AWR2944EVM User's Guide

User's Guide

Literature Number: SPRUJ22
NOVEMBER 2021

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1.1 Introduction

The AWR2944EVM is an easy-to-use evaluation board for the AWR294x mmWave sensing device, with direct connectivity to the DCA1000 EVM.This EVM kit contains everything needed to start developing software for the on-chip C66x DSP, ARM® Cortex®-R5F controller, and hardware accelerator (HWA 2.0). Also included is on-board emulation for programming and debugging as well as on-board buttons and LEDs for quick integration of a simple user interface.

1.2 Key Features

- On-board antenna
- XDS110 based JTAG emulation with Serial port for onboard QSPI flash programming.
- UART to USB Debug port for terminal access using FT4232H
- 60-pin, high-density (HD) connector for external JTAG/ Emulator Interface with TRACE and CSI2 support
- 60-pin, high-density (HD) connector for debug, SPI, I2C and LVDS
- RJ45 connector to stream the captured data over the network to the host PC
- MATEnet Ethernet interface to stream the captured data over the network to an automotive host
- Dual On-board CAN-FD transceiver
- One button and LED for basic user interface
- 12V power jack to power the board

1.3 What's Included

1.3.1 Kit Contents

- AWR2944EVM
- Micro USB cable
- Ethernet Cable
- Mounting brackets, screws, spacers and nuts, to allow placing the PCB vertical

Note

A 12V, > 2.5-A supply brick with a 2.1-mm barrel jack (center positive) is not included. TI recommends using an external power supply that complies with applicable regional safety standards, such as UL, CSA, VDE, CCC, PSE, and more. The length of the power cable should be < 3 m.

The following power supply has been tested to work with the AWR2944EVM: **SDI65-12-U-P5**.

1.3.2 mmWave Out-of-Box (OOB) Demo

TI provides sample demo codes to easily get started with the AWR2944 evaluation module (EVM) and to experience the functionality of the AWR2944 radar sensor. For details on getting started with these demos, see www.ti.com/tool/mmwave-sdk.

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CAUTION HOT SURFACE
CONTACT MAY CAUSE BURN
DO NOT TOUCH

Note

During operation, a minimum separation distance of 5 centimeters should be maintained between the user and the EVM.

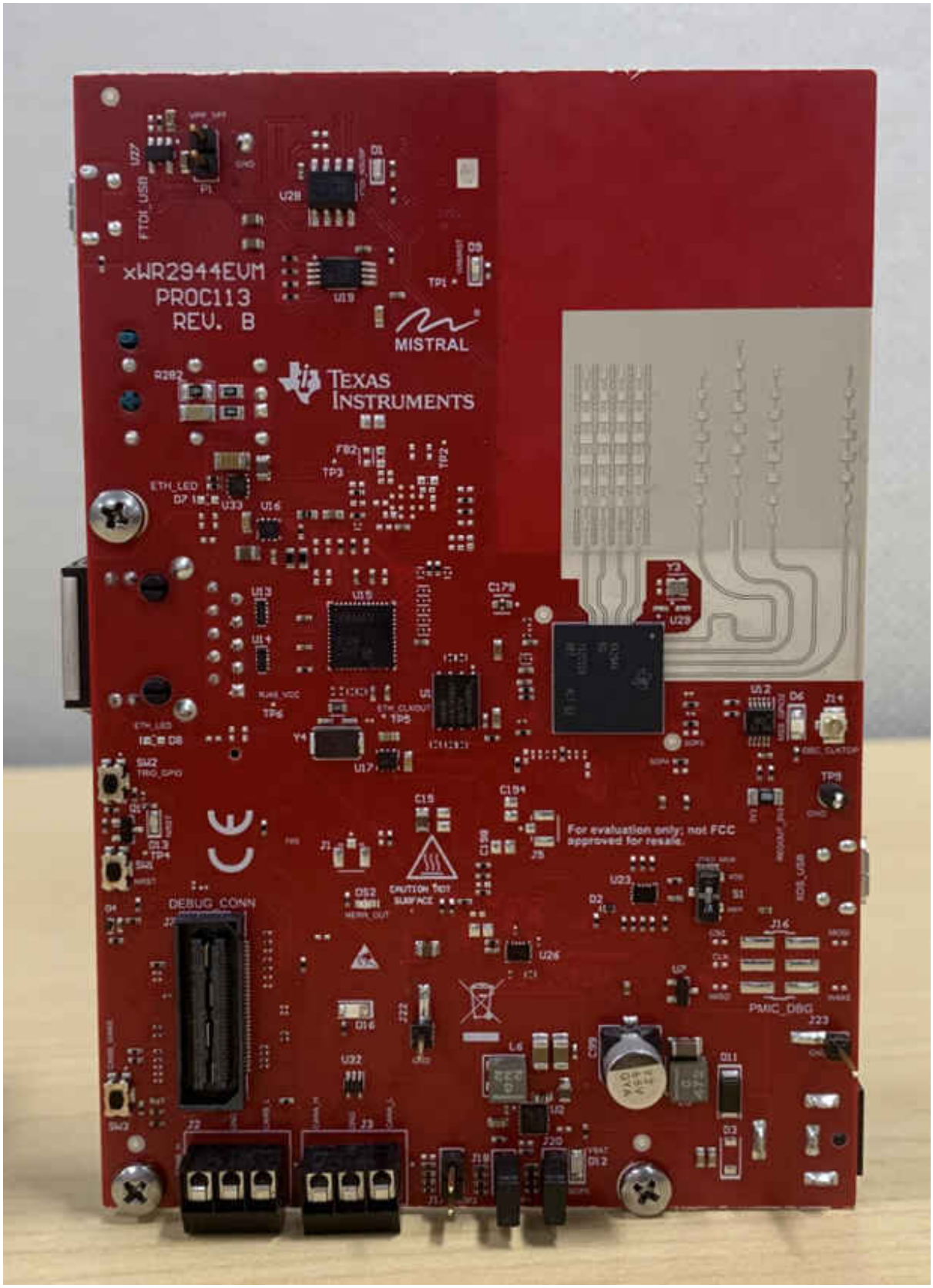


Figure 2-1. AWR2944EVM Front View

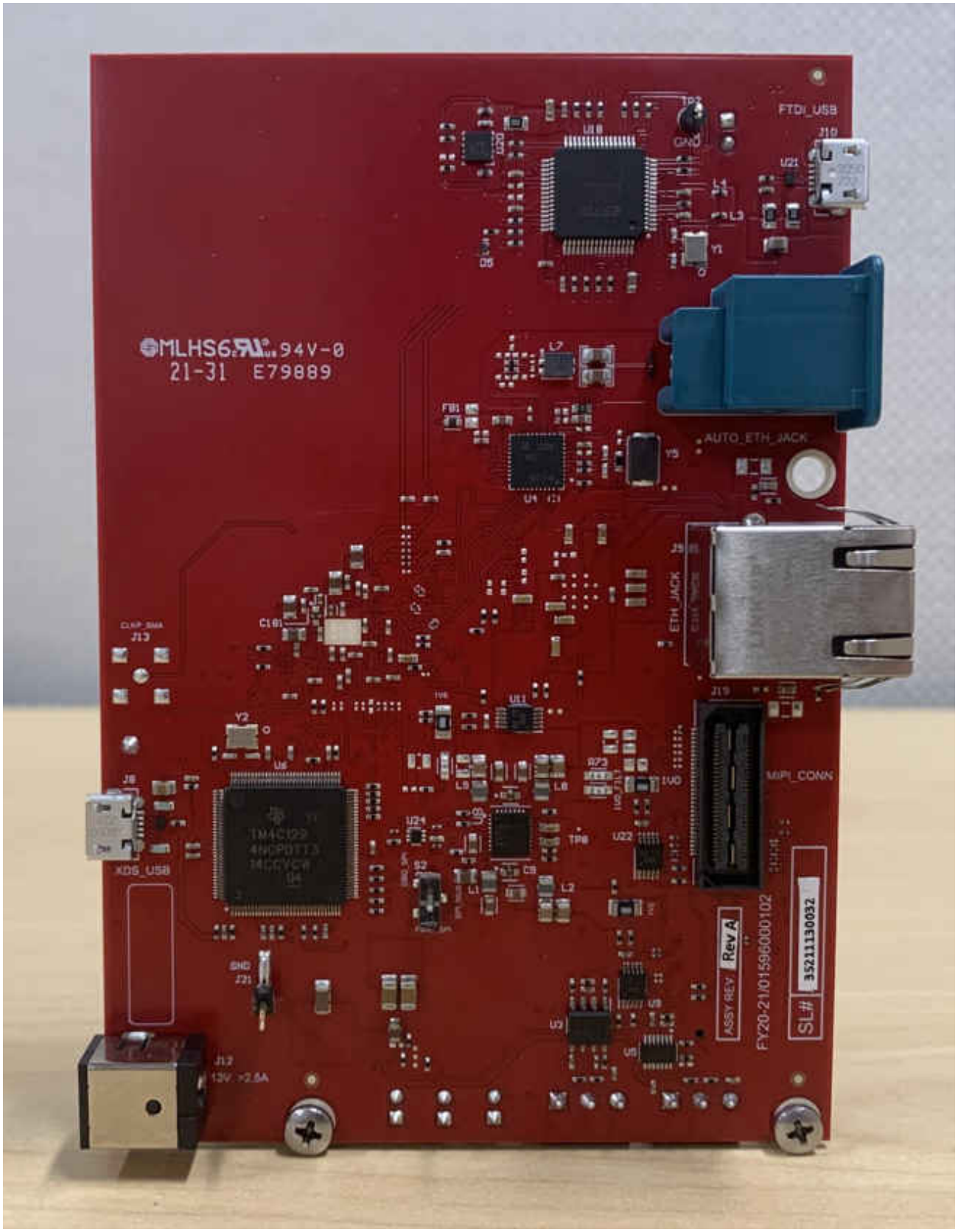


Figure 2-2. AWR2944EVM Back View

2.1 Block Diagram

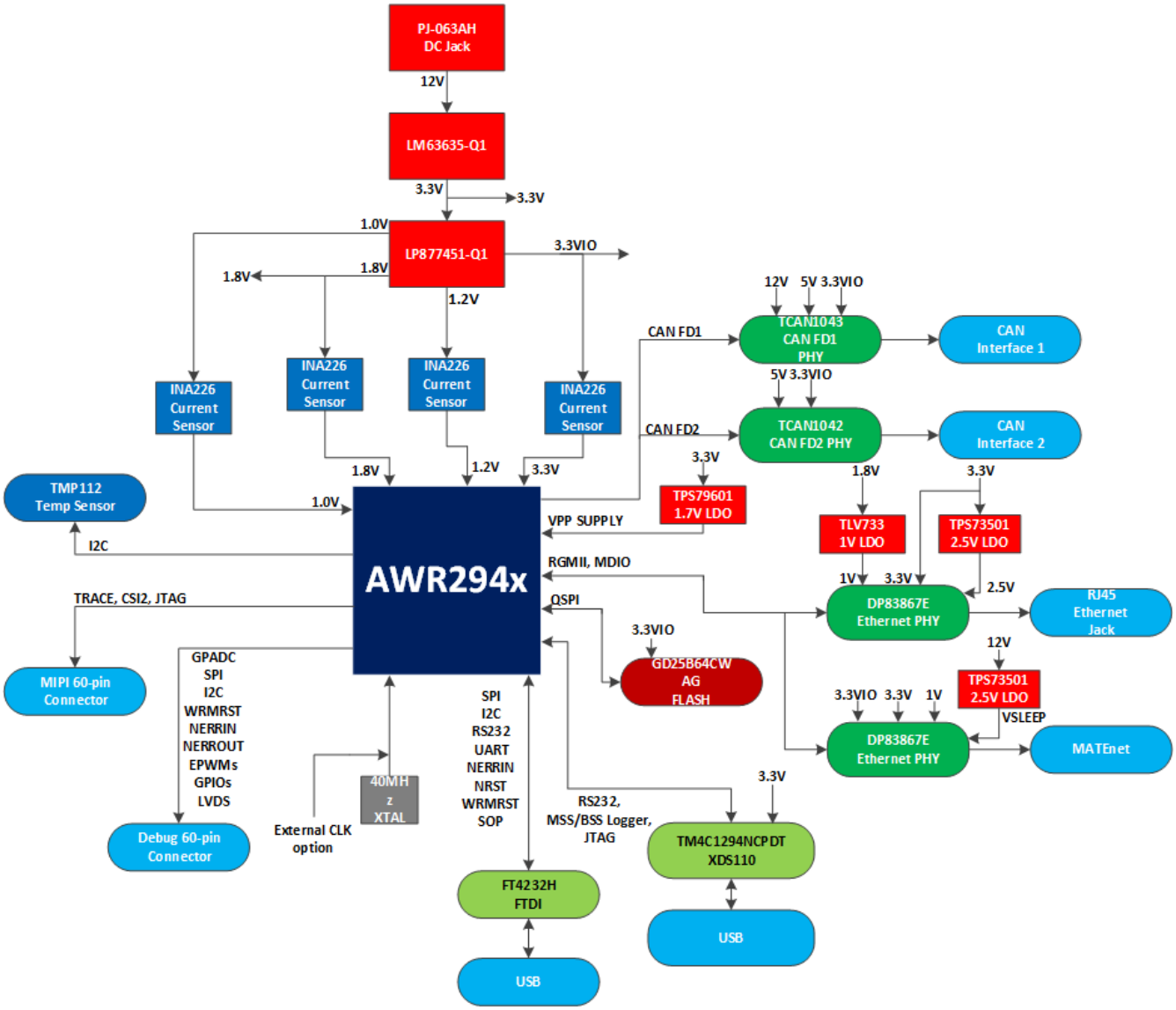


Figure 2-3. AWR2944EVM Block Diagram

2.2 PCB 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. Operate on an antistatic work surface. For more information on proper handling, refer to SSYA010A.

2.3 Power Connections

The AWR2944EVM is powered by the 12-V power jack (>2.5-A current capability). When power is provided the AR_NRST, VBAT_INT, and 5V0 LEDs should glow, indicating that the board is powered up.

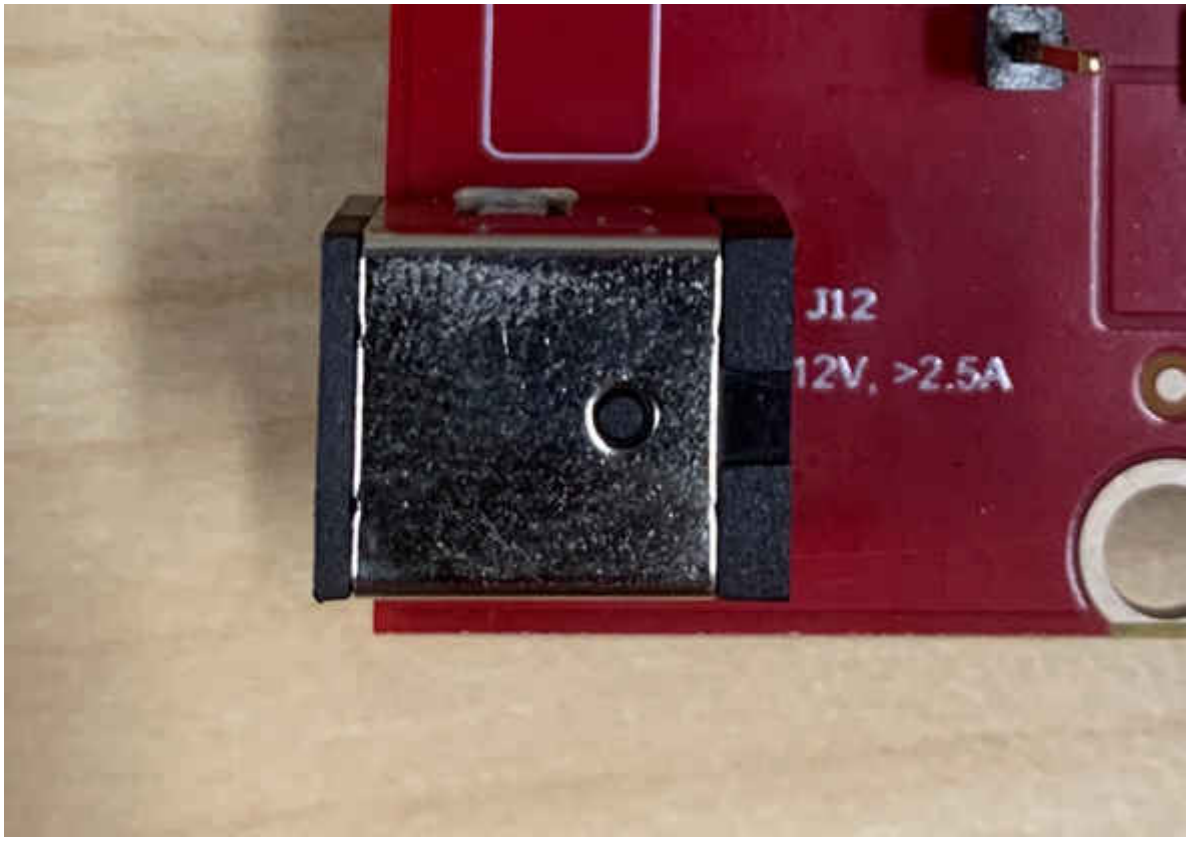


Figure 2-4. 12-V Power Connector

Note

After the 12-V power supply is provided to the EVM, it is recommended to press the NRST switch (SW1) one time to ensure a reliable boot-up state.

2.4 Connectors

2.4.1 MIPI 60-Pin Connector (J19)

This connector provides the standard MIPI 60-pin interface, as shown in Figure 5, for JTAG, CSI2 and trace capability through emulators such as the XDS560pro. Further information on the emulation and trace header can be found in the Emulation and Trace Headers Technical Reference Manual.This connector also provides access to the CSI_RX lanes which allow for playback or feeding external data and bypassing the RF front end, which enables testing and algorithm development on a known dataset.

To use this interface, the JTAG lines from the AWR2944EVM needs to be muxed to MIPI 60-pin connector. Refer to Section 2.7.1 for more details.

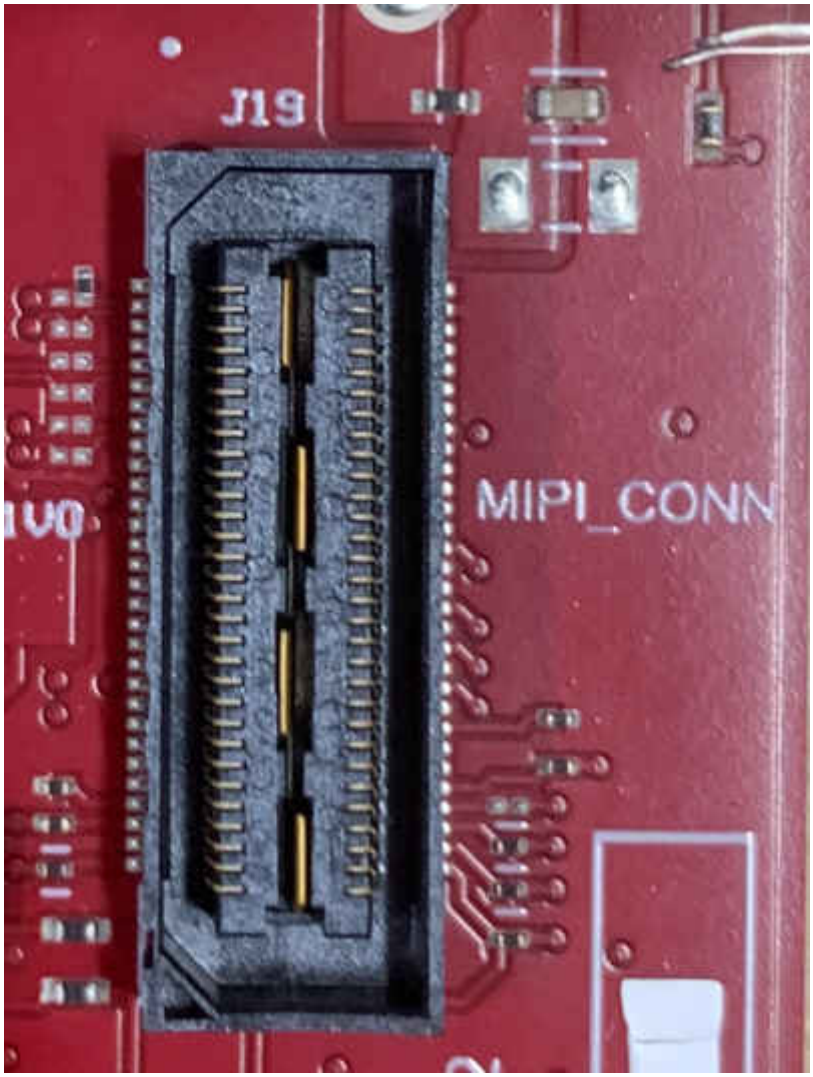


Figure 2-5. 60-pin MIPI Connector

Table 2-1 provides the pin assignment details for the MIPI 60-pin connector.

Table 2-1. J19 Pin Assignment

Pin Number	Description	Pin Number	Description
1	MIPI_VREF_DEBUG	2	MIPI_TMS
3	MIPI_TCK	4	MIPI_TDO
5	MIPI_TDI	6	MIPI_NRST
7	MIPI_RTCK	8	MIPI_TRSTPD
9	MIPI_JTAG_NRST	10	NC
11	NC	12	MIPI_VREF_DEBUG
13	TRACE_CLK	14	NC
15	MIPI_DBG_DETECT	16	GND
17	TRACE_CTL	18	NC
19	TRACE_DATA0	20	NC
21	TRACE_DATA1	22	NC
23	TRACE_DATA2	24	NC
25	TRACE_DATA3	26	NC

Table 2-1. J19 Pin Assignment (continued)

Pin Number	Description	Pin Number	Description
27	TRACE_DATA4	28	NC
29	TRACE_DATA5	30	NC
31	TRACE_DATA6	32	NC
33	TRACE_DATA7	34	NC
35	NC	36	NC
37	NC	38	NC
39	NC	40	NC
41	NC	42	GND
43	NC	44	CSI2_CLK_P
45	NC	46	CSI2_CLK_N
47	NC	48	GND
49	NC	50	CSI2_1_P
51	NC	52	CSI2_1_N
53	NC	54	GND
55	NC	56	CSI2_0_P
57	GND	58	CSI2_0_N
59	NC	60	GND

2.4.2 Debug Connector-60 pin (J7)

This connector enables interfacing of LVDS signals to the DCA1000 EVM for data capturing purposes.

Also it has SPI, I2C, JTAG, GPADC, WRMRST, NRROUT, EPWM, and other control signals from AWR2944EVM for debug purpose.

The SPI interface is multiplexed to the Debug Connector. For more details refer to Section 2.7.1.

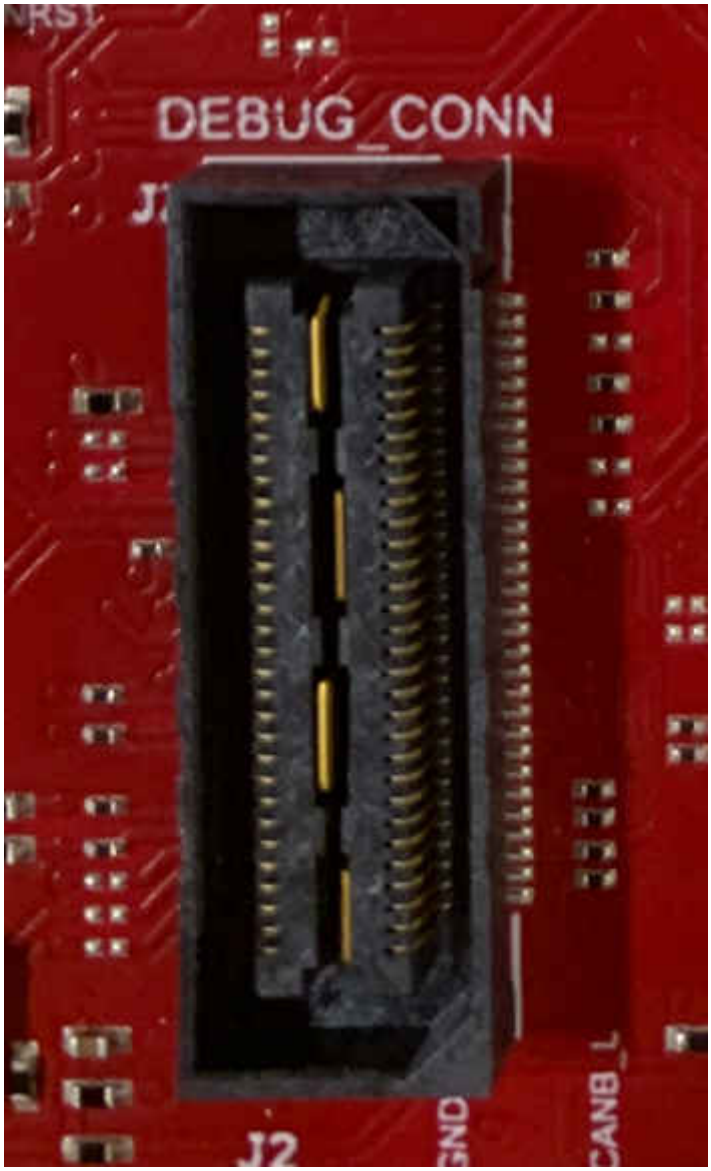


Figure 2-6. 60-pin Debug Connector

Table 2-2 provides the pin assignment details for the Debug 60-pin connector.

Table 2-2. J7 Pin Assignment

Pin Number	Description	Pin Number	Description
1	NC	2	NC
3	NC	4	XREF_CLK0
5	GND	6	MSS_EPWMA0
7	DBG_SPI_CS0	8	GND
9	DBG_SPI_CLK	10	MSS_SPIA_HOSTIRQ
11	DBG_SPI_MOSI	12	DBG_SPI_MISO
13	3.3V PULL_UP	14	XREF_CLK1
15	EMU_TCK	16	MCU_CLKOUT
17	EMU_TDI	18	GND
19	GPADC1	20	EMU_TMS

Table 2-2. J7 Pin Assignment (continued)

Pin Number	Description	Pin Number	Description
21	GPADC2	22	EMU_TDO
23	GPADC3	24	GND
25	GPADC4	26	LVDS_TX3_FRCLK_P
27	GPADC5	28	LVDS_TX3_FRCLK_N
29	GPADC6	30	GND
31	GPADC7	32	NC
33	GPADC8	34	NC
35	GPADC9	36	GND
37	MSS_SPIB_CS1	38	NC
39	SOP1_MSS_SPIB_CS2	40	NC
41	MSS_GPIO_0	42	GND
43	MSS_GPIO_1	44	LVDS_TX2_CLK_P
45	AR_WRMRST	46	LVDS_TX2_CLK_N
47	NC	48	GND
49	AR_NERROUT	50	LVDS_TX1_P
51	MSS_I2CA_SCL	52	LVDS_TX1_N
53	MSS_I2CA_SDA	54	
55	MSS_EPWMB0	56	LVDS_TX0_P
57	MSS_EPWMA1	58	LVDS_TX0_N
59	MSS_GPIO_3	60	GND

2.4.3 CAN-A Interface Connector (J3)

The J3 connector provides the CANA_L and CANA_H signals from the onboard can CAN-FD transceiver (TCAN1042HGVDRQ1). These can be directly wired to the CAN bus.

Figure 2-7. CAN_A Connector

Table 2-3 provides the pin assignment details for the CAN_A connector.

Table 2-3. J3 Pin Assignment

Pin Number	Description
1	CAN_L
2	GND
3	CAN_H

2.4.4 CAN-B Interface Connector (J2)

The J2 connector provides the CANB_L and CANB_H signals from the onboard can CAN-FD transceiver (TCAN1043ADYYRQ1). These can be directly wired to the CAN bus.

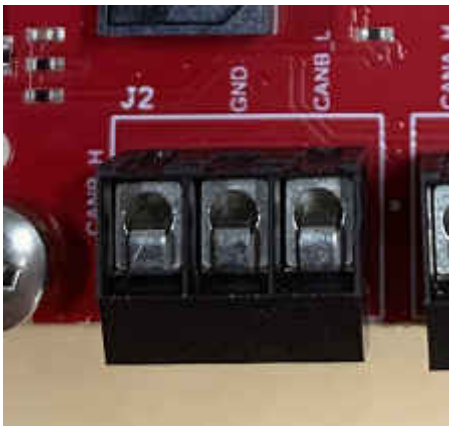


Figure 2-8. CAN_B Connector

Table 2-4 provides the pin assignment details for the CAN_B connector connector.

Table 2-4. J2 Pin Assignment

Pin Number	Description
1	CAN_L
2	GND
3	CAN_H

2.4.5 Ethernet Ports (J4 and J9)

The AWR2944EVM supports two RGMII Ethernet ports to provide the connection to the network. The J4 connector provides access over a MATEnet port (9-2304372-9 connector) via a DP83TC812R-Q1 PHY. The J9 port provides access over an RJ45 port via a DP83867ERGZR PHY. By default, the RGMII interfaces is connected to the J9 port only. In order to access the RGMII interface over the J4 connector several resistors must be populated. For more details please see Section 2.4.5.1 and refer to the Schematic, BOM, and Assembly and Database and Layout files.

This interface is intended to operate primarily as a 100Mbps ECU interface. It can also be used as an Instrumentation Interface.

It supports following features:

- Full Duplex 10Mbps/100Mbps wire rate Interface to Ethernet PHY over RGMII, parallel interface
- MDIO Clause 22 and 45 PHY management interface
- IEEE 1588 Synchronous Ethernet support

The Ethernet port is interfaced to the AWR2944 through the Ethernet PHY and is used to stream the captured data over the network to the host PC.

Figure 2-9 shows the Ethernet RJ45 Mag-Jack connector, and Table 2-5 provides the connector pin details.

Table 2-5. J9 Pin Assignment

Pin Number	Description	Pin Number	Description
1	GND	2	Test point
3	ETH_D4P	4	ETH_D4N
5	ETH_D3P	6	ETH_D3N
7	ETH_D2P	8	ETH_D2N
9	ETH_D1P	10	ETH_D1N

Table 2-5. J9 Pin Assignment (continued)

Pin Number	Description	Pin Number	Description
11	LED_ACTn	12	GND
13	GND	14	LED_LINKn
15	ETH_GND	16	ETH_GND

Figure 2-9. RJ45 Connector

Figure 2-10 shows the Ethernet MATEnet connector, and Table 2-6 provides the connector pin details.

Table 2-6. J4 Pin Assignment

Pin Number	Description	Pin Number	Description
1	TRD_P	2	TRD_M
S1	GND	S2	GND
S3	GND	S4	GND
S5	GND	S6	GND

Figure 2-10. MATEnet Connector

2.4.5.1 ECOs to Enable the DP83TC812R PHY

By default, the board is designed to be used with the DP83867E PHY with the RJ45 connector. To enable the DP83TC812R PHY with the MATEnet connector, the following hardware changes must be made. For help with locating these components on the PCB, refer to the provided Schematic, BOM, and assembly files.

1. Remove R98 and populate on R74
2. Remove R101 and populate on R230
3. Remove R103 and populate on R96
4. Remove R105 and populate on R100
5. Remove R121 and populate on R178
6. Remove R122 and populate on R225
7. Remove R195 and populate on R245
8. Remove R290 and populate on R234
9. Remove R325 and populate on R237
10. Remove R336 and populate on R238
11. Remove R338 and populate on R239
12. Remove R339 and populate on R240
13. Remove R413 and populate on R247
14. Remove R369 and populate on R249
15. Populate D18 and D19 ESD diodes
16. Populate C55
17. The bootstrap configuration pins can be populated/removed as needed depending on the use case

2.4.6 USB Connectors (J8, J10)

Note

The EVM should be powered on before the USB cables are connected. Plugging in the USB cables before powering on the board can cause the board to get stuck in a permanent reset state. In the event that this occurs, just unplug the USB cables, power cycle the EVM, and plug in the USB cables to resolve the issue.

The AWR2944EVM has two standard micro USB connectors.

Micro USB Connector J10 provides access to the AWR2944 UART, SPI, I2C, RS232, and SOP interfaces through the FTDI chip.

Table 2-7. J10 Pin Assignment

Pin Number	Description	Pin Number	Description
1	FTDI_VBUS	2	FTDI_USBD_N
3	FTDI_USBD_P	4	FTDI_USBID
5	GND	6	GND
7	GND	8	GND
9	GND	10	GND
11	GND		

Figure 2-11. FTDI USB Port

Micro USB connector J8 provides access to the JTAG, MSS_UARTA, and MSS_UARTB interfaces of the AWR2944 via the XDS110 emulator.

This is the UART interface used to flash the binary to the onboard serial flash and for Out-of-box (OOB) demo.

Note

The OOB demo requires only J8 to be connected to the PC. J10 is not used for the OOB demo.

Table 2-8. J8 Pin Assignment

Pin Number	Description	Pin Number	Description
1	XDSET_VBUS	2	XDSET_D_N
3	XDSET_D_P	4	XDSET_ID
5	GND	6	GND
7	NC	8	NC
9	GND	10	GND
11	GND		

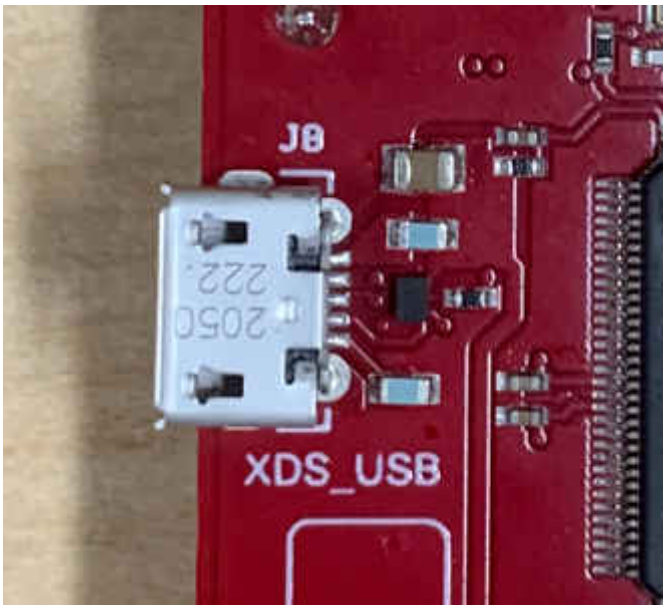


Figure 2-12. XDS USB Port

2.4.7 OSC_CLKOUT Connector (J14)

Connector J14 provides access to measure oscillator clock out signal from the AWR2944 device.

Figure 2-13. OSC Clock Port

2.4.8 PMIC SPI Connector (J16) (DNP)

Connector J16 provides access to the SPI and enable pins on the PMIC (U8). This part is not populated by default. To populate this connector with the appropriate part, please refer to the Schematic, BOM, and assembly files.

Table 2-9. J8 Pin Assignment

Pin Number	Description	Pin Number	Description
1	PMIC SPI_CS	2	PMIC SPI_MOSI
3	PMIC SPI_CLK	4	NC
5	PMIC SPI_MISO	6	PMIC ENABLE

2.4.9 Voltage Rails Ripple Measurement Connectors (J1, J5) (DNP)

J1 Provides access to measure ripple on 1V0_FILTERED (1.0 analog RF supply for AWR2944) voltage rail.

J5 Provides access to measure ripple on 1V8_FILTERED (1.8-V analog supply for AWR2944) voltage rail.

These connectors are not populated on the board by default. To populate these connectors with the appropriate part, please refer to the Schematic, BOM, and assembly files.

2.5 Antenna

The AWR2944EVM includes onboard etched antennas for the four receivers and four transmitters, which enables tracking multiple objects with their distance and angle information. This antenna design enables estimation of both azimuth and elevation angles, which enable object detection in a 3-D plane (see Figure 2-14).

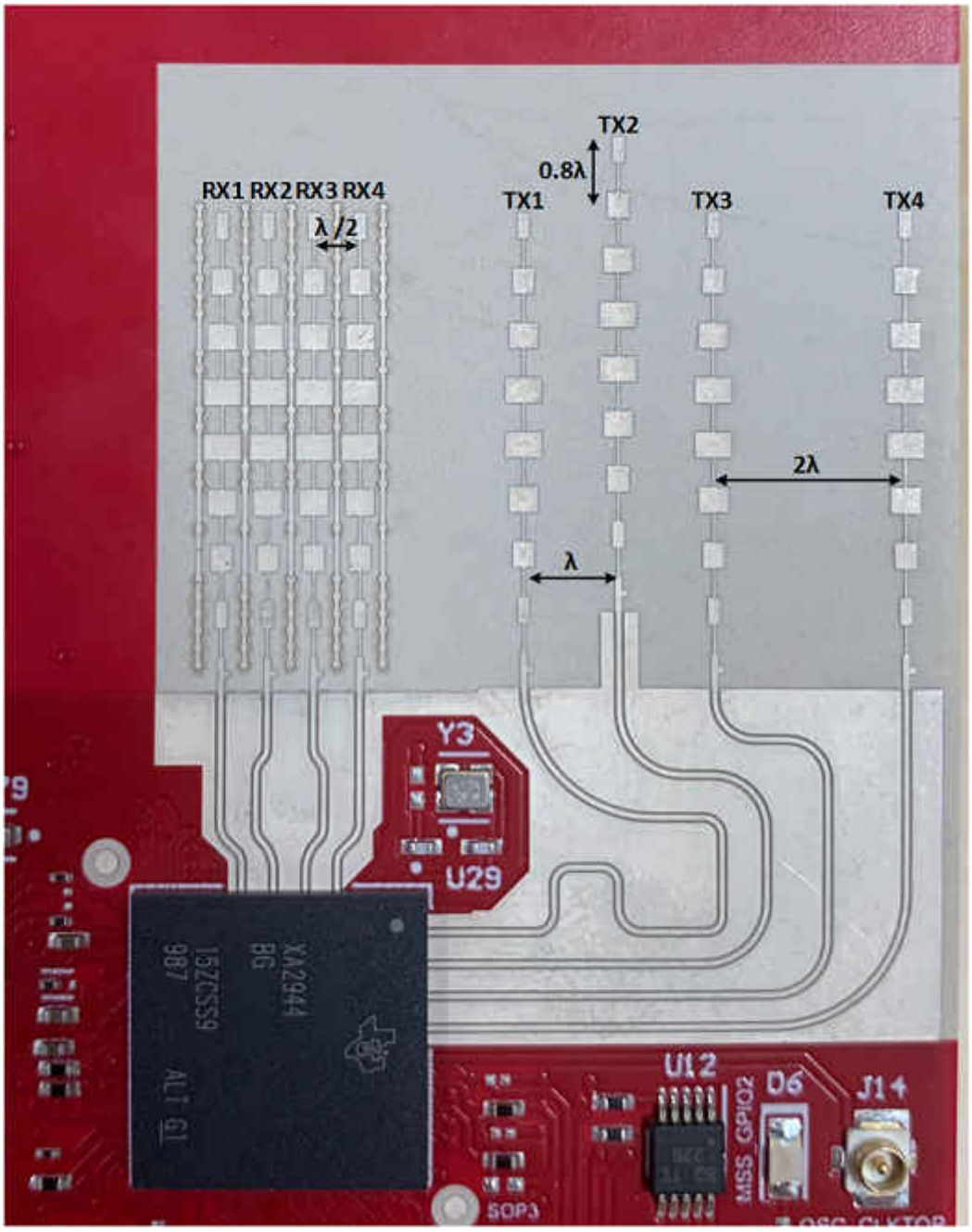


Figure 2-14. AWR2944EVM Antenna Design

The antenna placement shown in Figure 2-14 results in the virtual antenna array shown in Figure 2-15.

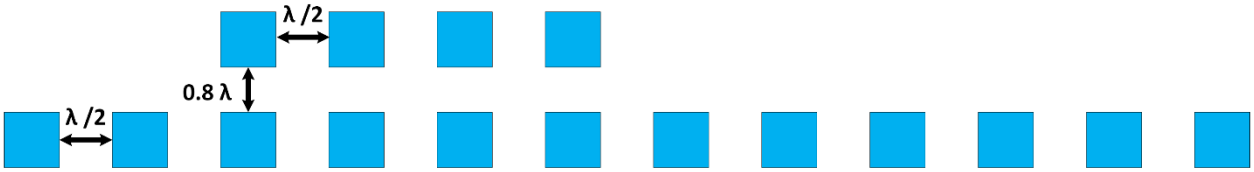


Figure 2-15. Virtual Antenna Array

The antenna peak gain is 13 dBi across the frequency band of 76 to 81 GHz. The radiation pattern of the antenna in the horizontal plan (H-plane) and elevation plan (E-plane) is as shown in Figure 2-16 and Figure 2-17, respectively.

The beamwidth of the antenna design can be determined from the radiation patterns provided below. For example, based on 3-dB drop in the gain as compared to bore sight, the horizontal 3dB-beamwidth is approximately ±30 degrees (see Figure 2-16), and elevation 3dB-beamwidth is approximately ±3 degrees (see Figure 2-17). Similarly, the horizontal 6dB beamwidth is approximately ±45 degrees (see Figure 2-16) and the elevation 6dB-beamwidth is approximately ±5 degrees (see Figure 2-17).

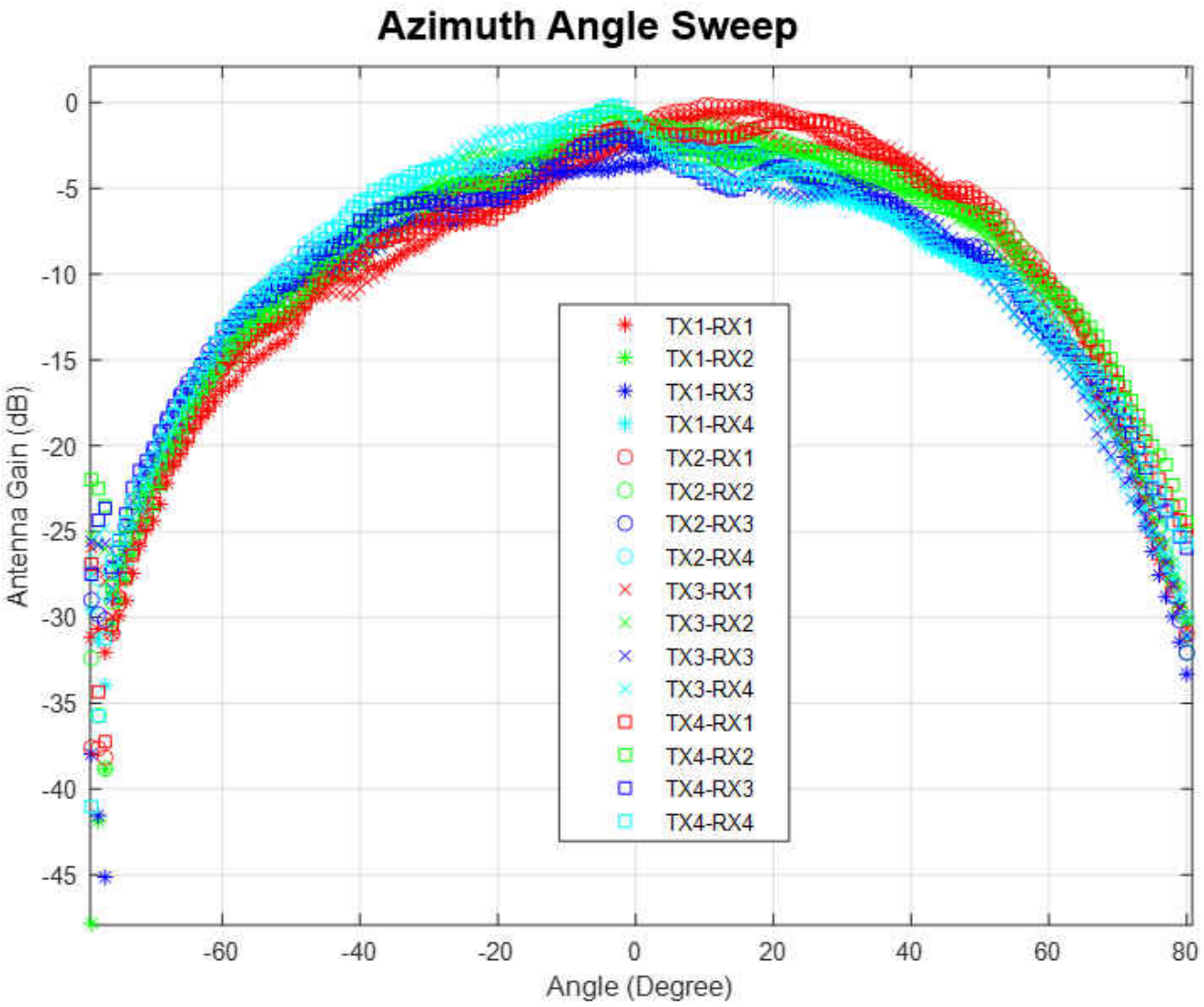


Figure 2-16. Azimuth Radiation Pattern

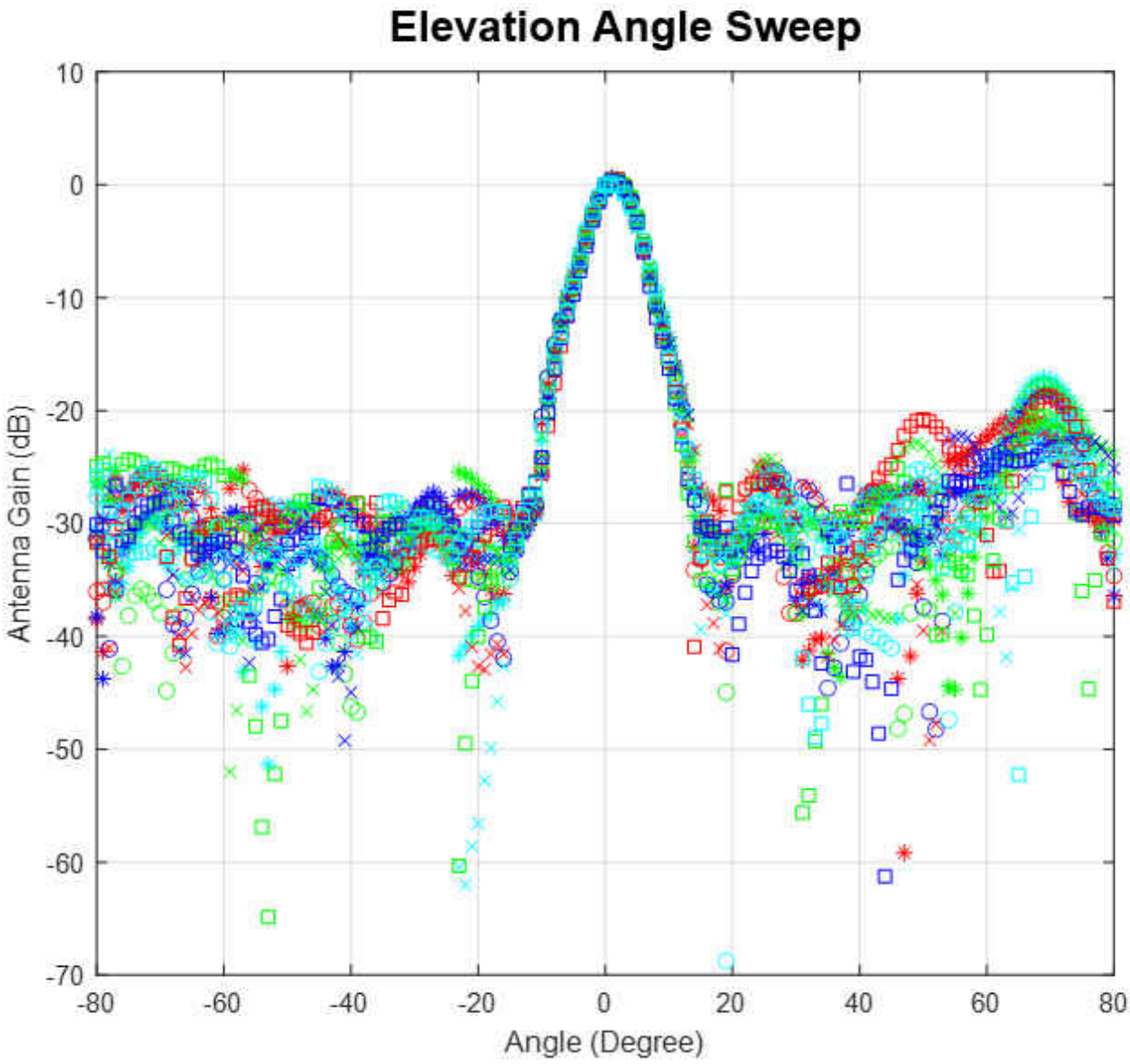


Figure 2-17. Elevation Radiation Pattern

2.6 On-board Sensors

The AWR2944EVM provides access to an on-board temperature sensor (TMP112AIDRLR) and four on-board current sensors (INA226AIDGSR). These sensors can be controlled by the radar via I2C. For details about the I2C addresses of these sensors, refer to Section 2.9.3.

The current sensors are designed to measure the current being supplied to the various power rails of the AWR2944 device. For details on the supply nodes that can be measured using the current sensors, refer to Table 2-10.

Table 2-10. Current Sensor Supply Details

Reference Designator	Supply Node	PCB Net Name
U9	AWR 1.2-V Supply	1V2
U11	AWR 1.8-V Supply	1V8
U12	AWR 3.3-V Supply	3V3

Table 2-10. Current Sensor Supply Details (continued)

Reference Designator	Supply Node	PCB Net Name
U22	AWR 1.0-V Supply	1V0

2.7 PC Connection

The PC connectivity is provided via two micro USB connectors, J8 and J10.

2.7.1 XDS110 Interface

J8 provides access to the onboard XDS110 (TM4C1294NCPDT) emulator. This connection provides the following interfaces to the PC:

- JTAG for CCS connectivity
- MSS logger UART (can be used to get MSS code logs on the PC)

When the J8 USB is connected to the PC the device manager should recognize two XDS110 COM ports under Ports (COM & LPT).

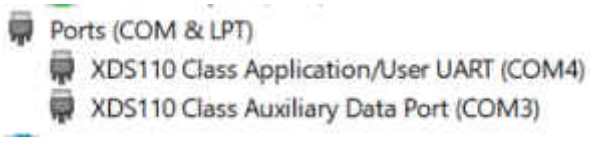


Figure 2-18. XDS110 COM Ports

XDS110 debug probe and data port are detected under Texas Instruments Debug Probes.

Figure 2-19. TI Debug Probes

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

2.7.2 FTDI Interface

J10 provides access to the onboard FTDI ports. This provides the following interfaces to the PC:

- FTDI Port A -> MSS_SPIA interface
- FTDI Port B-> MSS_I2C interface; Host INTR signal.
- FTDI Port C -> BSS_UART port; DSS_UART port (not populated by default); NRESET and WARMRST control signals.
- FTDI Port D -> MSS_RS232 port; SOP0, SOP1, and SOP2 control signals

When the USB is connected for the first time to the PC, Windows® maybe not be able to recognize the device. This is indicated in the device manager with yellow exclamation marks, as shown in Figure 2-20.

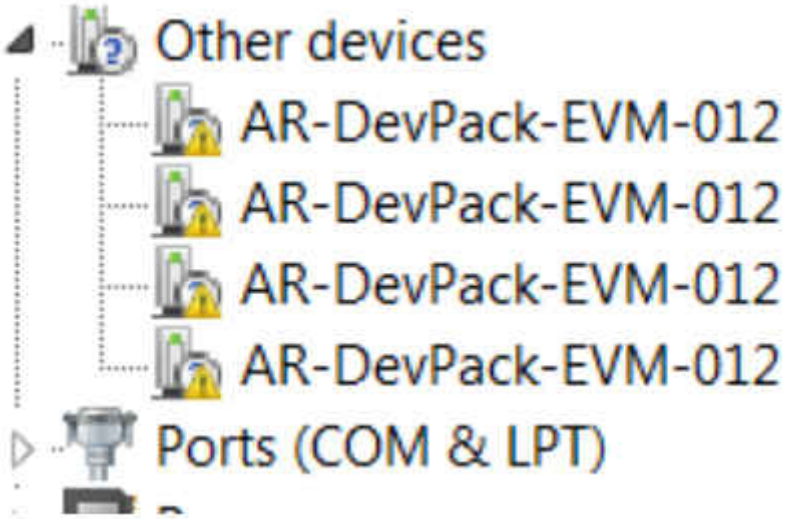


Figure 2-20. Uninstalled FTDI Drivers

To install the devices, download the latest FTDI drivers available in the mmwave SDK package. Right click on these devices, and update the drivers by pointing to the location where the FTDI drivers were installed (**C:\ti\mmwave_sdk_<version_number>\tools\ftdi**). This must be done for all four COM ports. When all four COM ports are installed, the device manager recognizes these devices and indicates the COM port numbers, as shown in Figure 2-21.

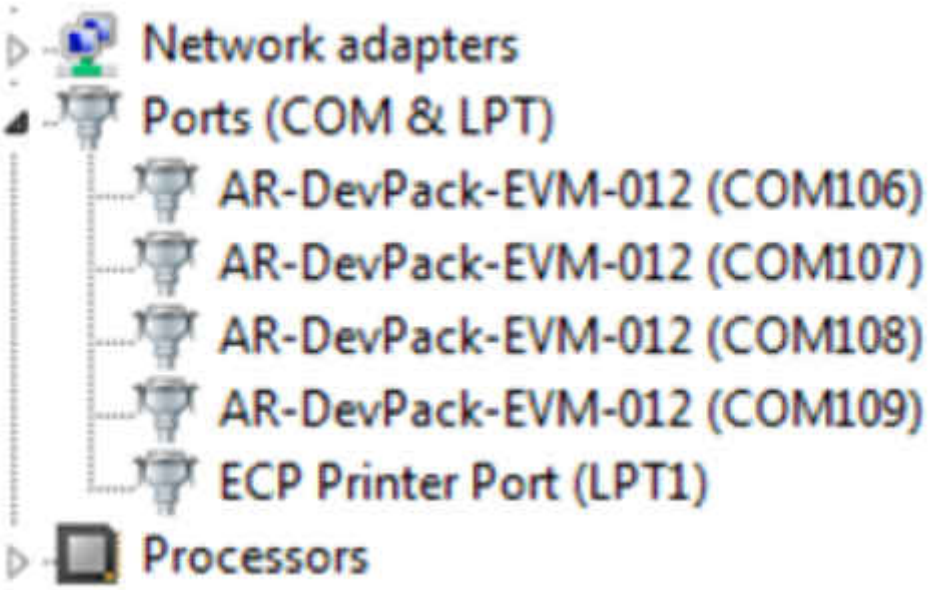


Figure 2-21. Installed FTDI Drivers

2.8 Connecting the AWR2944EVM to the DCA1000 EVM

The AWR2944EVM can be connected to the DCA1000 EVM platform to allow for LVDS data streaming. Figure 2-22 shows the AWR2944EVM interfaced to the DCA1000 EVM.

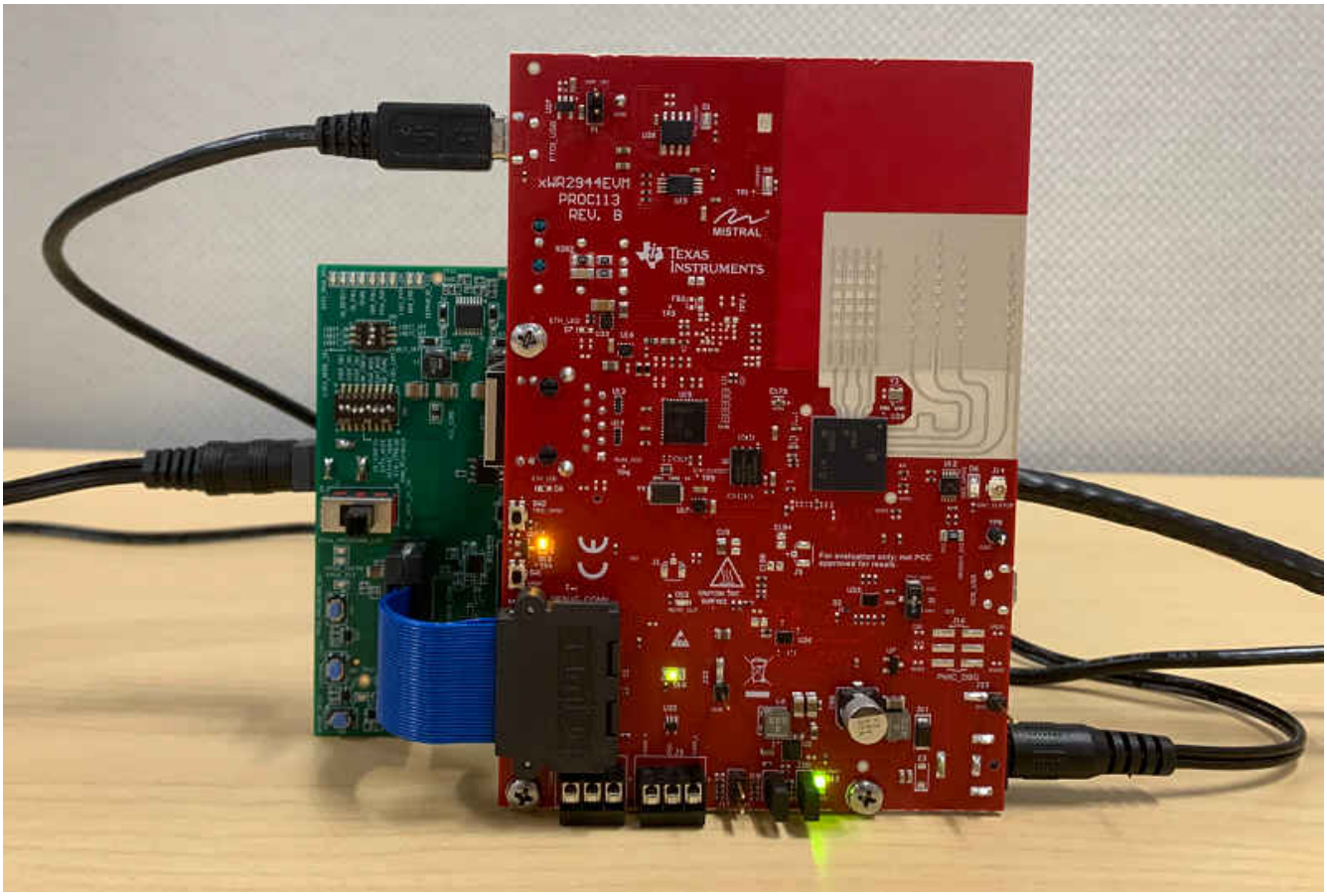


Figure 2-22. AWR2944EVM and DCA1000 EVM

When using the AWR2944EVM with the DCA1000 EVM, the following settings should be used.

1. Set the AWR2944EVM to SOP2 mode.

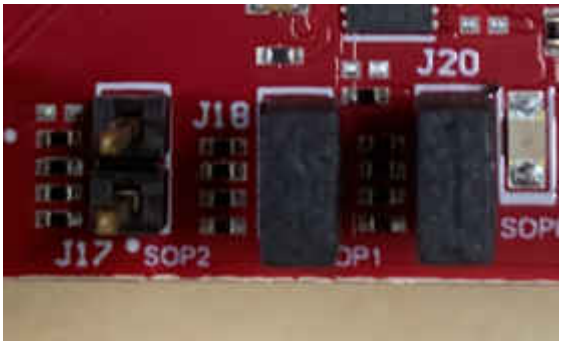


Figure 2-23. SOP2 Mode

2. Set the DCA1000 EVM switches to the following configuration.

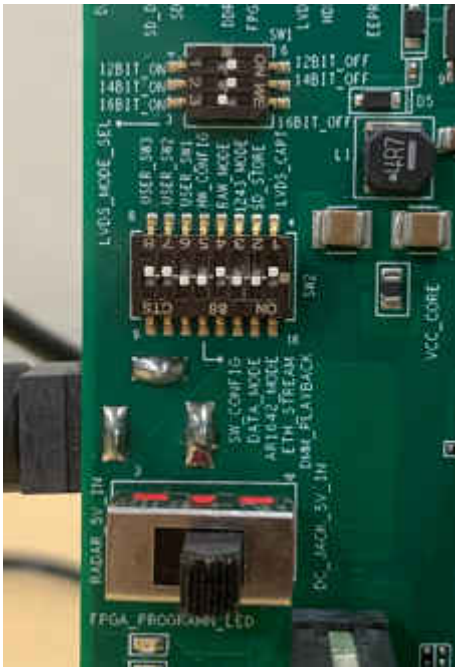


Figure 2-24. DCA1000 Switch Settings

3. The 12-V supply should be connected to J12 on the AWR2944EVM
4. A 5-V supply should be connected to J2 on the DCA1000 EVM
5. A micro USB cable should be connected to the FTDI port on the AWR2944EVM (J10)
6. The Samtec ribbon cable should be connected to J7 on the AWR2944EVM and J3 on the DCA1000 EVM
7. An RJ45 cable should be connected to J6 on the DCA1000 EVM

2.9 Jumpers, Switches, and LEDs

2.9.1 Switches

The AWR2944EVM contains two switches to mux various interfaces to different connectors on the EVM.

Table 2-11. MUX Switches

Reference	Usage	Comments	Image
S1	JTAG	When set to 'MIPI' position, the JTAG interface is routed to the MIPI 60-pin connector (J19). When set to 'XDS' position, the JTAG interface is routed to the XDS110 USB interface (J8)	

Table 2-11. MUX Switches (continued)

Reference	Usage	Comments	Image
S2	SPI	When set to 'PMIC_SPI' position, the MSS_SPIB interface is routed to the PMIC and to the J16 header. 1 When set to 'DBG_SPI', the MSS_SPIB interface is routed to the 60-pin debug header (J7)	

1. DNP resistors R5, R61, R167, and R176 must be populated to bring the MSS_SPIB interface out to the J16 header.

2.9.2 Sense On Power (SOP) Jumpers (J17, J18, J20)

The AWR2944EVM can be set to operate in different modes based on the state of the SOP [2:0] lines. These lines are sensed ONLY during boot up of the AWR2944 device. The state of the device is described in Table 2-12.

A closed jumper refers to a '1' and open the jumper refers to a '0' state of the SOP signal going to the AWR2944 device.

Note

The SOP[2:0] pins can also be controlled via the on-board FTDI. In this case the FTDI settings would override the jumper settings.

Table 2-12. SOP[0:2] Modes

Reference	Usage	Comments
J17 (SOP 2), J18 (SOP 1), J20 (SOP 0)	SOP[2:0]	101 (SOP mode 5) = Flashing mode 001 (SOP mode 4) = Functional mode 000 (SOP mode 3) = Reserved 011 (SOP mode 2) = Development mode 010 (SOP mode 1) = Reserved

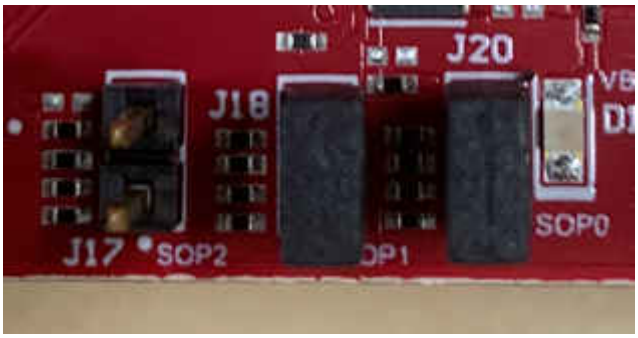


Figure 2-25. SOP Jumpers

Additionally, the SOP[4:3] signals defines the XTAL clock input as per the below configurations provided in Table 2-13.

Table 2-13. SOP[4:3] Modes

Reference	Usage	Comments
R303, R312 Populated. R301,R309 unpopulated	SOP[4:3]	00 = 40 MHz **(Default state)**
R301, R312 Populated. R303,R319 unpopulated		01 = 45.1584 MHz
R303, R309 Populated. R301,R312 unpopulated		10 = 49.152 MHz
R301, R309 Populated. R303,R312 unpopulated		11 = 50 MHz

2.9.3 I2C Connections

The board features temperature sensor for measuring onboard temperature, current sensors for current measurement for 1.2-V, 1.8-V, 3.3-V, 1V0_RF1, and 1V0_RF2 AWR2944 supply rails and EEPROM for storing board ID. These are connected to the AWR2944EVM through I2C bus.

Table 2-14 shows the list of I2C devices available in AWR2944EVM board and its address.

Table 2-14. I2C Device Addresses

Sensor Type	Reference Designator	Part Number	Slave Address
Temp sensor	U24	TMP112AIDRLR	0x49
Current sensor for 3.3-V rail	U12	INA226AIDGSR	0x44
Current sensor for 1.8-V rail	U11	INA226AIDGSR	0x41
Current sensor for 1.2-V Digital rail	U9	INA226AIDGSR	0x40
Current sensor for 1.0-V RF1 rail	U22	INA226AIDGSR	0x42
Current sensor for 1.0-V RF2 rail	U30	INA226AIDGSR	0x43
EEPROM	U28	CAV24C02WE-GT3	0x50

2.9.4 Push Buttons

Table 2-15. Push Button Switches

Reference	Usage	Comments	Image
SW1	RESET	This Switch is used to RESET the AWR2944, PMIC, XDS110 and FTDI device.	

Table 2-15. Push Button Switches (continued)

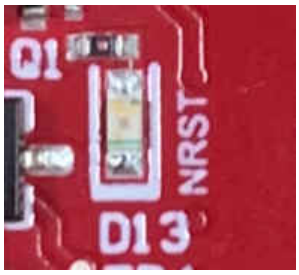
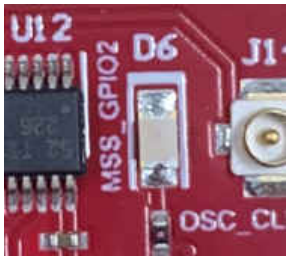
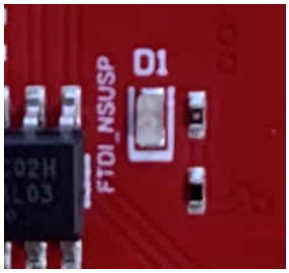
Reference	Usage	Comments	Image
SW2	GPIO_28	When pushed, the GPIO_28 shall be pulled to High.	
SW3	CANB_WAKE	Used to Wake up the CANB Transceiver	

2.9.5 LEDs

Table 2-16. On Board LEDs

Ref	Colour	Usage	Comments	Image
D12	Green	12-V supply indication	This LED indicates the presence of 12-V supply input	
D16	Green	5-V Supply	This LED indicates the presence of 5-V supply output	

Table 2-16. On Board LEDs (continued)

Ref	Colour	Usage	Comments	Image
D13	Yellow	NRST	This LED is used to indicate the state of NRST pin. If this LED is glowing, the device is out of reset.	
DS2	Red	NERROUT	Glows if there is any HW error in the AWR2944 device	
D9	Yellow	WRMRST	Open drain fail safe warm reset signal	
D6	Green	GPIO_2	Glows when the GPIO_2 is logic-1	
D1	Yellow	FTDI_SUSPEND_N	Glows when FTDI is in suspend state	

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3.1 Design Files

To view the schematics, assembly drawings, and BOM, see AWR2944EVM Schematic, Assembly Files, and BOM.

To view the design database and layout details, see AWR2944EVM Database and Layout Files.

3.2 Software, Development Tools, and Example Code

To enable quick development of end applications on the on-chip C66x DSP, ARM® Cortex®-R5F controller, and hardware accelerator (HWA 2.0), TI provides a software development kit (SDK) that includes demo codes, software drivers, emulation packages for debug, and more. These can be found at mmwave-sdk.

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