82. CACLM for Four Address Loads on One Side of PCB**



SPRS906\_PCB\_DDR3\_27

- A. It is very likely that the longest CK/ADDR\_CTRL Manhattan distance will be for Address Input 8 (A8) on the DDR3 memories. CACLM is based on the longest Manhattan distance due to the device placement. Verify the net class that satisfies this criteria and use as the baseline for CK/ADDR\_CTRL skew matching and length control.

The length of shorter CK/ADDR\_CTRL stubs as well as the length of the terminator stub are not included in this length calculation. Non-included lengths are grayed out in the figure.

Assuming A8 is the longest, CALM = CACLMY + CACLMX + 300 mils.

The extra 300 mils allows for routing down lower than the DDR3 memories and returning up to reach A8.

**Figure 7-83. CACLM for Two Address Loads on One Side of PCB**

**Table 7-50. CK and ADDR\_CTRL Routing Specification<sup>(2)(3)</sup>**

| NO.     | PARAMETER                                                                  | MIN | TYP | MAX                | UNIT |
|---------|----------------------------------------------------------------------------|-----|-----|--------------------|------|
| CARS31  | A1+A2 length                                                               |     |     | 500 <sup>(1)</sup> | ps   |
| CARS32  | A1+A2 skew                                                                 |     |     | 29                 | ps   |
| CARS33  | A3 length                                                                  |     |     | 125                | ps   |
| CARS34  | A3 skew <sup>(4)</sup>                                                     |     |     | 6                  | ps   |
| CARS35  | A3 skew <sup>(5)</sup>                                                     |     |     | 6                  | ps   |
| CARS36  | A4 length                                                                  |     |     | 125                | ps   |
| CARS37  | A4 skew                                                                    |     |     | 6                  | ps   |
| CARS38  | AS length                                                                  |     | 5   | 17 <sup>(1)</sup>  | ps   |
| CARS39  | AS skew                                                                    |     | 1.3 | 14 <sup>(1)</sup>  | ps   |
| CARS310 | AS+/AS- length                                                             |     | 5   | 12                 | ps   |
| CARS311 | AS+/AS- skew                                                               |     |     | 1                  | ps   |
| CARS312 | AT length <sup>(6)</sup>                                                   |     | 75  |                    | ps   |
| CARS313 | AT skew <sup>(7)</sup>                                                     |     | 14  |                    | ps   |
| CARS314 | AT skew <sup>(8)</sup>                                                     |     |     | 1                  | ps   |
| CARS315 | CK/ADDR_CTRL trace length                                                  |     |     | 1020               | ps   |
| CARS316 | Vias per trace                                                             |     |     | 3 <sup>(1)</sup>   | vias |
| CARS317 | Via count difference                                                       |     |     | 1 <sup>(15)</sup>  | vias |
| CARS318 | Center-to-center CK to other DDR3 trace spacing <sup>(9)</sup>             | 4w  |     |                    |      |
| CARS319 | Center-to-center ADDR_CTRL to other DDR3 trace spacing <sup>(9)(10)</sup>  | 4w  |     |                    |      |
| CARS320 | Center-to-center ADDR_CTRL to other ADDR_CTRL trace spacing <sup>(9)</sup> | 3w  |     |                    |      |

**Table 7-50. CK and ADDR\_CTRL Routing Specification<sup>(2)(3)</sup> (continued)**

| NO.     | PARAMETER                                       | MIN  | TYP | MAX  | UNIT |
|---------|-------------------------------------------------|------|-----|------|------|
| CARS321 | CK center-to-center spacing <sup>(11)(12)</sup> |      |     |      |      |
| CARS322 | CK spacing to other net <sup>(9)</sup>          | 4w   |     |      |      |
| CARS323 | Rcp <sup>(13)</sup>                             | Z0-1 | Z0  | Z0+1 | Ω    |
| CARS324 | Rtt <sup>(13)(14)</sup>                         | Z0-5 | Z0  | Z0+5 | Ω    |

- (1) Max value is based upon conservative signal integrity approach. This value could be extended only if detailed signal integrity analysis of rise time and fall time confirms desired operation.
- (2) The use of vias should be minimized.
- (3) Additional bypass capacitors are required when using the DDR\_1V5 plane as the reference plane to allow the return current to jump between the DDR\_1V5 plane and the ground plane when the net class switches layers at a via.
- (4) Non-mirrored configuration (all DDR3 memories on same side of PCB).
- (5) Mirrored configuration (one DDR3 device on top of the board and one DDR3 device on the bottom).
- (6) While this length can be increased for convenience, its length should be minimized.
- (7) ADDR\_CTRL net class only (not CK net class). Minimizing this skew is recommended, but not required.
- (8) CK net class only.
- (9) Center-to-center spacing is allowed to fall to minimum 2w for up to 1250 mils of routed length.
- (10) The ADDR\_CTRL net class of the other DDR EMIF is considered *other DDR3 trace spacing*.
- (11) CK spacing set to ensure proper differential impedance.
- (12) The most important thing to do is control the impedance so inadvertent impedance mismatches are not created. Generally speaking, center-to-center spacing should be either 2w or slightly larger than 2w to achieve a differential impedance equal to twice the singleended impedance, Z0.
- (13) Source termination (series resistor at driver) is specifically not allowed.
- (14) Termination values should be uniform across the net class.
- (15) Via count difference may increase by 1 only if accurate 3-D modeling of the signal flight times – including accurately modeled signal propagation through vias – has been applied to ensure all segment skew maximums are not exceeded.

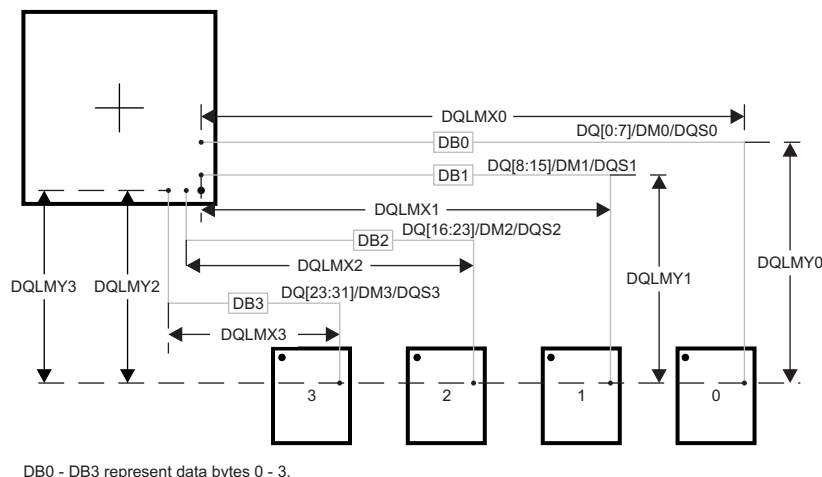
### 7.7.3.17.2 DQS and DQ Routing Specification

Skew within the DQS and DQ/DM net classes directly reduces setup and hold margin and thus this skew must be controlled. The only way to practically match lengths on a PCB is to lengthen the shorter traces up to the length of the longest net in the net class and its associated clock. As with CK and ADDR\_CTRL, a reasonable trace route length is to within a percentage of its Manhattan distance. DQLMn is defined as DQ Longest Manhattan distance n, where n is the byte number. For a 32-bit interface, there are four DQLMs, DQLM0-DQLM3. Likewise, for a 16-bit interface, there are two DQLMs, DQLM0-DQLM1.

#### NOTE

It is not required, nor is it recommended, to match the lengths across all bytes. Length matching is only required within each byte.

Given the DQS and DQ/DM pin locations on the processor and the DDR3 memories, the maximum possible Manhattan distance can be determined given the placement. [Figure 7-84](#) shows this distance for four loads. It is from this distance that the specifications on the lengths of the transmission lines for the data bus are determined. For DQS and DQ/DM routing, these specifications are contained in [Table 7-51](#).



SPRS906\_PCB\_DDR3\_28

There are four DQLMs, one for each byte (32-bit interface). Each DQLM is the longest Manhattan distance of the byte; therefore:

$$DQLM0 = DQLMX0 + DQLMY0$$

$$DQLM1 = DQLMX1 + DQLMY1$$

$$DQLM2 = DQLMX2 + DQLMY2$$

$$DQLM3 = DQLMX3 + DQLMY3$$

**Figure 7-84. DQLM for Any Number of Allowed DDR3 Devices**

**Table 7-51. Data Routing Specification<sup>(2)</sup>**

| NO.    | PARAMETER                                                       | MIN | TYP | MAX               | UNIT             |
|--------|-----------------------------------------------------------------|-----|-----|-------------------|------------------|
| DRS31  | DB0 length                                                      |     |     | 340               | ps               |
| DRS32  | DB1 length                                                      |     |     | 340               | ps               |
| DRS33  | DB2 length                                                      |     |     | 340               | ps               |
| DRS34  | DB3 length                                                      |     |     | 340               | ps               |
| DRS35  | DBn skew <sup>(3)</sup>                                         |     |     | 5                 | ps               |
| DRS36  | DQSn+ to DQSn- skew                                             |     |     | 1                 | ps               |
| DRS37  | DQSn to DBn skew <sup>(3)(4)</sup>                              |     |     | 5 <sup>(10)</sup> | ps               |
| DRS38  | Vias per trace                                                  |     |     | 2 <sup>(1)</sup>  | vias             |
| DRS39  | Via count difference                                            |     |     | 0 <sup>(10)</sup> | vias             |
| DRS310 | Center-to-center DBn to other DDR3 trace spacing <sup>(6)</sup> | 4   |     |                   | w <sup>(5)</sup> |
| DRS311 | Center-to-center DBn to other DBn trace spacing <sup>(7)</sup>  | 3   |     |                   | w <sup>(5)</sup> |
| DRS312 | DQSn center-to-center spacing <sup>(8)(9)</sup>                 |     |     |                   |                  |
| DRS313 | DQSn center-to-center spacing to other net                      | 4   |     |                   | w <sup>(5)</sup> |

(1) Max value is based upon conservative signal integrity approach. This value could be extended only if detailed signal integrity analysis of rise time and fall time confirms desired operation.

(2) External termination disallowed. Data termination should use built-in ODT functionality.

(3) Length matching is only done within a byte. Length matching across bytes is neither required nor recommended.

(4) Each DQS pair is length matched to its associated byte.

(5) Center-to-center spacing is allowed to fall to minimum 2w for up to 1250 mils of routed length.

(6) Other DDR3 trace spacing means other DDR3 net classes not within the byte.

(7) This applies to spacing within the net classes of a byte.

(8) DQS pair spacing is set to ensure proper differential impedance.

(9) The most important thing to do is control the impedance so inadvertent impedance mismatches are not created. Generally speaking, center-to-center spacing should be either 2w or slightly larger than 2w to achieve a differential impedance equal to twice the singleended impedance, Zo.

(10) Via count difference may increase by 1 only if accurate 3-D modeling of the signal flight times – including accurately modeled signal propagation through vias – has been applied to ensure DBn skew and DQSn to DBn skew maximums are not exceeded.

## 8 Device and Documentation Support

TI offers an extensive line of development tools, including methods to evaluate the performance of the processors, generate code, develop algorithm implementations, and fully integrate and debug software and hardware modules as listed below.

### 8.1 Device Nomenclature and Orderable Information

To designate the stages in the product development cycle, TI assigns prefixes to the part numbers of all microprocessors (MPUs) and support tools. Each device has one of three prefixes: X, P, or null (no prefix) (for example, TDA2Px). Texas Instruments recommends two of three possible prefix designators for its support tools: TMDX and TMDS. These prefixes represent evolutionary stages of product development from engineering prototypes (TMDX) through fully qualified production devices and tools (TMDS).

Device development evolutionary flow:

- X** Experimental device that is not necessarily representative of the final device's electrical specifications and may not use production assembly flow.
- P** Prototype device that is not necessarily the final silicon die and may not necessarily meet final electrical specifications.
- null** Production version of the silicon die that is fully qualified.

Support tool development evolutionary flow:

- TMDX** Development-support product that has not yet completed Texas Instruments internal qualification testing.
- TMDS** Fully-qualified development-support product.

X and P devices and TMDX development-support tools are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes."

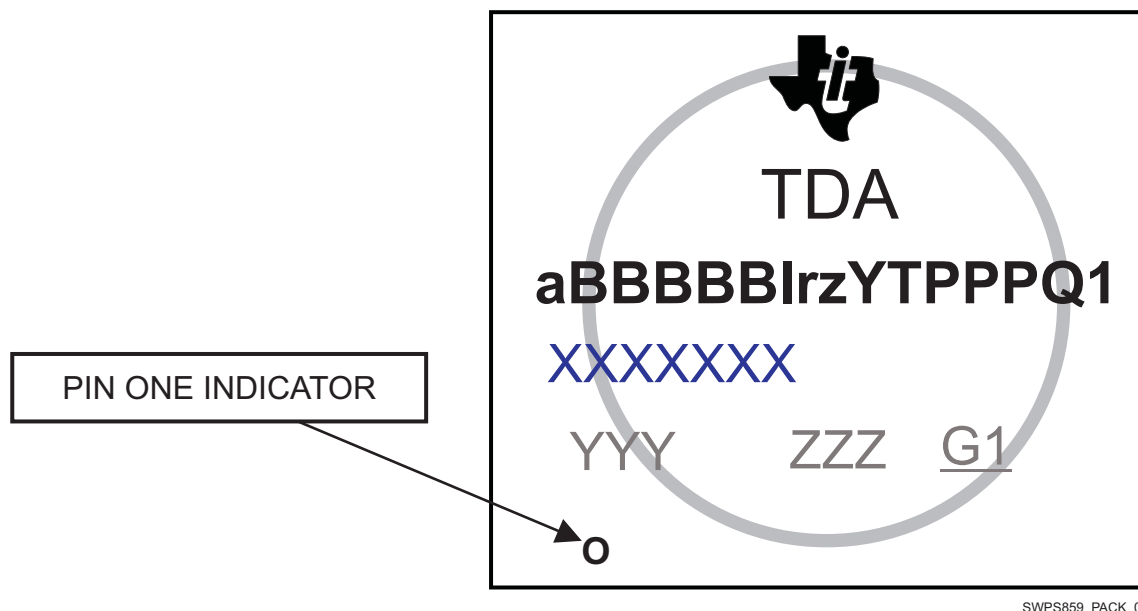
Production devices and TMDS development-support tools have been characterized fully, and the quality and reliability of the device have been demonstrated fully. TI's standard warranty applies.

Predictions show that prototype devices (X or P) have a greater failure rate than the standard production devices. Texas Instruments recommends that these devices not be used in any production system because their expected end-use failure rate still is undefined. Only qualified production devices are to be used.

For orderable part numbers of TDA2Px devices in the ABZ package type, see the Package Option Addendum of this document, the TI website ([www.ti.com](http://www.ti.com)), or contact your TI sales representative.

For additional description of the device nomenclature markings on the die, see the Silicon Errata (literature number SPRZ397).

### 8.1.1 Standard Package Symbolization



**Figure 8-1. Printed Device Reference**

#### NOTE

Some devices have a cosmetic circular marking visible on the top of the device package which results from the production test process. These markings are cosmetic only with no reliability impact.

### 8.1.2 Device Naming Convention

**Table 8-1. Nomenclature Description**

| FIELD<br>PARAMETER   | FIELD<br>DESCRIPTION                  | VALUES  |            | DESCRIPTION                                               |
|----------------------|---------------------------------------|---------|------------|-----------------------------------------------------------|
|                      |                                       | MARKING | ORDERABLE  |                                                           |
| a                    | Device evolution stage <sup>(1)</sup> | X       | Contact TI | Prototype                                                 |
|                      |                                       | P       |            | Preproduction (production test flow, no reliability data) |
|                      |                                       | BLANK   |            | Production                                                |
| BBBBB <sup>(3)</sup> | Base production part number           | TDA2PS  |            | ADAS 2 <sup>nd</sup> Generation Super Tier                |
|                      |                                       | TDA2PH  |            | ADAS 2 <sup>nd</sup> Generation High Tier                 |
|                      |                                       | TDA2PM  |            | ADAS 2 <sup>nd</sup> Generation Mid Tier                  |
|                      |                                       | TDA2PL  |            | ADAS 2 <sup>nd</sup> Generation Low Tier                  |
| I                    | Device Identity                       | A       |            | Scene Analysis                                            |
|                      |                                       | V       |            | Scene Viewing                                             |
|                      |                                       | E       |            | Ethernet Decode                                           |
|                      |                                       | R       |            | Driver Recorder                                           |
|                      |                                       | F       |            | Fusion                                                    |
|                      |                                       | G       |            | GFX enabled                                               |
|                      |                                       | X       |            | ADAS Superset                                             |
|                      |                                       | D       |            | DSP only                                                  |
| r                    | Device revision                       | BLANK   |            | SR 1.0                                                    |

**Table 8-1. Nomenclature Description (continued)**

| FIELD<br>PARAMETER | FIELD<br>DESCRIPTION       | VALUES    |           | DESCRIPTION                                                                                                                                    |
|--------------------|----------------------------|-----------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------|
|                    |                            | MARKING   | ORDERABLE |                                                                                                                                                |
| z                  | Device Speed               | A         |           | Indicates the speed grade for each of the cores in the device. For more information see <a href="#">Section 3.1, Device Comparison Table</a> . |
|                    |                            | B         |           |                                                                                                                                                |
|                    |                            | D         |           |                                                                                                                                                |
|                    |                            | F         |           |                                                                                                                                                |
|                    |                            | N         |           |                                                                                                                                                |
|                    |                            | R         |           |                                                                                                                                                |
|                    |                            | U         |           |                                                                                                                                                |
|                    |                            | T         |           |                                                                                                                                                |
| Y                  | Device type                | BLANK     |           | General purpose (Prototype and Production)                                                                                                     |
|                    |                            | E         |           | Emulation (E) devices                                                                                                                          |
|                    |                            | S         |           | High-Security device, Secure Boot Supported                                                                                                    |
|                    |                            | D         |           | High security devices                                                                                                                          |
| T                  | Temperature <sup>(2)</sup> | I         |           | Industrial: -40 °C to 85 °C (initial prototypes)                                                                                               |
|                    |                            | Q         |           | Full temp range: -40 °C to 125 °C                                                                                                              |
| PPP                | Package designator         | ABZ       |           | ABZ S-PBGA-N760 (23mm x 23mm) Package                                                                                                          |
| c                  | Carrier designator         | N/A       | BLANK     | Tray                                                                                                                                           |
|                    |                            | N/A       | R         | Tape & Reel                                                                                                                                    |
| Q1                 | Automotive Designator      | BLANK     |           | Does not meets automotive qualification                                                                                                        |
|                    |                            | Q1        |           | Meets Q100 equal requirements, with exceptions as specified in DM.                                                                             |
| XXXXXXX            |                            | As marked | N/A       | Lot Trace Code                                                                                                                                 |
| YYY                |                            | As marked | N/A       | Production Code, For TI use only                                                                                                               |
| ZZZ                |                            | As marked | N/A       | Production Code, For TI use only                                                                                                               |
| O                  |                            | As marked | N/A       | Pin one designator                                                                                                                             |
| G1                 |                            | As marked | N/A       | ECAT—Green package designator                                                                                                                  |

- (1) To designate the stages in the product development cycle, TI assigns prefixes to the part numbers. These prefixes represent evolutionary stages of product development from engineering prototypes through fully qualified production devices. Prototype devices are shipped against the following disclaimer:  
 "This product is still in development and is intended for internal evaluation purposes."  
 Notwithstanding any provision to the contrary, TI makes no warranty expressed, implied, or statutory, including any implied warranty of merchantability of fitness for a specific purpose, of this device.
- (2) Applies to device max junction temperature.
- (3) X577Px is the base part number for the superset device. Software should constrain the features used to match the intended production device.

#### NOTE

BLANK in the symbol or part number is collapsed so there are no gaps between characters.

## 8.2 Tools and Software

The following products support development for TDA2x platforms:

**TDA2Px Pad Configuration Tool** is an interactive pad-configuration tool that allows the user to visualize the device pad configuration state on power-on reset and then customize the configuration of the pads for the specific use-case and identify the device register settings associated to that configuration.

**TDA2Px Register Descriptor** is an interactive device register configuration tool that allows users to visualize the register state on power-on reset, and then customize the configuration of the device for the specific use-case.

**TDA2Px Clock Tree Tool** is interactive clock tree configuration software that allows the user to visualize the device clock tree, interact with clock tree elements and view the effect on PRCM registers, interact with the PRCM registers and view the effect on the device clock tree, and view a trace of all the device registers affected by the user interaction with the clock tree.

For a complete listing of development-support tools for the processor platform, visit the Texas Instruments website at [www.ti.com](http://www.ti.com). For information on pricing and availability, contact the nearest TI field sales office or authorized distributor.

## 8.3 Documentation Support

The following documents describe the TDA2Px devices.

**TRM**      [SPRUIF0 TDA2Px SoC for Advanced Driver Assistance Systems \(ADAS\) Technical Reference Manual](#) Details the integration, the environment, the functional description, and the programming models for each peripheral and subsystem in the TDA2x family of devices.

**Errata**      **TDA2Px Silicon Errata** Describes known advisories on silicon and provides workarounds.

### 8.3.1 FCC Warning

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

### 8.3.2 Information About Cautions and Warnings

This book may contain cautions and warnings.

#### CAUTION

This is an example of a caution statement.

A caution statement describes a situation that could potentially damage your software or equipment.

#### WARNING

This is an example of a warning statement.

A warning statement describes a situation that could potentially cause harm to you.

The information in a caution or a warning is provided for your protection. Please read each caution and warning carefully.

## 8.4 Receiving Notification of Documentation Updates

To receive notification of documentation updates — including silicon errata — go to the product folder for your device on [www.ti.com](http://www.ti.com). In the upper right-hand corner, click the "Alert me" button. This registers you to receive a weekly digest of product information that has changed (if any). For change details, check the revision history of any revised document.

## 8.5 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI Embedded Processors Wiki** *Texas Instruments Embedded Processors Wiki*.

Established to help developers get started with Embedded Processors from Texas Instruments and to foster innovation and growth of general knowledge about the hardware and software surrounding these devices.

## 8.6 Trademarks

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## 8.7 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## 8.8 Export Control Notice

Recipient agrees to not knowingly export or re-export, directly or indirectly, any product or technical data (as defined by the U.S., EU, and other Export Administration Regulations) including software, or any controlled product restricted by other applicable national regulations, received from disclosing party under nondisclosure obligations (if any), or any direct product of such technology, to any destination to which such export or re-export is restricted or prohibited by U.S. or other applicable laws, without obtaining prior authorization from U.S. Department of Commerce and other competent Government authorities to the extent required by those laws.

## 8.9 Glossary

**TI Glossary** This glossary lists and explains terms, acronyms, and definitions.

## 9 Mechanical Packaging Information

The following pages include mechanical packaging information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

### 9.1 Mechanical Data

## PACKAGING INFORMATION

| Orderable part number | Status<br>(1) | Material type<br>(2) | Package   Pins    | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6)              |
|-----------------------|---------------|----------------------|-------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|----------------------------------|
| TDA2PSXTQABZQ1        | Active        | Production           | FCCSP (ABZ)   760 | 60   JEDEC TRAY (5+1) | Yes         | Call TI                              | Level-3-250C-168 HR               | -40 to 125   | TDA2PSXTQABZQ1<br>941<br>941 ABZ |
| TDA2PSXTQABZRQ1       | Active        | Production           | FCCSP (ABZ)   760 | 400   LARGE T&R       | Yes         | Call TI                              | Level-3-250C-168 HR               | -40 to 125   | TDA2PSXTQABZQ1<br>941<br>941 ABZ |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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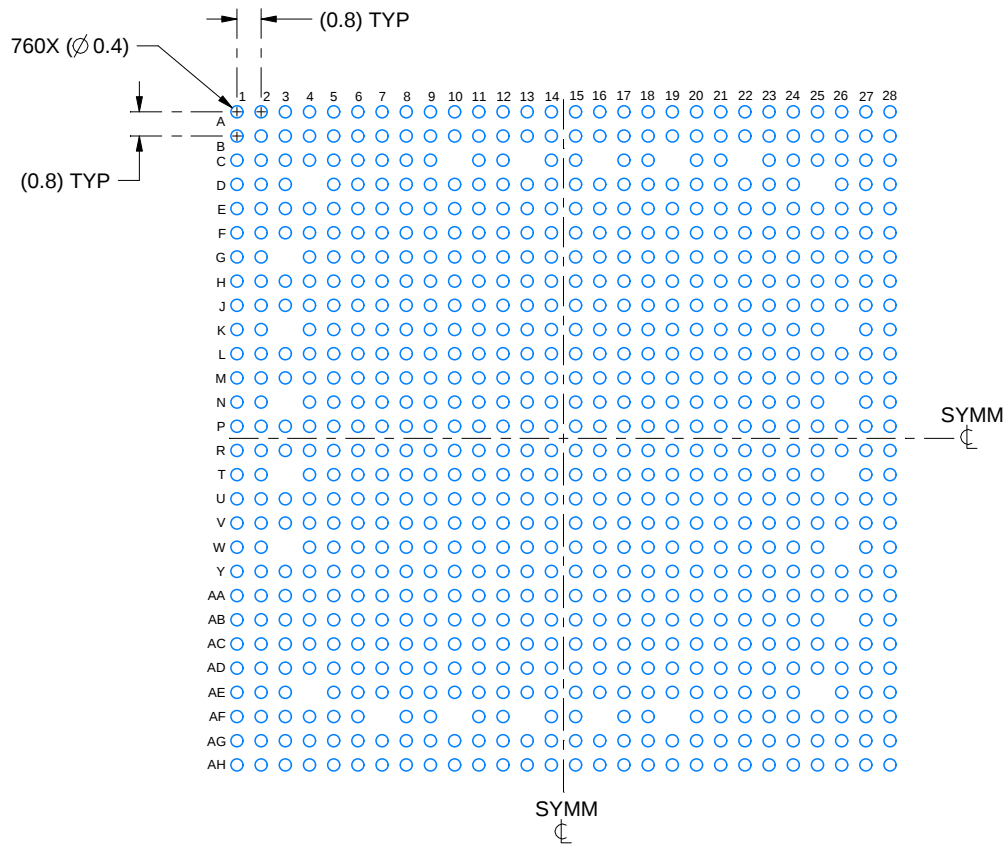


# EXAMPLE BOARD LAYOUT

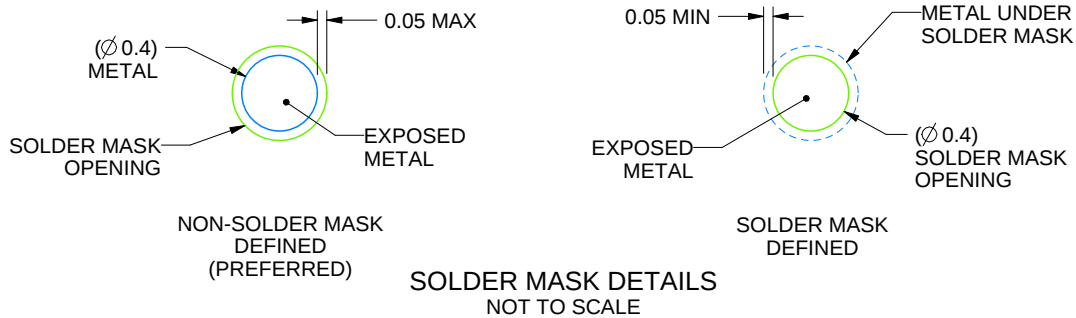
ABZ0760A

FCBGA - 1.63 mm max height

BALL GRID ARRAY



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 4X



4223581/B 01/2019

NOTES: (continued)

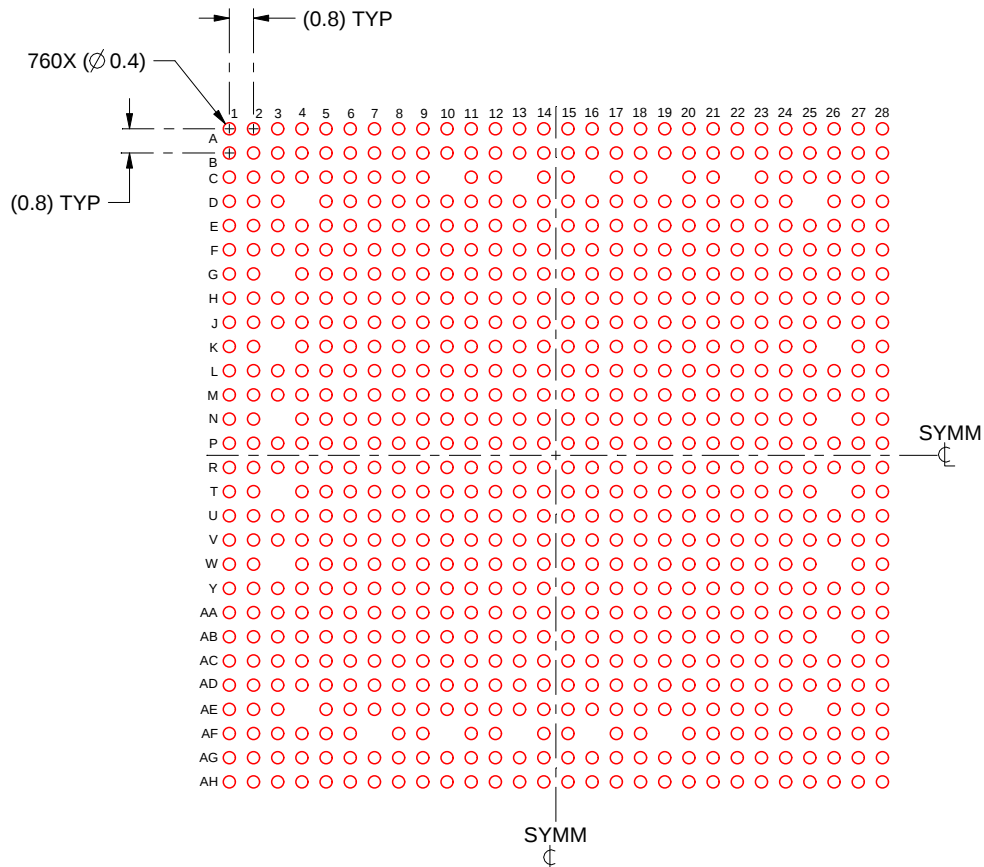
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SPRU811 ([www.ti.com/lit/spru811](http://www.ti.com/lit/spru811)).

# EXAMPLE STENCIL DESIGN

ABZ0760A

FCBGA - 1.63 mm max height

BALL GRID ARRAY



SOLDER PASTE EXAMPLE  
 BASED ON 0.15 mm THICK STENCIL  
 SCALE: 4X

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NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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Last updated 10/2025