# MSPM0G511x Mixed-Signal Microcontrollers With USB 2.0-FS Interface

## 1 Features

- **Core**
  - Arm® 32-bit Cortex®-M0+ CPU with memory protection unit, frequency up to 80 MHz
- PSA-L1 Certification targeted
- **Operating characteristics**
  - Extended temperature: –40°C up to 125°C
  - Wide supply voltage range: 1.62V to 3.6V
- **Memories**
  - Up to 128KB of flash memory with error correction code (ECC)
    - Dual-bank with address swap for OTA updates
  - 8KB data flash bank with ECC protection
  - Up to 32kB SRAM with ECC protection or hardware parity
- **High-performance analog peripherals**
  - One 12-bit 1.6Msps analog-to-digital converter (ADC) with up to 26 external channels
    - Configurable 1.6Msps with VREF1 or 0.9Msps with VREF2
    - 14-bit effective resolution at 100ksps with hardware averaging
  - One high-speed comparator (COMP) with integrated 8-bit reference DAC
    - 32ns propagation delay in high-speed mode
    - Support low-power mode operation down to <1µA
  - Programmable analog connections between ADC and COMP
  - Two voltage references (VREF)
    - VREF1: Configurable 1.4V or 2.5V internal voltage reference (with external VREF cap)
    - VREF2: Configurable 1.4V or 2.5V internal voltage reference (cap-less)
  - Integrated temperature sensor
- **Optimized low-power modes**
  - RUN: 103µA/MHz (CoreMark)
  - SLEEP: 34µA/MHz
  - STOP: 199µA at 4MHz
  - STANDBY: 1.5µA at 32kHz with RTC and full SRAM and state retention
  - SHUTDOWN: 88nA with IO wake-up capability
- **Intelligent digital peripherals**
  - 12-channel DMA controller
  - Four timers support up to 14 PWM channels
    - Two 16-bit general-purpose timers
    - One 16-bit general-purpose timer supports low-power operation in STANDBY mode
    - One 16-bit advanced timer with deadband support and complimentary outputs up to 8 PWM channels
  - One basic software timer including 4 independent configurable 16-bit counters
    - Ability to daisy-chain 2 of the 16-bit counters to form a 32-bit counter
    - Ability to generate 2x interrupt driven PWMs
  - Two windowed watchdog timers (WWDT), one independent watchdog timer (IWDT)
  - RTC with alarm and calendar mode
- **Enhanced communication interfaces**
  - Four configurable serial interfaces (UNICOMM)
    - Two supporting UART (LIN) or $I^2C$ (SMBus/PMBus)
    - One supporting UART or SPI
    - One supporting SPI interface up to 32Mbits/s
  - One USB2.0 interface supports full-speed (12-Mbps) compliant device and host mode functionality
    - Crystal-less USB device operation
    - Up to 8 bi-directional endpoints
  - One digital audio interface supporting several standardized serial interfaces to audio device
    - Transfer modes support
      - Controller transmitter / receiver
      - Target transmitter / receiver
    - Formats support
      - Standard (UM11732) I2S
      - Codec LSB / MSB Justified
      - DSP serial interface format that supports up to eight audio channels per data pin
      - PCM (short and long frame)
      - TDM Classic/I2S/Left Justified/Right Justified Formats up to 8 slots per frame
- **Clock system**
  - Internal 4 to 32MHz oscillator (SYSOSC) with up to ±1.2% accuracy
  - Phase-locked loop (PLL) up to 80 MHz
  - Internal 60MHz USB FLL oscillator with ±0.25% accuracy
  - Internal 32kHz low-frequency oscillator (LFOSC) with ±3% accuracy
  - External 4 to 48MHz crystal oscillator (HFXT)
  - External 32kHz crystal oscillator (LFXT)
  - External clock input
- **Security**
  - AES accelerator with support for GCM/GMAC, CCM/CBC-MAC, CBC, CTR
  - Secure key storage for up to four AES keys

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. UNLESS OTHERWISE NOTED, this document contains PRODUCTION DATA.

  - Flexible firewalls for protecting code and data
  - Cyclic redundancy checker (CRC-16, CRC-32)
- **Flexible I/O features**
  - Up to 59 total GPIOs
    - Two 5V-tolerant open-drain IOs
    - Three high-drive IOs with 20mA drive strength
    - Two high-speed IOs
- **Development support**
  - 2-pin serial wire debug (SWD)
- **Package options**
  - 64-pin LQFP (PM) (0.5mm pitch)
  - 48-pin LQFP (PT) (0.5mm pitch)
  - 48-pin VQFN (RGZ) (0.5mm pitch)
  - 32-pin VQFN (RHB) (0.5mm pitch)
  - 28-pin DSBGA (YCJ) (0.35mm pitch) - Preview
  - 28-pin WQFN (RUY) (0.4mm pitch)
  - 24-pin VQFN (RGE) (0.5mm pitch)
  - 20-pin VSSOP (DGS) (0.5mm pitch)
- **Family members** (also see *Device Comparison*)
  - MSPM0G5117: 128KB flash, 32KB RAM
  - MSPM0G5116: 64KB flash, 32KB RAM
  - MSPM0G5115: 32KB flash, 16KB RAM
- **Development kits and software** (also see *Tools and Software*)
  - LP-MSPM0G5187 LaunchPad™ development kit
  - MSPM0 Software Development Kit (SDK)

## 2 Applications

- Home Appliances
- Medical and Healthcare
- Building Automation
- Grid Infrastructure
- Mobile Phones
- Wearables
- PC Keyboard and Mouse
- E-cigarettes

## 3 Description

MSPM0G511x microcontrollers (MCUs) are part of the MSP highly integrated, ultra-low-power 32-bit MCU family based on the enhanced Arm® Cortex®-M0+ 32-bit core platform, operating at up to 80MHz frequency. These MCUs offer a blend of cost optimization and design flexibility for applications requiring up to 128KB of flash memory in small packages or high pin count packages (up to 64 pins). These devices include USB2.0-FS interface, digital audio interface, cybersecurity enablers, high performance integrated analog, and provide excellent low power performance across the operating temperature range.

Up to 128KB of embedded flash program memory with built-in error correction code (ECC) and up to 32KB SRAM with ECC and parity protection is provided. The flash memory is organized into two main banks to support field firmware updates, with address swap support provided between the two main banks.

A USB 2.0 full-speed interface (with integrated PHY, clock source, and termination resistors) is provided to support compliant host-mode and crystal-less device-mode functionality. Four configurable serial interface modules (UNICOMM) are provided, supporting up to three UART, two I2C, or two SPI. A digital audio interface is provided for a variety of audio applications and support multiple protocols such as I2S and TDM.

Flexible cybersecurity enablers can be used to support secure boot, secure in-field firmware updates, IP protection (execute-only memory), key storage, and more. Hardware acceleration is provided for a variety of AES symmetric cipher modes. The cybersecurity architecture is pending Arm® PSA Level 1 certification.

A set of high performance analog modules is provided, such as one sampling 12-bit 1.6Msps ADCs supporting up to 26 external channels, two on-chip voltage references (1.4V or 2.5V), and one high speed comparator with built-in 8-bit reference DAC.

The TI MSPM0 family of low-power MCUs consists of devices with varying degrees of analog and digital integration allowing for customers find the MCU that meets their project's needs. The MSPM0 MCU platform combines the Arm Cortex-M0+ platform with a holistic ultra-low-power system architecture, allowing system designers to increase performance while reducing energy consumption.

MSPM0G511x MCUs are supported by an extensive hardware and software ecosystem with reference designs and code examples to get the design started quickly. Development kits include a LaunchPad available for purchase. TI also provides a free MSPM0 Software Development Kit (SDK), which is available as a component of Code Composer Studio™ IDE desktop and cloud version within the TI Resource Explorer. MSPM0 MCUs are also supported by extensive online collateral, training with MSP Academy, and online support through the TI E2E™ support forums.


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For complete module descriptions, see the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

**CAUTION**

System-level ESD protection must be applied in compliance with the device-level ESD specification to prevent electrical overstress or disturbing of data or code memory. See *MSP430™ System-Level ESD Considerations* for more information. The principles in this application note are applicable to MSPM0 MCUs.

**Device Information**

| PART NUMBER | PACKAGE(1) | PACKAGE SIZE(2) |
|---|---|---|
| MSPM0G5115SPMR | PM (LQFP, 64) | 12mm x 12mm |
| MSPM0G5116SPMR | | |
| MSPM0G5117SPMR | | |
| MSPM0G5115SPTR | PT (LQFP, 48) | 9mm x 9mm |
| MSPM0G5116SPTR | | |
| MSPM0G5117SPTR | | |
| MSPM0G5115SRGZR | RGZ (VQFN, 48) | 7mm x 7mm |
| MSPM0G5116SRGZR | | |
| MSPM0G5117SRGZR | | |
| MSPM0G5115SRHBR | RHB (VQFN, 32) | 5mm x 5mm |
| MSPM0G5116SRHBR | | |
| MSPM0G5117SRHBR | | |
| MSPM0G5115S28YCJR | YCJ (DSBGA, 28) | 2.556mm x 1.637mm |
| MSPM0G5116S28YCJR | | |
| MSPM0G5117S28YCJR | | |
| MSPM0G5115SRUYR | RUY (WQFN, 28) | 4mm x 4mm |
| MSPM0G5116SRUYR | | |
| MSPM0G5117SRUYR | | |
| MSPM0G5115SRGER | RGE (VQFN, 24) | 4mm x 4mm |
| MSPM0G5116SRGER | | |
| MSPM0G5117SRGER | | |
| MSPM0G5115SDGS20R | DGS (VSSOP, 20) | 5.1mm x 4.9mm |
| MSPM0G5116SDGS20R | | |
| MSPM0G5117SDGS20R | | |

(1) For more information, see Section 12.
(2) The package size (length x width) is a nominal value and includes pins, where applicable

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# 4 Functional Block Diagram

Figure 4-1 shows the MSPM0G511x functional block diagram.

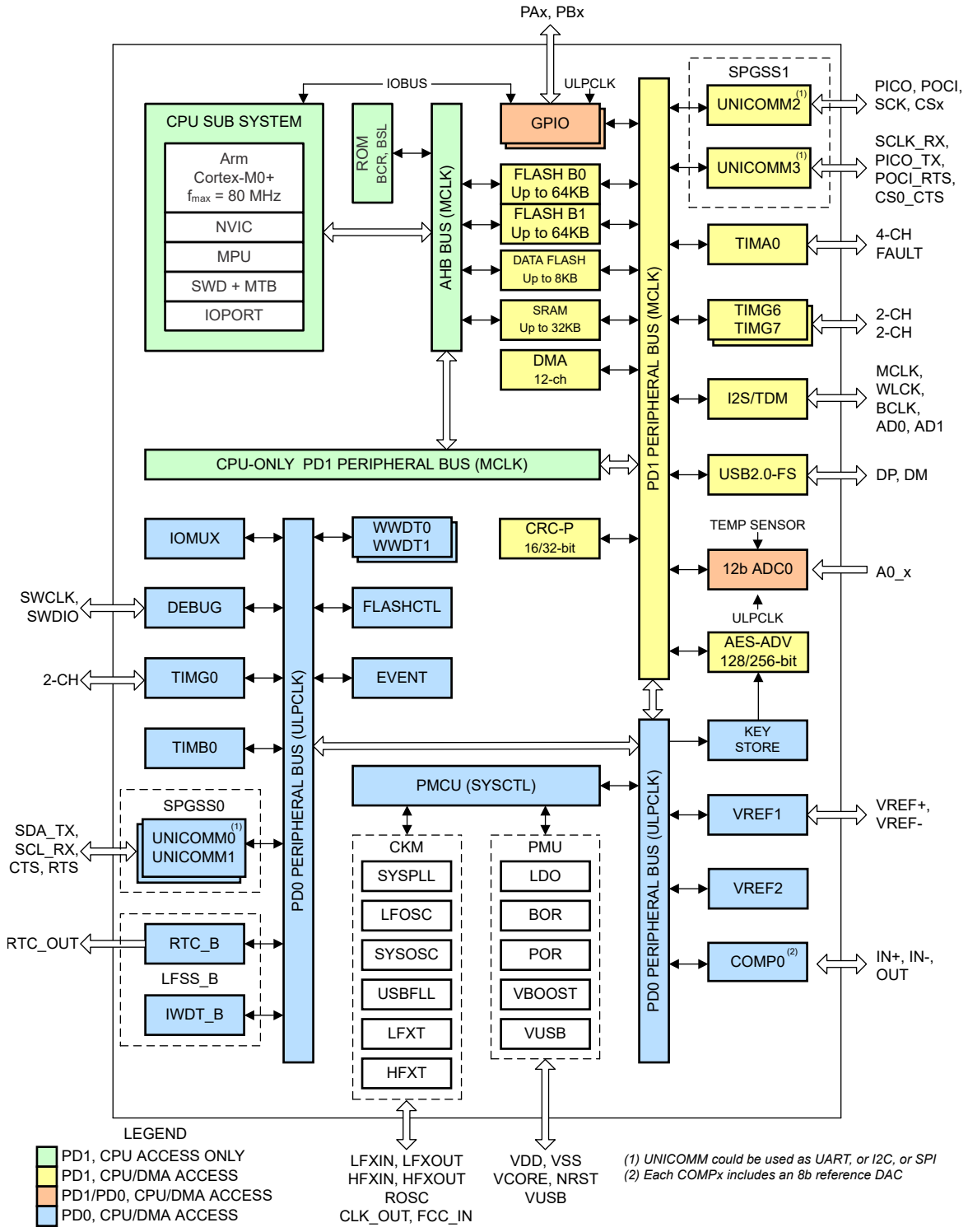



**Figure 4-1. MSPM0G511x Functional Block Diagram**


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# 5 Device Comparison

The following table summarizes the features of each device that is described in this data sheet.

**Table 5-1. Device Comparison Table**

| DEVICE NAME [1] [4] | FLASH / SRAM (KB) | QUAL [2] | USB2.0-FS / I2S | UART/I2C/SPI | ADC CHAN | GPIO | PACKAGE [3] |
|---|---|---|---|---|---|---|---|
| MSPM0G5115SPMR | 32 / 16 | S | 1 / 1 | 3/2/2 | 26 | 59 | 64 LQFP (0.5-mm pitch) [12mm x 12mm] |
| MSPM0G5116SPMR | 64 / 32 | S | 1 / 1 | 3/2/2 | 26 | 59 | |
| MSPM0G5117SPMR | 128 / 32 | S | 1 / 1 | 3/2/2 | 26 | 59 | |
| MSPM0G5115SPTR | 32 / 16 | S | 1 / 1 | 3/2/2 | 20 | 43 | 48 LQFP (0.5-mm pitch) [9mm x 9mm] |
| MSPM0G5116SPTR | 64 / 32 | S | 1 / 1 | 3/2/2 | 20 | 43 | |
| MSPM0G5117SPTR | 128 / 32 | S | 1 / 1 | 3/2/2 | 20 | 43 | |
| MSPM0G5115SRGZR | 32 / 16 | S | 1 / 1 | 3/2/2 | 20 | 43 | 48 VQFN (0.5-mm pitch) [7mm x 7mm] |
| MSPM0G5116SRGZR | 64 / 32 | S | 1 / 1 | 3/2/2 | 20 | 43 | |
| MSPM0G5117SRGZR | 128 / 32 | S | 1 / 1 | 3/2/2 | 20 | 43 | |
| MSPM0G5115SRHBR | 32 / 16 | S | 1 / 1 | 3/2/2 | 12 | 27 | 32 VQFN (0.5-mm pitch) [5mm x 5mm] |
| MSPM0G5116SRHBR | 64 / 32 | S | 1 / 1 | 3/2/2 | 12 | 27 | |
| MSPM0G5117SRHBR | 128 / 32 | S | 1 / 1 | 3/2/2 | 12 | 27 | |
| MSPM0G5115S28YCJR | 32 / 16 | S | 1 / 1 | 3/2/2 | 10 | 23 | 28 DSBGA (0.35-mm pitch) [2.556mm x 1.637mm] |
| MSPM0G5116S28YCJR | 64 / 32 | S | 1 / 1 | 3/2/2 | 10 | 23 | |
| MSPM0G5117S28YCJR | 128 / 32 | S | 1 / 1 | 3/2/2 | 10 | 23 | |
| MSPM0G5115SRUYR | 32 / 16 | S | 1 / 1 | 3/2/2 | 10 | 23 | 28 WQFN (0.4-mm pitch) [4mm x 4mm] |
| MSPM0G5116SRUYR | 64 / 32 | S | 1 / 1 | 3/2/2 | 10 | 23 | |
| MSPM0G5117SRUYR | 128 / 32 | S | 1 / 1 | 3/2/2 | 10 | 23 | |
| MSPM0G5115SRGER | 32 / 16 | S | 1 / 1 | 3/2/2 | 8 | 19 | 24 VQFN (0.5-mm pitch) [4mm x 4mm] |
| MSPM0G5116SRGER | 64 / 32 | S | 1 / 1 | 3/2/2 | 8 | 19 | |
| MSPM0G5117SRGER | 128 / 32 | S | 1 / 1 | 3/2/2 | 8 | 19 | |
| MSPM0G5115SDGS20R | 32 / 16 | S | 1 / 1 | 3/2/2 | 6 | 15 | 20 VSSOP (0.5-mm pitch) [5.1mm x 4.9mm] |
| MSPM0G5116SDGS20R | 64 / 32 | S | 1 / 1 | 3/2/2 | 6 | 15 | |
| MSPM0G5117SDGS20R | 128 / 32 | S | 1 / 1 | 3/2/2 | 6 | 15 | |


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## 5.1 Device Comparison Chart

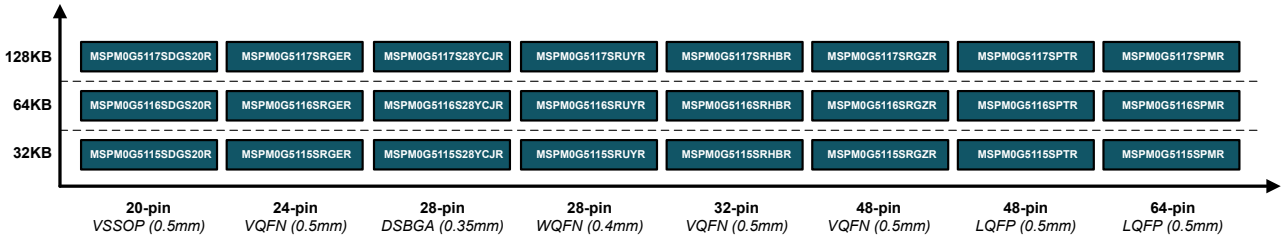



**Figure 5-1. Device Comparison Chart**

# 6 Pin Configuration and Functions

The System Configuration tool provides a graphical interface to enable, configurable, and generate initialization code for pin multiplexing and simplifying pin settings. The pin diagrams shown in the data sheet show the primary peripheral functions, some of the integrated device features, and available clock signals to simplify the device pinout.

For full descriptions of the pin functions, see the *Pin Attributes* and *Signal Descriptions* sections.

## 6.1 Pin Diagrams

For full pin configuration and functions for each package option, refer to Pin Attributes and Signal Descriptions.

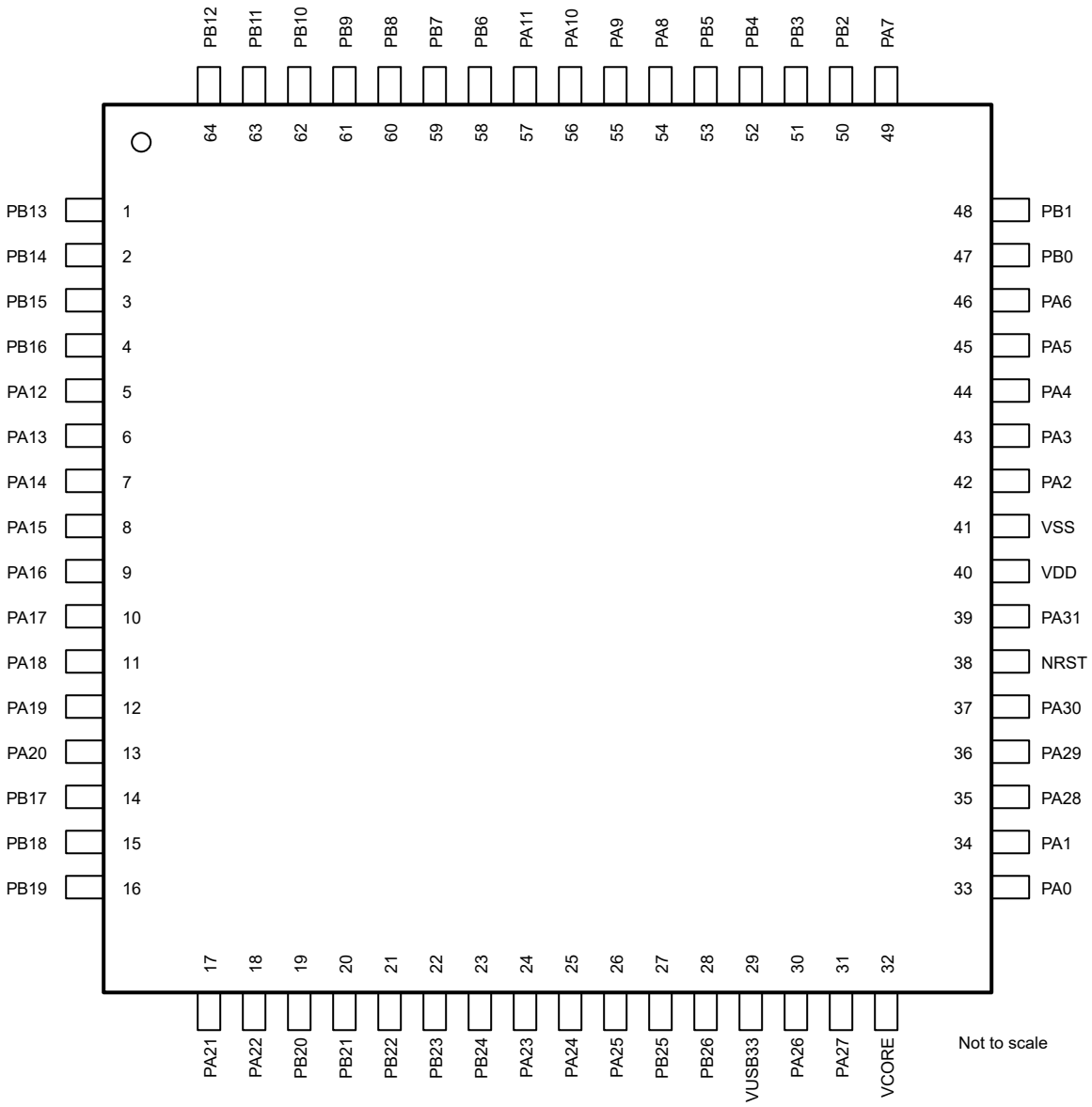



**Figure 6-1. 64-pin PM (0.5mm) (LQFP) Package Diagram**


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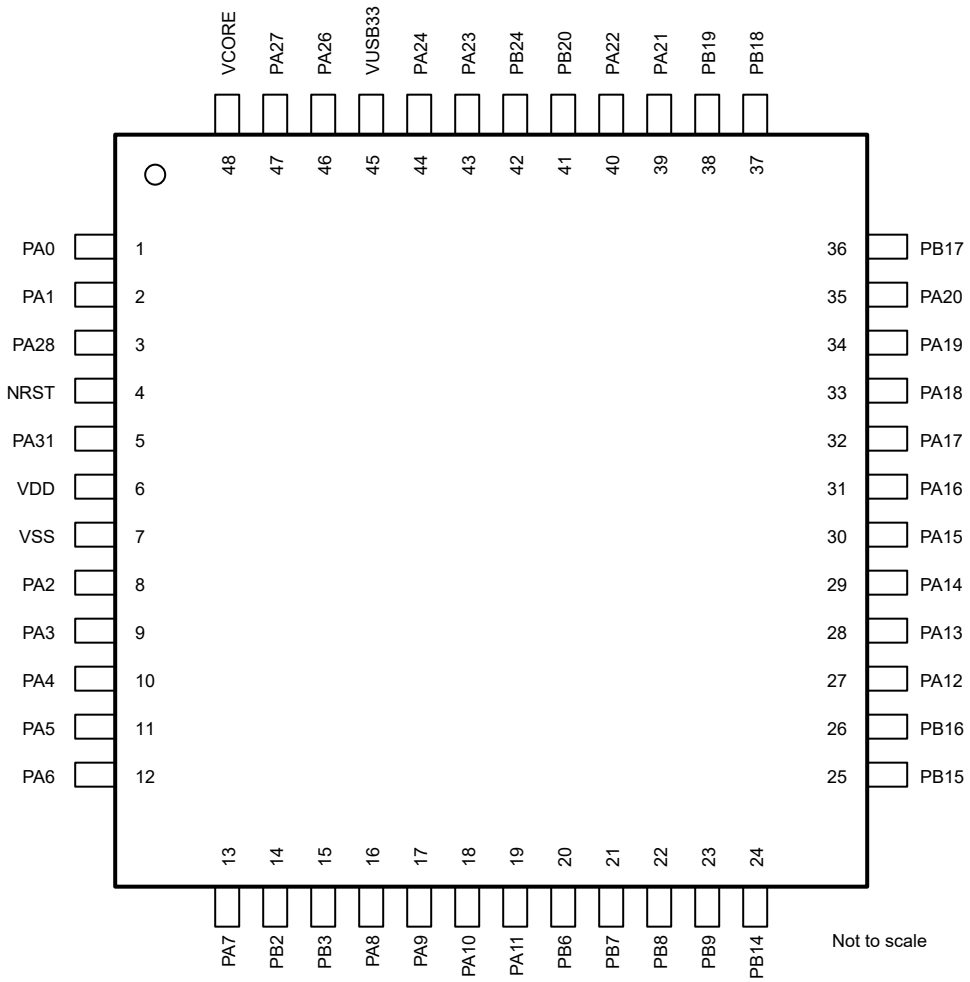



**Figure 6-2. 48-pin PT (0.5mm) (LQFP) Package Diagram**

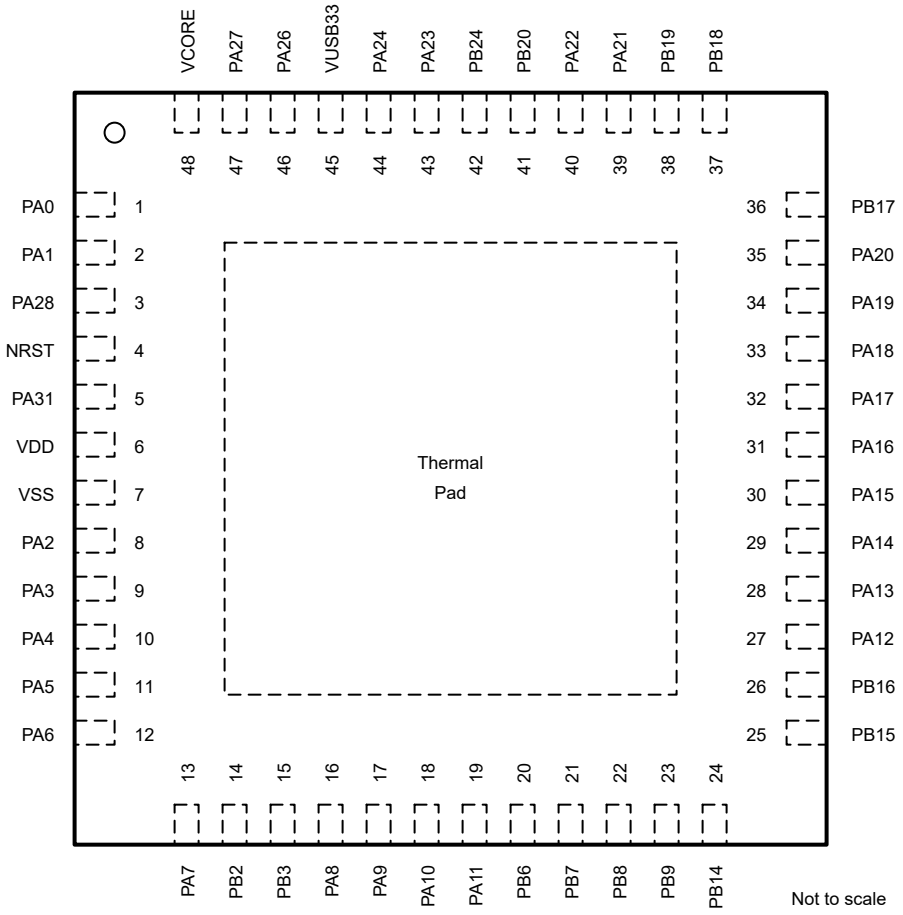



**Figure 6-3. 48-pin RGZ (0.5mm) (VQFN) Package Diagram**


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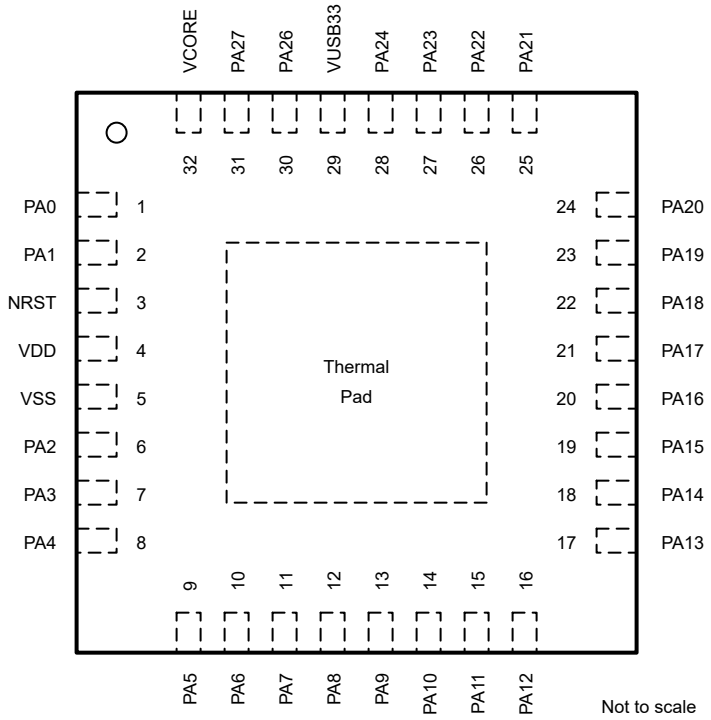



**Figure 6-4. 32-pin RHB (0.5mm) (VQFN) Package Diagram**

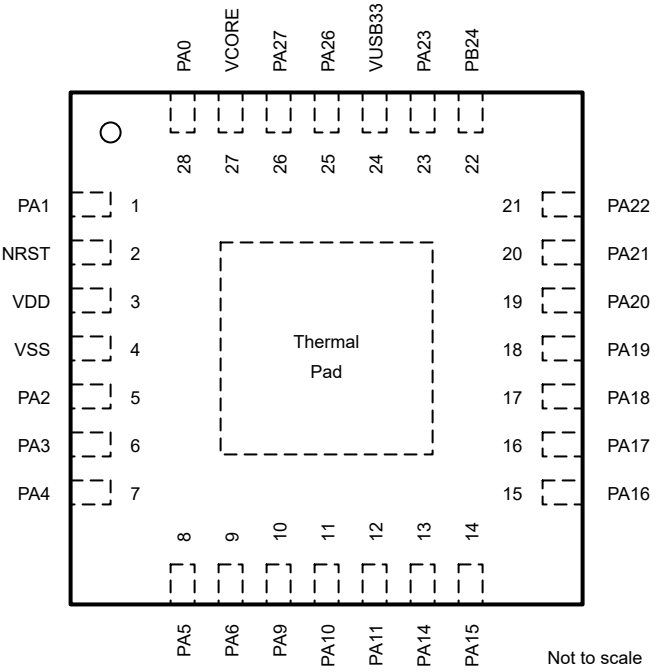



**Figure 6-5. 28-pin RUY (0.5mm) (WQFN) Package Diagram**

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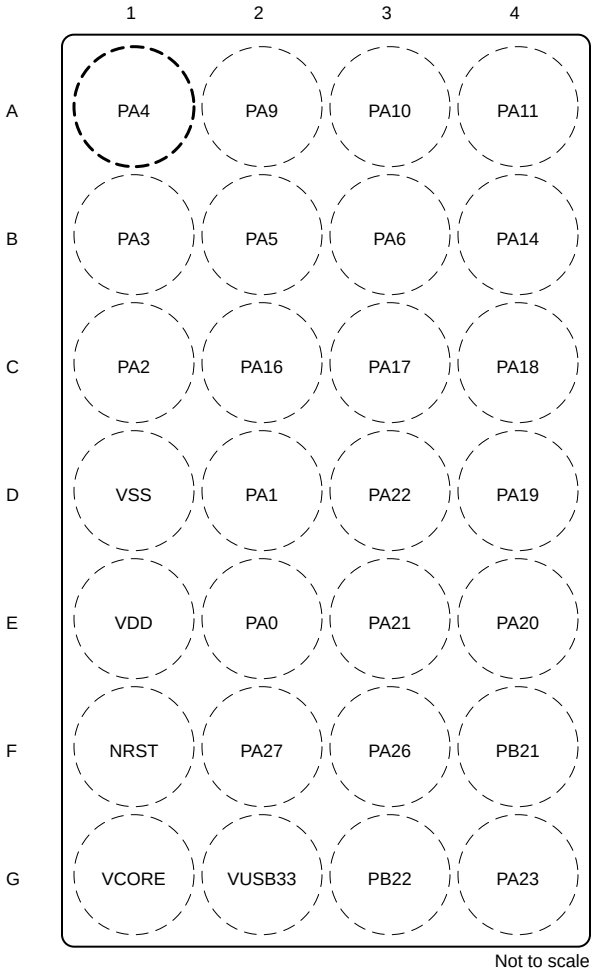



**Figure 6-6. 28-pin YCJ (0.35mm) (DSBGA) Package Diagram (Ball Mount Facing Down View)**


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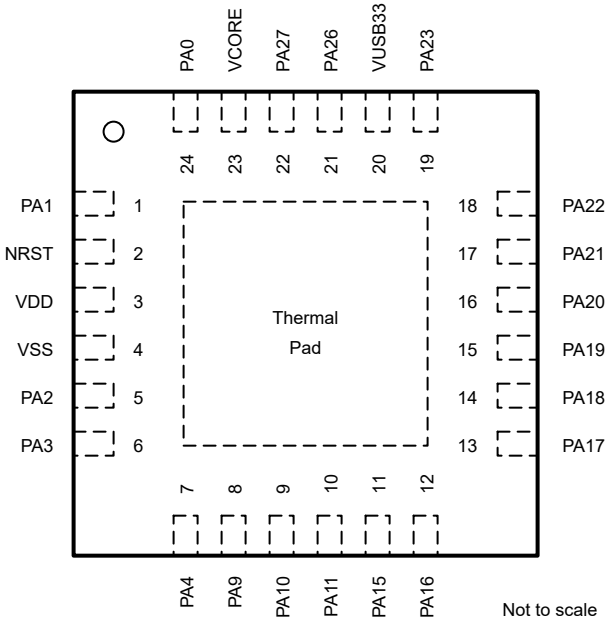



**Figure 6-7. 24-pin RGE (0.5mm) (VQFN) Package Diagram**

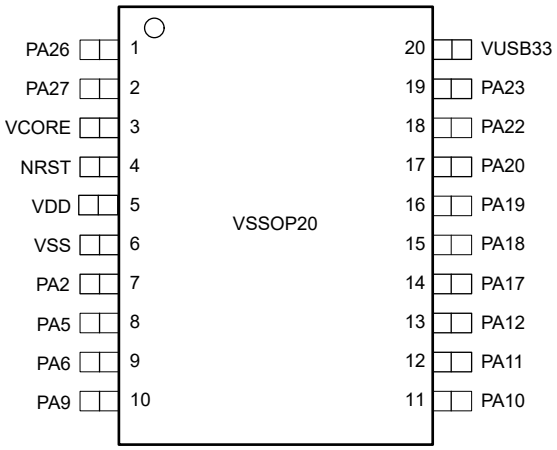



**Figure 6-8. 20-pin DGS (0.5mm) (VSSOP) Package Diagram**

## 6.2 Pin Attributes

The following table describes the functions available on every pin for each device package.

**Note**

Each digital I/O on a device is mapped to a specific Pin Control Management Register (PINCMx) that lets users configure the desired *Pin Function* using the PINCM.PF control bits.

Each digital I/O on a device is mapped to a specific Pin Control Management Register (PINCMx) which allows users to configure the desired Pin Function using the PINCM.PF control bits. The IOMUX only supports connecting one IOMUX-managed digital function to the pin at the same time. The PINCM.PF and PINCM.PC in IOMUX are recommended to be set to 0 when non-IOMUX managed functions (such as analog connections) are intended to be used on a pin. However, non-IOMUX managed signals (such as analog inputs and WAKE inputs) can be enabled on a pin at the same time that an IOMUX managed digital function is enabled on the pin,

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provided there is no contention between the functions. In this case, the designer must verify that no contention exists between the functions enabled on each pin.

**Table 6-1. Digital IO Features by IO Type**

| BUFFER TYPE | INVERSION CONTROL | DRIVE STRENGTH CONTROL | HYSTERESIS CONTROL | PULLUP RESISTOR | PULLDOWN RESISTOR | WAKEUP LOGIC | Power Domain |
|---|---|---|---|---|---|---|---|
| SDIO (standard drive) | Y | | | Y | Y | | VDD |
| SDIO (standard drive) with wake | Y | | | Y | Y | Y | VDD |
| HDIO (High drive) | Y | Y | | Y | Y | Y | VDD |
| HSIO (High speed) | Y | Y | | Y | Y | Y | VDD |
| ODIO (5V-tolerant open drain) | Y | | Y | | Y | Y | VDD |
| USBIO (USB2.0-FS) | Y | | | Y | Y | | VUSB33 |

**Table 6-2. Pin Attributes**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 2 | F1 | 2 | 3 | 4 | 4 | 38 | NRST | NRST | (Non-IOMUX 1) 0 | I | RESET |
| | | | | | | | | | WAKE | (Non-IOMUX 2) 0 | I | |
| 28 | E2 | 24 | 1 | 1 | 1 | 33 | PA0 PINCM1 0x40428000 | PA0 | 1 | IO | ODIO (5V-tol) | |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | FCC_IN | 3 | I | |
| | | | | | | | | | TIMA0_C0 | 4 | IO | |
| | | | | | | | | | TIMG0_C0 | 5 | IO | |
| | | | | | | | | | TIMA_FAL1 | 6 | I | |
| | | | | | | | | | UC0_SDA_TX | 7 | IO | |
| | | | | | | | | | BSLSDA | (Non-IOMUX 1) 0 | IOD | |
| | | | | | | | | | WAKE | (Non-IOMUX 2) 0 | I | |
| 1 | D2 | 1 | 2 | 2 | 2 | 34 | PA1 PINCM2 0x40428004 | PA1 | 1 | IO | ODIO (5V-tol) | |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_CS3 | 3 | O | |
| | | | | | | | | | TIMA0_C1 | 4 | IO | |
| | | | | | | | | | TIMG0_C1 | 5 | IO | |
| | | | | | | | | | TIMA_FAL2 | 6 | I | |
| | | | | | | | | | UC0_SCL_RX | 7 | IO | |
| | | | | | | | | | BSLSCL | (Non-IOMUX 1) 0 | IOD | |
| | | | | | | | | | WAKE | (Non-IOMUX 2) 0 | I | |
| 7 | 5 | C1 | 5 | 6 | 8 | 8 | 42 | PA2 PINCM7 0x40428018 | PA2 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_RTS | 2 | O | |
| | | | | | | | | | UC2_CS1 | 3 | O | |
| | | | | | | | | | TIMG7_C1 | 4 | IO | |
| | | | | | | | | | TIMA0_C0 | 5 | IO | |
| | | | | | | | | | TIMA0_C3N | 6 | O | |
| | | | | | | | | | TIMA0_C2N | 7 | O | |
| | | | | | | | | | TIMA_FAL0 | 8 | I | |
| | | | | | | | | | TIMA_FAL1 | 9 | I | |
| | | | | | | | | | UC3_CS0_CTS | 10 | IO | |
| | | | | | | | | | ROSC | (Non-IOMUX 1) 0 | A | |


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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | B1 | 6 | 7 | 9 | 9 | 43 | PA3<br>PINCM8<br>0x4042801c | PA3 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | UC2_CS1 | 3 | O | |
| | | | | | | | | | UC2_CS3 | 4 | O | |
| | | | | | | | | | TIMA0_C1 | 5 | IO | |
| | | | | | | | | | COMP0_OUT | 6 | O | |
| | | | | | | | | | TIMG7_C0 | 7 | IO | |
| | | | | | | | | | TIMA0_C2 | 8 | IO | |
| | | | | | | | | | UC1_CTS | 9 | I | |
| | | | | | | | | | LFXIN | (Non-IOMUX 1) 0 | A | |
| | 7 | A1 | 7 | 8 | 10 | 10 | 44 | PA4<br>PINCM9<br>0x40428020 | PA4 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_POCI | 3 | I | |
| | | | | | | | | | UC2_CS0 | 4 | O | |
| | | | | | | | | | TIMA0_C1N | 5 | O | |
| | | | | | | | | | LFCLK_IN | 6 | I | |
| | | | | | | | | | TIMG7_C1 | 7 | IO | |
| | | | | | | | | | TIMA0_C3 | 8 | IO | |
| | | | | | | | | | LFXOUT | (Non-IOMUX 1) 0 | A | |
| 8 | 8 | B2 | | 9 | 11 | 11 | 45 | PA5<br>PINCM10<br>0x40428024 | PA5 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | UC2_PICO | 3 | O | |
| | | | | | | | | | UC0_CTS | 4 | I | |
| | | | | | | | | | TIMG0_C0 | 5 | IO | |
| | | | | | | | | | FCC_IN | 6 | I | |
| | | | | | | | | | TIMG6_C0 | 7 | IO | |
| | | | | | | | | | TIMA_FAL1 | 8 | I | |
| | | | | | | | | | UC3_POCI_RTS | 9 | IO | |
| | | | | | | | | | HFXIN | (Non-IOMUX 1) 0 | A | |
| 9 | 9 | B3 | | 10 | 12 | 12 | 46 | PA6<br>PINCM11<br>0x40428028 | PA6 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_SCK | 3 | IO | |
| | | | | | | | | | UC0_RTS | 4 | O | |
| | | | | | | | | | TIMG0_C1 | 5 | IO | |
| | | | | | | | | | HFCLK_IN | 6 | I | |
| | | | | | | | | | TIMG6_C1 | 7 | IO | |
| | | | | | | | | | TIMA_FAL0 | 8 | I | |
| | | | | | | | | | TIMA0_C2N | 9 | O | |
| | | | | | | | | | UC3_PICO_TX | 10 | IO | |
| | | | | | | | | | HFXOUT | (Non-IOMUX 1) 0 | A | |

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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | PA7 | 1 | IO | |
| | | | | | | | | | UC2_POCI | 2 | I | |
| | | | | | | | | | UC2_CS2 | 3 | O | |
| | | | | | | | | PA7 | COMP0_OUT | 4 | O | |
| | | | | 11 | 13 | 13 | 49 | PINCM14 | TIMA0_C2 | 5 | IO | SDIO (standard) |
| | | | | | | | | 0x40428034 | TIMG7_C1 | 6 | IO | |
| | | | | | | | | | CLK_OUT | 7 | O | |
| | | | | | | | | | TIMA0_C1 | 8 | IO | |
| | | | | | | | | | FCC_IN | 9 | I | |
| | | | | | | | | | PA8 | 1 | IO | |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | UC2_CS0 | 3 | O | |
| | | | | | | | | | UC0_SDA_TX | 4 | IO | |
| | | | | | | | | PA8 | TIMA0_C0 | 5 | IO | |
| | | | | 12 | 16 | 16 | 54 | PINCM19 | TIMA_FAL2 | 6 | I | SDIO (standard) |
| | | | | | | | | 0x40428048 | TIMA_FAL0 | 7 | I | |
| | | | | | | | | | UC2_CS3 | 8 | O | |
| | | | | | | | | | I2S0_WCLK | 9 | IO | |
| | | | | | | | | | UC0_RTS | 10 | O | |
| | | | | | | | | | HFCLK_IN | 11 | I | |
| | | | | | | | | | PA9 | 1 | IO | |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_PICO | 3 | O | |
| | | | | | | | | | UC0_SCL_RX | 4 | IO | |
| | | | | | | | | PA9 | TIMA0_C0N | 5 | O | |
| 10 | 10 | A2 | 8 | 13 | 17 | 17 | 55 | PINCM20 | CLK_OUT | 6 | O | HSIO (High-speed) |
| | | | | | | | | 0x4042804c | TIMA0_C1 | 7 | IO | |
| | | | | | | | | | RTC_OUT | 8 | O | |
| | | | | | | | | | I2S0_BCLK | 9 | IO | |
| | | | | | | | | | UC3_SCK_RX | 10 | IO | |
| | | | | | | | | | UC0_CTS | 11 | I | |
| | | | | | | | | | PA10 | 1 | IO | |
| | | | | | | | | | UC0_SDA_TX | 2 | IO | |
| | | | | | | | | | UC2_POCI | 3 | I | |
| | | | | | | | | | UC1_SDA_TX | 4 | IO | |
| | | | | | | | | PA10 | TIMA0_C2 | 5 | IO | |
| 11 | 11 | A3 | 9 | 14 | 18 | 18 | 56 | PINCM21 | CLK_OUT | 6 | O | HDIO (high-drive) |
| | | | | | | | | 0x40428050 | TIMG0_C0 | 7 | IO | |
| | | | | | | | | | TIMA_FAL1 | 8 | I | |
| | | | | | | | | | I2S0_AD0 | 9 | IO | |
| | | | | | | | | | UC3_PICO_TX | 10 | IO | |
| | | | | | | | | | BSLTX | (Non-IOMUX 1) 0 | O | |
| | | | | | | | | | WAKE | (Non-IOMUX 2) 0 | I | |


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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 12 | A4 | 10 | 15 | 19 | 19 | 57 | PA11<br>PINCM22<br>0x40428054 | PA11 | 1 | IO | HDIO (high-drive) |
| | | | | | | | | | UC0_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_SCK | 3 | IO | |
| | | | | | | | | | UC1_SCL_RX | 4 | IO | |
| | | | | | | | | | TIMA0_C2N | 5 | O | |
| | | | | | | | | | COMP0_OUT | 6 | O | |
| | | | | | | | | | TIMG0_C1 | 7 | IO | |
| | | | | | | | | | TIMA_FAL0 | 8 | I | |
| | | | | | | | | | I2S0_AD1 | 9 | IO | |
| | | | | | | | | | UC3_POCI_RTS | 10 | IO | |
| | | | | | | | | | BSLRX | (Non-IOMUX 1) 0 | I | |
| | | | | | | | | | WAKE | (Non-IOMUX 2) 0 | I | |
| | | | | | | | | | COMP0_DAC8 | (Non-IOMUX 3) 0 | O | |
| 13 | | | | 16 | 27 | 27 | 5 | PA12<br>PINCM34<br>0x40428084 | PA12 | 1 | IO | HSIO (High-speed) |
| | | | | | | | | | UC3_CS0_CTS | 2 | IO | |
| | | | | | | | | | UC2_SCK | 3 | IO | |
| | | | | | | | | | COMP0_OUT | 4 | O | |
| | | | | | | | | | TIMA0_C3 | 5 | IO | |
| | | | | | | | | | FCC_IN | 6 | I | |
| | | | | | | | | | TIMG0_C0 | 7 | IO | |
| | | | | | | | | | UC1_CTS | 8 | I | |
| | | | | | | | | | I2S0_BCLK | 9 | IO | |
| | | | | | | | | | UC0_RTS | 10 | O | |
| | | | | | | | | | UC2_CS0 | 11 | O | |
| | | | | | | | | | A0_18 | (Non-IOMUX 1) 0 | A | |
| | | | | 17 | 28 | 28 | 6 | PA13<br>PINCM35<br>0x40428088 | PA13 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_POCI_RTS | 2 | IO | |
| | | | | | | | | | UC2_POCI | 3 | I | |
| | | | | | | | | | UC3_SCK_RX | 4 | IO | |
| | | | | | | | | | TIMA0_C3N | 5 | O | |
| | | | | | | | | | RTC_OUT | 6 | O | |
| | | | | | | | | | TIMG0_C1 | 7 | IO | |
| | | | | | | | | | UC3_CS0_CTS | 8 | IO | |
| | | | | | | | | | I2S0_AD0 | 9 | IO | |
| | | | | | | | | | UC1_RTS | 10 | O | |
| | | | | | | | | | UC2_CS3 | 11 | O | |
| | | | | | | | | | A0_17 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | COMP0_IN2- | (Non-IOMUX 2) 0 | A | |
| | 13 | B4 | | 18 | 29 | 29 | 7 | PA14<br>PINCM36<br>0x4042808c | PA14 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_CTS | 2 | I | |
| | | | | | | | | | UC2_PICO | 3 | O | |
| | | | | | | | | | UC3_PICO_TX | 4 | IO | |
| | | | | | | | | | TIMG7_C0 | 5 | IO | |
| | | | | | | | | | CLK_OUT | 6 | O | |
| | | | | | | | | | TIMG6_C0 | 7 | IO | |
| | | | | | | | | | I2S0_AD1 | 9 | IO | |
| | | | | | | | | | A0_16 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | COMP0_IN2+ | (Non-IOMUX 2) 0 | A | |

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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | | 11 | 19 | 30 | 30 | 8 | PA15<br>PINCM37<br>0x40428090 | PA15 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_RTS | 2 | O | |
| | | | | | | | | | UC2_CS3 | 3 | O | |
| | | | | | | | | | UC1_SCL_RX | 4 | IO | |
| | | | | | | | | | TIMA0_C2 | 5 | IO | |
| | | | | | | | | | COMP0_OUT | 6 | O | |
| | | | | | | | | | UC1_RTS | 7 | O | |
| | | | | | | | | | I2S0_WCLK | 8 | IO | |
| | | | | | | | | | A0_15 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | COMP0_IN3+ | (Non-IOMUX 2) 0 | A | |
| | 15 | C2 | 12 | 20 | 31 | 31 | 9 | PA16<br>PINCM38<br>0x40428094 | PA16 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_CTS | 2 | I | |
| | | | | | | | | | UC3_POCI_RTS | 3 | IO | |
| | | | | | | | | | UC1_SDA_TX | 4 | IO | |
| | | | | | | | | | TIMA0_C2N | 5 | O | |
| | | | | | | | | | FCC_IN | 6 | I | |
| | | | | | | | | | UC1_CTS | 7 | I | |
| | | | | | | | | | COMP0_OUT | 8 | O | |
| | | | | | | | | | I2S0_MCLK | 9 | IO | |
| | | | | | | | | | A0_14 | (Non-IOMUX 1) 0 | A | |
| 14 | 16 | C3 | 13 | 21 | 32 | 32 | 10 | PA17<br>PINCM39<br>0x40428098 | PA17 | 1 | IO | SDIO (standard with wake) |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | UC3_SCK_RX | 3 | IO | |
| | | | | | | | | | UC1_SCL_RX | 4 | IO | |
| | | | | | | | | | TIMA0_C3 | 5 | IO | |
| | | | | | | | | | TIMG7_C0 | 6 | IO | |
| | | | | | | | | | UC2_CS1 | 7 | O | |
| | | | | | | | | | I2S0_WCLK | 8 | IO | |
| | | | | | | | | | WAKE | (Non-IOMUX 1) 0 | I | |
| | | | | | | | | | A0_13 | (Non-IOMUX 2) 0 | A | |
| | | | | | | | | | COMP0_IN1- | (Non-IOMUX 3) 0 | A | |
| 15 | 17 | C4 | 14 | 22 | 33 | 33 | 11 | PA18<br>PINCM40<br>0x4042809c | PA18 | 1 | IO | SDIO (standard with wake) |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC3_PICO_TX | 3 | IO | |
| | | | | | | | | | UC1_SDA_TX | 4 | IO | |
| | | | | | | | | | TIMA0_C3N | 5 | O | |
| | | | | | | | | | TIMG7_C1 | 6 | IO | |
| | | | | | | | | | UC2_CS0 | 7 | O | |
| | | | | | | | | | TIMA_FAL2 | 8 | I | |
| | | | | | | | | | I2S0_MCLK | 9 | IO | |
| | | | | | | | | | BSL_invoke | (Non-IOMUX 1) 0 | I | |
| | | | | | | | | | WAKE | (Non-IOMUX 2) 0 | I | |
| | | | | | | | | | A0_12 | (Non-IOMUX 3) 0 | A | |
| | | | | | | | | | COMP0_IN1+ | (Non-IOMUX 4) 0 | A | |


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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 18 | D4 | 15 | 23 | 34 | 34 | 12 | PA19<br>PINCM41<br>0x404280a0 | PA19 | 1 | IO | SDIO (standard) |
| | | | | | | | | | SWDIO | 2 | IO | |
| | | | | | | | | | UC3_POCI_RTS | 3 | IO | |
| | | | | | | | | | UC1_SDA_TX | 4 | IO | |
| | | | | | | | | | TIMA0_C2 | 5 | IO | |
| | | | | | | | | | TIMG0_C0 | 6 | IO | |
| | | | | | | | | | I2S0_AD0 | 7 | IO | |
| | | | | | | | | | A0_1 | (Non-IOMUX 1) 0 | A | |
| 17 | 19 | E4 | 16 | 24 | 35 | 35 | 13 | PA20<br>PINCM42<br>0x404280a4 | PA20 | 1 | IO | SDIO (standard) |
| | | | | | | | | | SWCLK | 2 | I | |
| | | | | | | | | | UC3_SCK_RX | 3 | IO | |
| | | | | | | | | | UC1_SCL_RX | 4 | IO | |
| | | | | | | | | | TIMA0_C2N | 5 | O | |
| | | | | | | | | | TIMG0_C1 | 6 | IO | |
| | | | | | | | | | UC3_CS0_CTS | 7 | IO | |
| | | | | | | | | | I2S0_AD1 | 8 | IO | |
| | | | | | | | | | A0_0 | (Non-IOMUX 1) 0 | A | |
| | 20 | E3 | 17 | 25 | 39 | 39 | 17 | PA21<br>PINCM46<br>0x404280b4 | PA21 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_PICO_TX | 2 | IO | |
| | | | | | | | | | UC2_CS3 | 3 | O | |
| | | | | | | | | | UC1_CTS | 4 | I | |
| | | | | | | | | | TIMA0_C0 | 5 | IO | |
| | | | | | | | | | TIMG6_C0 | 6 | IO | |
| | | | | | | | | | COMP0_OUT | 7 | O | |
| | | | | | | | | | I2S0_AD0 | 8 | IO | |
| | | | | | | | | | A0_8 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | VREF- | (Non-IOMUX 2) 0 | A | |
| 18 | 21 | D3 | 18 | 26 | 40 | 40 | 18 | PA22<br>PINCM47<br>0x404280b8 | PA22 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_SCK_RX | 2 | IO | |
| | | | | | | | | | UC2_CS2 | 3 | O | |
| | | | | | | | | | UC1_RTS | 4 | O | |
| | | | | | | | | | TIMA0_C0N | 5 | O | |
| | | | | | | | | | TIMG6_C1 | 6 | IO | |
| | | | | | | | | | TIMA0_C1 | 7 | IO | |
| | | | | | | | | | I2S0_BCLK | 8 | IO | |
| | | | | | | | | | CLK_OUT | 9 | O | |
| | | | | | | | | | A0_7 | (Non-IOMUX 1) 0 | A | |
| 19 | 23 | G4 | 19 | 27 | 43 | 43 | 24 | PA23<br>PINCM53<br>0x404280d0 | PA23 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_PICO_TX | 2 | IO | |
| | | | | | | | | | UC2_CS3 | 3 | O | |
| | | | | | | | | | UC3_CS0_CTS | 4 | IO | |
| | | | | | | | | | TIMA0_C3 | 5 | IO | |
| | | | | | | | | | TIMG0_C0 | 6 | IO | |
| | | | | | | | | | TIMG7_C0 | 7 | IO | |
| | | | | | | | | | I2S0_WCLK | 8 | IO | |
| | | | | | | | | | VREF+ | (Non-IOMUX 1) 0 | A | |

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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | PA24 | 1 | IO | |
| | | | | | | | | | UC3_POCI_RTS | 2 | IO | |
| | | | | | | | | | UC2_CS2 | 3 | O | |
| | | | | | | | | PA24 | UC3_SCK_RX | 4 | IO | |
| | | | | 28 | 44 | 44 | 25 | PINCM54 | TIMA0_C3N | 5 | O | SDIO (standard) |
| | | | | | | | | 0x404280d4 | TIMG0_C1 | 6 | IO | |
| | | | | | | | | | TIMG7_C1 | 7 | IO | |
| | | | | | | | | | I2S0_AD1 | 8 | IO | |
| | | | | | | | | | A0_3 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | PA25 | 1 | IO | |
| | | | | | | | | | UC3_SCK_RX | 2 | IO | |
| | | | | | | | | | UC2_CS3 | 3 | O | |
| | | | | | | | | PA25 | UC3_PICO_TX | 4 | IO | |
| | | | | | | | 26 | PINCM55 | TIMA0_C3 | 5 | IO | SDIO (standard) |
| | | | | | | | | 0x404280d8 | TIMA0_C1N | 6 | O | |
| | | | | | | | | | COMP0_OUT | 7 | O | |
| | | | | | | | | | A0_2 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | PA26 | 1 | IO | |
| | | | | | | | | | UC0_SDA_TX | 3 | IO | |
| | | | | | | | | | UC1_SCL_RX | 4 | IO | |
| | | | | | | | | PA26 | TIMG7_C0 | 5 | IO | |
| 1 | 25 | F3 | 21 | 30 | 46 | 46 | 30 | PINCM58 | FCC_IN | 6 | I | USBIO |
| | | | | | | | | 0x404280e4 | TIMA_FAL0 | 7 | I | |
| | | | | | | | | | UC3_PICO_TX | 8 | IO | |
| | | | | | | | | | BSLUSB_DM | (Non-IOMUX 1) 0 | IO | |
| | | | | | | | | | USB_DM | (Non-IOMUX 2) 0 | IO | |
| | | | | | | | | | PA27 | 1 | IO | |
| | | | | | | | | | UC0_SCL_RX | 3 | IO | |
| | | | | | | | | | UC1_SDA_TX | 4 | IO | |
| | | | | | | | | | TIMG7_C1 | 5 | IO | |
| | | | | | | | | PA27 | CLK_OUT | 6 | O | |
| 2 | 26 | F2 | 22 | 31 | 47 | 47 | 31 | PINCM59 | RTC_OUT | 7 | O | USBIO |
| | | | | | | | | 0x404280e8 | COMP0_OUT | 8 | O | |
| | | | | | | | | | UC3_SCK_RX | 9 | IO | |
| | | | | | | | | | TIMA_FAL2 | 10 | I | |
| | | | | | | | | | BSLUSB_DP | (Non-IOMUX 1) 0 | IO | |
| | | | | | | | | | USB_DP | (Non-IOMUX 2) 0 | IO | |
| | | | | | | | | | PA28 | 1 | IO | |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | TIMA0_C1 | 3 | IO | |
| | | | | | | | | PA28 | TIMA0_C3 | 4 | IO | |
| | | | | | 3 | 3 | 35 | PINCM3 | TIMG7_C0 | 5 | IO | HDIO (high-drive) |
| | | | | | | | | 0x40428008 | TIMA_FAL0 | 6 | I | |
| | | | | | | | | | UC0_SDA_TX | 7 | IO | |
| | | | | | | | | | WAKE | (Non-IOMUX 1) 0 | I | |


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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 36 | PA29 PINCM4 0x4042800c | PA29 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC1_CTS | 3 | I | |
| | | | | | | | | | UC2_CS3 | 4 | O | |
| | | | | | | | | | TIMG6_C0 | 5 | IO | |
| | | | | | | | | | UC0_CTS | 6 | I | |
| | | | | | | | 37 | PA30 PINCM5 0x40428010 | PA30 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | UC1_RTS | 3 | O | |
| | | | | | | | | | UC2_CS2 | 4 | O | |
| | | | | | | | | | TIMG6_C1 | 5 | IO | |
| | | | | | | | | | UC0_RTS | 6 | O | |
| | | | | | 5 | 5 | 39 | PA31 PINCM6 0x40428014 | PA31 | 1 | IO | SDIO (standard with wake) |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_CS3 | 3 | O | |
| | | | | | | | | | TIMA0_C3N | 4 | O | |
| | | | | | | | | | TIMG7_C1 | 5 | IO | |
| | | | | | | | | | CLK_OUT | 6 | O | |
| | | | | | | | | | UC0_SCL_RX | 7 | IO | |
| | | | | | | | | | WAKE | (Non-IOMUX 1) 0 | I | |
| | | | | | | | 47 | PB0 PINCM12 0x4042802c | PB0 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_SDA_TX | 2 | IO | |
| | | | | | | | | | UC2_CS3 | 3 | O | |
| | | | | | | | | | UC0_SCL_RX | 4 | IO | |
| | | | | | | | | | TIMA0_C2 | 5 | IO | |
| | | | | | | | | | TIMG0_C0 | 6 | IO | |
| | | | | | | | 48 | PB1 PINCM13 0x40428030 | PB1 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_CS2 | 3 | O | |
| | | | | | | | | | UC0_SDA_TX | 4 | IO | |
| | | | | | | | | | TIMA0_C2N | 5 | O | |
| | | | | | | | | | TIMG0_C1 | 6 | IO | |
| | | | | | 14 | 14 | 50 | PB2 PINCM15 0x40428038 | PB2 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_PICO_TX | 2 | IO | |
| | | | | | | | | | UC1_SCL_RX | 3 | IO | |
| | | | | | | | | | UC1_CTS | 4 | I | |
| | | | | | | | | | TIMA0_C3 | 5 | IO | |
| | | | | | | | | | TIMG6_C0 | 6 | IO | |
| | | | | | | | | | UC2_PICO | 7 | O | |
| | | | | | | | | | HFCLK_IN | 8 | I | |
| | | | | | 15 | 15 | 51 | PB3 PINCM16 0x4042803c | PB3 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_SCK_RX | 2 | IO | |
| | | | | | | | | | UC1_SDA_TX | 3 | IO | |
| | | | | | | | | | UC1_RTS | 4 | O | |
| | | | | | | | | | TIMA0_C3N | 5 | O | |
| | | | | | | | | | TIMG6_C1 | 6 | IO | |
| | | | | | | | | | UC2_SCK | 7 | IO | |
| | | | | | | | | | TIMA0_C0 | 8 | IO | |

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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 52 | PB4 PINCM17 0x40428040 | PB4 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | UC3_CS0_CTS | 3 | IO | |
| | | | | | | | | | TIMA0_C1 | 4 | IO | |
| | | | | | | | | | TIMA0_C2 | 5 | IO | |
| | | | | | | | | | TIMG0_C0 | 6 | IO | |
| | | | | | | | 53 | PB5 PINCM18 0x40428044 | PB5 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC3_POCI_RTS | 3 | IO | |
| | | | | | | | | | TIMA0_C1N | 4 | O | |
| | | | | | | | | | TIMA0_C2N | 5 | O | |
| | | | | | | | | | TIMG0_C1 | 6 | IO | |
| | | | | | 20 | 20 | 58 | PB6 PINCM23 0x40428058 | PB6 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SDA_TX | 2 | IO | |
| | | | | | | | | | UC3_CS0_CTS | 3 | IO | |
| | | | | | | | | | UC2_CS1 | 4 | O | |
| | | | | | | | | | TIMG6_C0 | 5 | IO | |
| | | | | | | | | | TIMA_FAL2 | 6 | I | |
| | | | | | 21 | 21 | 59 | PB7 PINCM24 0x4042805c | PB7 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_SCL_RX | 2 | IO | |
| | | | | | | | | | UC3_POCI_RTS | 3 | IO | |
| | | | | | | | | | UC2_CS2 | 4 | O | |
| | | | | | | | | | TIMG6_C1 | 5 | IO | |
| | | | | | 22 | 22 | 60 | PB8 PINCM25 0x40428060 | PB8 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_CTS | 2 | I | |
| | | | | | | | | | UC3_PICO_TX | 3 | IO | |
| | | | | | | | | | COMP0_OUT | 4 | O | |
| | | | | | | | | | TIMA0_C0 | 5 | IO | |
| | | | | | 23 | 23 | 61 | PB9 PINCM26 0x40428064 | PB9 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_RTS | 2 | O | |
| | | | | | | | | | UC3_SCK_RX | 3 | IO | |
| | | | | | | | | | TIMA0_C1 | 4 | IO | |
| | | | | | | | | | TIMA0_C0N | 5 | O | |
| | | | | | | | 62 | PB10 PINCM27 0x40428068 | PB10 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_CS0_CTS | 2 | IO | |
| | | | | | | | | | UC2_CS1 | 3 | O | |
| | | | | | | | | | COMP0_OUT | 4 | O | |
| | | | | | | | | | TIMG0_C0 | 5 | IO | |
| | | | | | | | | | TIMG6_C0 | 6 | IO | |
| | | | | | | | | | I2S0_WCLK | 7 | IO | |
| | | | | | | | 63 | PB11 PINCM28 0x4042806c | PB11 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_POCI_RTS | 2 | IO | |
| | | | | | | | | | UC2_CS2 | 3 | O | |
| | | | | | | | | | CLK_OUT | 4 | O | |
| | | | | | | | | | TIMG0_C1 | 5 | IO | |
| | | | | | | | | | TIMG6_C1 | 6 | IO | |
| | | | | | | | | | I2S0_BCLK | 7 | IO | |


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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 64 | PB12 PINCM29 0x40428070 | PB12 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_PICO_TX | 2 | IO | |
| | | | | | | | | | UC2_CS0 | 3 | O | |
| | | | | | | | | | TIMA_FAL1 | 4 | I | |
| | | | | | | | | | TIMA0_C1 | 5 | IO | |
| | | | | | | | | | TIMA0_C2 | 6 | IO | |
| | | | | | | | | | I2S0_AD0 | 7 | IO | |
| | | | | | | | 1 | PB13 PINCM30 0x40428074 | PB13 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_SCK_RX | 2 | IO | |
| | | | | | | | | | UC3_CS0_CTS | 3 | IO | |
| | | | | | | | | | TIMA_FAL2 | 4 | I | |
| | | | | | | | | | TIMA0_C1N | 5 | O | |
| | | | | | | | | | TIMA0_C3 | 6 | IO | |
| | | | | | | | | | I2S0_AD1 | 7 | IO | |
| | | | | | 24 | 24 | 2 | PB14 PINCM31 0x40428078 | PB14 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC2_CS3 | 2 | O | |
| | | | | | | | | | UC3_POCI_RTS | 3 | IO | |
| | | | | | | | | | TIMA0_C2 | 4 | IO | |
| | | | | | | | | | TIMA0_C0 | 5 | IO | |
| | | | | | | | | | I2S0_MCLK | 7 | IO | |
| | | | | | | | | | A0_21 | (Non-IOMUX 1) 0 | A | |
| | | | | | 25 | 25 | 3 | PB15 PINCM32 0x4042807c | PB15 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_PICO_TX | 2 | IO | |
| | | | | | | | | | UC3_CS0_CTS | 3 | IO | |
| | | | | | | | | | TIMG7_C0 | 4 | IO | |
| | | | | | | | | | A0_20 | (Non-IOMUX 1) 0 | A | |
| | | | | | 26 | 26 | 4 | PB16 PINCM33 0x40428080 | PB16 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC3_SCK_RX | 2 | IO | |
| | | | | | | | | | UC3_POCI_RTS | 3 | IO | |
| | | | | | | | | | TIMG7_C1 | 4 | IO | |
| | | | | | | | | | A0_19 | (Non-IOMUX 1) 0 | A | |
| | | | | | 36 | 36 | 14 | PB17 PINCM43 0x404280a8 | PB17 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_SCL_RX | 2 | IO | |
| | | | | | | | | | UC2_PICO | 3 | O | |
| | | | | | | | | | TIMG0_C0 | 4 | IO | |
| | | | | | | | | | TIMA0_C2 | 5 | IO | |
| | | | | | | | | | A0_11 | (Non-IOMUX 1) 0 | A | |
| | | | | | 37 | 37 | 15 | PB18 PINCM44 0x404280ac | PB18 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_SDA_TX | 2 | IO | |
| | | | | | | | | | UC2_SCK | 3 | IO | |
| | | | | | | | | | TIMG0_C1 | 4 | IO | |
| | | | | | | | | | TIMA0_C2N | 5 | O | |
| | | | | | | | | | A0_10 | (Non-IOMUX 1) 0 | A | |

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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 38 | 38 | 16 | PB19 PINCM45 0x404280b0 | PB19 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_CTS | 2 | I | |
| | | | | | | | | | UC2_POCI | 3 | I | |
| | | | | | | | | | TIMG7_C1 | 4 | IO | |
| | | | | | | | | | COMP0_OUT | 5 | O | |
| | | | | | | | | | A0_9 | (Non-IOMUX 1) 0 | A | |
| | | | | | 41 | 41 | 19 | PB20 PINCM48 0x404280bc | PB20 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_SDA_TX | 2 | IO | |
| | | | | | | | | | UC3_CS0_CTS | 3 | IO | |
| | | | | | | | | | UC2_CS2 | 4 | O | |
| | | | | | | | | | TIMA0_C2 | 5 | IO | |
| | | | | | | | | | TIMA_FAL1 | 6 | I | |
| | | | | | | | | | TIMA0_C1 | 7 | IO | |
| | | | | | | | | | A0_6 | (Non-IOMUX 1) 0 | A | |
| | | F4 | | | | | 20 | PB21 PINCM49 0x404280c0 | PB21 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_SCL_RX | 2 | IO | |
| | | | | | | | | | UC3_POCI_RTS | 3 | IO | |
| | | | | | | | | | UC1_SDA_TX | 4 | IO | |
| | | | | | | | | | A0_25 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | COMP0_IN0+ | (Non-IOMUX 2) 0 | A | |
| | | G3 | | | | | 21 | PB22 PINCM50 0x404280c4 | PB22 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_SDA_TX | 2 | IO | |
| | | | | | | | | | UC3_PICO_TX | 3 | IO | |
| | | | | | | | | | UC1_SCL_RX | 4 | IO | |
| | | | | | | | | | A0_24 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | | | COMP0_IN0- | (Non-IOMUX 2) 0 | A | |
| | | | | | | | 22 | PB23 PINCM51 0x404280c8 | PB23 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC1_CTS | 2 | I | |
| | | | | | | | | | UC3_SCK_RX | 3 | IO | |
| | | | | | | | | | TIMA_FAL0 | 4 | I | |
| | | | | | | | | | COMP0_OUT | 5 | O | |
| | | | | | | | | | A0_22 | (Non-IOMUX 1) 0 | A | |
| | 22 | | | | 42 | 42 | 23 | PB24 PINCM52 0x404280cc | PB24 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC2_CS3 | 2 | O | |
| | | | | | | | | | UC2_CS1 | 3 | O | |
| | | | | | | | | | UC3_POCI_RTS | 4 | IO | |
| | | | | | | | | | TIMA0_C3 | 5 | IO | |
| | | | | | | | | | TIMA0_C1N | 6 | O | |
| | | | | | | | | | A0_5 | (Non-IOMUX 1) 0 | A | |
| | | | | | | | 27 | PB25 PINCM56 0x404280dc | PB25 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_CTS | 2 | I | |
| | | | | | | | | | UC2_CS0 | 3 | O | |
| | | | | | | | | | TIMA_FAL0 | 4 | I | |
| | | | | | | | | | TIMA_FAL1 | 5 | I | |
| | | | | | | | | | TIMA_FAL2 | 6 | I | |
| | | | | | | | | | COMP0_OUT | 7 | O | |
| | | | | | | | | | FCC_IN | 8 | I | |
| | | | | | | | | | A0_4 | (Non-IOMUX 1) 0 | A | |


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**Table 6-2. Pin Attributes (continued)**

| DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN | PIN NAME/ IOMUX REG/ IOMUX ADDR | SIGNAL NAME | IOMUX PF | SIGNAL TYPE | BUFFER TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 28 | PB26<br>PINCM57<br>0x404280e0 | PB26 | 1 | IO | SDIO (standard) |
| | | | | | | | | | UC0_RTS | 2 | O | |
| | | | | | | | | | UC2_CS1 | 3 | O | |
| | | | | | | | | | TIMA0_C0 | 4 | IO | |
| | | | | | | | | | TIMA0_C3 | 5 | IO | |
| | | | | | | | | | TIMG6_C0 | 6 | IO | |
| | | | | | | | | | COMP0_OUT | 7 | O | |
| | | | | | | | | | FCC_IN | 8 | I | |
| | | | | | | | | | A0_23 | (Non-IOMUX 1) 0 | A | |
| 3 | 27 | G1 | 23 | 32 | 48 | 48 | 32 | VCORE | VCORE | (Non-IOMUX 1) 0 | PWR | PWR |
| 5 | 3 | E1 | 3 | 4 | 6 | 6 | 40 | VDD | VDD | (Non-IOMUX 1) 0 | PWR | PWR |
| 6 | 4 | D1 | 4 | 5 | 7 | 7 | 41 | VSS | VSS | (Non-IOMUX 1) 0 | PWR | PWR |
| 20 | 24 | G2 | 20 | 29 | 45 | 45 | 29 | VUSB33 | VUSB33 | (Non-IOMUX 1) 0 | PWR | PWR |

## 6.3 Signal Descriptions

Many MSPM0 signals are made available on multiple device pins. The following list describes the column headers:

1. **SIGNAL NAME**: The name of the signal which can be connected to one of the specified pins.
2. **PIN TYPE**: The signal direction and signal type:
   - I = Input
   - O = Output
   - IO = Input, output, or simultaneous input and output
   - ID = Input with open-drain behavior
   - OD = Output with open-drain behavior
   - IOD = Input, output, or simultaneous input and output with open-drain behavior
   - A = Analog
   - PWR = Power function
3. **DESCRIPTION**: A description of the signal.
4. **PIN**: Associated pin number.

For additional information on the pin multiplexing scheme, refer to the IOMUX chapter of the . *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

**Note**

The IOMUX only supports connecting one IOMUX-managed digital function to the pin at the same time. However, non-IOMUX managed signals (such as analog inputs and WAKE inputs) can be enabled on a pin at the same time that an IOMUX managed digital function is enabled on the pin. In this case, the designer must verify that no contention exists between the functions enabled on each pin.

**Table 6-3. Analog to Digital Converter (ADC) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| A0_0 | A | ADC0 analog input channel 0 | 17 | 19 | E4 | 16 | 24 | 35 | 35 | 13 |
| A0_1 | A | ADC0 analog input channel 1 | 16 | 18 | D4 | 15 | 23 | 34 | 34 | 12 |
| A0_2 | A | ADC0 analog input channel 2 | | | | | | | | 26 |
| A0_3 | A | ADC0 analog input channel 3 | | | | | 28 | 44 | 44 | 25 |
| A0_4 | A | ADC0 analog input channel 4 | | | | | | | | 27 |
| A0_5 | A | ADC0 analog input channel 5 | | 22 | | | | 42 | 42 | 23 |

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**Table 6-3. Analog to Digital Converter (ADC) Signal Descriptions (continued)**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| A0_6 | A | ADC0 analog input channel 6 | | | | | | 41 | 41 | 19 |
| A0_7 | A | ADC0 analog input channel 7 | 18 | 21 | D3 | 18 | 26 | 40 | 40 | 18 |
| A0_8 | A | ADC0 analog input channel 8 | | 20 | E3 | 17 | 25 | 39 | 39 | 17 |
| A0_9 | A | ADC0 analog input channel 9 | | | | | | 38 | 38 | 16 |
| A0_10 | A | ADC0 analog input channel 10 | | | | | | 37 | 37 | 15 |
| A0_11 | A | ADC0 analog input channel 11 | | | | | | 36 | 36 | 14 |
| A0_12 | A | ADC0 analog input channel 12 | 15 | 17 | C4 | 14 | 22 | 33 | 33 | 11 |
| A0_13 | A | ADC0 analog input channel 13 | 14 | 16 | C3 | 13 | 21 | 32 | 32 | 10 |
| A0_14 | A | ADC0 analog input channel 14 | | 15 | C2 | 12 | 20 | 31 | 31 | 9 |
| A0_15 | A | ADC0 analog input channel 15 | | 14 | | 11 | 19 | 30 | 30 | 8 |
| A0_16 | A | ADC0 analog input channel 16 | | 13 | B4 | | 18 | 29 | 29 | 7 |
| A0_17 | A | ADC0 analog input channel 17 | | | | | 17 | 28 | 28 | 6 |
| A0_18 | A | ADC0 analog input channel 18 | 13 | | | | 16 | 27 | 27 | 5 |
| A0_19 | A | ADC0 analog input channel 19 | | | | | | 26 | 26 | 4 |
| A0_20 | A | ADC0 analog input channel 20 | | | | | | 25 | 25 | 3 |
| A0_21 | A | ADC0 analog input channel 21 | | | | | | 24 | 24 | 2 |
| A0_22 | A | ADC0 analog input channel 22 | | | | | | | | 22 |
| A0_23 | A | ADC0 analog input channel 23 | | | | | | | | 28 |
| A0_24 | A | ADC0 analog input channel 24 | | | G3 | | | | | 21 |
| A0_25 | A | ADC0 analog input channel 25 | | | F4 | | | | | 20 |

**Table 6-4. Bootstrap Loader (BSL) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| BSLRX | I | BSL UART receive signal (RXD) | 12 | 12 | A4 | 10 | 15 | 19 | 19 | 57 |
| BSLSCL | IOD | BSL I2C clock signal (SCL) | | 1 | D2 | 1 | 2 | 2 | 2 | 34 |
| BSLSDA | IOD | BSL I2C data signal (SDA) | | 28 | E2 | 24 | 1 | 1 | 1 | 33 |
| BSLTX | O | BSL UART transmit signal (TXD) | 11 | 11 | A3 | 9 | 14 | 18 | 18 | 56 |
| BSLUSB_DM | IO | BSL USB device firmware update (DFU) minus signal (USB_DM) | 1 | 25 | F3 | 21 | 30 | 46 | 46 | 30 |
| BSLUSB_DP | IO | BSL USB device firmware update (DFU) positive signal (USB_DP) | 2 | 26 | F2 | 22 | 31 | 47 | 47 | 31 |
| BSL_invoke | I | BSL invoke signal (if BSL is enabled, must be HIGH during BOOTRST for a BSL entry, and LOW during BOOTRST to prevent BSL entry) | 15 | 17 | C4 | 14 | 22 | 33 | 33 | 11 |

**Table 6-5. Clock Module (CKM) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| CLK_OUT | O | CLK_OUT digital clock output from the PMCU | 10, 11, 18, 2 | 10, 11, 13, 21, 26 | A2, A3, B4, D3, F2 | 18, 22, 8, 9 | 11, 13, 14, 18, 26, 31 | 13, 17, 18, 29, 40, 47, 5 | 13, 17, 18, 29, 40, 47, 5 | 18, 31, 39, 49, 55, 56, 63, 7 |
| FCC_IN | I | Frequency clock counter (FCC) input signal | 1, 13, 8 | 15, 25, 28, 8 | B2, C2, E2, F3 | 12, 21, 24 | 1, 11, 16, 20, 30, 9 | 1, 11, 13, 27, 31, 46 | 1, 11, 13, 27, 31, 46 | 27, 28, 30, 33, 45, 49, 5, 9 |


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**Table 6-5. Clock Module (CKM) Signal Descriptions (continued)**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| HFCLK_IN | I | High frequency clock digital clock input signal | 9 | 9 | B3 | | 10, 12 | 12, 14, 16 | 12, 14, 16 | 46, 50, 54 |
| HFXIN | A | High frequency crystal oscillator (HFXT) signal | 8 | 8 | B2 | | 9 | 11 | 11 | 45 |
| HFXOUT | A | High frequency crystal oscillator (HFXT) signal | 9 | 9 | B3 | | 10 | 12 | 12 | 46 |
| LFCLK_IN | I | Low frequency clock digital clock input signal | | 7 | A1 | 7 | 8 | 10 | 10 | 44 |
| LFXIN | A | Low frequency crystal oscillator (LFXT) signal | | 6 | B1 | 6 | 7 | 9 | 9 | 43 |
| LFXOUT | A | Low frequency crystal oscillator (LFXT) signal | | 7 | A1 | 7 | 8 | 10 | 10 | 44 |
| ROSC | A | SYSOSC frequency correction loop (FCL) external resistor signal | 7 | 5 | C1 | 5 | 6 | 8 | 8 | 42 |

**Table 6-6. Comparator (COMP) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| COMP0_OUT | O | COMP0 digital output signal | 12, 13, 2 | 12, 14, 15, 20, 26, 6 | A4, B1, C2, E3, F2 | 10, 11, 12, 17, 22, 6 | 11, 15, 16, 19, 20, 25, 31, 7 | 13, 19, 22, 27, 30, 31, 38, 39, 47, 9 | 13, 19, 22, 27, 30, 31, 38, 39, 47, 9 | 16, 17, 22, 26, 27, 28, 31, 43, 49, 5, 57, 60, 62, 8, 9 |
| COMP0_DAC8 | O | COMP0 Reference DAC output | 12 | 12 | A4 | 10 | 15 | 19 | 19 | 57 |
| COMP0_IN0+ | A | COMP0 non-inverting input channel 0 | | | F4 | | | | | 20 |
| COMP0_IN0- | A | COMP0 inverting input channel 0 | | | G3 | | | | | 21 |
| COMP0_IN1+ | A | COMP0 non-inverting input channel 1 | 15 | 17 | C4 | 14 | 22 | 33 | 33 | 11 |
| COMP0_IN1- | A | COMP0 inverting input channel 1 | 14 | 16 | C3 | 13 | 21 | 32 | 32 | 10 |
| COMP0_IN2+ | A | COMP0 non-inverting input channel 2 | | 13 | B4 | | 18 | 29 | 29 | 7 |
| COMP0_IN2- | A | COMP0 inverting input channel 2 | | | | | 17 | 28 | 28 | 6 |
| COMP0_IN3+ | A | COMP0 non-inverting input channel 3 | | 14 | | 11 | 19 | 30 | 30 | 8 |

**Table 6-7. Digital Audio Interface (I2S) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| I2S0_BCLK | IO | Digital audio interface (I2S0) bit clock signal | 10, 13, 18 | 10, 21 | A2, D3 | 18, 8 | 13, 16, 26 | 17, 27, 40 | 17, 27, 40 | 18, 5, 55, 63 |
| I2S0_MCLK | IO | Digital audio interface (I2S0) auxiliary output signal | 15 | 15, 17 | C2, C4 | 12, 14 | 20, 22 | 24, 31, 33 | 24, 31, 33 | 11, 2, 9 |
| I2S0_WCLK | IO | Digital audio interface (I2S0) word clock signal | 14, 19 | 14, 16, 23 | C3, G4 | 11, 13, 19 | 12, 19, 21, 27 | 16, 30, 32, 43 | 16, 30, 32, 43 | 10, 24, 54, 62, 8 |
| I2S0_AD0 | IO | Digital audio interface (I2S0) audio data 0 signal | 11, 16 | 11, 18, 20 | A3, D4, E3 | 15, 17, 9 | 14, 17, 23, 25 | 18, 28, 34, 39 | 18, 28, 34, 39 | 12, 17, 56, 6, 64 |

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**Table 6-7. Digital Audio Interface (I2S) Signal Descriptions (continued)**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| I2S0_AD1 | IO | Digital audio interface (I2S0) audio data 0 signal | 12, 17 | 12, 13, 19 | A4, B4, E4 | 10, 16 | 15, 18, 24, 28 | 19, 29, 35, 44 | 19, 29, 35, 44 | 1, 13, 25, 57, 7 |

**Table 6-8. General Purpose Input Output Module Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| PA0 | IO | GPIO port A input/output 0 | | 28 | E2 | 24 | 1 | 1 | 1 | 33 |
| PA1 | IO | GPIO port A input/output 1 | | 1 | D2 | 1 | 2 | 2 | 2 | 34 |
| PA2 | IO | GPIO port A input/output 2 | 7 | 5 | C1 | 5 | 6 | 8 | 8 | 42 |
| PA3 | IO | GPIO port A input/output 3 | | 6 | B1 | 6 | 7 | 9 | 9 | 43 |
| PA4 | IO | GPIO port A input/output 4 | | 7 | A1 | 7 | 8 | 10 | 10 | 44 |
| PA5 | IO | GPIO port A input/output 5 | 8 | 8 | B2 | | 9 | 11 | 11 | 45 |
| PA6 | IO | GPIO port A input/output 6 | 9 | 9 | B3 | | 10 | 12 | 12 | 46 |
| PA7 | IO | GPIO port A input/output 7 | | | | | 11 | 13 | 13 | 49 |
| PA8 | IO | GPIO port A input/output 8 | | | | | 12 | 16 | 16 | 54 |
| PA9 | IO | GPIO port A input/output 9 | 10 | 10 | A2 | 8 | 13 | 17 | 17 | 55 |
| PA10 | IO | GPIO port A input/output 10 | 11 | 11 | A3 | 9 | 14 | 18 | 18 | 56 |
| PA11 | IO | GPIO port A input/output 11 | 12 | 12 | A4 | 10 | 15 | 19 | 19 | 57 |
| PA12 | IO | GPIO port A input/output 12 | 13 | | | | 16 | 27 | 27 | 5 |
| PA13 | IO | GPIO port A input/output 13 | | | | | 17 | 28 | 28 | 6 |
| PA14 | IO | GPIO port A input/output 14 | | 13 | B4 | | 18 | 29 | 29 | 7 |
| PA15 | IO | GPIO port A input/output 15 | | 14 | | 11 | 19 | 30 | 30 | 8 |
| PA16 | IO | GPIO port A input/output 16 | | 15 | C2 | 12 | 20 | 31 | 31 | 9 |
| PA17 | IO | GPIO port A input/output 17 | 14 | 16 | C3 | 13 | 21 | 32 | 32 | 10 |
| PA18 | IO | GPIO port A input/output 18 | 15 | 17 | C4 | 14 | 22 | 33 | 33 | 11 |
| PA19 | IO | GPIO port A input/output 19 | 16 | 18 | D4 | 15 | 23 | 34 | 34 | 12 |
| PA20 | IO | GPIO port A input/output 20 | 17 | 19 | E4 | 16 | 24 | 35 | 35 | 13 |
| PA21 | IO | GPIO port A input/output 21 | | 20 | E3 | 17 | 25 | 39 | 39 | 17 |
| PA22 | IO | GPIO port A input/output 22 | 18 | 21 | D3 | 18 | 26 | 40 | 40 | 18 |
| PA23 | IO | GPIO port A input/output 23 | 19 | 23 | G4 | 19 | 27 | 43 | 43 | 24 |
| PA24 | IO | GPIO port A input/output 24 | | | | | 28 | 44 | 44 | 25 |
| PA25 | IO | GPIO port A input/output 25 | | | | | | | | 26 |
| PA26 | IO | GPIO port A input/output 26 | 1 | 25 | F3 | 21 | 30 | 46 | 46 | 30 |
| PA27 | IO | GPIO port A input/output 27 | 2 | 26 | F2 | 22 | 31 | 47 | 47 | 31 |
| PA28 | IO | GPIO port A input/output 28 | | | | | | 3 | 3 | 35 |
| PA29 | IO | GPIO port A input/output 29 | | | | | | | | 36 |
| PA30 | IO | GPIO port A input/output 30 | | | | | | | | 37 |
| PA31 | IO | GPIO port A input/output 31 | | | | | | 5 | 5 | 39 |
| PB0 | IO | GPIO port B input/output 0 | | | | | | | | 47 |
| PB1 | IO | GPIO port B input/output 1 | | | | | | | | 48 |
| PB2 | IO | GPIO port B input/output 2 | | | | | | 14 | 14 | 50 |
| PB3 | IO | GPIO port B input/output 3 | | | | | | 15 | 15 | 51 |
| PB4 | IO | GPIO port B input/output 4 | | | | | | | | 52 |
| PB5 | IO | GPIO port B input/output 5 | | | | | | | | 53 |


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**Table 6-8. General Purpose Input Output Module Signal Descriptions (continued)**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| PB6 | IO | GPIO port B input/output 6 | | | | | | 20 | 20 | 58 |
| PB7 | IO | GPIO port B input/output 7 | | | | | | 21 | 21 | 59 |
| PB8 | IO | GPIO port B input/output 8 | | | | | | 22 | 22 | 60 |
| PB9 | IO | GPIO port B input/output 9 | | | | | | 23 | 23 | 61 |
| PB10 | IO | GPIO port B input/output 10 | | | | | | | | 62 |
| PB11 | IO | GPIO port B input/output 11 | | | | | | | | 63 |
| PB12 | IO | GPIO port B input/output 12 | | | | | | | | 64 |
| PB13 | IO | GPIO port B input/output 13 | | | | | | | | 1 |
| PB14 | IO | GPIO port B input/output 14 | | | | | | 24 | 24 | 2 |
| PB15 | IO | GPIO port B input/output 15 | | | | | | 25 | 25 | 3 |
| PB16 | IO | GPIO port B input/output 16 | | | | | | 26 | 26 | 4 |
| PB17 | IO | GPIO port B input/output 17 | | | | | | 36 | 36 | 14 |
| PB18 | IO | GPIO port B input/output 18 | | | | | | 37 | 37 | 15 |
| PB19 | IO | GPIO port B input/output 19 | | | | | | 38 | 38 | 16 |
| PB20 | IO | GPIO port B input/output 20 | | | | | | 41 | 41 | 19 |
| PB21 | IO | GPIO port B input/output 21 | | | F4 | | | | | 20 |
| PB22 | IO | GPIO port B input/output 22 | | | G3 | | | | | 21 |
| PB23 | IO | GPIO port B input/output 23 | | | | | | | | 22 |
| PB24 | IO | GPIO port B input/output 24 | | 22 | | | | 42 | 42 | 23 |
| PB25 | IO | GPIO port B input/output 25 | | | | | | | | 27 |
| PB26 | IO | GPIO port B input/output 26 | | | | | | | | 28 |

**Table 6-9. IOMUX Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| WAKE | I | Input signal to wake the device from SHUTDOWN mode | 11, 12, 14, 15, 4 | 1, 11, 12, 16, 17, 2, 28 | A3, A4, C3, C4, D2, E2, F1 | 1, 10, 13, 14, 2, 24, 9 | 1, 14, 15, 2, 21, 22, 3 | 1, 18, 19, 2, 3, 32, 33, 4, 5 | 1, 18, 19, 2, 3, 32, 33, 4, 5 | 10, 11, 33, 34, 35, 38, 39, 56, 57 |

**Table 6-10. Power Management Unit (PMU) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| VCORE | PWR | VCORE capacitor connection | 3 | 27 | G1 | 23 | 32 | 48 | 48 | 32 |
| VDD | PWR | VDD supply | 5 | 3 | E1 | 3 | 4 | 6 | 6 | 40 |
| VSS | PWR | VSS (ground) | 6 | 4 | D1 | 4 | 5 | 7 | 7 | 41 |

**Table 6-11. Real-time Clock (RTC) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| RTC_OUT | O | Real-time clock output signal | 10, 2 | 10, 26 | A2, F2 | 22, 8 | 13, 17, 31 | 17, 28, 47 | 17, 28, 47 | 31, 55, 6 |

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**Table 6-12. Serial Wire Debug (SWD) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| SWCLK | I | Serial wire debug interface clock input signal | 17 | 19 | E4 | 16 | 24 | 35 | 35 | 13 |
| SWDIO | IO | Serial wire debug interface data input/output signal | 16 | 18 | D4 | 15 | 23 | 34 | 34 | 12 |

**Table 6-13. System Controller (SYSCTL) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| NRST | I | Active-low reset signal (must be logic high for the device to start) | 4 | 2 | F1 | 2 | 3 | 4 | 4 | 38 |

**Table 6-14. Timer (TIMx) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| TIMA0_C0 | IO | TIMA0 capture/compare 0 signal | 7 | 20, 28, 5 | C1, E2, E3 | 17, 24, 5 | 1, 12, 25, 6 | 1, 15, 16, 22, 24, 39, 8 | 1, 15, 16, 22, 24, 39, 8 | 17, 2, 28, 33, 42, 51, 54, 60 |
| TIMA0_C1 | IO | TIMA0 capture/compare 1 signal | 10, 18 | 1, 10, 21, 6 | A2, B1, D2, D3 | 1, 18, 6, 8 | 11, 13, 2, 26, 7 | 13, 17, 2, 23, 3, 40, 41, 9 | 13, 17, 2, 23, 3, 40, 41, 9 | 18, 19, 34, 35, 43, 49, 52, 55, 61, 64 |
| TIMA0_C2 | IO | TIMA0 capture/compare 2 signal | 11, 16 | 11, 14, 18, 6 | A3, B1, D4 | 11, 15, 6, 9 | 11, 14, 19, 23, 7 | 13, 18, 24, 30, 34, 36, 41, 9 | 13, 18, 24, 30, 34, 36, 41, 9 | 12, 14, 19, 2, 43, 47, 49, 52, 56, 64, 8 |
| TIMA0_C3 | IO | TIMA0 capture/compare 3 signal | 13, 14, 19 | 16, 22, 23, 7 | A1, C3, G4 | 13, 19, 7 | 16, 21, 27, 8 | 10, 14, 27, 3, 32, 42, 43 | 10, 14, 27, 3, 32, 42, 43 | 1, 10, 23, 24, 26, 28, 35, 44, 5, 50 |
| TIMA0_C0N | O | TIMA0 capture/compare 0 complementary output | 10, 18 | 10, 21 | A2, D3 | 18, 8 | 13, 26 | 17, 23, 40 | 17, 23, 40 | 18, 55, 61 |
| TIMA0_C1N | O | TIMA0 capture/compare 1 complementary output | | 22, 7 | A1 | 7 | 8 | 10, 42 | 10, 42 | 1, 23, 26, 44, 53 |
| TIMA0_C2N | O | TIMA0 capture/compare 2 complementary output | 12, 17, 7, 9 | 12, 15, 19, 5, 9 | A4, B3, C1, C2, E4 | 10, 12, 16, 5 | 10, 15, 20, 24, 6 | 12, 19, 31, 35, 37, 8 | 12, 19, 31, 35, 37, 8 | 13, 15, 42, 46, 48, 53, 57, 9 |
| TIMA0_C3N | O | TIMA0 capture/compare 3 complementary output | 15, 7 | 17, 5 | C1, C4 | 14, 5 | 17, 22, 28, 6 | 15, 28, 33, 44, 5, 8 | 15, 28, 33, 44, 5, 8 | 11, 25, 39, 42, 51, 6 |
| TIMA_FAL0 | I | Timer fault input 0 | 1, 12, 7, 9 | 12, 25, 5, 9 | A4, B3, C1, F3 | 10, 21, 5 | 10, 12, 15, 30, 6 | 12, 16, 19, 3, 46, 8 | 12, 16, 19, 3, 46, 8 | 22, 27, 30, 35, 42, 46, 54, 57 |
| TIMA_FAL1 | I | Timer fault input 1 | 11, 7, 8 | 11, 28, 5, 8 | A3, B2, C1, E2 | 24, 5, 9 | 1, 14, 6, 9 | 1, 11, 18, 41, 8 | 1, 11, 18, 41, 8 | 19, 27, 33, 42, 45, 56, 64 |


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**Table 6-14. Timer (TIMx) Signal Descriptions (continued)**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| TIMA_FAL2 | I | Timer fault input 2 | 15, 2 | 1, 17, 26 | C4, D2, F2 | 1, 14, 22 | 12, 2, 22, 31 | 16, 2, 20, 33, 47 | 16, 2, 20, 33, 47 | 1, 11, 27, 31, 34, 54, 58 |
| TIMG0_C0 | IO | TIMG0 capture/compare 0 signal | 11, 13, 16, 19, 8 | 11, 18, 23, 28, 8 | A3, B2, D4, E2, G4 | 15, 19, 24, 9 | 1, 14, 16, 23, 27, 9 | 1, 11, 18, 27, 34, 36, 43 | 1, 11, 18, 27, 34, 36, 43 | 12, 14, 24, 33, 45, 47, 5, 52, 56, 62 |
| TIMG0_C1 | IO | TIMG0 capture/compare 1 signal | 12, 17, 9 | 1, 12, 19, 9 | A4, B3, D2, E4 | 1, 10, 16 | 10, 15, 17, 2, 24, 28 | 12, 19, 2, 28, 35, 37, 44 | 12, 19, 2, 28, 35, 37, 44 | 13, 15, 25, 34, 46, 48, 53, 57, 6, 63 |
| TIMG6_C0 | IO | TIMG6 capture/compare 0 signal | 8 | 13, 20, 8 | B2, B4, E3 | 17 | 18, 25, 9 | 11, 14, 20, 29, 39 | 11, 14, 20, 29, 39 | 17, 28, 36, 45, 50, 58, 62, 7 |
| TIMG6_C1 | IO | TIMG6 capture/compare 1 signal | 18, 9 | 21, 9 | B3, D3 | 18 | 10, 26 | 12, 15, 21, 40 | 12, 15, 21, 40 | 18, 37, 46, 51, 59, 63 |
| TIMG7_C0 | IO | TIMG7 capture/compare 0 signal | 1, 14, 19 | 13, 16, 23, 25, 6 | B1, B4, C3, F3, G4 | 13, 19, 21, 6 | 18, 21, 27, 30, 7 | 25, 29, 3, 32, 43, 46, 9 | 25, 29, 3, 32, 43, 46, 9 | 10, 24, 3, 30, 35, 43, 7 |
| TIMG7_C1 | IO | TIMG7 capture/compare 1 signal | 15, 2, 7 | 17, 26, 5, 7 | A1, C1, C4, F2 | 14, 22, 5, 7 | 11, 22, 28, 31, 6, 8 | 10, 13, 26, 33, 38, 44, 47, 5, 8 | 10, 13, 26, 33, 38, 44, 47, 5, 8 | 11, 16, 25, 31, 39, 4, 42, 44, 49 |

**Table 6-15. Unified Communication Module (Unicomm) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| UC0_CTS | I | Unified Communication Module UC0: UART CTS signal | 10, 8 | 10, 13, 15, 8 | A2, B2, B4, C2 | 12, 8 | 13, 18, 20, 9 | 11, 17, 29, 31, 38 | 11, 17, 29, 31, 38 | 16, 27, 36, 45, 55, 7, 9 |
| UC0_RTS | O | Unified Communication Module UC0: UART RTS signal | 13, 9 | 14, 9 | B3 | 11 | 10, 12, 16, 19 | 12, 16, 27, 30 | 12, 16, 27, 30 | 28, 37, 46, 5, 54, 8 |
| UC0_SCL_RX | IO | Unified Communication Module UC0: I2C SCL or UART RX signal | 10, 12, 2 | 1, 10, 12, 26 | A2, A4, D2, F2, F4 | 1, 10, 22, 8 | 13, 15, 2, 31 | 17, 19, 2, 36, 47, 5 | 17, 19, 2, 36, 47, 5 | 14, 20, 31, 34, 39, 47, 48, 55, 57 |
| UC0_SDA_TX | IO | Unified Communication Module UC0: I2C SDA or UART TX signal | 1, 11 | 11, 25, 28 | A3, E2, F3, G3 | 21, 24, 9 | 1, 12, 14, 30 | 1, 16, 18, 3, 37, 41, 46 | 1, 16, 18, 3, 37, 41, 46 | 15, 19, 21, 30, 33, 35, 47, 48, 54, 56 |
| UC1_CTS | I | Unified Communication Module UC1: UART CTS signal | 13 | 15, 20, 6 | B1, C2, E3 | 12, 17, 6 | 16, 20, 25, 7 | 14, 22, 27, 31, 39, 9 | 14, 22, 27, 31, 39, 9 | 17, 22, 36, 43, 5, 50, 60, 9 |

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**Table 6-15. Unified Communication Module (Unicomm) Signal Descriptions (continued)**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| UC1_RTS | O | Unified Communication Module UC1: UART RTS signal | 18, 7 | 14, 21, 5 | C1, D3 | 11, 18, 5 | 17, 19, 26, 6 | 15, 23, 28, 30, 40, 8 | 15, 23, 28, 30, 40, 8 | 18, 37, 42, 51, 6, 61, 8 |
| UC1_SCL_RX | IO | Unified Communication Module UC1: I2C SCL or UART RX signal | 1, 10, 12, 14, 15, 17, 9 | 1, 10, 12, 14, 16, 17, 19, 25, 7, 9 | A1, A2, A4, B3, C3, C4, D2, E4, F3, G3 | 1, 10, 11, 13, 14, 16, 21, 7, 8 | 10, 13, 15, 19, 2, 21, 22, 24, 30, 8 | 10, 12, 14, 17, 19, 2, 21, 30, 32, 33, 35, 46, 5 | 10, 12, 14, 17, 19, 2, 21, 30, 32, 33, 35, 46, 5 | 10, 11, 13, 21, 30, 34, 36, 39, 44, 46, 50, 53, 55, 57, 59, 8 |
| UC1_SDA_TX | IO | Unified Communication Module UC1: I2C SDA or UART TX signal | 11, 14, 15, 16, 2, 8 | 11, 15, 16, 17, 18, 26, 28, 6, 8 | A3, B1, B2, C2, C3, C4, D4, E2, F2, F4 | 12, 13, 14, 15, 22, 24, 6, 9 | 1, 12, 14, 20, 21, 22, 23, 31, 7, 9 | 1, 11, 15, 16, 18, 20, 3, 31, 32, 33, 34, 47, 9 | 1, 11, 15, 16, 18, 20, 3, 31, 32, 33, 34, 47, 9 | 10, 11, 12, 20, 31, 33, 35, 37, 43, 45, 51, 52, 54, 56, 58, 9 |
| UC2_PICO | O | Unified Communication Module UC2: SPI PICO signal | 10, 8 | 10, 13, 8 | A2, B2, B4 | 8 | 13, 18, 9 | 11, 14, 17, 29, 36 | 11, 14, 17, 29, 36 | 14, 45, 50, 55, 7 |
| UC2_POCI | I | Unified Communication Module UC2: SPI POCI signal | 11 | 11, 7 | A1, A3 | 7, 9 | 11, 14, 17, 8 | 10, 13, 18, 28, 38 | 10, 13, 18, 28, 38 | 16, 44, 49, 56, 6 |
| UC2_SCK | IO | Unified Communication Module UC2: SPI SCK signal | 12, 13, 9 | 12, 9 | A4, B3 | 10 | 10, 15, 16 | 12, 15, 19, 27, 37 | 12, 15, 19, 27, 37 | 15, 46, 5, 51, 57 |
| UC3_PICO_TX | IO | Unified Communication Module UC3: SPI PICO or UART TX signal | 1, 11, 15, 19, 9 | 11, 13, 17, 20, 23, 25, 9 | A3, B3, B4, C4, E3, F3, G3, G4 | 14, 17, 19, 21, 9 | 10, 14, 18, 22, 25, 27, 30 | 12, 14, 18, 22, 25, 29, 33, 39, 43, 46 | 12, 14, 18, 22, 25, 29, 33, 39, 43, 46 | 11, 17, 21, 24, 26, 3, 30, 46, 50, 56, 60, 64, 7 |
| UC3_POCI_RTS | IO | Unified Communication Module UC3: SPI POCI or UART RTS signal | 12, 16, 8 | 12, 15, 18, 22, 8 | A4, B2, C2, D4, F4 | 10, 12, 15 | 15, 17, 20, 23, 28, 9 | 11, 19, 21, 24, 26, 28, 31, 34, 42, 44 | 11, 19, 21, 24, 26, 28, 31, 34, 42, 44 | 12, 2, 20, 23, 25, 4, 45, 53, 57, 59, 6, 63, 9 |
| UC3_SCK_RX | IO | Unified Communication Module UC3: SPI SCK or UART RX signal | 10, 14, 17, 18, 2 | 10, 16, 19, 21, 26 | A2, C3, D3, E4, F2 | 13, 16, 18, 22, 8 | 13, 17, 21, 24, 26, 28, 31 | 15, 17, 23, 26, 28, 32, 35, 40, 44, 47 | 15, 17, 23, 26, 28, 32, 35, 40, 44, 47 | 1, 10, 13, 18, 22, 25, 26, 31, 4, 51, 55, 6, 61 |
| UC2_CS0 | O | Unified Communication Module UC2: SPI CS0 signal | 13, 15 | 17, 7 | A1, C4 | 14, 7 | 12, 16, 22, 8 | 10, 16, 27, 33 | 10, 16, 27, 33 | 11, 27, 44, 5, 54, 64 |
| UC2_CS1 | O | Unified Communication Module UC2: SPI CS1 signal | 14, 7 | 16, 22, 5, 6 | B1, C1, C3 | 13, 5, 6 | 21, 6, 7 | 20, 32, 42, 8, 9 | 20, 32, 42, 8, 9 | 10, 23, 28, 42, 43, 58, 62 |


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**Table 6-15. Unified Communication Module (Unicomm) Signal Descriptions (continued)**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| UC2_CS2 | O | Unified Communication Module UC2: SPI CS2 signal | 18 | 21 | D3 | 18 | 11, 26, 28 | 13, 21, 40, 41, 44 | 13, 21, 40, 41, 44 | 18, 19, 25, 37, 48, 49, 59, 63 |
| UC2_CS3 | O | Unified Communication Module UC2: SPI CS3 signal | 19 | 1, 14, 20, 22, 23, 6 | B1, D2, E3, G4 | 1, 11, 17, 19, 6 | 12, 17, 19, 2, 25, 27, 7 | 16, 2, 24, 28, 30, 39, 42, 43, 5, 9 | 16, 2, 24, 28, 30, 39, 42, 43, 5, 9 | 17, 2, 23, 24, 26, 34, 36, 39, 43, 47, 54, 6, 8 |
| UC3_CS0_CTS | IO | Unified Communication Module UC3: SPI CS0 or UART CTS signal | 13, 17, 19, 7 | 19, 23, 5 | C1, E4, G4 | 16, 19, 5 | 16, 17, 24, 27, 6 | 20, 25, 27, 28, 35, 41, 43, 8 | 20, 25, 27, 28, 35, 41, 43, 8 | 1, 13, 19, 24, 3, 42, 5, 52, 58, 6, 62 |

**Table 6-16. Universal Serial Bus (USB) Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| USB_DM | IO | USB Data minus signal | 1 | 25 | F3 | 21 | 30 | 46 | 46 | 30 |
| USB_DP | IO | USB Data positive signal | 2 | 26 | F2 | 22 | 31 | 47 | 47 | 31 |
| VUSB33 | PWR | USB Power Supply signal | 20 | 24 | G2 | 20 | 29 | 45 | 45 | 29 |

**Table 6-17. Voltage Reference Signal Descriptions**

| SIGNAL NAME | PIN TYPE | DESCRIPTION | DGS20 PIN | RUY PIN | YCJ PIN | RGE PIN | RHB PIN | RGZ PIN | PT PIN | PM PIN |
|---|---|---|---|---|---|---|---|---|---|---|
| VREF+ | A | Voltage reference positive input | 19 | 23 | G4 | 19 | 27 | 43 | 43 | 24 |
| VREF- | A | Voltage reference negative input | | 20 | E3 | 17 | 25 | 39 | 39 | 17 |

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## 6.4 Connections for Unused Pins

Table 6-18 lists the correct termination of unused pins.

**Table 6-18. Connection of Unused Pins**

| PIN (1) | POTENTIAL | COMMENT |
|---|---|---|
| PAx, PBx | Open | Set corresponding pin functions to GPIO (PINCMx.PF = 0x1) and configure unused pins to output low or input with internal pullup/ pulldown resistor. |
| NRST | VCC | NRST is an active-low reset signal; it must be pulled high to VCC or the device will not start, for more information refer to Section 9.1 |

(1) Any unused pin with a function that is shared with general-purpose I/O should follow the "PAx and PBx" unused pin connection guidelines.


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# 7 Specifications

## 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| VDD | Supply voltage | At VDD pin | –0.3 | 4.1 | V |
| VUSB33 | Supply voltage | At VUSB33 pin | –0.3 | 4.6 | V |
| $V_I$ | Input voltage | Applied to any 5-V tolerant open-drain pins | –0.3 | 5.5 | V |
| | | Applied to any common tolerance pins | –0.3 | $V_{DD}$ + 0.3 (4.1 MAX) | V |
| | | Applied to USB pins (DP, DM) | –0.3 | 4.6 | V |
| $I_{VDD}$ (3) | Current into VDD pin (source) | -40 °C ≤ $T_j$ ≤ 130 °C | | 80 | mA |
| | Current into VDD pin (source) | -40 °C ≤ Tj ≤ 90 °C | | 100 | mA |
| $I_{VSS}$ (3) | Current out of VSS pin (sink) | -40 °C ≤ $T_j$ ≤ 130 °C | | 80 | mA |
| | Current out of VSS pin (sink) | -40 °C ≤ Tj ≤ 90 °C | | 100 | mA |
| $I_{VUSB33}$ | Current into VUSB33 pin (source) | -40 °C ≤ $T_j$ ≤ 130 °C | | 50 | mA |
| $I_{IO}$ | Current of SDIO pin | Current sunk or sourced by SDIO pin, VDD>=2.7V | | 6 | mA |
| | Current of HSIO pin | Current sunk or sourced by HSIO pin, VDD>=2.7V | | 6 | mA |
| | Current of HDIO pin | Current sunk or sourced by HDIO pin | | 20 | mA |
| | Current of ODIO pin | Current sunk by ODIO pin | | 20 | mA |
| | Current of USBIO pin | Current sunk or sourced by USBIO pin (in GPIO mode) | | 4 | mA |
| | | Current sunk or sourced by USBIO pin (in USB mode) | | 25 | mA |
| $I_D$ | Supported diode current | Diode current at any device pin (excluding Open Drain IO) | -2 | 2 | mA |
| $T_A$ | Ambient temperature | Ambient temperature | -40 | 125 | °C |
| $T_J$ | Junction temperature | Junction temperature | -40 | 130 | °C |
| $T_{stg}$ | Storage temperature(2) | Storage temperature(2) | –40 | 150 | °C |

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime
(2) Higher temperatures may be applied during board soldering according to the current JEDEC J-STD-020 specification with peak reflow temperatures not higher than classified on the device label on the shipping boxes or reels.
(3) For applications running at VDD=1.62V, I_VDD/I_VSS<=20mA is required to ensure device functionality

## 7.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/ JEDEC JS-001, all pins(1) | ±2000 | V |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101, all pins(2) | ±500 | V |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

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## 7.3 Recommended Operating Conditions

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

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| VDD | Supply voltage | 1.62 | | 3.6 | V |
| VCORE | Voltage on VCORE pin (2) | | 1.35 | | V |
| VUSB33 | Supply voltage for USB DP/DM IOs in USB mode | 3 | 3.3 | 3.6 | V |
| | Supply voltage for USB DP/DM IOs in GPIO mode | 1.62 | 3.3 | 3.6 | V |
| $C_{VDD}$ | Capacitor connected between VDD and VSS (1) | | 10 | | uF |
| $C_{VCORE}$ | Capacitor connected between VCORE and VSS (1) (2) | | 470 | | nF |
| $T_A$ | Ambient temperature | –40 | | 125 | °C |
| $T_J$ | Max junction temperature | | | 130 | °C |
| $f_{MCLK\ (PD1\ bus\ clock)}$ | MCLK, CPUCLK frequency with 2 flash wait states (3) | | | 80 | MHz |
| | MCLK, CPUCLK frequency with 1 flash wait state (3) | | | 48 | |
| | MCLK, CPUCLK frequency with 0 flash wait states (3) | | | 24 | |
| $f_{ULPCLK\ (PD0\ bus\ clock)}$ | ULPCLK frequency | | | 40 | MHz |

(1) Connect $C_{VDD}$ and $C_{VCORE}$ between VDD/VSS and VCORE/VSS, respectively, as close to the device pins as possible. A low-ESR capacitor with at least the specified value and tolerance of ±20% or better is required for $C_{VDD}$ and $C_{VCORE}$.
(2) The VCORE pin must only be connected to $C_{VCORE}$. Do not supply any voltage or apply any external load to the VCORE pin.
(3) Wait states are managed automatically by the system controller (SYSCTL) and do not need to be configured by application software unless MCLK is sourced from a high speed clock source (HSCLK sourced from HFCLK or SYSPLL).

## 7.4 Thermal Information

| THERMAL METRIC(1) | | PACKAGE | VALUE | UNIT |
|---|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | LQFP-64 (PM) | 64.4 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | 24.1 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | 41.2 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | 1.5 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | 40.8 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | N/A | °C/W |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | LQFP-48 (PT) | 73.2 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | 29.3 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | 44.8 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | 1.8 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | 44.4 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | N/A | °C/W |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | VQFN-48 (RGZ) | 29.3 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | 20.3 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | 12.3 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | 0.5 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | 12.2 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | 4.4 | °C/W |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | VQFN-32 (RHB) | 33.6 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | 25.7 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | 13.9 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | 0.5 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | 13.9 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | 4.4 | °C/W |


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| THERMAL METRIC[1] | | PACKAGE | VALUE | UNIT |
|---|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | WQFN-28 (RUY) | 42.6 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | 29.1 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | 18.3 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | 0.5 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | 18.3 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | 4.8 | °C/W |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | DSBGA-28 (YCJ) | TBD | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | TBD | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | TBD | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | TBD | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | TBD | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | N/A | °C/W |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | VQFN-24 (RGE) | 42.3 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | 34.1 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | 19 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | 0.8 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | 19.1 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | 5 | °C/W |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | VSSOP-20 (DGS20) | 87.7 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | | 30 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | | 44.8 | °C/W |
| $\Psi_{JT}$ | Junction-to-top characterization parameter | | 0.9 | °C/W |
| $\Psi_{JB}$ | Junction-to-board characterization parameter | | 44.4 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | | N/A | °C/W |

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

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## 7.5 Supply Current Characteristics

### 7.5.1 RUN/SLEEP Modes

VDD=3.3V. All inputs tied to 0V or VDD. Outputs do not source or sink any current. All peripherals are disabled.

| PARAMETER | | MCLK | -40°C | | 25°C | | 85°C | | 105°C | | 125°C | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | |
| **RUN Mode** | | | | | | | | | | | | | |
| $IDD_{RUN}$ | MCLK=SYSPLL, SYSPLLREF=SYSOSC, CoreMark, execute from flash | 80MHz | 8.1 | | 8.2 | | 8.4 | | 8.5 | | 8.7 | | mA |
| | | 48MHz | 5.1 | | 5.3 | | 5.4 | | 5.6 | | 5.8 | | |
| | MCLK=SYSOSC, CoreMark, execute from flash | 32MHz | 3.9 | | 4 | | 4.1 | | 4.2 | | 4.5 | | |
| | | 4MHz | 0.7 | | 0.8 | | 0.9 | | 1 | | 1.3 | | |
| | MCLK=SYSPLL, SYSPLLREF=SYSOSC, CoreMark, execute from SRAM | 80MHz | 7.4 | | 7.6 | | 7.7 | | 7.9 | | 8.2 | | |
| | | 48MHz | 4.9 | | 5 | | 5.1 | | 5.3 | | 5.6 | | |
| | MCLK=SYSOSC, CoreMark, execute from SRAM | 32MHz | 3.4 | | 3.5 | | 3.6 | | 3.8 | | 4.1 | | |
| | | 4MHz | 0.7 | | 0.7 | | 0.9 | | 1 | | 1.3 | | |
| $IDD_{RUN}$, per MHz | MCLK=SYSPLL, SYSPLLREF=SYSOSC, CoreMark, execute from flash | 80MHz | 101 | | 103 | | 105 | | 106 | | 109 | | uA/MHz |
| | MCLK=SYSPLL, SYSPLLREF=SYSOSC, While(1), execute from flash | 80MHz | 50 | 60 | 51 | 63 | 53 | 68 | 54 | 77 | 59 | 85 | |
| **SLEEP Mode** | | | | | | | | | | | | | |
| $IDD_{SLEEP}$ | MCLK=SYSPLL, SYSPLLREF=SYSOSC, CPU is halted | 80MHz | 2640 | 3253 | 2685 | 3439 | 2796 | 3950 | 2920 | 4596 | 3214 | 5111 | uA |
| | | 48MHz | 2008 | 2406 | 2046 | 2669 | 2155 | 3272 | 2279 | 3936 | 2578 | 4445 | |
| | MCLK=SYSOSC, CPU is halted | 32MHz | 1518 | 1848 | 1548 | 2001 | 1654 | 2603 | 1776 | 3240 | 2070 | 3861 | |
| | | 4MHz | 479 | 620 | 498 | 660 | 604 | 1193 | 727 | 1720 | 1021 | 2658 | |
| $IDD_{SLEEP}$, per MHz | MCLK=SYSPLL, SYSPLLREF=SYSOSC, CPU is halted | 80MHz | 33 | | 34 | | 35 | | 37 | | 40 | | uA/MHz |

### 7.5.2 STOP/STANDBY Modes

VDD=3.3V. All inputs tied to 0V or VDD. Outputs do not source or sink any current. All peripherals not noted are disabled.

| PARAMETER | | ULPCLK | -40°C | | 25°C | | 85°C | | 105°C | | 125°C | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | |
| **STOP Mode** | | | | | | | | | | | | | |
| $IDD_{STOP0}$ | SYSOSC=32MHz, USE4MHZSTOP=0, DISABLESTOP=0 | 4MHz | 421 | 467 | 427 | 481 | 430 | 530 | 434 | 550 | 445 | 570 | uA |
| $IDD_{STOP1}$ | SYSOSC=4MHz, USE4MHZSTOP=1, DISABLESTOP=0 | | 195 | 224 | 199 | 229 | 203 | 290 | 208 | 340 | 219 | 370 | |
| $IDD_{STOP2}$ | SYSOSC off, DISABLESTOP=1, ULPCLK=LFCLK | 32kHz | 53 | 66 | 55 | 72 | 59 | 140 | 63 | 180 | 74 | 230 | |
| **STANDBY Mode** | | | | | | | | | | | | | |


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VDD=3.3V. All inputs tied to 0V or VDD. Outputs do not source or sink any current. All peripherals not noted are disabled.

| PARAMETER | | ULPCLK | -40°C | | 25°C | | 85°C | | 105°C | | 125°C | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | |
| $IDD_{STBY0}$ | LFCLK=LFXT, STOPCLKSTBY=0, RTC enabled | 32kHz | 1.8 | 5 | 1.9 | 5 | 4 | 38 | 7 | 71 | 18 | 99 | uA |
| $IDD_{STBY1}$ | LFCLK=LFOSC, STOPCLKSTBY=1, RTC enabled | | 1.4 | 3 | 1.5 | 4 | 4 | 39 | 7 | 67 | 18 | 93 | |
| | LFCLK=LFXT, STOPCLKSTBY=1, RTC enabled | | 1.4 | 3 | 1.5 | 4 | 4 | 39 | 7 | 67 | 17 | 93 | |
| | LFCLK=LFXT, STOPCLKSTBY=1, GPIOA enabled | | 1.3 | 3 | 1.4 | 4 | 4 | 39 | 7 | 67 | 17 | 93 | |

### 7.5.3 SHUTDOWN Mode

All inputs tied to 0V or VDD. Outputs do not source or sink any current. Core regulator is powered down.

| PARAMETER | | VDD | -40°C | | 25°C | | 85°C | | 105°C | | 125°C | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | TYP | MAX | |
| $IDD_{SHDN}$ | Supply current in SHUTDOWN mode | 3.3V | 52 | | 88 | | 526 | | 1222 | | 3406 | | nA |

## 7.6 Power Supply Sequencing

### 7.6.1 Power Supply Ramp

Figure 7-1 gives the relationship of POR- POR+, BOR0-, and BOR0+ during power-up and power-down.

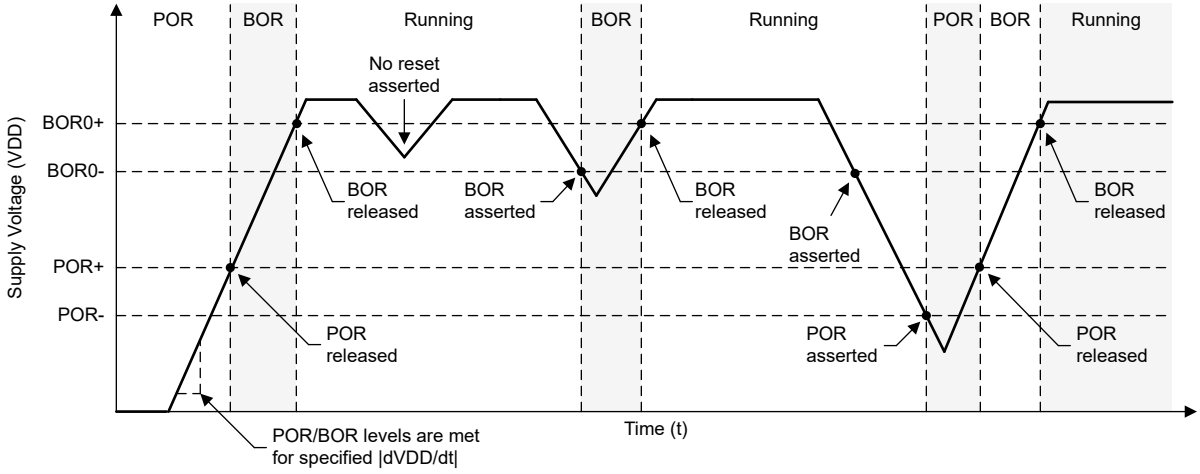



**Figure 7-1. Power Cycle POR/BOR Conditions - VDD**

### 7.6.2 POR and BOR

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| dVDD/dt | VDD (supply voltage) slew rate | Rising | | | 0.1 | V/us |
| | | Falling[1] | | | 0.01 | |
| | | Falling, STANDBY | | | 0.1 | V/ms |
| $V_{POR+}$ | Power-on reset voltage level | Rising | 0.95 | 1.30 | 1.59 | V |
| $V_{POR-}$ | | Falling | 0.9 | 1.25 | 1.54 | V |
| $V_{HYS, POR}$ | POR hysteresis | | 30 | 58 | 74 | mV |

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{BOR0+, COLD}$ | Brown-out reset voltage level 0 (default level) | -40 °C ≤ $T_a$ ≤ 125 °C Cold start, rising | 1.40 | 1.48 | 1.61 | V |
| $V_{BOR0+}$ | | Rising(1) | 1.56 | 1.59 | 1.62 | |
| $V_{BOR0-}$ | | Falling(1) | 1.55 | 1.58 | 1.61 | |
| $V_{BOR0, STBY}$ | | STANDBY mode | 1.51 | 1.56 | 1.61 | |
| $V_{BOR1+}$ | Brown-out-reset voltage level 1 | Rising(1) | 2.13 | 2.17 | 2.21 | V |
| $V_{BOR1-}$ | | Falling(1) | 2.10 | 2.14 | 2.18 | |
| $V_{BOR1, STBY}$ | | STANDBY mode | 2.06 | 2.13 | 2.20 | |
| $V_{BOR2+}$ | Brown-out-reset voltage level 2 | Rising(1) | 2.73 | 2.77 | 2.82 | V |
| $V_{BOR2-}$ | | Falling(1) | 2.7 | 2.74 | 2.79 | |
| $V_{BOR2, STBY}$ | | STANDBY mode | 2.62 | 2.71 | 2.8 | |
| $V_{BOR3+}$ | Brown-out-reset voltage level 3 | Rising(1) | 2.88 | 2.96 | 3.04 | V |
| $V_{BOR3-}$ | | Falling(1) | 2.85 | 2.93 | 3.01 | |
| $V_{BOR3, STBY}$ | | STANDBY mode | 2.82 | 2.92 | 3.02 | |
| $V_{HYS,BOR}$ | Brown-out reset hysteresis | Level 0 | | 15 | 21 | mV |
| | | Levels 1-3 | | 34 | 40 | |
| $T_{PD, BOR}$ | BOR propagation delay | RUN/SLEEP/STOP mode | | | 5 | us |
| | | STANDBY mode | | | 100 | us |

(1) Device operating in RUN, SLEEP, or STOP mode.

## 7.7 Flash Memory Characteristics

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **Supply** | | | | | | |
| $VDD_{PGM/ERASE}$ | Program and erase supply voltage | | 1.62 | | 3.6 | V |
| $IDD_{ERASE}$ | Supply current from VDD during erase operation | Supply current delta | | | 10 | mA |
| $IDD_{PGM}$ | Supply current from VDD during program operation | Supply current delta | | | 10 | mA |
| **Endurance** | | | | | | |
| NWEC(HI_ENDURANCE) | Erase/program cycle endurance for chosen 32 sectors of flash (1) | | 100 | | | k cycles |
| NWEC (NORMAL_ENDURANCE) | Erase/program cycle endurance (Flash not used for HI_ENDURANCE) (1) | | 10 | | | k cycles |
| $NE_{(MAX)}$ | Total erase operations before failure (2) | | 802 | | | k erase operations |
| $NW_{(MAX)}$ | Write operations per word line before sector erase (3) | | | | 83 | write operations |
| **Retention** | | | | | | |
| $t_{RET_85}$ | Flash memory data retention | -40°C <= Tj <= 85°C | 60 | | | years |
| $t_{RET_105}$ | Flash memory data retention | -40°C <= Tj <= 105°C | 11.4 | | | years |
| **Program and Erase Timing** | | | | | | |
| $t_{PROG (WORD, 64)}$ | Program time for flash word (4) (6) | | | 50 | 275 | µs |
| $t_{PROG (SEC, 64)}$ | Program time for 1kB sector (5) (6) | | | 6.4 | | ms |
| $t_{ERASE (SEC)}$ | Sector erase time | ≤2k erase/program cycles, $T_j$≥25°C | | 4 | 20 | ms |


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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{ERASE\ (SEC)}$ | Sector erase time | ≤10k erase/program cycles, $T_j$≥25°C | | 20 | 150 | ms |
| $t_{ERASE\ (SEC)}$ | Sector erase time | <10k erase/program cycles | | 20 | 200 | ms |
| $t_{ERASE\ (BANK)}$ | Bank erase time | <10k erase/program cycles | | 22 | 220 | ms |

(1) Up to 32 application-chosen sectors from the main flash bank(s) or data bank can be used as high endurance sectors. This enables applications that frequently update flash data such as EEPROM emulation.
(2) Total number of cumulative erase operations supported by the flash before failure. A sector erase or bank erase operation is considered to be one erase operation.
(3) Maximum number of write operations allowed per word line before the word line must be erased. If additional writes to the same word line are required, a sector erase is required once the maximum number of write operations per word line is reached.
(4) Program time is defined as the time from when the program command is triggered until the command completion interrupt flag is set in the flash controller.
(5) Sector program time is defined as the time from when the first word program command is triggered until the final word program command completes and the interrupt flag is set in the flash controller. This time includes the time needed for software to load each flash word (after the first flash word) into the flash controller during programming of the sector.
(6) Flash word size is 64 data bits (8 bytes). On devices with ECC, the total flash word size is 72 bits (64 data bits plus 8 ECC bits).

## 7.8 Timing Characteristics

VDD=3.3V, $T_a$=25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **Wakeup Timing** | | | | | | |
| $t_{WAKE,\ SLEEP}$ | Wakeup time from SLEEP0 to RUN (1) | | | 1.5 | | us |
| | Wakeup time from SLEEP1 to RUN (1) | | | 1.8 | | |
| | Wakeup time from SLEEP2 to RUN (1) | | | 2.4 | | |
| $t_{WAKE,\ STOP}$ | Wakeup time from STOP0 to RUN (SYSOSC enabled) (1) | | | 8 | | us |
| | Wakeup time from STOP1 to RUN (SYSOSC enabled) (1) | | | 10 | | |
| | Wakeup time from STOP2 to RUN (SYSOSC disabled) (1) | | | 10 | | |
| $t_{WAKE,\ STANDBY}$ | Wakeup time from STANDBY0 to RUN (1) | | | 10.9 | | us |
| | Wakeup time from STANDBY1 to RUN (1) | | | 10.9 | | |
| $t_{WAKEUP,\ SHDN}$ | Wakeup time from SHUTDOWN to RUN (2) | Fast boot enabled | | 285 | | us |
| | | Fast boot disabled | | 313 | | |
| **Asynchronous Fast Clock Request Timing** | | | | | | |
| $t_{DELAY,\ SLEEP}$ | Delay time from edge of asynchronous request to first 32MHz MCLK edge | Mode is SLEEP1 | | 0.34 | | us |
| | | Mode is SLEEP2 | | 0.94 | | |
| $t_{DELAY,\ STOP}$ | Delay time from edge of asynchronous request to first 32MHz MCLK edge | Mode is STOP0 | | 0.1 | | us |
| | | Mode is STOP1 | | 2.4 | | |
| | | Mode is STOP2 | | 0.9 | | |
| $t_{DELAY,\ STANDBY}$ | Delay time from edge of asynchronous request to first 32MHz MCLK edge | Mode is STANDBY0 | | 3 | | us |
| | | Mode is STANDBY1 | | 3.1 | | |
| **Startup Timing** | | | | | | |
| $t_{START,\ RESET}$ | Device cold startup time from reset/ power-up (3) | Fast boot enabled | | 310 | | us |
| | | Fast boot disabled | | 350 | | |
| **NRST Timing** | | | | | | |
| $t_{RST,\ BOOTRST}$ | Pulse length on NRST pin to generate BOOTRST | ULPCLK≥4MHz | | 1.5 | | us |
| | | ULPCLK=32kHz | | 29 | | |

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VDD=3.3V, $T_a$=25℃ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{RST, POR}$ | Pulse length on NRST pin to generate POR | | | 1 | | s |

(1) The wake-up time is measured from the edge of an external wake-up signal (GPIO wake-up event) to the time that the first instruction of the user program is executed, with glitch filter disabled (FILTEREN=0x0) and fast wake enabled (FASTWAKEONLY=1) .
(2) The wake-up time is measured from the edge of an external wake-up signal (IOMUX wake-up event) to the time that first instruction of the user program is executed.
(3) The start-up time is measured from the time that VDD crosses VBOR0- (cold start-up) to the time that the first instruction of the user program is executed.

## 7.9 Clock Specifications

### *7.9.1 System Oscillator (SYSOSC)*

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{SYSOSC}$ | Factory trimmed SYSOSC frequency | SYSOSCCFG.FREQ=00 (BASE) | | 32 | | MHz |
| | | SYSOSCCFG.FREQ=01 | | 4 | | |
| | User trimmed SYSOSC frequency | SYSOSCCFG.FREQ=10, SYSOSCTRIMUSER.FREQ=10 | | 24 | | |
| | | SYSOSCCFG.FREQ=10, SYSOSCTRIMUSER.FREQ=01 | | 16 | | |
| $f_{SYSOSC}$ | SYSOSC frequency accuracy when frequency correction loop (FCL) is enabled and an ideal ROSC resistor is assumed (1) (2) | SETUSEFCL=1, $T_a$ = 25 ℃ | -0.60 | | 0.68 | % |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 85 ℃ | -0.80 | | 0.93 | |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 105 ℃ | -0.80 | | 1.1 | |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 125 ℃ | -0.80 | | 1.3 | |
| $f_{SYSOSC}$ | SYSOSC accuracy when frequency correction loop (FCL) is enabled with $R_{OSC}$ resistor put at $R_{OSC}$ pin, for factory trimmed frequencies(1) (5) (6) | SETUSEFCL=1, $T_a$ = 25 ℃, ±0.1% ±25ppm $R_{OSC}$ | -0.7 | | 0.78 | % |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 85 ℃, ±0.1% ±25ppm $R_{OSC}$ | -1.1 | | 1.2 | |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 105 ℃, ±0.1% ±25ppm $R_{OSC}$ | -1.1 | | 1.4 | |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 125 ℃, ±0.1% ±25ppm $R_{OSC}$ | -1.1 | | 1.7 | |
| $f_{SYSOSC}$ | SYSOSC frequency accuracy when frequency correction loop (FCL) is enabled when the internal ROSC resistor is used, 32MHz(4) (5) (6) | SETUSEFCL=1, $T_a$ = 25 ℃ | 0 | | 1 | % |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 125 ℃ | -2.1 | | 1.6 | |
| $f_{SYSOSC}$ | SYSOSC frequency accuracy when frequency correction loop (FCL) is enabled when the internal ROSC resistor is used, 4MHz(4) (5) (6) | SETUSEFCL=1, $T_a$ = 25 ℃ | 0 | | 1.6 | % |
| | | SETUSEFCL=1, -40 ℃ ≤ $T_a$ ≤ 125 ℃ | -2.3 | | 1.8 | |
| $f_{SYSOSC}$ | SYSOSC accuracy when frequency correction loop (FCL) is disabled, 32MHz(5) (6) | SETUSEFCL=0, SYSOSCCFG.FREQ=00, -40 ℃ ≤ $T_a$ ≤ 125 ℃ | -2.6 | | 1.8 | % |
| $f_{SYSOSC}$ | SYSOSC accuracy when frequency correction loop (FCL) is disabled, for factory trimmed frequencies, 4MHz(5) (6) | SETUSEFCL=0, SYSOSCCFG.FREQ=01, -40 ℃ ≤ $T_a$ ≤ 125 ℃ | -2.8 | | 2.1 | % |
| $R_{OSC}$ | External resistor put between ROSC pin and VSS (1) | SETUSEFCL=1 | | 100 | | kΩ |
| $t_{settle, SYSOSC}$ | Settling time to target accuracy (3) | SETUSEFCL=1, ±0.1% 25ppm $R_{OSC}$ (1) | | | 30 | us |

(1) The SYSOSC frequency correction loop (FCL) enables high SYSOSC accuracy via an external reference resistor ($R_{OSC}$) which must be connected between the device ROSC pin and VSS when using the FCL. Accuracies are shown for a ±0.1% ±25ppm $R_{OSC}$; relaxed tolerance resistors may also be used (with reduced SYSOSC accuracy). See the SYSOSC section of the technical reference manual


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for details on computing SYSOSC accuracy for various $R_{OSC}$ accuracies. $R_{OSC}$ does not need to be populated if the FCL is not enabled.

(2) Represents the device accuracy only. The tolerance and temperature drift of the ROSC resistor used must be combined with this spec to determine final accuracy. Performance for a ±0.1% ±25ppm $R_{OSC}$ is given as a reference point.

(3) When SYSOSC is waking up (for example, when exiting a low power mode) and FCL is enabled, the SYSOSC will initially undershoot the target frequency $f_{SYSOSC}$ by an additional error of up to $f_{settle,SYSOSC}$ for the time $t_{settle,SYSOSC}$, after which the target accuracy is achieved.

(4) The SYSOSC frequency correction loop (FCL) enables high SYSOSC accuracy via an internal reference resistor when using the FCL. See the SYSOSC section of the technical reference manual for details on computing SYSOSC accuracy.

(5) SYSOSC Accuracy is measured in the default power-up state, with MCLK = SYSOSC, the CPU is running a while(1) loop, and the SYSPLL is disabled.

(6) SYSOSC is measured with the internal FCC counter using an external 1ms pulse as the measurement trigger.

### 7.9.2 Low Frequency Oscillator (LFOSC)

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{LFOSC}$ | LFOSC frequency | | | 32768 | | Hz |
| | LFOSC accuracy | -40 °C ≤ $T_a$ ≤ 125 °C | –5 | | 5 | % |
| | | -40 °C ≤ $T_a$ ≤ 85 °C | –3 | | 3 | % |
| $I_{LFOSC}$ | LFOSC current consumption | | | 300 | | nA |
| $t_{start, LFOSC}$ | LFOSC start-up time | | | 1 | | ms |

### 7.9.3 System Phase Lock Loop (SYSPLL)

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{SYSPLLREF}$ | SYSPLL reference frequency range(2) | | 4 | | 48 | MHz |
| $f_{VCO}$ | VCO output frequency | | 80 | | 400 | MHz |
| $f_{SYSPLL}$ | SYSPLL output frequency range (1) | SYSPLLCLK0, SYSPLLCLK1 | 2.5 | | 200 | MHz |
| | | SYSPLLCLK2X | 10 | | 400 | |
| $DC_{PLL}$ | SYSPLL output duty cycle | $f_{SYSPLLREF}$=32MHz, $f_{VCO}$=160MHz | 45 | | 55 | % |
| $Jitter_{SYSPLL}$ | SYSPLL RMS cycle-to-cycle jitter(3) | $f_{SYSPLLREF}$=32MHz, $f_{VCO}$=160MHz | | 60 | | ps |
| | SYSPLL RMS period jitter(3) | | | 45 | | |
| $I_{SYSPLL}$ | SYSPLL current consumption | $f_{SYSPLLREF}$=32MHz, $f_{VCO}$=160MHz | | 322 | | uA |
| $t_{start, SYSPLL}$ | SYSPLL start-up time | $f_{SYSPLLREF}$=32MHz, PDIV=3, QDIV=39, $f_{VCO}$=160MHz, ±0.5% accuracy | | 14 | 24 | us |

(1) The SYSPLL may support higher output frequencies than the device clock system supports. Ensure that the device maximum frequency specifications are not violated when configuring the SYSPLL output frequencies.

(2) Please refer to SYSPLL tuning parameters in Table 2-6 inside the _:AMP:_

(3) PDIV=2 (8MHz loop frequency) is recommended for optimal performance

### 7.9.4 USB Frequency Lock Loop (USBFLL)

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{USBFLLREF}$ | USBFLL reference frequency range | USBFLLREF=LFXT | | 32768 | | Hz |
| | | USBFLLREF=SOF | | 1000 | | |
| $f_{USBFLL}$ | USBFLL output frequency | | | 60 | | MHz |
| | USBFLL output frequency accuracy | Locked | -0.25 | | 0.25 | % |
| | USBFLL output frequency accuracy | Unlocked | -8 | | 6 | % |
| $I_{USBFLL}$ | USBFLL current consumption | $f_{USBFLL}$=60MHz | | 480 | | uA |
| $t_{start, USBFLL}$ | USBFLL start-up time | Unlocked (Loop=disable) | | | 170 | ns |

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{lock,\ USBFLL}$ | USBFLL lock time | $f_{USBFLL}$=60MHz, ±0.25% accuracy, USBFLLREF=LFXT | | 0.3 | 1 | ms |
| $t_{lock,\ USBFLL}$ | | $f_{USBFLL}$=60MHz, ±0.25% accuracy, USBFLLREF=SOF | | 5 | 16 | ms |

### 7.9.5 Low Frequency Crystal/Clock

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **Low frequency crystal oscillator (LFXT)** | | | | | | |
| $f_{LFXT}$ | LFXT frequency | | | 32768 | | Hz |
| $DC_{LFXT}$ | LFXT duty cycle | | 30 | | 70 | % |
| $OA_{LFXT}$ | LFXT crystal oscillation allowance | | | 419 | | kΩ |
| $C_{L,\ eff}$ | Integrated effective load capacitance(1) | | | 1 | | pF |
| $t_{start,\ LFXT}$ | LFXT start-up time | Fast LFXT start-up enabled(4) | | 200 | | ms |
| $I_{LFXT}$ | LFXT current consumption | XT1DRIVE=0, LOWCAP=1 | | 200 | | nA |
| **Low frequency digital clock input (LFCLK_IN)** | | | | | | |
| $f_{LFIN}$ | LFCLK_IN frequency (2) | SETUSEEXLF=1 | 29491 | 32768 | 36045 | Hz |
| $DC_{LFIN}$ | LFCLK_IN duty cycle (2) | SETUSEEXLF=1 | 40 | | 60 | % |
| **LFCLK Monitor** | | | | | | |
| $f_{FAULTLF}$ | LFCLK monitor fault frequency (3) | MONITOR=1 | 2800 | 4200 | 8400 | Hz |

(1) This includes parasitic bond and package capacitance (≈2pF per pin), calculated as $C_{LFXIN} \times C_{LFXOUT}/(C_{LFXIN}+C_{LFXOUT})$, where $C_{LFXIN}$ and $C_{LFXOUT}$ are the total capacitance at LFXIN and LFXOUT, respectively.
(2) The digital clock input (LFCLK_IN) accepts a logic level square wave clock.
(3) The LFCLK monitor may be used to monitor the LFXT or LFCLK_IN. It will always fault below the MIN fault frequency, and will never fault above the MAX fault frequency.
(4) When using LFXT, the user must ensure that the crystal is properly rated to support the start-up drive load (e.g. 0.1uW)

### 7.9.6 High Frequency Crystal/Clock

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **High frequency crystal oscillator (HFXT)** | | | | | | |
| $f_{HFXT}$ | HFXT frequency | HFXTRSEL=00 | 4 | | 8 | MHz |
| | | HFXTRSEL=01 | 8.01 | | 16 | |
| | | HFXTRSEL=10 | 16.01 | | 32 | |
| | | HFXTRSEL=11 | 32.01 | | 48 | |
| $DC_{HFXT}$ | HFXT duty cycle | HFXTRSEL=00 | 40 | | 65 | % |
| | | HFXTRSEL=01 | 40 | | 60 | |
| | | HFXTRSEL=10 | 40 | | 60 | |
| | | HFXTRSEL=11 | 40 | | 60 | |
| $OA_{HFXT}$ | HFXT crystal oscillation allowance | HFXTRSEL=00 (4 to 8MHz range) | | 2 | | kΩ |
| $C_{L,\ eff}$ | Integrated effective load capacitance(1) | | | 1 | | pF |
| $t_{start,\ HFXT}$ | HFXT start-up time (2) | HFXTRSEL=11, 32MHz crystal | | 0.5 | | ms |
| $I_{HFXT}$ | HFXT current consumption(2) | $f_{HFXT}$=4MHz, $R_m$=300Ω, $C_L$=12pF | | 100 | | uA |
| | | $f_{HFXT}$=48MHz, $R_m$=30Ω, $C_L$=12pF, $C_m$=6.26fF, $L_m$=1.76mH | | 600 | | |
| **High frequency digital clock input (HFCLK_IN)** | | | | | | |
| $f_{HFIN}$ | HFCLK_IN frequency (3) | USEEXTHFCLK=1 | 4 | | 48 | MHz |


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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $DC_{HFIN}$ | HFCLK_IN duty cycle (3) | USEEXTHFCLK=1 | 40 | | 60 | % |

(1) This includes parasitic bond and package capacitance (≈2pF per pin), calculated as $C_{HFXIN} \times C_{HFXOUT}/(C_{HFXIN}+C_{HFXOUT})$, where $C_{HFXIN}$ and $C_{HFXOUT}$ are the total capacitance at HFXIN and HFXOUT, respectively.
(2) The HFXT startup time ($t_{start, HFXT}$) is measured from the time the HFXT is enabled until stable oscillation for a typical crystal. Start-up time is dependent upon crystal frequency and crystal specifications. Refer to the HFXT section of the MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual.Current consumption increases with higher RSEL and start up time is decreases with higher RSEL.
(3) The digital clock input (HFCLK_IN) accepts a logic level square wave clock.

## 7.10 Digital IO

### 7.10.1 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{IH}$ | High level input voltage | ODIO (1) | VDD≥1.62V | 0.7*VDD | | 5.5 | V |
| | | | VDD≥2.7V | 2 | | 5.5 | V |
| | | USBIO | GPIO mode VUSB33≥1.62V | 0.7*VUSB33 | | VUSB33+0.3 | V |
| | | All I/O except ODIO & Reset | VDD≥1.62V | 0.7*VDD | | VDD+0.3 | V |
| $V_{IL}$ | Low level input voltage | ODIO | VDD≥1.62V | -0.3 | | 0.3*VDD | V |
| | | | VDD≥2.7V | -0.3 | | 0.8 | V |
| | | USBIO | GPIO mode VUSB33≥1.62V | -0.3 | | 0.3*VUSB33 | V |
| | | All I/O except ODIO & Reset | VDD≥1.62V | -0.3 | | 0.3*VDD | V |
| $V_{HYS}$ | Hysteresis | ODIO | | 0.05*VDD | | | V |
| | | USBIO | GPIO mode VUSB33≥1.62V | 0.1*VUSB33 | | | V |
| | | All I/O except ODIO | | 0.1*VDD | | | V |
| $I_{lkg}$ | High-Z leakage current (All packages except PM) | SDIO(2) (3) | 1.62V ≤ VDD ≤ 3.6V, -40 °C ≤ $T_a$ ≤ 125 °C | | | 50(4) | nA |
| | High-Z leakage current (PM package) | SDIO(2) (3) | 1.62V ≤ VDD ≤ 3.6V, -40 °C ≤ $T_a$ ≤ 25 °C | | | 70(4) | nA |
| | | | 1.62V ≤ VDD ≤ 3.6V, -40 °C ≤ $T_a$ ≤ 125 °C | | | 400(4) | nA |
| $I_{lkg}$ | High-Z leakage current | USBIO(2) (3) | 1.62V ≤ VUSB33 ≤ 3.6V, $T_{a=}$ 25 °C | | 10(4) | | nA |
| | | | 1.62V ≤ VUSB33 ≤ 3.6V, $T_a$ = 125 °C | | 200(4) | | nA |
| $R_{PU}$ | Pull up resistance | All I/O except ODIO and USBIO | VIN = VSS | | 40 | | kΩ |
| | | USBIO | GPIO mode IN = VSS | | 33 | | |
| $R_{PD}$ | Pull down resistance | All I/O except USBIO | VIN = VDD | | 40 | | kΩ |
| | | USBIO | GPIO mode VIN = VUSB33 | | 14 | | |
| $C_I$ | Input capacitance | | VDD = 3.3V | | 5 | | pF |

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over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{OH}$ | High level output voltage | SDIO | VDD≥2.7V, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 25 °C | VDD-0.4 | | | V |
| | | | VDD≥2.7V, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 125 °C | VDD-0.45 | | | |
| | | HSIO | VDD≥2.7V, DRV=1, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, DRV=1, $\|I_{IO}\|_{,max}$=3mA<br>VDD≥1.62V, DRV=1, $\|I_{IO}\|_{,max}$=2mA<br>-40 °C ≤ $T_a$ ≤ 25 °C | VDD-0.4 | | | |
| | | | VDD≥2.7V, DRV=1, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, DRV=1, $\|I_{IO}\|_{,max}$=3mA<br>VDD≥1.62V, DRV=1, $\|I_{IO}\|_{,max}$=2mA<br>-40 °C ≤ $T_a$ ≤ 125 °C | VDD-0.45 | | | |
| | | | VDD≥2.7V, DRV=0, $\|I_{IO}\|_{,max}$=4mA<br>VDD≥1.71V, DRV=0, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, DRV=0, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 25 °C | VDD-0.4 | | | |
| | | | VDD≥2.7V, DRV=0, $\|I_{IO}\|_{,max}$=4mA<br>VDD≥1.71V, DRV=0, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, DRV=0, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 125 °C | VDD-0.45 | | | |
| | | HDIO | VDD≥2.7V, DRV=1[(5)], $\|I_{IO}\|_{,max}$=20mA<br>VDD≥1.71V, DRV=1[(5)], $\|I_{IO}\|_{,max}$=10mA | VDD-0.4 | | | |
| | | | VDD≥2.7V, DRV=0, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, DRV=0, $\|I_{IO}\|_{,max}$=2mA | VDD-0.4 | | | |
| | | USBIO | GPIO mode<br>VUSB33≥2.7V, $\|I_{IO}\|_{,max}$=4mA<br>VUSB33≥1.71V, $\|I_{IO}\|_{,max}$=2mA<br>VUSB33≥1.62V, $\|I_{IO}\|_{,max}$=1.5mA | 0.8*VUSB33 | | | |


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over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{OL}$ | Low level output voltage | SDIO | VDD≥2.7V, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 25 °C | | | 0.4 | V |
| | | | VDD≥2.7V, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 125 °C | | | 0.45 | |
| | | HSIO | VDD≥2.7V, DRV=1, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, DRV=1, $\|I_{IO}\|_{,max}$=3mA<br>VDD≥1.62V, DRV=1, $\|I_{IO}\|_{,max}$=2mA<br>-40 °C ≤ $T_a$ ≤ 25 °C | | | 0.4 | |
| | | | VDD≥2.7V, DRV=1, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, DRV=1, $\|I_{IO}\|_{,max}$=3mA<br>VDD≥1.62V, DRV=1, $\|I_{IO}\|_{,max}$=2mA<br>-40 °C ≤ $T_a$ ≤ 125 °C | | | 0.45 | |
| | | | VDD≥2.7V, DRV=0, $\|I_{IO}\|_{,max}$=4mA<br>VDD≥1.71V, DRV=0, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, DRV=0, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 25 °C | | | 0.4 | |
| | | | VDD≥2.7V, DRV=0, $\|I_{IO}\|_{,max}$=4mA<br>VDD≥1.71V, DRV=0, $\|I_{IO}\|_{,max}$=2mA<br>VDD≥1.62V, DRV=0, $\|I_{IO}\|_{,max}$=1.5mA<br>-40 °C ≤ $T_a$ ≤ 125 °C | | | 0.45 | |
| | | HDIO | VDD≥2.7V, DRV=1(5), $\|I_{IO}\|_{,max}$=20mA<br>VDD≥1.71V, DRV=1(5), $\|I_{IO}\|_{,max}$=10mA | | | 0.4 | |
| | | | VDD≥2.7V, DRV=0, $\|I_{IO}\|_{,max}$=6mA<br>VDD≥1.71V, DRV=0, $\|I_{IO}\|_{,max}$=2mA | | | 0.4 | |
| | | USBIO | GPIO mode<br>VUSB33≥2.7V, $\|I_{IO}\|_{,max}$=4mA<br>VUSB33≥1.71V, $\|I_{IO}\|_{,max}$=2mA<br>VUSB33≥1.62V, $\|I_{IO}\|_{,max}$=1.5mA | | | 0.2*VUSB33 | |
| | | ODIO | VDD≥2.7V, $I_{OL,max}$=8mA<br>VDD≥1.71V, $I_{OL,max}$=4mA<br>-40 °C ≤ $T_a$ ≤ 25 °C | | | 0.4 | |
| | | | VDD≥2.7V, $I_{OL,max}$=8mA<br>VDD≥1.71V, $I_{OL,max}$=4mA<br>-40 °C ≤ $T_a$ ≤ 125 °C | | | 0.45 | |

(1) I/O Types: ODIO = 5V Tolerant Open-Drain , SDIO = Standard-Drive , HSIO = High-Speed, HDIO = High-Drive, USBIO = USB protocol
(2) The leakage current is measured with VSS or VDD applied to the corresponding pin(s), unless otherwise noted.
(3) The leakage of the digital port pins is measured individually. The port pin is selected for input and the pullup/pulldown resistor is disabled.
(4) This value is for SDIO not muxed with any analog inputs. If the SDIO is muxed with analog inputs then the leakage can be higher.
(5) When operating a HDIO in DRV=1 high drive strength configuration, a series resistor is necessary to limit the signal slew rate

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### 7.10.2 Switching Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $f_{max}$ | Port output frequency(1) | SDIO | VDD ≥ 2.7V, CL= 20pF | | | 32 | MHz |
| | | | VDD ≥ 1.71V, CL= 20pF | | | 16 | |
| | | HSIO | VDD ≥ 2.7V, DRV = 1, CL= 20pF | | | 40 | |
| | | | VDD ≥ 2.7V, DRV = 0, CL= 20pF | | | 32 | |
| | | | VDD ≥ 1.71V, DRV = 1, CL= 20pF | | | 24 | |
| | | | VDD ≥ 1.71V, DRV = 0, CL= 20pF | | | 16 | |
| | | HDIO | VDD ≥ 2.7V, DRV = 1(2), CL= 20pF | | | 20 | |
| | | | VDD ≥ 2.7V, DRV = 0, CL= 20pF | | | 20 | |
| | | | VDD ≥ 1.71V, DRV = 1(2), CL= 20pF | | | 16 | |
| | | | VDD ≥ 1.71V, DRV = 0, CL= 20pF | | | 16 | |
| | | USBIO | GPIO mode<br>VUSB33 ≥ 2.7V, CL= 20pF | | | 32 | |
| | | | GPIO mode<br>VUSB33 ≥ 1.71V, CL= 20pF | | | 16 | |
| | | ODIO | VDD ≥ 1.71V, FM+, CL= 20pF - 100pF | | | 1 | |
| $t_r$,$t_f$ | Output rise/fall time | SDIO | VDD ≥ 2.7V, CL= 20pF | | | 3.5 | ns |
| | | | VDD ≥ 1.71V, $C_L$= 20pF | | | 6.6 | |
| | | HSIO | VDD ≥ 2.7V, DRV = 1, CL= 20pF | | | 1.8 | |
| | | | VDD ≥ 2.7V, DRV = 0, CL= 20pF | | | 5.9 | |
| | | | VDD ≥ 1.71V, DRV = 1, CL= 20pF | | | 3.7 | |
| | | | VDD ≥ 1.71V, DRV = 0, CL= 20pF | | | 12.6 | |
| | | HDIO | VDD ≥ 2.7V, DRV = 1, CL= 20pF | | | 1.7 | |
| | | | VDD ≥ 2.7V, DRV = 0, CL= 20pF | | | 3.8 | |
| | | | VDD ≥ 1.71V, DRV = 1, CL= 20pF | | | 3.1 | |
| | | | VDD ≥ 1.71V, DRV = 0, CL= 20pF | | | 8.2 | |
| | | USBIO | GPIO mode<br>VUSB33 ≥ 2.7V, CL= 20pF | | | 7 | |
| | | | GPIO mode<br>VUSB33 ≥ 1.71V, CL= 20pF | | | 14 | |
| $t_f$ | Output fall time | ODIO | VDD ≥ 1.71V, FM+, CL= 20pF-100pF | 20*VDD/5.5 | | 120 | ns |

(1) I/O Types: ODIO = 5V Tolerant Open-Drain , SDIO = Standard-Drive , HSIO = High-Speed , HDIO = High-Drive, USBIO = USB protocol
(2) When operating a HDIO in DRV=1 high drive strength configuration, a series resistor is necessary to limit the signal slew rate

## 7.11 Analog Mux VBOOST

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{VBST}$ | VBOOST current adder | MCLK/ULPCLK is LFCLK | | 0.8 | | uA |
| | | MCLK/ULPCLK is not LFCLK, SYSOSC frequency is 4MHz | | 10.6 | | |
| $t_{START,VBST}$ | VBOOST startup time | | | 12 | 20 | us |


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## 7.12 ADC

### 7.12.1 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted), all TYP values are measured at 25°C and all accuracy parameters are measured using 12-bit resolution mode (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $Vin_{(ADC)}$ | Analog input voltage range(1) | Applies to all ADC analog input pins | 0 | | VDD | V |
| $V_{R+}$ | Positive ADC reference voltage | $V_{R+}$ sourced from VDD | | VDD | | V |
| | | $V_{R+}$ sourced from external reference pin (VREF+) | 1.4 | | VDD | V |
| | | $V_{R+}$ sourced from internal reference (VREF) | | VREF | | V |
| $V_{R-}$ | Negative ADC reference voltage | | | 0 | | V |
| Fs | ADC sampling frequency | RES = 0x0 (12-bit mode), External/Internal Reference(VRSEL=1h) | | | 1.6 | Msps |
| | | RES = 0x1 (10-bit mode), External/Internal Reference(VRSEL1h) | | | 1.7 | |
| | | RES = 0x2 (8-bit mode), External/Internal Reference(VRSEL=1h) | | | 2 | |
| $F_S$ | ADC sampling frequency | RES = 0x0 (12-bit mode), Internal Reference(VRSEL=2h) | | | 0.9 | Msps |
| | | RES = 0x1 (10-bit mode), Internal Reference(VRSEL=2h) | | | 1 | |
| | | RES = 0x2 (8-bit mode), Internal Reference(VRSEL=2h) | | | 1.2 | |
| $I_{(ADC)}$ | Operating supply current into VDD terminal | $F_S$ = 1.6MSPS, External reference(VRSEL=1h),$V_{R+}$ = VDD | | 350 | | µA |
| $I_{(ADC)}$ | Operating supply current into VDD terminal | $F_S$ = 1.6MSPS, Internal reference(VRSEL=1h),VREF = 2.5V (VREF1 power consumption included) | | 550 | | µA |
| | | $F_S$ = 0.9MSPS,Internal reference(VRSEL=2h),VREF = 2.5V (VREF2 power consumption included) | | 400 | | |
| $C_{S/H}$ | ADC sample-and-hold capacitance | | | 0.22 | | pF |
| Rin | ADC switch resistance | | | 15 | | kΩ |
| ENOB | Effective number of bits | Fin=10kHz,External Reference(VRSEL=1h)(2) | 10 | 10.6 | | bit |
| | | Fin=1kHz,External reference with over sampling(2) | | 11.8 | | |
| | | Fin=10kHz,Internal reference(VRSEL=1h or 2h), VREF = 2.5V | 9.2 | 10.2 | | |
| SNR | Signal-to-noise ratio | Fin=10kHz,External Reference(VRSEL=1h)(2) | | 67 | | dB |
| | | Fin=1kHz,External reference with over sampling(2) | | 75 | | |
| | | Fin=10kHz,Internal reference(VRSEL=1h or 2h), $V_{R+}$ = VREF = 2.5V | | 62 | | |
| $PSRR_{DC}$ | Power supply rejection ratio, DC | External reference(VRSEL=1h), VDD = $VDD_{(min)}$ to $VDD_{(max)}$ (2) | | 66 | | dB |
| | | Internal reference(VRSEL=1h or 2h), $V_{R+}$ = VREF = 2.5V, VDD=2.7 to 3.6 | | 60 | | dB |
| $T_{wakeup}$ | ADC Wakeup Time | Assumes internal reference is active | | | 5 | us |
| $V_{SupplyMon}$ | Supply Monitor voltage divider (VDD/3) accuracy | ADC input channel: Supply Monitor (3) | -1.5 | | +1.5 | % |
| $I_{SupplyMon}$ | Supply Monitor voltage divider current consumption | ADC input channel: Supply Monitor | | 10 | | uA |
| $V_{USBMon}$ | Supply Monitor voltage divider (VUSB33/3) accuracy | ADC input channel: VUSB Monitor (4) | -1.5 | | +1.5 | % |
| $I_{USBMon}$ | Supply Monitor voltage divider current consumption | ADC input channel: VUSB Monitor | | 10 | | uA |

(1) The analog input voltage range must be within the selected ADC reference voltage range $V_{R+}$ to $V_{R-}$ for valid conversion results.
(2) All external reference specifications are measured with $V_{R+}$ = VREF+ = VDD = 3.3V and $V_{R-}$ = VREF- = VSS = 0V and external 1uF cap on VREF+ pin
(3) Analog power supply monitor. Analog input on channel 31 is disconnected and is internally connected to the voltage divider which is VDD/3.
(4) Analog VUSB monitor. Analog input on channel 30 is disconnected and is internally connected to the voltage divider which is VUSB33/3.

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### 7.12.2 Switching Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{ADCCLK}$ | ADC clock frequency | | 4 | | 32 | MHz |
| $t_{ADC\ trigger}$ | Software trigger minimum width | | 3 | | | ADCCLK cycles |
| $t_{Sample_step}$ | Sampling time for step input | 12-bit mode, $R_S$ = 50Ω, $C_{pext}$ = 10pF | 188 | | | ns |
| $t_{Sample_VREF}$ | Sample time with VREF | ADC CHANNEL=28,12-bit mode, VDD as reference | 4 | | | µs |
| $t_{Sample_SupplyMon}$ | Sample time with Supply Monitor (VDD/3) | ADC CHANNEL=31,12-bit mode,Internal reference(VRSEL=1h or 2h) | 5 | | | µs |
| $t_{Sample_USBMon}$ | Sample time with VUSB Monitor (VUSB33/3) | ADC CHANNEL=30,12-bit mode,Internal reference(VRSEL=1h or 2h) | 5 | | | µs |

### 7.12.3 Linearity Parameters

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted), all TYP values are measured at 25℃ and all linearity parameters are measured using 12-bit resolution mode (unless otherwise noted) (1)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $E_I$ | Integral linearity error (INL) | External reference | -2 | | 2 | LSB |
| $E_D$ | Differential linearity error (DNL) | External reference (2) | -1 | | 1 | LSB |
| $E_O$ | Offset error | External reference (2) | -5 | | 5 | mV |
| $E_G$ | Gain error | External reference(VRSEL=1h) (2) | -6 | | 6 | LSB |

(1) Total Unadjusted Error (TUE) can be calculated from $E_I$ , $E_O$ , and $E_G$ using the following formula: TUE = $\sqrt{(E_I^2 + |E_O|^2 + E_G^2)}$
Note: You must convert all of the errors into the same unit, usually LSB, for the above equation to be accurate
(2) VDD reference specifications are measured with $V_{R+}$ = VDD = 3.3V and $V_{R-}$ = VSS = 0V.

### 7.12.4 Typical Connection Diagram

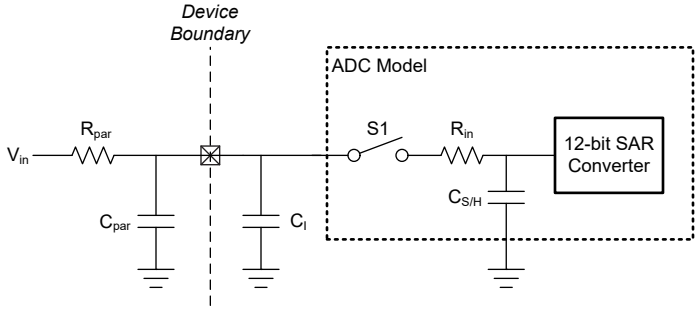



**Figure 7-2. ADC Input Network**

1. Refer to Electrical Characteristics for the values of $R_{in}$ and $C_{S/H}$
2. Refer to Electrical Characteristics for the value of $C_I$
3. $C_{par}$ and $R_{par}$ represent the parasitic capacitance and resistance of the external ADC input circuitry

Use the following equations to solve for the minimum sampling time (T) required for an ADC conversion:

1. Tau = $(R_{par} + R_{in})* C_{S/H} + R_{par}*(C_{par} + C_I)$
2. K= $\ln(2^n/\text{Settling error}) - \ln((C_{par} + C_I)/C_{S/H})$
3. T (Min sampling time) = K*Tau


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## 7.13 Temperature Sensor

over operating free-air temperature range (unless otherwise noted)(1)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $TS_{TRIM}$ | Factory trim temperature (2) | ADC and VREF configuration: RES=0 (12-bit mode), VRSEL=2h (VREF=1.4V), cap=1uF on VREF+, ADC $t_{Sample}$=12.5µs | 27 | 30 | 33 | ℃ |
| $TS_c$ | Temperature coefficient | -40 °C ≤ $T_j$ ≤ 130 °C | -2.05 | -1.9 | -1.75 | mV/℃ |
| $t_{SET, TS}$ | Temperature sensor settling time (3) | ADC and VREF configuration: RES=0 (12-bit mode), VRSEL= 2h (VREF=1.4V), ADC CHANNEL=29 | | | 12.5 | us |

(1) Effective absolute temperature accuracy may be computed by combining the relative temperature accuracy together with the trim accuracy, and accounting for any analog to digital conversion error.
(2) Higher absolute accuracy may be achieved through user calibration. Please refer to temperature sensor chapter in detailed description section.
(3) This is the minimum required ADC sampling time when measuring the temperature sensor.

## 7.14 VREF1

### 7.14.1 Voltage Characteristics (VREF1)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $VDD_{min}$ | Minimum supply voltage needed for VREF operation | BUFCONFIG = 1 | 1.62 | | | V |
| | | BUFCONFIG = 0 | 2.7 | | | |
| VREF | Voltage reference output voltage | BUFCONFIG = 1 | 1.38 | 1.4 | 1.42 | V |
| | | BUFCONFIG = 0 | 2.46 | 2.5 | 2.54 | |

### 7.14.2 Electrical Characteristics (VREF1)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{VREF}$ | VREF operating supply current | BUFCONFIG = {0, 1}, No load | | 189 | 330 | µA |
| $I_{Drive}$ | VREF output drive strength (1) | Drive strength supported on VREF+ device pin | | | 100 | µA |
| $I_{SC}$ | VREF short circuit current | | | | 100 | mA |
| $TC_{VREF}$ | Temperature coefficient of VREF (Bandgap+VRBUF) (2) | BUFCONFIG = {1} | | | 80 | ppm/°C |
| $TC_{VREF}$ | Temperature coefficient of VREF (Bandgap+VRBUF) (2) | BUFCONFIG = {0} | | | 80 | ppm/°C |
| $TC_{drift}$ | Long term VREF drift | Time = 1000 hours, BUFCONFIG = {0, 1}, T = 25℃ | | | 300 | ppm |
| $PSRR_{DC}$ | VREF Power supply rejection ratio, DC | VDD = 1.7 V to VDDmax, BUFCONFIG = 1 | 60 | 70 | | dB |
| | | VDD = 2.7 V to VDDmax, BUFCONFIG = 0 | 50 | 60 | | |
| $V_{noise}$ | RMS noise at VREF output (0.1 Hz to 100 MHz) | BUFCONFIG = 1 | | 350 | | µVrms |
| | | BUFCONFIG = 0 | | 500 | | |
| $C_{VREF}$ | Recommended VREF decoupling capacitor on VREF+ pin (3) (4) (5) | | 0.7 | 1 | 1.15 | µF |
| $T_{startup}$ | VREF startup time | BUFCONFIG = {0, 1} , VDD ≥ 2.7 V, $C_{VREF}$ = 1µF | | | 200 | µS |
| $T_{refresh}$ | VREF External capacitor refresh time | | 31.25 | | | |

(1) The specified MAX output drive strength is supported regardless of which peripherals are being used in the device.
(2) The temperature coefficient of the VREF output is the sum of $TC_{VRBUF}$ and the temperature coefficient of the internal bandgap reference.
(3) Decoupling capacitor ($C_{VREF}$) is required when using the internal voltage reference VREF and should be connected from the VREF+ pin to VREF-/GND. When using the VREF+/- pins to supply an external reference, a decoupling capacitor value should be selected based on the external reference source.
(4) A ceramic capacitor with package size of 0805 or smaller is preferred. Up to ±20% tolerance is acceptable

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(5) The VREF module should only be enabled when $C_{VREF}$ is connected and should not be enabled otherwise.

## 7.15 VREF2

### 7.15.1 Voltage Characteristics (VREF2)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $VDD_{min}$ | Minimum supply voltage needed for VREF operation | BUFCONFIG = 1 | 1.62 | | | V |
| | | BUFCONFIG = 0 | 2.7 | | | |
| VREF | Voltage reference output voltage | BUFCONFIG = 1 | 1.38 | 1.4 | 1.42 | V |
| | | BUFCONFIG = 0 | 2.46 | 2.5 | 2.54 | |

### 7.15.2 Electrical Characteristics (VREF2)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{VREF}$ | VREF operating supply current | BUFCONFIG = {0, 1}, No load | | 130 | 200 | µA |
| $TC_{VREF}$ | Temperature coefficient of VREF (Bandgap+VRBUF) (1) | BUFCONFIG = {0,1} | | | 80 | ppm/°C |
| $TC_{drift}$ | Long term VREF drift | Time = 1000 hours, BUFCONFIG = {0, 1}, T = 25°C | | | 300 | ppm |
| $PSRR_{DC}$ | VREF Power supply rejection ratio, DC | VDD = 1.7 V to VDDmax, BUFCONFIG = 1 | 60 | 70 | | dB |
| | | VDD = 2.7 V to VDDmax, BUFCONFIG = 0 | 50 | 60 | | |
| $V_{noise}$ | RMS noise at VREF output (0.1 Hz to 100 MHz) | BUFCONFIG = 1 | | 350 | | µVrms |
| | | BUFCONFIG = 0 | | 500 | | |
| $T_{startup}$ | VREF startup time | BUFCONFIG = {0, 1} , VDD ≥ 2.7 V | | | 20 | us |

(1) The temperature coefficient of the VREF output is the sum of $TC_{VRBUF}$ and the temperature coefficient of the internal bandgap reference.

## 7.16 Comparator (COMP)

### 7.16.1 Comparator Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **Comparator Electrical Characteristics** | | | | | | |
| $V_{CM}$ | Common mode input range | | 0 | | VDD | V |
| $V_{offset}$ | Input offset voltage | | -20 | | 20 | mV |
| $V_{hys}$ | DC input hysteresis | HYST=00h | | 0.4 | | mV |
| | | HYST=01h | | 10 | | |
| | | HYST=02h | | 20 | | |
| | | HYST=03h | | 30 | | |
| $t_{PD_ls}$ | Propagation delay, response time | Output Filter off, Overdrive = 100 mV, High Speed Mode | | 32 | 50 | ns |
| | | Output Filter off, Overdrive = 100 mV, Low Power Mode | | 1.2 | 4 | µs |
| $t_{en}$ | Comparator enable time | Startup time to reach propagation delay specification, High Speed Mode (comparator only) | | | 5 | µs |
| | | Startup time to reach propagation delay specification, Low Power Mode (comparator only) | | | 10 | µs |


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over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{comp}$ | Comparator current consumption. | Vcm = VDD/2, 100mV overdrive, DAC output as a voltage reference, VDD is reference for DAC, High Speed Mode | | 130 | 200 | µA |
| | | Vcm = VDD/2, 100mV overdrive, DAC output as a voltage reference, VDD is reference for DAC, Low Power Mode | | 0.85 | 2.7 | µA |
| | | Vcm = VDD/2, 100mV overdrive, comparator only. High Speed Mode | | 120 | 180 | µA |
| | | Vcm = VDD/2, 100mV overdrive, comparator only, Low Power Mode | | 0.7 | 2.1 | µA |
| $I_{comp}$ | Comparator +VREF current consumption in low power | Vcm = VDD/2, 100mV overdrive, DAC output as a voltage reference, Internal VREF is reference for DAC, Low Power Mode. VREF registers SHCYCLE=0xC0, HCYCLE=0xC0, SHMODE=1 | | 3 | | uA |
| **8-bit DAC Electrical Characteristics** | | | | | | |
| $V_{dac}$ | DAC output range | | 0 | | VDD | V |
| $V_{dac-code}$ | 8-bit DAC output voltage for a given code | VIN = reference voltage into 8-bit DAC, code n = 0 to 255 | | VIN × (n+1) / 256 | | V |
| INL | Integral nonlinearity of 8-bit DAC | | -1 | | 1 | LSB |
| DNL | Differential nonlinearity of 8-bit DAC | | -1 | | 1 | LSB |
| Gain error | Gain error of 8-bit DAC | Reference voltage = VDD | -2 | | 2 | % of FSR |
| Offset error | Offset error of 8-bit DAC | | -5 | | 5 | mV |
| Output Impedance | 8-bit DAC output impedance | | | 50 | | kΩ |
| $t_{dac_settle}$ | 8-bit DAC settling time in static mode | DACCODE0 = 0 → 255, DAC output accurate to 1 LSB, DAC out-put on pin PA11, Cload = 15pF | | 6 | | µs |
| | | DACCODE0 = 0 → 255, DAC output accurate to 1 LSB | | 1.5 | | µs |

## 7.17 I2C

### *7.17.1 I2C Characteristics*

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

| PARAMETERS | | TEST CONDITIONS | Standard mode | | Fast mode | | Fast mode plus | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | MAX | MIN | MAX | MIN | MAX | |
| $f_{I2C}$ | I2C input clock frequency | | 2 | 32 | 8 | 32 | 20 | 32 | MHz |
| $f_{SCL}$ | SCL clock frequency | | 0.025 | 0.1 | | 0.4 | | 1 | MHz |
| $t_{HD,STA}$ | Hold time (repeated) START | | 4 | | 0.6 | | 0.26 | | us |
| $t_{LOW}$ | Low period of the SCL clock | | 4.7 | | 1.3 | | 0.5 | | us |
| $t_{HIGH}$ | High period of the SCL clock | | 4 | | 0.6 | | 0.26 | | us |
| $t_{SU,STA}$ | Setup time for a repeated START | | 4.7 | | 0.6 | | 0.26 | | us |
| $t_{HD,DAT}$ | Data hold time | | 0 | | 0 | | 0 | | ns |
| $t_{SU,DAT}$ | Data setup time | | 250 | | 100 | | 50 | | ns |
| $t_{SU,STO}$ | Setup time for STOP | | 4 | | 0.6 | | 0.26 | | us |
| $t_{BUF}$ | bus free time between a STOP and START condition | | 4.7 | | 1.3 | | 0.5 | | us |
| $t_{VD;DAT}$ | data valid time | | | 3.45 | | 0.9 | | 0.45 | us |
| $t_{VD;ACK}$ | data valid acknowledge time | | | 3.45 | | 0.9 | | 0.45 | us |

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### 7.17.2 I2C Filter

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

| PARAMETERS | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{SP}$ | Pulse duration of spikes suppressed by input filter | AGFSELx = 0 | | 6 | | ns |
| | | AGFSELx = 1 | | 14 | 35 | |
| | | AGFSELx = 2 | | 22 | 60 | |
| | | AGFSELx = 3 | | 35 | 90 | |

### 7.17.3 I²C Timing Diagram

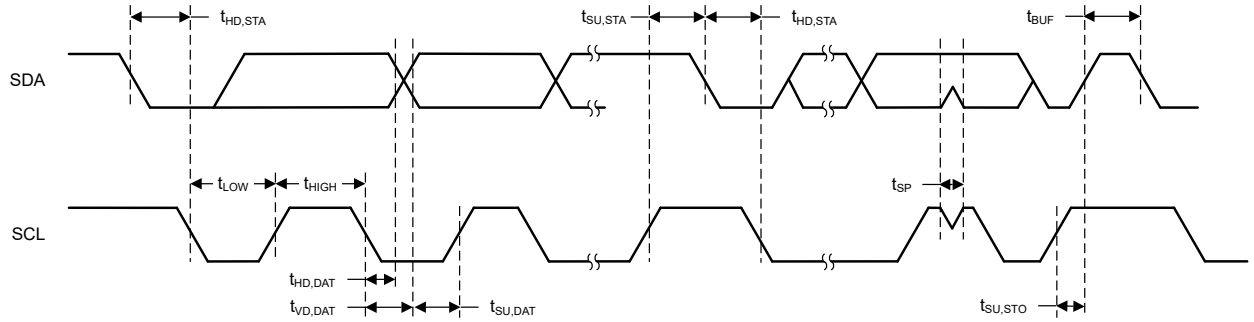



**Figure 7-3. I2C Timing Diagram**

## 7.18 SPI

### 7.18.1 SPI

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

| PARAMETERS | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **SPI** | | | | | | |
| $f_{SPI}$ | SPI clock frequency | Clock max speed >= 32MHz<br>1.62 < VDD < 3.6V<br>Peripheral or Controller mode | | | 16[4] | MHz |
| | | Clock max speed >= 48MHz<br>1.62 < VDD < 2.7V<br>Peripheral or Controller mode with High speed IO | | | 24[4] | |
| | | Clock max speed >= 64MHz<br>2.7 < VDD < 3.6V<br>Peripheral or Controller mode with High speed IO | | | 32[4] | |
| $DC_{SCK}$ | SCK Duty Cycle | | 40 | 50 | 60 | % |
| **Controller** | | | | | | |
| $t_{SCLK_H/L}$ | SCLK High or Low time | | (tSPI/2) - 1 | tSPI / 2 | (tSPI/2) + 1 | ns |
| $t_{CS.LEAD}$ | CS lead-time, CS active to clock | SPH=0 | 1 SPI Clock | | | ns |
| | | SPH=1 | 1/2 SPI Clock | | | |
| $t_{CS.LAG}$ | CS lag time, Last clock to CS inactive | SPH=0 | 1/2 SPI Clock | | | ns |
| | | SPH=1 | 1 SPI Clock | | | |
| $t_{CS.ACC}$ | CS access time, CS active to PICO data out | | | | 1/2 SPI Clock | ns |


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

| PARAMETERS | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{CS.DIS}$ | CS disable time, CS inactive to PICO high inpedance | | | | 1 SPI Clock | ns |
| $t_{SU.CI}$ | POCI input data setup time (1) | 2.7 < VDD < 3.6V, delayed sampling enabled | 6 | | | ns |
| | | 1.62 < VDD < 2.7V, delayed sampling enabled | 9 | | | |
| | | 2.7 < VDD < 3.6V, no delayed sampling | 28 | | | |
| | | 1.62 < VDD < 2.7V, no delayed sampling | 35 | | | |
| $t_{HD.CI}$ | POCI input data hold time | delayed sampling enabled | 24 | | | ns |
| | | no delayed sampling | 0 | | | |
| $t_{VALID.CO}$ | PICO output data valid time (2) | | | | 7 | ns |
| $t_{HD.CO}$ | PICO output data hold time (3) | | 0 | | | ns |
| **Peripheral** | | | | | | |
| $t_{CS.LEAD}$ | CS lead-time, CS active to clock | | 10.5 | | | ns |
| $t_{CS.LAG}$ | CS lag time, Last clock to CS inactive | | 1 | | | ns |
| $t_{CS.ACC}$ | CS access time, CS active to POCI data out | | | | 45 | ns |
| $t_{CS.DIS}$ | CS disable time, CS inactive to POCI high inpedance | | | | 45 | ns |
| $t_{SU.PI}$ | PICO input data setup time | | 7.5 | | | ns |
| $t_{HD.PI}$ | PICO input data hold time | | 2 | | | ns |
| $t_{VALID.PO}$ | POCI output data valid time(2) | 2.7 < VDD < 3.6V | | | 25 | ns |
| | | 1.62 < VDD < 2.7V | | | 29 | |
| $t_{HD.PO}$ | POCI output data hold time(3) | | 5.5 | | | ns |

(1) The POCI input data setup time can be fully compensated when delayed sampling feature is enabled.
(2) Specifies the time to drive the next valid data to the output after the output changing SCLK clock edge
(3) Specifies how long data on the output is valid after the output changing SCLK clock edge
(4) fSPIclk = 1/2tLO/HI with tLO/HI = max(tVALID,CO + tSU,PI, tSU,CI + tVALID,PO).

### 7.18.2 SPI Timing Diagram

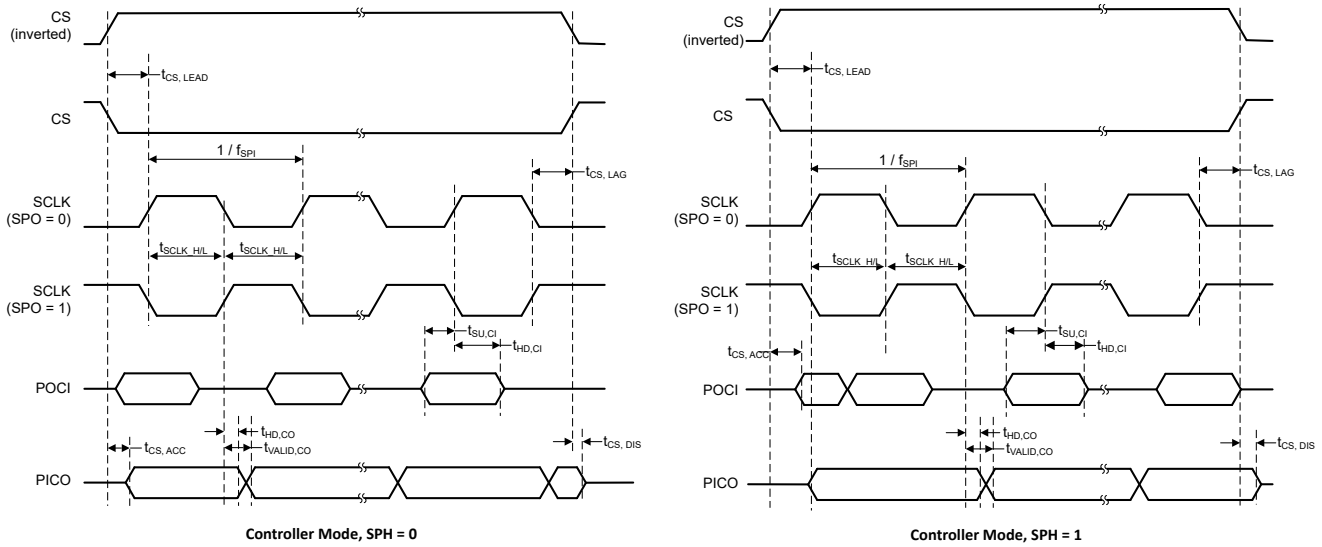



**Figure 7-4. SPI timing diagram - Controller Mode**

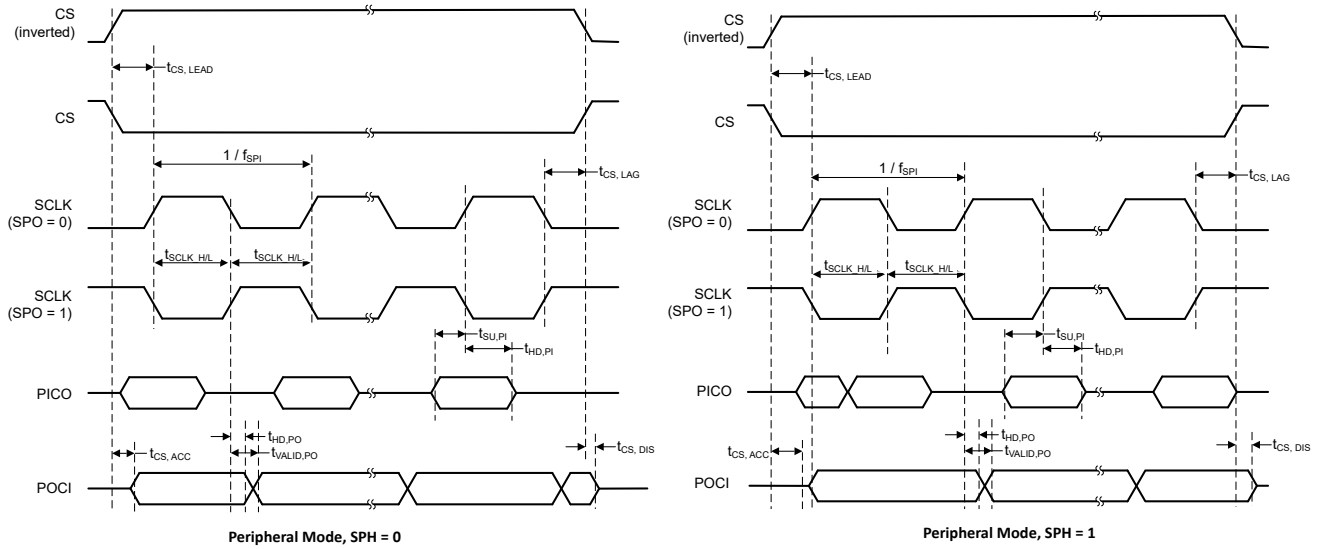



**Figure 7-5. SPI timing diagram - Peripheral Mode**

## 7.19 UART

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

| PARAMETERS | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{UART}$ | UART input clock frequency | UART in Power Domain1 | | | 80 | MHz |
| | | UART in Power Domain0 | | | 40 | |
| $f_{BITCLK}$ | BITCLK clock frequency(equals baud rate in MBaud) | UART in Power Domain1 | | | 10 | MHz |
| | | UART in Power Domain0 | | | 5 | |

## 7.20 USB Specifications

### *7.20.1 USB Characteristics (USB mode)*

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $I_{VUSB33}$ | VUSB33 pin quiescent current | VUSB33 | USB mode (3V ≤ VUSB33 ≤ 3.6V), USB bus IDLE | | 445 | | uA |
| | | VUSB33 | USB mode (3V ≤ VUSB33 ≤ 3.6V), USB SUSPEND mode | | 180 | | uA |
| | | VUSB33 | GPIO mode (1.62V ≤ VUSB33 ≤ 3.6V) | | 10 | | nA |
| $V_{CM}$ | Differential input common mode range | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | 0.8 | | 2.5 | V |
| $V_{DI}$ | Differential input voltage | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | 0.2 | | | V |
| $V_{IH}$ | Static SE input logic-high level | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | 0.7*VUSB33 | | | V |
| $V_{IL}$ | Static SE input logic-low level | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | | | 0.3*VUSB33 | V |
| $V_{HYS}$ | Static SE input logic-low level | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | 10 | 50 | 300 | mV |
| $Z_{IN}$ | Input impedance | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | 300 | | | kΩ |
| $Z_{DRV}$ | D+, D– impedance | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | 28 | | 44 | Ω |
| $R_{PU}$ | Pull up resistance | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V), IDLE bus | | 1.1 | | kΩ |
| $R_{PD}$ | Pull down resistance | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) | | 18 | | kΩ |


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over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{OH}$ | D+, D– | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) $\|I_{IO}\|_{,max}$=2.5mA | 2.8 | | 3.6 | V |
| $V_{OL}$ | D+, D– | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) $\|I_{IO}\|_{,max}$=2.5mA | 0 | | 0.3 | V |
| $V_{CRS}$ | Output Signal Crossover Voltage | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) Rpd on D+/D-/Pu on D- only | 1.3 | | 2.0 | V |
| $t_r$ | Rise time | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) Full speed, differential, $C_L$ = 50 pF, 10%/90%, Rpu on D+ | 4 | | 20 | ns |
| $t_f$ | Fall time | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) Full speed, differential, $C_L$ = 50 pF, 10%/90%, Rpu on D+ | 4 | | 20 | ns |
| $t_{rfm}$ | Rise & Fall Time Matching | USBIO (1) | USB mode (3V ≤ VUSB33 ≤ 3.6V) Full speed, differential, $C_L$ = 50 pF, 10%/90%, Rpu on D+ | 90 | | 111 | % |

(1) I/O Types: ODIO = 5V Tolerant Open-Drain , SDIO = Standard-Drive , HSIO = High-Speed, HDIO = High-Drive, USBIO = USB protocol

## 7.21 Serial Audio

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

| PARAMETERS | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **Controller Mode** | | | | | | |
| $f_{BCLK}$ | Serial Audio bit clock frequency | Transmitter mode | | | 6.144 | MHz |
| | | Receiver mode | | | 12.288 | MHz |
| $t_{VALID.WCLK}$ | Word Clock output valid time | | | | 16 | ns |
| $t_{HOLD:WCLK}$ | Word Clock output hold time | | 7 | | | ns |
| $t_{VALID:ADx}$ | Data output valid time | Transmitter mode | | | 56 | ns |
| $t_{HOLD:ADx}$ | Data output hold time | Transmitter mode | 11 | | | ns |
| $t_{SU.ADx}$ | Data input setup time | Receiver mode | 4 | | | ns |
| $t_{HOLD.ADx}$ | Data input hold time | Receiver mode | 1 | | | ns |
| **Target Mode** | | | | | | |
| $f_{BCLK}$ | Serial Audio bit clock frequency | Transmitter mode | | | 12.288 | MHz |
| | | Receiver mode | | | 6.144 | MHz |
| $t_{SU.WCLK}$ | Word Clock input setup time | | 15 | | | ns |
| $t_{HOLD:WCLK}$ | Word Clock input hold time | | 1 | | | ns |
| $t_{VALID:ADx}$ | Data output valid time | Transmitter mode | | | 37 | ns |
| $t_{HOLD:ADx}$ | Data output hold time | Transmitter mode | 8 | | | ns |
| $t_{SU.ADx}$ | Data input setup time | Receiver mode | 3 | | | ns |
| $t_{HOLD.ADx}$ | Data input hold time | Receiver mode | 1 | | | ns |

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## 7.22 TIMx

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

| PARAMETERS | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{res}$ | Timer resolution time | TIMx in Power Domain 1, $f_{TIMxCLK}$ = 80MHz | 12.5 | | | ns |
| | | TIMx in Power Domain 0, $f_{TIMxCLK}$ = 40MHz | 25 | | | ns |
| | | | 1 | | | $t_{TIMxCLK}$ |

## 7.23 Emulation and Debug

### *7.23.1 SWD Timing*

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

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{SWD}$ | SWD frequency | | | | 10 | MHz |


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# 8 Detailed Description

The following sections describe all of the components that make up the devices in this data sheet. The peripherals integrated into these devices are configured by software through Memory Mapped Registers (MMRs). For more details, see the corresponding chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.1 Functional Block Diagram

Figure 8-1 shows the MSPM0G511x functional block diagram.

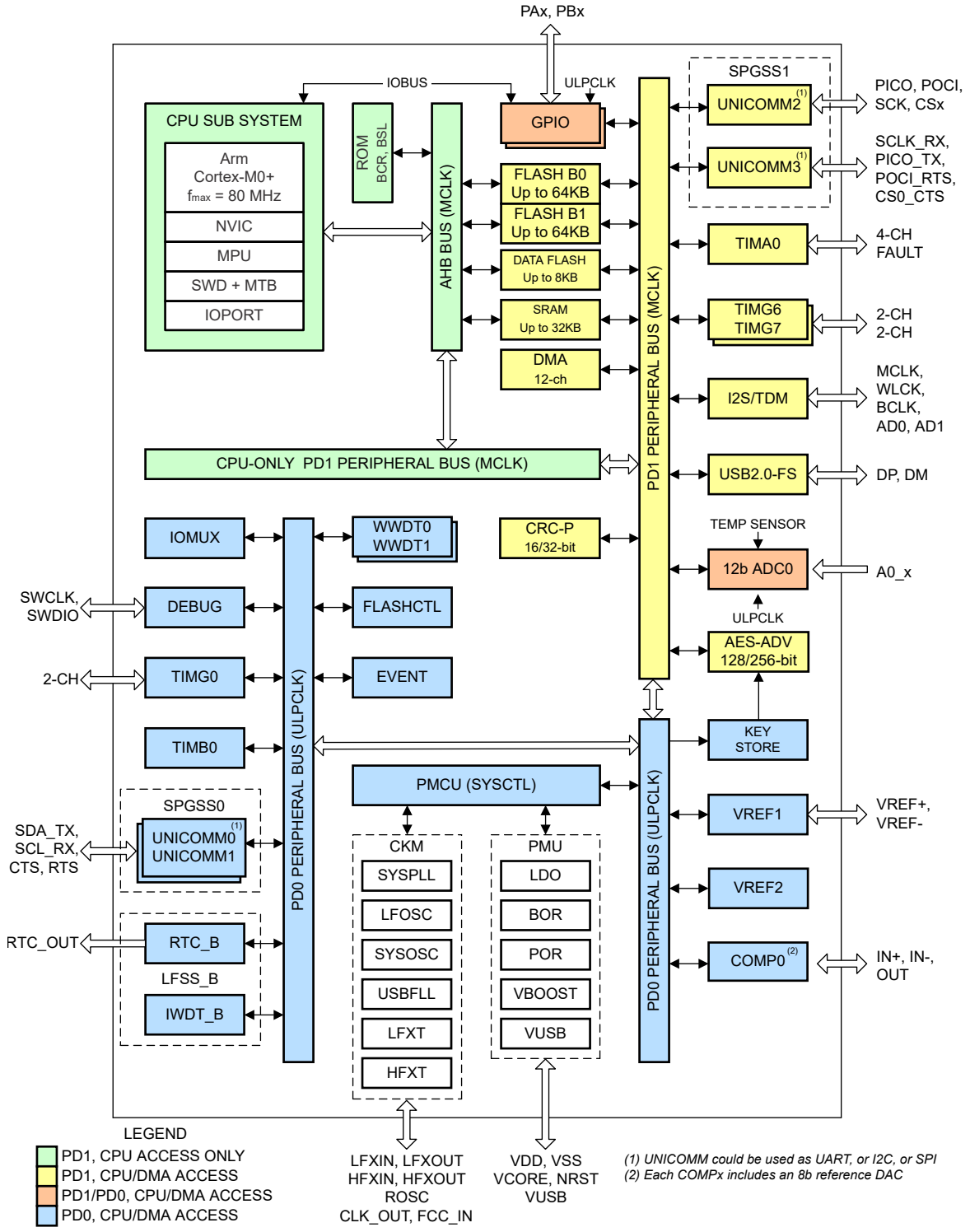



**Figure 8-1. MSPM0G511x Functional Block Diagram**

## 8.2 CPU

The CPU sub system (MCPUSS) implements an ARM Cortex-M0+ CPU, an instruction pre-fetch/cache, a system timer, a memory protection unit, and interrupt management features. The ARM Cortex-M0+ is a cost-


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optimized, 32-bit CPU which delivers high performance and low power to embedded applications. Key features of the CPU Sub System include:

- ARM Cortex-M0+ CPU supporting clock frequencies from 32kHz to 80MHz
  - ARMv6-M Thumb instruction set (little endian) with single-cycle 32x32 multiply instruction
  - Single-cycle access to GPIO registers via ARM single-cycle IO port
- Pre-fetch logic to improve sequential code execution, and I-cache with 4 64-bit cache lines
- System timer (SysTick) with 24-bit down counter and automatic reload
- Memory protection unit (MPU) with 8 programmable regions
- Nested vectored interrupt controller (NVIC) with 4 programmable priority levels and tail-chaining
- Interrupt groups for expanding the total interrupt sources, with jump index for low interrupt latency

## 8.3 Operating Modes

MSPM0G MCUs provide five main operating modes (power modes) to allow for optimization of the device power consumption based on application requirements. In order of decreasing power, the modes are: RUN, SLEEP, STOP, STANDBY, and SHUTDOWN. The CPU is active executing code in RUN mode. Peripheral interrupt events can wake the device from SLEEP, STOP, or STANDBY mode to the RUN mode. SHUTDOWN mode completely disables the internal core regulator to minimize power consumption, and wake is only possible via NRST, SWD, or a logic level match on certain IOs. RUN, SLEEP, STOP, and STANDBY modes also include several configurable policy options (e.g. RUN.x) for balancing performance with power consumption.

To further balance performance and power consumption, MSPM0G devices implement two power domains: PD1 (for the CPU, memories, and high performance peripherals), and PD0 (for low speed, low power peripherals). PD1 is always powered in RUN and SLEEP modes, but is disabled in all other modes. PD0 is always powered in RUN, SLEEP, STOP, and STANDBY modes. PD1 and PD0 are both disabled in SHUTDOWN mode.

### *8.3.1 Functionality by Operating Mode (MSPM0G511x)*

Supported functionality in each operating mode is given in Table 8-1.

Functional key:

- **EN**: The function is enabled in the specified mode.
- **DIS**: The function is disabled (either clock or power gated) in the specified mode, but the function's configuration is retained.
- **OPT**: The function is optional in the specified mode, and remains enabled if configured to be enabled.
- **NS**: The function is not automatically disabled in the specified mode, but it is not supported.
- **OFF**: The function is fully powered off in the specified mode, and no configuration information is retained. When waking up from an OFF state, all module registers must be re-configured to the desired settings by application software.

**Table 8-1. Supported Functionality by Operating Mode**

| OPERATING MODE | | RUN | | | SLEEP | | | STOP | | | STANDBY | | SHUTDOWN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RUN0 | RUN1 | RUN2 | SLEEP0 | SLEEP1 | SLEEP2 | STOP0 | STOP1 | STOP2 | STANDBY0 | STANDBY1 | |
| Oscillators | SYSOSC | EN | | DIS | EN | | DIS | OPT[1] | EN | DIS | DIS | | OFF |
| | LFOSC or LFXT | EN (LFOSC or LFXT) | | | | | | | | | | | OFF |
| | HFXT | OPT | DIS | | OPT | DIS | | DIS | | | DIS | | OFF |
| | SYSPLL | OPT | DIS | | OPT | DIS | | DIS[4] | | | DIS[4] | | OFF |
| | USBFLL | OPT | DIS | | OPT | DIS | | DIS | | | DIS | | OFF |

**Table 8-1. Supported Functionality by Operating Mode (continued)**

| OPERATING MODE | | RUN | | | SLEEP | | | STOP | | | STANDBY | | SHUTDOWN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RUN0 | RUN1 | RUN2 | SLEEP0 | SLEEP1 | SLEEP2 | STOP0 | STOP1 | STOP2 | STANDBY0 | STANDBY1 | |
| Clocks | CPUCLK | 80 MHz | 32 kHz | | DIS | | | | | | | | OFF |
| | MCLK to PD1 | 80 MHz | 32 kHz | | 80 MHz | 32 kHz | | DIS | | | | | OFF |
| | ULPCLK to PD0 | 40 MHz | 32 kHz | | 40 MHz | 32 kHz | | 4 MHz (1) | 4 MHz | 32 kHz | 32 kHz | DIS | OFF |
| | ULPCLK to TIMG0, TIMB0 | 40 MHz | 32 kHz | | 40 MHz | 32 kHz | | 4 MHz (1) | 4 MHz | 32 kHz | 32 kHz | 32 kHz (2) | OFF |
| | RTCCLK | 32 kHz | | | | | | | | | | | OFF |
| | USBCLK | OPT | DIS | | OPT | DIS | | DIS | | | DIS | | OFF |
| | MFCLK | OPT | DIS | | OPT | DIS | | OPT | | DIS | DIS | | OFF |
| | LFCLK to PD0/1 | 32 kHz | | | | | | | | | | DIS | OFF |
| | LFCLK to TIMG0, TIMB0 | 32 kHz | | | | | | | | | | 32 kHz (2) | OFF |
| | LFCLK Monitor | OPT | | | | | | | | | | | OFF |
| | MCLK Monitor | OPT | | | | | | | | | | DIS | OFF |
| PMU | POR monitor | EN | | | | | | | | | | | |
| | BOR monitor | EN | | | | | | | | | | | OFF |
| | Core regulator | FULL DRIVE | | | | | | REDUCED DRIVE | | | LOW DRIVE | | OFF |
| Core Functions | CPU | EN | | | DIS | | | | | | | | OFF |
| | DMA | OPT | | | | | | DIS (triggers supported) | | | | | OFF |
| | Flash | EN | | | | | | DIS | | | | | OFF |
| | SRAM | EN | | | | | | DIS | | | | | OFF |
| PD1 Peripherals | UC2/3 | OPT | | | | | | OFF | | | | | OFF |
| | USB2.0-FS | OPT | DIS | | OPT | DIS | | OFF | | | | | OFF |
| | I2S/TDM | OPT | DIS | | OPT | DIS | | OFF | | | | | OFF |
| | TIMA0 | OPT | | | | | | OFF | | | | | OFF |
| | TIMG6/7 | OPT | | | | | | OFF | | | | | OFF |
| | AESADV | OPT | | | | | | OFF | | | | | OFF |
| | CRC-P | OPT | | | | | | DIS | | | | | OFF |
| PD0 Peripherals | GPIOA/B (3) | OPT | | | | | | | | | | OPT (2) | OFF |
| | UC0/1 | OPT | | | | | | | | | | OPT (2) | OFF |
| | TIMG0 | OPT | | | | | | | | | | OPT (2) | OFF |
| | TIMB0 | OPT | | | | | | | | | | OPT (2) | OFF |
| | WWDT0/1 | OPT | | | | | | | | | | DIS | OFF |
| | IWDT | OPT | | | | | | | | | | | OFF |
| | RTC_B | OPT | | | | | | | | | | | OFF |
| | Keystore | OPT | | | | | | | | | | | OFF |
| Analog | VREF1 | OPT | | | | | | | | | | | OFF |
| | VREF2 | OPT | | | | | | | | NS | | | OFF |
| | ADC0 (3) | OPT | | | | | | | | NS (triggers supported) | | | OFF |
| | COMP0 | OPT | OPT (ULP) | | OPT | OPT (ULP) | | OPT | | OPT (ULP) | | | OFF |
| | Temperature Sensor | OPT | | | | | | | | | OFF | | OFF |


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**Table 8-1. Supported Functionality by Operating Mode (continued)**

| OPERATING MODE | RUN | | | SLEEP | | | STOP | | | STANDBY | | SHUTDOWN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RUN0 | RUN1 | RUN2 | SLEEP0 | SLEEP1 | SLEEP2 | STOP0 | STOP1 | STOP2 | STANDBY0 | STANDBY1 | |
| IOMUX and IO Wakeup | EN | | | | | | | | | | | DIS w/ WAKE |
| Wake Sources | N/A | | | ANY IRQ | | | PD0 IRQ | | | | | IOMUX, NRST, SWD |

(1) If STOP0 is entered from RUN1 (SYSOSC enabled but MCLK sourced from LFCLK), SYSOSC remains enabled as it was in RUN1, and ULPCLK remains at 32 kHz as it was in RUN1. If STOP0 is entered from RUN2 (SYSOSC was disabled and MCLK was sourced from LFCLK), SYSOSC remains disabled as it was in RUN2, and ULPCLK remains at 32 kHz as it was in RUN2.
(2) When using the STANDBY1 policy for STANDBY, only specific peripherals (TIMG0, TIMB0, and RTC) are clocked. Other PD0 peripherals can generate an asynchronous fast clock request upon external activity but are not actively clocked.
(3) For ADCx and GPIO Ports A and B, the digital logic is in PD0 and the register interface is in PD1. These peripherals support fast single-cycle register access when PD1 is active and also support basic operation down to STANDBY mode where PD0 is still active.
(4) SYSPLL is not automatically disabled, and needs to be manually disabled through the HSCLKEN.SYSPLLEN field within the SYSCTL registers in order to reduce power consumption.

## 8.4 Power Management Unit (PMU)

The power management unit (PMU) generates the internally regulated core supplies for the device and provides supervision of the external supply (VDD). The PMU also contains the bandgap voltage reference used by the PMU itself as well as analog peripherals. Key features of the PMU include:

- Power-on reset (POR) supply monitor
- Brown-out reset (BOR) supply monitor with early warning capability using three programmable thresholds
- Core regulator with support for RUN, SLEEP, STOP, and STANDBY operating modes to dynamically balance performance with power consumption
- Parity-protected trim to immediately generate a power-on reset (POR) in the event that a power management trim is corrupted

For more details, see the PMU chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.5 Clock Module (CKM)

The clock module provides the following oscillators:

- **LFOSC**: Internal low-frequency oscillator (32KHz)
- **SYSOSC**: Internal high-frequency oscillator (4MHz or 32MHz with factory trim, 16MHz or 24MHz with user trim)
- **LFXT/LFCKIN** : Low-frequency external crystal oscillator or digital clock input (32KHz)
- **HFXT/HFCKIN**: High-frequency external crystal oscillator or digital clock input (4 to 48MHz)
- **SYSPLL**: System phase locked loop with 3 outputs (32 to 80MHz)
- **USBFLL**: Internal frequency-locked-loop (FLL) oscillator (60MHz)

The following clocks are distributed by the clock module for use by the processor, bus, and peripherals:

- **MCLK**: Main system clock for PD1 peripherals, derived from SYSOSC, LFCLK, or HSCLK, active in RUN and SLEEP modes
- **CPUCLK**: Clock for the processor (derived from MCLK), active in RUN mode
- **ULPCLK**: Ultra-low power clock for PD0 peripherals, active in RUN, SLEEP, STOP, and STANDBY modes
- **MFCLK**: 4MHz fixed mid-frequency clock for peripherals, available in RUN, SLEEP, and STOP modes
- **LFCLK**: 32kHz fixed low-frequency clock for peripherals or MCLK, active in RUN, SLEEP, STOP, and STANDBY modes
- **ADCCLK**: ADC clock, available in RUN, SLEEP and STOP modes

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- **CLK_OUT**: Used to output a clock externally, available in RUN, SLEEP, STOP, and STANDBY modes
- **HFCLK**: High frequency clock derived from HFXT or HFCLK_IN, available in RUN and SLEEP modes
- **HSCLK**: High speed clock derived from HFCLK, SYSPLL, or USBFLL and is available in RUN and SLEEP modes
- **USBCLK**: USB clock, available in RUN and SLEEP modes
- **DAICLK**: Digital audio interface clock, available in RUN mode

For more details, see the CKM chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.6 DMA

The direct memory access (DMA) controller allows movement of data from one memory address to another without CPU intervention. For example, the DMA can be used to move data from ADC conversion memory to SRAM. The DMA reduces system power consumption by allowing the CPU to remain in low power mode, without having to awaken to move data to or from a peripheral.

The DMA in these devices support the following key features:

- 12 independent DMA transfer channels
  - 6 full-feature channel (DMA0-DMA5), supporting repeated transfer modes
  - 6 basic channels (DMA6-DMA11) supporting single transfer modes
- Configurable DMA channel priorities
- Byte (8-bit), short word (16-bit), word (32-bit) and long word (64-bit) and long-long word (128-bit) or mixed byte and word transfer capability
- Transfer counter block size supports up to 64k transfers of any data type
- Configurable DMA transfer trigger selection
- Active channel interruption to service other channels
- Early interrupt generation for ping-pong buffer architecture
- Cascading channels upon completion of activity on another channel
- Stride mode to support data re-organization, such as 3-phase metering applications
- Gather mode

**Table 8-2. DMA Features**

| Feature | FULL | BASIC |
|---|---|---|
| Channel# | 0,1,2,3,4,5 | 6,7,8,9,10,11 |
| Repeat Mode | Yes | - |
| Table & Fill Mode | Yes | - |
| Gather Mode | Yes | - |
| Pre-IRQ | Yes | - |
| Auto Enable | Yes | Yes |
| Long Long (128-bit) Transfer | Yes | Yes |
| Stride Mode | Yes | Yes |
| Cascading Channel Support | Yes | Yes |

Table 8-3 lists the available triggers for the DMA which are configured using the DMATCTL.DMATSEL control bits in the DMA memory mapped registers.

**Table 8-3. DMA Trigger Mapping**

| DMACTL.DMATSEL | Trigger Source | DMACTL.DMATSEL | Trigger Source |
|---|---|---|---|
| 0 | Software | 12 | UC3.TX Publisher 2 |
| 1 | Generic Subscriber (FSUB_0) | 13 | I2S Publisher 1 |
| 2 | Generic Subscriber (FSUB_1) | 14 | I2S Publisher 2 |
| 3 | AESADV Publisher 1 | 15 | USB-FS Publisher 1 |
| 4 | AESADV Publisher 2 | 16 | USB-FS Publisher 2 |


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**Table 8-3. DMA Trigger Mapping (continued)**

| DMACTL.DMATSEL | Trigger Source | DMACTL.DMATSEL | Trigger Source |
|---|---|---|---|
| 5 | UC0.RX Publisher 1 | 17 | USB-FS Publisher 3 |
| 6 | UC0.TX Publisher 2 | 18 | USB-FS Publisher 4 |
| 7 | UC1.RX Publisher 1 | 19 | USB-FS Publisher 5 |
| 8 | UC1.TX Publisher 2 | 20 | USB-FS Publisher 6 |
| 9 | UC2.RX Publisher 1 | 21 | USB-FS Publisher 7 |
| 10 | UC2.TX Publisher 2 | 22 | USB-FS Publisher 8 |
| 11 | UC3.RX Publisher 1 | 23 | ADC0 DMA Trigger |

For more details, see the DMA chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.7 Events

The event manager transfers digital events from one entity (for example, a peripheral) to another (for example, a second peripheral, the DMA, or the CPU). The event manager implements event transfer through a defined set of event publishers (generators) and subscribers (receivers) which are interconnected through an event fabric containing a combination of static and programmable routes.

Events which are transferred by the event manager include:

- Peripheral event transferred to the CPU as an interrupt request (IRQ) (Static Event)
  - Example: RTC interrupt is sent to the CPU
- Peripheral event transferred to the DMA as a DMA trigger (DMA Event)
  - Example: UART data receive trigger to DMA to request a DMA transfer
- Peripheral event transferred to another peripheral to directly trigger an action in hardware (Generic Event)
  - Example: TIMx timer peripheral publishes a periodic event to the ADC subscriber port, and the ADC uses the event to trigger start-of-sampling

Refer to Event chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual* for more information.

**Table 8-4. Generic Event Channels**

A generic route is either a point-to-point (1:1) route or a point-to-two (1:2) splitter route route in which the peripheral publishing the event is configured to use one of several available generic route channels to publish its event to another entity (or entities, in the case of a splitter route), where an entity may be another peripheral, a generic DMA trigger event, or a generic CPU event.

| CHANID | Generic Route Channel Selection | Channel Type |
|---|---|---|
| 0 | No generic event channel selected | N/A |
| 1 | Generic event channel 1 selected | 1 : 1 |
| 2 | Generic event channel 2 selected | 1 : 1 |
| 3 | Generic event channel 3 selected | 1 : 1 |
| 4 | Generic event channel 4 selected | 1 : 1 |
| 5 | Generic event channel 5 selected | 1 : 1 |
| 6 | Generic event channel 6 selected | 1 : 1 |
| 7 | Generic event channel 7 selected | 1 : 1 |
| 8 | Generic event channel 8 selected | 1 : 1 |
| 9 | Generic event channel 9 selected | 1 : 1 |
| 10 | Generic event channel 10 selected | 1 : 1 |
| 11 | Generic event channel 11 selected | 1 : 1 |
| 12 | Generic event channel 12 selected | 1 : 2 (splitter) |
| 13 | Generic event channel 13 selected | 1 : 2 (splitter) |
| 14 | Generic event channel 14 selected | 1 : 2 (splitter) |

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**Table 8-4. Generic Event Channels (continued)**

A generic route is either a point-to-point (1:1) route or a point-to-two (1:2) splitter route route in which the peripheral publishing the event is configured to use one of several available generic route channels to publish its event to another entity (or entities, in the case of a splitter route), where an entity may be another peripheral, a generic DMA trigger event, or a generic CPU event.

| CHANID | Generic Route Channel Selection | Channel Type |
|---|---|---|
| 15 | Generic event channel 15 selected | 1 : 2 (splitter) |

## 8.8 Memory

### *8.8.1 Memory Organization*

Table 8-5 summarizes the memory map of the devices. For more information about the memory region detail, see the *Platform Memory Map* section in the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual* .

**Table 8-5. Memory Organization**

| MEMORY REGION | SUBREGION | MSPM0G5115 | MSPM0G5116 | MSPM0G5117 |
|---|---|---|---|---|
| Code (Flash Bank 0) | MAIN ECC Corrected | 16KB | 32KB | 64KB |
| | | 0x0000.0000 to 0x0000.3FFF | 0x0000.0000 to 0x0000.7FFF | 0x0000.0000 to 0x0000.FFFF |
| | MAIN ECC Uncorrected | 0x0040.0000 to 0x0040.3FFF | 0x0040.0000 to 0x0040.7FFF | 0x0040.0000 to 0x0040.FFFF |
| | Flash ECC Code | 0x0080.0000 to 0x0080.3FFF | 0x0080.0000 to 0x0080.7FFF | 0x0080.0000 to 0x0080.FFFF |
| Code (Flash Bank 1) | MAIN ECC Corrected | 16KB | 32KB | 64KB |
| | | 0x0000.4000 to 0x0000.7FFF | 0x0000.8000 to 0x0000.FFFF | 0x0001.0000 to 0x0001.FFFF |
| | MAIN ECC Uncorrected | 0x0040.4000 to 0x0040.7FFF | 0x0040.8000 to 0x0040.FFFF | 0x0041.0000 to 0x0001.FFFF |
| | Flash ECC Code | 0x0080.4000 to 0x0080.7FFF | 0x0080.8000 to 0x0080.FFFF | 0x0081.0000 to 0x0001.FFFF |
| Data Flash Bank | Data Flash ECC Corrected | 8KB | 8KB | 8KB |
| | | 0x41D0.0000 to 0x41D0.1FFF | 0x41D0.0000 to 0x41D0.1FFF | 0x41D0.0000 to 0x41D0.1FFF |
| | Data Flash Unchecked | 0x41E0.0000 to 0x41E0.1FFF | 0x41E0.0000 to 0x41E0.1FFF | 0x41E0.0000 to 0x41E0.1FFF |
| | Data Flash ECC Code | 0x41F0.0000 to 0x41F0.1FFF | 0x41F0.0000 to 0x41F0.1FFF | 0x41F0.0000 to 0x41F0.1FFF |
| SRAM (SRAM) | SRAM ECC Corrected | 16KB | 32KB | 32KB |
| | | 0x2000.0000 to 0x2000.3FFF | 0x2000.0000 to 0x2000.7FFF | 0x2000.0000 to 0x2000.7FFF |
| | SRAM Parity Checked | 0x2010.0000 to 0x2010.3FFF | 0x2010.0000 to 0x2010.7FFF | 0x2010.0000 to 0x2010.7FFF |
| | SRAM Unchecked | 0x2020.0000 to 0x2020.3FFF | 0x2020.0000 to 0x2020.7FFF | 0x2020.0000 to 0x2020.7FFF |
| | SRAM ECC/Parity Code | 0x2030.0000 to 0x2030.3FFF | 0x2030.0000 to 0x2030.7FFF | 0x2030.0000 to 0x2030.7FFF |


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**Table 8-5. Memory Organization (continued)**

| MEMORY REGION | SUBREGION | MSPM0G5115 | MSPM0G5116 | MSPM0G5117 |
|---|---|---|---|---|
| Peripheral | Peripherals | 0x4000.0000 to 0x40FF.FFFF | 0x4000.0000 to 0x40FF.FFFF | 0x4000.0000 to 0x40FF.FFFF |
| | NONMAIN Corrected | 1KB | 1KB | 1KB |
| | | 0x41C0.0000 to 0x41C0.03FF | 0x41C0.0000 to 0x41C0.03FF | 0x41C0.0000 to 0x41C0.03FF |
| | NONMAIN Uncorrected | 0x41C1.0000 to 0x41C1.03FF | 0x41C1.0000 to 0x41C1.03FF | 0x41C1.0000 to 0x41C1.03FF |
| | NONMAIN ECC Code | 0x41C2.0000 to 0x41C2.03FF | 0x41C2.0000 to 0x41C2.03FF | 0x41C2.0000 to 0x41C2.03FF |
| | FACTORY Corrected | 512Bytes | 512Bytes | 512Bytes |
| | | 0x41C4.0000 to 0x41C4.01FF | 0x41C4.0000 to 0x41C4.01FF | 0x41C4.0000 to 0x41C4.01FF |
| | FACTORY Uncorrected | 0x41C5.0000 to 0x41C5.01FF | 0x41C5.0000 to 0x41C5.01FF | 0x41C5.0000 to 0x41C5.01FF |
| | FACTORY ECC code | 0x41C6.0000 to 0x41C6.01FF | 0x41C6.0000 to 0x41C6.01FF | 0x41C6.0000 to 0x41C6.01FF |
| Subsystem | | 0x6000.0000 to 0x7FFF.FFFF | 0x6000.0000 to 0x7FFF.FFFF | 0x6000.0000 to 0x7FFF.FFFF |
| System PPB | | 0xE000.0000 to 0xE00F.FFFF | 0xE000.0000 to 0xE00F.FFFF | 0xE000.0000 to 0xE00F.FFFF |

### *8.8.2 Peripheral File Map*

Table 8-6 lists the available peripherals and the register base address for each.

**Table 8-6. Peripherals Summary**

| Peripheral Name | Base Address | Size |
|---|---|---|
| ADC0 | 0x4000.0000 | 0x2000 |
| VREF | 0x4003.0000 | 0x2000 |
| WWDT0 | 0x4008.0000 | 0x2000 |
| WWDT1 | 0x4008.2000 | 0x2000 |
| TIMG0 | 0x4008.4000 | 0x2000 |
| RTC_B | 0x4009.4000 | 0x2000 |
| GPIOA | 0x400A.0000 | 0x2000 |
| GPIOB | 0x400A.2000 | 0x2000 |
| KEYSTORE | 0x400A.C000 | 0x2000 |
| SYSCTL | 0x400A.F000 | 0x4000 |
| TIMB0 | 0x400B.8000 | 0x2000 |
| DEBUGSS | 0x400C.7000 | 0x2000 |
| EVENT | 0x400C.9000 | 0x3000 |
| NVM | 0x400C.D000 | 0x2000 |
| MCPUSS | 0x4040.0000 | 0x2000 |
| MTB | 0x4040.2000 | 0x1000 |
| MTBRAM | 0x4040.3000 | 0x0020 |

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**Table 8-6. Peripherals Summary (continued)**

| Peripheral Name | Base Address | Size |
|---|---|---|
| IOMUX | 0x4042.8000 | 0x2000 |
| DMA | 0x4042.A000 | 0x2000 |
| CRC | 0x4044.0000 | 0x2000 |
| AESADV | 0x4044.2000 | 0x2000 |
| I2S | 0x4047.B000 | 0x2000 |
| USB FS | 0x4047.F000 | 0x81000 |
| ADC0 (1) | 0x4055.6000 | 0x2000 |
| TIMA0 | 0x4086.0000 | 0x2000 |
| TIMG6 | 0x4086.8000 | 0x2000 |
| TIMG7 | 0x4086.A000 | 0x2000 |
| UNICOMM0 | 0x40A8.0000 | 0x2000 |
| UC0.UART | 0x40A0.1000 | 0x1000 |
| UC0.I2CC | 0x40A2.1000 | 0x1000 |
| UC0.I2CT | 0x40A4.1000 | 0x1000 |
| UNICOMM1 | 0x40A8.2000 | 0x2000 |
| UC1.UART | 0x40A0.3000 | 0x1000 |
| UC1.I2CC | 0x40A2.3000 | 0x1000 |
| UC1.I2CT | 0x40A4.3000 | 0x1000 |
| SPG0 | 0x40A0.0000 | 0x1000 |
| UNICOMM2 | 0x40B8.0000 | 0x2000 |
| UC2.SPI | 0x40B6.1000 | 0x1000 |
| UNICOMM3 | 0x40B8.2000 | 0x2000 |
| UC3.UART | 0x40B0.3000 | 0x1000 |
| UC3.SPI | 0x40B6.3000 | 0x1000 |
| SPG1 | 0x40B0.0000 | 0x1000 |

(1) Aliased region of ADC0 memory-mapped registers


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### 8.8.3 Peripheral Interrupt Vector

Table 8-7 shows the IRQ number and the interrupt group number for each periperals in this device.

**Table 8-7. Interrupt vector number**

| Peripheral Name | NVIC IRQ | Group IIDX |
|---|---|---|
| WWDT0 | 0 | 0 |
| WWDT1 | 0 | 1 |
| DEBUGSS | 0 | 2 |
| FLASHCTL | 0 | 3 |
| EVENT SUB PORT 0 | 0 | 4 |
| EVENT SUB PORT 1 | 0 | 5 |
| SYSCTL | 0 | 6 |
| GPIOA | 1 | 0 |
| GPIOB | 1 | 1 |
| COMP0 | 1 | 2 |
| TIMB0 | 2 | - |
| ADC0 | 4 | - |
| USBFS | 6 | - |
| UC0 | 9 | - |
| UC1 | 10 | - |
| I2S | 11 | - |
| UC2 | 13 | - |
| UC3 | 14 | - |
| TIMG0 | 16 | - |
| TIMG6 | 17 | - |
| TIMA0 | 18 | - |
| TIMG7 | 20 | - |
| AESADV | 28 | - |
| RTC_B | 30 | - |
| DMA0 | 31 | - |

## 8.9 Flash Memory

A dual bank of non-volatile flash memory (up to 128kB total) and a separate data flash bank (8kB) is provided for storing executable program code and application data.

Key features of the flash include:

- Hardware ECC protection (encode and decode) with single bit error correction and double-bit error detection
- In-circuit program and erase operations supported across the entire recommended supply range
- Small 1kB sector sizes (minimum erase resolution of 1kB)
- Up to 100,000 program/erase cycles on the 32kB of the flash memory (any sector including data flash bank), with up to 10,000 program/erase cycles on the remaining flash memory (devices with 32kB support 100,000 cycles on the entire flash memory)
- Bank address swap for in-system, over-the-air (OTA) firmware updates

For a complete description of the flash memory, see the NVM chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.10 SRAM

MSPM0 MCUs include a low power, high performance SRAM memory with zero wait state access across the supported CPU frequency range of the device. MSPM0G511x series provides up to 32KB SRAM with hardware

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ECC and parity protection. SRAM memory may be used for storing volatile information such as the call stack, heap, global data, and code. The SRAM memory content is fully retained in run, sleep, stop, and standby operating modes. SRAM contents are lost in shutdown mode.

A write-execute mutual exclusion mechanism is provided to allow the application to partition the SRAM into two sections: a read-write (RW) partition and a read-execute (RX) partition. The SRAMBOUNDARY register in SYSCTL needs to be configured to set up these partitions. The RX partition occupies the upper portion of the SRAM address space. Write protection is useful when placing executable code into SRAM as it provides a level of protection against unintentional overwrites of code by either the CPU or DMA. Placing code in SRAM can improve performance of critical loops by enabling zero wait state operation and lower power consumption. Preventing code execution from the RW partition improves security by preventing self-modifying code execution ability.

## 8.11 GPIO

The general purpose input/output (GPIO) peripheral provides the user with a means to write data out and read data in to and from the device pins. Through the use of the Port A and Port B GPIO peripherals, MSPM0G511x series support up to 59 GPIO pins.

The key features of the GPIO module include:

- 0 wait state MMR access from CPU
- Set/Clear/Toggle multiple bits without the need of a read-modify-write construct in software
- GPIOs with "Standard with Wake" drive functionality able to wake the device from SHUTDOWN mode
- User controlled input filtering
- GPIO "FastWake" feature enables low-power wakeup from STOP and STANDBY modes for any GPIO port

For more details, see the GPIO chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.12 IOMUX

The IOMUX peripheral enables IO pad configuration and controls digital data flow to and from the device pins. The key features of the IOMUX include:

- IO Pad configuration registers allow for programmable drive strength, speed, pullup-down, and more
- Digital pin muxing allows for multiple peripheral signals to be routed to the same IO pad
- Pin functions and capabilities are user-configured using the PINCM register

For more details, see the IOMUX chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.13 ADC

The 12-bit analog-to-digital converter (ADC) module in these devices, supports fast 12-bit conversions with single-ended inputs.

ADC features include:

- 12-bit output resolution at 1.68Msps with greater than 11-bit ENOB
- HW averaging enables 14-bit effective resolution at 100ksps
- Up to 26 total external input channels
- Internal channels for temperature sensing and supply monitoring
- Software selectable reference:
  - Configurable internal shared reference voltage (VREF1) of 1.4V and 2.5V (requires decoupling capacitor on VREF+/- pins) to support 1.6Msps
  - Configurable internal only reference voltage (VREF2) of 1.4V and 2.5V to support 0.9Msps
  - MCU supply voltage (VDD)
  - External reference supplied to the ADC through the VREF+/- pins
- Operates in RUN, SLEEP, and STOP modes

Table 8-8 shows the ADC channel mapping in the device.


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**Table 8-8. ADC Channel Mapping**

| CHANNEL[0:15] | SIGNAL NAME(2) | CHANNEL[16:31] | SIGNAL NAME(1) (2) |
|---|---|---|---|
| | ADC0 | | ADC0 |
| 0 | A0_0 | 16 | A0_16 |
| 1 | A0_1 | 17 | A0_17 |
| 2 | A0_2 | 18 | A0_18 |
| 3 | A0_3 | 19 | A0_19 |
| 4 | A0_4 | 20 | A0_20 |
| 5 | A0_5 | 21 | A0_21 |
| 6 | A0_6 | 22 | A0_22 |
| 7 | A0_7 | 23 | A0_23 |
| 8 | A0_8 / *VREF-* | 24 | A0_24 |
| 9 | A0_9 | 25 | A0_25 |
| 10 | A0_10 | 26 | - |
| 11 | A0_11 | 27 | - |
| 12 | A0_12 | 28 | *VREFINT* |
| 13 | A0_13 | 29 | *Temperature Sensor* |
| 14 | A0_14 | 30 | *VUSB Monitor* |
| 15 | A0_15 | 31 | *Supply/Battery Monitor* |

(1) *Italicized* signal names are purely internal to the device. These signals are used for internal peripheral interconnections.
(2) For more information about device analog connections please refer to Section 8.27

For more details, see the ADC chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.14 Temperature Sensor

The temperature sensor provides a voltage output that changes linearly with device temperature. The temperature sensor output is internally connected to one of ADC input channels to enable a temperature-to-digital conversion.

A unit-specific single-point calibration value for the temperature sensor is provided in the factory constants memory region. This calibration value represents the ADC conversion result (in ADC code format) corresponding to the temperature sensor being measured in 12-bit mode with the 1.4-V internal VREF at the factory trim temperature ($TS_{TRIM}$).

The ADC and VREF configuration for the above measurement is as the following: RES=0 (12-bit mode), VRSEL=2h (internal VREF), BUFCONFIG=1h (1.4V VREF), ADC $t_{Sample}$=12.5µs. This calibration value can be used with the temperature sensor temperature coefficient ($TS_c$) to estimate the device temperature.

See the temperature sensor section of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual* for guidance on estimating the device temperature with the factory trim value.

## 8.15 VREF

The shared voltage reference modules (VREF1 and VREF2) in these devices contain a configurable voltage reference buffer which allows users to supply a stable reference to on-board analog peripherals. It also supports bringing in an external reference for applications where higher accuracy is required.

VREF1 features include:

- 1.4V and 2.5V user-selectable internal references
- Internal reference supports full speed ADC operation at 1.6Msps
- Support for comparator operation
- Support for bringing in an external reference on VREF+/- device pins

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- Requires a decoupling capacitor placed on VREF+/- pins for proper operation. See VREF for more details.

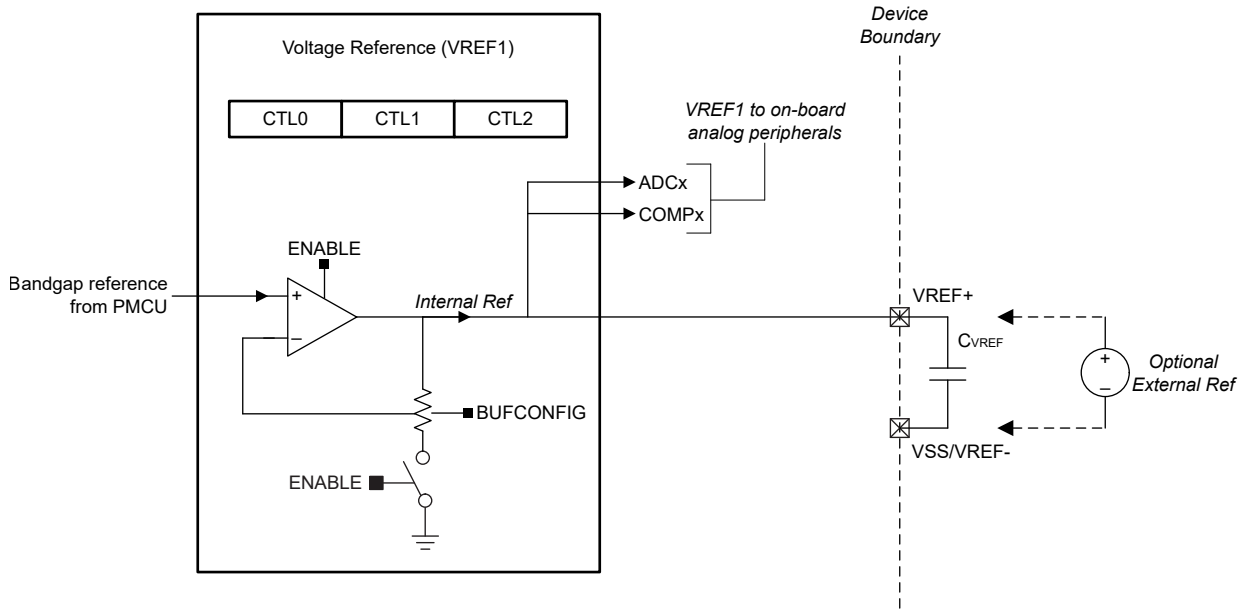



**Figure 8-2. VREF1 module**

VREF2 (VREFINT) features include:

- 1.4V and 2.5V user-selectable internal references
- Internal reference supports reduced speed ADC operation at 0.9Msps
- Does not require a decoupling capacitor placed on VREF+/- pins for proper operation.

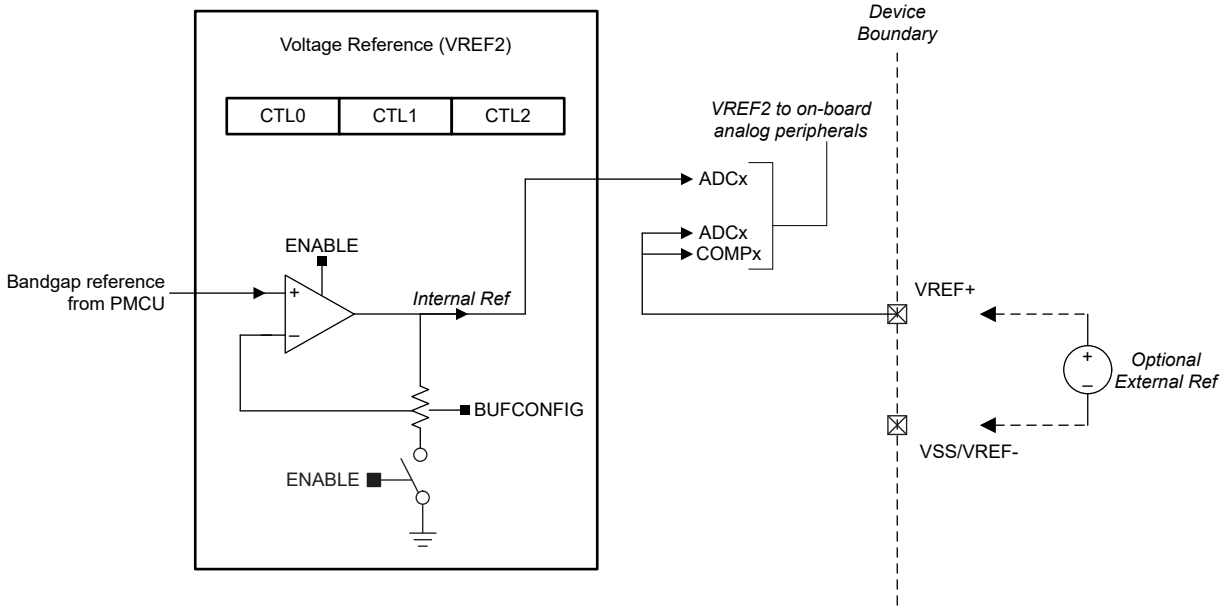



**Figure 8-3. VREF2 (VREFINT) module**

For more details, see the VREF chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.


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## 8.16 COMP

The comparator peripheral in the device compares the voltage levels on two inputs terminals and provides a digital output based on this comparison. It supports the following key features:

- Programmable hysteresis
- Programmable reference voltage:
  - External reference voltage (VREF IO)
  - Internal VREF1 reference voltage (1.4V, 2.5V)
  - Integrated 8-bit reference DAC
- Configurable operation modes:
  - High-speed mode
  - Low-power mode
- Programmable output glitch filter delay
- Supports 6 blanking sources from TIMx instances (see Table 8-9)
- Device wakeup from all low power modes using comparator output
- Output connected to advanced timer fault handling mechanism
- Selection of comparator channel inputs from device pins or internal analog module (see Table 8-10)

**Table 8-9. COMP Blanking Source Table**

| CTL2.BLANKSRC | BLANKING SOURCE |
|---|---|
| 1 | TIMA0.CC2 |
| 2 | TIMA0.CC3 |
| 3 | TIMG0.CC0 |
| 4 | TIMG0.CC1 |
| 5 | TIMG6.CC1 |
| 6 | TIMG7.CC1 |

**Table 8-10. COMP0 Input Channel Selection**

| IPSEL / IMSEL BITS | POSITIVE TERMINAL INPUT | NEGATIVE TERMINAL INPUT |
|---|---|---|
| 0x0 | COMP0_IN0+ | COMP0_IN0- |
| 0x1 | COMP0_IN1+ | COMP0_IN1- |
| 0x2 | COMP0_IN2+ | COMP0_IN2- |
| 0x3 | COMP0_IN3+ | - |
| 0x5 | - | Temperature Sensor |

For more information about device analog connections, see Section 8.27.

For more details, see the COMP chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.17 Security

This device offers several security features, including:

- Debug security
- Device identify
- AES-128/256 accelerator with support for GCM/GMAC, CCM/CBC-MAC, CBC, CTR,
- Flexible firewalls for protecting code and data
  - Flash write-erase protection
  - Flash read-execute protection
  - Flash IP protection
  - SRAM write-execute mutual exclusion
- Secure boot
- Secure firmware update

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- Secure key storage for up to four AES keys
- Customer secure code
- Hardware monotonic counter
- Cyclic redundancy checker (CRC-16, CRC-32) with support for custom polynomial

For more details, see the Security chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.18 AESADV

The AES advanced (AESADV) accelerator module performs encryption and decryption of 128-bit data blocks with a 128-bit or 256-bit key in hardware according to the advanced encryption standard (AES). AES is a symmetric-key block cipher algorithm specified in FIPS PUB 197.

The AESADV accelerator features include:

- AES operation with 128-bit and 256-bit keys
- Key scheduling in hardware
- Enc/decrypt only modes: CBC, CFB-1, CFB-8, CFB-128, OFB-128, CTR/ICM
- Authentication only modes: CBC-MAC, CMAC
- AES-CCM
- AES-GCM
- AES-CCM and AES-GCM modes support continuation with hold/resume of payload data
- 32-bit word access to provide key data, input data, and output data
- AESADV ready interrupt
- DMA triggers for input/output data
- Supported in RUN and SLEEP (see the *Operating Modes* section of the device technical reference manual)

For more details, see the AESADV chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.19 Keystore

The Keystore controller provides secure management of the Advanced Encryption Engine (AES) keys. The use-model of the keystore controller is to securely deposit keys into it during the execution of customer secure code, and have the AES engine access them subsequently in a secure manner without leaking any key data to observers. Both 128 and 256-bit keys can be stored in the keystore's key slots. The keystore and its interaction with the AES engine are designed for secure operation including thwarting partial key modification attacks.

- Support for storage of up to 4 keys

For more details, see the KEYSTORE chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.20 CRC-P

The cyclical redundancy check (CRC) module provides a signature for an input data sequence. Key features of the CRC module include:

- Support for 16-bit CRC based on CRC16-CCITT
- Support for 32-bit CRC based on CRC32-ISO3309
- Support for bit reversal
- Support for custom polynomials

For more details, see the CRC chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.21 Serial Communication Interfaces


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### 8.21.1 UNICOMM (UART/I²C/SPI)

UNICOMM is a highly flexible peripheral which can be configured as a UART, SPI, I²C-Controller or I²C-Target function. The user can select one of the serial interfaces before configuration and data transfer. The peripheral uses a common FIFO per instance to maximize the device capability based on the operating state. A scalable peripheral group combines one or more UNICOMM for special functions like I²C loopback and is an optional configuration. Table 8-11 describes the grouping of UNICOMM, peripheral serial interfaces available and FIFO depth.

**Table 8-11. UNICOMM (UCx) Serial Peripheral**

| Scalable Peripheral Group | Unicomm Instance | Local UCx Index | Global UCx Index | UART | I²C Controller | I²C Target | SPI | FIFO Depth |
|---|---|---|---|---|---|---|---|---|
| SPG0 (PD0) | UC0 | 0 | 0 | Yes | Yes | Yes | - | 4 |
| | UC1 | 1 | 1 | Yes | Yes | Yes | - | 4 |
| SPG1 (PD1) | UC2 | 0 | 2 | - | - | - | Yes | 4 |
| | UC3 | 1 | 3 | Yes | - | - | Yes | 4 |

For more details, see the UNICOMM chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

#### 8.21.1.1 UART (UNICOMM)

The UNICOMM-UART peripheral function provide the following key features:

- Standard asynchronous communication bits for start, stop, and parity
- Fully programmable serial interface
  - 5, 6, 7 or 8 data bits
  - Even, odd, stick, or no-parity bit generation and detection
  - 1 or 2 stop bit generation
  - LSB-first or MSB-first data transmit and receive
  - Line-break detection
  - Programmable baud rate generation with oversampling by 16, 8 or 3
- Support for waking up SYSOSC via an asynchronous fast clock request upon start bit detection when operating in low power modes
- Support transmit and receive loopback mode operation
- See Table 8-12 for detail information on supported protocols and features

**Table 8-12. UNICOMM-UART feature support**

| UNICOMM-UART Features | | (Advanced) | (Basic w/ LIN) | (Basic) |
|---|---|---|---|---|
| Feature Tag | Feature Description | UC0 | UC1 | UC3 |
| - | Active in Stop and Standby Mode | Yes | Yes | - |
| UART-RX-TIMEOUT | Receive timeout and Line timeout | Yes | Yes | Yes |
| UART-IDLELINE-MULTIPROC | Idle-Line Multiprocessor | Yes | Yes | Yes |
| UART-FLOW-CONTROL | Flow control (CTS/RTS) with support for RS-485 | Yes | Yes | Yes |
| UART-MULTIDROP-9-BIT | 9-bit UART mode for multidrop systems with addressable peripherals | Yes | Yes | Yes |
| UART-EXT-DRIVER | External driver output enable | Yes | - | - |
| UART-SMARTCARD | ISO7816 smart card mode | Yes | - | Yes |
| UART-LIN | Local Interconnect Network (LIN) | Yes | Yes | - |
| UART-DALI-MANCHESTER | IEC62386 Digital Addressable Lighting Interface (DALI) | Yes | - | - |
| UART-IRDA | IrDA encoding and decoding | Yes | - | - |

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**Table 8-12. UNICOMM-UART feature support (continued)**

| UNICOMM-UART Features | | (Advanced) | (Basic w/ LIN) | (Basic) |
|---|---|---|---|---|
| Feature Tag | Feature Description | UC0 | UC1 | UC3 |
| UART-FIFO | RX and TX FIFO | 4 | 4 | 4 |
| UART-DMA | Direct memory access (DMA) | Yes | Yes | Yes |

For more details, see the UART (UNICOMM) chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

#### 8.21.1.2 I2C (UNICOMM)

The inter-integrated circuit interface ($I^2C$) peripherals in these devices provide bidirectional data transfer with other I2C devices on the bus and support the following key features:

- 7-bit and 10-bit addressing mode with multiple 7-bit target addresses
- Multiple-controller transmitter or receiver mode
- Target receiver or transmitter mode with configurable clock stretching
- Support Standard-mode (Sm), with a bit rate up to 100 kbit/s
- Support Fast-mode (Fm), with a bit rate up to 400 kbit/s
- Support Fast-mode Plus (Fm+), with a bit rate up to 1 Mbit/s
  - Supported on open drain IOs (ODIO) and high-drive (HDIO) IOs only
- Separated transmit and receive FIFOs support DMA data transfer
- Support SMBus 3.0 with PEC, ARP, timeout detection and host support
- Wakeup from low power mode on address match
- Support analog glitch filter for input signal glitch suppression
- 4-entry transmit and receive FIFOs

- See Table 8-13 and Table 8-14 for detailed information on supported features for controller and target functions

**Table 8-13. I2C Controller (UNICOMM) Features**

| Supported Features | (Advanced) |
|---|---|
| UNICOMM Instance | UC0, UC1 |
| Supports standard-mode (Sm) | Yes |
| Supports Fast-mode (Fm) | Yes |
| Supports Fast-mode Plus (Fm+) | Yes |
| Supports analog glitch filter | Yes |
| Supports digital glitch filter | - |
| Supports burst mode | Yes |
| Supports SMBus mode | Yes |

**Table 8-14. I2C Target (UNICOMM) Features**

| Supported Features | (Advanced) |
|---|---|
| UNICOMM Instance | UC0, UC1 |
| Supports standard-mode (Sm) | Yes |
| Supports Fast-mode (Fm) | Yes |
| Supports Fast-mode Plus (Fm+) | Yes |
| Supports analog glitch filter | Yes |
| Supports digital glitch filter | - |


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**Table 8-14. I2C Target (UNICOMM) Features (continued)**

| Supported Features | (Advanced) |
|---|---|
| **UNICOMM Instance** | **UC0, UC1** |
| Supports second target address & mask | Yes |
| Supports SMBus mode | Yes |
| Supports low power wakeup | Yes |

For more details, see the I2C (UNICOMM) chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

#### 8.21.1.3 SPI (UNICOMM)

The serial peripheral interface (SPI) peripherals in these devices support the following key features:

- Support ULPCLK/2 bit rate and up to 32Mbits/s in both controller and peripheral mode [1]
- Configurable as a controller or a peripheral
- Support for up to 4 chip select for both controller and peripheral
- Supports single parity for transmit and receive
- Programmable clock prescaler and bit rate
- Programmable data frame size from 4 bits to 16 bits (controller mode) and 7 bits to 16 bit (peripheral mode)
- Transmit and receive FIFOs (4 entries each with 16 bits per entry) supporting DMA data transfer
- Supports TI mode and Motorola mode
- Support single bit parity in both transmit and receive paths
- See SPI (UNICOMM) Features for detailed information on supported features

**Table 8-15. SPI (UNICOMM) Features**

| SPI Features | (Advanced) | SPI1 (Basic) |
|---|---|---|
| **UNICOMM Instance** | **UC2** | **UC3** |
| Controller and Peripheral mode | Yes | Yes |
| Supports Parity function | Yes | Yes |
| Supports Repeat mode transfer | Yes | - |
| Supports Receive timeout | Yes | - |
| Supports Command/Data control | Yes | - |
| Supports 4 chip selects | Yes | - |

For more details, see the SPI (UNICOMM) chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

### *8.21.2 Universal Serial Bus (USB)*

The USB controller operates as a full-speed or low-speed function controller during point-to-point communications with USB host or device functions.

The USB module has the following features:

- USB 2.0 full-speed and low-speed operation
- Integrated PHY
- Four transfer types: control, interrupt, bulk, and isochronous
- 16 endpoints
  - One dedicated control IN endpoint and one dedicated control OUT endpoint

[1] Only SPI signals on HSIO pins support data rate > 16 Mbits/s; see *Pin Diagrams* for HSIO pins.

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  - 7 configurable IN endpoints and 7 configurable OUT endpoints
- 2kB of dedicated endpoint memory
- Supports USB device firmware update (DFU)

Figure 8-4 shows the USB block diagram.

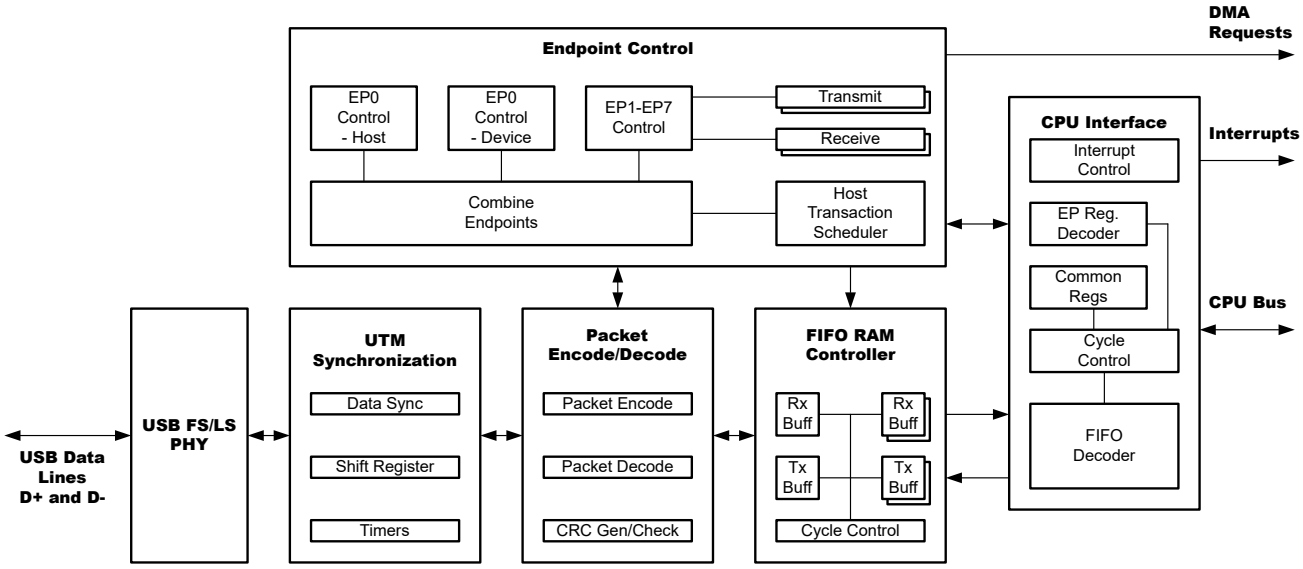



**Figure 8-4. USB Block Diagram**

**Note**

The accuracy of the on-chip USBFLL will meet the accuracy requirements of the USB protocol in device mode. For host mode, an external crystal in combination with the internal PLL oscillator is required. For applications using the USB in host mode, see electrical characteristics section for clock frequency requirements.

### *8.21.3 Digital Audio Interface - I2S/TDM*

The I2S/TDM module provides a standardized serial interface to transfer audio data. The module can be configured in different modes including I2S standards, LSB or MSB-justified, PCM/DSP and TDM for example. It can be used in conjunction with the DMA controller.

Features:

- Configurable and independent transmitter and receiver functions on data lines
- Configurable controller or target function
- Integrated transmitter and receiver FIFO with packing feature and FIFO depth = 4
- Clock generator to target specific audio frequency generation
- Data size configuration from 8 to 32-bit audio word size
- Audio protocol: I2S, LSB or MSB-justified, PCM/DSP, TDM
- Up to 8 slots available in TDM format
- Empty slot configuration for sending 0's, 1's or Hi-Z
- Configurable bit clock sampling edge
- Frame synchronization configurable for offset and bit length
- Independent DMA request for transmitter and receiver functions

For more details, see the I2S/TDM chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.


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## 8.22 Low-Frequency Sub System (LFSS)

The Low-Frequency Sub-System (LFSS) is a sub-system which combines several functional peripherals under one shared subsystem. These peripherals are clocked by the low frequency clock (LFCLK) or need to be active during low power modes. The LFCLK has a typical frequency of 32kHz and is mainly intended for long-term timekeeping.

LFSS in this device contains following components:

- Real-time clock (RTC_B) with additional prescalar extension and timestamp captures
- An asynchronous Independent Watchdog Timer (IWDT)

For more details, see the LFSS chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.23 RTC_B

The RTC_B instance of the real-time clock operates off of a 32kHz input clock source (typically a low frequency crystal) and provides a time base to the application with multiple options for interrupts to the CPU. The RTC_B provides common key features in relation to the Low-Frequency Sub System (LFSS).

Common key features of the RTC_B include:

- Counters for seconds, minutes, hours, day of the week, day of the month, month, and year
- Binary or BCD format
- Leap-year handling
- One customizable alarm interrupt based on minute, hour, day of the week, and day of the month
- Interval alarm interrupt to wake every minute, every hour, at midnight, or at noon
- Interval alarm interrupt providing periodic wake-up at 4096, 2048, 1024, 512, 256, or 128 Hz
- Interval alarm interrupt providing periodic wake-up at 64, 32, 16, 8, 4, 2, 1, and 0.5 Hz
- Calibration for crystal offset error (up to +/- 240ppm)
- Compensation for temperature drift (up to +/- 240ppm)
- RTC clock output to pin for calibration

Table 8-16 shows the RTC features supported in this device.

**Table 8-16. RTC_B Key Features**

| RTC Features | RTC_B |
|---|---|
| Power enable register | - |
| Real-time clock and calendar mode providing seconds, minutes, hours, day of week, day of month, and year | Yes |
| Selectable binary or binary-coded decimal (BCD) format | Yes |
| Leap-year correction (valid for year 1901 through 2099) | Yes |
| Two customizable calendar alarm interrupts based on minute, hour, day of the week, and day of the month | Yes |
| Interval alarm interrupt to wake every minute, every hour, at midnight, or at noon | Yes |
| Periodic interrupt to wake at 4096, 2048, 1024, 512, 256, or 128 Hz | Yes |
| Periodic interrupt to wake at 64, 32, 16, 8, 4, 2, 1, and 0.5 Hz | Yes |
| Interrupt capability down to STANDBY mode with STOPCLKSTBY | Yes |
| Calibration for crystal offset error and crystal temperature drift (up to ±240 ppm total) | Yes |
| RTC clock output to pin for calibration (GPIO) | - |
| RTC clock output to pin for calibration (TIO) | - |
| Three bit prescaler for heartbeat function with interrupt generation | - |

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**Table 8-16. RTC_B Key Features (continued)**

| RTC Features | RTC_B |
|---|---|
| RTC external clock selection of untrimmed 32kHz, trimmed 512Hz, 256Hz or 1 Hz | - |
| RTC time stamp capture upon detection of a timer stamp event, including:<br>• TIO event<br>• VDD fail event | - |
| RTC counter lock function | - |

For more details, see the RTC chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.24 IWDT_B

The independent watchdog timer (IWDT) in the LFSS is a device-independent supervisor which monitors code execution and overall hang up scenarios of the device. Due to the nature of LFSS, this IWDT has its own system independent clock source. If the application software does not successfully reset the watchdog within the programmed time, the watchdog generates a POR reset to the device.

Key features of the IWDT include:

- A 25-bit counter
- Counter driven from LFOSC (fixed 32kHz clock path) with a programmable clock divider
- Eight selectable watchdog timer periods (2ms to 2hr)

For more details, see the IWDT chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.25 WWDT

The windowed watchdog timer (WWDT) can be used to supervise the operation of the device, specifically code execution. The WWDT can be used to generate a reset or an interrupt if the application software does not successfully reset the watchdog within a specified window of time. Key features of the WWDT include:

- 25-bit counter
- Programmable clock divider
- Eight software selectable watchdog timer periods
- Eight software selectable window sizes
- Support for stopping the WWDT automatically when entering a sleep mode
- Interval timer mode for applications which do not require watchdog functionality

For more details, see the WWDT chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

## 8.26 Timers (TIMx)

There are three types of timer peripherals in these devices support that following key features: TIMGx (general-purpose timer), TIMAx (advanced timer), and TIMBx (basic timer). TIMGx is a subset of TIMAx, which means common features between timer instances are software compatible. For specific configurations, see Table 8-17:

Specific features for the general-purpose timer **(TIMGx)** include:

- 16-/32-bit up, down, up-down or down-up counter, with repeat-reload mode
- Selectable and configurable clock source
- 8-bit programmable prescaler to divide the counter clock frequency
- Two independent channels for
  - Output compare
  - Input capture


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  - PWM output
  - One-shot mode
- Shadow CC register available in TIMG6, TIMG7
- Shadow register for load available in TIMG6, TIMG7
- Support synchronization and cross trigger among different TIMx instances
- Support interrupt/DMA trigger generation and cross peripherals (such as ADC) trigger capability

Specific features for the advanced timer **(TIMAx)** include:

- 16-bit down or up-down counter, with repeat-reload mode
- Selectable and configurable clock source
- 8-bit programmable prescaler to divide the counter clock frequency
- Repeat counter to generate an interrupt or event only after a given number of cycles of the counter
- Up to four independent channels for
  - Output compare
  - Input capture
  - PWM output
  - One-shot mode
- Shadow register for load and CC register available
- Complementary output PWM with programmable dead band insertion
- Asymmetric PWM
- Configurable fault handling mechanism for
  - Fast PWM responses (<40ns) to external fault inputs or comparator events
  - Outputting signals in a safe user-defined state when a latched fault condition has occurred
- Support synchronization and cross trigger among different TIMx instances
- Support interrupt and DMA trigger generation and cross peripherals (such as ADC) trigger capability
- Two additional capture/compare channels for internal events

Specific features for the basic software timer **(TIMBx)** include:

- Support for a counter array containing 4 counters
- Each counter is a 16 bit counter
- Clocked by the PD0 bus clock (ULPCLK)
- Ability to concatenate 2 or more counters to create longer time durations
- Ability to measure timing properties of external events
  - Duration between 2 pulses on an event
  - Counting the number of events
  - Ability to start/stop the counter based on external events or internal events

**Table 8-17. TIMx Configurations**

| TIMER NAME | POWER DOMAIN | RESOLUTION | PRESCALER | REPEAT COUNTER | CAPTURE / COMPARE CHANNELS | PHASE LOAD | SHADOW LOAD | SHADOW CC | DEADBAND | FAULT | QEI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TIMG0 | PD0 | 16-bit | 8-bit | – | 2 | – | – | – | – | – | – |
| TIMG6 | PD1 | 16-bit | 8-bit | – | 2 | – | – | – | – | – | – |
| TIMG7 | PD1 | 16-bit | 8-bit | – | 2 | – | Yes | Yes | – | – | – |
| TIMA0 | PD1 | 16-bit | 8-bit | 8-bit | 4 | Yes | Yes | Yes | Yes | Yes | – |
| TIMB0 | PD0 | 16-bit | – | – | – | – | – | – | – | – | – |

**Table 8-18. TIMx Cross Trigger Map**

| TSEL.ETSEL Selection | PD0 Timers | PD1 Timers | | |
|---|---|---|---|---|
| | TIMG0 | TIMA0 | TIMG6 | TIMG7 |
| 0 | TIMA0.TRIG0 | TIMA0.TRIG0 | TIMA0.TRIG0 | TIMA0.TRIG0 |
| 1 | TIMG0.TRIG0 | TIMG0.TRIG0 | TIMG0.TRIG0 | TIMG0.TRIG0 |
| 2 | TIMG6.TRIG0 | TIMG6.TRIG0 | TIMG6.TRIG0 | TIMG6.TRIG0 |
| 3 | TIMG7.TRIG0 | TIMG7.TRIG0 | TIMG7.TRIG0 | TIMG7.TRIG0 |

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**Table 8-18. TIMx Cross Trigger Map (continued)**

| TSEL.ETSEL Selection | PD0 Timers | PD1 Timers | | |
|---|---|---|---|---|
| | TIMG0 | TIMA0 | TIMG6 | TIMG7 |
| 4 to 31 | Reserved | | | |

**Table 8-19. TIMBx Clock Source Selection**

| CTRREGSx.CTL0.CLKSEL | Counter update from event source |
|---|---|
| 0 | Bus Clock |
| 1 | Overflow from Counter 0 |
| 2 | Overflow from Counter 1 |
| 3 | Overflow from Counter 2 |
| 4 to 8 | Reserved |
| 9 | GPIO0 Publisher 1 |
| 10 | GPIO0 Publisher 2 |
| 11 | GPIO1 Publisher 1 |
| 12 | GPIO1 Publisher 2 |
| 13 | DMA Interrupt |
| 14 | Reserved |
| 15 | TIMBx Generic Event Subscriber |

**Table 8-20. TIMBx Start/Stop/Reset Source Selection**

| CTRREGSx.CTL0.STARTSEL<br>CTRREGSx.CTL0.STOPSEL<br>CTRREGSx.CTL0.RESETSEL | Start/Stop/Reset from event source |
|---|---|
| 0 | No Action |
| 1 | Overflow from Counter 0 |
| 2 | Overflow from Counter 1 |
| 3 | Overflow from Counter 2 |
| 4 to 8 | Reserved |
| 9 | GPIO0 Publisher 1 |
| 10 | GPIO0 Publisher 2 |
| 11 | GPIO1 Publisher 1 |
| 12 | GPIO1 Publisher 2 |
| 13 | DMA Interrupt |
| 14 | Reserved |
| 15 | TIMBx Generic Event Subscriber |

For more details, see the TIMx chapter of the MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual


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## 8.27 Device Analog Connections

Figure 8-5 shows the internal analog connection of the device.

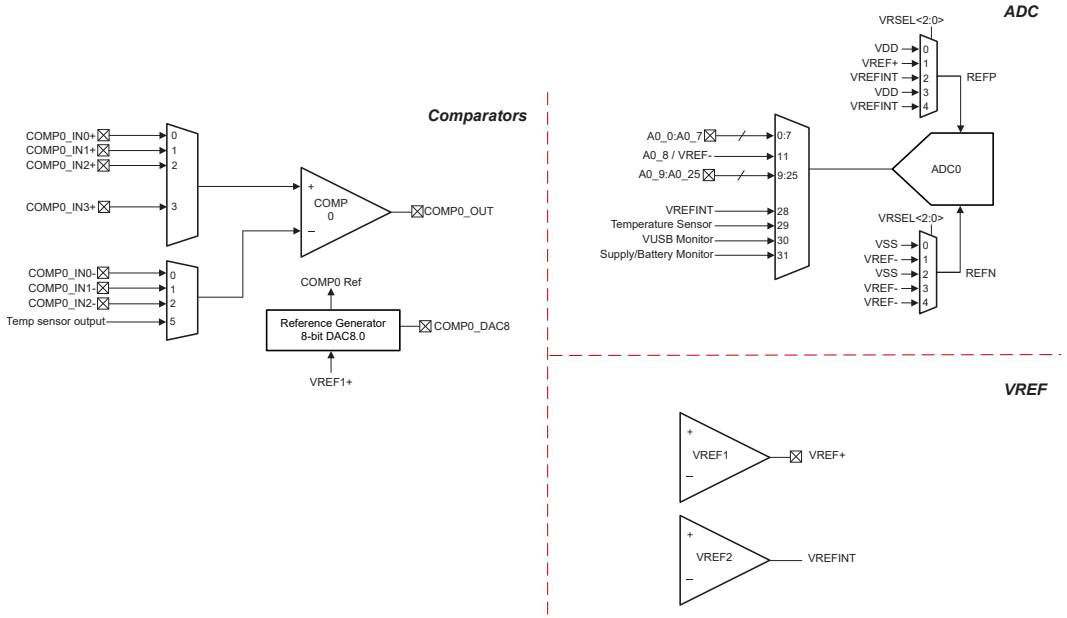



**Figure 8-5. Device Analog Connection**

## 8.28 Input/Output Diagrams

The IOMUX manages the selection of which peripheral function is to be used on a digital IO. It also provides the controls for the output driver, input path, and the wake-up logic for wakeup from SHUTDOWN mode. For more information, refer to the IOMUX section of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

The mixed-signal IO pin slice diagram for a full featured IO pin is shown in Figure 8-6. Not all pins will have analog functions, wake-up logic, drive strength control, and pullup or pulldown resistors available. See the device-specific data sheet for detailed information on what features are supported for a specific pin.

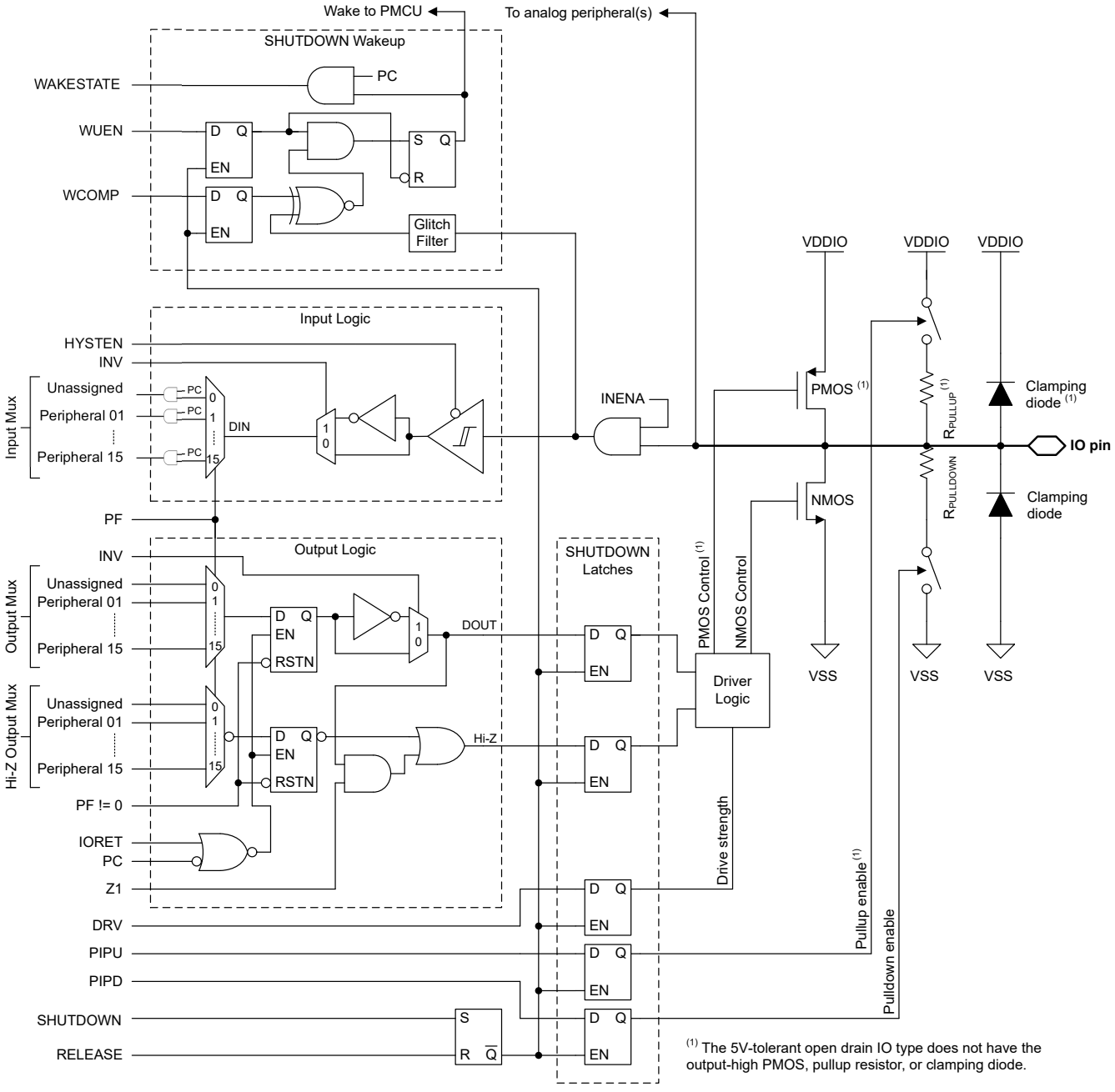



**Figure 8-6. Superset Input/Output Diagram**


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## 8.29 Serial Wire Debug Interface

A serial wire debug (SWD) two-wire interface is provided via an ARM compatible serial wire debug port (SW-DP) to enable access to multiple debug functions within the device. For a complete description of the debug functionality offered on MSPM0 devices, see the DEBUG chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual*.

**Table 8-21. Serial Wire Debug Pin Requirements and Functions**

| DEVICE SIGNAL | DIRECTION | SWD FUNCTION |
|---|---|---|
| SWCLK | Input | Serial wire clock from debug probe |
| SWDIO | Input/Output | Bi-directional (shared) serial wire data |

## 8.30 Boot Strap Loader (BSL)

The boot strap loader (BSL) enables configuration of the device as well as programming of the device memory through a serial interface such as UART, $I^2C$, or USB. Access to the device memory and configuration through the BSL is protected by a 256-bit user-defined password, and it is possible to completely disable the BSL in the device configuration, if desired. The BSL is enabled by default from TI to support use of the BSL for production programming.

Using the BSL can involve the following pins, depending on the method:

- UART interface: BSLRX and BSLTX signals
- $I^2C$ interface: BSLSCL and BSLSDA signals
- USB interface: BSLUSB_DM and BSLUSB_DP
- Additional methods: BSL_invoke and NRST signals may be used for controlled invokation of the bootloader by an external host

If enabled, the BSL may be invoked (started) in the following ways:

- The BSL is invoked during the boot process if the BSL_invoke pin state matches the defined BSL_invoke logic level. If the device fast boot mode is enabled, this invocation check is skipped. An external host can force the device into the BSL by asserting the invoke condition and applying a reset pulse to the NRST pin to trigger a BOOTRST, after which the device will verify the invoke condition during the reboot process and start the BSL if the invoke condition matches the expected logic level.
- The BSL is automatically invoked during the boot process if the reset vector and stack pointer are left unprogrammed. As a result, a blank device from TI will invoke the BSL during the boot process without any need to provide a hardware invoke condition on the BSL_invoke pin. This enables production programming using just the serial interface signals.
- The BSL may be invoked at runtime from application software by issuing a SYSRST with BSL entry command.

**Table 8-22. BSL Pin Requirements and Functions**

| DEVICE SIGNAL | CONNECTION | BSL FUNCTION |
|---|---|---|
| BSLRX | Required for UART | UART receive signal (RXD), an input |
| BSLTX | Required for UART | UART transmit signal (TXD) an output |
| BSLSCL | Required for I2C | $I^2C$ BSL clock signal (SCL) |
| BSLSDA | Required for I2C | $I^2C$ BSL data signal (SDA) |
| BSLUSB_DM | Required for USB | USB data minus signal (D-) |
| BSLUSB_DP | Required for USB | USB data positive signal (D+) |
| BSL_invoke | Optional | Active-high digital input used to start the BSL during boot |
| NRST | Optional | Active-low reset pin used to trigger a reset and subsequent check of the invoke signal (BSL_invoke) |

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For a complete description of the BSL functionality and command set, see the MSPM0 boot strap loader user's guide.

## 8.31 Device Factory Constants

All devices include a memory-mapped FACTORY region which provides read-only data describing the capabilities of a device as well as any factory-provided trim information for use by application software. Please refer to Factory Constants chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual* for more information.

**Table 8-23. DEVICEID**

DEVICEID address is 0x41C4.0004, PARTNUM is bit 12 to 27, MANUFACTURER is bit 1 to 11.

| Device | PARTNUM | MANUFACTURER |
|---|---|---|
| MSPM0G5115 | 0xBBBC | 0x17 |
| MSPM0G5116 | 0xBBBC | 0x17 |
| MSPM0G5117 | 0xBBBC | 0x17 |

**Table 8-24. USERID**

USERID address is 0x41C4.0008, PART is bit 0 to 15, VARIANT is bit 16 to 23

| Device | Part | Variant |
|---|---|---|
| MSPM0G5115SPMR | 0x8DCB | 0x10 |
| MSPM0G5115SPTR | 0x8DCB | 0x11 |
| MSPM0G5115SRGZR | 0x8DCB | 0x12 |
| MSPM0G5115SRHBR | 0x8DCB | 0x13 |
| MSPM0G5115SRGER | 0x8DCB | 0x14 |
| MSPM0G5115SDGS20R | 0x8DCB | 0x16 |
| MSPM0G5115SRUYR | 0x8DCB | 0x17 |
| MSPM0G5115S28YCJR | 0x8DCB | 0x18 |
| MSPM0G5116SPMR | 0xD851 | 0x10 |
| MSPM0G5116SPTR | 0xD851 | 0x11 |
| MSPM0G5116SRGZR | 0xD851 | 0x12 |
| MSPM0G5116SRHBR | 0xD851 | 0x13 |
| MSPM0G5116SRGER | 0xD851 | 0x14 |
| MSPM0G5116SDGS20R | 0xD851 | 0x16 |
| MSPM0G5116SRUYR | 0xD851 | 0x17 |
| MSPM0G5116S28YCJR | 0xD851 | 0x18 |
| MSPM0G5117SPMR | 0x778B | 0x10 |
| MSPM0G5117SPTR | 0x778B | 0x11 |
| MSPM0G5117SRGZR | 0x778B | 0x12 |
| MSPM0G5117SRHBR | 0x778B | 0x13 |
| MSPM0G5117SRGER | 0x778B | 0x14 |
| MSPM0G5117SDGS20R | 0x778B | 0x16 |
| MSPM0G5117SRUYR | 0x778B | 0x17 |
| MSPM0G5117S28YCJR | 0x778B | 0x18 |

## 8.32 Identification

### Revision and Device Identification

The hardware revision and device identification values are stored in the memory-mapped FACTORY region, refer to Device Factory Constants section, which provides read-only data describing the capabilities of a device


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as well as any factory-provided trim information for use by application software. Refer to Factory Constants chapter of the *MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual* for more information.

The device revision and identification information are also included as part of the top-side marking on the device package. The device-specific errata sheet describes these markings (see Section 10.4)

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# 9 Applications, Implementation, and Layout

## 9.1 Typical Application

**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, as well as validating and testing their design implementation to confirm system functionality.

### *9.1.1 Schematic*

TI recommends connecting a combination of a 10-µF and a 0.1-µF low-ESR ceramic decoupling capacitor across the VDD and VSS pins, as well as placing these capacitors as close as possible to the supply pins that they decouple (within a few millimeters) to achieve a minimal loop area. The 10-µF bulk decoupling capacitor is a recommended value for most applications, but this capacitance may be adjusted if needed based upon the PCB design and application requirements. For example, larger bulk capacitors can be used, but this can affect the supply rail ramp-up time.

The NRST reset pin must be pulled up to VDD (supply level) for the device to release from RESET state and start the boot process. TI recommends connecting an external 47-kΩ pullup resistor with a 10-nF pulldown capacitor for most applications, enabling the NRST pin to be controlled by another device or a debug probe.

The SYSOSC frequency correction loop (FCL) circuit utilizes an external 100-kΩ with 0.1% tolerance resistor with a temperature coefficient (TCR) of 25ppm/C or better populated between the ROSC pin and VSS. This resistor establishes a reference current to stabilize the SYSOSC frequency through a correction loop. This resistor is required if the FCL feature is used for higher accuracy, and it is not required if the SYSOSC FCL is not enabled. When the FCL mode is not used, the PA2 pin may be used as a digital input/output pin.

A 0.47-µF tank capacitor is required for the VCORE pin and must be placed close to the device with minimum distance to the device ground. Do not connect other circuits to the VCORE pin.

For the 5-V-tolerant open drain (ODIO), a pullup resistor is required to output high for I2C and UART functions, as the open drain IO only implement a low-side NMOS driver and no high-side PMOS driver. The 5V-tolerant open drain IO are fail-safe and may have a voltage present even if VDD is not supplied.

The USB circuit requires a capacitor across the VUSB and VSS pins. If VUSB sourced from VCC, recommend connecting a 0.1-µF low-ESR ceramic decoupling capacitor. If VUSB sourced from a separated power supply, recommend connecting a combination of a 1-µF and a 0.1-µF low-ESR ceramic decoupling capacitor. As well as place the capacitor as close as possible to the supply pins that they decouple (within a few millimeters) to achieve a minimal loop area.


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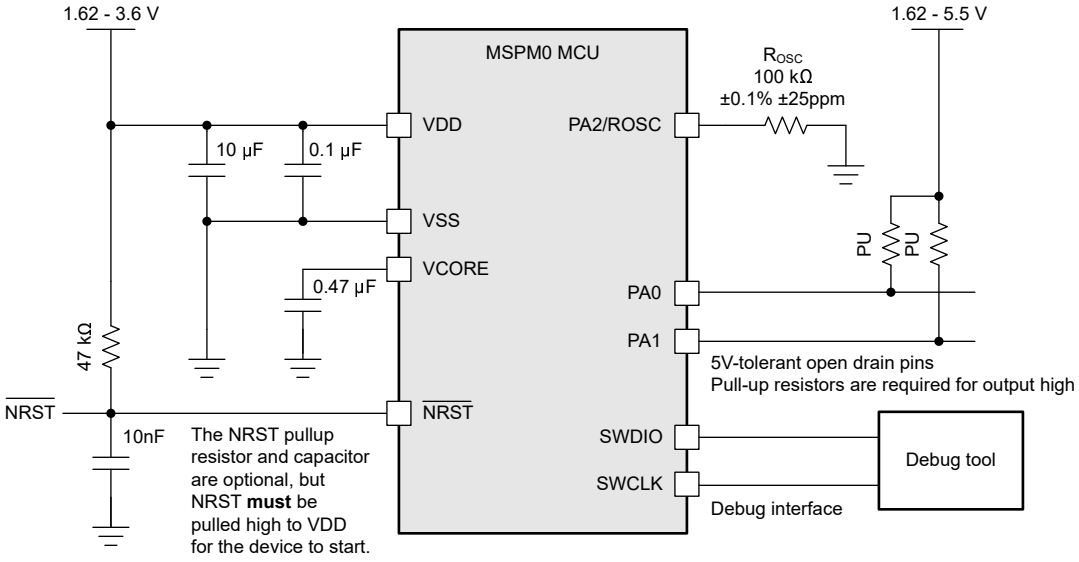



**Figure 9-1. Basic Application Schematic**

# 10 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

## 10.1 Getting Started and Next Steps

For more information on the MSP low-power microcontrollers and the tools and libraries that are available to help with development, visit the Texas Instruments *Arm Cortex-M0+ MCUs* page.

## 10.2 Device Nomenclature

To designate the stages in the product development cycle, TI assigns prefixes to the part numbers of all MSP MCU devices and support tools. . Each MSP MCU commercial family member has one of two prefixes: MSP or X. These prefixes represent evolutionary stages of product development from engineering prototypes (X) through fully qualified production devices (MSP).

**X** – Experimental device that is not necessarily representative of the final device's electrical specifications

**MSP** – Fully qualified production device

**X** devices are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes." MSP devices 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) have a greater failure rate than the standard production devices. TI 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.

TI device nomenclature also includes a suffix with the device family name. This suffix indicates the temperature range, package type, and distribution format. Figure 10-1 provides a legend for reading the complete device name.

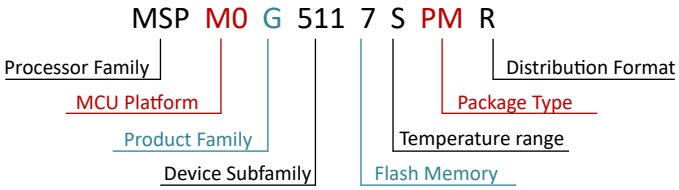



**Figure 10-1. Device Nomenclature**

**Table 10-1. Device Nomenclature**

| | |
|---|---|
| **Processor Family** | MSP = Mixed-signal processor<br>X= Experimental silicon |
| **MCU Platform** | M0 = Arm based 32-bit M0+ |
| **Product Family** | G = 80-MHz frequency |
| **Device Subfamily** | 511 = 1x USB2.0-FS, 1x I2S, 1x ADC, 1x COMP |
| **Flash Memory** | 5 = 32KB<br>6= 64KB<br>7= 128KB |
| **Temperature Range** | S = –40°C to 125°C |
| **Package Type** | See the Device Comparison section and https://www.ti.com/packaging |


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**Table 10-1. Device Nomenclature (continued)**

| | |
|---|---|
| **Distribution Format** | T = Small reel<br>R = Large reel<br>No marking = Tube or tray |

For orderable part numbers of MSP devices in different package types, see the Package Option Addendum of this document, ti.com, or contact your TI sales representative.

## 10.3 Tools and Software

### Design Kits and Evaluation Modules

| | |
|---|---|
| MSPM0 LaunchPad (LP) Boards: LP-MSPM0G5187 | Empowers you to immediately start developing on the industry's best integrated analog and most cost-optimized general purpose MSPM0 MCU family. Exposes all device pins and functionality; includes some built-in circuitry, out-of-box software demos, and on-board XDS110 debug probe for programming/debugging/ EnergyTrace.<br>The LP ecosystem includes dozens of BoosterPack stackable plug-in modules to extend functionality. |

### Embedded Software

| | |
|---|---|
| MSPM0 Software Development Kit (SDK) | Contains software drivers, middleware libraries, documentation, tools, and code examples that create a familiar and easy user experience for all MSPM0 devices. |

### Software Development Tools

| | |
|---|---|
| TI Developer Zone | Start your evaluation and development on a web browser without any installation. Cloud tools also have a downloadable, offline version. |
| TI Resource Explorer | Online portal to TI SDKs. Accessible in CCS IDE or in TI Cloud Tools. |
| SysConfig | Intuitive GUI to configure device and peripherals, resolve system conflicts, generate configuration code, and automate pin mux settings. Accessible in CCS IDE ,in TI Cloud Tools or a standalone version. (offline version) |
| MSP Academy | Great starting point for all developers to learn about the MSPM0 MCU Platform with training modules that span a wide range of topics. Part of TIRex. |
| GUI Composer | GUIs that simplify evaluation of certain MSPM0 features, such as configuring and monitoring a fully integrated analog signal chain without any code needed. |

### IDE & compiler toolchains

| | |
|---|---|
| Code Composer Studio™ (CCS) | Code Composer Studio is an integrated development environment (IDE) for TI's microcontrollers and processors. It comprises a suite of tools used to develop and debug embedded applications. CCS is completely free to use and is available on Eclipse and Theia frameworks. |
| IAR Embedded Workbench® IDE | IAR Embedded Workbench for Arm delivers a complete development toolchain for building and debugging embedded applications for MSPM0.The included IAR C/C++ Compiler generates highly optimized code for your application, and the C-SPY Debugger is a fully integrated debugger for source and disassembly level debugging with support for complex code and data breakpoint. |
| Keil® MDK IDE | Arm Keil MDK is a complete debugger and C/C++ compiler toolchain for building and debugging embedded applications for MSPM0.Keil MDK includes a fully integrated debugger for source and disassembly level debugging.MDK provides full CMSIS compliance. |
| TI Arm-Clang | TI Arm Clang is included in Code Composer Studio. |

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| | |
|---|---|
| GNU Arm Embedded Toolchain | The MSPM0 SDK supports development using the open-source Arm GNU Toolchain.Arm GCC is supported by Code Composer Studio (CCS). |

## 10.4 Documentation Support

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

The following documents describe the MSPM0 MCUs. Copies of these documents are available on the Internet at www.ti.com.

### Technical Reference Manual

| | |
|---|---|
| MSPM0 G-Series 80-MHz Microcontrollers Technical Reference Manual | This manual describes the modules and peripherals of the MSPM0G family of devices. Each description presents the module or peripheral in a general sense. Not all features and functions of all modules or peripherals are present on all devices. In addition, modules or peripherals can differ in their exact implementation on different devices. Pin functions, internal signal connections, and operational parameters differ from device to device. See the device-specific data sheet for these details. |

## 10.5 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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.

## 10.6 Trademarks

LaunchPad™, Code Composer Studio™, and TI E2E™ are trademarks of Texas Instruments.
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All trademarks are the property of their respective owners.

## 10.7 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.

## 10.8 Glossary

| | |
|---|---|
| TI Glossary | This glossary lists and explains terms, acronyms, and definitions. |

# 11 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

**Changes from November 1, 2025 to December 31, 2025 (from Revision * (November 2025) to Revision A (December 2025))** **Page**


- Updated USB pin IO max voltage ratings in absolute maximum ratings specifications table ..... 35
- Added max current loading specification for VUSB33 pin in absolute maximum ratings specifications table.. 35
- Updated IDD supply current specification values across multiple operating modes in the Supply Current Characteristics specifications table..... 35
- Updated cold-boot BOR specification values in the POR and BOR specifications table ..... 35
- Updated SYSOSC accuracy values for internal-resistor FCL-ON mode condition in SYSOSC specifications table..... 35



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- Updated USBFLL output accuracy and lock time specifications in USBFLL specifications table..... 35
- Added I_lkg specification values for USBIO type in Digital IO Electrical Characteristics specifications table..35
- Added PSRR_DC specification values in ADC Electrical Characteristics specifications table.....35
- Updated test conditions for ENOB and SNR to FIN=1kHz in oversampling mode for ADC Electrical Characteristics specifications table.....35
- Added I_VUSB33 quiescent current specification values in the USB Characteristics (USB Mode) specificaftions table..... 35
- Updated I2S specification values in the Serial Audio specifications table.....35
- Added detailed DMA Features table to DMA detailed descriptions section..... 64
- Updated maximum ADC speeds claimed in ADC detailed descriptions section..... 70
- Added VREF1 and VREF2 connection diagrams in VREF detailed descriptions section..... 71
- Updated maximum ADC speeds claimed in VREF detailed descriptions section..... 71
- Updated security detailed description sections to properly list all security features..... 73
- Updated UNICOMM feature descriptions and instance mapping table to include global and local indexing details..... 75
- Updated analog connections diagram..... 83

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## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable 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.

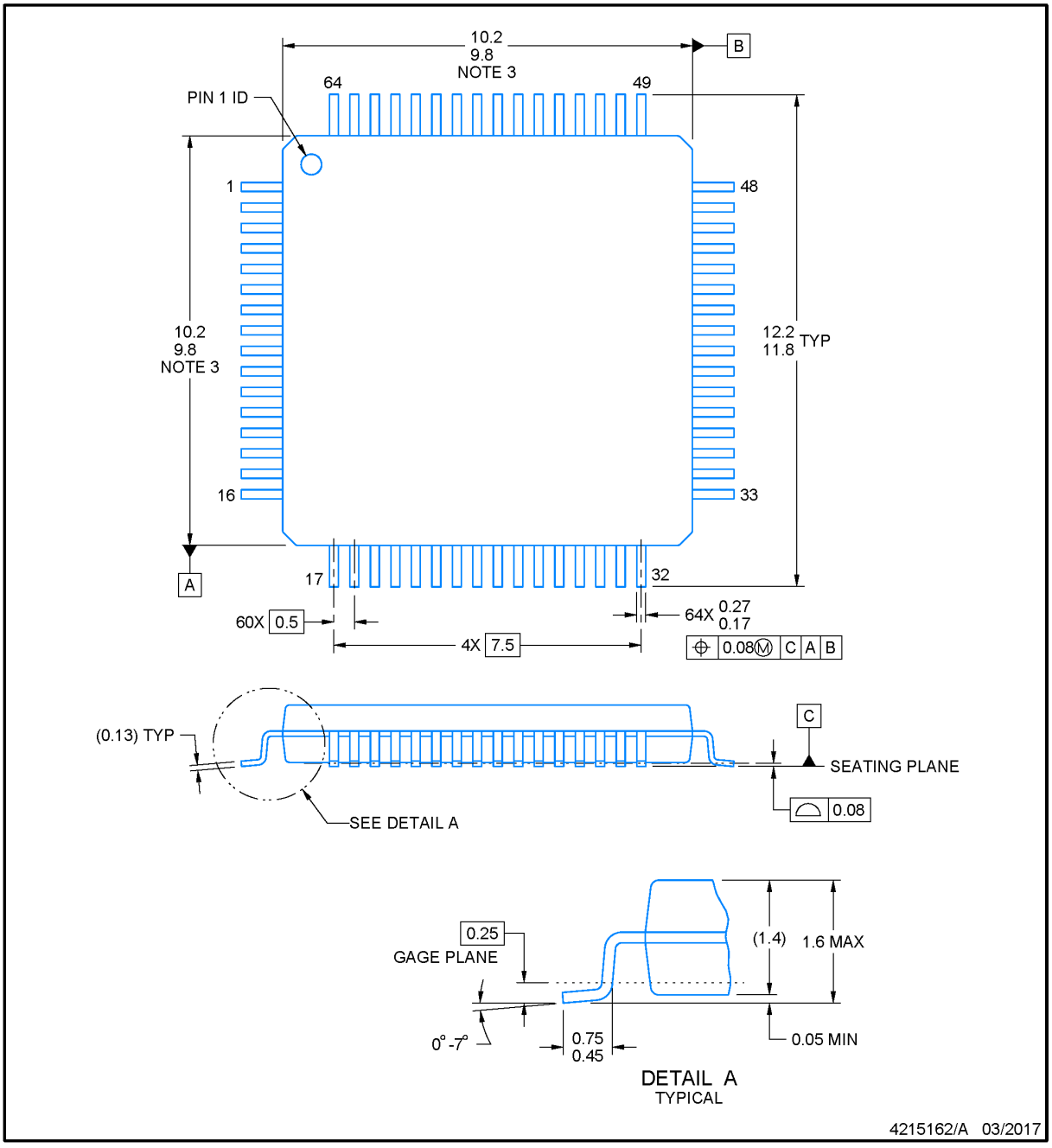

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# PACKAGE OUTLINE

## PM0064A

## LQFP - 1.6 mm max height

PLASTIC QUAD FLATPACK




NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MS-026.

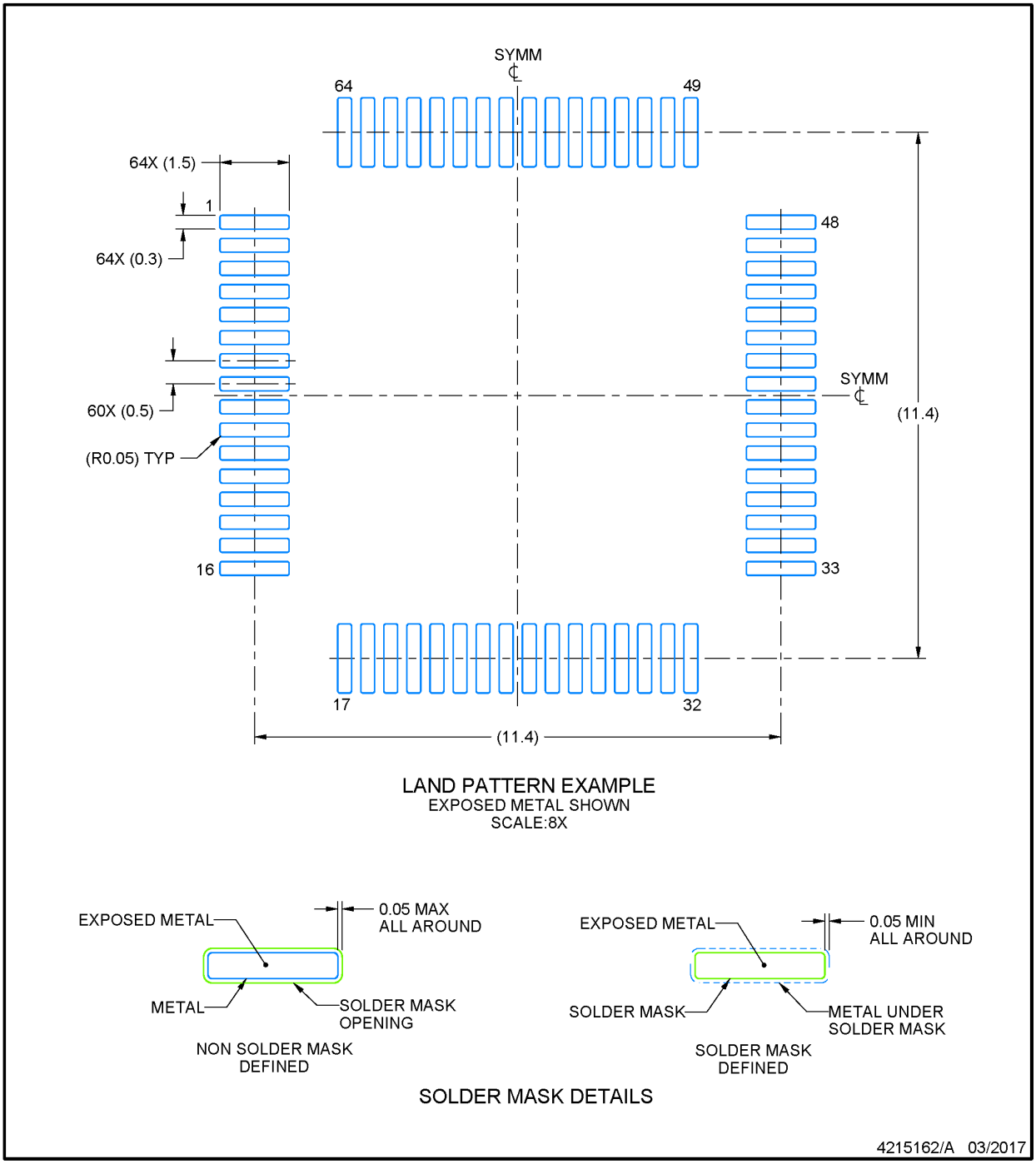
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# EXAMPLE BOARD LAYOUT

## PM0064A

### LQFP - 1.6 mm max height

PLASTIC QUAD FLATPACK




NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
7. For more information, see Texas Instruments literature number SLMA004 (www.ti.com/lit/slma004).

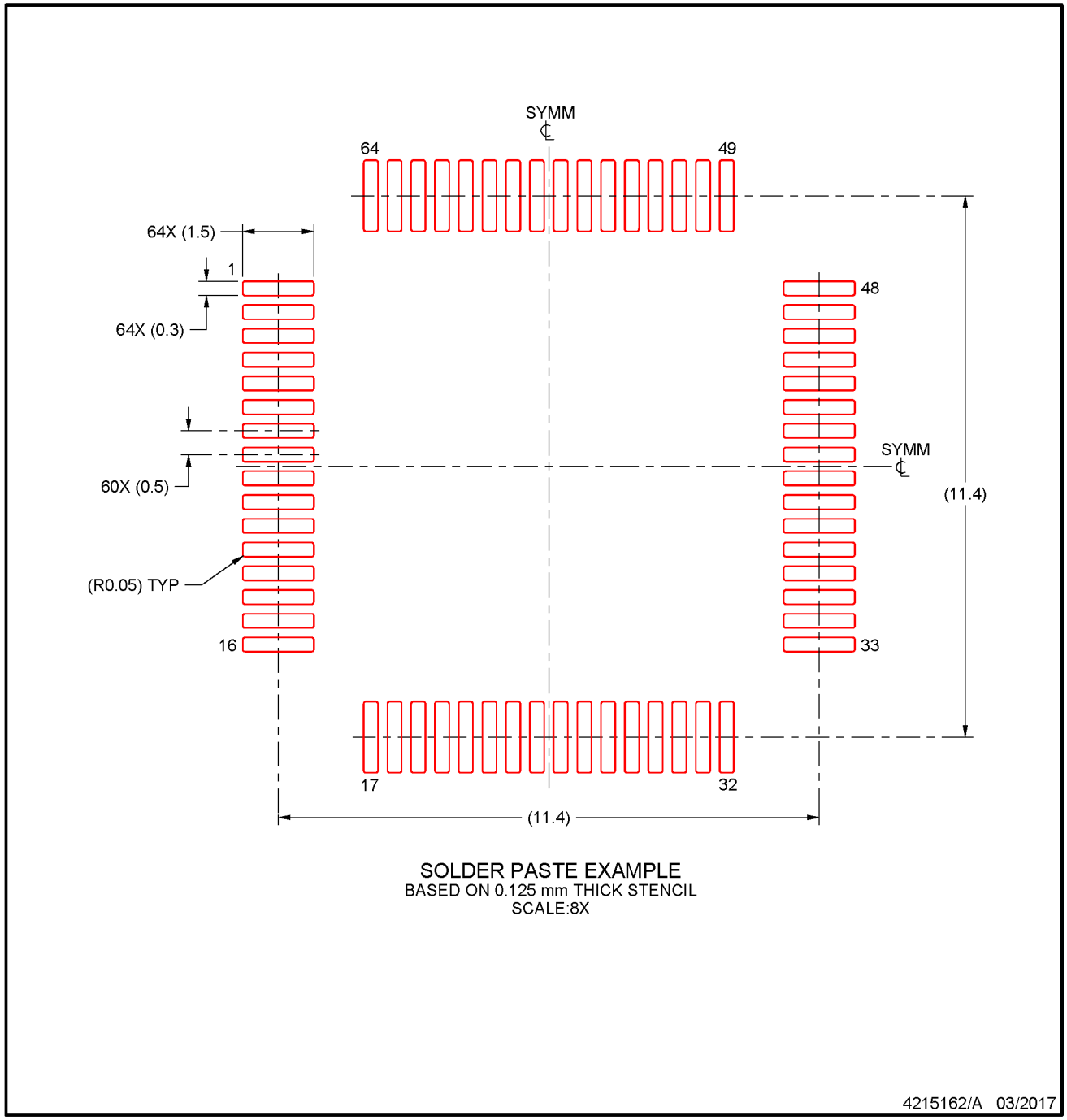

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# EXAMPLE STENCIL DESIGN

## PM0064A

## LQFP - 1.6 mm max height

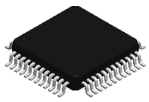
PLASTIC QUAD FLATPACK




NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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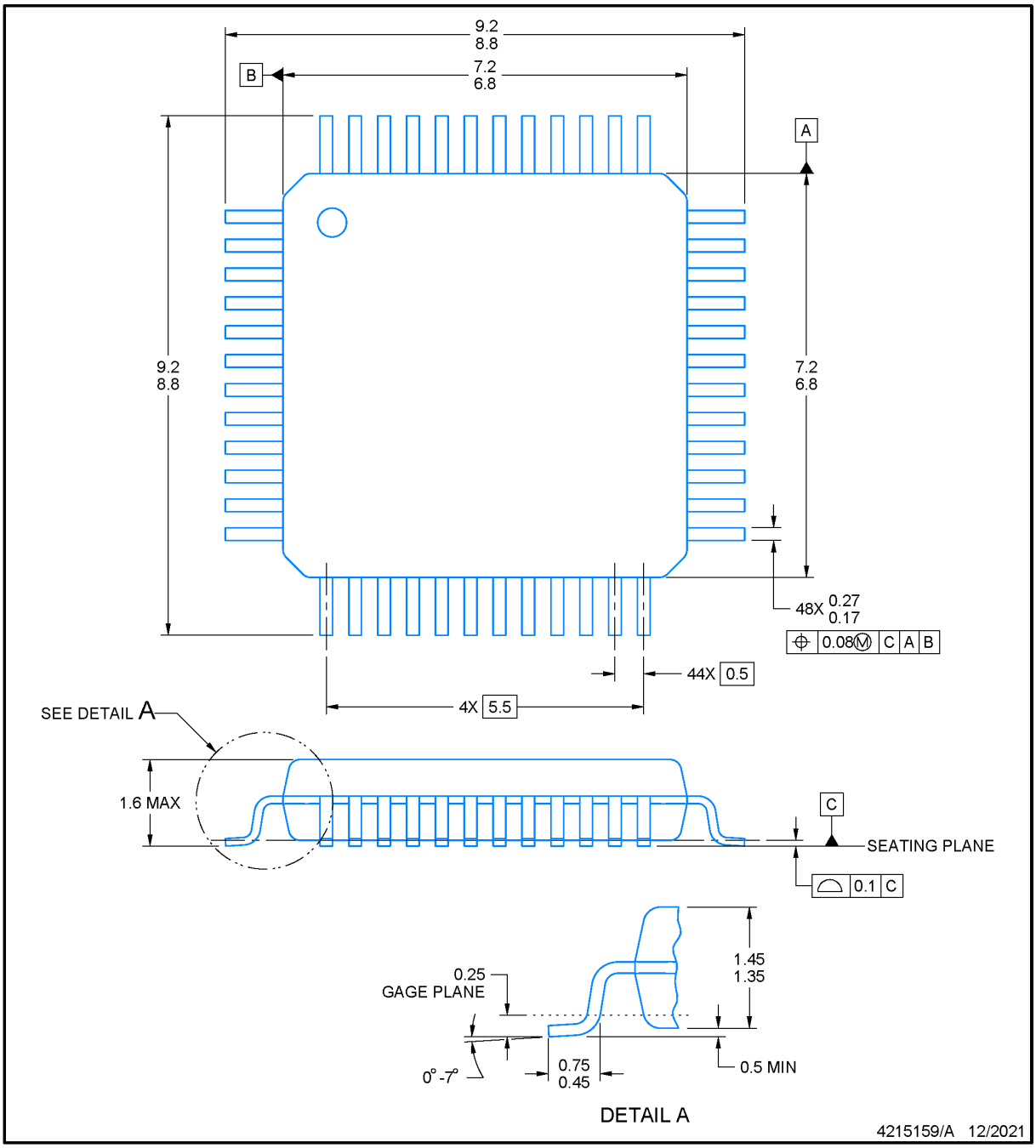


# PACKAGE OUTLINE

## PT0048A

## LQFP - 1.6 mm max height

LOW PROFILE QUAD FLATPACK




NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration MS-026.
4. This may also be a thermally enhanced plastic package with leads conected to the die pads.

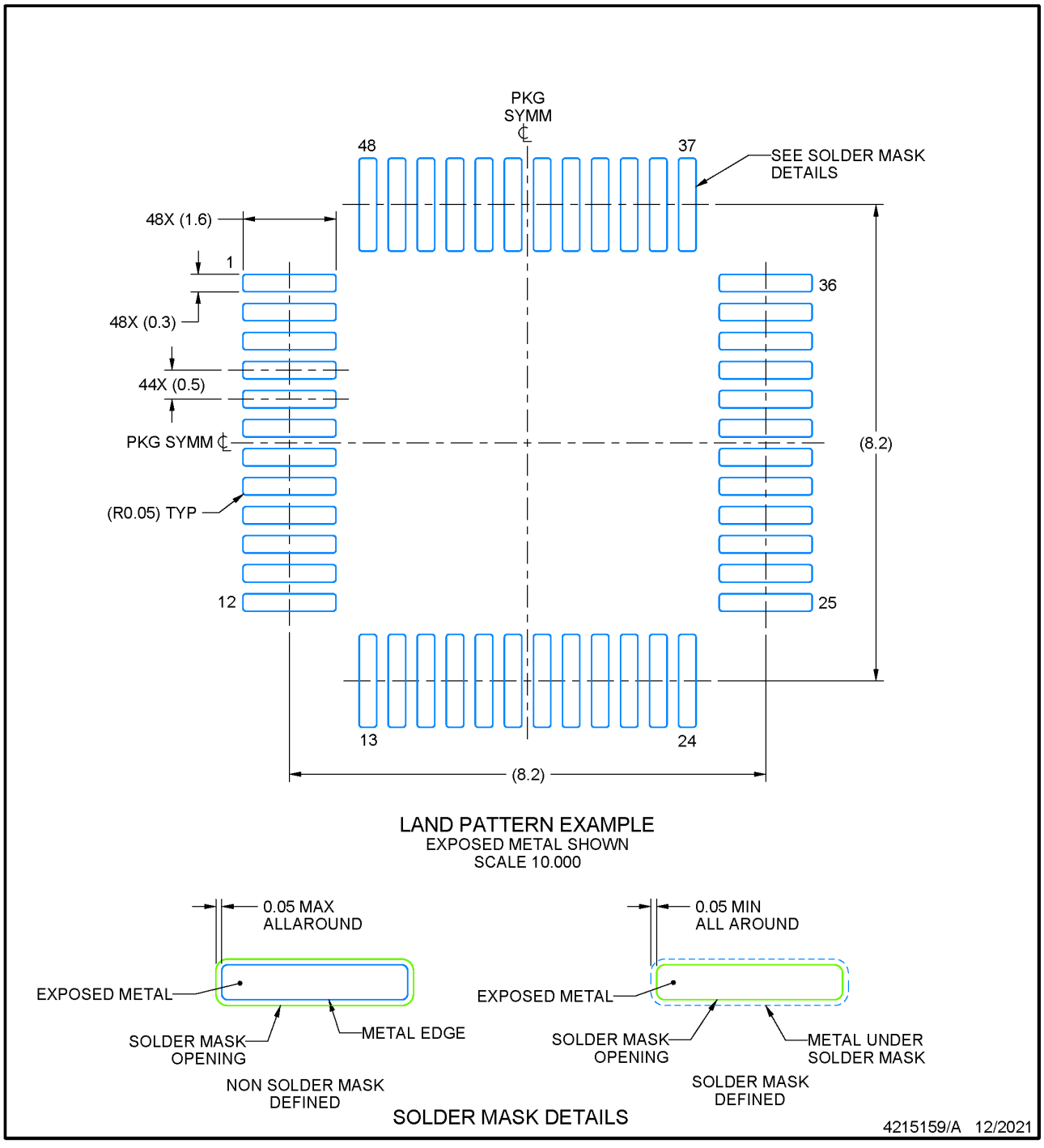

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# EXAMPLE BOARD LAYOUT

## PT0048A

### LQFP - 1.6 mm max height

LOW PROFILE QUAD FLATPACK




NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

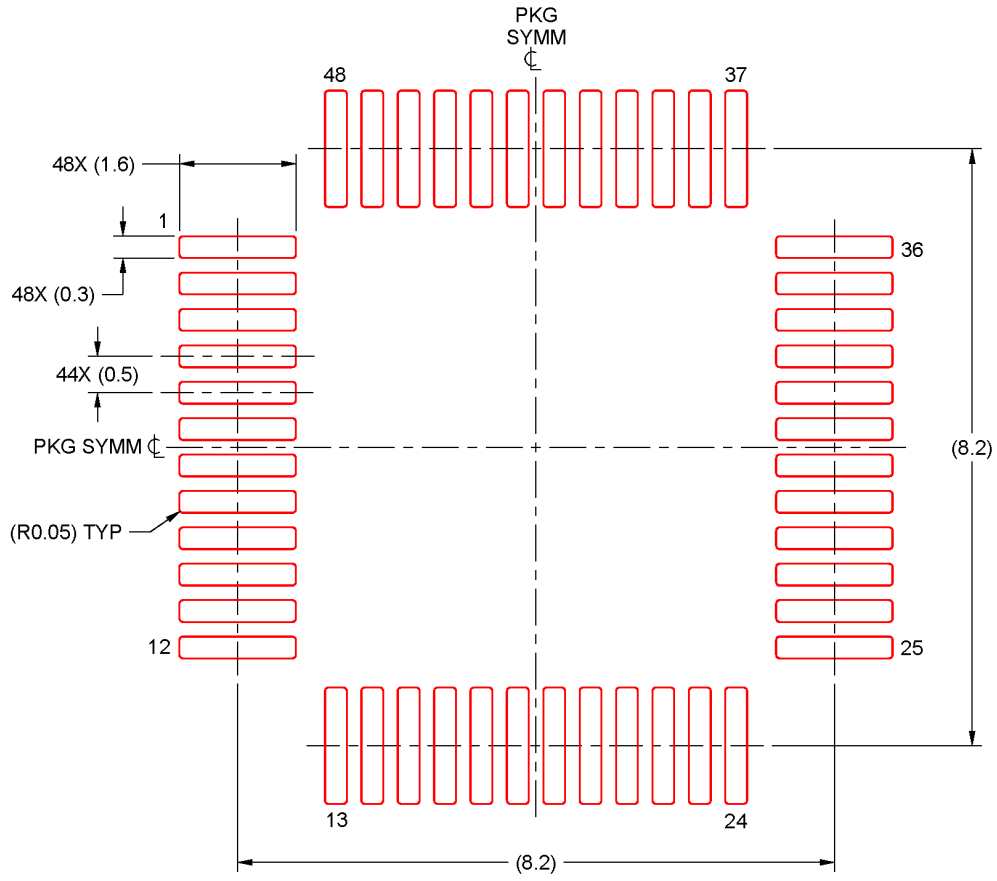
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# EXAMPLE STENCIL DESIGN

## PT0048A

## LQFP - 1.6 mm max height

LOW PROFILE QUAD FLATPACK




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 10X

4215159/A 12/2021

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.


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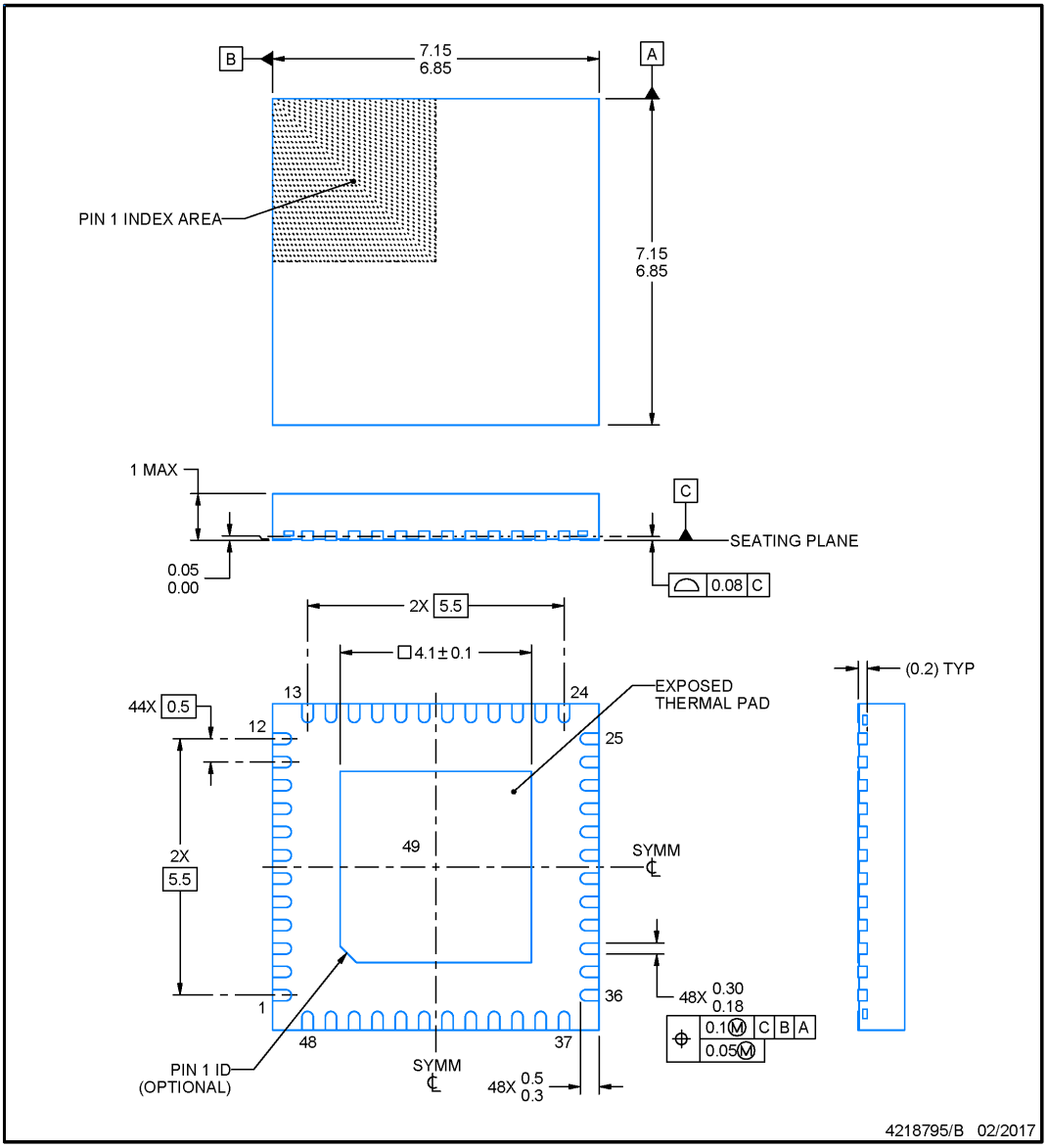
# PACKAGE OUTLINE

## RGZ0048B



## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

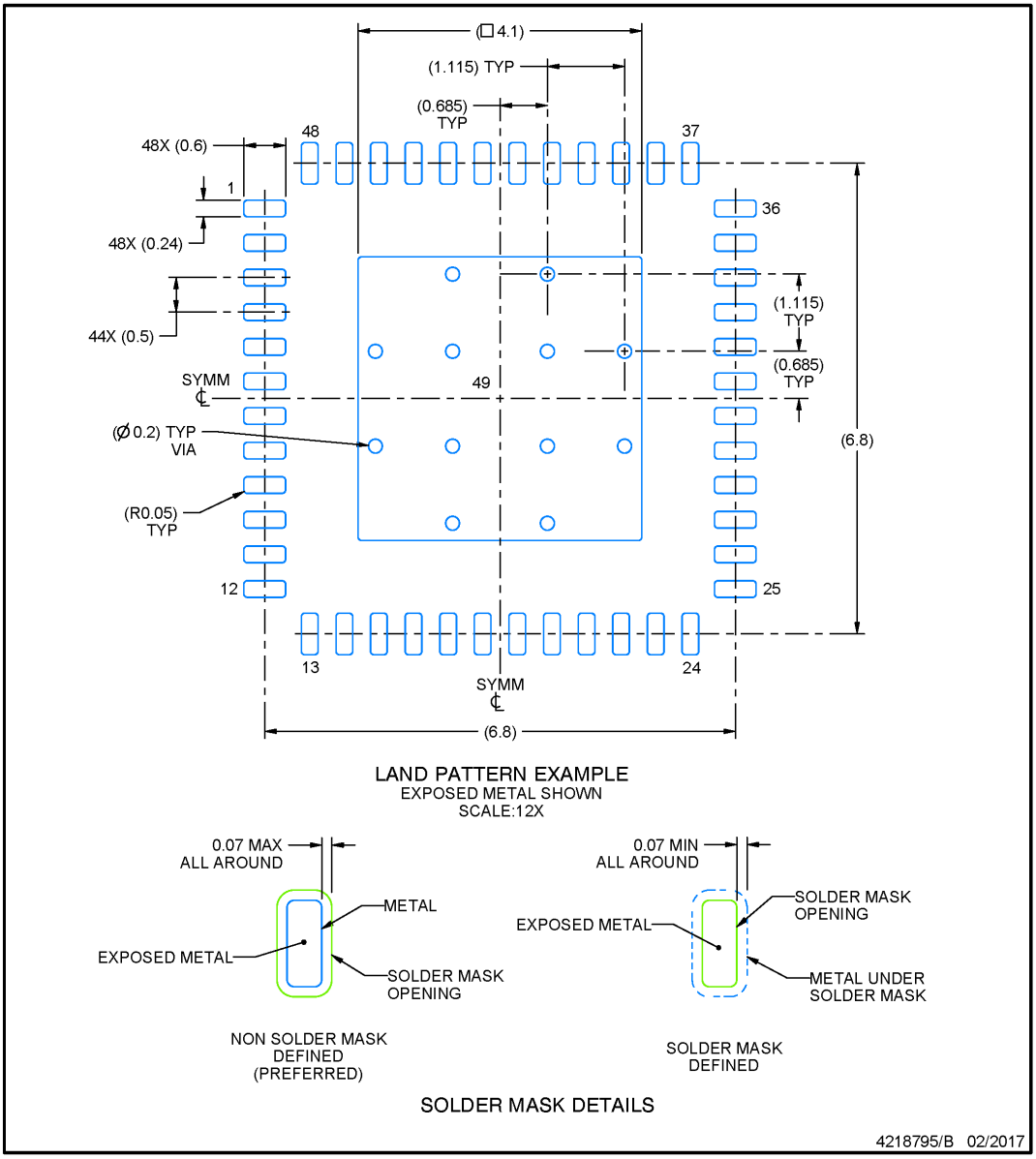


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## EXAMPLE BOARD LAYOUT

**RGZ0048B** — **VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD




NOTES: (continued)

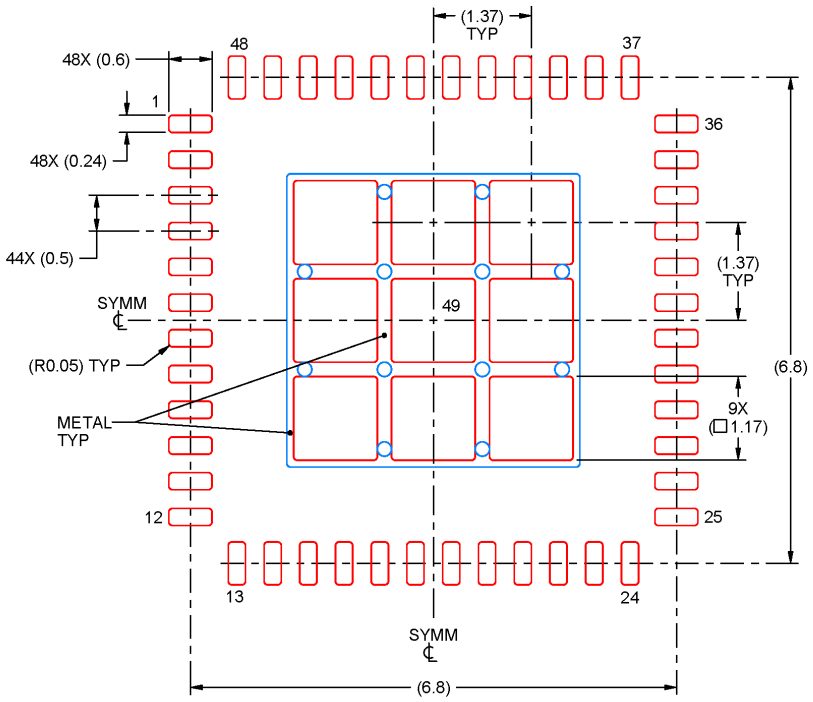
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.


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## EXAMPLE STENCIL DESIGN

**RGZ0048B** — **VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 49
73% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:12X

4218795/B 02/2017

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



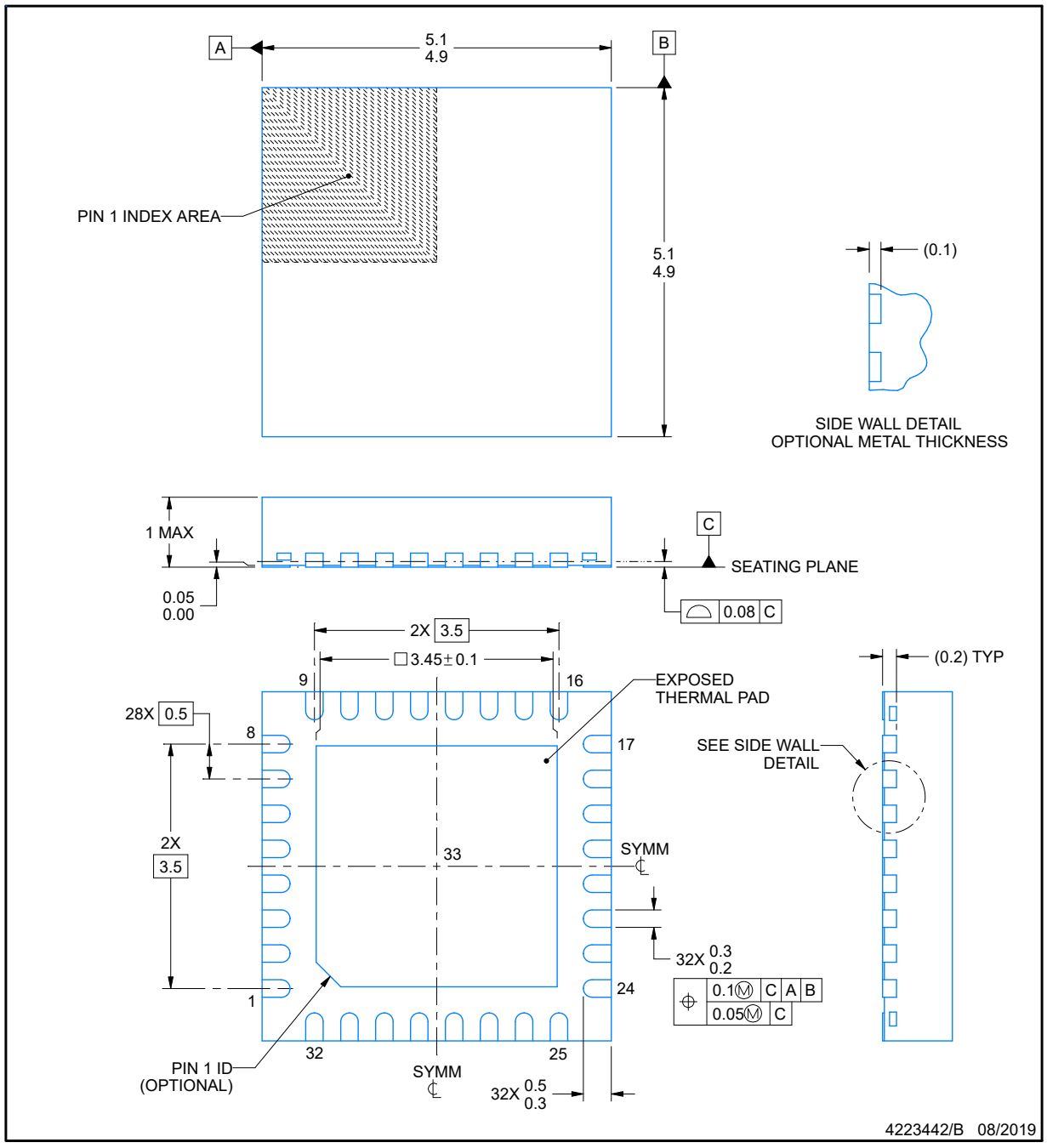
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# PACKAGE OUTLINE

## RHB0032E

### VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

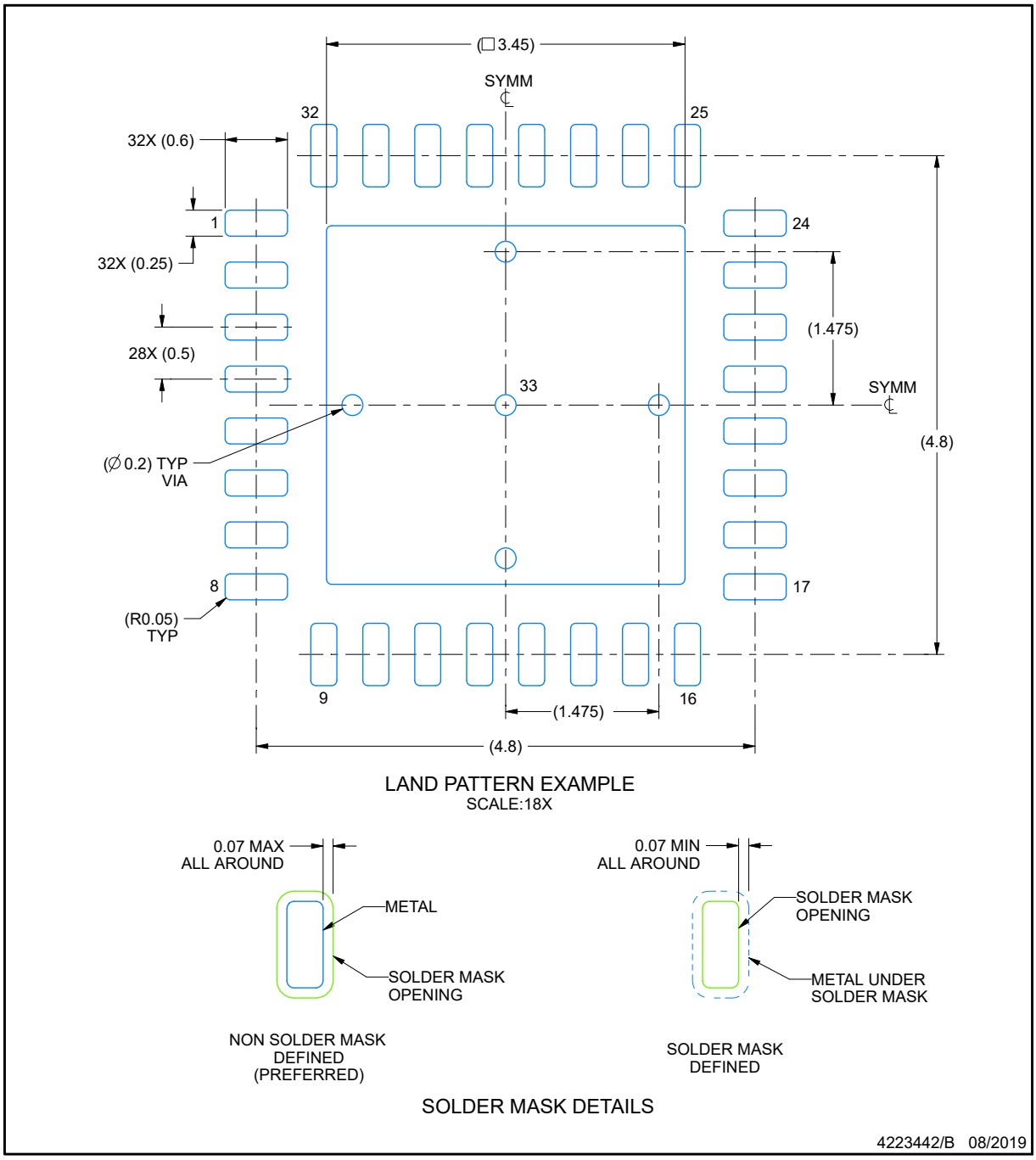

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# EXAMPLE BOARD LAYOUT

## RHB0032E

## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

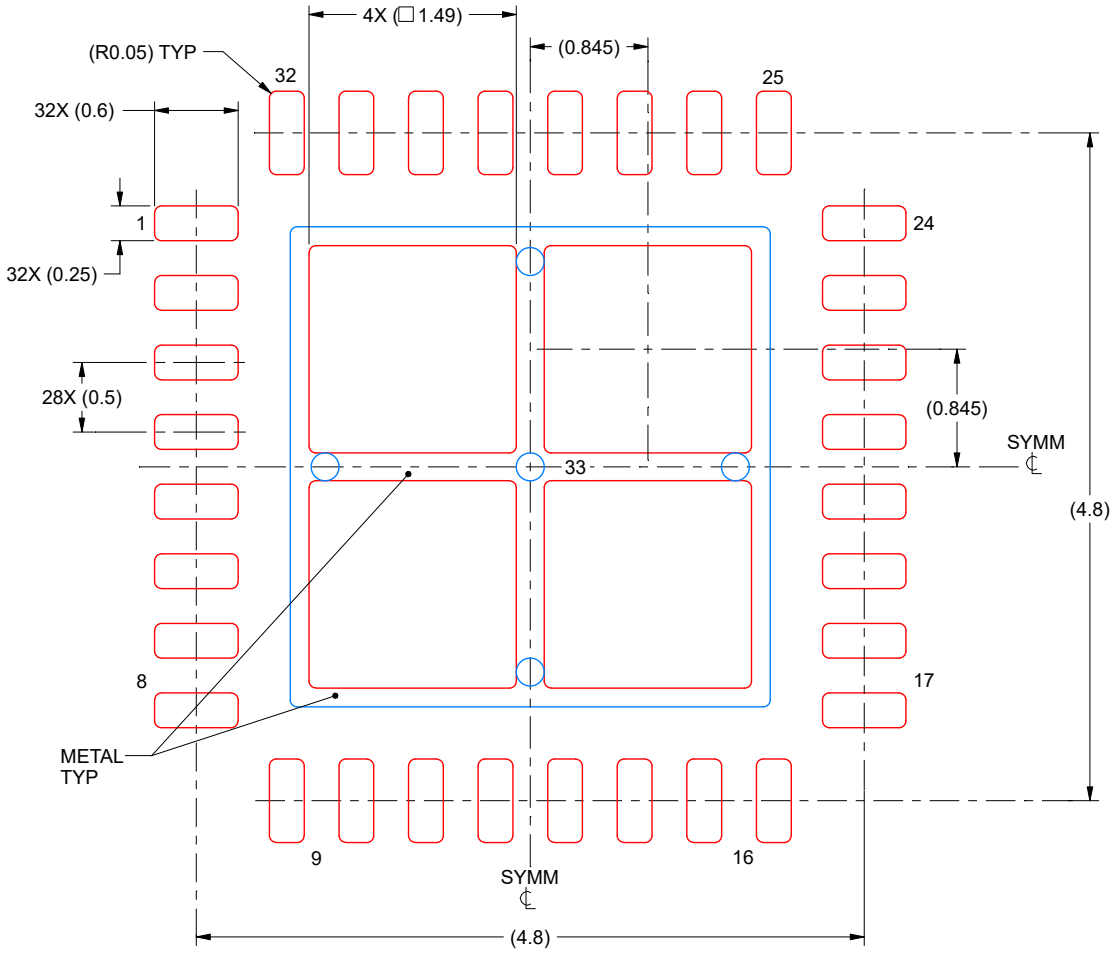
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# EXAMPLE STENCIL DESIGN

## RHB0032E

### VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 33:
75% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4223442/B 08/2019

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

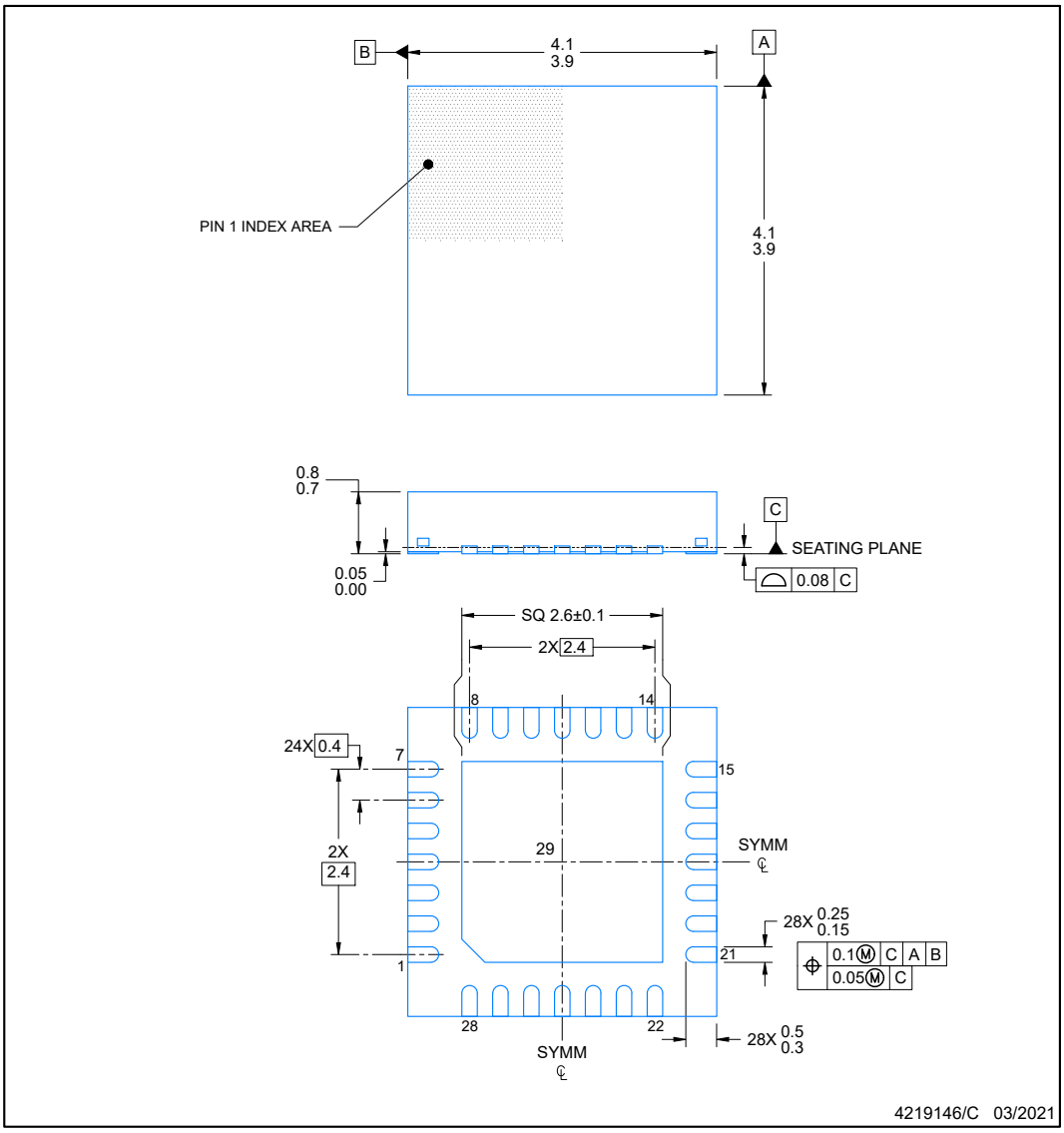

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# PACKAGE OUTLINE

## RUY0028A

**WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK-NO LEAD




NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

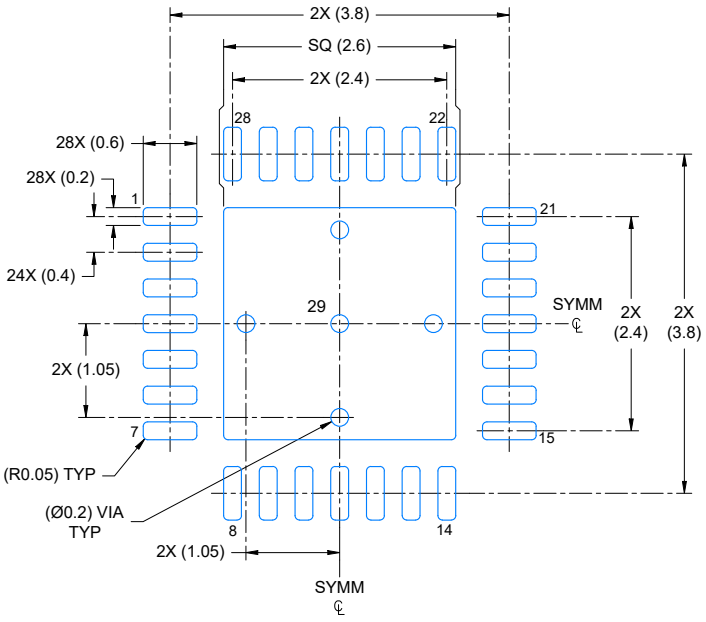


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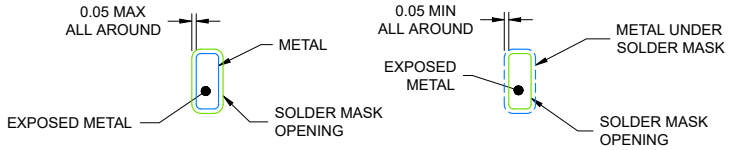
## EXAMPLE BOARD LAYOUT

**RUY0028A** — **WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK-NO LEAD




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X




NON SOLDER MASK DEFINED (PREFERRED)

SOLDER MASK DEFINED

SOLDER MASK DETAILS

4219146/C 03/2021

NOTES: (continued)

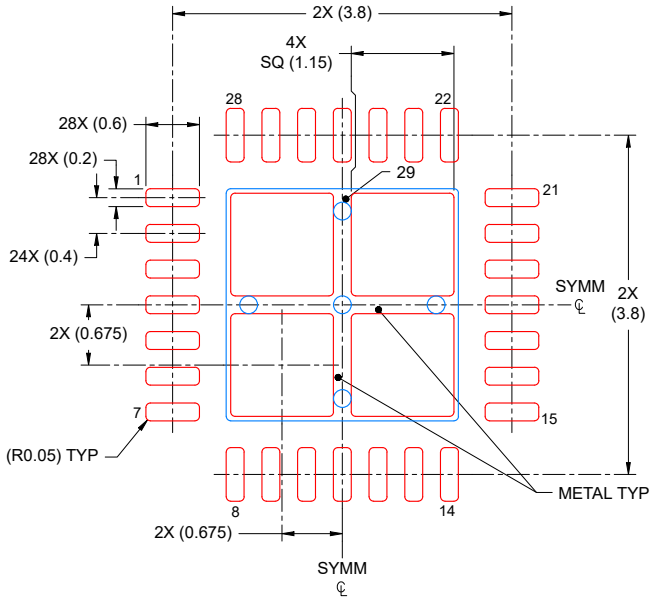
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.


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## EXAMPLE STENCIL DESIGN

**RUY0028A** — **WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK-NO LEAD




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
78% PRINTED COVERAGE BY AREA
SCALE: 15X

4219146/C 03/2021

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



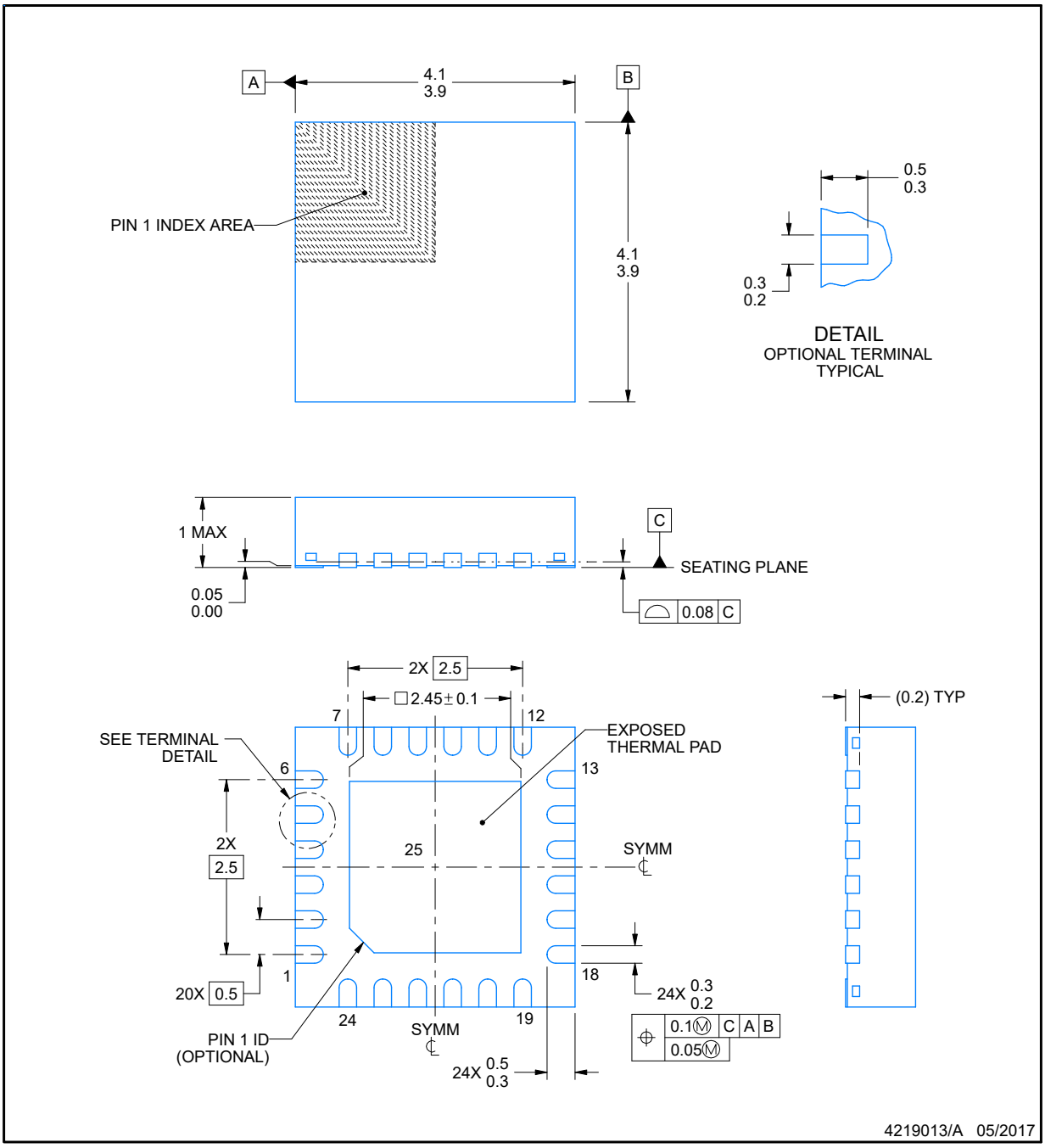
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# RGE0024B

# PACKAGE OUTLINE

## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

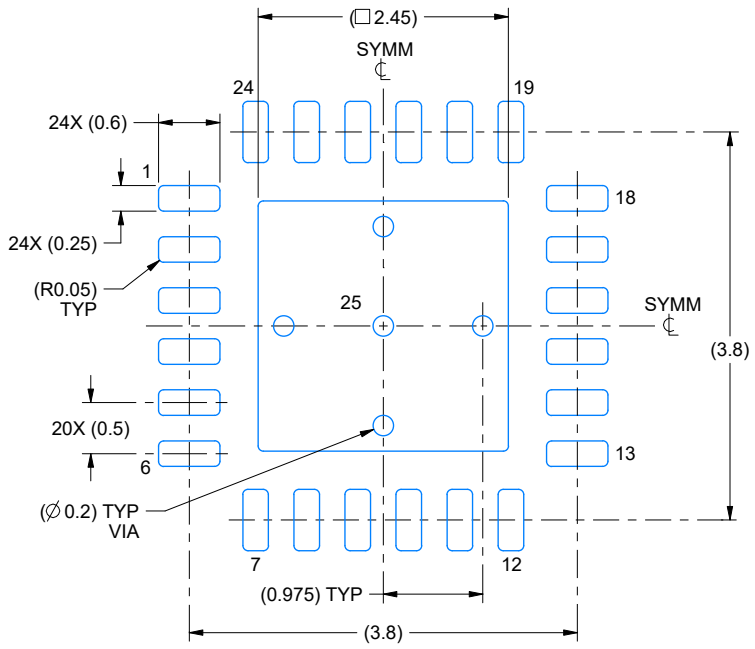

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# EXAMPLE BOARD LAYOUT

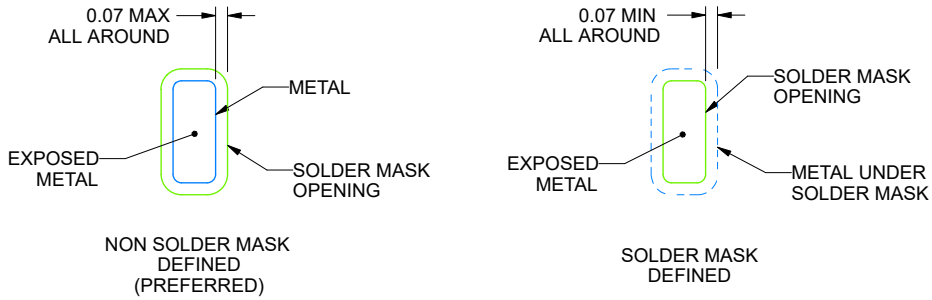
## RGE0024B

## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X




SOLDER MASK DETAILS

4219013/A 05/2017

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

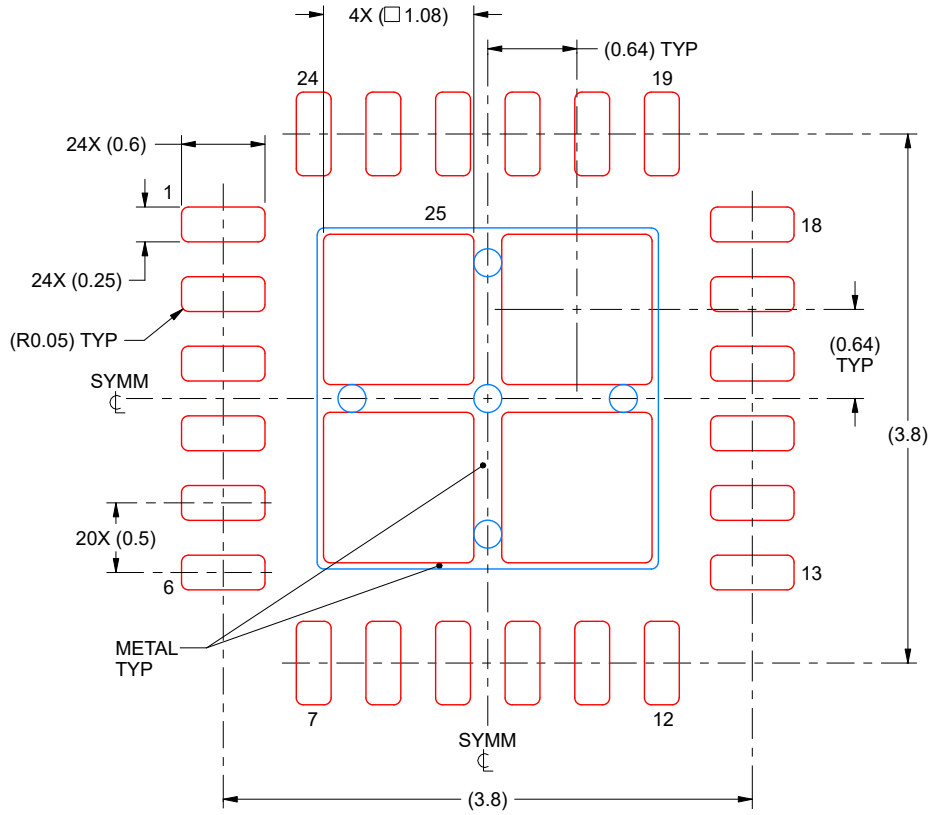
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# EXAMPLE STENCIL DESIGN

## RGE0024B

## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 25
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4219013/A 05/2017

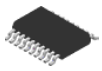
NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.


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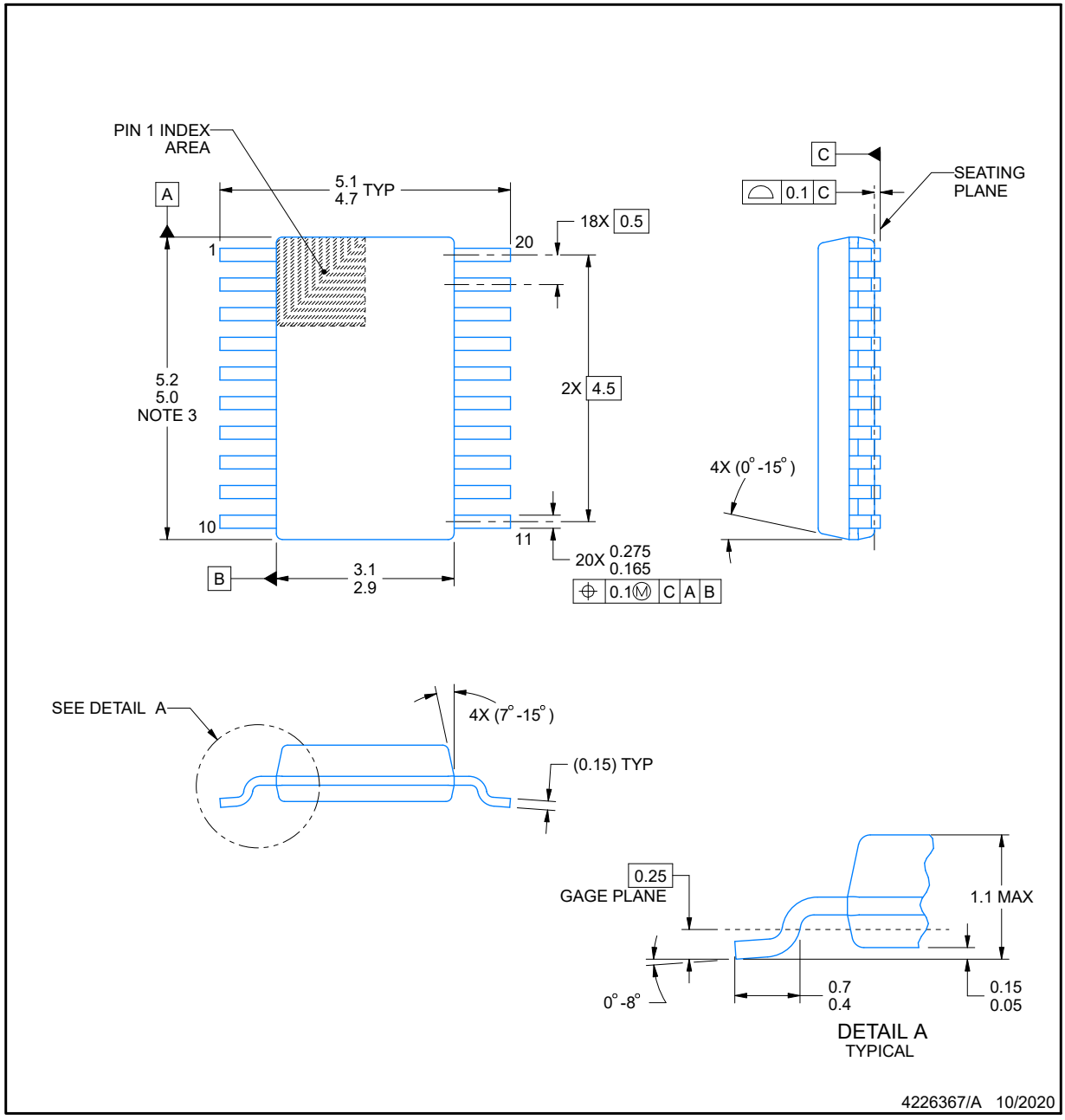
# PACKAGE OUTLINE

## DGS0020A



## VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE




PowerPAD is a trademark of Texas Instruments.

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. No JEDEC registration as of September 2020.
5. Features may differ or may not be present.

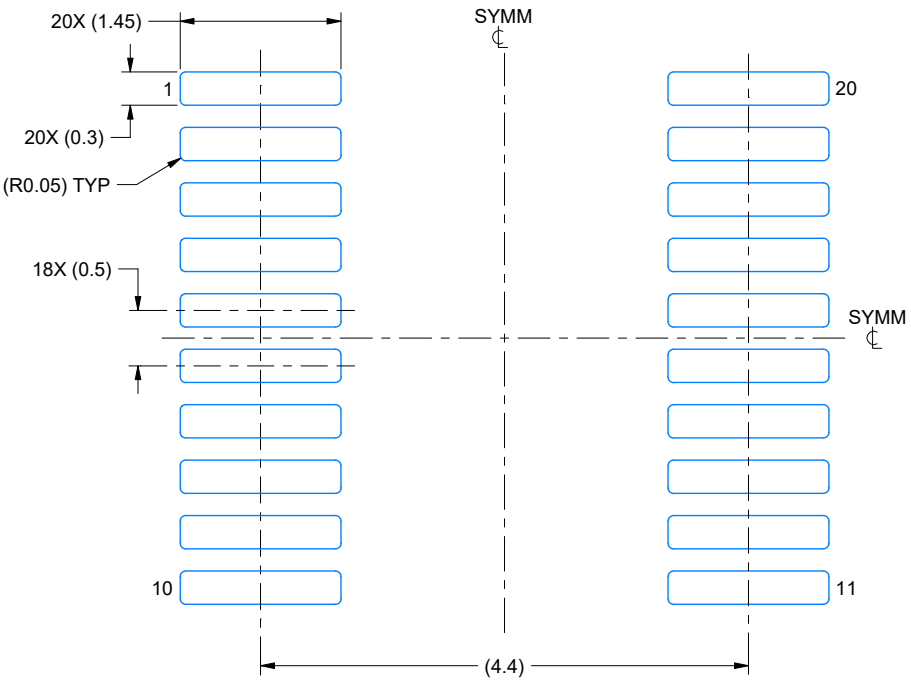
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## EXAMPLE BOARD LAYOUT

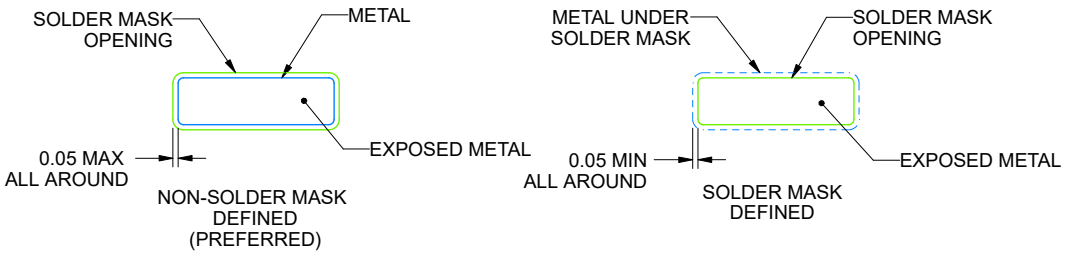
### DGS0020A

### VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE




LAND PATTERN EXAMPLE
SCALE: 16X




SOLDER MASK DETAILS

4226367/A 10/2020

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.
10. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.

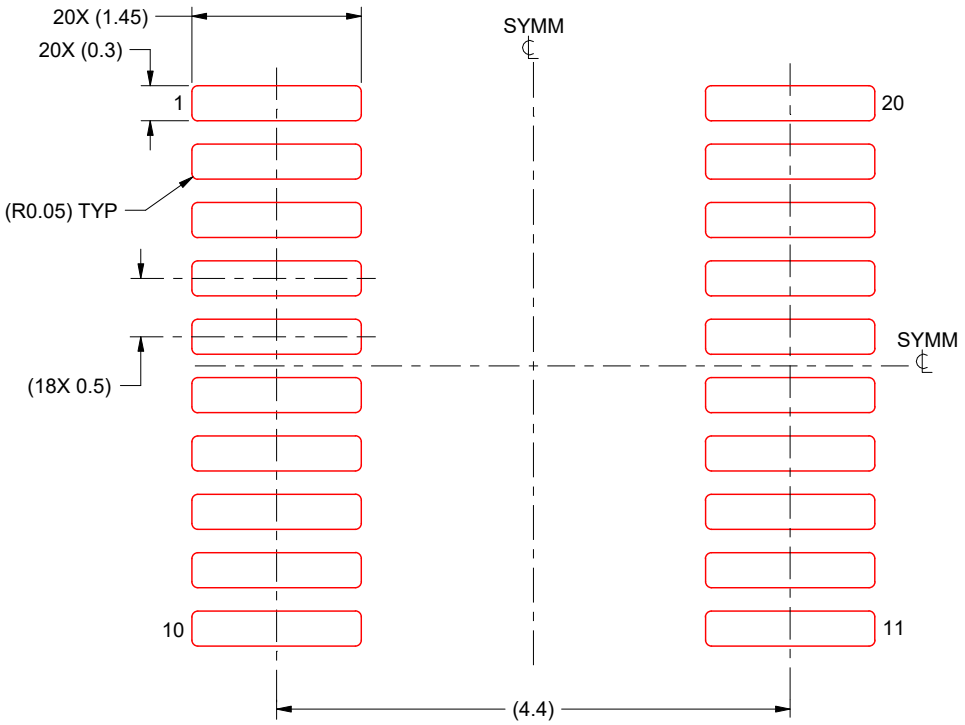

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# EXAMPLE STENCIL DESIGN

## DGS0020A

## VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 16X

4226367/A 10/2020

NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

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## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| MSPM0G5115SDGS20R | Active | Production | VSSOP (DGS) \| 20 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 5115S |
| MSPM0G5115SPMR | Active | Production | LQFP (PM) \| 64 | 1000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | M0G5115S |
| MSPM0G5115SRGER | Active | Production | VQFN (RGE) \| 24 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | MSPM0 G5115S |
| MSPM0G5115SRGZR | Active | Production | VQFN (RGZ) \| 48 | 4000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | MSPM0 G5115S |
| MSPM0G5115SRHBR | Active | Production | VQFN (RHB) \| 32 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | MSPM0 G5115S |
| MSPM0G5115SRUYR | Active | Production | WQFN (RUY) \| 28 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | MSPM0 G5115S |
| MSPM0G5116SDGS20R | Active | Production | VSSOP (DGS) \| 20 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 5116S |
| MSPM0G5116SPMR | Active | Production | LQFP (PM) \| 64 | 1000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | M0G5116S |
| MSPM0G5116SPTR | Active | Production | LQFP (PT) \| 48 | 1000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | M0G5116S |
| MSPM0G5116SRGER | Active | Production | VQFN (RGE) \| 24 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | MSPM0 G5116S |
| MSPM0G5116SRGZR | Active | Production | VQFN (RGZ) \| 48 | 4000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | MSPM0 G5116S |
| MSPM0G5116SRHBR | Active | Production | VQFN (RHB) \| 32 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | MSPM0 G5116S |
| MSPM0G5116SRUYR | Active | Production | WQFN (RUY) \| 28 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | MSPM0 G5116S |
| MSPM0G5117SDGS20R | Active | Production | VSSOP (DGS) \| 20 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 5117S |
| MSPM0G5117SPMR | Active | Production | LQFP (PM) \| 64 | 1000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | M0G5117S |
| MSPM0G5117SPTR | Active | Production | LQFP (PT) \| 48 | 1000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | M0G5117S |
| MSPM0G5117SRGER | Active | Production | VQFN (RGE) \| 24 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | MSPM0 G5117S |
| MSPM0G5117SRGZR | Active | Production | VQFN (RGZ) \| 48 | 4000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | MSPM0 G5117S |
| MSPM0G5117SRHBR | Active | Production | VQFN (RHB) \| 32 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | MSPM0 G5117S |
| MSPM0G5117SRUYR | Active | Production | WQFN (RUY) \| 28 | 5000 \| LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | MSPM0 G5117S |

(1) **Status:** For more details on status, see our product life cycle.

(2) **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.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **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.

(5) **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.

(6) **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.

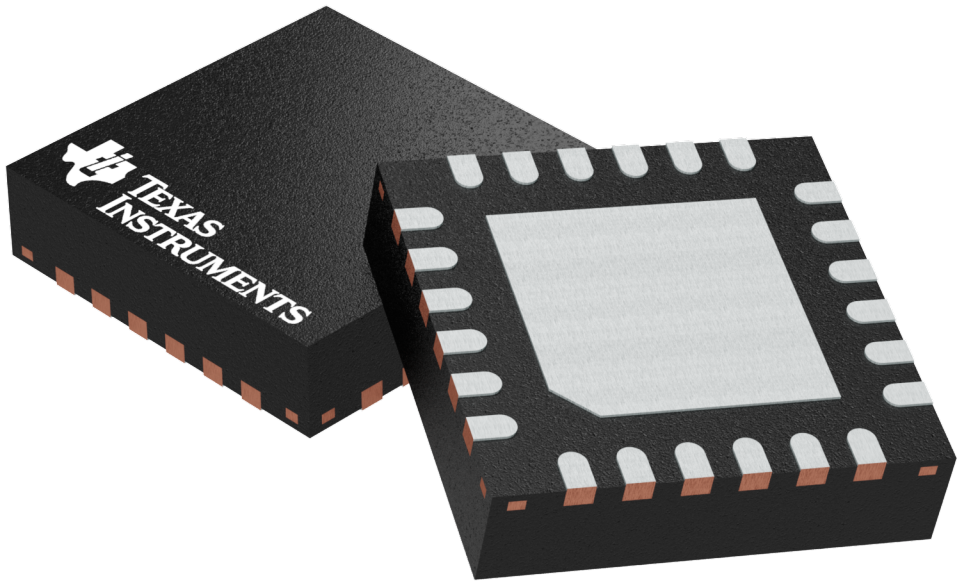
**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

# GENERIC PACKAGE VIEW

## RGE 24 VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD




Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

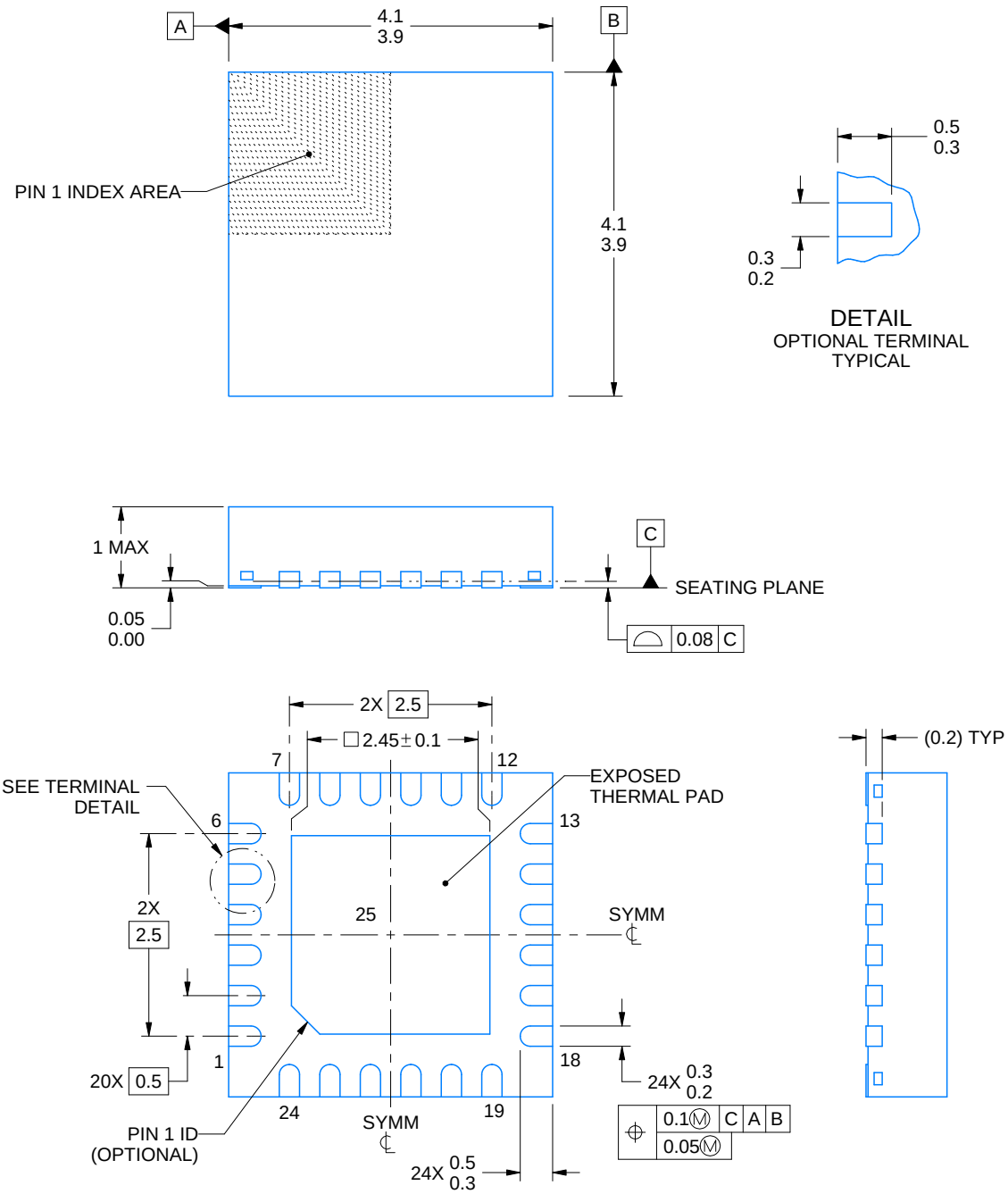
4204104/H

# PACKAGE OUTLINE

## RGE0024B

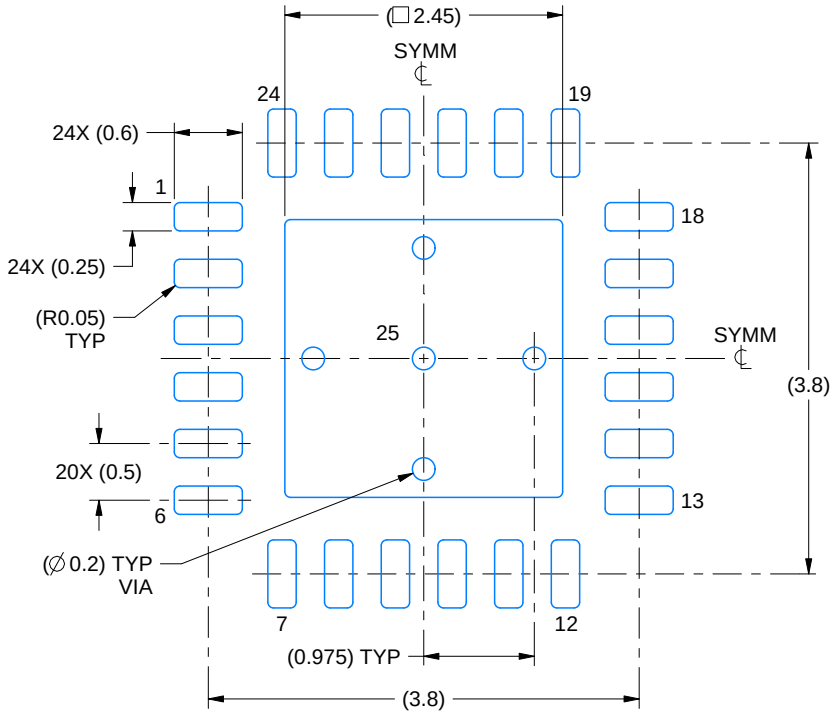
## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

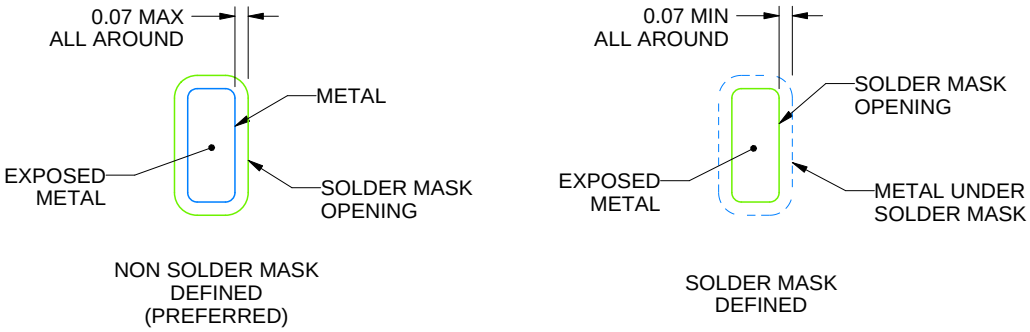



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

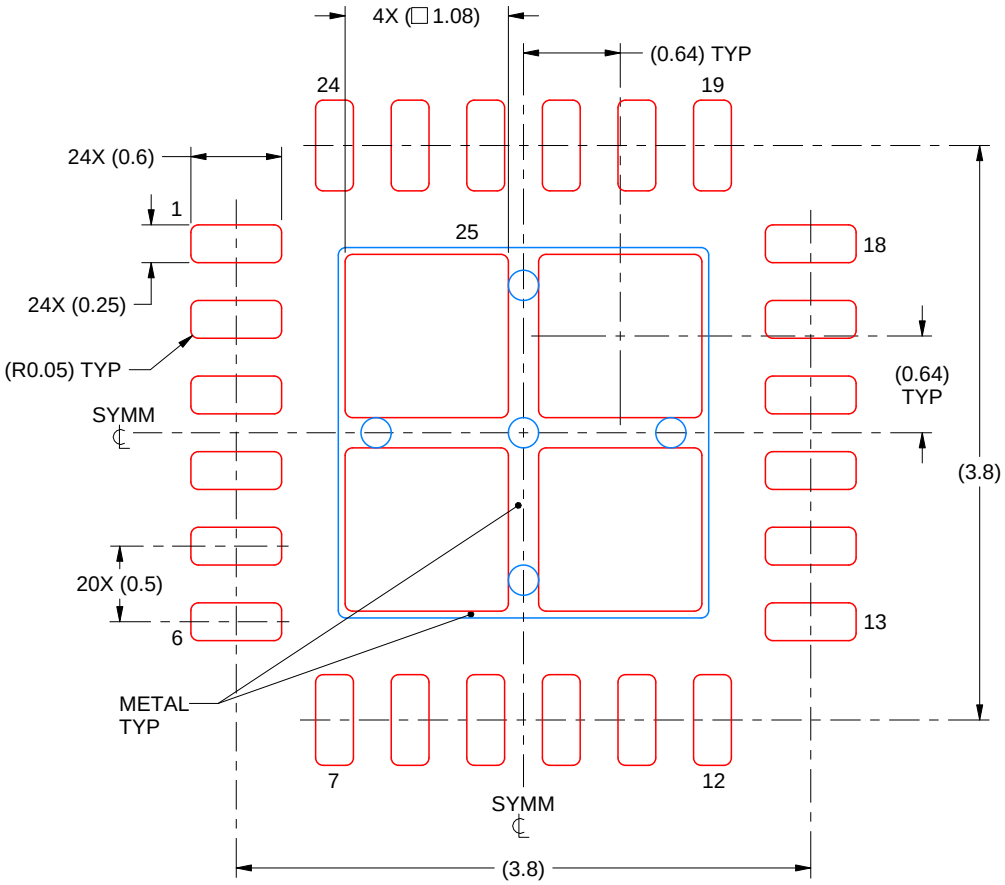



SOLDER MASK DETAILS

4219013/A 05/2017

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 25
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4219013/A 05/2017

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

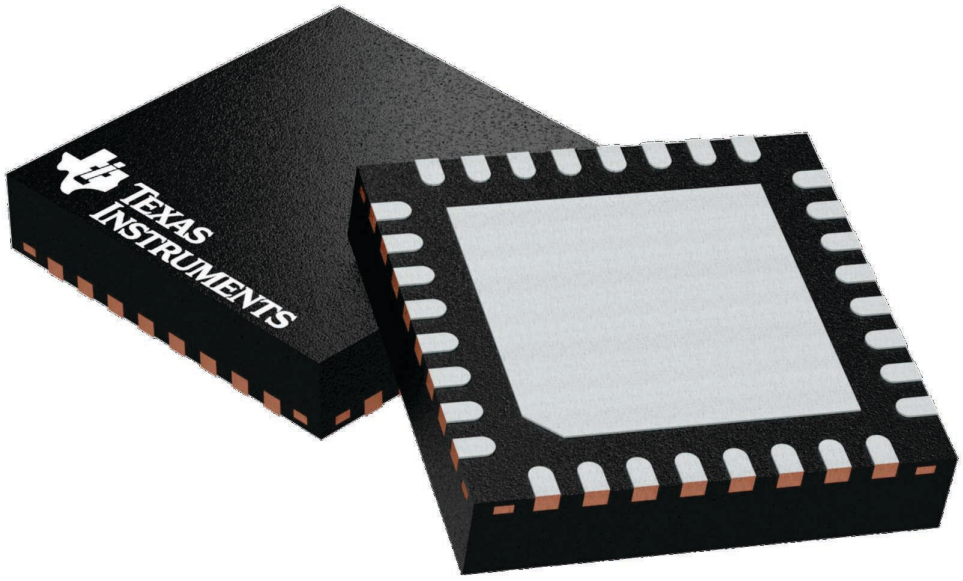
# GENERIC PACKAGE VIEW

## RHB 32

## VQFN - 1 mm max height

**5 x 5, 0.5 mm pitch**

PLASTIC QUAD FLATPACK - NO LEAD




Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

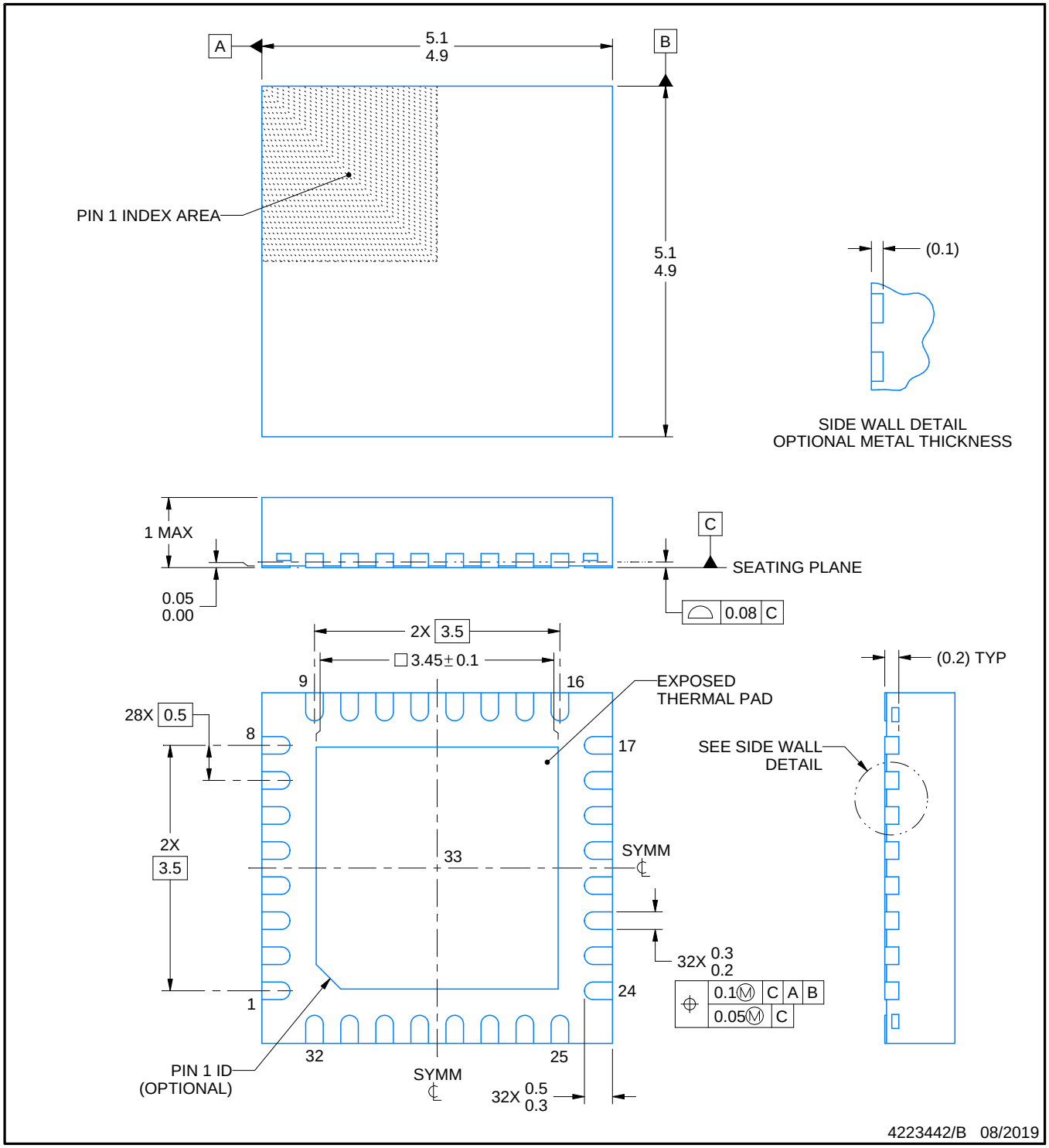
4224745/A

# RHB0032E

# PACKAGE OUTLINE

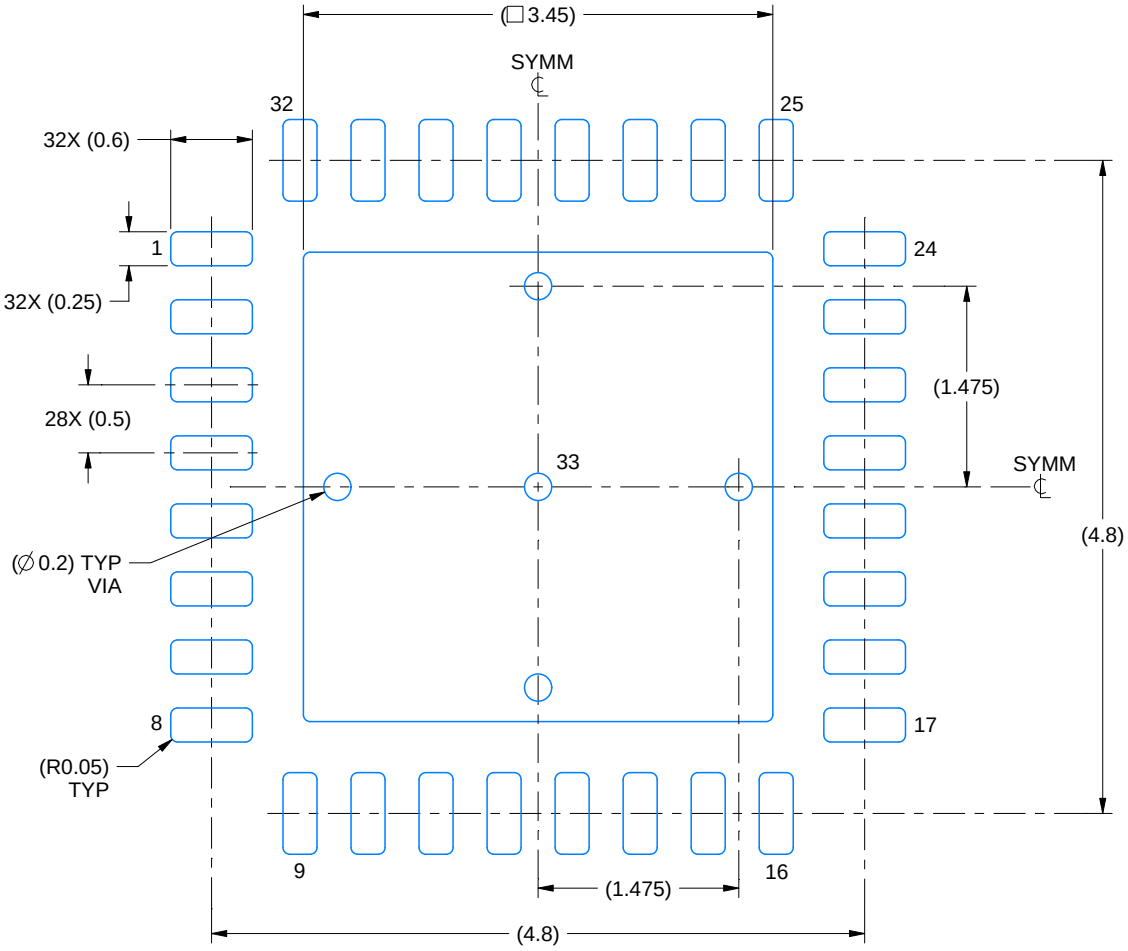
## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

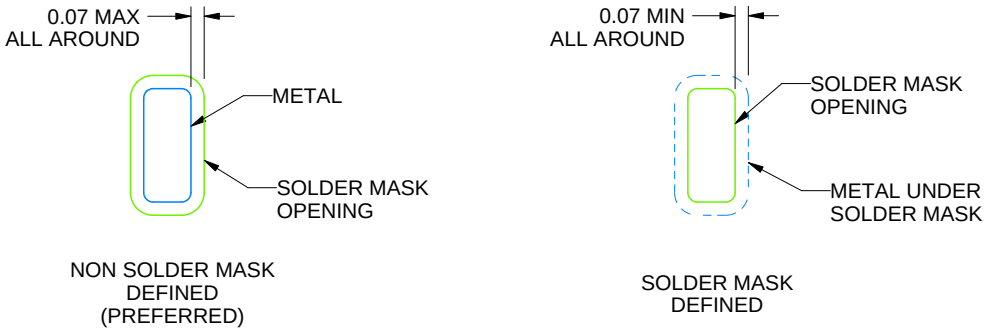



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.




LAND PATTERN EXAMPLE
SCALE:18X

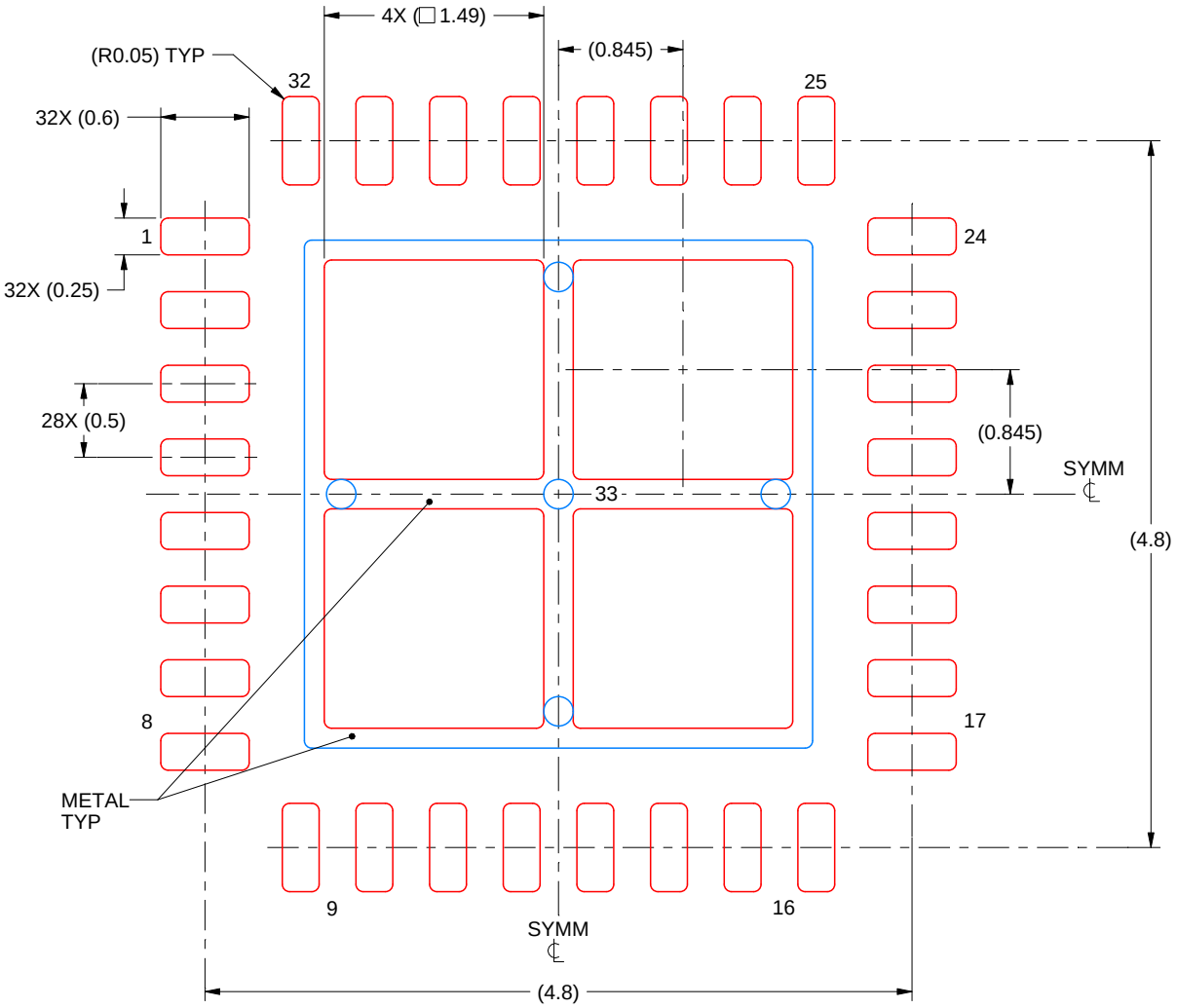



SOLDER MASK DETAILS

4223442/B 08/2019

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 33:
75% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4223442/B 08/2019

NOTES: (continued)

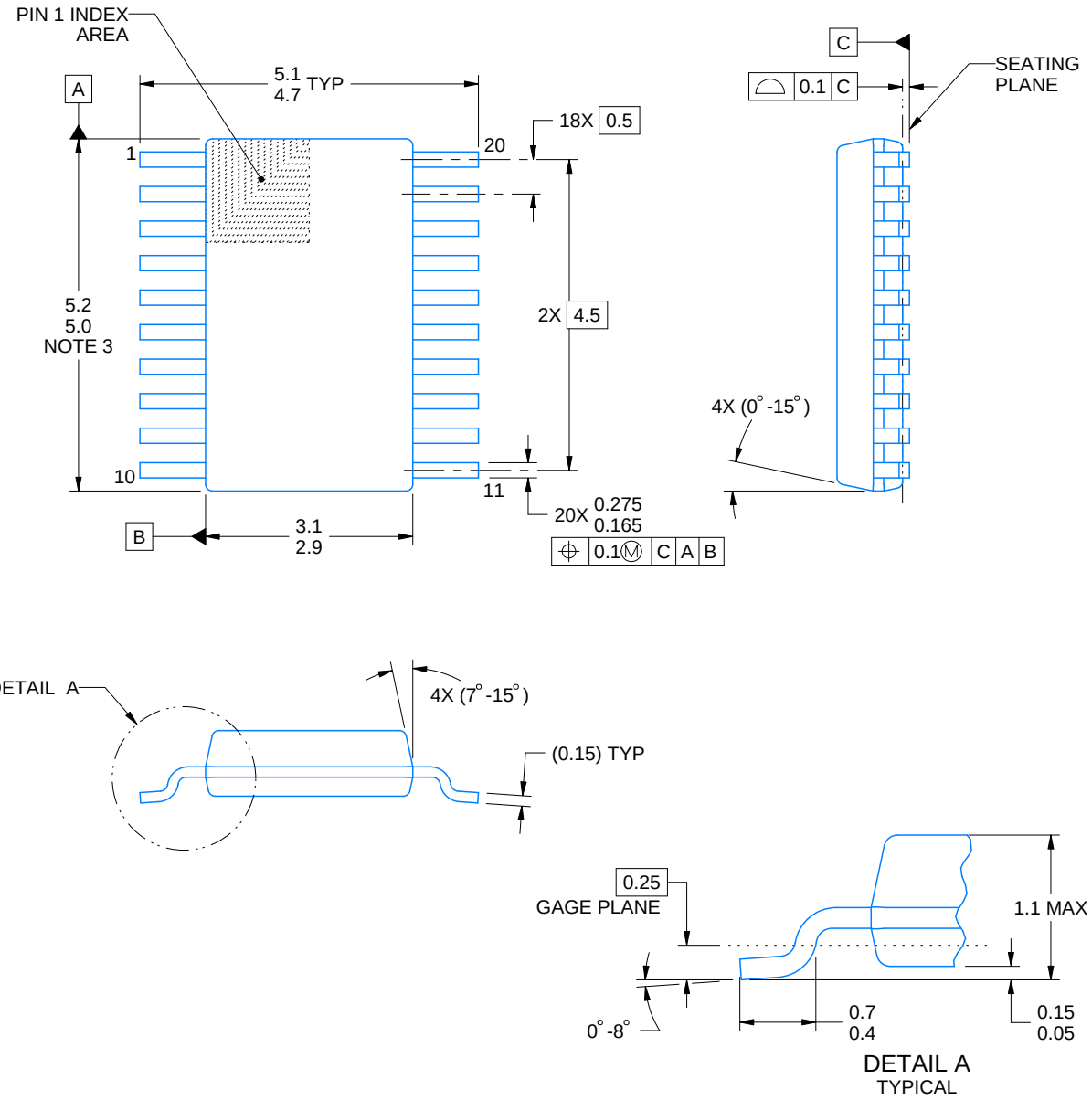
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

# PACKAGE OUTLINE

## DGS0020A

## VSSOP - 1.1 mm max height

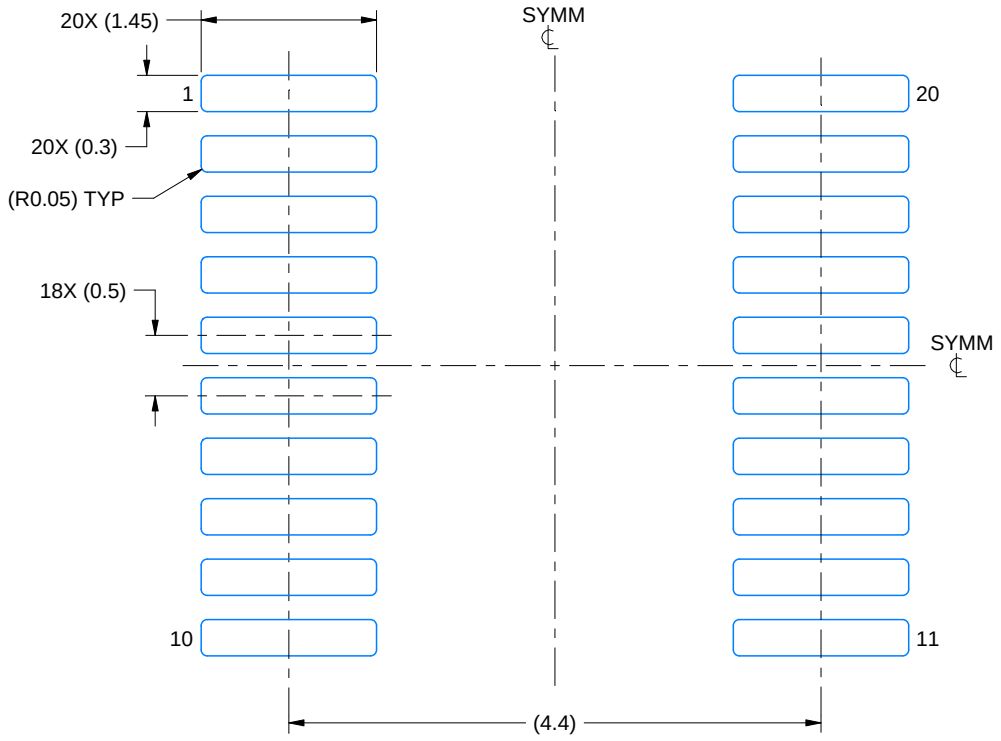
SMALL OUTLINE PACKAGE



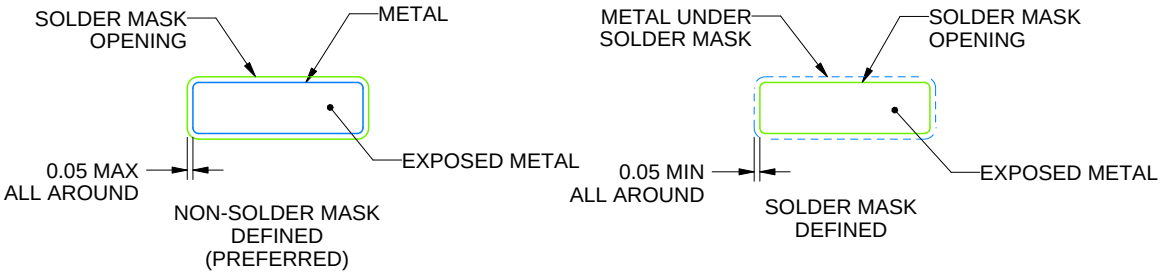

PowerPAD is a trademark of Texas Instruments.

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. No JEDEC registration as of September 2020.
5. Features may differ or may not be present.




LAND PATTERN EXAMPLE
SCALE: 16X

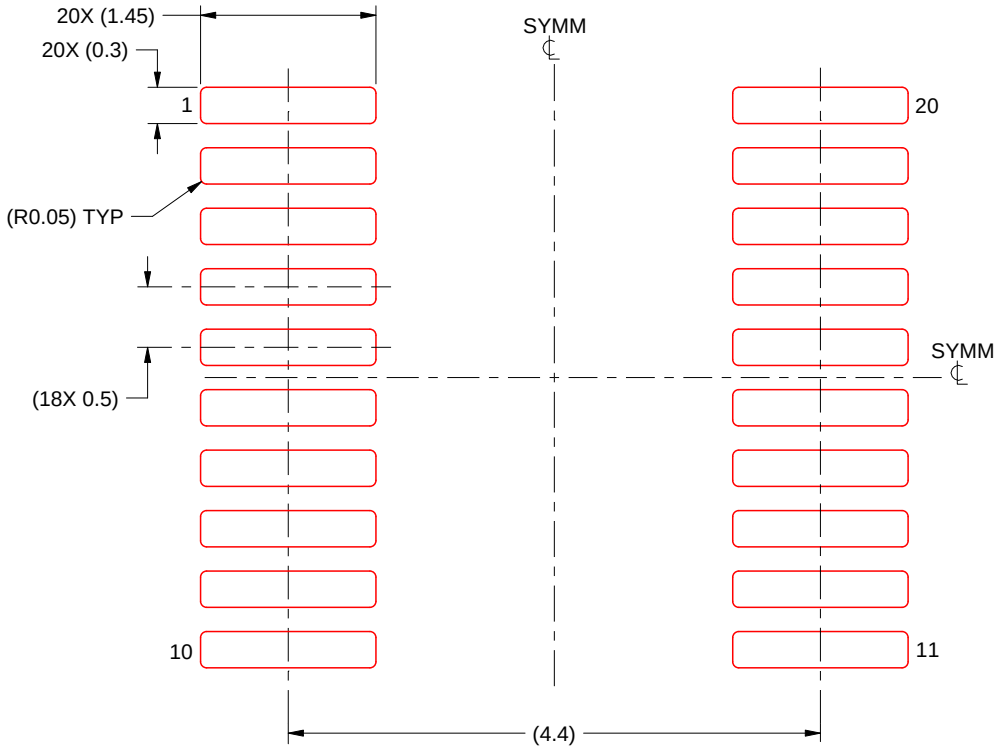



SOLDER MASK DETAILS

4226367/A 10/2020

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.
10. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 16X

4226367/A 10/2020

NOTES: (continued)

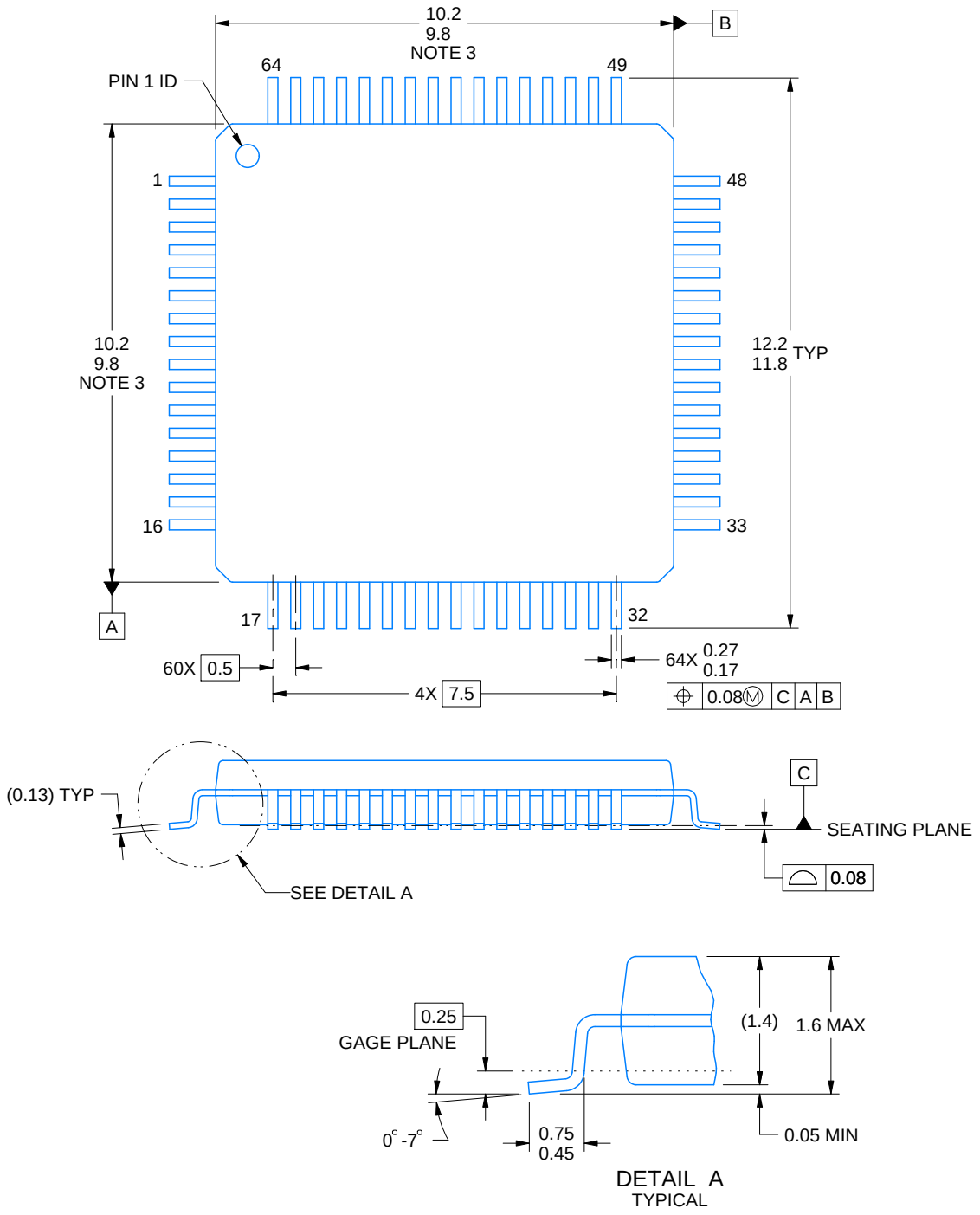
11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

# PACKAGE OUTLINE

## PM0064A

## LQFP - 1.6 mm max height

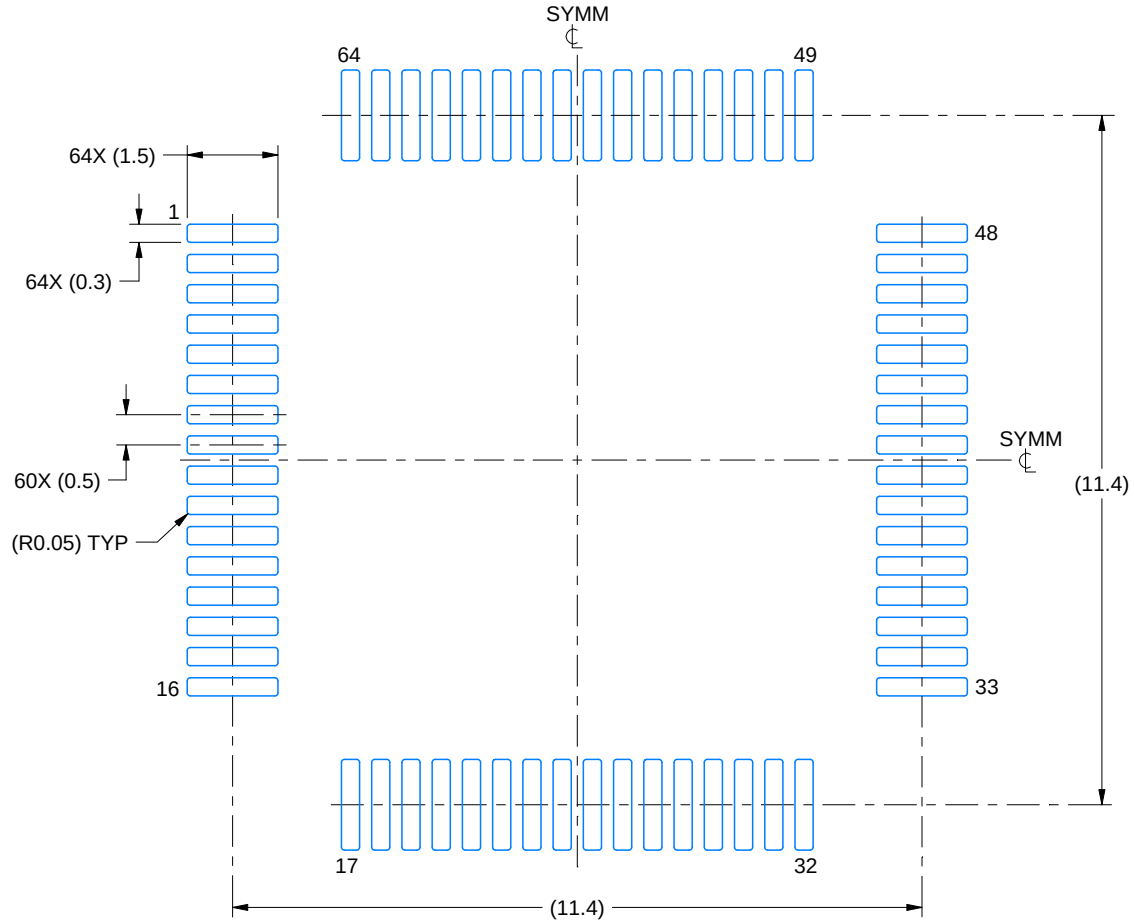
PLASTIC QUAD FLATPACK



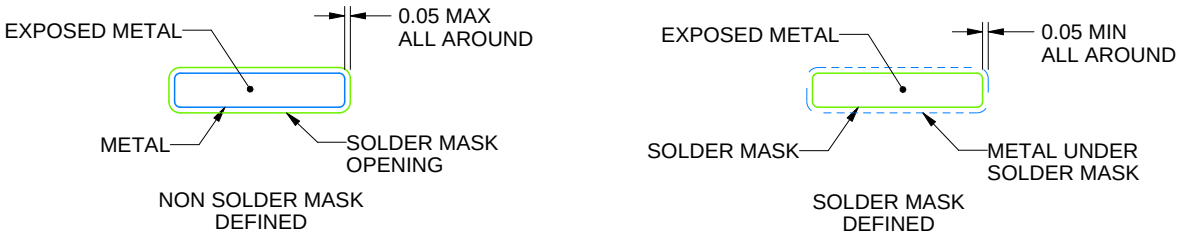

4215162/A 03/2017

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MS-026.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X

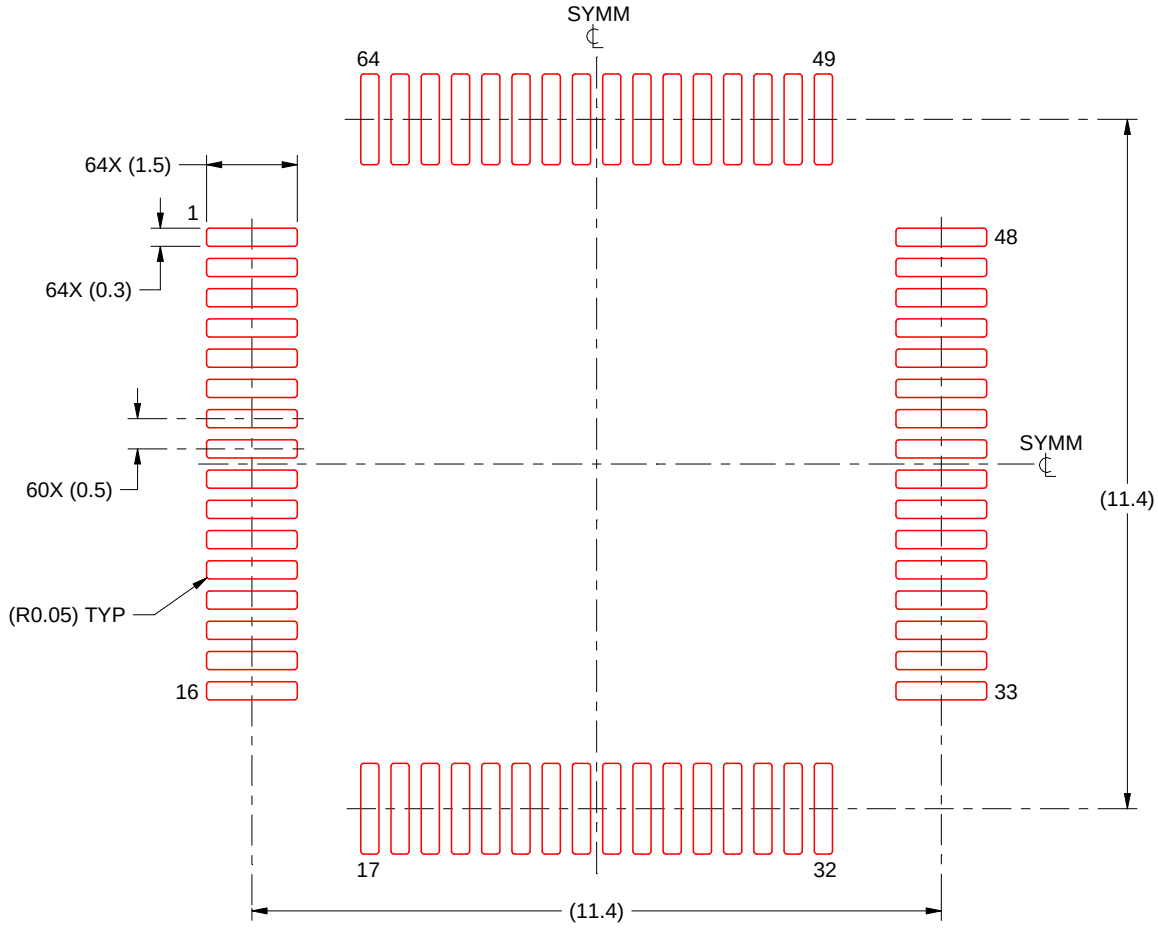



SOLDER MASK DETAILS

4215162/A 03/2017

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
7. For more information, see Texas Instruments literature number SLMA004 (www.ti.com/lit/slma004).




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:8X

4215162/A 03/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

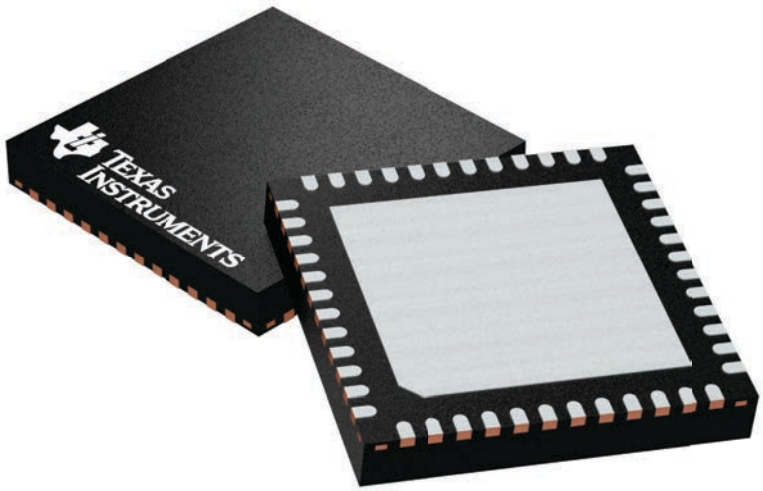
# GENERIC PACKAGE VIEW

## RGZ 48

## VQFN - 1 mm max height

**7 x 7, 0.5 mm pitch**

PLASTIC QUADFLAT PACK- NO LEAD




Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

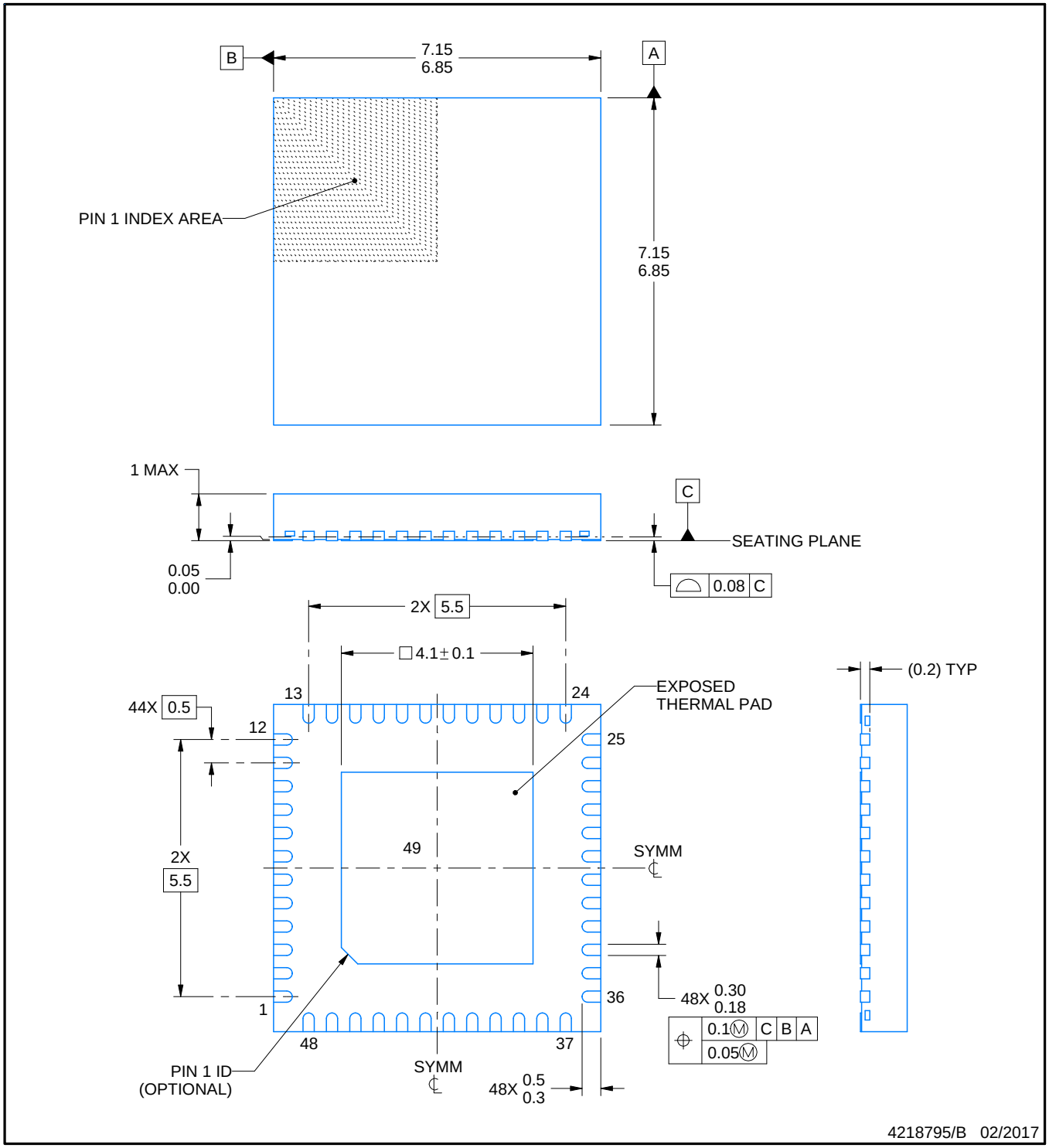
4224671/A

# RGZ0048B

# PACKAGE OUTLINE

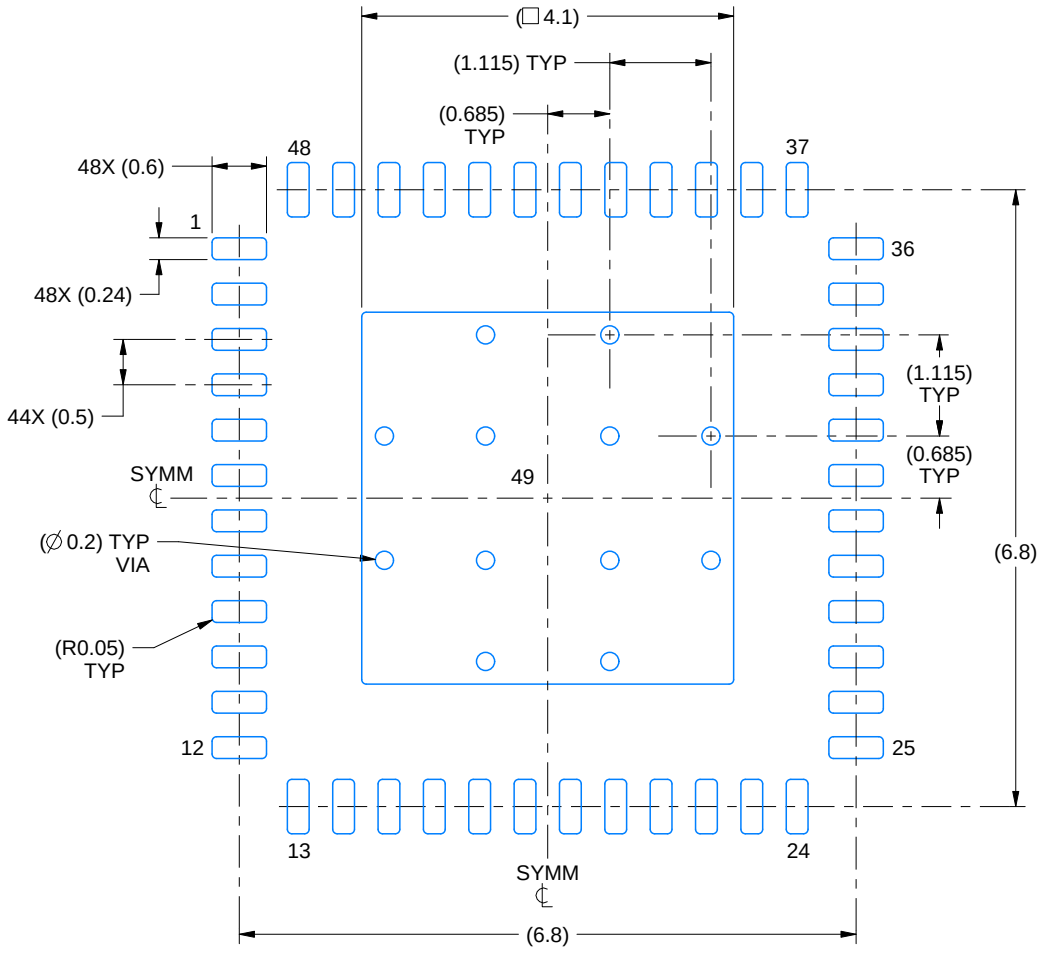
## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

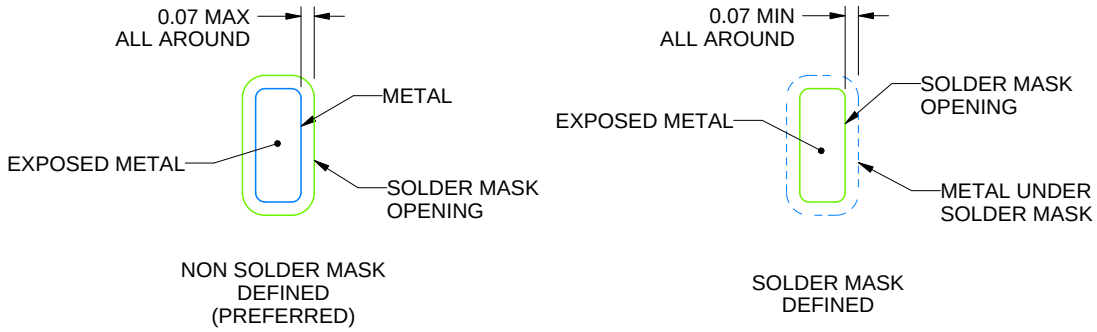



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:12X

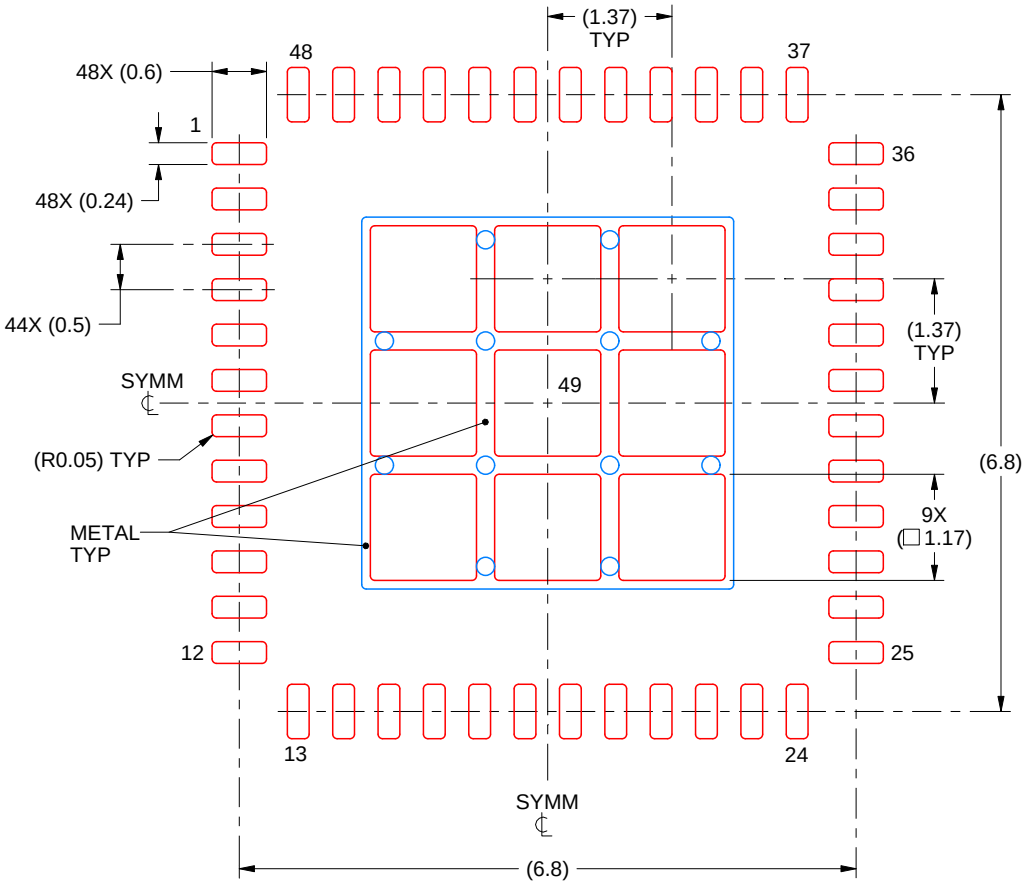



SOLDER MASK DETAILS

4218795/B 02/2017

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 49
73% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:12X

4218795/B 02/2017

NOTES: (continued)

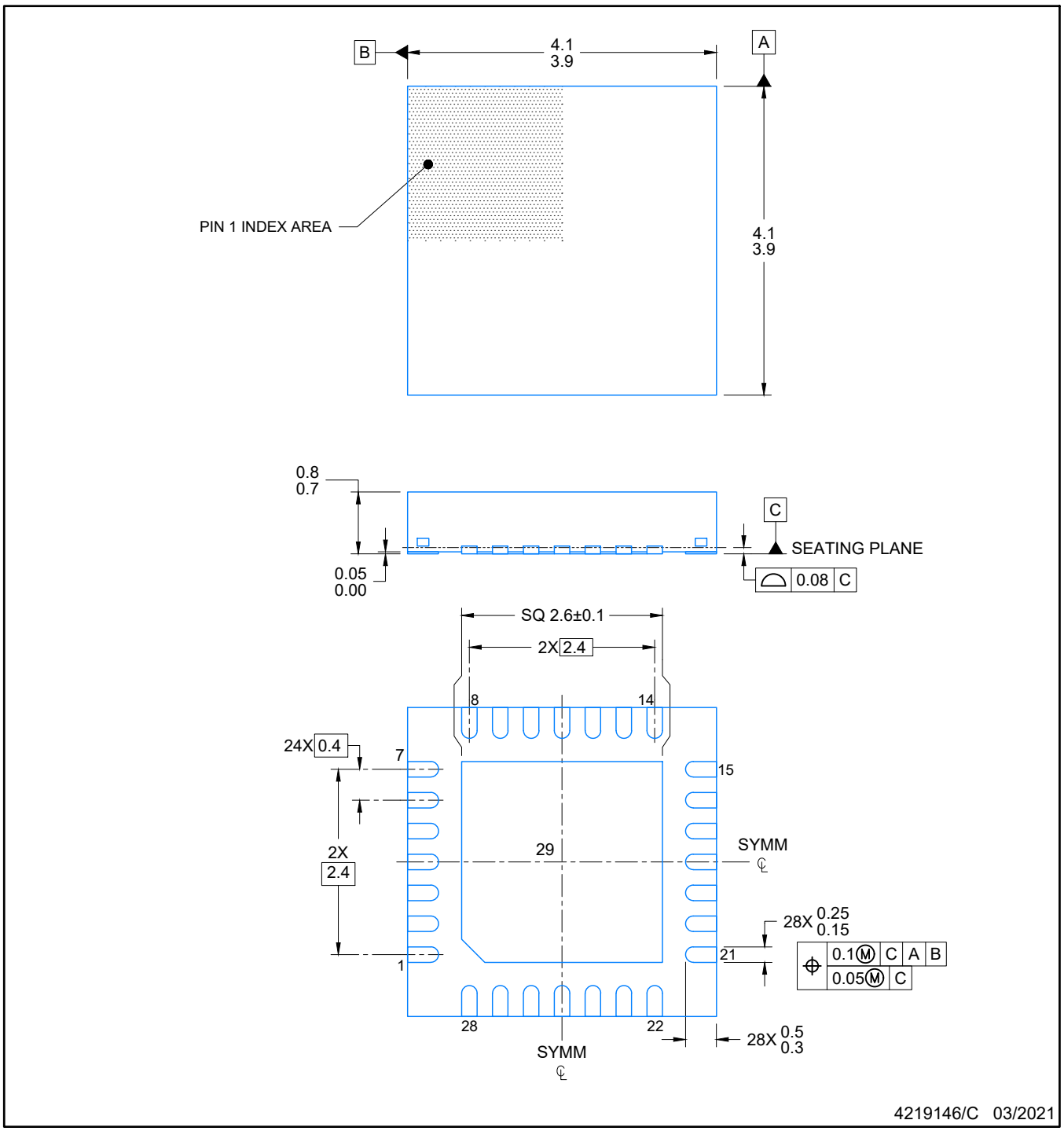
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

# PACKAGE OUTLINE

## RUY0028A

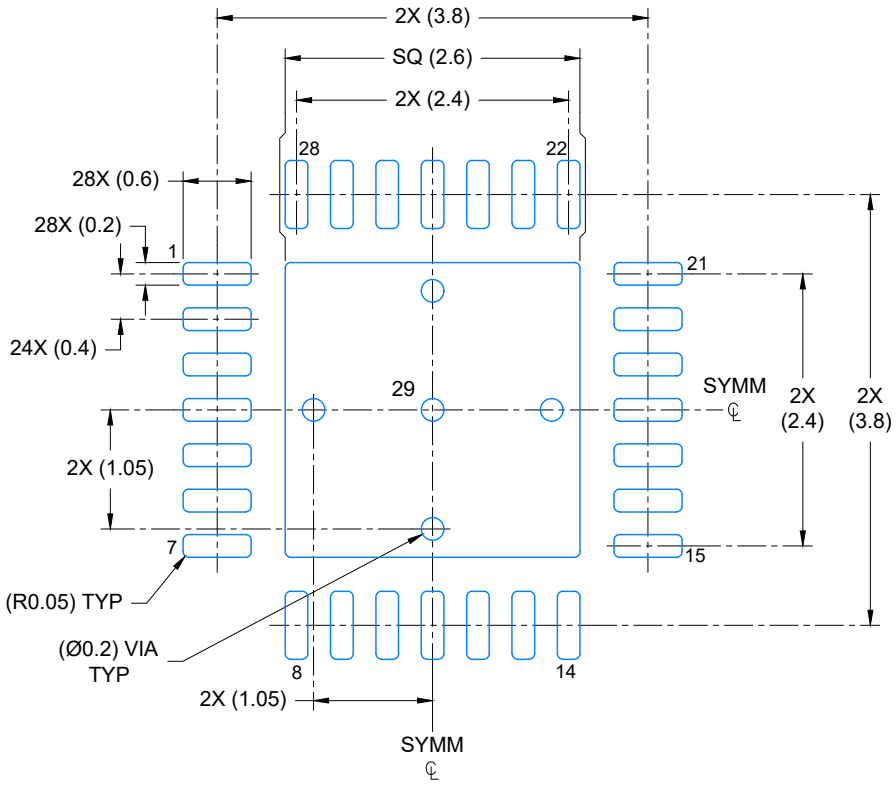
## WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK-NO LEAD

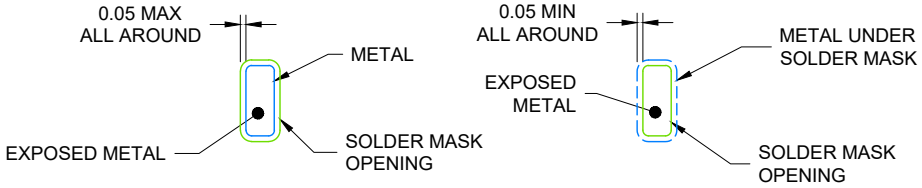



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X




NON SOLDER MASK DEFINED (PREFERRED)

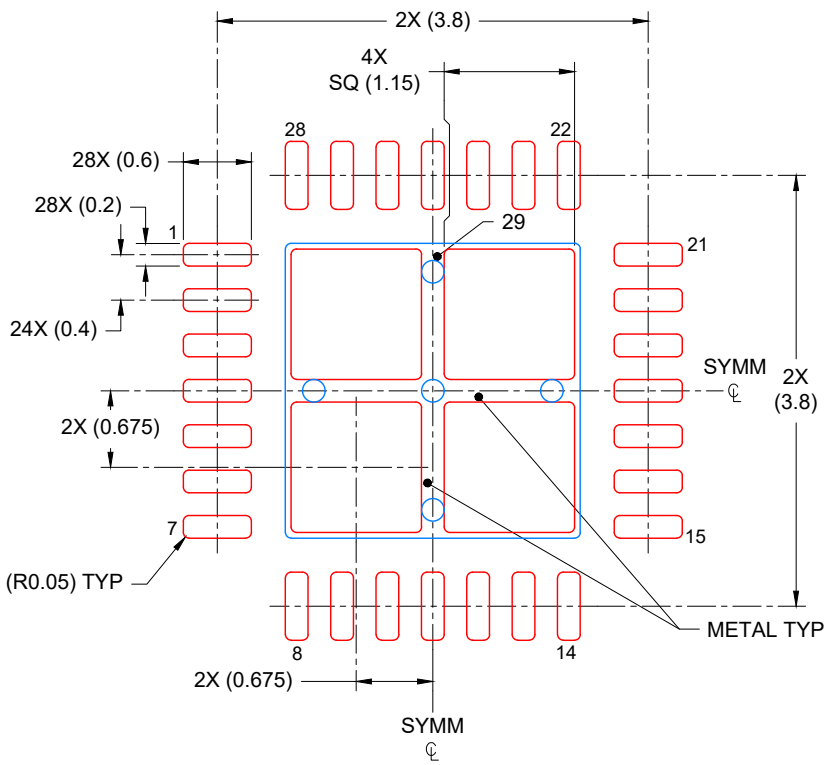
SOLDER MASK DEFINED

SOLDER MASK DETAILS

4219146/C 03/2021

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.




SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
78% PRINTED COVERAGE BY AREA
SCALE: 15X

4219146/C 03/2021

NOTES: (continued)

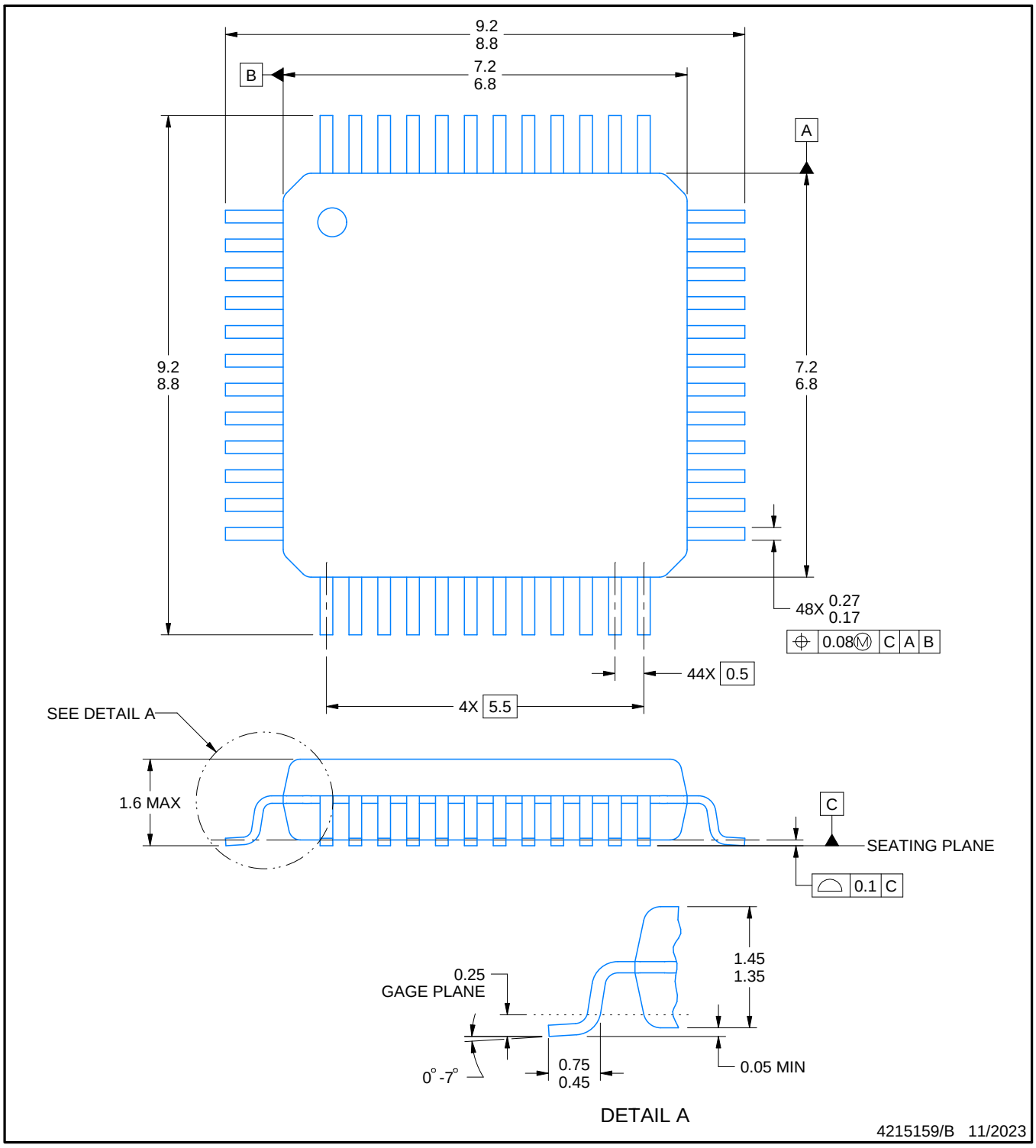
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

# PACKAGE OUTLINE

## PT0048A

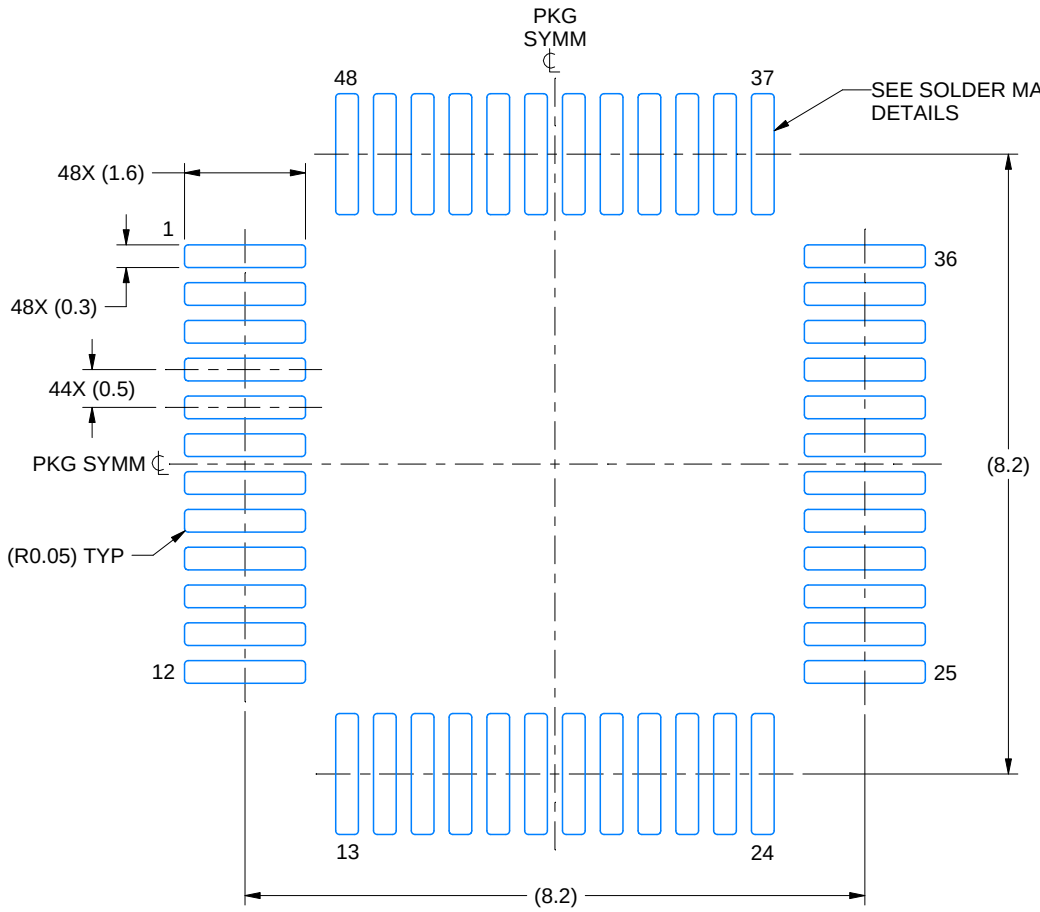
## LQFP - 1.6 mm max height

LOW PROFILE QUAD FLATPACK

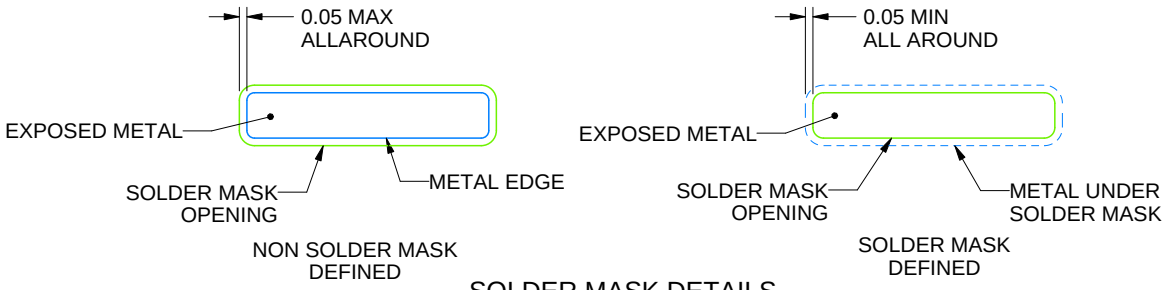



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration MS-026.
4. This may also be a thermally enhanced plastic package with leads conected to the die pads.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE 10.000

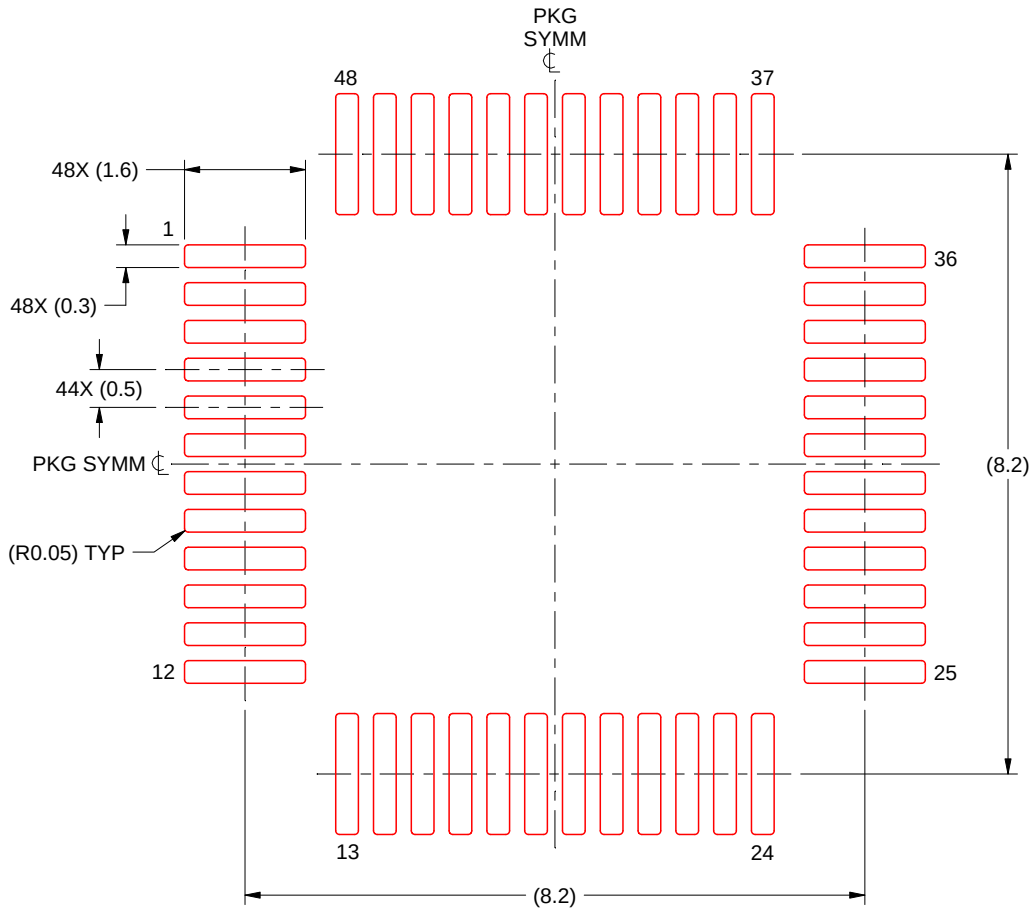



SOLDER MASK DETAILS

4215159/B 11/2023

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 10X

4215159/B 11/2023

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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