User's Guide

IWRL6432BOOST/AWRL6432BOOST EVM: FR4-Based Low Power 60 GHz mm-Wave Sensor EVM User Guide

Chethan Kumar Y. B.

1 Abstract

The xWRL6432BOOST from Texas Instruments is an easy-to-use low cost FR4-based evaluation board for the xWRL6432 mmWave sensing device, with standalone operation and 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.

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Trademarks

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2 Getting Started

2.1 Key Features

- FR4-based PCB substrate
- Wide field of view antenna, targeted for wall mount applications
- Industrial: Building automation, Presence / motion detection, Displacement sensing, Robotics, Security and Surveillance, Vital sign detection, Gesture, Factory automation applications
- Automotive: In cabin sensing, Occupancy detection, Child presence detection, Intruder detection, Seat belt reminder, Gesture applications
- XDS110 JTAG interface with USB connectivity for code development and debugging
- Power optimized discrete DCDC power management solution
- Relaxed PCB rules: lower manufacturing cost
  – No micro vias, only through via
  – No vias on the BGA pads
- Serial port for onboard QSPI flash programming
- 60-pin, high-density (HD) connectors for raw analog-to-digital converter (ADC) data
- Onboard CAN-FD transceiver
- On board LIN PHY transceiver for automotive variant.
- USB powered standalone mode of operation
- EVM is designed as booster pack to connect with other LaunchPad EVMs
- On board 16Mbit QSPI flash

2.2 Kit Contents

xWRL6432BOOST includes the following:

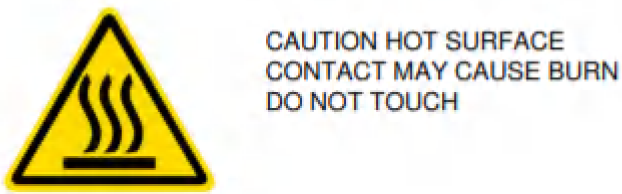
- XWRL6432BOOST Evaluation board
- Micro USB cable
- Quick Start Guide

2.3 mmWave Out of Box Demo

TI® provides sample demo codes to easily get started with the XWRL6432BOOST evaluation module (EVM) and to experience the functionality of the XWRL6432 mmWave sensor. For details on getting started with these demos visit mmWave SDK on ti.com page.

3 Hardware

Note



The XWRL6432BOOST includes three receivers and two transmitters with a wide field of view sitting on an FR4 PCB substrate.

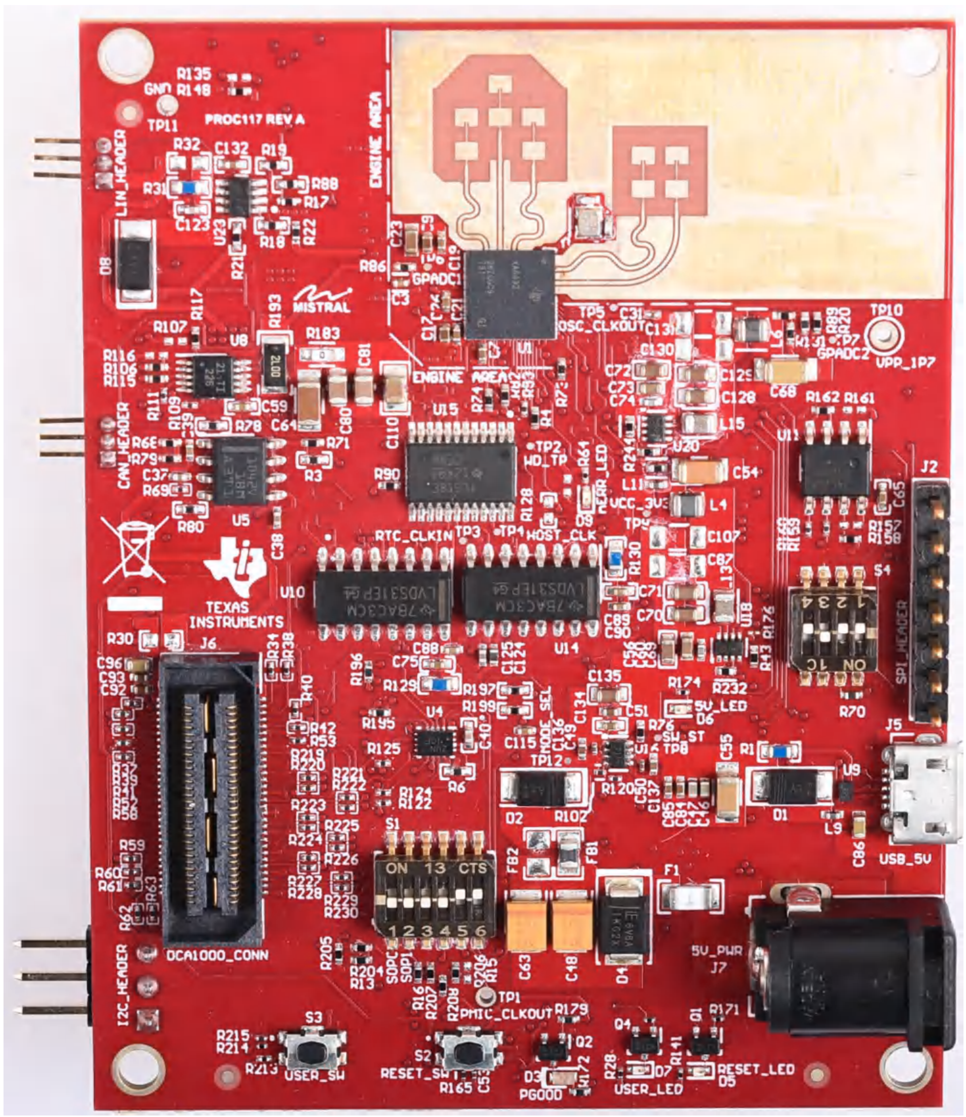


Figure 3-1. XWRL6432BOOST Top View

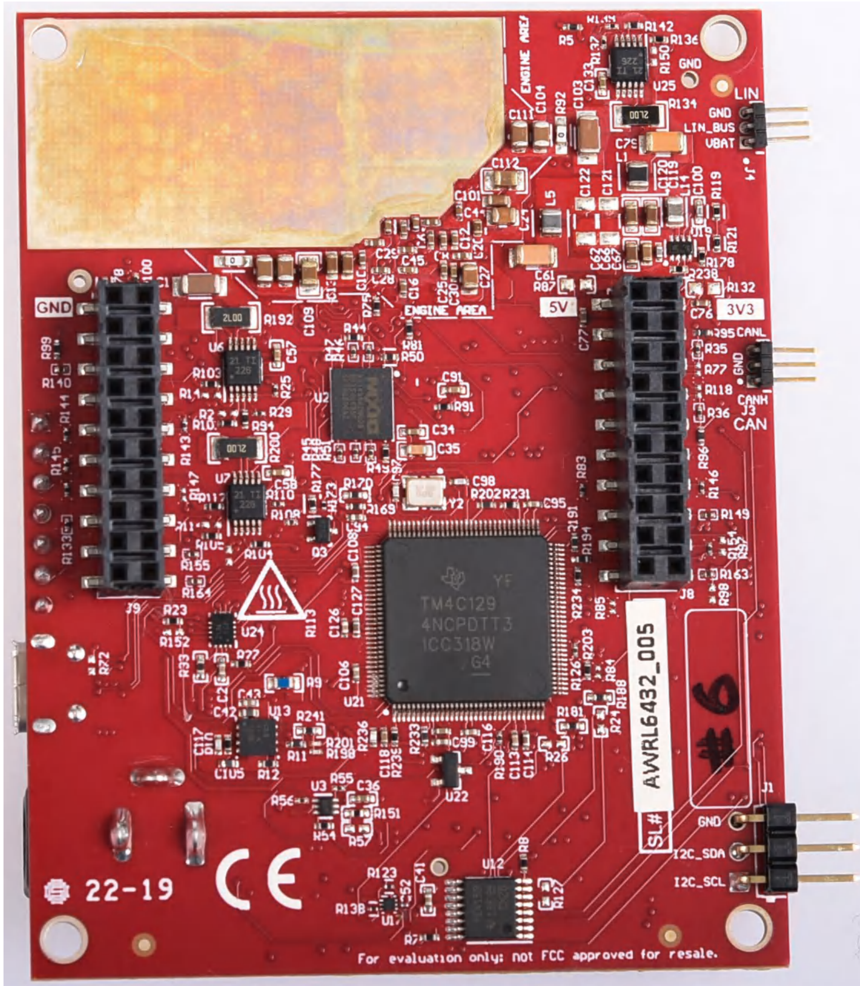


Figure 3-2. XWRL6432BOOST Bottom View

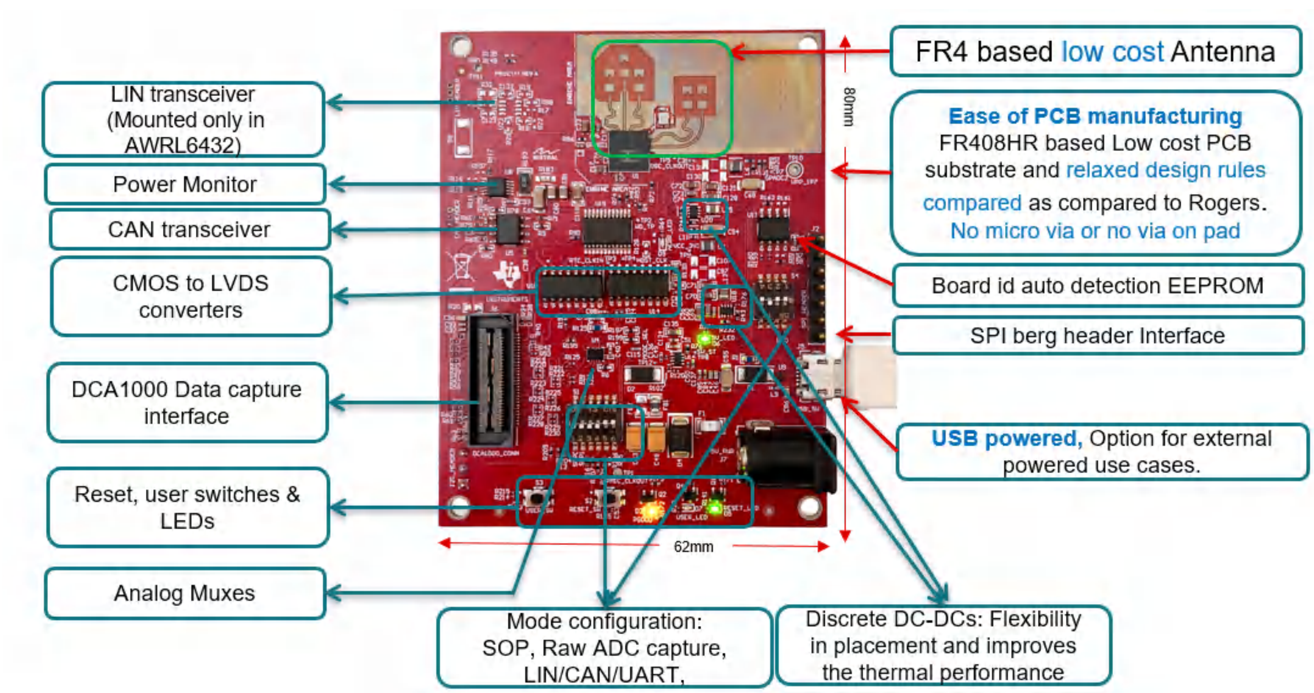


Figure 3-3. Salient Features of EVM (Top side)

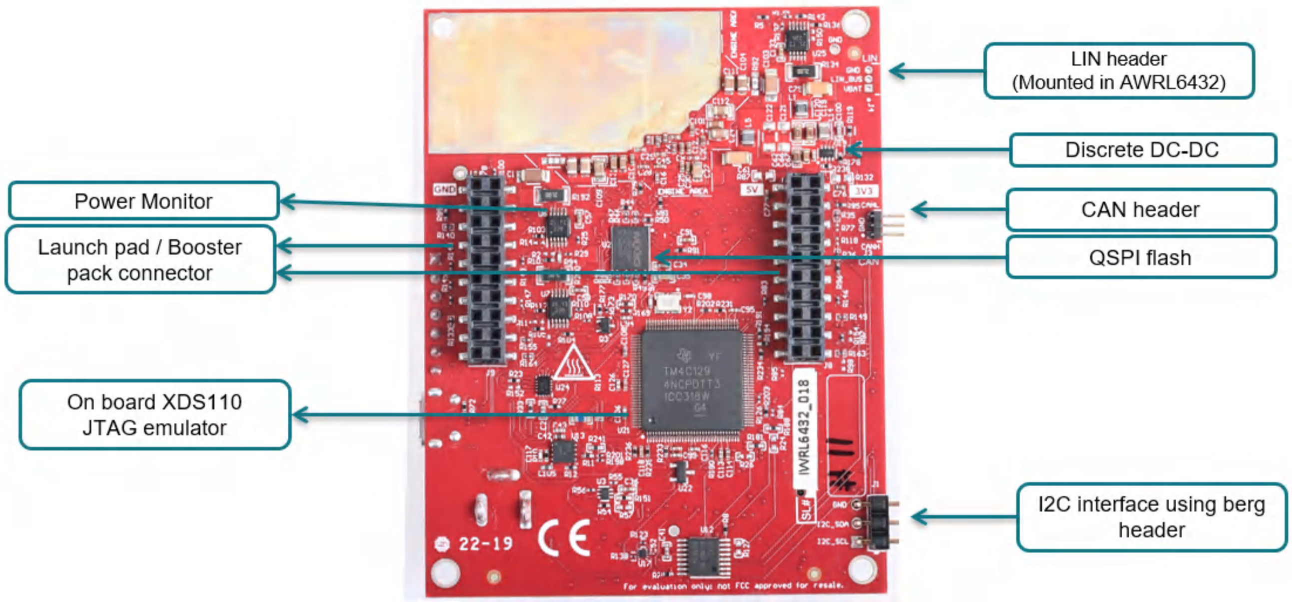


Figure 3-4. Salient features of EVM (Bottom side)

3.1 Block Diagram

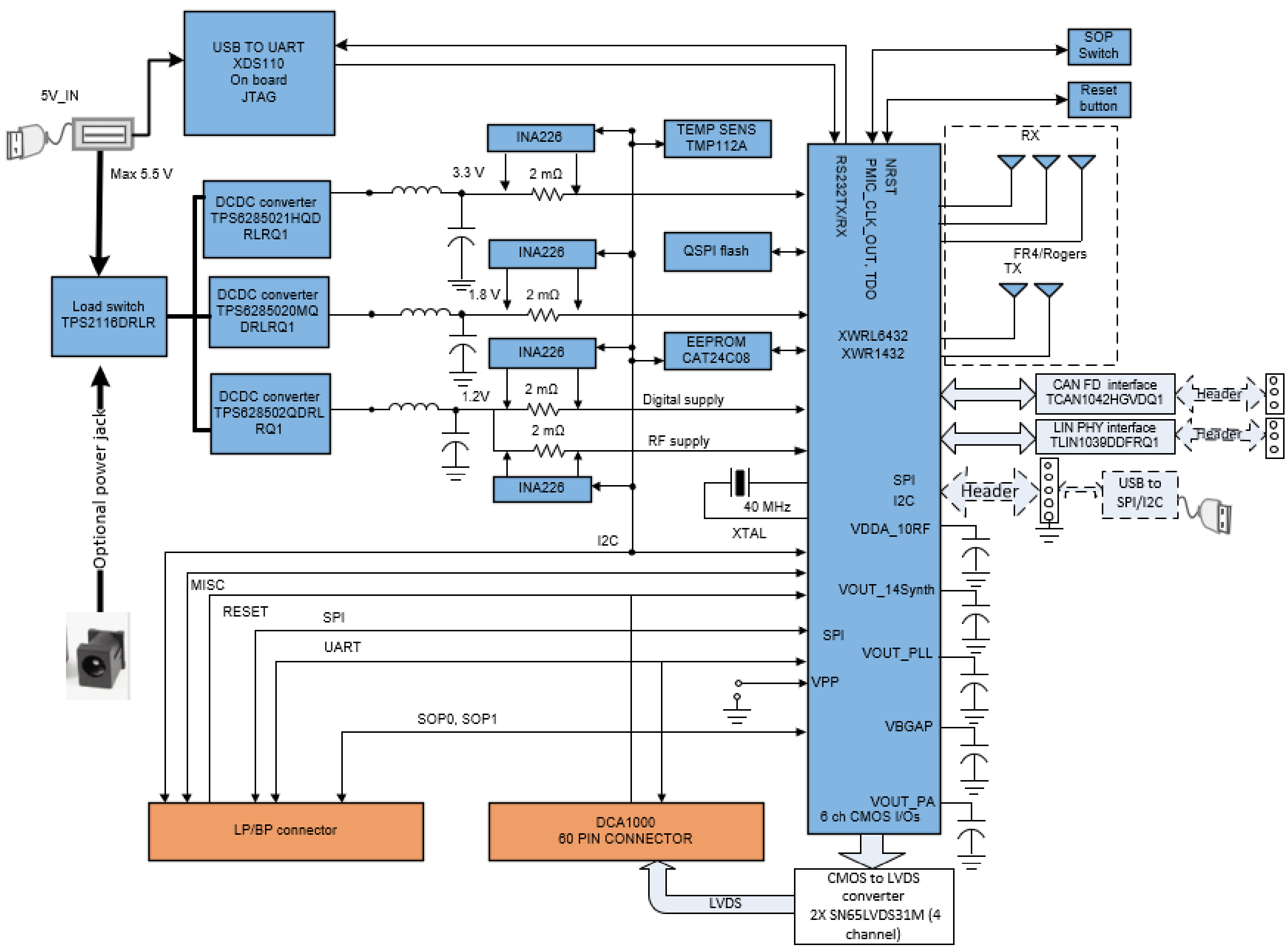


Figure 3-5. Functional block diagram

Figure 3-5 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.

4 EVM Mux Block Diagram

Muxing options for the EVM shows different muxing options for the digital signals. The device is pin limited to support different features simultaneously; hence various internal IPs and signals are pin multiplexed. EVM provides de-muxing options using various analog mux and sliding switch options. Figure 4-1 shows different muxing switch positions to enable different muxing options to connect to different peripherals.

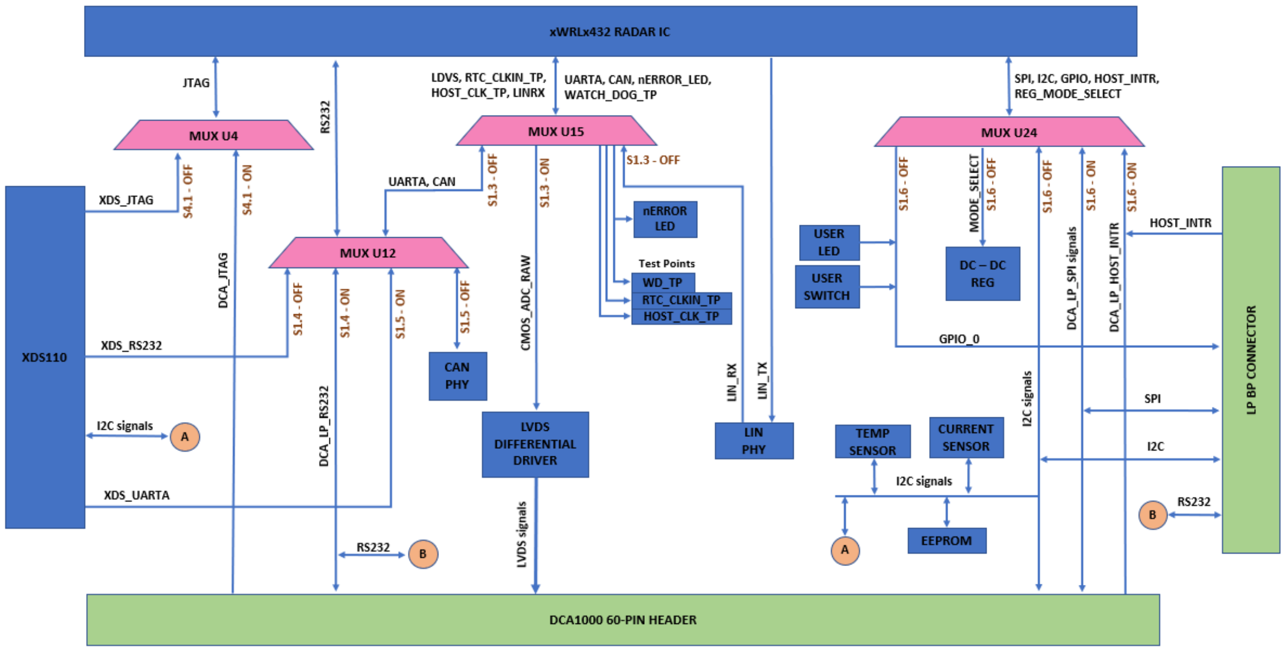


Figure 4-1. Muxing options for the EVM

5 PCB Storage and Handling Recommendations:

This EVM contains components that can potentially be damaged by electrostatic discharge. Always transport and store the EVM in its 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 SSYA010A.

5.1 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 would remain intact. To avoid oxidation, the PCB should 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.

5.2 Higher Power Demanding Applications:

Most of the EVM could be operated with a single USB cable itself. For higher power consumption applications where a single USB-port cannot supply power needed, use an external 5V / 2A or higher power adaptor.

6 XWRL6432BOOST Antenna

The XWRL6432BOOST includes 3 receivers and 2 transmitters FR4 based antennas on the PCB. Figure 6-1 shows the Antenna configuration.

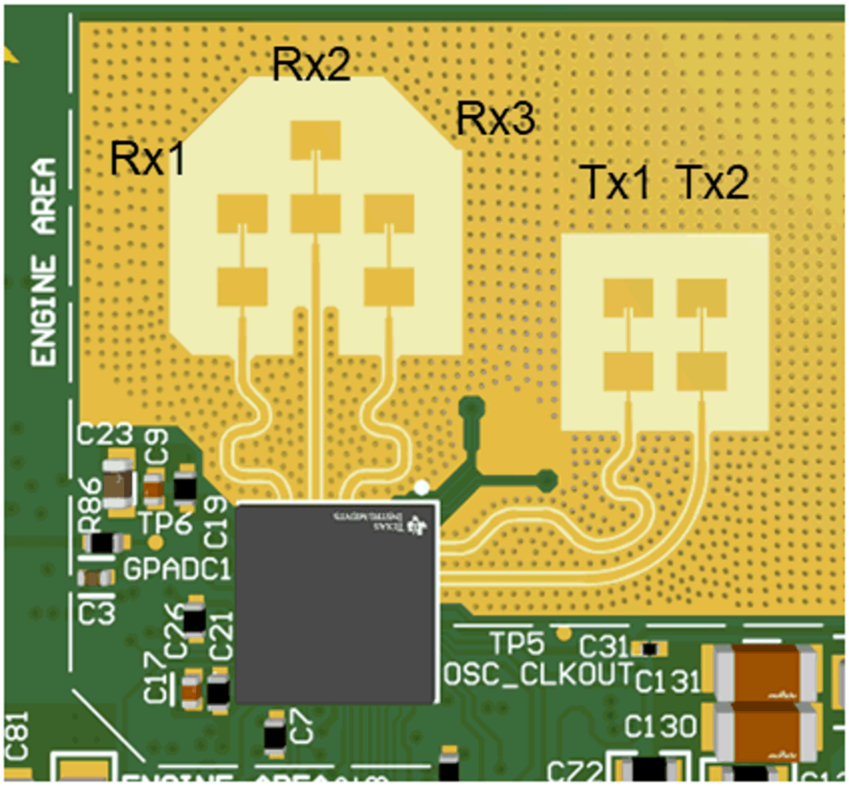


Figure 6-1. TX and Rx Antennas of the EVM

Note

The XWRL6432BOOST has an antenna gain of ~5-6 dBi across different antenna pairs

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6.1 PCB material

Material used for this PCB is FR408HR ½ oz dual ply 2x1067 spread glass construction for the Antenna and transmission lines and 370HR is used for the rest of the layers.

Layer	Cu Thick. (mils)	Cu Foil wt (oz)	DK	Lam. Thick. (mils)	Description
1	1.60	0.5 oz			0.5oz + Plating
			3.30	5.00	Core FR408HR 5.00mils 2x1067 0.5 oz / 1 oz RTF
2	1.20	1 oz			
			3.90	5.85	Prepreg 370HR 1080(68)/1080(68)
3	1.20	1 oz			
			4.25	10.00	Core 370HR 10.00mils 2x2116 1 oz / 1 oz RTF
4	1.20	1 oz			
			3.90	5.65	Prepreg 370HR 1080(68)/1080(68)
5	1.20	1 oz			
			4.25	10.00	Core 370HR 10.00mils 2x2116 1 oz / 1 oz RTF
6	1.20	1 oz			
			3.90	6.05	Prepreg 370HR 1080(68)/1080(68)
7	1.20	1 oz			
			4.25	5.00	Core 370HR 5.00mils 1x2116 1 oz / 0.5 oz RTF
8	1.60	0.5 oz			0.5oz + Plating

* The outer finished copper thickness showed on the stack-up is nominal thickness instead of minimum value. The nominal value is used to simulate stack-up . The minimum value will follow the spec or IPC 6012 which specified.

Layer	Drill Type
1 - 8	PTH

58.95 Thickness over Soldermask

6.1.1 Transmitter and receiver virtual array

Transmitter and receiver antennas positions in Figure 6-2 form a virtual array of 6 transmitter and receiver pairs. This allows object detections finer azimuthal angular resolution (29°) and coarse elevation angular resolution (58°). Receiver antennas are spaced at distance D (Lambda/2) and Transmitter antenna Tx1 and Tx2 spaced at 2D (lambda) in azimuthal plane and D (Lambda/2) in elevation plane. Tx1 and Tx2 are placed at D (lambda/2) in the elevation and 2D (Lambda) in azimuth plane.

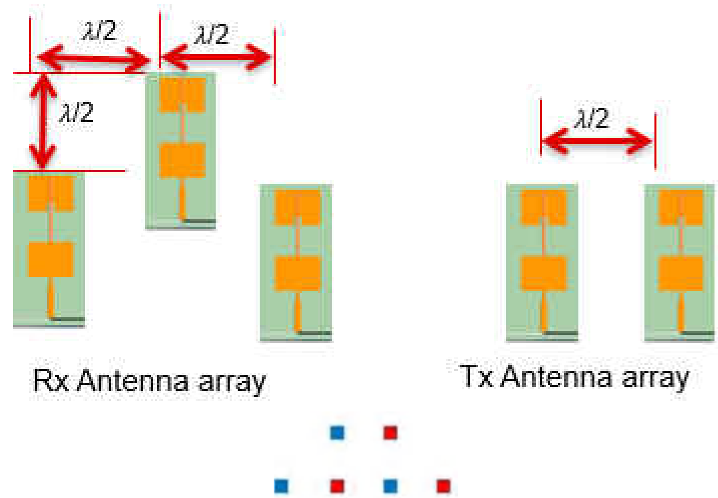


Figure 6-2. Virtual antenna array

Figure 6-2 shows the antenna radiation pattern with regard to azimuth and Figure 6-3 shows the antenna radiation pattern with regard to elevation for TX1 and TX2. Both 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, you must see a -12db (Tx (-6dB) + Rx(-6dB)) number from the boresight.

Note

Wavelength (Lambda) is computed based on a frequency of 62GHz. Antenna placements are according to this frequency.

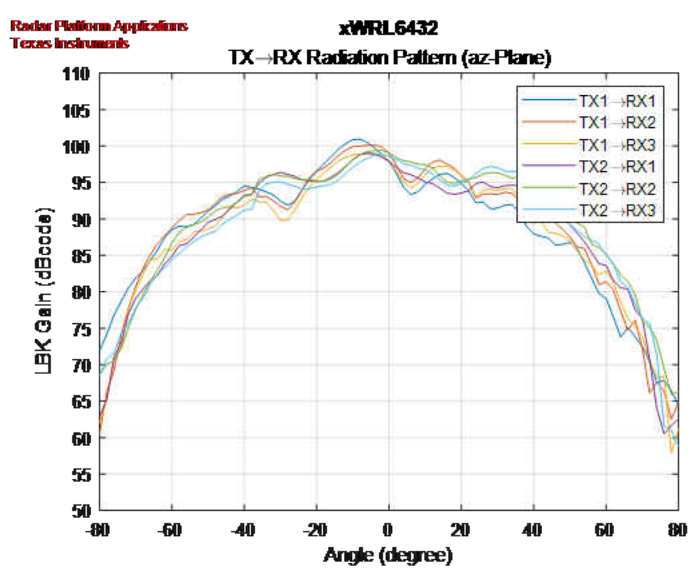


Figure 6-3. Azimuth Antenna Radiation Patterns

Measured azimuthal radiation pattern for all Tx to Rx pairs (Corner reflector placed at ~5 meters with a 4- GHz bandwidth chirp starting at 59GHz)

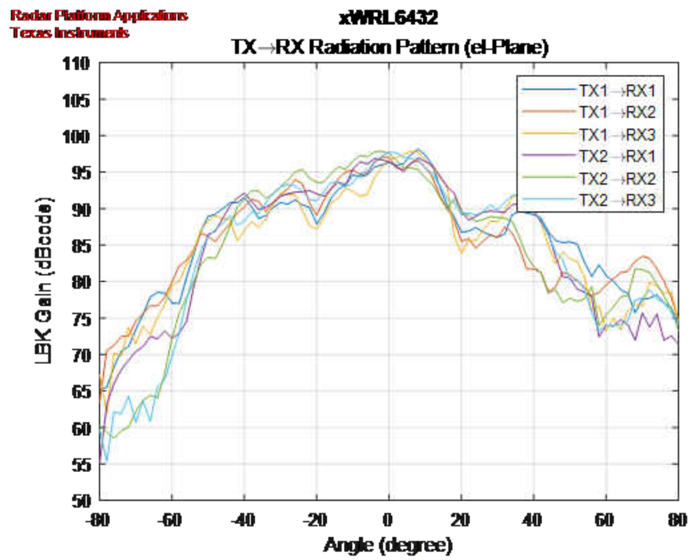


Figure 6-4. Elevation Antenna Radiation Patterns

Measured elevation radiation pattern for all TX to RX pairs (Corner reflector placed at ~5 meters with a 4-GHz bandwidth chirp starting at 59GHz)

Note

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

6.2 Switch Settings

Figure 6-5 shows the part designators and positions of the switches (S1 and S4) on the XWRL6432BOOST.

Figure 6-5. S1 Switch for Various Mode Settings

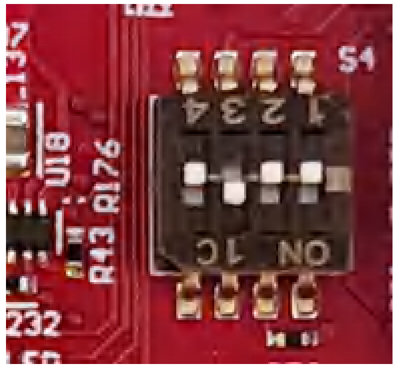


Figure 6-6. S4 Switch for Various mode Settings

Figure 6-7 provides the different boot mode configurations to the device. Device supports application mode, QSPI flashing mode (Device management mode), and debug modes. This mode (SOP) configuration shown below in Figure 6-7 must be exercised first. After the SOP settings nRESET need to be issued to register the SOP settings. Figure 6-7 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 6-7. SOP Switches

6.3 LEDs

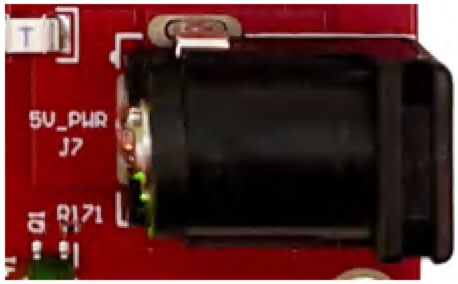
Table 6-1 contains the list of LEDs on the XWRL6432BOOST.

Table 6-1. List of LEDs

LED reference designators	Description
D6	5V 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

6.4 Connectors

Higher current support: When using the EVM with the external power adaptor, the 5-V supply is provided by the external power adaptor. For most of the use-cases this external power supply option is not used, power is derived from the USB interface.



Note

After the 5-V power supply is provided to the EVM, TI recommends pressing the NRST switch one time to ensure a reliable boot-up state.

Note

All digital IO pins of the device (except NRESET) are non-failsafe; hence, care needs to be taken that they are not driven externally without the VIO supply being present to the device.

6.5 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 Radar Studio, and getting application data sent through the UART

Figure 6-8. USB Connector (J5)

6.6 DCA1000 HD Connector

The 60-pin HD connector shown in Figure 6-9 provides the high-speed data and controls signals (SPI, UART, I2C, NRST, NERROR, and SOPs) to the DCA1000.

Figure 6-9. DCA1000 HD Connector

6.7 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.

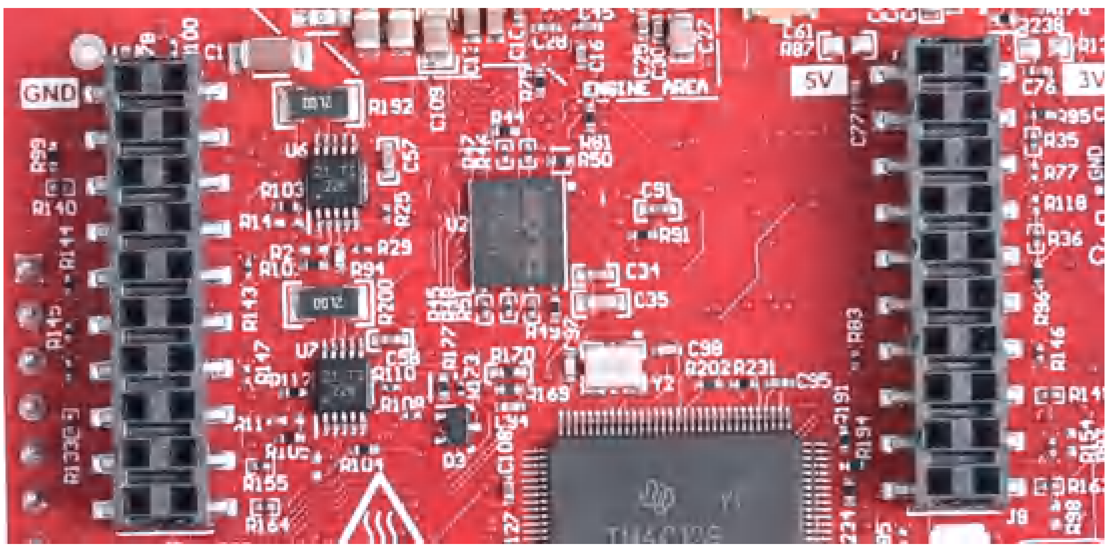


Figure 6-10. Booster pack connector

6.8 CANFD 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.

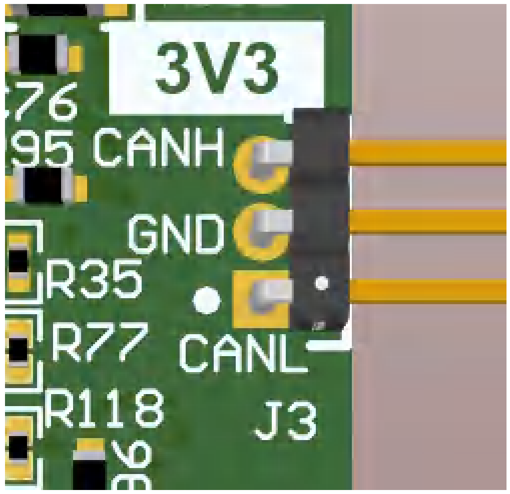


Figure 6-11. CANFD Connector

The J3 connector shown in Figure 6-11 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 interface signals; one of the two paths must be selected. CAN signals are selected to PHY by changing the switch S1.5 to off position.

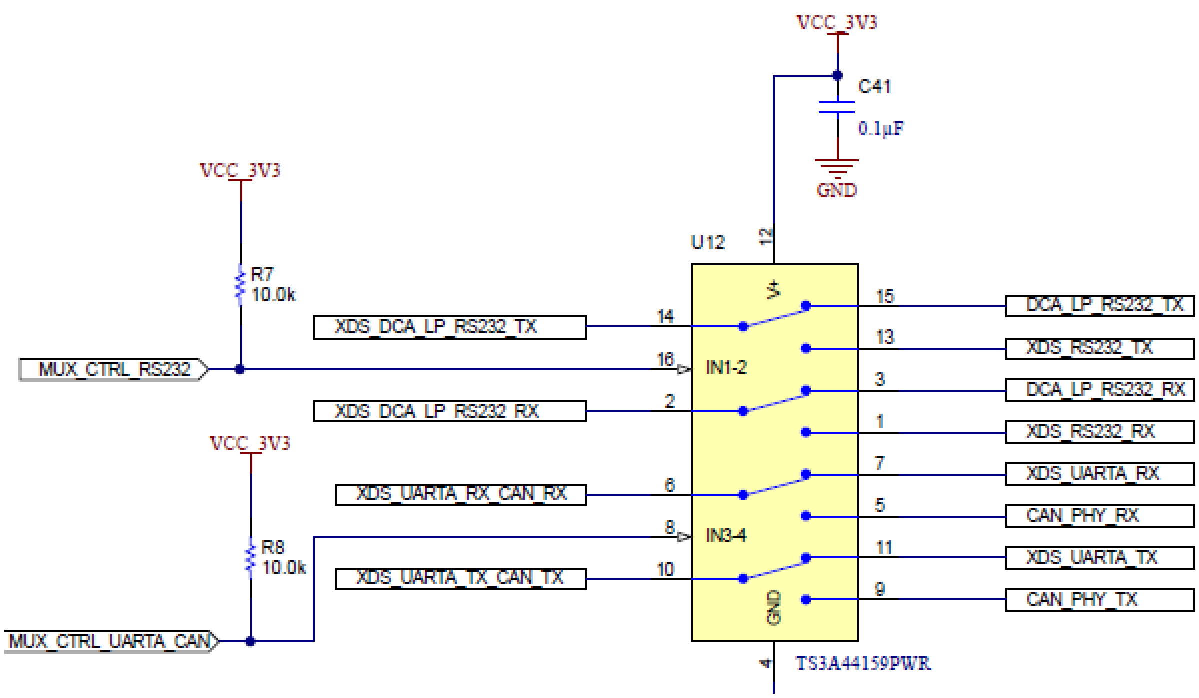


Figure 6-12. Analog Mux for the CAN PHY Switch

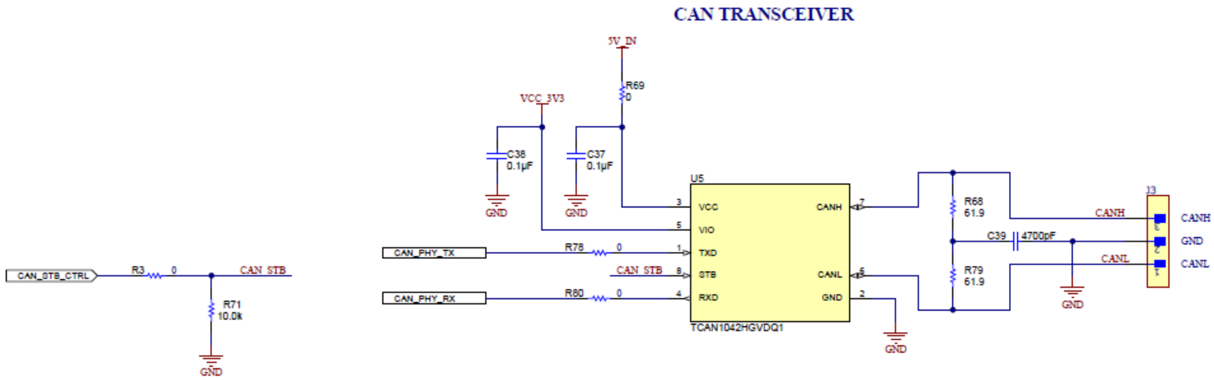


Figure 6-13. CAN FD PHY used in the EVM

6.9 LIN PHY connection

Figure 6-14 shows the LIN PHY (TLIN1039DDFRQ1) interface to the device. There are no switches for the LIN PHY interface. LIN PHY could 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.

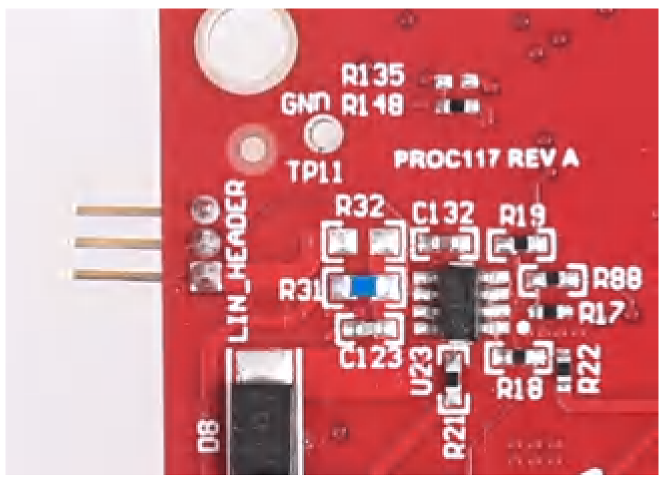


Figure 6-14. LIN header and PHY interface

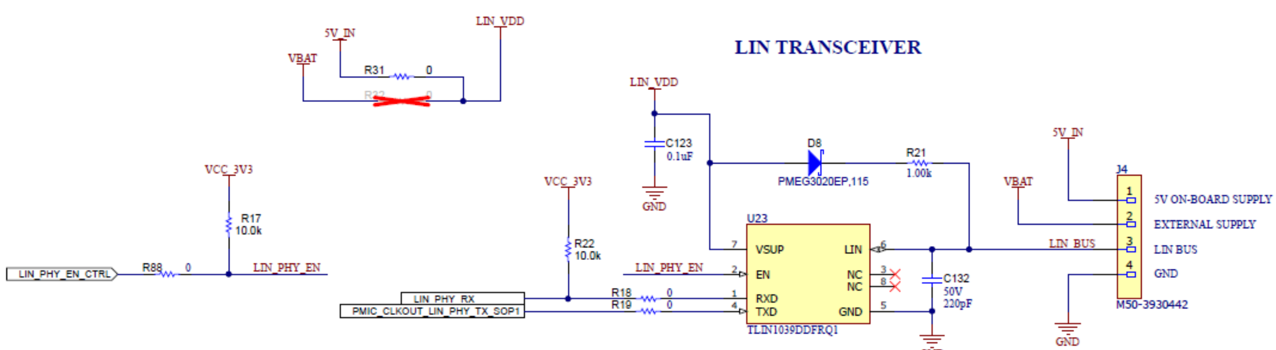


Figure 6-15. LIN PHY interface

6.10 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.

6.10.1 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.

6.11 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 standalone mode of operation as shown in Figure 6-16, the power is supplied through a single 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 6-16.

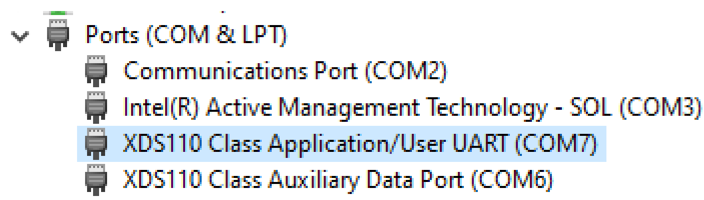


Figure 6-16. Virtual COM port

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

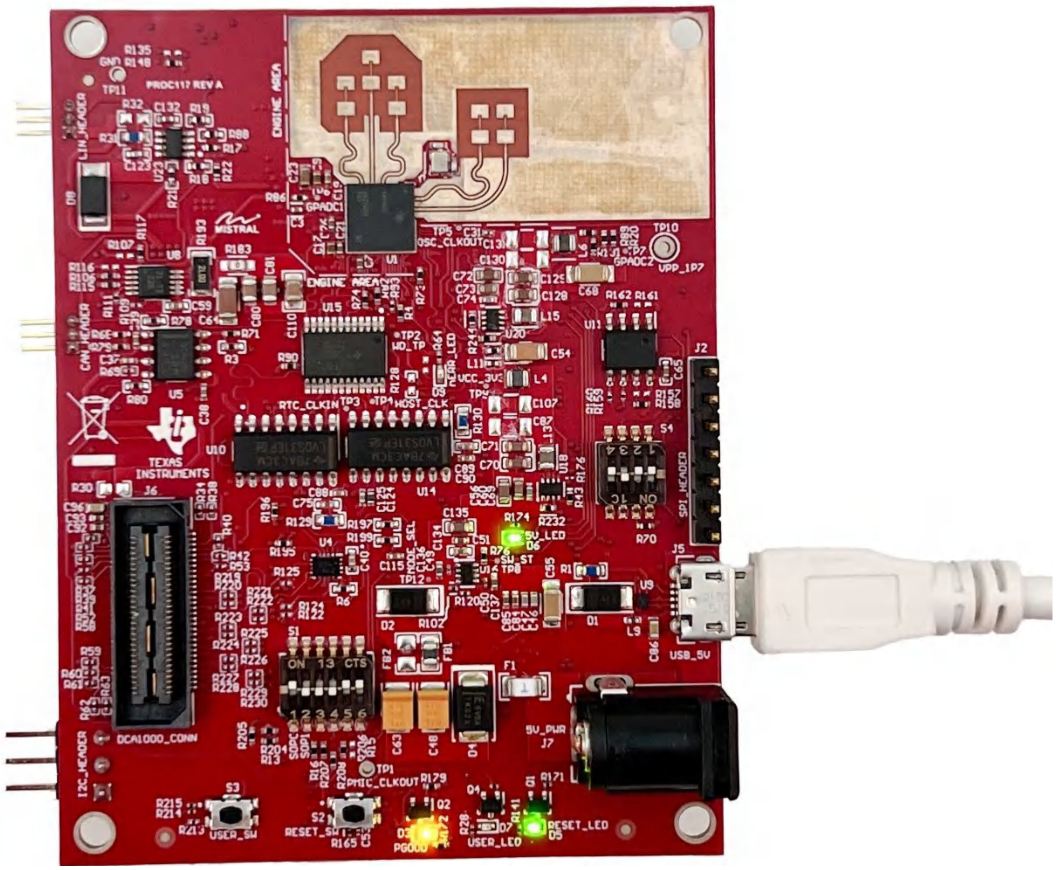


Figure 6-17. EVM in functional mode using standalone operation

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

6.12 Flashing the Board

1. Ensure the drivers have been successfully installed and COM ports enumerated.
2. Configure the SOP to flashing mode.
3. Press the reset switch to ensure 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.

6.13 DCA1000EVM Mode

The setup for raw data capture using DCA1000EVM is shown in Figure 6-18.

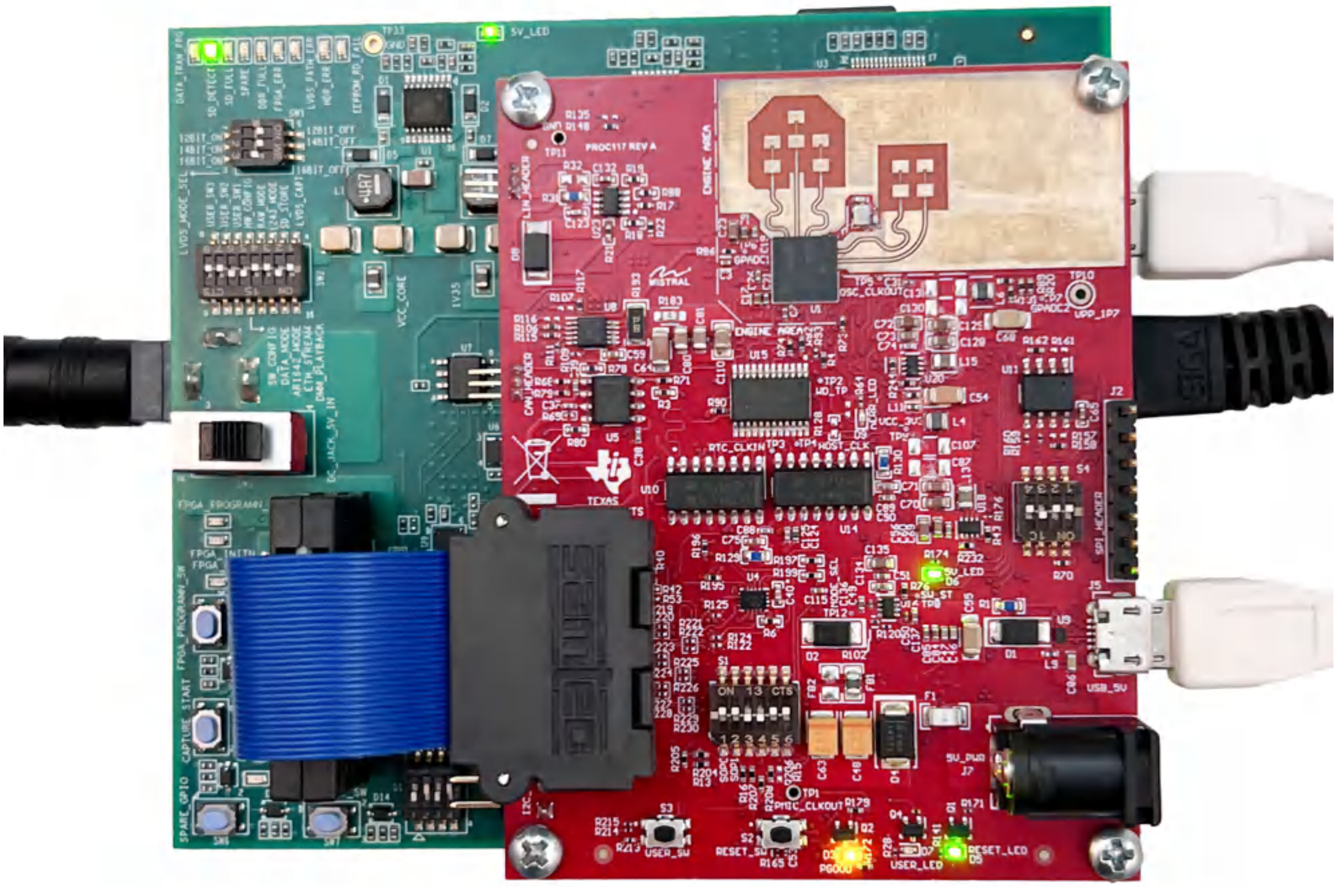


Figure 6-18. DCA1000EVM mode top view

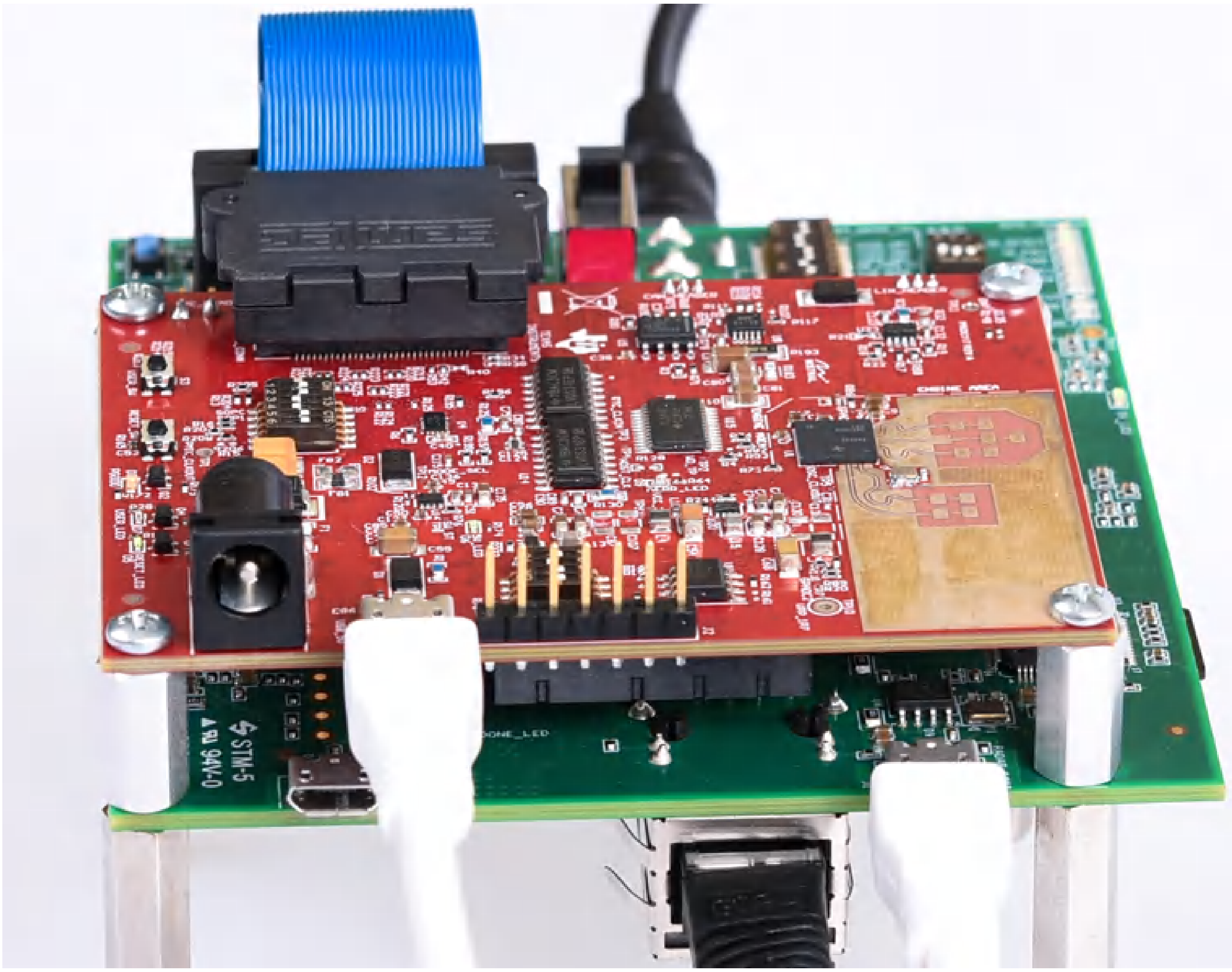


Figure 6-19. DCA1000EVM mode side view

Please refer to Figure 6-7 shown in the beginning of this document for the switch settings for the DCA1000 raw ADC capture card.

6.13.1 RDIF interface for Raw ADC capture

XWRL6432 doesn't have LVDS I/Os, mainly to reduce the overall power consumption of the SOC. However, DCA1000 board needs LVDS signals on the clock and data interface for raw ADC capture so CMOS to LVDS converters are used on the board as shown below. 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 need to be used for this purpose. Low power mmWave studio interpret the RDIF interface and provides the raw ADC data visualization platform for further signal processing.

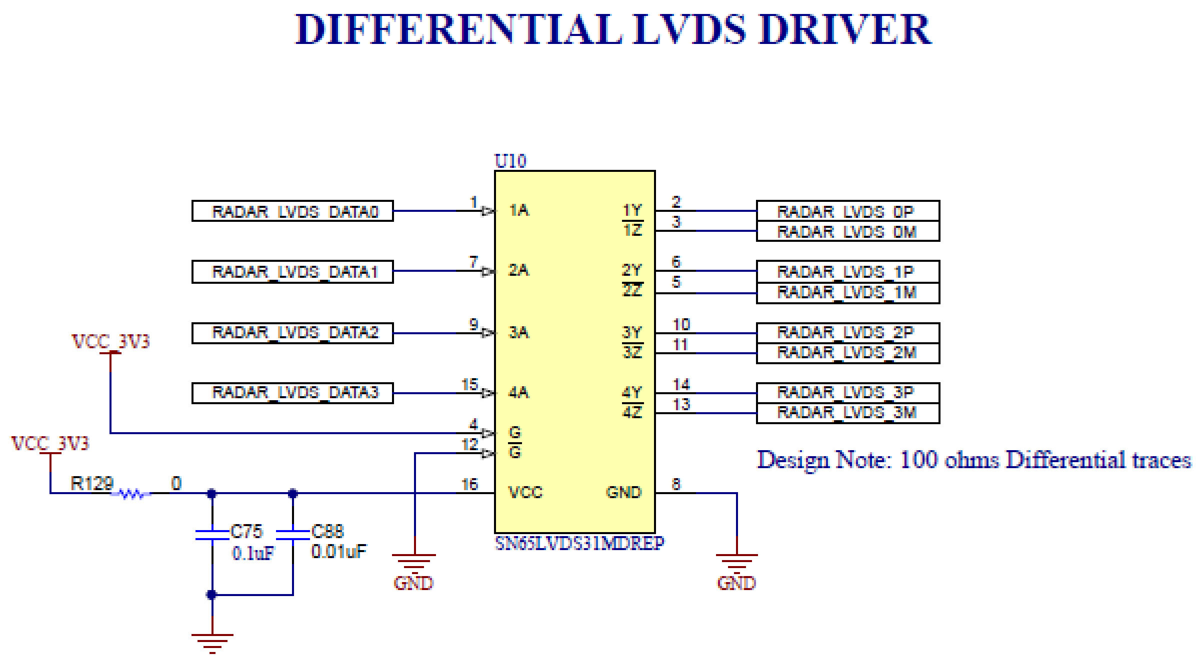


Figure 6-20. DCA1000 CMOS TO LVDS Conversation for Data Lines

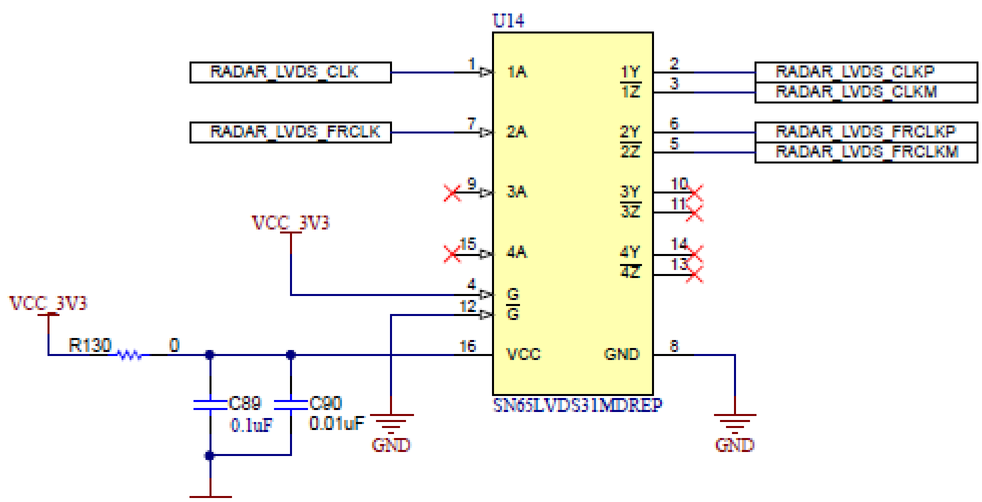


Figure 6-21. DCA1000 CMOS TO LVDS Conversation for Clock and Control Lines

7 Software, Development Tools, and Example Code

To enable quick development of end applications on the ARM® Cortex® M4F core in the XWRL6432, TI provides a software development kit (SDK) that includes demo codes, software drivers, emulation packages for debug, and more.

For more information, please refer to mmWave low power SDK user guide.

Below are the steps to running the demo visualizer using the EVM.

7.1 XWRL6432 Demo Visualization Getting Started

1. Step 1 : Connect the EVM to the PC via USB
2. Step 2 : Select the Device on the Visualizer. Check the SOP settings for “Functional mode”
3. Step 3 : “AUTO Detect” COM ports
4. Step 4 : In “System Config” tab of the visualizer perform “Scene Selection”
5. Step 5 : “Send Config to Device”
6. Step 6 : “Plots” tab should display point cloud information

8 TI E2E Community

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

9 References

1. DCA1000EVM Data Capture Card User’s Guide
2. mmwave-sdk.

Revision History

DATE	REVISION	NOTES
December 2022	*	Initial Release