# TI Designs: TIDEP-01002 Cost-Optimized Digital Cluster Automotive Reference Design (DCARD) with Jacinto™ Automotive Processors

# Texas Instruments

#### Description

The Jacinto<sup>™</sup> DRA71x-based digital cluster automotive reference design (DCARD) is a costoptimized design for reconfigurable digital cluster systems. DCARD is a complete and self-contained 6-layer PCB design to enable 60 fps digital cluster solutions on 1920 × 720 resolution displays while optimizing overall system bill of materials (BOM). This design targets applications such as reconfigurable digital cluster, hybrid clusters with active graphics, heads-up display, and driver identification and monitoring.

#### Resources

TIDEP-01002	Design Folder
DRA71x Infotainment Applications Processor	Product Folder
DS90C189-Q1	Product Folder
TAS2505	Product Folder
TCAN1043-Q1	Product Folder
DP83TC811R-Q1	Product Folder



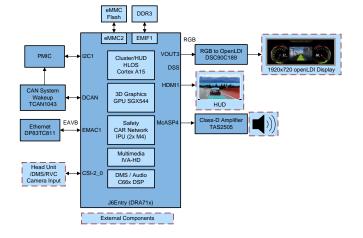
ASK Our E2E™ Experts

#### Features

- Jacinto<sup>™</sup> DRA71x Automotive Processor to Render and Drive 60 fps Cluster Graphics on a 1920 × 720 Resolution Cluster Display
- Optimized Texas Instruments<sup>™</sup> Power Management Solution Including LM87523 and LM5141
- OpenLDI Cluster Display Support With DSC90C189 Serializer
- Single Zone Audio Output With TAS2505 Class-D Amplifier
- Wake-up From CAN With TCAN1043 CAN Transceiver
- Ethernet Enabled With DP83TC811 Phy
- CSI-2 Camera Input for Rear-view or Driver Monitoring Camera Integration
- Secondary Display Output Through HDMI Interface for HUD Integration
- 6-layer PCB Design to Minimize System BOM

#### Applications

- Reconfigurable Digital Cluster
- Hybrid Cluster With Active Graphics
- Heads-up Display
- Driver Monitoring and Identification







An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

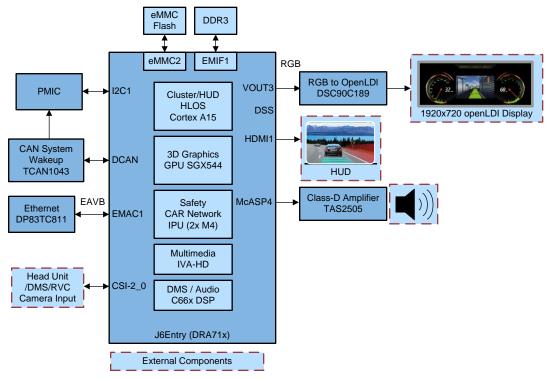


#### 1 System Description

The Jacinto<sup>™</sup> DRA71x-based digital cluster automotive reference design (DCARD) is a cost-optimized design for reconfigurable digital cluster systems. DCARD is a complete and self-contained 6-layer PCB design to enable 60 fps digital cluster solutions on 1920 × 720 resolution displays while optimizing overall system BOM. DCARD also supports single zone audio output for warning chimes, wake-up from CAN, and Ethernet connectivity. Additional functionality can be added based on end-product requirements. For example, camera input is available to integrate rear-view camera or driver monitoring and second display output can be used to drive heads-up-display (HUD). System power management is optimized to minimize overall system BOM for reconfigurable digital cluster use-case. This design targets applications such as reconfigurable digital cluster, hybrid clusters with active graphics, heads-up display, and driver identification and monitoring.

#### 2 System Overview

#### 2.1 Block Diagram





## 2.2 Design Considerations

2

#### 2.2.1 DRA71x Automotive Processor

This reference design uses the DRA71x automotive processor to render 3D cluster graphics at 60 fps and to drive the  $1920 \times 720$  digital cluster display. It handles all the peripheral inputs and to deliver the outputs to the respected ports. The DRA71x automotive processor also integrates C66x DSP that can be used to integrate driver monitoring and identification functionality. The device features a simplified power supply rail mapping, which enables lower cost PMIC solutions.



System Overview

#### 2.2.2 Power Architecture

This reference design has optimized power architecture. The input to the design can be a 12-V power source similar to a car battery. Details of power stages are illustrated in the following figures.

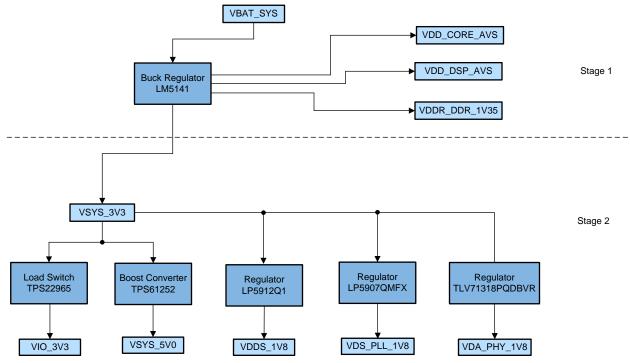


Figure 2. Stage1 and Stage 2 Power Infrastructure Block Diagram

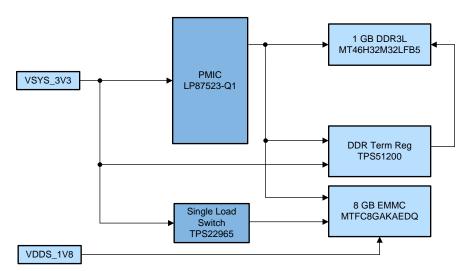


Figure 3. Memory Power Block Diagram



4

www.ti.com

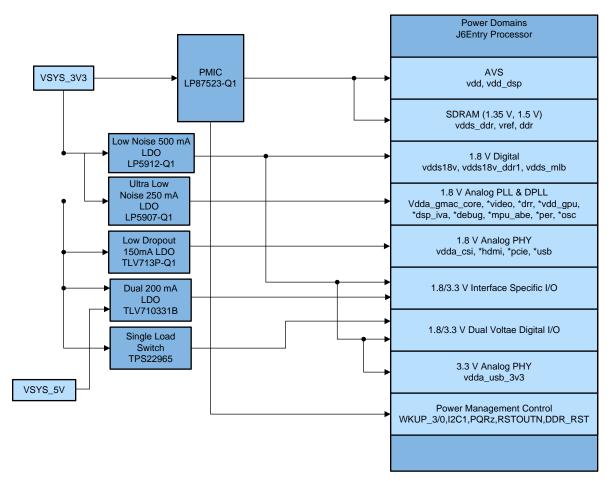


Figure 4. Processor Power Block Diagram

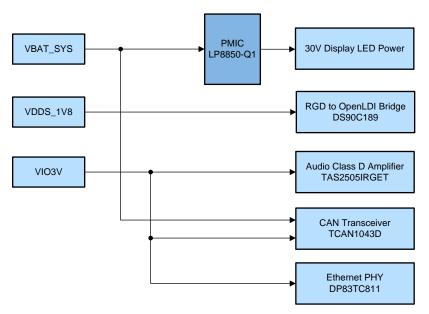


Figure 5. Active Power Block Diagram



#### 2.2.3 Display

This reference design supports dual display output: cluster display and HUD display. Cluster display is a 1920  $\times$  720 OpenLDI LCD display, and the DRA71x automotive processor renders 60 fps cluster graphics. An optional HUD output is available through an HDMI interface.

#### 2.2.4 Class-D Audio Amplifier

This reference design supports single zone audio output for warning chimes with a TAS2005 Class-D amplifier. The TAS2505 device is a low-power digital input speaker amp with support for 24-bit digital I2S data mono playback. The outputs are placed on the design to connect speakers.

#### 2.2.5 OpenLDI Serializer

This reference design uses a DSC90C189 serializer to convert RGB output from the DRA71x automotive processor to dual OpenLDI output to drive the cluster display at 1920 × 720 resolution. The DS90C189-Q1 is a low-power bridge for automotive applications that reduces the size of the RGB interface between the host application processor and the display.

#### 2.2.6 CAN

This reference design supports CAN interface using a TCAN1043. This reference design also enables wake-up from CAN and Wake Input using a TCAN1043 Transceiver.

#### 2.2.7 Ethernet

Ethernet interface is supported on this reference design to enable content from other subsystems such as navigation content from a head-unit to be displayed on the cluster display. A DP83TC811R-Q1 Ethernet Phy is used to interface with the DRA71x automotive processor where content sent over the Ethernet interface is processed.

#### 3 Highlighted Products

This reference design features the following TI<sup>™</sup> devices. Refer to the corresponding data sheets for additional information.

- DRA71x Infotainment Applications Processor
- DS90C189-Q1
- TAS2505
- TCAN1043-Q1
- DP83TC811R-Q1

#### 3.1 DRA71x Infotainment Applications Processor

The DRA71x architecture is designed to deliver high-performance concurrences for automotive applications in a cost-effective solution, which provides full scalability from the Jacinto<sup>™</sup> DRA7x family of infotainment processors including graphics, voice, HDMI, multimedia, and smartphone projection mode capabilities.

Programmability is provided by a single-core Arm<sup>®</sup> Cortex<sup>®</sup>-A15 RISC CPU with Neon extensions and a TI<sup>™</sup> C66x VLIW floating-point DSP core. The Arm<sup>®</sup> processor allows developers to keep control functions separate from other algorithms programmed on the DSP and coprocessors, which reduces the complexity of the system software.

- Video, image, and graphics processing support:
  - Full-HD video (1920p × 1080p, 60 fps)
  - Multiple video input and video output 2D and 3D graphics
- Arm<sup>®</sup> Cortex<sup>®</sup>-A15 microprocessor subsystem
- C66x floating-point VLIW DSP
- DDR3/DDR3L memory interface (EMIF) module



Highlighted Products

#### 3.2 DS90C189-Q1 Dual Pixel FPD-Link (LVDS) Serializer

The DS90C189-Q1 is a low-power bridge for automotive applications that reduces the size of the RGB interface between the host GPU and the Display.

- AEC-Q100 Qualified for Automotive Applications
- 150 mW Typical Power Consumption at 185 MHz (SIDO mode)
- Drives QXGA and WQXGA Class Displays
- Two Operating Modes:
  - Single Pixel In, Single Pixel Out (SISO): 105 MHz Maximum
  - Single Pixel In, Dual Pixel Out (SIDO): 185 MHz Maximum
- Supports 24-Bit RGB
- 64-Pin VQFN Package (small 9 mm × 9 mm × 0.9 mm)

#### 3.3 TAS2505 Class-D Amplifier

The TAS2505 device is a low-power digital input speaker amp with support for 24-bit digital I2S data mono playback.

- Digital Input Mono Speaker Amp
- Supports 8-kHz to 96-kHz Sample Rates
- Mono Class-D BTL Speaker Driver (2 W into 4  $\Omega$  or 1.7 W into 8  $\Omega$ )
- Mono Headphone Driver
- Two Single-Ended Inputs With Output Mixing and Level Control
- Embedded Power-On-Reset
- Integrated LDO
- Programmable Digital Audio Processing Blocks for Bass Boost, Treble, EQ With up to Six Biquads for Playback
- 24-Pin VQFN Package (4 mm × 4 mm)

## 3.4 TCAN1043-Q1 CAN Transceiver with CAN FD and Wake Input

The TCAN1043xx-Q1 meets the physical layer requirements of the ISO 11898–2 (2016) High-Speed Controller Area Network (CAN) specification providing an interface between the CAN bus and the CAN protocol controller. These devices support both classical CAN and CAN FD up to 2 megabits per second (Mbps).

- AEC Q100: Qualified for Automotive Applications
- Meets the Requirements of the ISO 11898-2 (2016)
  - Three Operating Modes:
  - Normal Mode
  - Standby Mode with INH Output and Local and Remote Wake up Request
  - Low-Power Sleep Mode with INH Output and Local and Remote Wake up Request

## 3.5 DP83TC811-Q1 Automotive Ethernet PHY

The DP83TC811-Q1 is a single-port automotive Ethernet PHY compliant to IEEE802.3bw. The device provides all physical layer functions required to transmit and receive data over single twisted-pair cables. Additionally, the DP83TC811-Q1 provides flexibility to connect to a MAC through a standard MII, RMII, RGMII, and SGMII.

- Qualified for automotive applications
- Low active power: 3.3 V VDDA/VDDIO
- Configurable I/O voltages: 3.3 V, 2.5 V, and 1.8 V
- Power saving features



## 4 Hardware, Software, Testing Requirements, and Test Results

#### 4.1 Hardware

Front and back views of DCARD hardware are shown in Figure 6 and Figure 7.

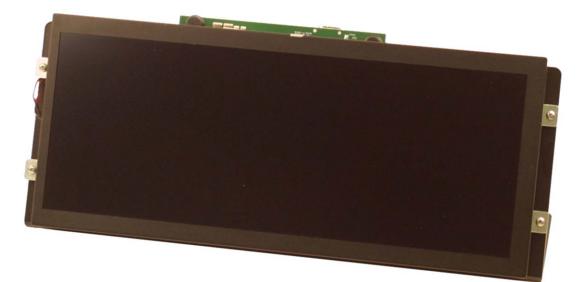


Figure 6. DCARD Front View



#### Figure 7. DCARD Back View

#### 4.1.1 Interfaces

Figure 8 shows and Table 1 describes the DCARD interfaces.



Figure 8. DCARD Interfaces

#### Table 1. DCARD Interfaces

Legend	Description
1	USB-UART Terminal Console, J7
2	HDMI Connector
3	Cluster Display output
4	Power Cable (12 V, 5A)
5	LED Indicating Power Supply is Stable
6	JTAG Connector
7	Boot Switch, SW1
8	Wake/Power Mode Switch, SW2
9	Connector for Can and Audio output

#### 4.1.2 Power

A variable power supply or 12-V power adaptor must be used to power the reference design.



#### 4.1.3 Wakeup/Power – DCAN

DCARD supports various power-up options selected with switch SW2 (see Figure 8).

- Bypass mode:
  - CAN wake-up is bypassed and DCARD is powered with 12V supply
- CAN Wake Up mode:
  - CAN wakeup through CAN transceiver is activated and power to DCARD is controlled through CAN transceiver
  - In this mode, DCARD will power-up for first time when 12V is applied. However, application
    processor is expected to put DCAN transceiver in the standby mode, which in turn will power off
    DCARD. After that, wake-up activity will be controlled by CAN bus. When there is an activity on
    CAN bus, CAN transceiver wakes up the system and powers DCARD.

#### 4.1.4 Display

- CDTech 12.3 inch, 1920 × 720 screen mounted to PCB Board
- HDMI to support HUD integration

#### 4.1.5 Memory and Flash

- 2 GB of DDR3 (MT46H32M32LFB5-5)
- eMMC Flash, 8 GB v5.1 compliance, HS-400 (MTFC8GAKAEDQ-AIT)

#### 4.1.6 Debug

- JTAG Support
- UART-over-USB for terminal access. USB to serial FTDI chip.

#### 4.1.7 Boot Mode Settings

Boot mode on DCARD is set using the boot switch (SW1) as shown in Figure 9. See Figure 8 for location.

- For SD boot, set SW1 to 0x110111
- For eMMC boot, set SW1 to 0x111111



Figure 9. Boot Mode Switch SW1 Settings

#### 4.2 Software

Please contact Texas Instruments<sup>™</sup> to see the latest cluster software demo package run on DCARD.

#### 4.3 Testing and Results

Successful load of cluster demonstration software on the DCARD setup.



Figure 10. Testing



#### 5 Design Files

#### 5.1 Schematics

To download the schematics, see the design files at TIDEP-01002.

#### 5.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDEP-01002.

#### 5.3 Layout Prints

To download the layer plots, see the design files at TIDEP-01002.

#### 5.4 Altium Project

To download the Altium Designer® project files, see the design files at TIDEP-01002.

#### 5.5 Gerber Files

To download the Gerber files, see the design files at TIDEP-01002.

#### 5.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDEP-01002.

#### 6 Related Documentation

- 1. Texas Instruments, DRA72x (SR2.0, SR1.0), DRA71x (SR2.1, SR2.0) SoC for Automotive Infotainment Technical Reference Manual
- 2. Texas Instruments, DRA71x Infotainment Applications Processor Data Sheet

#### 6.1 Trademarks

Jacinto, E2E, Texas Instruments, TI are trademarks of Texas Instruments. Altium Designer is a registered trademark of Altium LLC or its affiliated companies. Arm, Cortex are registered trademarks of Arm Limited. All other trademarks are the property of their respective owners.

#### 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 © 2019, Texas Instruments Incorporated