Design Guide: TIDEP-01020

Automotive Domain Controller for Gateway, Assisted and Automated Driving Systems Reference Design

Description

Decentralized vehicle architectures on the road today use individual ECUs that lack processing power and high-speed interfaces to handle the complex tasks and data movement needs of newly emerging automotive architectures. Higher level functions require the correct combination of DMIPS, data bandwidth and power efficiency. The DRA829V and TDA4VM processors in our Jacinto™ 7 processor family provide necessary performance, power, and automotive interfaces needed for these architectures.

This automotive reference design can enable domain-based architectures while showcasing the performance capabilities of DRA829V and TDA4VM SoCs. This 8-layer PCB design is optimized to reduce cost and time-to-market, making it a great way to evaluate Jacinto 7 processors with a fully functional domain controller board while enabling automotive connectivity interfaces including Ethernet, CAN-FD, and PCIe. Note: This DRA829/TDA4VM SoCs 8-layer reference design is tailored toward customers focused on cost, power, and size optimization rather than full entitlement of features; the design focuses only on a subset of the capabilities of the DRA829/TDA4VM SoCs. For superset features, please refer to the DRA829V Jacinto Automotive Processors, Silicon Revision 1.0 data sheet. For engineers who want to unlock more capabilities of the DRA829V or TDA4VM processors, please note that we also have a 10-layer PCB design for that purpose.

Features

- DRA829 and TDA4 SoCs as domain controller
- Optimized design on 8-layer PCB
- Auto Connectivity (Ethernet, PCIe, CAN-FD)
- Multiple camera input for rear-view, driver monitoring or surround view
- Multiple high resolution display output
- Multi-zone audio input and output
- Dual-tuner for DAB/HD/AM/FM radio and diversity
- Connectivity (BT, WiFi, GPS, GNSS)

Applications

- Advanced Driver Assistance Systems (ADAS)
- Automotive Infotainment and Cluster
- Automotive Gateway
- ADAS Domain Controller

Resources

TIDEP-01020 Design Folder
DRA829, TPS6594-Q1, 941AS-Q1 Product Folder
DP83TC-Q1, TCAN1043-Q1, TCAN1042-Q1 Product Folder
TAS6421-Q1, TPA6304-Q1 Product Folder

Ask our TI E2E™ support experts
1 System Description

This 8-layer reference design is based on the DRA829 and TDA4VM automotive applications processor, a highly optimized and scalable device that meets increasing compute and data bandwidth requirements of the automotive industry. The DRA829/TDA4VM Integrates an optimal mix of performance, low power, and data bandwidth to meet evolving market trends. DRA829/TDA4VM is based off a heterogeneous architecture which integrates connectivity, a variety traditional automotive (CAN-FD) and high-speed peripherals (PCIe, USB3.x, Gigabit Ethernet), safety and security (via integrated HSM). Integrated PCIe and Ethernet switches enable increased data movement with low software overhead and lower BOM.

The reference design supports multiple external high-resolution displays. The design also enables 4x camera input for rear-view camera, driver monitoring system (DMS) or surround view (SRV) applications. A dual tuner is used to support AM/FM/HD/DAB and diversity, expanding use to both European and American markets. 4 zone audio output and 4 zone audio input allows for seamless surround sound and speech recognition. With increasing use of connectivity functions and FOTA in the automotive space, the design includes a module that enables enable BT and WiFi. Telematics is also showcased in the design via GPS and GNSS capabilities.

This reference design serves as a starting point for OEMs and Tier1 to easily and quickly create a fully functional DRA829/TDA4VM solution in the automotive space. Leveraging this design can substantially decrease development costs and time to market.

1.1 Key System Specifications

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SoC</td>
<td>DRA829/TDA4VM</td>
</tr>
<tr>
<td>Power</td>
<td>12 V</td>
</tr>
<tr>
<td>Display</td>
<td>• eDP connector</td>
</tr>
<tr>
<td></td>
<td>• DSI output with FDPLink support</td>
</tr>
<tr>
<td>Backlight</td>
<td>Supported via PWM</td>
</tr>
<tr>
<td>Camera</td>
<td>4x 2Mpixel camera input for DMS/SRV</td>
</tr>
<tr>
<td>Radio</td>
<td>Dual tuner to support AM/FM/HD/DAB and diversity</td>
</tr>
<tr>
<td>Audio</td>
<td>• 4 zone audio output</td>
</tr>
<tr>
<td></td>
<td>• 4 zone audio input (2x Line In, 2x Mic)</td>
</tr>
<tr>
<td></td>
<td>• Warning Chimes</td>
</tr>
<tr>
<td>Auto Connectivity</td>
<td>• Ethernet, CAN Wakeup, CAN-FD, USBSS</td>
</tr>
<tr>
<td>Connectivity</td>
<td>• BT</td>
</tr>
<tr>
<td></td>
<td>• WiFi</td>
</tr>
<tr>
<td>Telematics</td>
<td>• GPS</td>
</tr>
<tr>
<td></td>
<td>• GNSS</td>
</tr>
<tr>
<td>Memory</td>
<td>• 8 GB of LPDDR4 at 3733 MT/s</td>
</tr>
<tr>
<td></td>
<td>• 32 GB eMMC/UFS eMMC Flash</td>
</tr>
<tr>
<td></td>
<td>• 64 MB OSPI</td>
</tr>
<tr>
<td>Wakeup</td>
<td>Via CAN, PMIC</td>
</tr>
</tbody>
</table>
2 System Overview

2.1 Block Diagram

2.2 Design Considerations

• Showcase DRA829/TDA4VM domain controller SoC features
• Demonstrate optimized system reference design
• Cost-optimized automotive Q100 parts where possible to minimize total system BOM
2.3 Power Considerations

The Power Tree Design is shown in Figure 2-2 and Figure 2-3.
2.4 Highlighted Products

2.4.1 Processor

The reference design is based on the DRA829/TDA4VM SoC. The DRA829/TDA4VM is a heterogeneous automotive processor with dual ARM Cortex-A72 cores and six ARM R5Fs to support a variety of processing and real-time applications. The SoC also has integrated 4-port PCIe and 8-port Ethernet switch allowing for high data bandwidth communication in gateway applications.

2.4.2 Power Supply

The reference design is based off of a 12V input and uses dual TPS6594x-Q1 in the power topology. The TPS6594x-Q1 is a PMIC that integrates optimized power management, ASIL-D features, and wakeup functionality into a chip.

2.4.3 Display

This reference design supports multiple high resolution display outputs based on DSI and eDP interfaces. eDP interface can drive multiple displays in a daisy-chain using Multi Stream Transport (MST).

2.4.4 FPDLink Serializer

The reference design uses the DS90UB941AS-Q1 to serialize DSI output from the DRA829/TDA4VM automotive processor to FPD-Link III format. This enables serial transmission over long distances and signal is deserialized on receiving end.

2.4.5 Input/Cameras

The reference design uses the DS90UB960-Q1 hub to receive serialized sensor data from up to four independent video streams and is aggregated into the CSI-2 input of DRA829/TDA4VM processor. The DS90UB960-Q1 receives data from sensors such cameras supporting full HD 1080p/2MP resolution at 60-Hz frame rates.

2.4.6 Ethernet

The Ethernet interface is supported on this reference design to enable transfer of data content from other subsystems. A DP83TC811R-Q1 Ethernet Phy is used to interface with the DRA829/TDA4VM automotive processor where content sent over the Ethernet interface is processed.
2.4.7 CAN

This reference design supports the CAN interface using a TCAN1043 and TCAN1042. The TCAN1043 transceiver supports CAN-FD functionality and meets the requirements of the ISO 11898-2. The device has wakeup pin support enabling DRA829/TDA4VM wakeup without need for an external MCU. CAN wakeup integration details as follows:

- Mode 1: OFF
- Mode 2: Wakeup
  - CAN module is in standby mode. Signal can wake up CAN which in turns on PMIC and rest of the board.
- Mode 3: ON
  - CCARD is ON and fully functional


2.4.8 Class-D Amplifier

This reference design supports 4-zone audio output with the TPA6304-Q1 four-channel Class-D Burr-Brown audio amplifier. This reference design supports single zone audio output for warning chimes with a TAS6421 Class-D amplifier. Both devices implement a 2.1 MHz PWM switching frequency that enables a cost optimized solution in a very small PCB footprint while offering exceptional sound quality with up to 40 kHz audio bandwidth.

2.4.9 Other Products

2.4.9.1 Radio Tuner

The reference design uses the Si47972 Dual tuner to support AM/FM/, HRC MRC, DAB, phase diversity and weatherband++. AM/FM & phase diversity + HD MRC functionality is targeted for North America and AM/FM & phase diversity + DAB functionality is targeted for Europe.

2.4.9.2 Bluetooth/WiFi

The reference design uses the SX-PCEAC2 module for dual band 802.11 a/b/g/n/ac and Bluetooth support. The module supports high performance up to throughputs of 867 Mbps and connects to the DRA829/TDA4VM processor via a mini-PCIE form factor.

2.4.9.3 GPS/GNSS

The reference design uses the U-Blox GPS Neo M8U/M8L MX8030 chipset for GPS and GNSS functionality.

2.4.9.4 Memory

The reference design uses two 4GB MT53D1024M32D4DT memory banks for a total of 8 GB of onboard LPDDR4 memory running at 3733 MT/s. For on-board NAND flash, the design uses the MTFC32GAPALNA which is 32 GB of NAND flash connected to DRA829/TDA4VM's eMMC interface. To support fast booting over OSPI, the board uses the MT35XU512ABA1G12 for 64 MB of NOR Flash.
3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware and Software

This reference design is a hardware-only design and end-users will need to develop their own software tailored to their system. Resources are provided below on basic hardware setup and software references.

3.1.1 Hardware

The board requires a 12V DC power supply to power up. To fully utilize all hardware interfaces on the reference design, it is recommended that following external parts should be connected:

3.1.2 Software

There is no official software development kit (SDK) available for this design. SDK for DRA829/TDA4VM EVM is available at https://www.ti.com/tool/PROCESSOR-SDK-DRA8X-TDA4X and can be used as starting point to port this hardware if desired.
3.2 Testing and Results

3.2.1 Test Setup
Diagnostic tests were run on the board after power up (12 V DC power brick) with no external components attached (no displays, speakers, or cameras)

3.2.2 Test Results
The following tests were run on board.

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Validated. Powers up drawing about 250mA@12V and runs up to 1.2A@12V when tests are running.</td>
</tr>
<tr>
<td>CCS connect</td>
<td>Validated</td>
</tr>
<tr>
<td>Boot Mode Settings</td>
<td>Validated</td>
</tr>
<tr>
<td>UART Consoles</td>
<td>Validated</td>
</tr>
<tr>
<td>DDR</td>
<td>LPDDR4 at 3733 MT/s validated</td>
</tr>
<tr>
<td>eMMC</td>
<td>Validated</td>
</tr>
<tr>
<td>OSPI</td>
<td>Validated</td>
</tr>
<tr>
<td>SDCARD</td>
<td>Validated</td>
</tr>
<tr>
<td>I2C</td>
<td>Validated with PMIC, ID-EEPROM, UB941, TAS6304, TAS2505</td>
</tr>
<tr>
<td>GPIO</td>
<td>Validated</td>
</tr>
<tr>
<td>LEDs</td>
<td>Validated</td>
</tr>
</tbody>
</table>
4 Design Files

4.1 Schematics
To download the schematics, see the design files at TIDEP-01020.
For the 10-layer board, please see the following TIDEP-01020.

4.2 Bill of Materials
To download the bill of materials (BOM), see the design files at TIDEP-01020.
For the 10-layer board, please see the following TIDEP-01020.

4.3 PCB Layout Recommendations
To download the layer plots, see the design files at TIDEP-01020.
For the 10-layer board, please see the following TIDEP-01020.

4.4 Gerber Files
To download the Gerber files, see the design files at TIDEP-01020.
For the 10-layer board, please see the following TIDEP-01020.

4.5 Assembly Drawings
To download the assembly drawings, see the design files at TIDEP-01020.
For the 10-layer board, please see the following TIDEP-01020.

5 Related Documentation
2. Texas Instruments, *DRA829 Applications Processor Data Sheet*
3. Texas Instruments, *DRA829Vx Evaluation Module*
4. Texas Instruments, *Software Development Kit for DRA8x and TDA4x Jacinto Automotive Processors*

5.1 Trademarks
Jacinto™ is a trademark of TI.
TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.
**Revision History**

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

<table>
<thead>
<tr>
<th>Changes from Revision * (June 2020) to Revision A (October 2020)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Updated Description...........................................................................................................................................</td>
<td>1</td>
</tr>
</tbody>
</table>
IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2020, Texas Instruments Incorporated