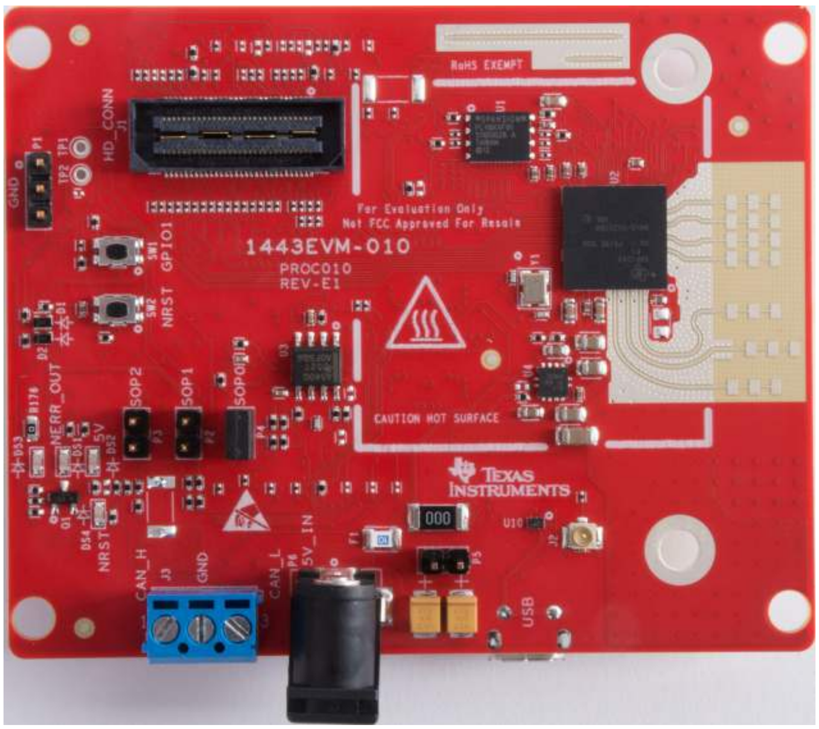
User's Guide
SWRU518D−May 2017−Revised May 2020

# IWR1443BOOST Evaluation Module mmWave Sensing Solution



## Contents



## List of Figures



## List of Tables

# 1 Getting Started [1][2][3]

## 1.1 Introduction

The IWR1443 BoosterPack™ is an easy-to-use evaluation board for the single-chip IWR1443 mmWave sensing device from TI, with direct connectivity to the TI MCU LaunchPad™ ecosystem. The evaluation board contains everything needed to start developing on a low-power ARM®-R4F controller. The evaluation board includes onboard emulation for programming and debugging, onboard buttons, and LEDs, for quick integration of a simple user interface. The standard 20-pin BoosterPack headers make the evaluation board compatible with a wide variety of TI MCU LaunchPads and enables easy prototyping.

## 1.2 Key Features

- 40-pin LaunchPad standard that leverages the LaunchPad ecosystem
- XDS110-based JTAG emulation with serial port, for onboard QSPI flash programming
- Backchannel UART through USB to PC, for logging purposes
- Onboard antenna
- 60-pin high density (HD) connector, for raw ADC data over CSI, or the high-speed debug interface
- Onboard CAN transceiver
- One button and two LEDs, for user interaction
- 5-V power jack, to power the board

## 1.3 What is Included

### 1.3.1 Kit Contents

- IWR1443BOOST
- Mounting brackets, screws, and nuts, to allow placing the PCB vertical
- Micro USB cable to connect to the PC

**NOTE:** *Not* included: 5 V, >2.5-A supply brick with 2.1-mm barrel jack (center positive). TI recommends using an external power supply that complies with applicable regional safety standards such as UL, CSA, VDE, CCC, PSE, and so on. The cable length of the power cord must be < 3 m.

### 1.3.2 mmWave Proximity Demo

TI provides sample demo codes to easily get started with the IWR1443 evaluation module and experience the functionality of the IWR1443 mmWave sensor. For details on getting started with these demos, see the mmWave SDK User Guide.

(1) BoosterPack, LaunchPad are trademarks of Texas Instruments.
(2) ARM is a registered trademark of ARM Limited.
(3) Windows is a registered trademark of Microsoft Corporation.

## 2 Hardware

Figure 1 and Figure 2 show the front and rear views of the evaluation board, respectively.

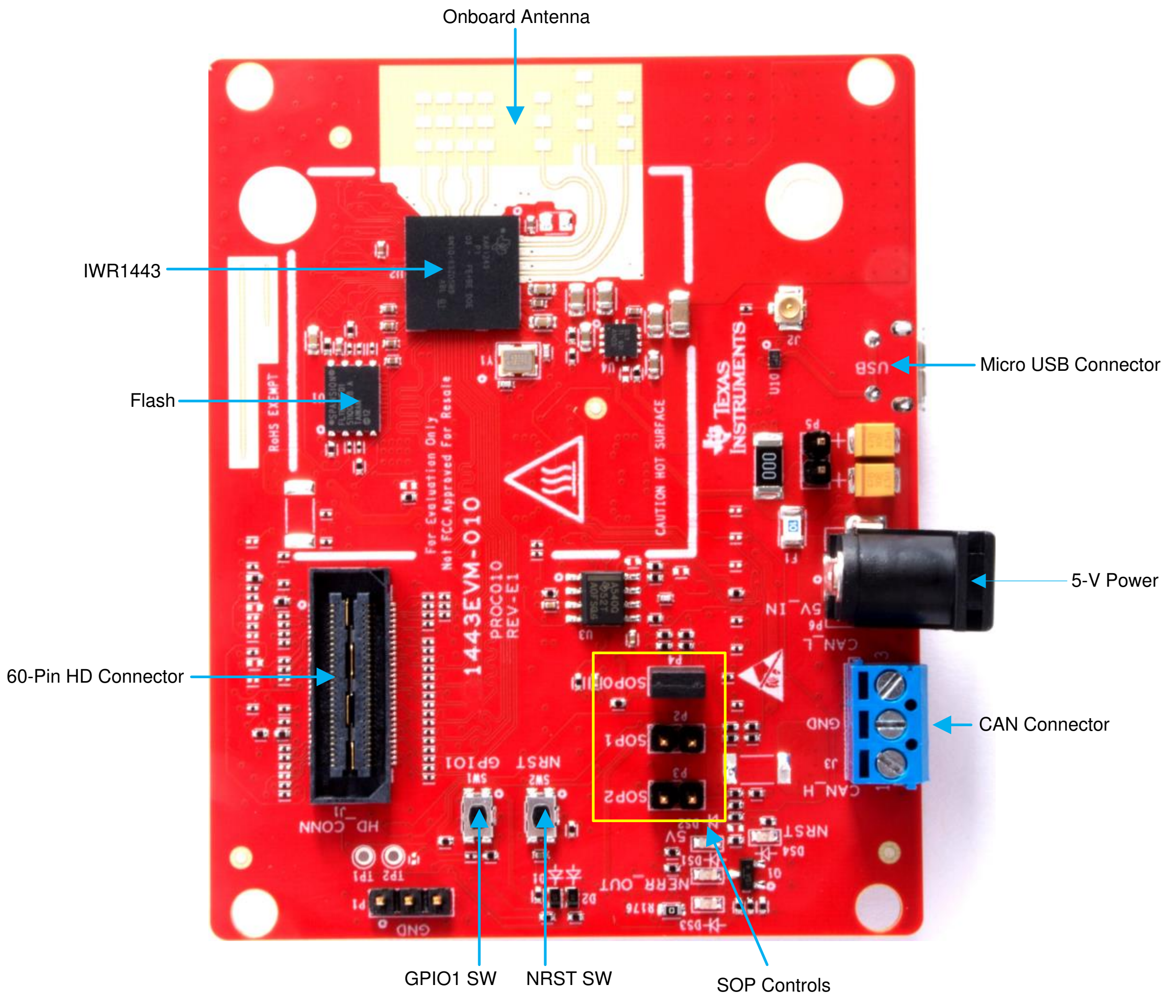



**Figure 1. EVM Front View**

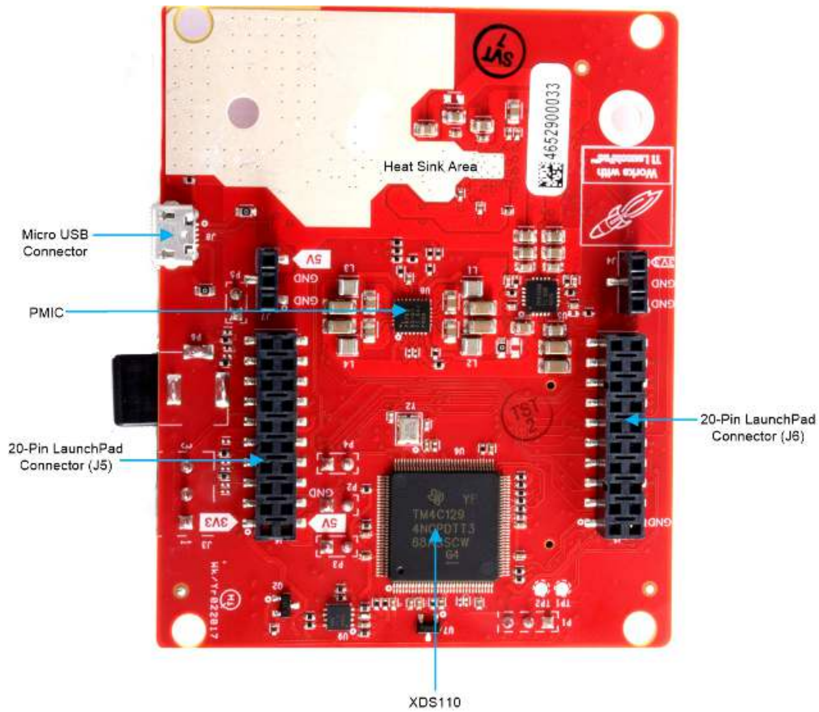



**Figure 2. EVM Rear View**

## 2.1 Block Diagram

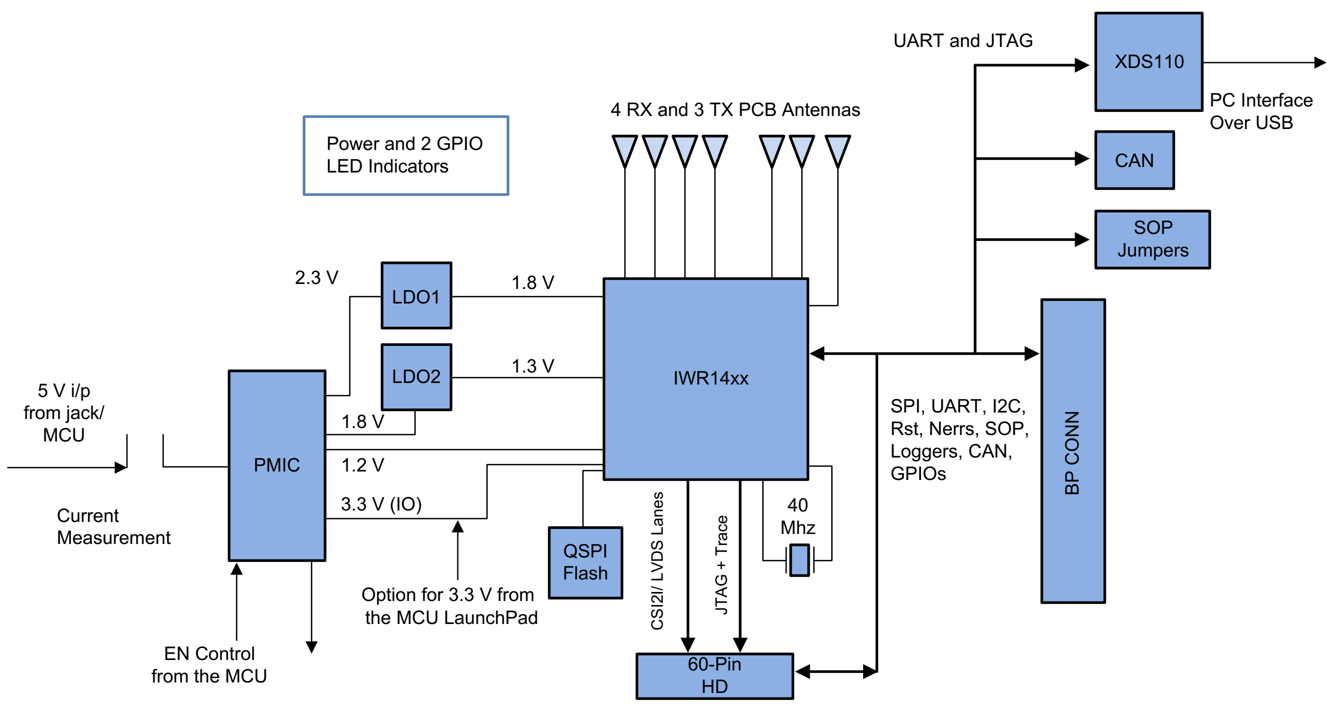





**Figure 3. IWR14xxBOOST Block Diagram**

## 2.2 Connecting BoosterPack™ to LaunchPad™ or MMWAVE-DEVPACK

This BoosterPack can be stacked on top of the Launchpad, or the MMWAVE-DEVPACK, using the two 20-pin connectors. The connectors do not have a *key* to prevent the misalignment of the pins or reverse connection. Therefore, ensure reverse mounting does not take place. On the IWR1443 BoosterPack, we have provided 3V3 marking near pin 1 (see Figure 4). This same marking is provided on compatible LaunchPads which must aligned before powering up the boards.

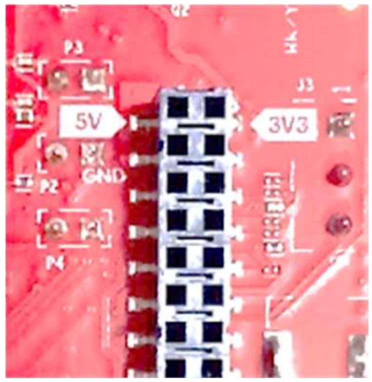



**Figure 4. 3V3 and 5-V Mark on the LaunchPad™ (White Triangle)**

## 2.3 Power Connections

The BoosterPack is powered by the 5-V power jack (5-A current limit). As soon as the power is provided, the NRST and 5-V LEDs glow, indicating that the board is powered up (see Figure 5).

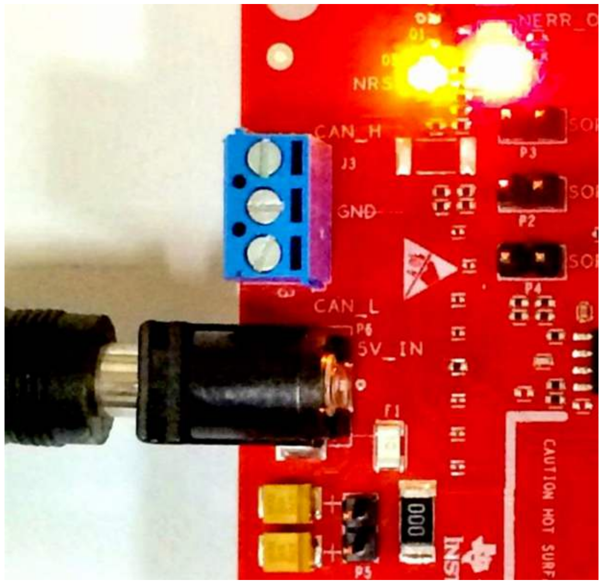



**Figure 5. Power Connector**

---

**NOTE:** After the 5-V power supply is provided to the EVM, TI recommends pressing the NRST switch (SW2) once to ensure a reliable boot up state.

---

## 2.4 Connectors

### 2.4.1 20-Pin BoosterPack™ Connectors

The BoosterPack has the standard LaunchPad connectors (J5 and J6) which enable the BoosterPack to be directly connected to all TI MCU LaunchPads (see Table 1). While connecting the BoosterPack to other LaunchPads, ensure the pin 1 orientation is correct by matching the 3V3 and 5-V signal marking on the boards (see Figure 6).

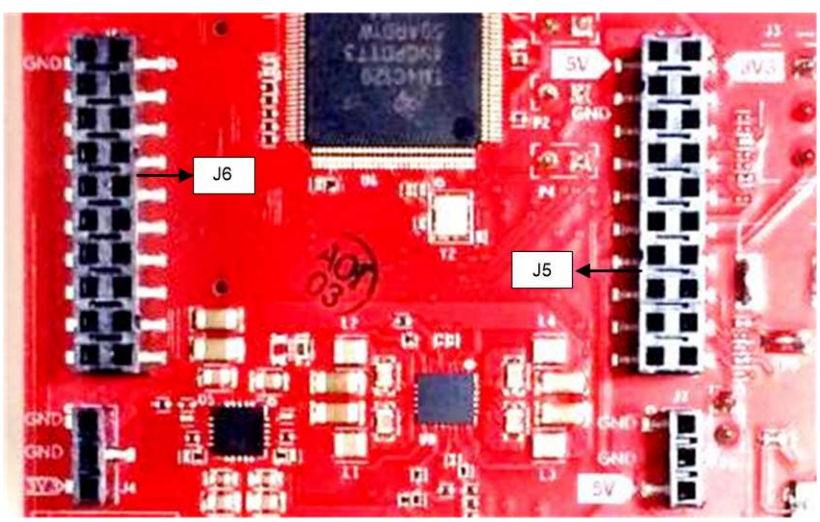



**Figure 6. 20-Pin BoosterPack™ Connectors (J5 and J6)**

Table 1 and Table 2 provide the connector-pin information.

**Table 1. 20-Pin Connector Definition (J6)**

| Pin Number | Description | Pin Number | Description |
|---|---|---|---|
| 1 | AR_NERR_OUT | 2 | GND |
| 3 | AR_NERRIN | 4 | NC |
| 5 | AR_MCUCLKOUT | 6 | AR_CS1 |
| 7 | NC | 8 | AR_GPIO_1 |
| 9 | AR_MSS_LOGGER | 10 | AR_NRST_MCU |
| 11 | AR_WARMRST | 12 | AR_MOSI1 |
| 13 | AR_BSS_LOGGER | 14 | AR_MISO1 |
| 15 | MCU_SOP2 | 16 | AR_HOSTINTR1 |
| 17 | MCU_SOP1 | 18 | AR_GPIO_2 |
| 19 | MCU_SOP0 | 20 | NC |

**Table 2. 20-Pin Connector Definition (J5)**

| Pin Number | Description | Pin Number | Description |
|---|---|---|---|
| 1 | MCU_3V3 | 2 | MCU_5v (5V_IN) |
| 3 | NC | 4 | GND |
| 5 | AR_RS232TX | 6 | AR_ANATEST1 |
| 7 | AR_RS232RX | 8 | AR_ANATEST2 |
| 9 | AR_SYNC_IN | 10 | AR_ANATEST3 |
| 11 | NC | 12 | AR_ANATEST4 |
| 13 | AR_SPICLK1 | 14 | PGOOD (onboard VIO) |
| 15 | AR_GPIO_0 | 16 | PMIC_EN1 |
| 17 | AR_SCL | 18 | AR_SYNC_OUT_SOP1 |
| 19 | AR_SDA | 20 | AR_PMIC_CLKOUT_SOP2 |

- PGOOD – This signal indicates the state of the onboard VIO supply for the IWR device coming from the onboard PMIC. A high on the PGOOD signal (3.3 V) indicates that the supply is stable. Because the IOs are not failsafe, the MCU must ensure that it does not drive any IO signals to the IWR device before this IO supply is stable. Otherwise, there could be leakage current into the IOs.
- PMIC Enable – This signal goes onboard PMIC enable. The MCU can use this signal to completely shut down the PMIC and IWR device to save power. The power up of the PMIC takes approximately 5 ms once the Enable signal is released.

**NOTE:** To enable this feature, the R102 resister must be populated on the EVM.

- ANA1/2/3/4 – These are inputs to the GPADCs (general purpose ADC) available on the IWR1443 device.

### 2.4.2 60-Pin High Density (HD) Connector

The 60-pin HD connector provides high speed CSI/LVDS data, and controls signals (SPI, UART, I2C, NRST, NERR, and SOPs) and JTAG debug signals (see Table 3). This connector can be connected to the MMWAVE-DEVPACK board and interface with the TSW1400 (see Figure 7).

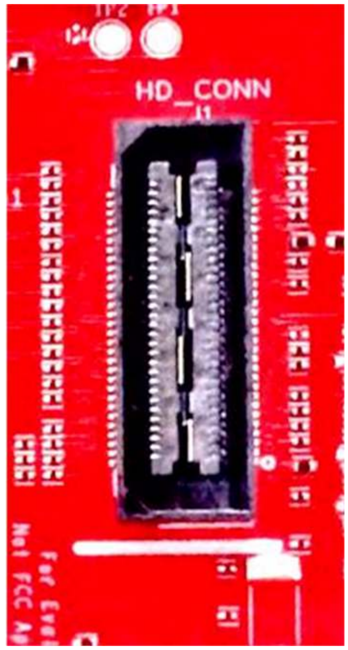



**Figure 7. High Density Connector (60 Pin)**

**Table 3. HD Connector Pin Definition**

| Pin Number | Description | Pin Number | Description |
|---|---|---|---|
| 1 | 5 V | 2 | 5V_IN |
| 3 | 5 V | 4 | AR_TDO_SOP0 |
| 5 | AR_TDI | 6 | AR_TCK |
| 7 | AR_CS1 | 8 | AR_TMS |
| 9 | AR_SPICLK1 | 10 | AR_HOSTINTR1 |
| 11 | AR_MOSI1 | 12 | AR_MISO1 |
| 13 | PGOOD (onboard VIO) | 14 | AR_NERR_OUT |
| 15 | NC | 16 | AR_SYNC_IN |
| 17 | NC | 18 | GND |
| 19 | NC | 20 | AR_LVDS_VALIDP |
| 21 | NC | 22 | AR_LVDS_VALIDM |
| 23 | NC | 24 | GND |
| 25 | NC | 26 | AR_LVDSSCSI_FRCLKP |
| 27 | NC | 28 | AR_LVDSSCSI_FRCLKM |
| 29 | NC | 30 | GND |
| 31 | NC | 32 | AR_LVDSSCSI_3P |
| 33 | NC | 34 | AR_LVDSSCSI_3M |
| 35 | NC | 36 | GND |
| 37 | NC | 38 | AR_LVDSSCSI_2P |
| 39 | NC | 40 | AR_LVDSSCSI_2M |
| 41 | NC | 42 | GND |
| 43 | NC | 44 | AR_LVDSSCSI_CLKP |

**Table 3. HD Connector Pin Definition (continued)**

| Pin Number | Description | Pin Number | Description |
|---|---|---|---|
| 45 | NC | 46 | AR_LVDSSCSI_CLKM |
| 47 | NC | 48 | GND |
| 49 | NC | 50 | AR_LVDSSCSI_1P |
| 51 | AR_SDA | 52 | AR_LVDSSCSI_1M |
| 53 | AR_SCL | 54 | GND |
| 55 | AR_RS232RX | 56 | AR_LVDSSCSI_0P |
| 57 | AR_RS232TX | 58 | AR_LVDSSCSI_0M |
| 59 | AR_NRST_MCU | 60 | GND |

PGOOD – This signal indicates that the state of the onboard VIO supply for the IWR device coming from the onboard PMIC. A high on the PGOOD signal (3.3 V) indicates the supply is stable. Because the I/Os are not failsafe, the MCU must ensure that it does not drive any I/O signals to the IWR device before this I/O supply is stable, to avoid leakage current into the I/Os.

### 2.4.3 CAN Interface Connector

The J3 connector provides the CAN_L and CAN_H signals (see Figure 8) from the onboard CAN transceiver (SN65HVDA540). These signals can be directly wired to the CAN bus.

Because the digital CAN signals (TX and RX) are muxed with the SPI signals on the IWR device, one of the two paths must be selected. To enable the CAN interface, the R11 and R12 resisters muct be populated with 0 Ω, and the R4, R6, R28, and R63 resisters must be removed to disconnect the SPI path.

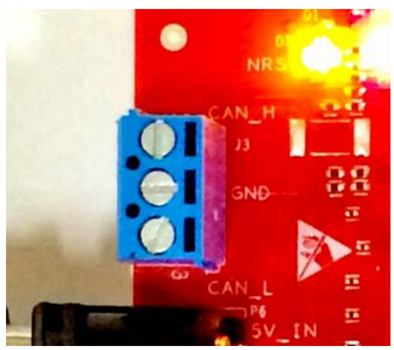



**Figure 8. CAN Connector**

### 2.5 PC Connection

Connectivity is provided using the micro USB connector over the onboard XDS110 (TM4C1294NCPDT) emulator. This connection provides the following interfaces to the PC:

- JTAG for CCS connectivity
- Control UART for flashing the onboard serial flash, downloading FW using RADAR studio, and getting application data sent over the UART
- MSS logger UART, which can be used to get MSS code logs on the PC

When the USB is connected to the PC the device manager recognizes the following COM ports, as shown in Figure 9:

- XDS110 Class Application/User UART → the control UART port
- XDS110 Class Auxiliary Data port → the MSS logger port

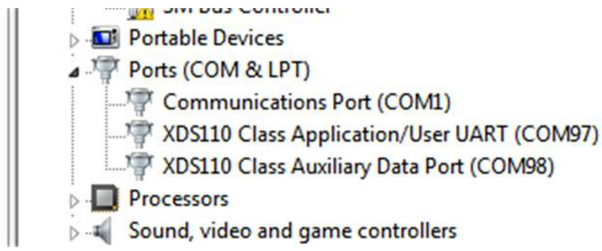



**Figure 9. XDS110 Ports**

If Windows® is unable to recognize the COM ports previously shown, install the emupack available here

Table 4 lists the UART ports corresponding pin names on IWR1443 package.

**Table 4. Pin Names**

| | Pin Name | Pin Number | Signal Name in Data Sheet | EVM Signal Reference |
|---|---|---|---|---|
| Control UART port TX | RS232_TX | N6 | RS232_TX | AR_RS232TX |
| Control UART port RX | RS232_RX | N5 | RS232_RX | AR_RS232RX |
| MSS logger port | SPI_CLK_2 | R5 | MSS_UARTB_TX | AR_MSS_LOGGER |

#### 2.5.1 Erasing Onboard Serial Flash

Before loading the code to the serial flash or connecting the board to RADAR Studio, TI recommends completely erasing the onboard serial flash. The instructions to erase the onboard serial flash are in the *mmWave SDK User Guide*.

#### 2.5.2 Connection With MMWAVE-DEVPACK

Users may be required to use the DevPack along with the BoosterPack for the following use cases:

- Connecting to RADAR studio. This tool provides capability to configure the mmWave front end from the PC. This tool is available in the DFP package.
- Capturing high-speed LVDS data using the TSW1400 platform from TI. This device allows the user to capture raw ADC data over the high-speed debug interface and post process it in the PC. The RADAR Studio tool provides an interface to the TSW1400 platform as well, so that the front end configurations and data capture can be done using a single interface. Details on this board can be found at http://www.ti.com/tool/tsw1400evm

For details on these use cases, see the mmWave-DevPack User Guide.

Mmwave SDK out-of-box demos do not require DevPack. For other labs, check the hardware requirements of the lab user guide.

### 2.6 Antenna

The BoosterPack includes onboard etched antennas for the four receivers and three transmitters, which enables tracking multiple objects with their distance and angle information. This antenna design enables estimation of both azimuth and elevation angles, which enables object detection in a 3-D plane (see Figure 10).

In the mmwave SDK, the antenna configuration is selected using bitmask. For example, 2 transmit antennas can be enabled through bitmask 0b101 (such as tx1 and tx3). The corresponding physical location of rx1 to rx4 and tx1 to tx3 and are labeled in Figure 10.

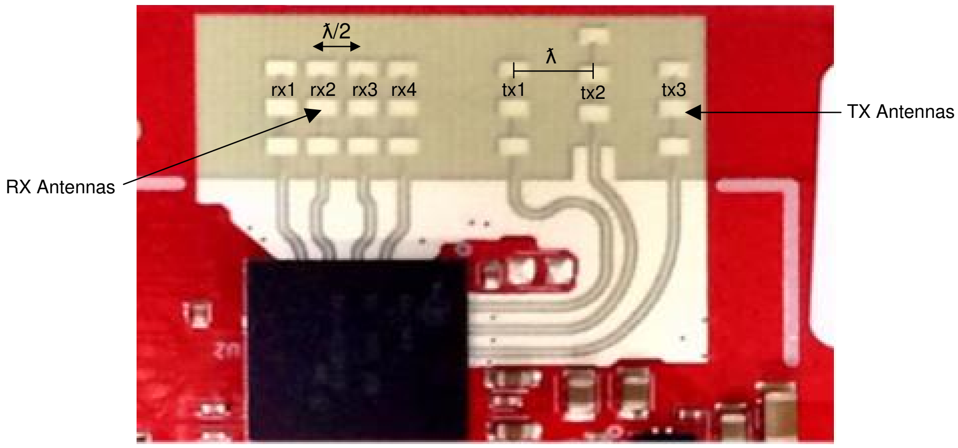



**Figure 10. PCB Antenna**

The antenna peak gain is > 10.5 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 11 and Figure 12.

The beamwidth of the antenna design can be determined from the radiation patterns. For example, at 78 GHz, based on 3-dB drop in the gain as compared to bore sight, the horizontal 3dB-beamwidth is approximately ±28 degrees (see Figure 11), and elevation 3dB-beamwidth is approximately ±14 degrees (see Figure 12). Similarly, the horizontal 6dB-beamwidth is approximately ±50 degrees (see Figure 11) and the elevation 6dB-beamwidth is approximately ±20 degrees (see Figure 12).

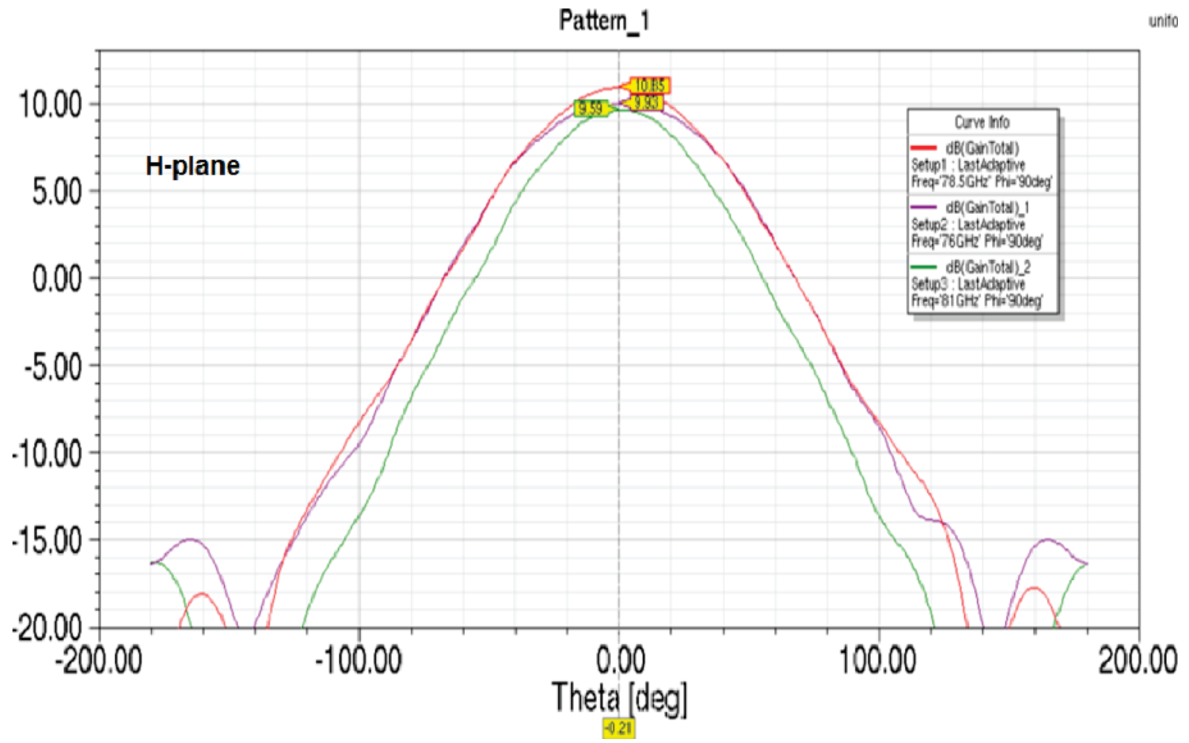



**Figure 11. Antenna Pattern in H-Plane**

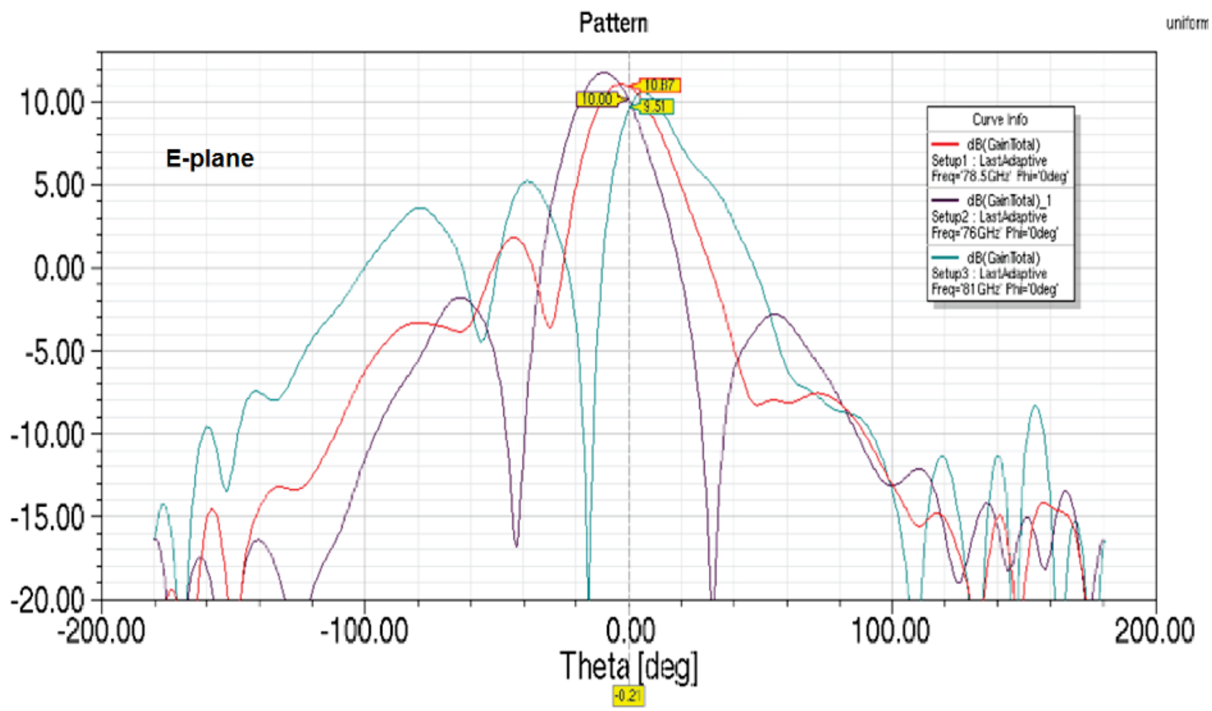



**Figure 12. Antenna Pattern in E-Plane**

## 2.7 Jumpers, Switches, and LEDs

### 2.7.1 Sense On Power Jumpers

The IWR1443 device can be set to operate in three different modes, based on the state of the SOP (sense on power) lines (see Figure 13). These lines are *only* sensed during boot up of the IWR device. The state of the device is described by Table 5.

A closed jumper refers to a *1* and an open jumper refers to a *0* state of the SOP signal going to the IWR device.

**Table 5. SOP Modes**

| Reference | Use | Comments |
|---|---|---|
| P3 (SOP 2) | SOP[2:0] | 101 (SOP mode 5) = Flash programming<br>001 (SOP mode 4) = Functional mode<br>011 (SOP mode 2) = Dev mode |
| P2 (SOP 1) | | |
| P4 (SOP 0) | | |

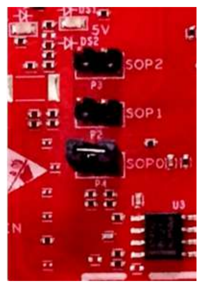


**Figure 13. SOP Jumpers**

### 2.7.2 Current Measurement

The P5 jumper enables measurement of the current being consumed by the reference design (IWR device + PMIC + LDOs) at the 5-V level.

To measure the current, R118 must be removed and a series ammeter can be put across the P5 pins (see Figure 14).

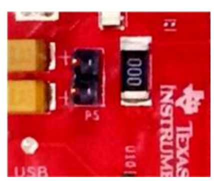


**Figure 14. Current Measurement Point**

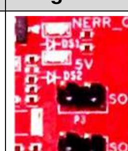
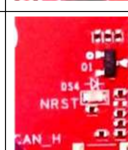
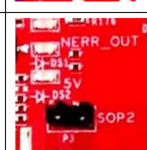
### 2.7.3 Push Buttons and LEDs

Table 6 and Table 7 list the push button and LED uses, respectively.

**Table 6. Push Buttons**

| Reference | Use | Comments | Image |
|---|---|---|---|
| SW2 | RESET | This button is used to reset the IWR1443 device. This signal is also brought out on the 20-pin connector and 60-pin HD connector, so that an external processor can control the IWR device.<br>The onboard XDS110 can also use this reset. |  |
| SW1 | GPIO_1 | When this button is pushed, the GPIO_1 is pulled to $V_{cc}$. |  |

**Table 7. LEDs**

| Reference | Color | Use | Comments | Image |
|---|---|---|---|---|
| DS2 | Red | 5-V supply indication | This LED indicates the presence of the 5-V supply. |  |
| DS4 | Yellow | nRESET | This LED is used to indicate the state of nRESET pin. If this LED is on, the device is out of reset. This LED glows only after the 5-V supply is provided. |  |
| DS1 | Red | NERR_OUT | This LED turns on if there is any hardware error in the IWR device. |  |
| DS3 | Yellow | GPIO_1 | This LED turns on when the GPIO is logic-1. |  |

# 3 Design Files and Software Tools

The schematics, assembly, and BOM are available here. The design and layout database files are available here.

**NOTE:** Boards with a Rev 'C' sticker have had capacitor C56 (VBGAP decoupling capacitor) changed from 0.22 µF to 0.047 µF (part number CGA2B3X7R1H473K050BB). TI recommends that customers incorporate this change with an equivalent capacitor in their designs.

## *3.1 Software, Development Tools, and Example Codes*

To enable quick development of an end application on the R4F core in the IWR1443, TI provides a software development kit (SDK) which includes demo codes, software drivers, an emulation package for debug, and so on. The SDK is available at mmwave-sdk.

# 4 Mechanical Mounting of PCB

The field of view of the radar sensor is orthogonal to the PCB. The L-brackets provided with the IWR1443 EVM kit, along with the screws and nuts help in the vertical mounting of the EVM. Figure 15 shows how the L-brackets can be assembled.

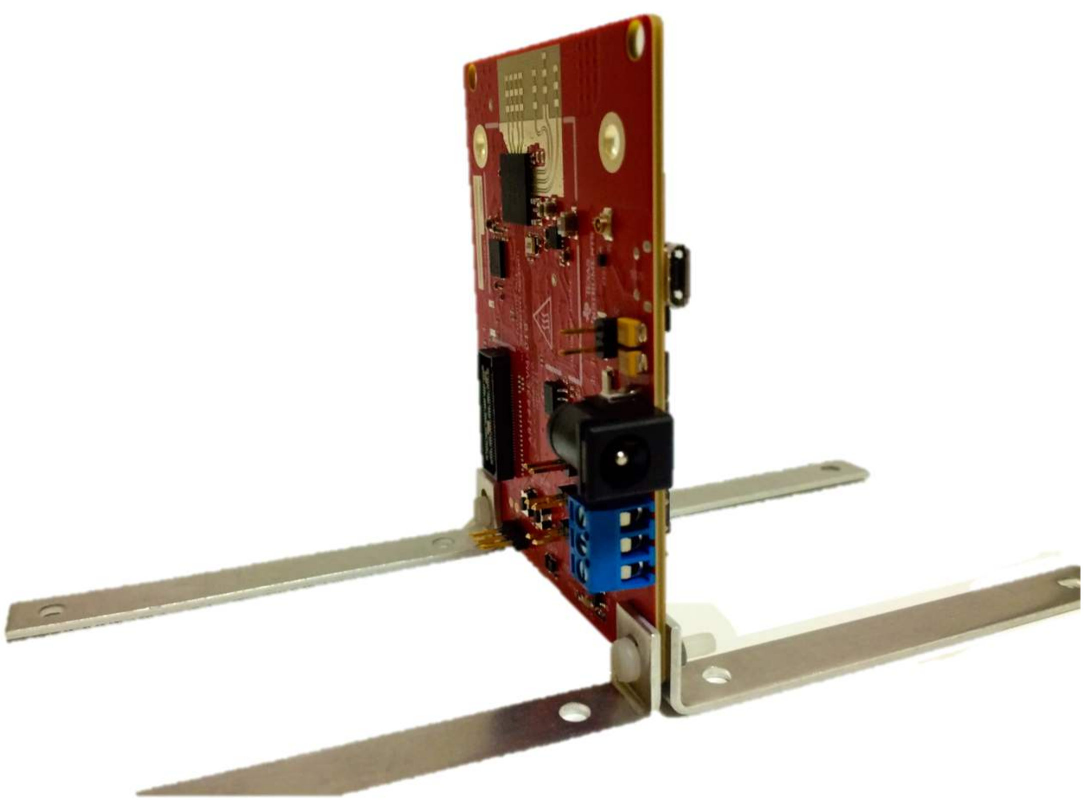


**Figure 15. Vertical Assembly of the EVM**

## 5 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 an open environment. This oxidation causes the surface around the antenna region to blacken. To avoid this effect, store the PCB in an ESD cover and keep it at controlled room temperature with low humidity conditions. All ESD precautions must be taken while using and handling the EVM.

## 6 Regulatory Information

The IWR1443 evaluation module (IWR1443BOOST) is in compliance with Directive 2014/53/EU. The full text of TI's EU Declaration of Conformity is available here.

The compliance has been verified in the operating bands 76 – 77 GHz and 77 – 81 GHz. Should the user choose to configure the EVM to operate outside the test conditions, it should be operated inside a protected or controlled environment, such as a shielded chamber. This evaluation board is intended only for development, and is not for use in an end product or part of an end product. Developers and integrators that incorporate the chipset in any end products are responsible for obtaining applicable regulatory approvals for such an end product.

The European RF exposure radiation limit is fulfilled if a minimum distance of 5 cm between the users body and the radio transmitter is respected.

**NOTE:** The EUT has been tested in the 76 – 77 GHz band (2 Tx at a time) at a maximum peak power of 26 dBm EIRP, and in the 77 – 81 GHz band (1 Tx at a time) with maximum peak power of 21 dBm EIRP across the temperature range of –20ºC to 60ºC.

## 7 Troubleshooting

EVM board power-up failure: refer to Section 2.2 for desired power connections. Both the NRST and 5-V LEDs should glow brightly. When a non-functional or non-sufficient current capacity power supply is used with this EVM, the EVM LEDs do not turn on. Refer to Section 2.7.3 for LED information.

# Revision History

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

**Changes from April 1, 2018 to May 30, 2020** **Page**

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265