EVM User's Guide: xWRL1432BOOST-BSD

Low Power 77GHz mmWave Sensor

TEXAS INSTRUMENTS

Description

The AWRL1432BOOST-BSD and IWRL1432BOOST-BSD EVMs from Texas Instruments are 77GHz evaluation boards for the xWRL1432 mmWave family of sensing devices. The xWRL1432BOOST-BSD supports standalone operation as well as direct connectivity to the DCA1000EVM for raw ADC capture and signal processing development. This EVM contains everything required to start developing software for on-chip Hardware accelerator and low power ARM® Cortex® - M4F controllers.

Applications

- Low-cost vehicle Blind Spot Detection (BSD)
- Mircomobility systems (skateboards, e-scooters, hoverboard, ...)
- Low-power bicycle radar for rider safety
- Off-highway vehicle applications

Get Started

1. Visit xWRL1432BOOST-BSD EVM product page. Automotive - AWRL1432BOOST-BSD. Industrial - IWRL1432BOOST-BSD.
2. Navigate to the Radar Toolbox and install the toolbox to your PC.
3. The automotive varient user's guide is located here: *radar_toolbox\source\ti\examples\Automotive_ADAS_and_Parking\awrl1432_entry_level_blind_spot_detection\docs*

The industrial varient user's guide is located here:

radar_toolbox\source\ti\examples\Industrial_and_Personal_Electronics\Bike_Radar\docs Further explore the Radar Toolbox for more information, applications, and resources.

Features

- High RF Performance RO3003 PCB substrate
- Wide azimuthal field of view antenna, targeted for Blind Spot Detection applications
- Vehicle detection at 130+ meters
- XDS110 JTAG interface with USB connectivity for code development and debugging
- Power optimized discrete DCDC power management
- Serial port for onbaord QSPI flash programming of onboard 16Mbit QSPI Flash
- 60-pin, high-density (HD) connectors for raw analog-to-digital converter (ADC) data
- Onboard CAN-SPI, and CAN-FD transcievers
- Onboard LIN PHY transceiver for automotive variant.
- USB powered standalone mode of operation
- EVM is designed as booster pack to connect with other LaunchPad EVMs

xWRL1432BOOST-BSD EVM

1 Evaluation Module Overview

1.1 Introduction

The xWRL1432 mmWave Sensor device is an integrated single chip mmWave sensor based on FMCW radar technology. The device is capable of operation in the 76-GHz to 81-GHz band. The xWRL1432 is designed for low power, self-monitored, ultra-accurate radar systems in the automotive and industrial space of applications.

The xWRL1432BOOST-BSD is an easy-to-use 77 GHz mmWave sensor evaluation module based on the xWRL1432 device with on board High Performance Antenna using ROGERS RO3003 substrate. This EVM enables access to point-cloud data and power over USB interface. The xWRL1432BOOST-BSD supports direct connectivity to the DCA1000EVM development kit. The xWRL1432BOOST-BSD also has a 12V operated TCAN4550 for Automotive applications. This kit is supported by mmWave Radar Toolbox, demos and software including mmWave Software Development Kit (MMWAVE-L-SDK) and TI's Code Composer Studio.

Additional boards may be used to enable additional functionality. For example, DCA1000EVM enables access to sensor's raw ADC data capture. An on board XDS110 enables software development via TI's CCS.

The xWRL1432BOOST-BSD can interface with the MCU LaunchPad™ development kit ecosystem.

The AWRL1432BOOST-BSD and IWRL1432BOOST-BSD evaulation modules are not compatable with the Out-of-Box Demo (OOB Demo). Rather, they are shipped pre-flashed with Blind Spot Detection demos. These two demos use different processing chains and are not exchangable. Paths to these can be found in Getting Started Step 3.

1.2 Kit Contents

xWRL1432BOOST-BSD includes the following:

- xWRL1432BOOST-BSD Evaluation board
- Micro USB cable
- Quick Start Guide

1.3 Specification

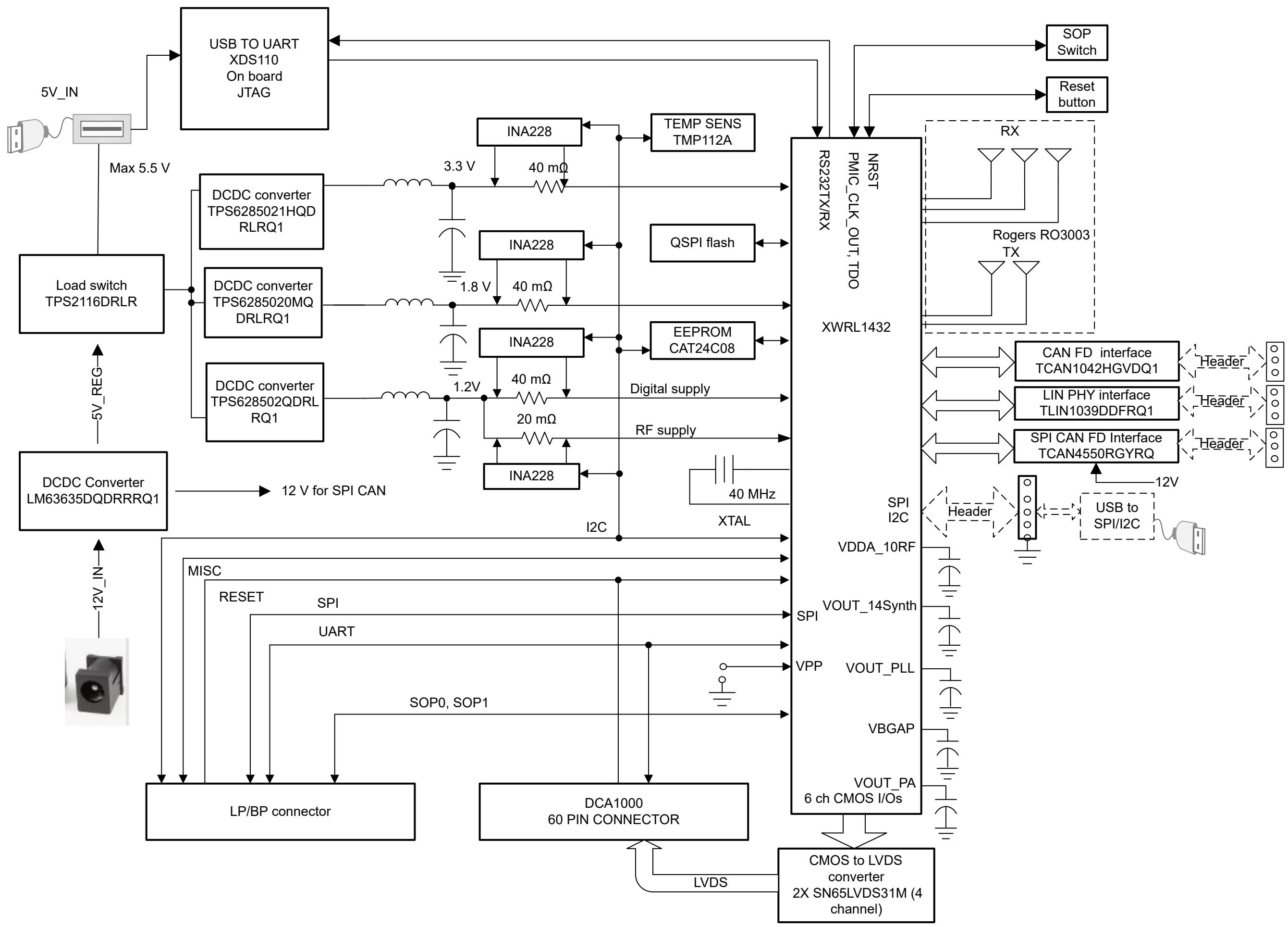

Figure 1-1. Functional Block Diagram

Figure 1-1 shows the functional block diagram. The EVM contains the essential components for the TI mm-Wave radar system: DCDC, SFLASH, SOP configuration, Filter, TI mmWave Radar chip, a USB to UART converter, and a 60-pin Samtec connector for interfacing with the DCA1000. The board also hosts a booster pack connector which can be connected to TI's LaunchPad boards.

1.4 Device Information

The documents listed in Table 1-1 provide information regarding additional Texas Instruments integrated circuits used in the assembly of the xWRL1432BOOST-BSD EVM. This user's guide is available from the TI web site under literature number SWRU619.

Table 1-1. Related Device Documentation

Devices Used on the EVM	Data Sheet
TMP112-Q1	TMP112AQDRLRQ1
TS3A5018	TS3A5018RSVR
TCAN1042HGV-Q1	TCAN1042HGVDQ1
INA228A	INA228AIDGST
TPD4E004D	TPD4E004DRYR
SN65LVDS31MD	SN65LVDS31MDREP
TS3A44159	TS3A44159PWR
TPS79601D	TPS79601DRBR
TS3A27518E	TS3A27518EPWR

Table 1-1. Related Device Documentation (continued)

Devices Used on the EVM	Data Sheet
TPS2116D	TPS2116DRLR
SN74LVC1G11D	SN74LVC1G11DSFR
TPS628502-Q1	TPS6285021HQDRLRQ1
TPS6285020-Q1	TPS6285020MQDRLRQ1
LM4040C25Q	LM4040C25QDBZR
TLIN1039-Q1	TLIN1039DDFRQ1
TCAN4550-Q1	TCAN4550RGYRQ1

2 Hardware

	**CAUTION** **Hot surface.** **Contact can cause burns** **Do not touch.**

The xWRL1432BOOST-BSD includes three receivers and two transmitters hosted on a High RF Performance RO3003 PCB substrate.

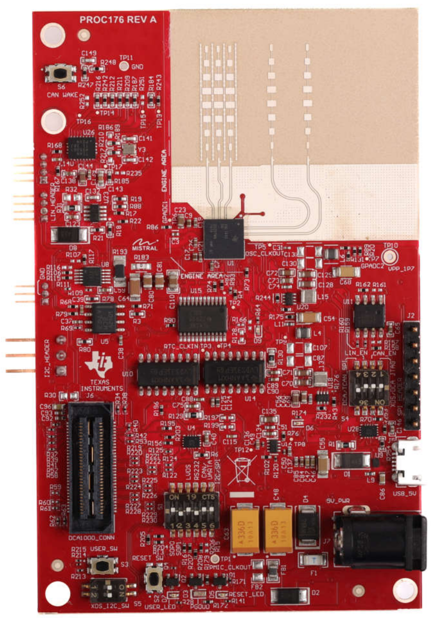

Figure 2-1. xWRL1432BOOST-BSD (Top View)

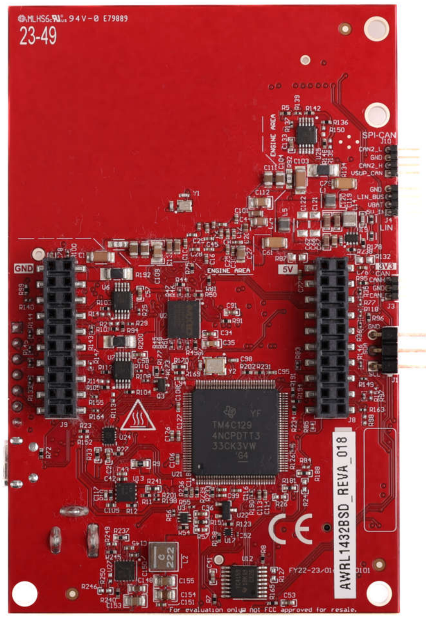

Figure 2-2. xWRL1432BOOST-BSD (Bottom View)

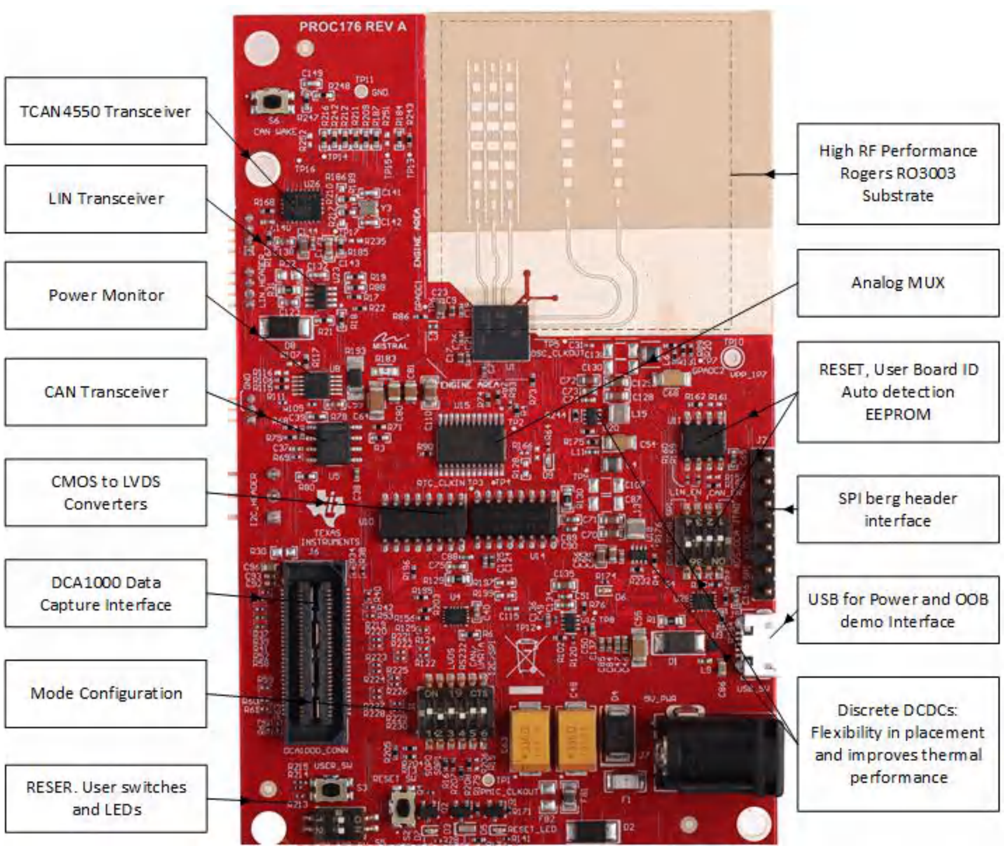

Figure 2-3. Salient Features of EVM (Top Side)

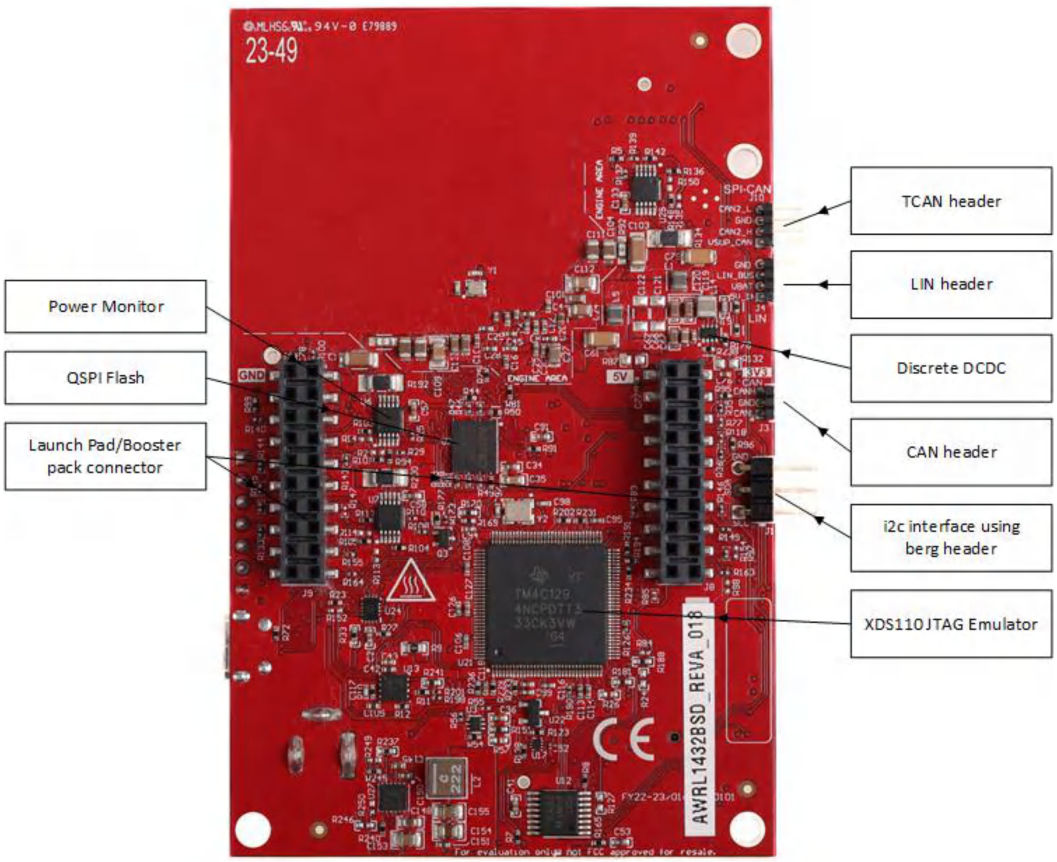

Figure 2-4. Salient Features of EVM (Bottom Side)

2.1 xWRL1432BOOST-BSD Antenna

The xWRL1432BOOST-BSD includes three receiver and two transmitter antennas. These antennas are designed as a high gain series-fed patch antenna connected to the the device using Grounded Coplanar Waveguide. To achieve best performance at high frequencies, Rogers RO3003 was selected as the dielectric substrate for the antennas. Figure 2-5 shows the antenna configuration.

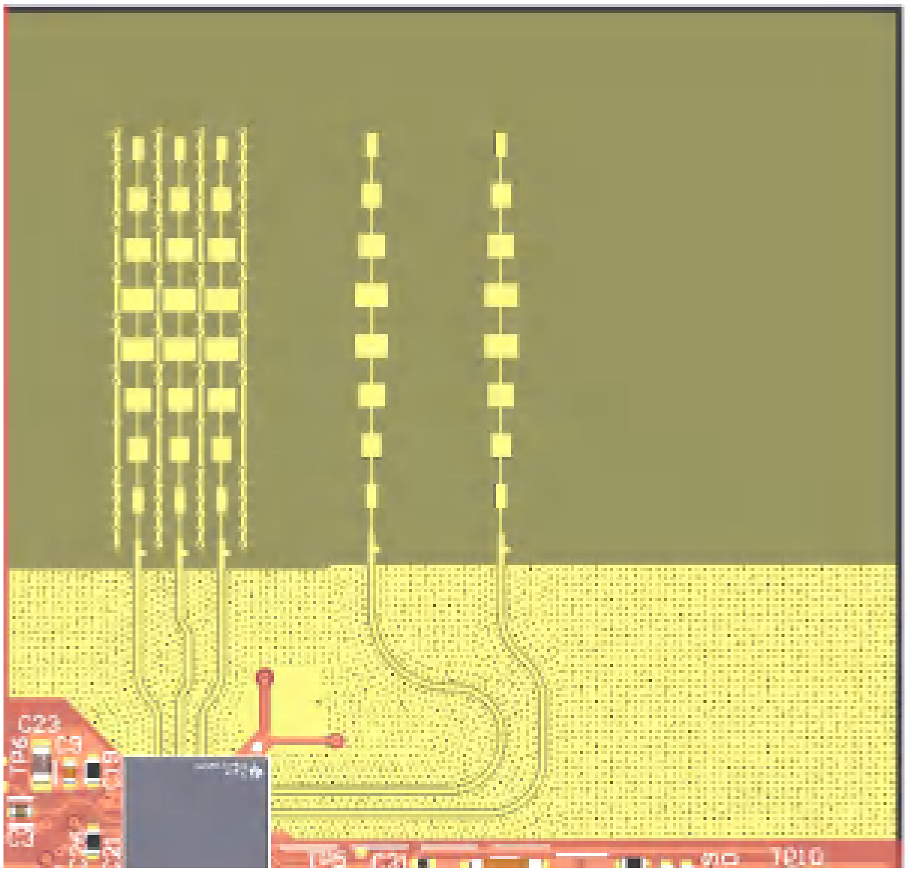

Figure 2-5. TX and Rx Antennas of the EVM

Note

Each of the series fed patch antennas on the xWRL1432BOOST-BSD has a gain of approximately 13 dBi. The three RX antennas are located on the left, and the two TX antennas are lcated on the right.

2.1.1 PCB Material

Dielectric material used for this PCB is Rogers RO3003 of 5mil thickness with rolled copper for the Antenna and transmission lines while 370HR is used for the rest of the layers.

#	Name	Material	Type	Weight	Thickness	Dk	Df
	Top Overlay		Overlay				
	Top Solder	Solder Resist	Solder Mask		0.8mil	1	
1	Top Layer		Signal	1oz	1.6mil		
	Dielectric 1	RO3003	Core		5mil	3	
2	L2_GND1		Signal	1oz	1.4mil		
	Dielectric 2	PCL370HR	Prepreg		5.85mil	3.9	
3	L3_SIG1		Signal	1/2oz	1.2mil		
	Dielectric 3	PCL370HR	Core		10mil	4.25	
4	L4_PWR1		Signal	1/2oz	1.2mil		
	Dielectric 4	PCL370HR	Prepreg		5.65mil	3.9	
5	L5_PWR2		Signal	1/2oz	1.2mil		
	Dielectric 5	PCL370HR	Prepreg		10mil	4.25	
6	L6_SIG2		Signal	1/2oz	1.2mil		
	Dielectric 6	PCL370HR	Core		5.5mil	3.9	
7	L7_GND2		Signal	1/2oz	1.2mil		
	Dielectric 7	PCL370HR	Core		5mil	4.25	
8	Bottom Layer		Signal	1oz	1.6mil		
	Bottom Solder	Solder Resist	Solder Mask		0.8mil	1	
	Bottom Overlay		Overlay				

2.1.1.1 Transmitter and Receiver Virtual Array

Transmitter and receiver antennas positions shown in Figure 2-6 form a virtual array of six transmitter-receiver pairs. This improves object detections by creating a finer azimuthal angular resolution (19°). Receiver antennas are spaced at distance D (Lambda/2) and Transmitter antenna Tx1 and Tx2 spaced at 1.5D (3lambda/2) in the azimuthal plane. No antenna elements are placed in the evilvational plane.

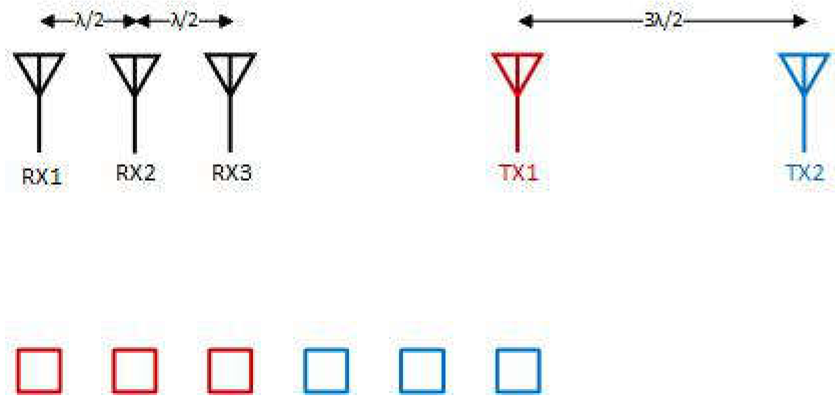

Figure 2-6. Virtual Antenna Array

Figure 2-6 shows the antenna radiation pattern with regard to azimuth and the antenna radiation pattern with regard to elevation for TX1 and TX2. Both figures show the radiation pattern for TX1 and TX2 and RX1, RX2 and RX3 together. All of the measurements were done with a Tx and Rx combination together. Thus, for the -6dB beam width, the user must see a -12db (Tx (-6dB) + Rx(-6dB)) number from the boresight.

To reliably measure the complete virtual array radiation pattern in both the azithmal and elivational planes, a trihedral corner reflector was placed approximately 5 m from the EVM at boresight. The device was configured with a 1.0-GHz chirp and then swept across its azimuth and elevation. The raw ADC data was captured using a DCA-1000EVM and the resulting ADC data was post-processed. When visualized, it is possible to see the finer azithmal resolution in Figure 2-7 compared to lower elevational FoV seen in Figure 2-8.

Note

Wavelength (Lambda) is computed based on a frequency of 78.5 GHz. Antenna placements were selected according to this frequency.

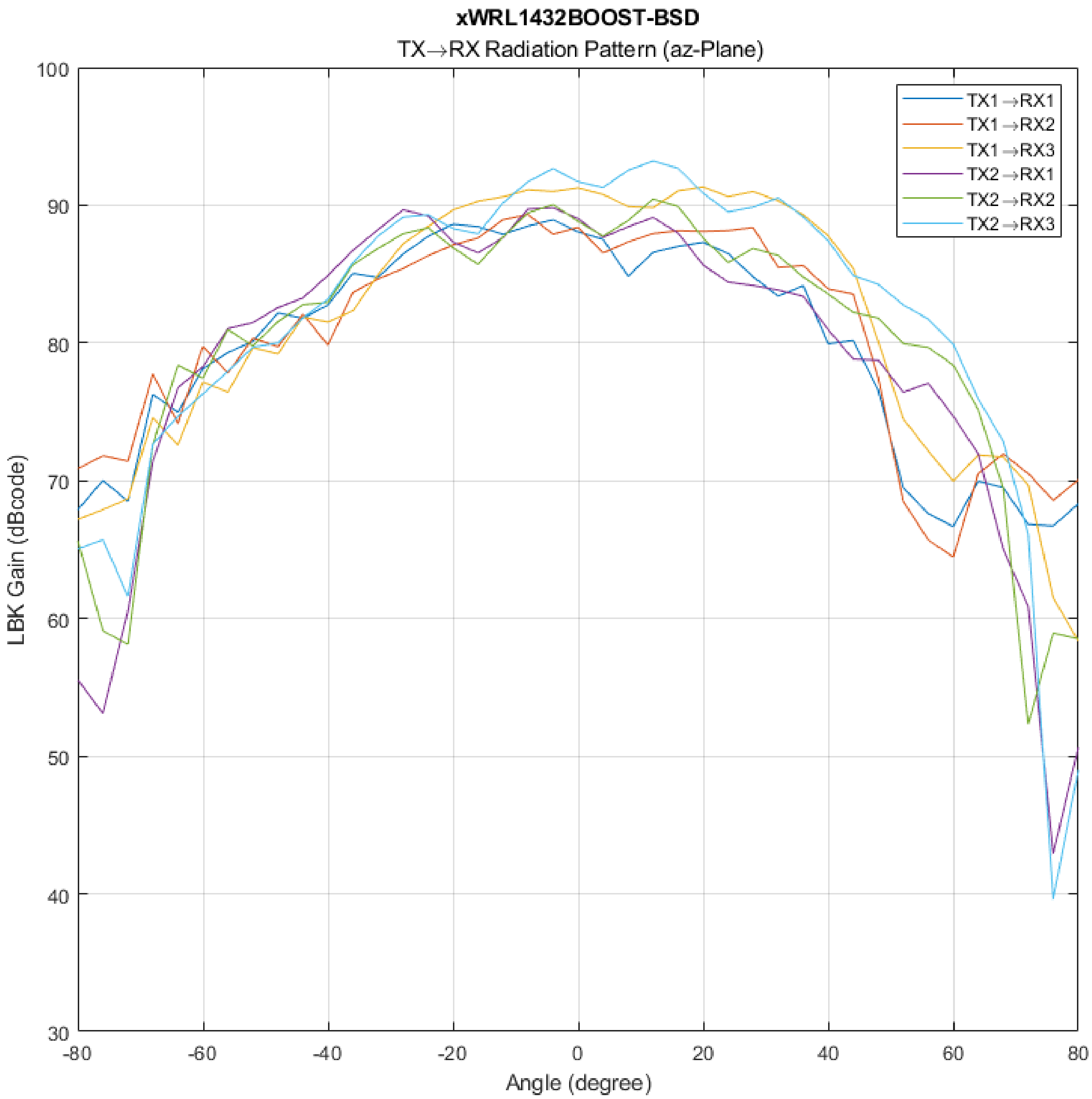

Figure 2-7. xWRL1432BOOST-BSD EVM Antenna Azithmal Radiation Pattern

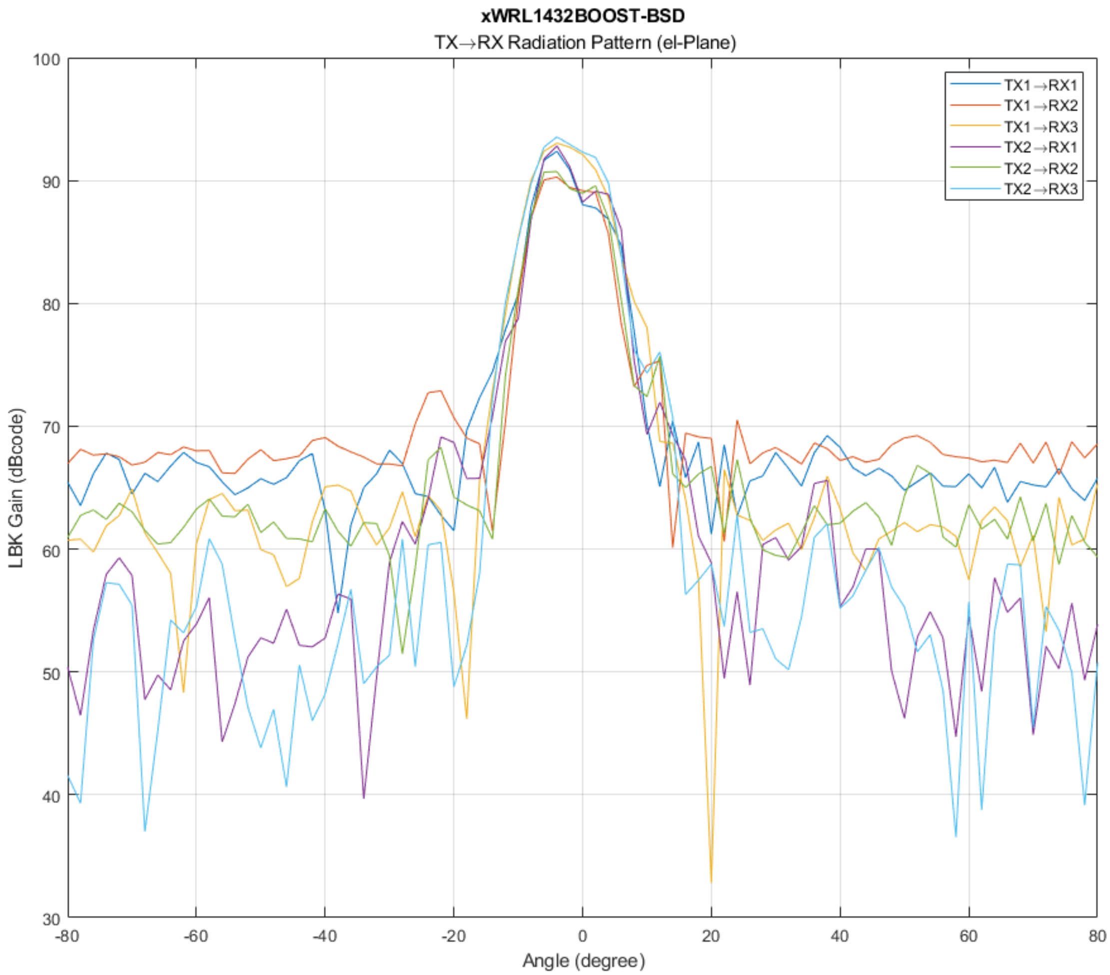

Figure 2-8. xWRL1432BOOST-BSD EVM Antenna Elevational Radiation Pattern

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Note

In accordance to the EN 62311 RF exposure test, a minimum separation distance of 20 centimeters must be maintained between the user and the EVM during operation.

2.2 EVM Mux Block Diagram

Figure 2-9 shows the different muxing options for the digital signals. The xWRL1432 is pin limited and must support different features simultaneously; therefore various internal IPs and signals are pin multiplexed. The EVM provides de-muxing options using various analog mux and sliding switch configurations. Figure 2-9 shows the different muxing switch positions to enable various muxing options to connect to different peripherals.

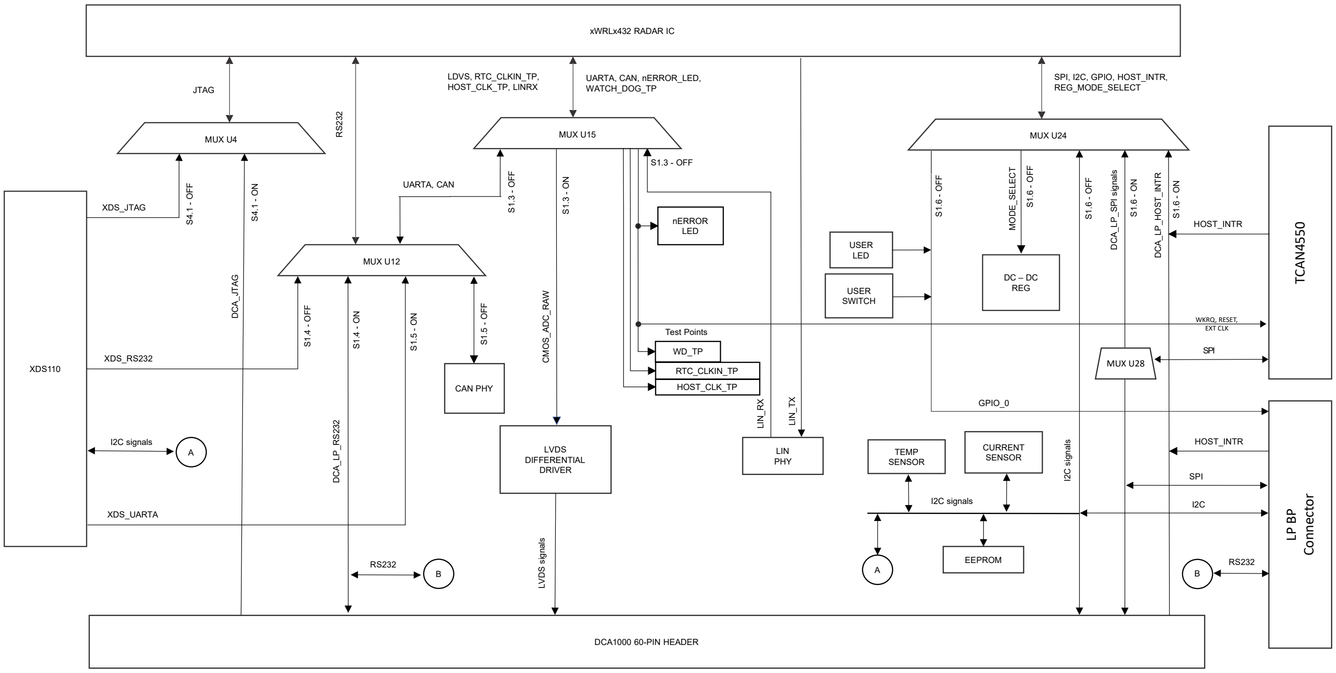


Figure 2-9. Muxing Options for the EVM

2.3 Switch Settings

Figure 2-10 shows the part designators and positions of the switches (S1 and S4) on the xWRL1432BOOST-BSD.

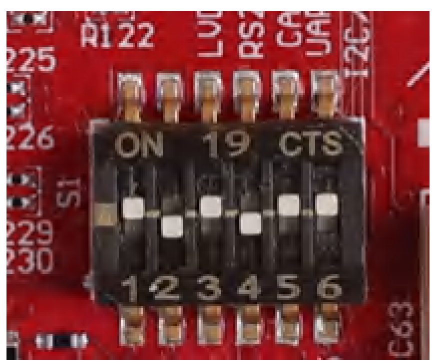


Figure 2-10. S1 Switch for Various Mode Settings

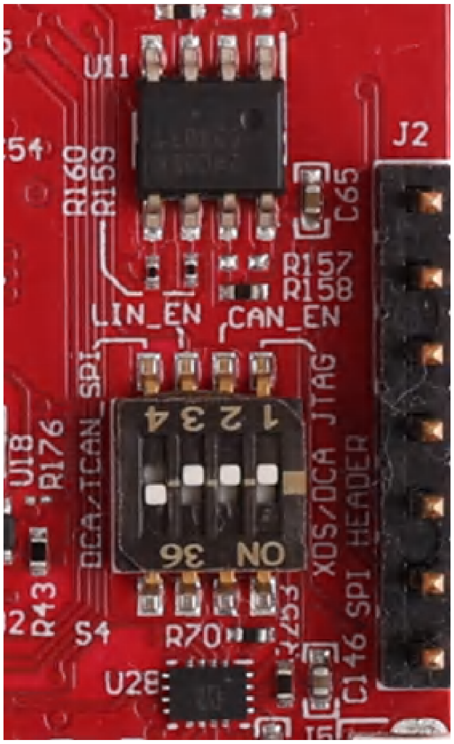


Figure 2-11. S4 Switch for Various Mode Settings

Figure 2-12 provides the different boot mode configurations to the device. The device supports application mode, QSPI flashing mode (Device management mode), and debug mode. The mode (SOP) configurations shown below in Figure 2-12 must be exercised first. After the SOP settings nRESET needs to be issued to register the SOP settings. Figure 2-12 also provides the switch position for different modes of operation supported by the device and EVM.

	OFF	On	Flashing	Functional	Debug Mode (w/ DCA1000)
S1.1			Off	On	On
S1.2			Off	Off	On
S1.3	LVDS	LIN_RX, XDS_UARTA/Can, NERROR_LED, WATCH_DOG_TP, RTC_CLK_IN_TP, HOST_CLK_TPA	Off	Off	Off
S1.4	XDS_RS232	DCA_LP_RS232	Off	Off	Off
S1.5	CAN	XDS_UARTA	On	On	On
S1.6	I2C, REG_MODE, LED_SW_GPIO	SPI	On	On	On
S4.1	XDS_JTAG	DCA_JTAG	Off	Off	Off
S4.2	CAN PHY: Stand by Mode Disable	CAN PHY: Stand by Mode Enable	Off	Off	Off
S4.3	LIN PHY: Enable	LIN PHY: Disable	On	On	On
S4.4	-	-	-	-	-

Figure 2-12. SOP and MUX switches

2.4 LEDs

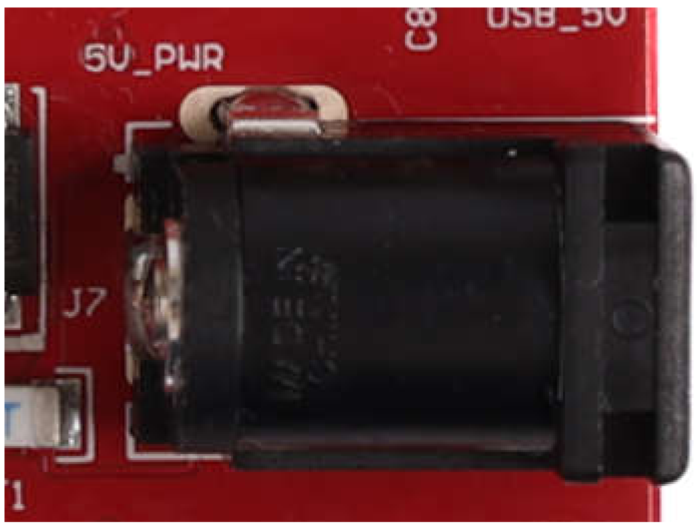
Table 2-1 contains the list of LEDs on the xWRL1432BOOST-BSD.

Table 2-1. List of LEDs

LED reference designators	Description
D6	5 V Power indication
D5	Reset LED.
D9	NERROR LED Note: There is switch settings are needed to enable this.
D7	User LED: Customer programmable. Note: There is switch settings are needed to enable this.
D3	Power good indication

2.5 Connectors

Higher current support: When using the EVM with the external power adapter, the 12-V supply is provided by the external power adapter. This power supply must be connected when working with the onboard TCAN4550. For all other use cases, this external power supply option is not used and power is derived from the USB interface.



Note

After the 12-V power supply is provided to the EVM, TI recommends pressing the NRST switch one time to verify for a reliable boot-up state.

Note

All digital IO pins of the device (except NRESET) are not fail safe. Therefore, care needs to be taken that the digital IO pins are not driven externally without the VIO supply being present to the device.

2.6 USB Connector

The USB connector provides a 5-V supply input to power the device; additionally the PC interface is brought out on this connector:

- UART for flashing the onboard serial flash, downloading FW through mmWave Studio, and getting application data sent through the UART

Figure 2-13. USB Connector (J5)

2.7 DCA1000 HD Connector

The 60-pin HD connector shown in Figure 2-14 provides the high-speed data and controls signals (SPI, UART, I2C, NRST, NERROR, and SOPs) to the DCA1000.

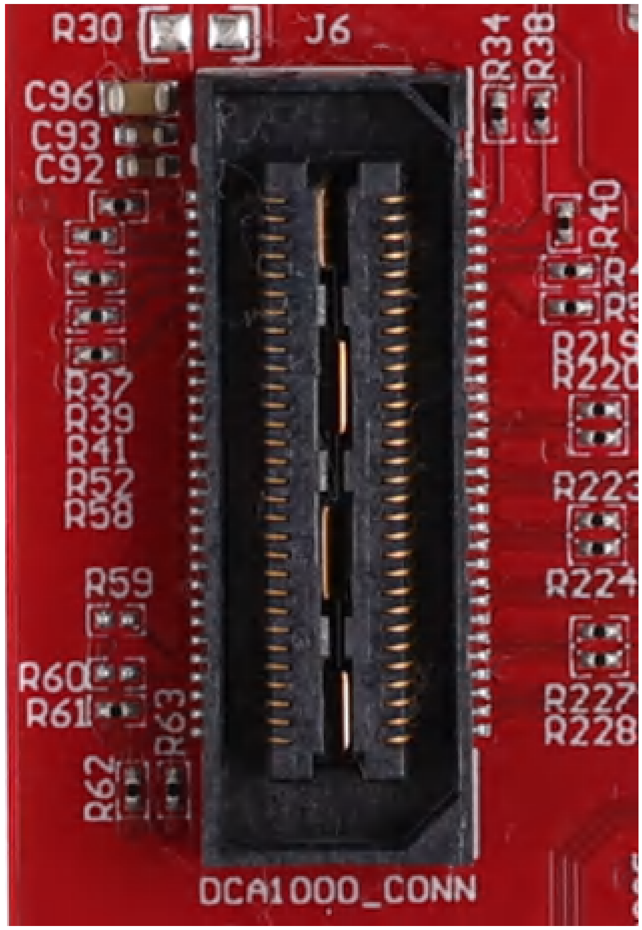


Figure 2-14. DCA1000 HD Connector

2.8 Booster Pack Connector for the LaunchPad Connectivity

J8/J9 are the booster pack connectors provided for the connectivity option with the other TI LaunchPad ecosystem.

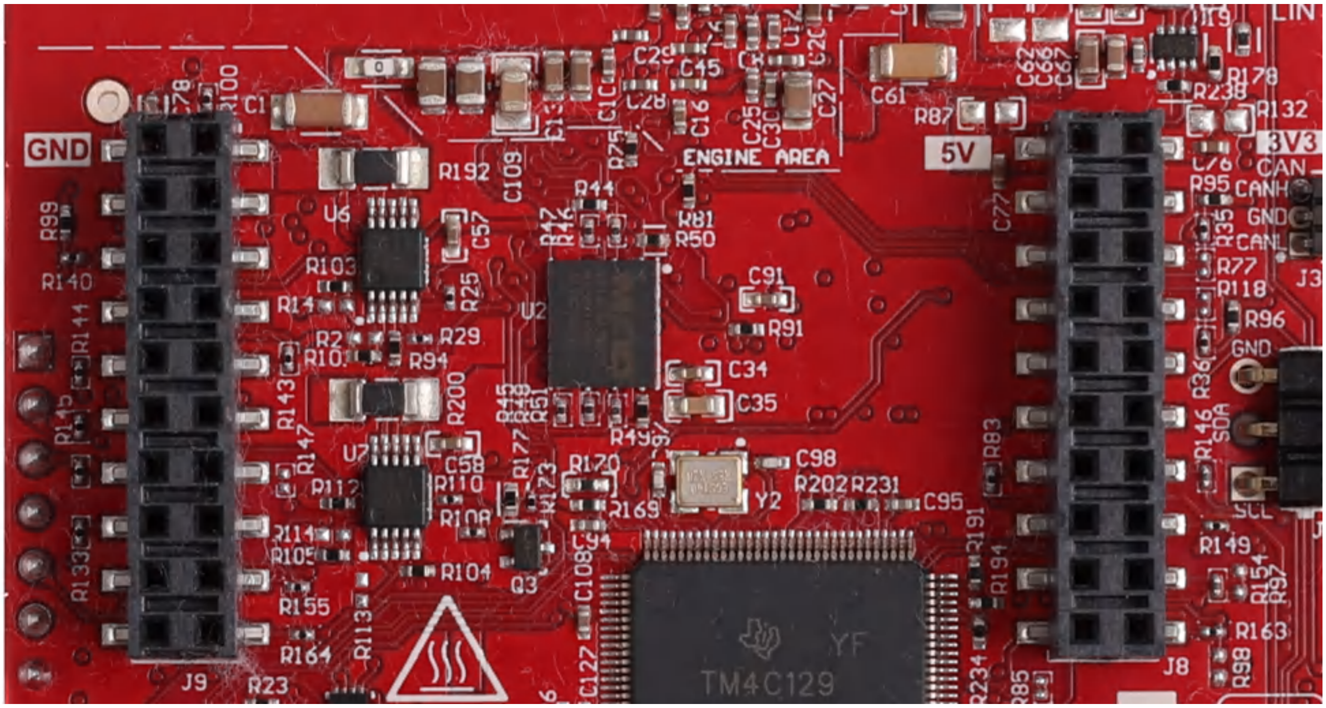


Figure 2-15. Booster Pack Connector

2.9 SPI-CAN Driver

The SPI-CAN driver allows for the radar device to communicate to the CAN bus using SPI connectivity. This functionality comes from TI's TCAN4550 family of TCAN drivers. This driver can be selected by turning on (closing) S4.4. This routes the SPI connection from the DCA, LP, and FTDI to the TCAN bus. This TCAN bus can be accessed using J10. The driver can be woken up by pressing S6. A 12V supply must be connected to J7 DC jack.

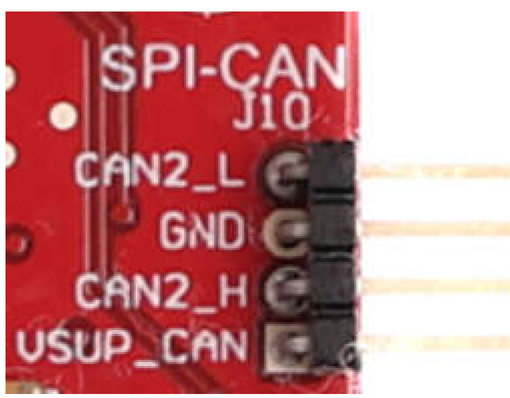


Figure 2-16. SPI-CAN Connector

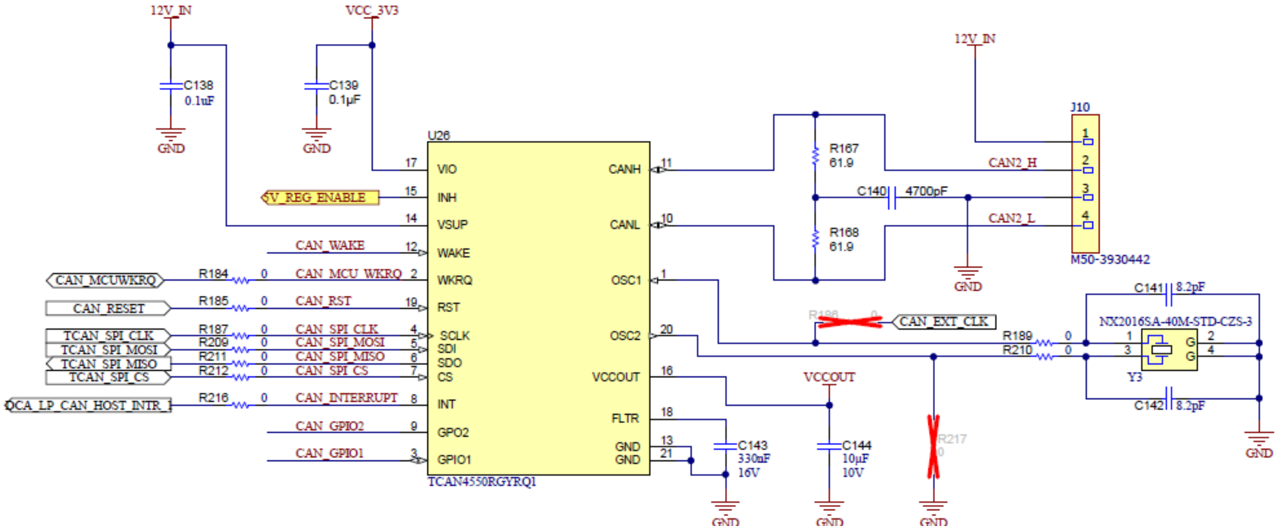


Figure 2-17. SPI-CAN Interface

2.10 CAN-FD Connector

The CAN connector provides access to the CAN_FD interfaces (CAN_L and CAN_H signals) from the onboard CAND-FD transceivers. These signals can be directly wired to the CAN bus.

Figure 2-18. CANFD Connector

The J3 connector shown in Figure 2-18 provides the CAN_L and CAN_H signals from the onboard CAND-FD transceivers (TCAN1042HGVDRQ1). These signals are wired to the CAN bus after muxing with the SPI signals; one of the two paths must be selected. CAN signals are selected to PHY by changing the switch S1.5 to off position.

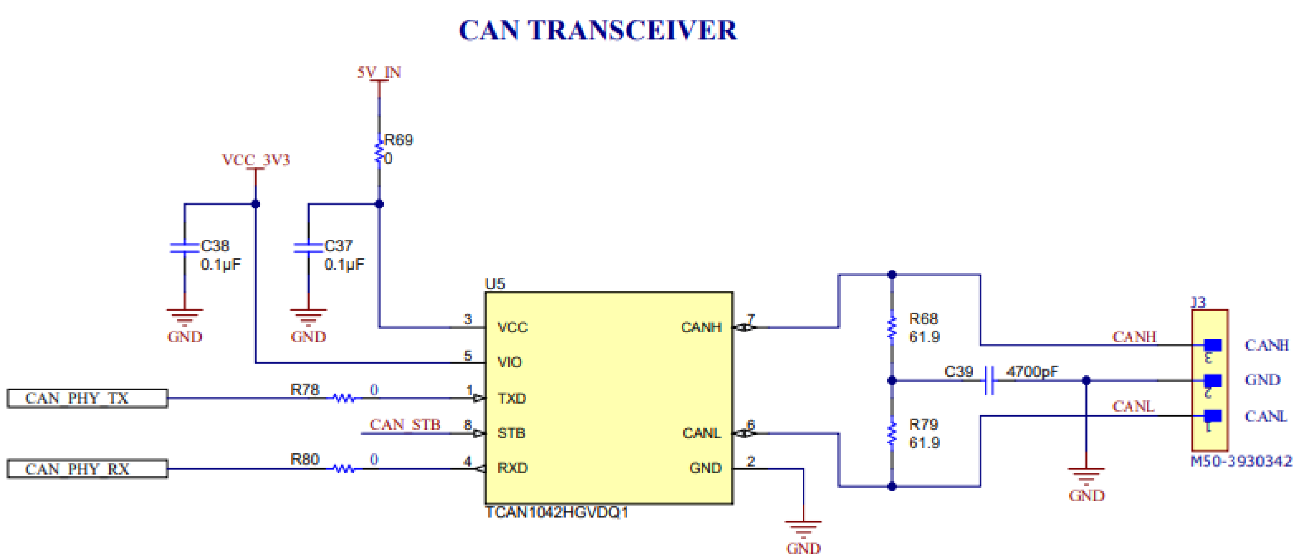


Figure 2-19. CAN FD PHY Used in the EVM

2.11 LIN PHY Connection

Figure 2-20 shows the LIN PHY (TLIN1039DDFRQ1) interface to the device. There are no switches for the LIN PHY interface. LIN PHY can operate with different supply voltage than the mmWave sensor, hence external VBAT option is provided for the LIN VDD supply, by default 5V_IN supply is provided. To enable external VBAT supply, R32 resistor need to be mounted and R31 resistor need to be removed.

Figure 2-20. LIN header and PHY Interface

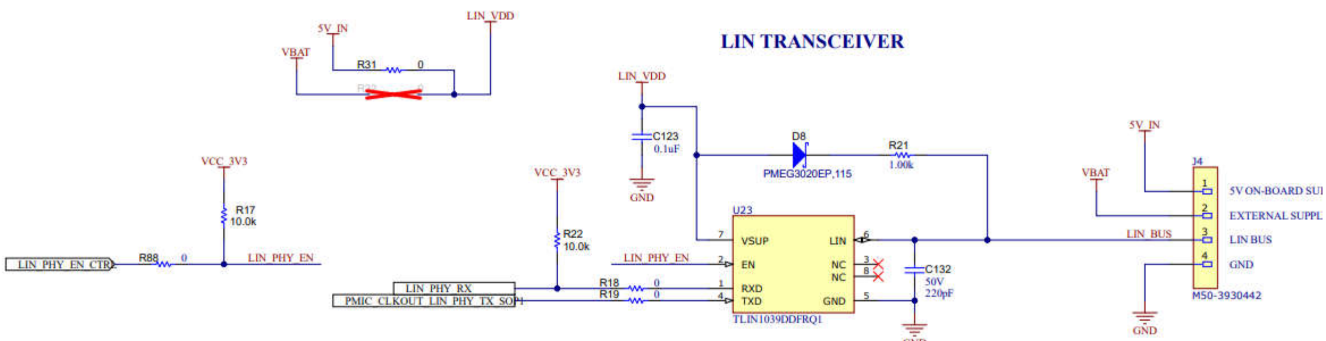


Figure 2-21. LIN PHY Interface

2.12 I2C Connections

The board features an EEPROM, current sensors, and temperature sensor for measuring on-board temperature. These are connected to the I2C bus and can be isolated using the zero Ω provided on the hardware. External I2C headers also provided for easy interface to I2C bus.

2.12.1 EEPROM

The board features an EEPROM for storing the board specific IDs (for the identification of the EVM through the XDS110 interface). Please refer to device schematics for the I2C addresses.

2.13 XDS110 Interface

J5 provides access to the onboard XDS110 (TM4C1294NCPDT) emulator. This connection provides the following interfaces to the PC:

- JTAG for CCS connectivity
- Application/user UART (Configuration and data communication to PC)

When used in the standalone mode of operation as shown in Figure 2-22, the power is supplied through a single 5V USB connector; the same USB connector J5 is also used for configuration and data transfer through the XDS110 USB to UART converter. When enumerated correctly, the 2 UART ports from the XDS110 are displayed on the device manager as a virtual COM Port, similar to that shown in Figure 2-22.

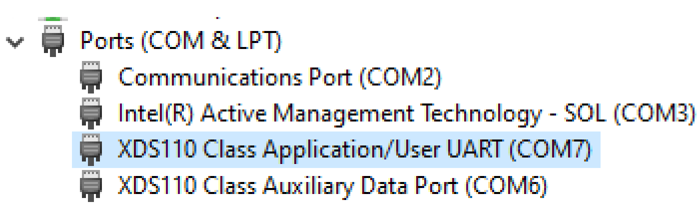


Figure 2-22. Virtual COM Port

If the PC is unable to recognize the above COM ports, install the latest EMUpack.

EVM uses single UART port for both device configuration and processed data communication to PC.

2.14 Flashing the Board

1. Verify that the drivers have been successfully installed and COM ports enumerated.
2. Configure the SOP to flashing mode.
3. Press the reset switch to verify that the board boots up in the right mode.
4. Run the visualizer and use the flashing tab and follow the instruction or use Uniflash tool.
5. Enter the application port number for the flashing interface.
6. Load image to serial flash. Please refer mmWave SDK for the flash binary for running out of box demos.

2.15 DCA1000EVM Mode

The setup for raw data capture using DCA1000EVM is shown in Figure 2-23.

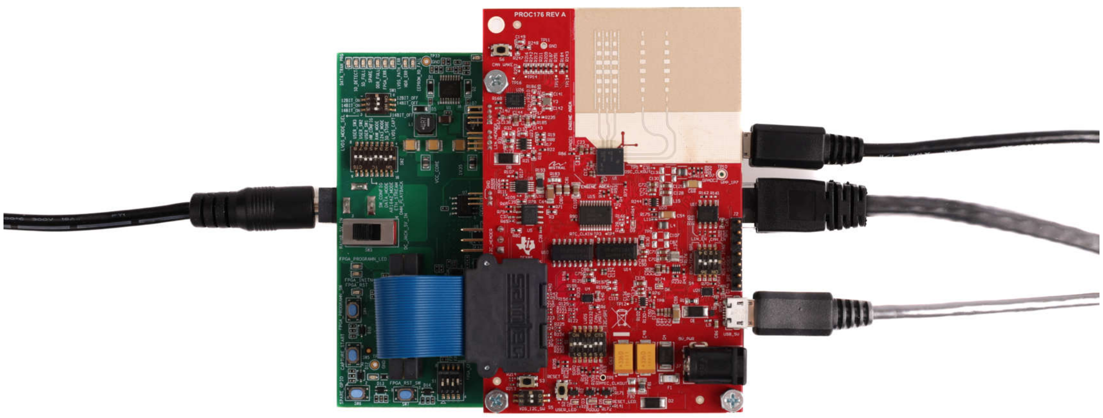


Figure 2-23. DCA1000EVM Mode (Top View)

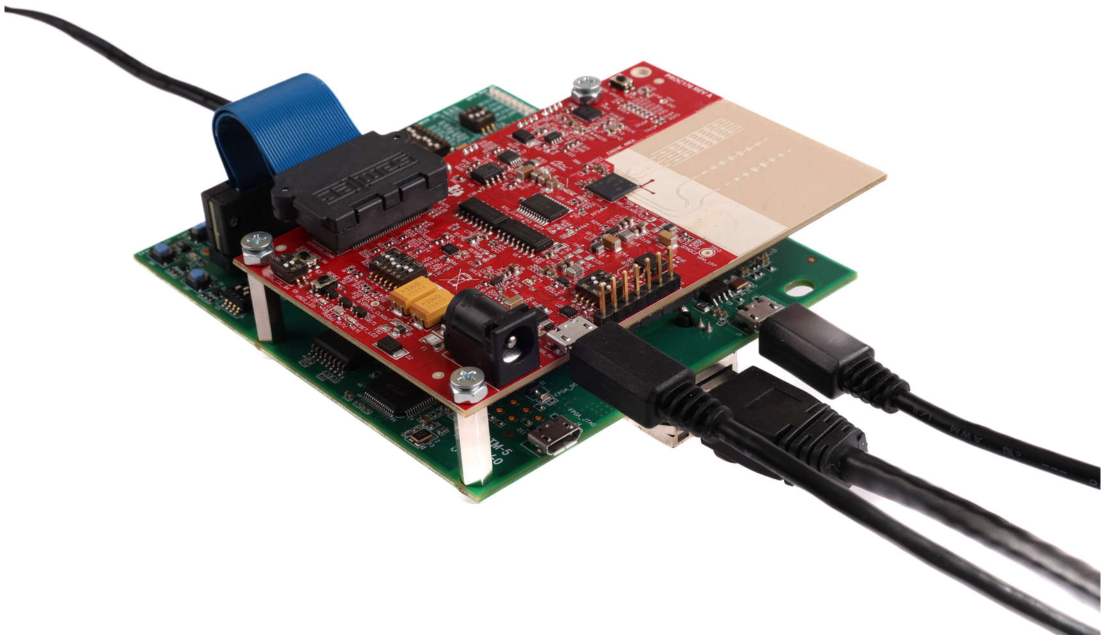


Figure 2-24. DCA1000EVM Mode (Side View)

Please refer to Figure 2-12 shown in the beginning of this document for the switch settings for the DCA1000 raw ADC capture card.

2.15.1 RDIF Interface for Raw ADC Capture

The xWRL1432 doesn't have LVDS I/Os, mainly to reduce the overall power consumption of the SOC. However, the DCA1000 board needs LVDS signals on the clock and data interface for raw ADC capture. Therefore, CMOS to LVDS converters are used on the board as shown below. The data capture interface uses RDIF (Radar Data interface) for transferring the data between mmWave device and DCA1000 capture card. There is no change needed in the DCA1000 capture card for this purpose, however a new low power mmWave studio needs to be used for this purpose. Low Power mmWaveStudio interprets the RDIF interface and provides the raw ADC data visualization platform for further signal processing.

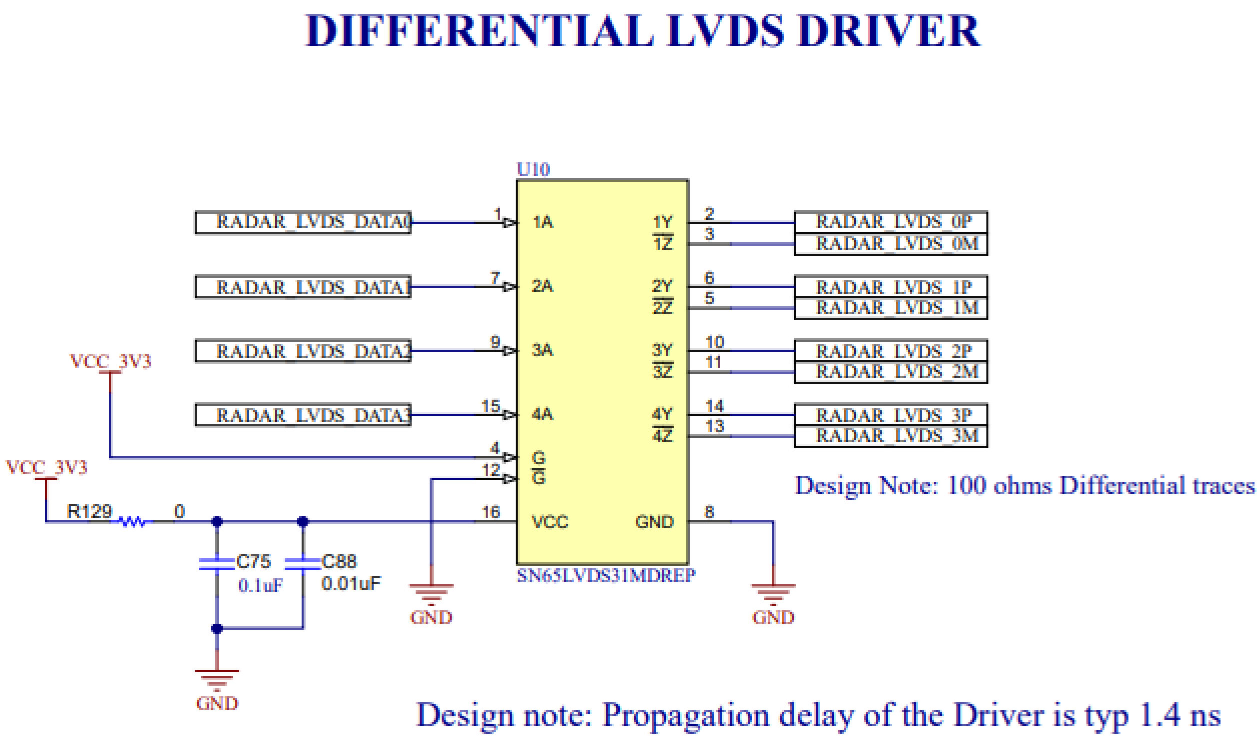


Figure 2-25. DCA1000 CMOS TO LVDS Conversation for Data Lines

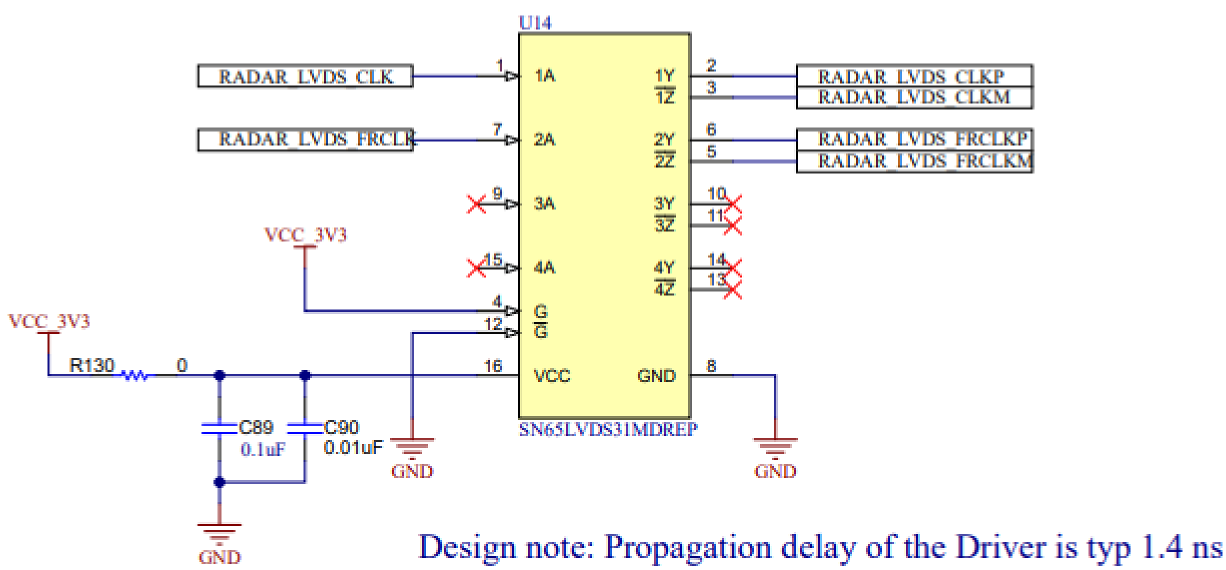


Figure 2-26. DCA1000 CMOS TO LVDS Conversation for Clock and Control Lines

2.16 PCB Storage and Handling Recommendations:

This EVM contains components that can potentially be damaged by electrostatic discharge. Always transport and store the EVM in the supplied ESD bag when not in use. Handle using an antistatic wristband and operate on an antistatic work surface. For more information on proper handling, refer to SSYA010.

2.16.1 PCB Storage and Handling Recommendations

The immersion silver finish of the PCB provides a better high-frequency performance, but is also prone to oxidation in open environment. This oxidation causes the surface around the antenna region to blacken, however mmWave Radar performance remains intact. To avoid oxidation, the PCB must be stored in an ESD cover and kept at a controlled room temperature with low humidity conditions. All ESD precautions must be taken while using and handling the EVM.

2.16.2 Higher Power Demanding Applications

Most of the EVM can be operated with a single USB cable itself. For higher power consumption applications where a single USB-port cannot supply the power needed, use an external 12 V/2A or higher power adapter.

3 Software

3.1 Software, Development Tools, and Example Code

To enable quick development of end applications on the ARM Cortex-M4F core in the xWRL1432, TI provides a software development kit (SDK) that includes demo code, example software, software drivers, emulation packages for debug, and more.

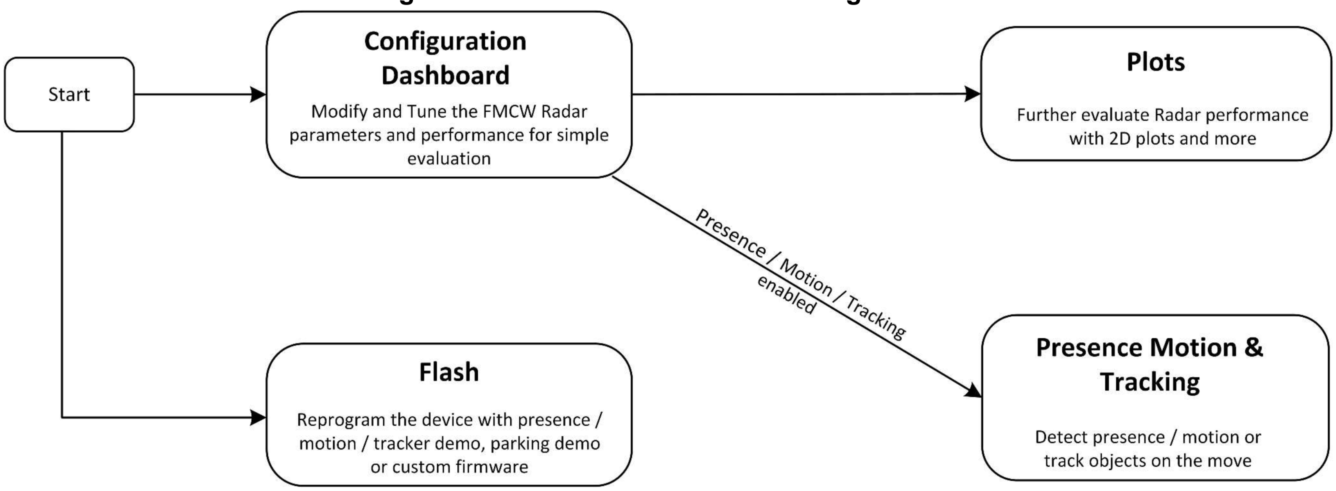
For more information, please refer to mmWave Low Power SDK user's guide (MMWAVE-L-SDK).

Additional demonstrations, documentation, and knowledge about IWRL1432, radar theory, and TI's mmWave Radar sensors can be found in the TI Radar Toolbox.

Follow the steps below to run the demo visualizer using the EVM.

3.1.1 xWRL1432 Demo Visualization Getting Started

Figure 3-1. Demo Visualization Getting Started



For this section, there are two applicable visualizers which can be used: One intended for rear-facing bicycle radar (Applications Visualizer), and one for low cost ADAS BSD radar. They can both be found in the TI Radar Toolbox.

ADAS BSD Visualizer location:
Radar_toolbox\source\ti\examples\ADAS\awrl1432_entry_level_blind_spot_detection\gui\src

Applications Visualizer location: *Radar_toolbox\tools\visualizers\Applications_Visualizer\Industrial_Visualizer*

Follow these steps to use the EVM with the provided BSD demo:

- Step 1: Set the SOP switches to functional mode (see Figure 2-12)
- Step 2: Connect the EVM to the PC via USB.
- Step 3: Press nRESET (S2)
- Step 4: Configure Device.
  1. Navigate to the BSD Visualizer using the path above and launch it
  2. Click "Live Display"
  3. Enter -1 and click "OK" to allow for continuous chirping
  4. Enter the CLI COM port and DATA COM port (these can be seen in Device Manager)
  5. Click "Load Configuration" and then click "Done:.
- Step 5: Use provided MATLAB plots to view the radar data

Follow these steps to use the EVM with the provided Industrial demo:

- Step 1: Set the SOP switches to functional mode (see Figure 2-12)
- Step 2: Connect the EVM to the PC via USB.
- Step 3: Press nRESET (S2)

- Step 4: Configure Device.
    1. Navigate to the Instustrial Visualizer using the path above and launch it
    2. Select the CLI COM port and DATA COM port (these can be seen in Device Manager)
    3. Select Demo to be "Bike Radar"
    4. Click "Select Configuration" and navigate to the desired configuration file
    5. Click on "Start and Send Configuration".
- Step 5: Use "3D Plot" and "Range Plot" to view raw data

Follow these steps to use the device with a different demo:

- Step 1: Download and install UniFlash
- Step 2: Run UniFlash
- Step 3: Set the SOP switches to flashing mode (see Figure 2-12)
- Step 4: Connect the EVM to the PC via USB.
- Step 5: Press nRESET (S2)
- Step 6: Select and install a different demonstration.
    1. Find and select IWRL1432 in the list of devices then click "Start"
    2. For "Meta Image 1", click "Browse" then search for and select the desired binary
        a. You may need to change the sought file type to "All files"
    3. Under quick settings, set the COM port to the lower of the two EVM comports
    4. Click "Load Image"
- After flashing, change the SOP switches to funcitonal mode (see Figure 2-12). Your EVM is now ready to use.

4 Hardware Design Files

4.1 Schematics, PCB Layout and Bill of Materials (BOM)

xWRL1432BOOST-BSD EVM Schematic, PCB Layouts, and Bill of Materials (BOM) can be found on SWRR184.

4.2 EVM Design Database

xWRL1432BOOST EVM Design Database containing Altium Project Source files can be found on SWRR183.

5 Additional Information

Trademarks

All trademarks are the property of their respective owners.

6 References

1. DCA1000EVM Data Capture Card User's Guide
2. MMWAVE-L-SDK
3. Radar Toolbox
4. TI Bicycle Rider Safety Demonstration
5. mmWave Radar for eBike and Scooter Safety Applications
6. UniFlash

6.1 TI E2E Community

Search the forums at e2e.ti.com. If you cannot find your answer, post your question to the community!

Revision History

Changes from July 1, 2024 to December 31, 2024 (from Revision * (July 2024) to Revision A (December 2024)) **Page**

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