Design Guide: TIDA-010967
Low-Power Two-Layer mmWave Radar Reference Design

Description

This reference design demonstrates the low-cost and low-power capabilities of TI's IWRL6432AOP mmWave sensor. The design supports interfaces with connectivity devices through use of castellated pins or 1.27mm-pitch connectors. This design uses a UART-to-USB converter for flashing the firmware and to run the demonstration. The reference design is developed with FR4 material using a two-layer PCB stackup. This design can demonstrate applications such as presence detection and non-human classification. Visualizers display radar-sensing data and detection results directly in the GUI on a PC.

Resources

TIDA-010967	Design Folder
IWRL6432AOP, TPS628502	Product Folder
TPS2116, TIDA-010254	Product Folder

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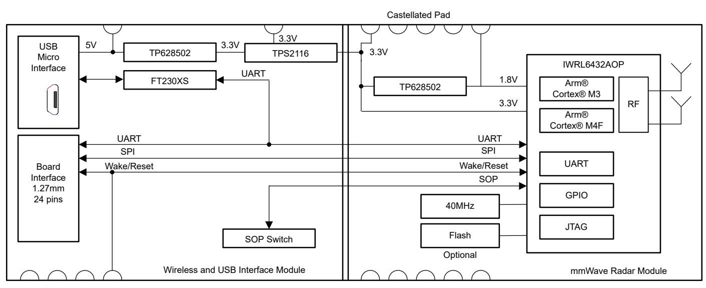
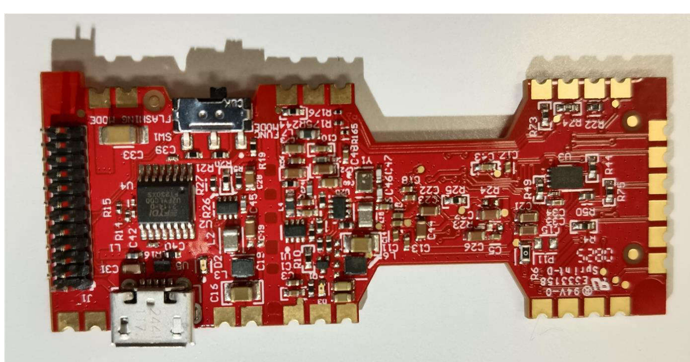
Features

- 57GHz to 64GHz mmWave radar using the IWRL6432AOP with integrated Antenna On Package (AOP)
- Low-power consumption
- Low-cost, two-layer PCB design
- Small form factor: 22.8mm × 38mm (mmWave radar sensor section)
- Castellated pad for customizing integrated modules
- Offers power-optimized test results
- Demonstrates human-counting and human-tracking applications

Applications

- Occupancy detection (people tracking, people counting)
- Motion detector
- Video doorbell
- Automated door and gate
- IP network camera
- Thermostat
- Air conditioner outdoor unit
- Air conditioner indoor unit
- TV





1 System Description

Motion detectors, smart locks, video doorbells, and IP network cameras require human or movement detection in one area to wake up a system from sleep mode. Typically, a PIR sensor is used in the design. Now, mmWave radar technology is a popular technology for providing these functions. Better detection results like range, velocity, and angle of reflection data are features of mmWave radar technology. This reference design demonstrates a module design by utilizing the IWRL6432AOP, a low-power, 57GHz to 64GHz mmWave radar sensor. The module size is 22.8mm × 59mm on a two-layer, printed circuit board (PCB).

This module utilizes castellated pads, which connect radar power and signal pins to a customized controller board. The module also utilizes a 1.27mm interface connector, which connects to a TIDA-010254 base board. The TIDA-010254 base board contains a CC1352R microcontroller, which provides long-range connection and ultra-low power consumption. The CC1352R is a multiprotocol, sub-1 GHz, and 2.4GHz wireless microcontroller (MCU) supporting *Bluetooth*® 5.2 LE, IEEE 802.15.4, Zigbee®, and so on.

This module supports different power sources. A USB 5VDC supply or DC power adapter based 5VDC supply can be used as the main power source. A TPS628502 buck converter, is utilized to convert input 5VDC to output 3.3VDC. The reference design also has an onboard DC regulator for 1.8V power supply, which powers the IWRL6432AOP radar 1.8V power blocks. Additionally, this module can also be powered through castellated pads with 3.3VDC input, which can be connected to a customized controller board, or test devices.

This design guide addresses design theory, and the test results of this reference design.

1.1 Key System Specifications

Table 1-1. Key System Specifications

PARAMETER	SPECIFICATIONS
Input power source	USB 5VDC, or 3.3VDC and 1.8VDC
Radar type	IWRL6432AOP mmWave Radar
System power consumption	3.0–10.0mW average (limited to test environment)
Radar field of view *azimuth*	±70°
Radar field of view *elevation*	±70°
Radar maximum range	15m (limited to test environment)
Radar range resolution	0.18m (limited to test environment)
Radar maximum velocity	36m/s (limited to test environment)
Radar velocity resolution	About 0.08m/s (minor motion detection mode) (limited to test environment)

2 System Overview

This reference design contains two sections in the PCB: a mmWave radar sensor section, and the wireless and USB interface section. The mmWave radar sensor section contains the IWRL6432AOP radar sensor and a TPS628502 buck converter to convert 3.3VDC input to 1.8VDC output. The wireless and USB interface part contains a FT230XS USB-to-UART converter and a TPS628502 buck converter.

This reference design is powered by a 5VDC supply from a USB port. The 5VDC or 3.3VDC of the power adapter can be an alternative power supply, due to different application cases.

This reference design utilizes a UART interface for the mmWave programmable interface and sends out the point cloud data. Additionally, the design utilizes a FT230XS USB-to-UART converter as a connection to the PC.

Two modules can be separated by splitting the cut lines. So, the mmWave radar modules are used with castellated pads for integration to a customized board.

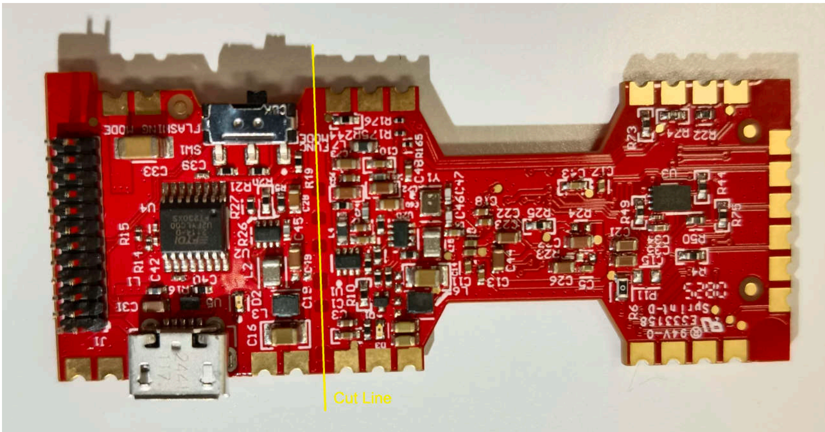


Figure 2-1. Cut Line

2.1 Block Diagram

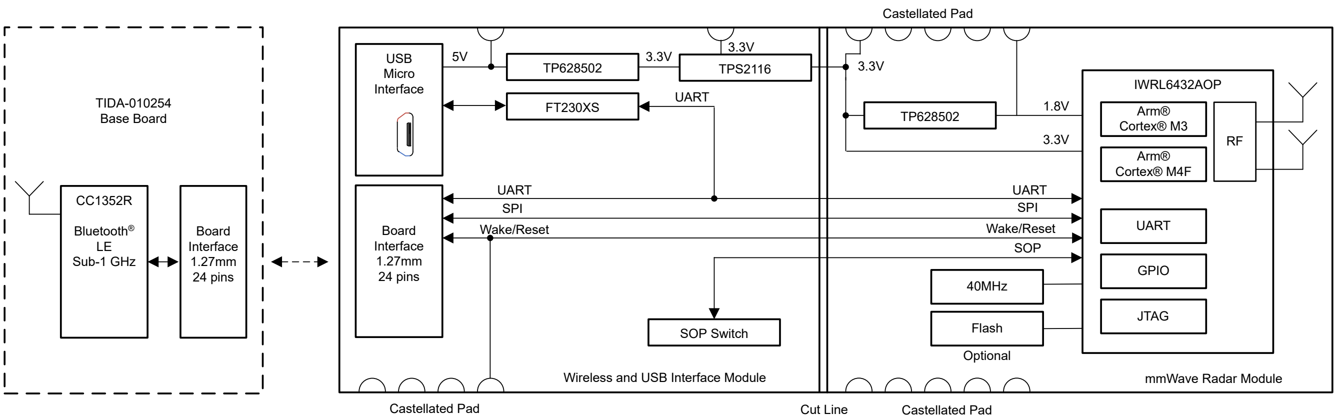


Figure 2-2. TIDA-010967 System Block Diagram

2.2 Design Considerations

In this design, the mmWave radar sensor detection data is sent over the UART port.

2.2.1 mmWave Radar Sensor Application

This design can demonstrate human-tracking, and non-human classification applications. These applications examples are from the mmWave software development kit (SDK) demonstration motion_and_presence_detection project. The example configuration is the same as the *IWRL6432AOPEVM*. The following code block is an example of a configuration file.

```
% ***************************************************************
% PresenceDetect:  Chirp configuration and Processing chain are
% optimized to detect any kind of motion, including fine movements
% (even small movements that are present while sitting still,
% such as, movement caused by typing, breathing, etc.).  However,
% there is no velocity measurement reported in this case.
% It is typically useful for applications such as identifying
% presence or absence of occupants in an indoor setting.
% Localization (Angle estimation) of the object is possible.
% ***************************************************************
sensorStop 0
channelCfg 7 3 0
chirpComnCfg 20 0 0 128 1 30 2
chirpTimingCfg 6 28 0 90 59.75
frameCfg 8 0 403 1 250 0
guiMonitor 2 2 0 0 0 1 1 0 0 0 0
sigProcChainCfg 64 8 2 0 4 4 0 .5
cfarCfg 2 4 3 2 0 12.0 0 0.8 0 1 1 1
aoaFovCfg -60 60 -40 40
rangeSelCfg 0.1 4.0
clutterRemoval 1
antGeometryCfg 1 1 1 0 0 1 1 3 1 2 0 3 2.5 2.5
compRangeBiasAndRxChanPhase 0.0 1.00000 0.00000 1.00000 0.00000 1.00000 0.00000 1.00000 0.00000
1.00000 0.00000 1.00000 0.00000
adcDataSource 0 adc_data_0001_CtestAdc6Ant.bin
adcLogging 0
lowPowerCfg 1
factoryCalibCfg 1 0 38 3 0x1ff000
mpdBoundaryBox 1 0 1.48 0 1.95 0 3
mpdBoundaryBox 2 0 1.48 1.95 3.9 0 3
mpdBoundaryBox 3 -1.48 0 0 1.95 0 3
mpdBoundaryBox 4 -1.48 0 1.95 3.9 0 3
sensorPosition 0 0 1.44 0 0
minorStateCfg 5 4 40 8 4 30 8 8
clusterCfg 1 0.5 2
baudRate 1250000
sensorStart 0 0 0 0
```

After the configuration is sent, the IWRL6432AOP starts sending out radar result data through the UART port.

For more detailed information on the mmWave people tracking and people-counting examples, see *IWRL6432 People Tracking*.

2.2.2 IWRL6432AOP UART Communication

A USB-to-UART converter (FX230XS-R) is used to communicate with the IWRL6432AOP device and the PC through a UART port with a baud rate of 115200.

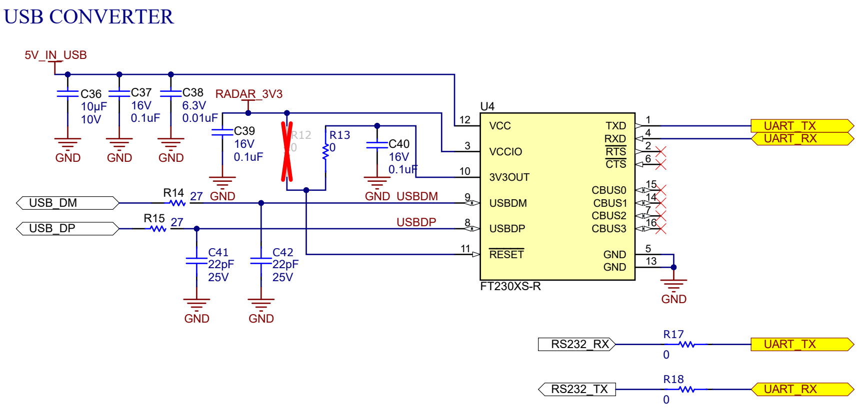


Figure 2-3. USB-to-UART Converter Schematic

A virtual UART port (the user UART COM port number can be different on a different PC) is found in the *Device Manager* program. This port is able to send and receive the radar data to a Visualizer GUI. This virtual UART port is also used to upload the firmware to the IWRL6432AOP device.

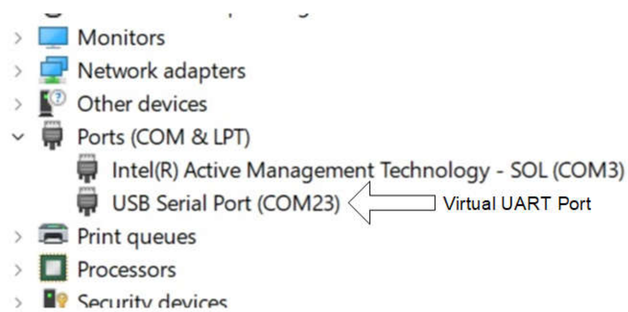


Figure 2-4. Virtual UART Port on PC

2.2.3 Wireless Communication

This design uses a 1.27mm interface connector, which connects to the TIDA-010254 base board.

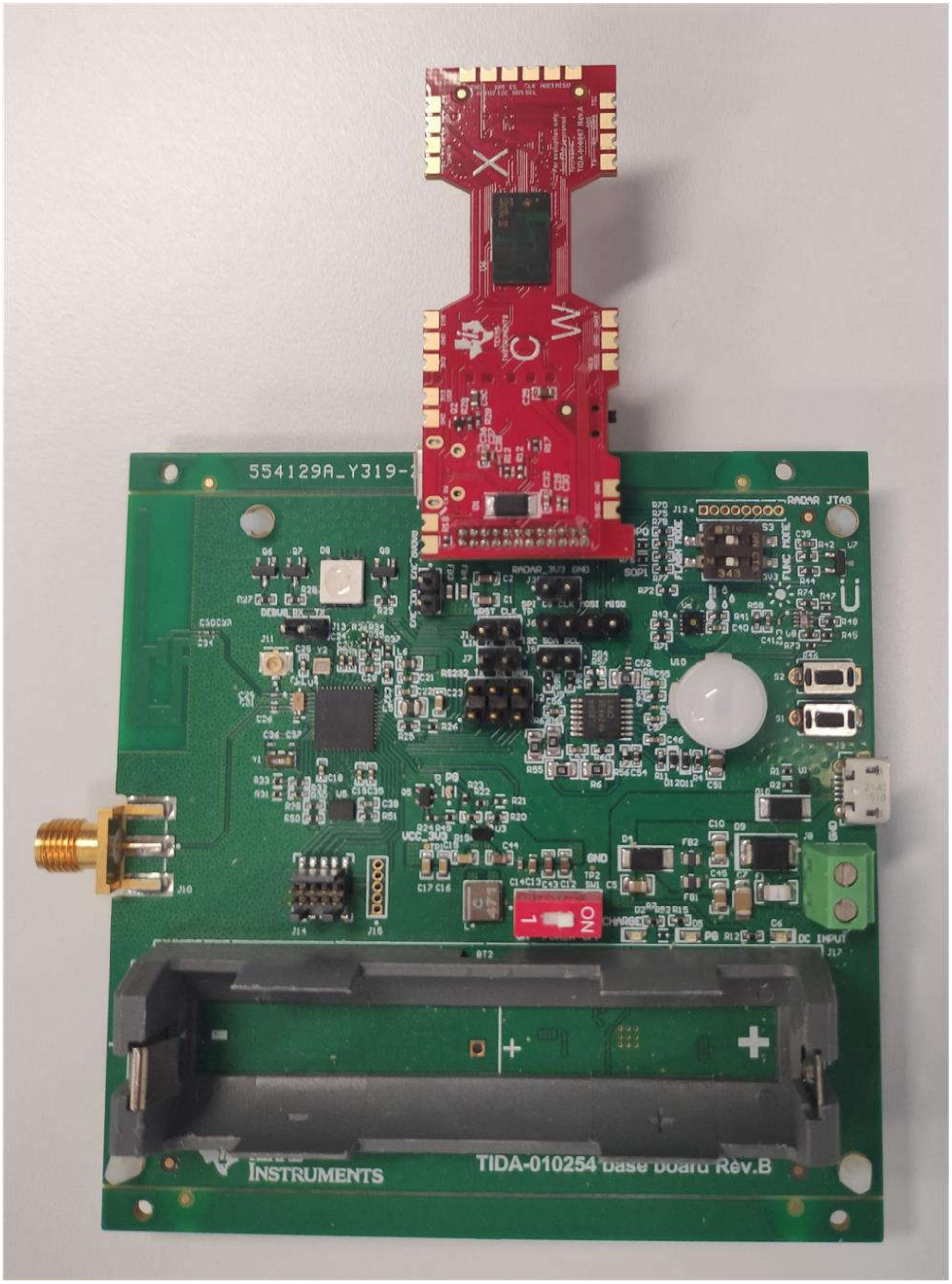


Figure 2-5. Connect to TIDA-010254 Base Board

The TIDA-010254 base board contains a CC1352R device, which supports Bluetooth LE or sub-1 GHz.

A LAUNCHXLCC1352R1 wireless MCU LaunchPad™ Development Kit is used as Bluetooth LE or sub-1 GHz client, to receive the resulting radar data from the CC1352R device on the base board. Then, the LAUNCHXLCC1352R1 sends the data to a PC by using a virtual UART port which is realized with the XDS110 simulator on the LAUNCHXLCC1352R1.

Using this method, radar data is sent by wireless communication.

2.2.4 Power Supply Design

This reference design considers the following power supply specifications:

- The IWRL6432AOP radar requires multiple voltage rails. This design uses two power rails: 3.3V and 1.8V.
- The IWRL6432AOP radar I/O voltage is set to 3.3V. The I/O can be changed to 1.8V by mounting R11 and unmounting L7.

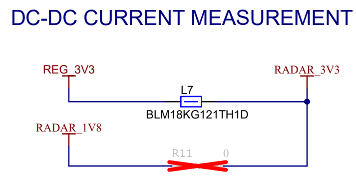


Figure 2-6. IWRL6432AOP GPIO Power Rail Selection

- The main power supply is 5.0V from the USB port, or 3.3V from the castellated pads.

2.2.5 IWRL6432AOP Power Supply Considerations

The IWRL6432AOP radar utilizes two power rails for operation. The current design implements a two-rail BOM-optimized design.

1. 1.2V digital, SRAM, and RF power are generated internal to the device
2. 3.3V IO supply
3. 1.8V VDDA, VCO, CLK and VIOIN_18 supply

In this design, 3.3V and 1.8V are used as input power source. Table 2-1 lists the peak currents on each of the rails.

Table 2-1. Power Source Current Requirements

POWER RAIL	PEAK CURRENT
5V	300mA

For the device peak current requirement per voltage rail, see also the *IWRL6432AOP Single-Chip 57 to 64GHz Industrial Radar Sensor with Antenna On Package (AOP)* data sheet.

2.2.6 IWRL6432AOP Fan Out

The key power and digital interface signals are carefully routed out from the IWRL6432AOP BGA package, primarily utilizing free space near the horizontal edges and the center of the device. The absence of via-in-pad simplifies manufacturing processes and reduces PCB cost, yielding a significant cost benefit for two-layer boards.

Designing signals on a two-layer PCB poses significant challenges due to tight constraints, necessitating proper design considerations and careful routing. To preserve the Field of View (FOV) of the antenna, designers must exercise extra caution when placing tall components within the restricted radius of the IWRL6432AOP keepout area. Conversely, the BGA pads along the horizontal edges of the IWRL6432AOP facilitate efficient packing of the center and north section and south section of the package. Figure 2-7 illustrates an exemplary implementation of fan out.

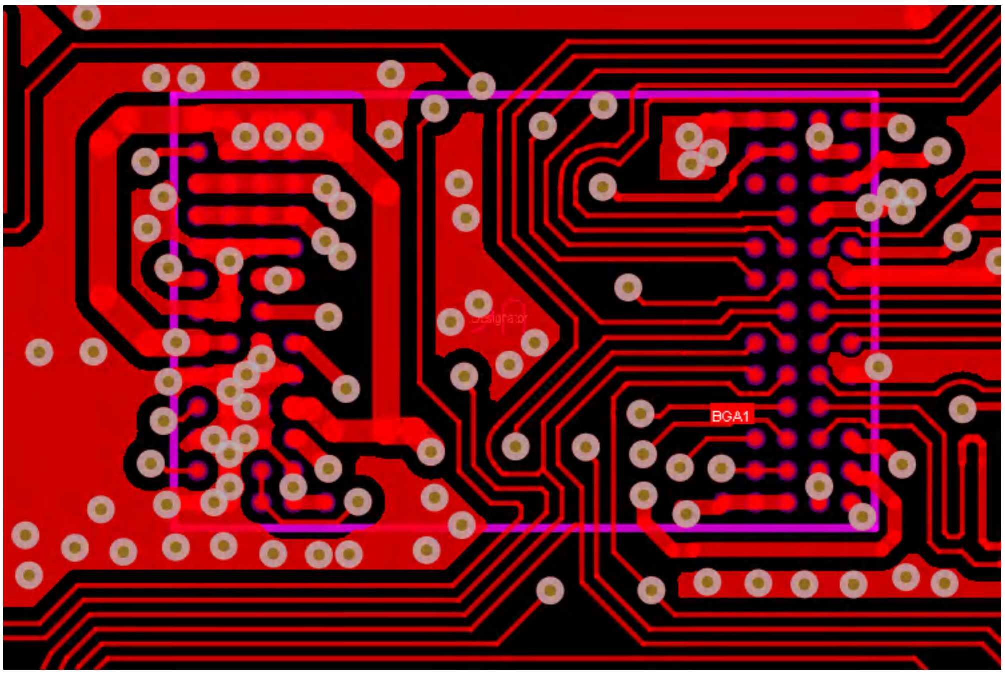


Figure 2-7. TIDA-010967: IWRL6432AOP Fan Out

2.2.7 Cost Optimization Techniques

The design implements multiple PCB cost-optimization techniques making the PCB affordable. The cost-optimization techniques are discussed in the following list.

1. *Two-layer PCB design:*

   The design is implemented on a two-layer PCB, significantly reducing fabrication costs. Utilizing only two layers also minimizes the number of plating cycles, thereby reducing the turnaround time and further lowering manufacturing expenses. The simplified stackup avoids the need for buried or blind vias, making the board a beneficial choice for high-volume production with minimal yield risk.
2. *Cost-effective substrate selection:*

   The PCB leverages the ultra-low-cost FR4 as the core substrate. Since the antenna is integrated within the Antenna-on-Package (AoP): high-frequency, low-loss laminate is not required, enabling further cost savings. The ultra-low-cost FR4 offers sufficient thermal and electrical performance for digital interfaces and power delivery without requiring high RF performance materials.

3. *Via-in-pad elimination:*

   Via-in-pad is completely eliminated in favor of a dog-bone fan-out strategy for BGA routing. This approach avoids the additional cost associated with via filling, planarization, and plating processes typically required for via-in-pad structures. The dog-bone routing makes sure there is reliable solder joint formation and simplifies rework or inspection, especially for mid-pitch BGAs.

2.2.8 Comparison Between TIDA-010967 and IWRL6432AOPEVM

The TIDA-010967 and IWRL6432AOPEVM are both designs to evaluate the IWRL6432AOP mmWave radar sensor, but these designs serve different purposes and are optimized accordingly. This section contains a detailed comparison highlighting the differences in design approach, hardware implementation, and use-case orientation.

The TIDA-010967 design has the following benefits:

1. *Easy to Production:* The TIDA-010967 can be implemented directly on production hardware, making the design preferable for cost-sensitive end-product designs. Whereas, the IWRL6432AOPEVM is designed purely for evaluation and development purposes.
2. *Cost Optimization:* The TIDA-010967 features a low-cost, two-power rail BOM-optimized design, reducing the BOM count and cost. The IWRL6432AOPEVM; however, is power-optimized and uses a broader set of components to support broader evaluation capabilities.
3. *Low-Cost PCB Stackup:* The TIDA-010967 is built on a 2-layer PCB, offering a significant cost advantage for mass production. Whereas the EVM uses a 4-layer PCB to support better signal integrity and power distribution, preferable for development use.
4. *Easy to Test:* The TIDA-010967 uses the FT230XS USB-to-UART converter, which is cost-effective and an excellent choice for small designs. The TIDA-010967 includes castellated pins to interface with customized production, hardware, and test. IWRL6432AOPEVM integrates the XDS110 debugger, offering UART and JTAG for comprehensive debugging.
5. *Small Board Size and Easy to Integrate:* The form factor of the TIDA-010967 is small and compact, supporting easy integration with the main board of a customer, like a wireless module. The EVM is relatively large, which accommodates evaluation circuitry and debugging features.

2.3 Highlighted Products

2.3.1 IWRL6432AOP

The IWRL6432AOP mmWave Sensor device is an Antenna-on-Package (AOP) device that is an evolution within integrated single-chip mmWave sensors. The device is based on Frequency Modulated Continuous Wave (FMCW) radar technology. The device is capable of operation in the 57GHz to 63.9GHz band and is partitioned into mainly four power domains:

- *RF or Analog Subsystem*: This block includes all the RF and Analog components required to transmit and receive the RF signals.
- *Front-End Controller Subsystem (FECSS)*: FECSS contains processor Arm® Cortex®-M3, responsible for radar front-end configuration, control, and calibration.
- *Application Subsystem (APPSS)*: APPSS is where the device implements a user-programmable Arm Cortex-M4 allowing for custom control and interface applications. Top Subsystem (TOPSS) is part of the APPSS power domain and contains the clocking and power management subblocks.
- *Hardware Accelerator (HWA)*: HWA block supplements the APPSS by offloading common radar processing such as fast Fourier transform (FFT), Constant False Alarm Rate (CFAR), scaling, and compression.

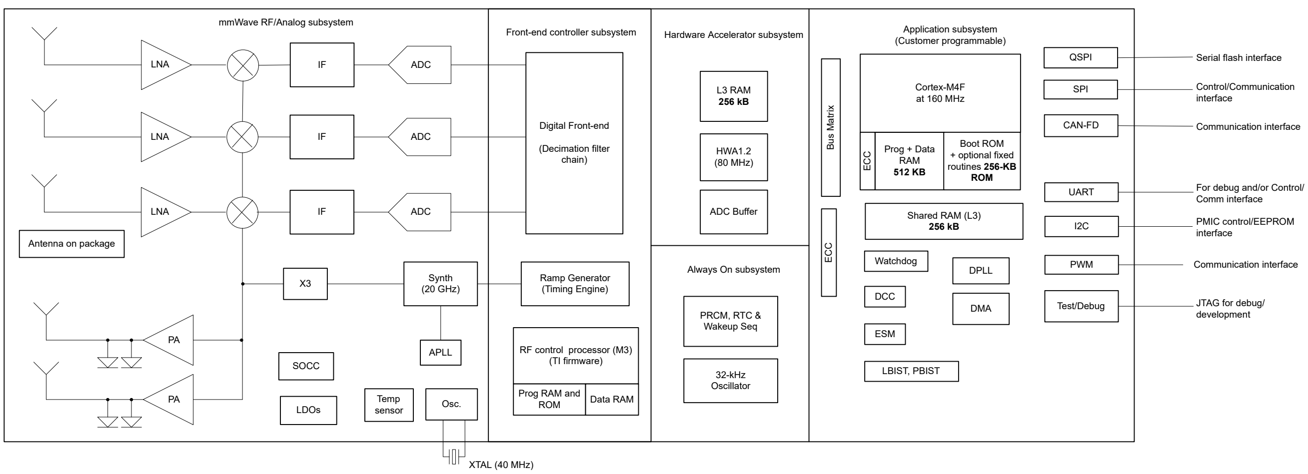


Figure 2-8. IWRL6432AOP Block Diagram

IWRL6432AOP is specifically designed to have separate control for each of the previously-mentioned power domains to control states (power ON or OFF) based on use-case requirements. The device also features the capability to exercise various low-power states like sleep and deep sleep, where low-power sleep mode is achieved by clock gating and by turning off some of the internal IP blocks of the device. The device also provides the option of keeping some contents of the device, like the application image or RF profile retained in such scenarios.

Additionally, the device is built with TI's low-power 45nm RF Complementary Metal-Oxide-Semiconductor (CMOS) process and enables unprecedented levels of integration in an extremely small form factor. IWRL6432AOP is designed for low-power, self-monitored, ultra-accurate radar systems in the industrial (and personal electronics) space.

These systems are for applications such as the following:

- Building or factory automation
- Commercial or residential security
- Personal electronics
- Presence detection or motion detection
- Gesture detection or gesture recognition for human-machine interfaces (HMI)

2.3.1.1 Antenna Radiation Patterns Measurement

The IWRL6432AOP sensor integrates three receive channels and two transmit channels AoP.

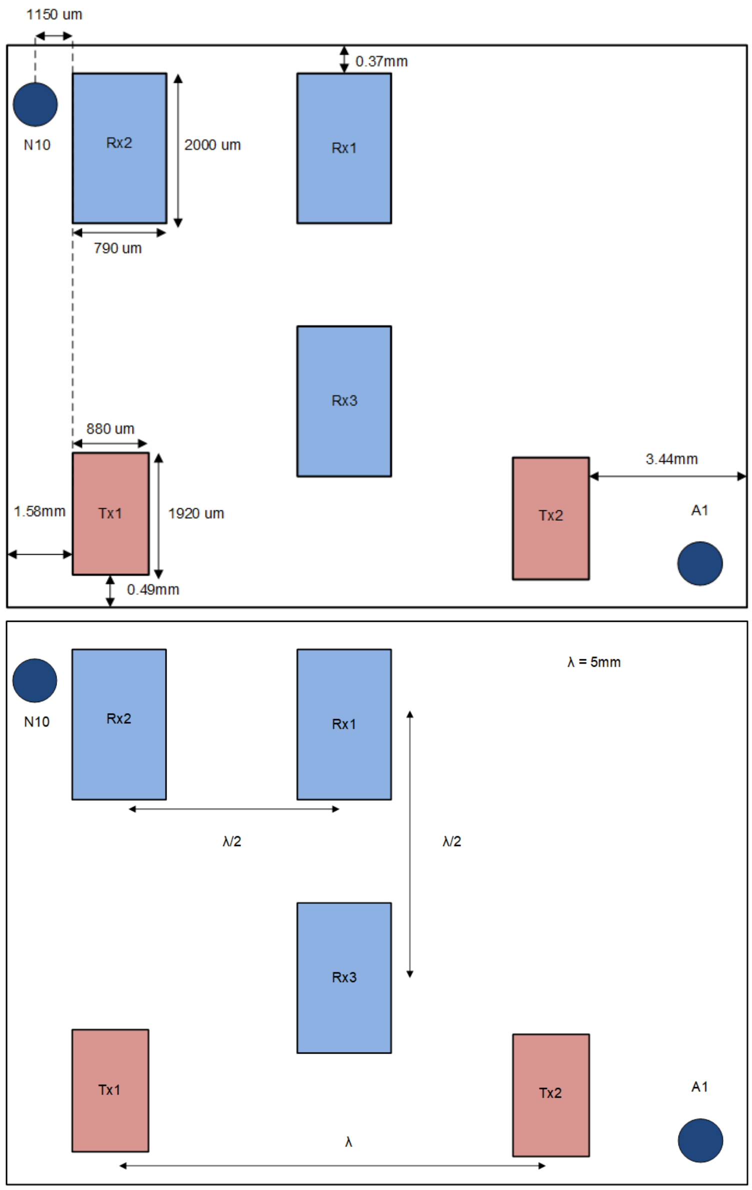
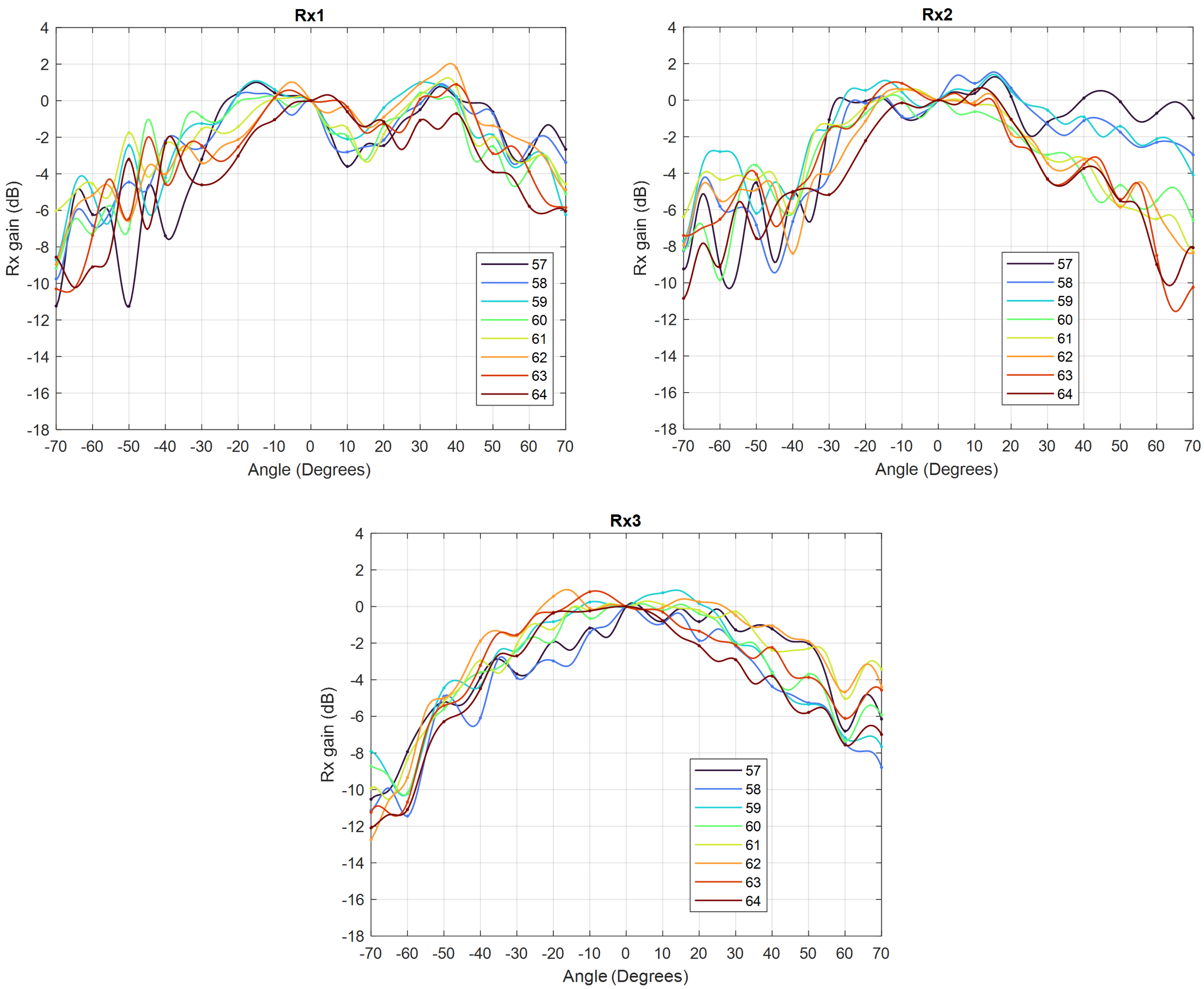


Figure 2-9. TX and RX Antennas of the IWRL6432AOP

This module has the same azimuth and elevation antenna radiation patterns as the IWRL6432AOP radar.

RX Gain Plot Across Azimuth (Normalized to Boresight)



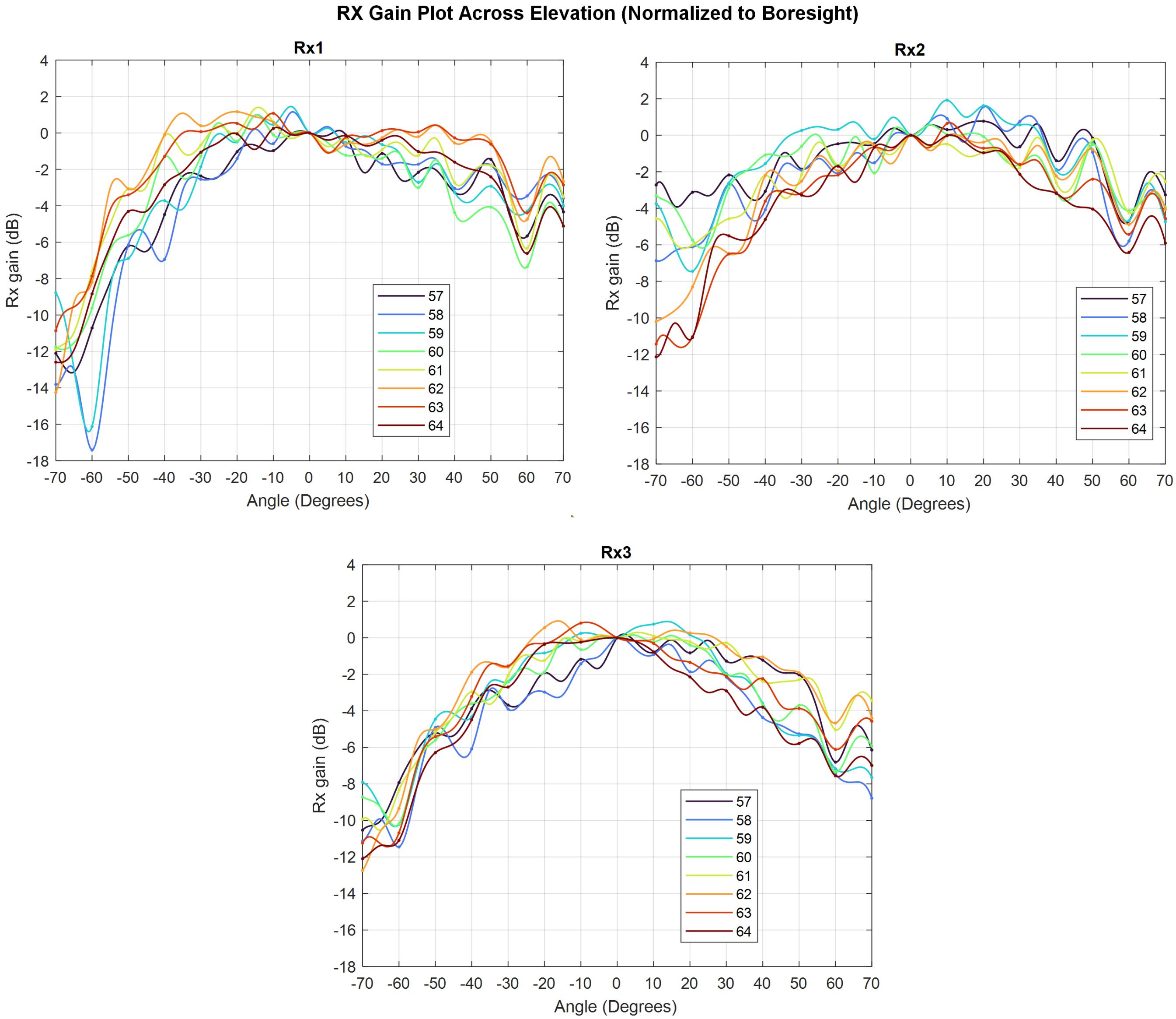


Figure 2-10. Transmitter Antenna Radiation Pattern

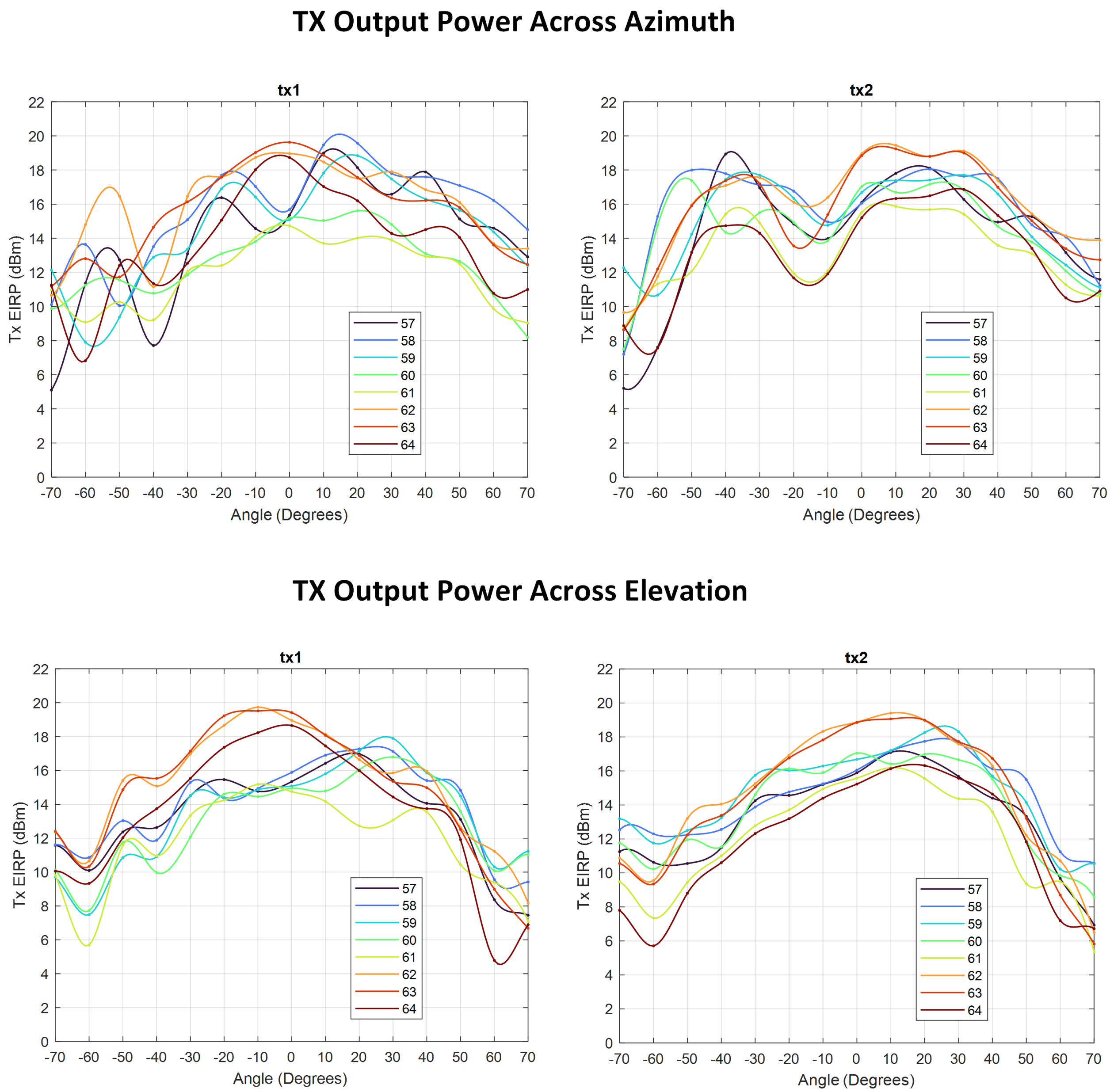


Figure 2-11. Transmitter Antenna Radiation Pattern

2.3.2 TPS628502

The TPS62850x is a family of pin-to-pin 1A, 2A (continuous), and 3A (peak) high-efficiency, easy-to-use synchronous step-down DC/DC converters. The devices are based on a peak current mode control topology. Low resistive switches allow up to 2A continuous output current and 3A peak current. The switching frequency is externally adjustable from 1.8MHz to 4MHz and can also be synchronized to an external clock in the same frequency range. In PWM and PFM mode, the TPS62850x automatically enters power-save mode at light loads to maintain high efficiency across the whole load range. The device offers spread spectrum clocking as an option. When SSC is enabled, the switching frequency is randomly changed in PWM mode when the internal clock is used. The frequency variation is typically between the nominal switching frequency and up to 288kHz above the nominal switching frequency. The TPS62850x provides a 1% output voltage accuracy in PWM mode, which helps design a power supply with high-output voltage accuracy, fulfilling tight supply voltage requirements of digital processors and Field-Programmable Gate Array (FPGA).

The TPS62850x is available in an 8-pin, 1.60mm × 2.10mm SOT583 package.

Onboard configuration: An 18kΩ resistor is connected from COMP or FSET to GND. This value of the resistor sets the device in the following configuration:

1. Switching frequency set to 3.3MHz
2. Spread spectrum clocking (SSC) enabled
3. Compensation setting 2 for best transient response.

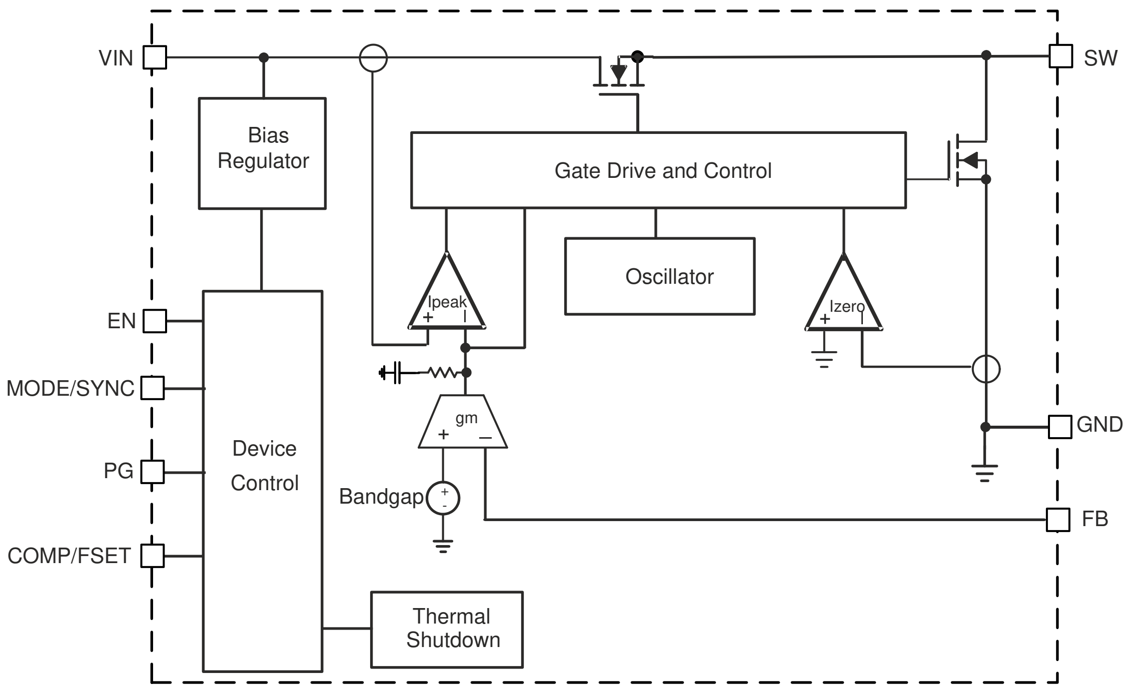


Figure 2-12. TPS628502 Block Diagram

2.3.3 TPS2116

The TPS2116 is a power multiplexer device with a voltage rating of 1.6V to 5.5V and a maximum current rating of 2.5A. The device uses N-channel MOSFETs to switch between supplies while providing a controlled slew rate when the voltage is first applied.

Due to the low quiescent of 1.32µA (typical) and low standby current of 50nA (typical), the TPS2116 is an excellent choice for systems where a battery is connected to one of the inputs. These low currents extend the life and operation of the battery when in use.

The TPS2116 can be configured for two different switchover behaviors depending on the application. Automatic priority mode prioritizes the supply connected to VIN1 and switches over to the secondary supply (VIN2) when VIN1 drops. Manual mode allows the user to toggle a GPIO or enable the signal to switch between channels.

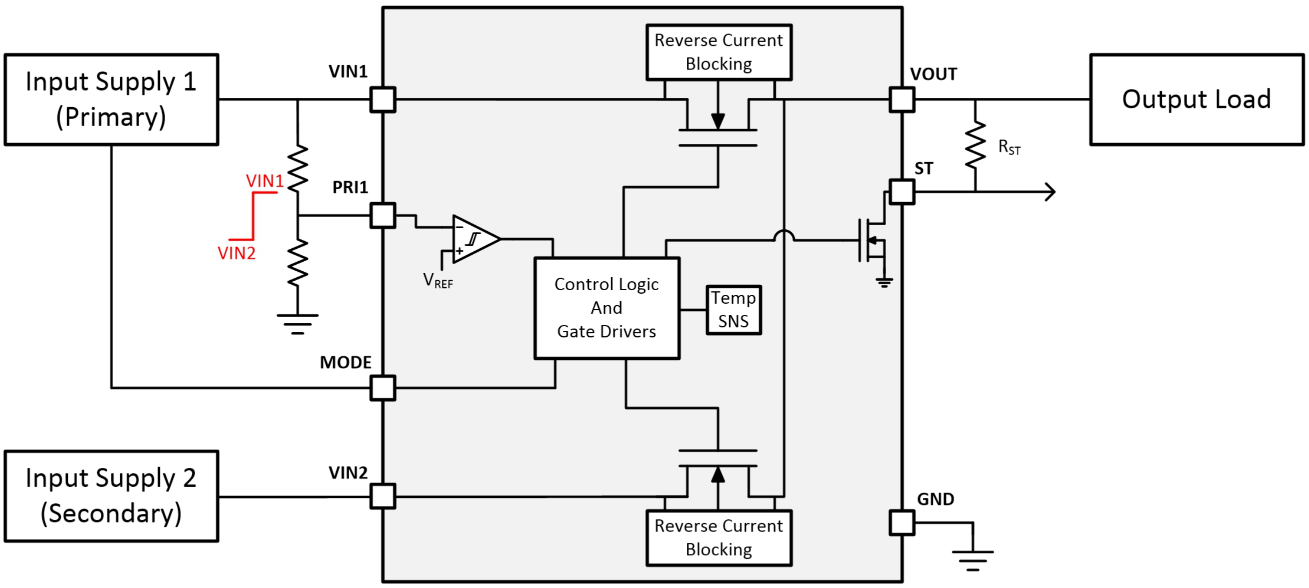


Figure 2-13. TPS2116 Block Diagram

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Hardware Requirements

This reference design includes:

- The reference design module, which contains the IWRL6432AOP radar sensor, FT230XS USB to UART converter, and castellated pads with a 1.27mm interface connector.
- A TIDA-010254 base board, which connects this reference design module with a 1.27mm interface connector.
- A LAUNCHXLCC1352R1 wireless MCU LaunchPad™ development kit: communicates with the TIDA-010254 base board through Bluetooth LE and UART emulation over a USB link with the PC GUI.
- A PC with Visualizer GUI software which visually shows radar sensing data and the detecting result.

3.1.1 Getting Started Hardware

3.1.1.1 Design Module Initialization: IWRL6432AOP Programming

Complete the following steps to initialize this reference design module:

1. Select IWRL6432AOP Sense-on-Power (SOP) mode, by using SW1 on the design module. Table 3-1 provides a description of the SOP modes. A "*0*" represents pulling the pin low and a "*1*" represents pulling the pin high. The switch SW1 position *right* represents "*0*" and *left* represents "*1*".

Table 3-1. SOP0 Mode

MODE	SOP0	MODE DESCRIPTION
1	0	Flashing mode: The host flashes the user application or firmware to Quad Serial Peripheral Interface (QSPI) flash
2	1	Functional mode: IWRL6432AOP loads the user application from QSPI flash to the internal RAM and runs the application from RAM. User configuration is sent to the device over the UART interface.

2. Set the SOP mode to flashing mode (see Figure 3-1).

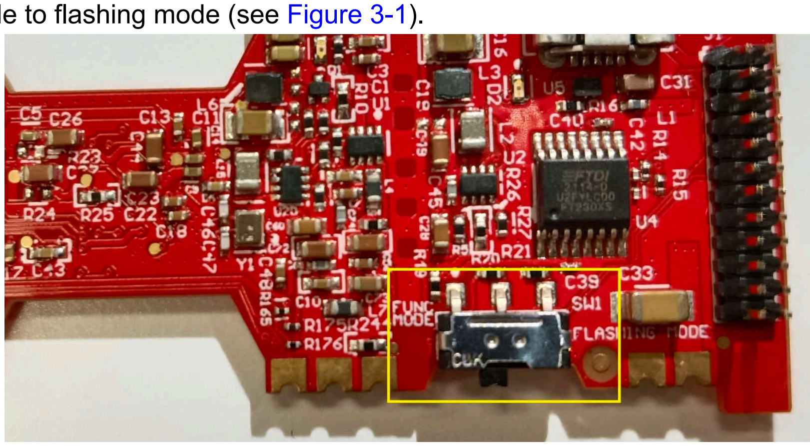


Figure 3-1. Set up the SOP to Flashing Mode

3. Connect the design module to a PC. Use a USB cable to connect the micro receptacle USB connector (J2) on the design module and the USB connector of the PC.

The IWRL6432AOP radar sensor on the design module is ready for programming.

TI provides the Code Composer Studio™ software for firmware programming and debugging. See also the Code Composer Studio™ integrated development environment (IDE) user guide to get the CCSTUDIO software.

The UNIFLASH software can also be used to flash the IWRL6432AOP.

TI also provides a mmWave Software Development Kit (SDK) to flash a binary file to IWRL6432AOP. See the mmWave-L-SDK tool page to get this SDK.

Use the following steps to flash the IWRL6432AOP image file by using mmWave SDK:

1. Open the visualizer software in the SDK. Visualizer is found in the folder where the SDK is installed: Root directory:

   ```
   \MMWAVE_L_SDK installed directory\tools\visualizer
   ```

2. Select the *Flash* tab and enter the UART port number manually. Select the *Enter* key on the PC.

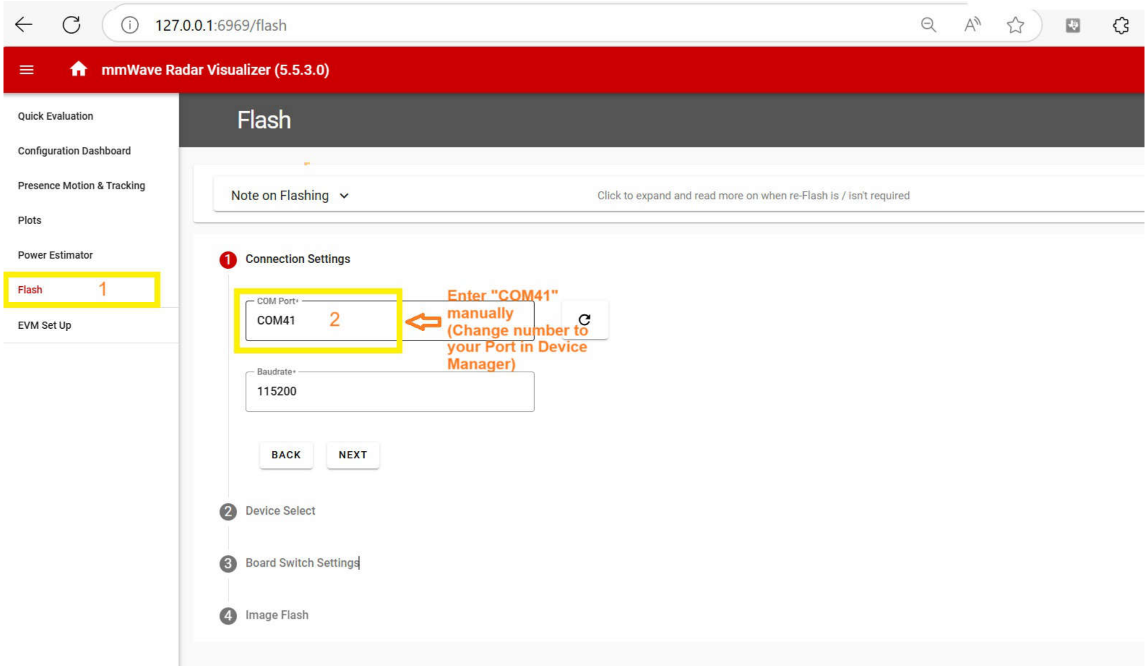


Figure 3-2. Select UART Port

3. Select XWRL6432AOP in the *Device Select* section. Click the *Enter* key on the PC.

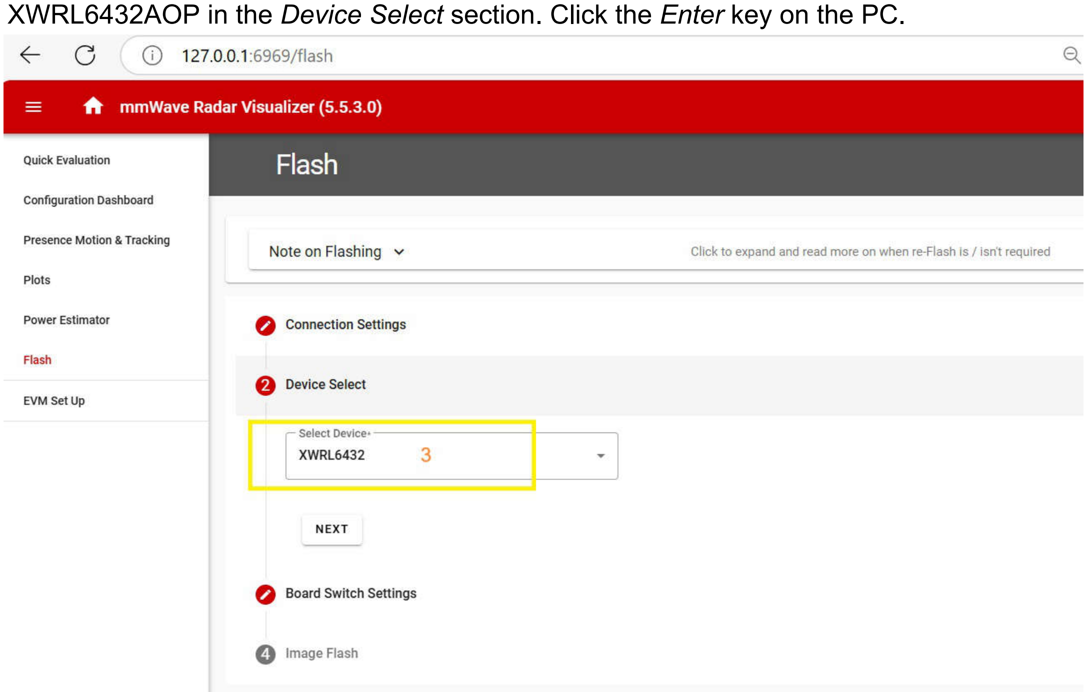


Figure 3-3. Device Select

4. Select the *SWITCH SETTINGS CONFIRMED* button in the *Board Switch Settings* section. Click the *Enter* key on the PC.

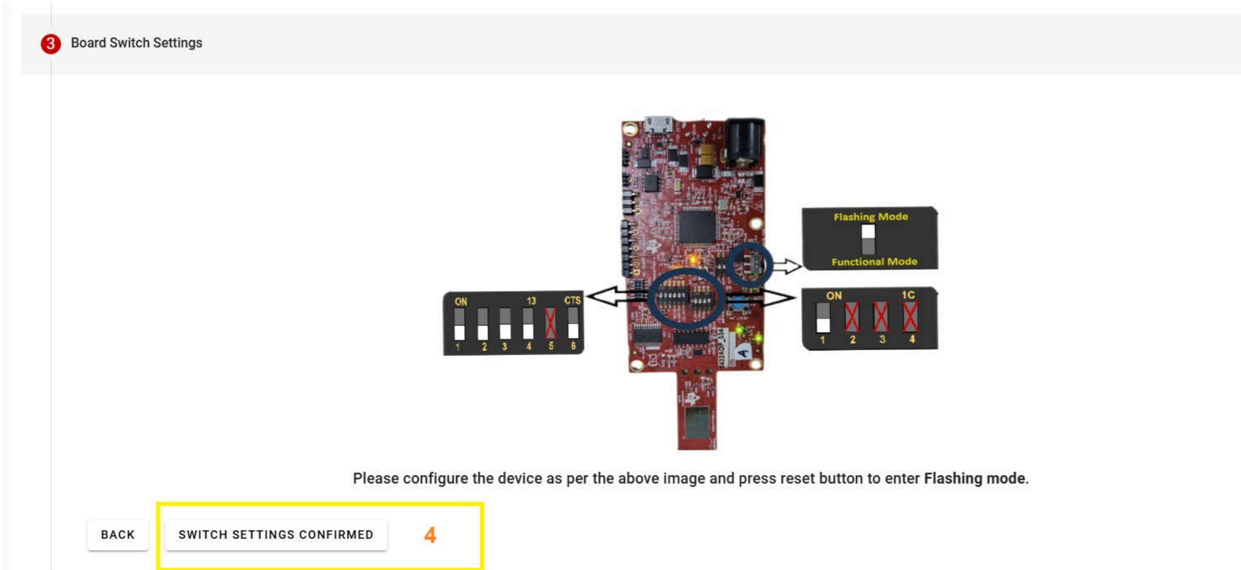


Figure 3-4. Board Switch Settings

Note

The image refers to the IWRL6432AOP EVM switch setting. Ignore switch settings in this design.

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1. Select the *Custom Image* icon.
2. Click the *Upload* button. Select the

```
motion_and_presence_detetion_demo_aop.release.appimage
```

file, which is generated with the last build in the image file steps. Obtain this file from the project folder, that is;

```
SDK installed
directory\examples\mmw_demo\motion_and_presence_detection\prebuilt_binaries\xwrL64xx-aop
```

3. Click the *Flash* button and flash the image to IWRL6432AOP.

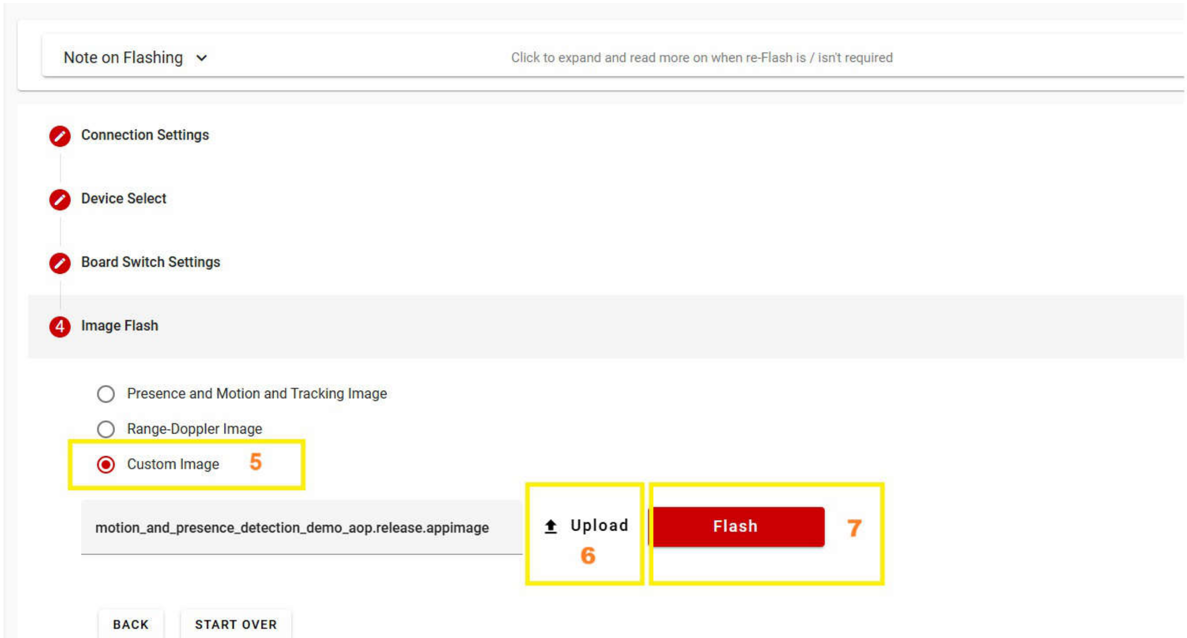

Figure 3-5. Image Flash

After the IWRL6432AOP programming completes, unplug the USB cable to power off the radar module and switch SW1 to the *Function* mode.

Use the following steps to flash the IWRL6432AOP image file by using UniFlash:

1. Open the UniFlash software
2. Select *mmWave* from the *Category* header
3. Select *IWRL6432* from the field of available devices
4. Click the *Start* button.

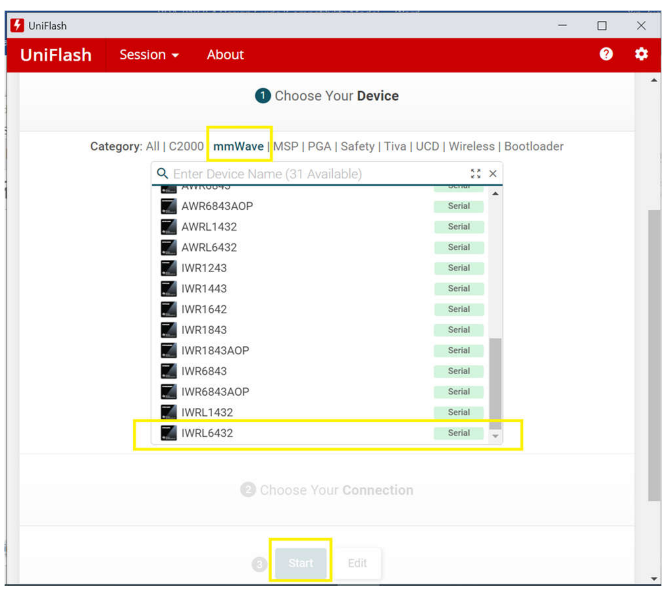

Figure 3-6. UniFlash Configuration for IWRL6432AOP

5. Under *Flash Image(s)*, click the green *Browse* button by *Meta Image 1*
6. Select the

   ```
   motion_and_presence_detetion_demo_aop.release.appimage
   ```

   file, which is generated with the last build in the image file steps. Obtain this file from the project folder, that is;

   ```
   SDK installed
   directory\examples\mmw_demo\motion_and_presence_detection\prebuilt_binaries\xwrL64xx-aop
   ```

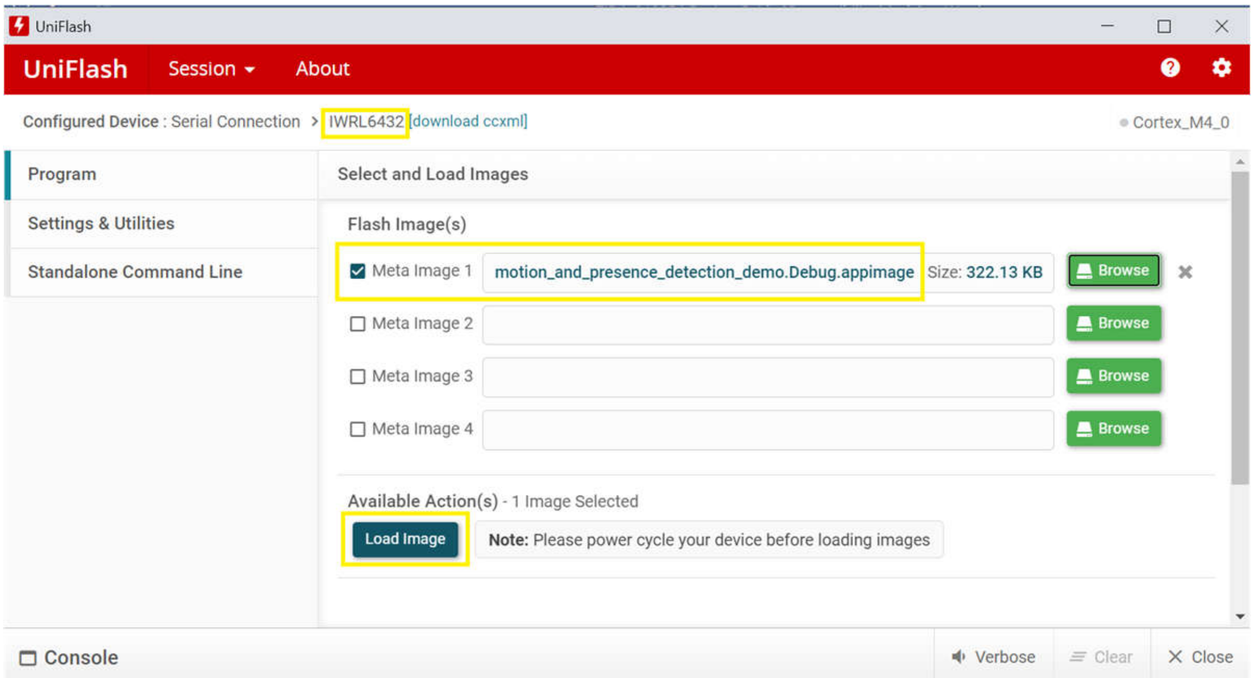

Figure 3-7. UniFlash Software Load Image for IWRL6432AOP

7. Under *Quick Settings*, input the *COMxx* manually. The "xx" is the UART port number shown in the system manager program on the PC, which connects to the USB-to-UART converter on this design module.

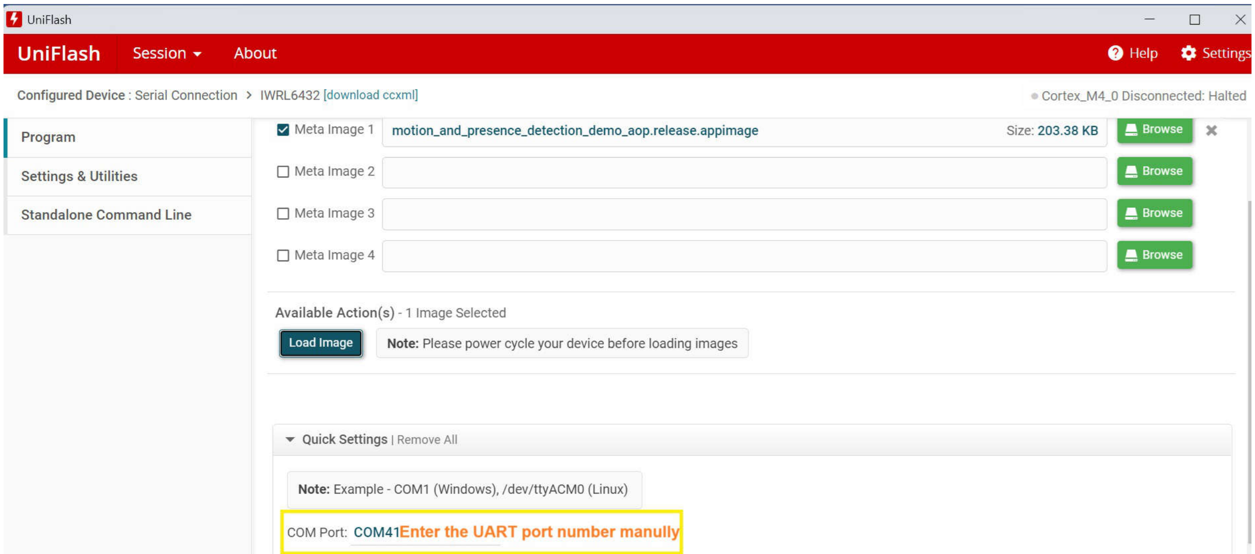

Figure 3-8. UniFlash Software Quick Settings

8. Click the *Load Image* Button and flash the image to IWRL6432AOP.

After the IWRL6432AOP programming completes, unplug the USB cable to power off the radar module and switch SW1 to the *Function* mode.

3.2 Software Requirements

This reference design software includes:

- Motion and presence detection example from mmWave SDK, which is flashed to IWRL6432AOP radar by hardware setup procedure. The mmWave SDK is available from mmWave-SDK.
- Visualizer GUI, which software visually shows the radar data. The GUI is available from mmWave-Radar Toolbox. Download the toolbox to the local PC. The GUI is in the project folder, that is;

```
Radar Toolbox installed
directory\tools\visualizers\Applications_Visualizer\Industrial_Visualizer\
```

Use the UniFlash software or visualizer software to flash the binary file of the *motion and presence detection example* to the IWRL6432AOP radar.

3.3 Test Setup

3.3.1 Motion and Presence Detection Demonstration Setup

Use the following setup procedures for the *motion and presence detection* example demonstration:

1. Clamp this radar module on a tripod. The height is 1.8m from the ground, and there is no downward tilt: 0 degree.

Figure 3-9. Design Module on a Tripod

2. Connect a USB cable to this design module to a PC, to power up the module and communicate with the IWRL6432AOP device on the module used by the USB-to-UART converter.

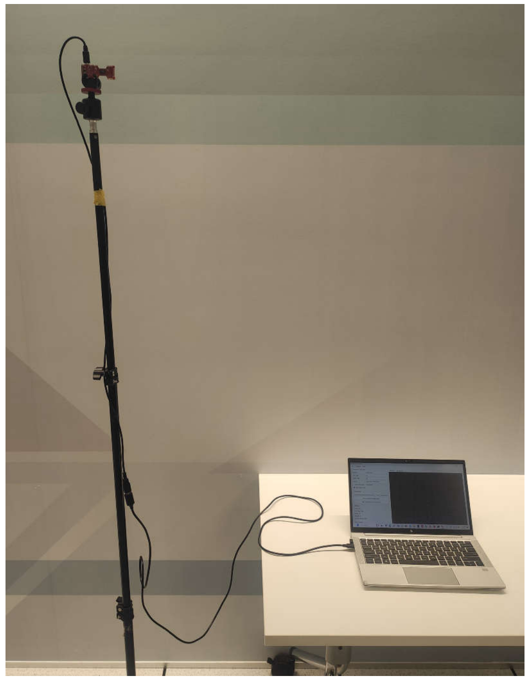

Figure 3-10. Demonstration Position Setup

3. Run the Visualizer GUI software from *mmWave-Radar Toolbox* on a PC and start the demonstration. Click the button with the four steps shown in Figure 3-11. The GUI configuration file in step 2 is from *mmWave-SDK*. The GUI configuration file folder is:

```
Radar Toolbox installed directory
\examples\mmw_demo\motion_and_presence_detection\profiles\xwrL64xx-aop\PresenceDetect.cfg
```

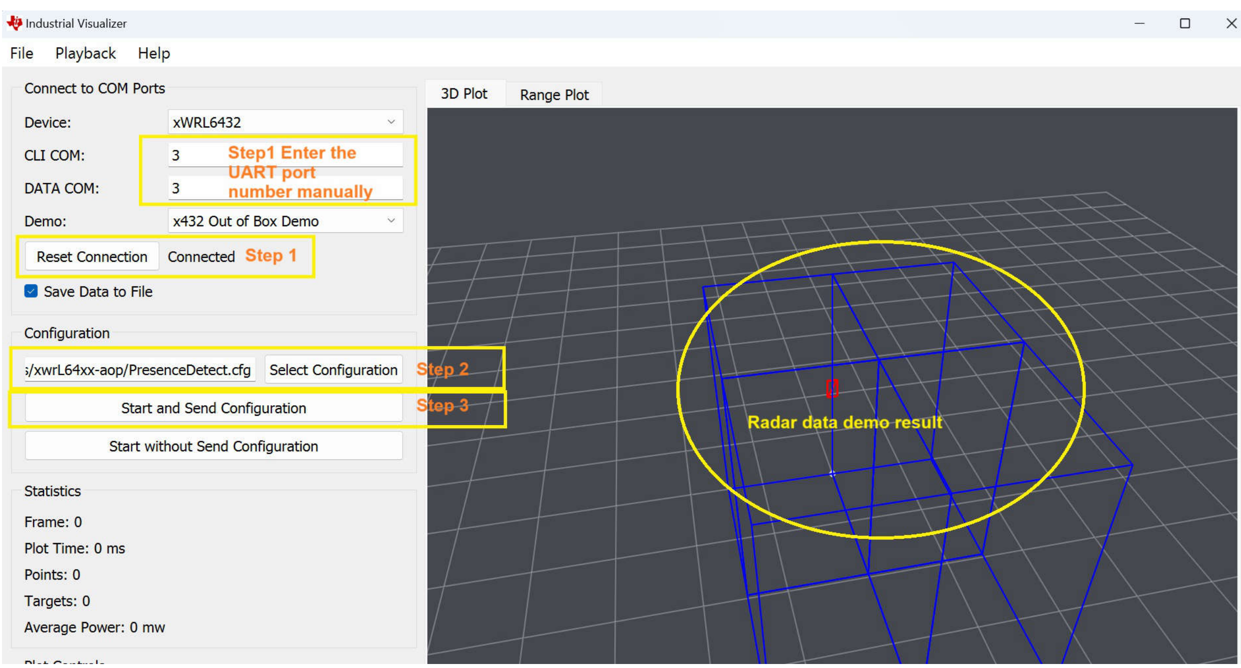

Figure 3-11. Visualizer GUI Software for Demonstration

3.3.2 Bluetooth® LE Communication Demonstration Setup

Use the following setup procedures for the motion and presence detection demonstration with Bluetooth LE communication:

1. Connect this radar module to a TIDA-010254 base board. Clamp the combination boards on a tripod. The height is 1.8m high from the ground, and there is no downward tilt: 0 degree.
2. Power up the base board and radar module with an 18650 Li-ion battery.

Figure 3-12. Design Module With TIDA-010254 Base Board on a Tripod

3. Use a USB cable to power up and connect the LAUNCHXLCC1352R1 wireless MCU LaunchPad™ to a PC.

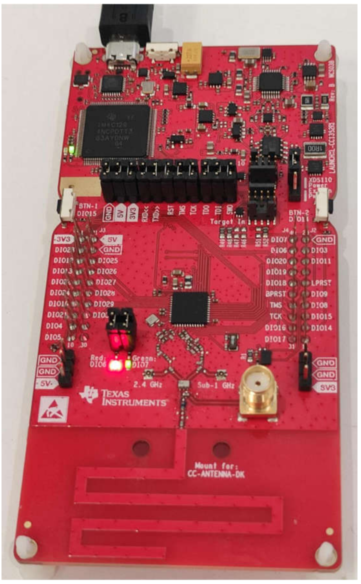

Figure 3-13. LAUNCHXLCC1352R1 Connected to a PC

4. Position the LAUNCHXLCC1352R1 near the base board and this design radar module. TI suggests making the distance less than 1m.

Figure 3-14. Bluetooth® LE Demonstration Position Setup

5. Run the Visualizer GUI software from mmWave-Radar Toolbox on the PC and start the demonstration. Click the button using the three steps shown in Figure 3-15.

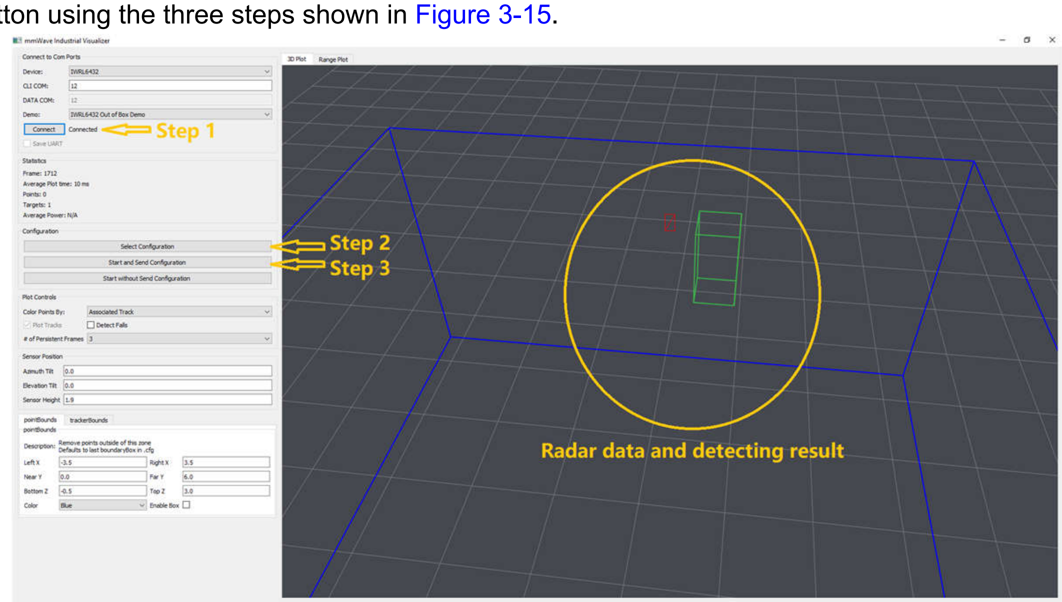

Figure 3-15. Visualizer GUI Software for Demonstration

3.4 Test Results

3.4.1 Motion and Presence Detection Demonstration Test Result

The demonstration in Figure 3-16 shows person tracking in the Visualizer GUI software.

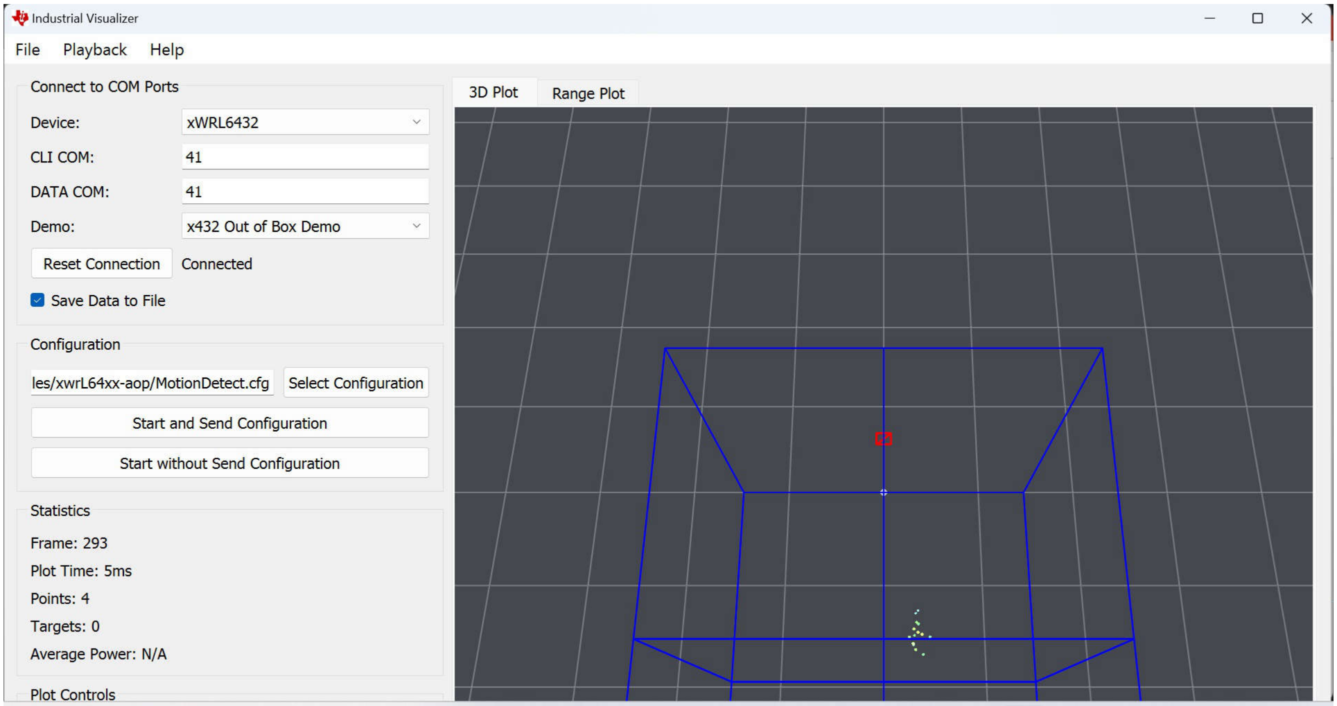

Figure 3-16. Visualizer GUI Software for Motion and Presence Detection Demonstration

The detect distance is larger than 8m at ±70 degrees.

For more detailed information on the mmWave people tracking and people-counting test results, see the *IWRL6432 People Tracking* user guide.

Note

TIDA-010967 is designed to operate the DC regulator in Auto Mode with PFM switching and Forced PWM switching simultaneously. This approach enables significant reduction in system-level power consumption, but can lead to increased parameter deviation in the range profile under specific configuration conditions, thereby degrading performance in certain cases.

3.4.2 Bluetooth® LE Communication Demonstration Test Result

This demonstration utilizes Bluetooth LE Serial Port Profile (SPP) protocol to transmit the radar detection data to the Visualizer GUI software.

The Visualizer GUI software demonstration result is same as the motion and presence detection demonstration test result.

The distance of the Bluetooth LE communication is measured to be approximately 8m in an office environment with open air. For more test setup and details, see the *TIDA-010254* reference design.

3.4.3 Power Consumption Test Results

The power current consumption test point is L4. Remove L4 and connect a digital multimeter across L4 to this design module.

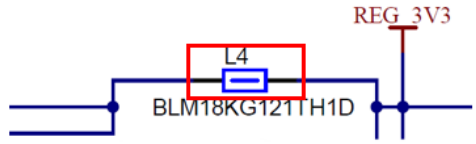

Figure 3-17. Power Consumption Schematic Setup

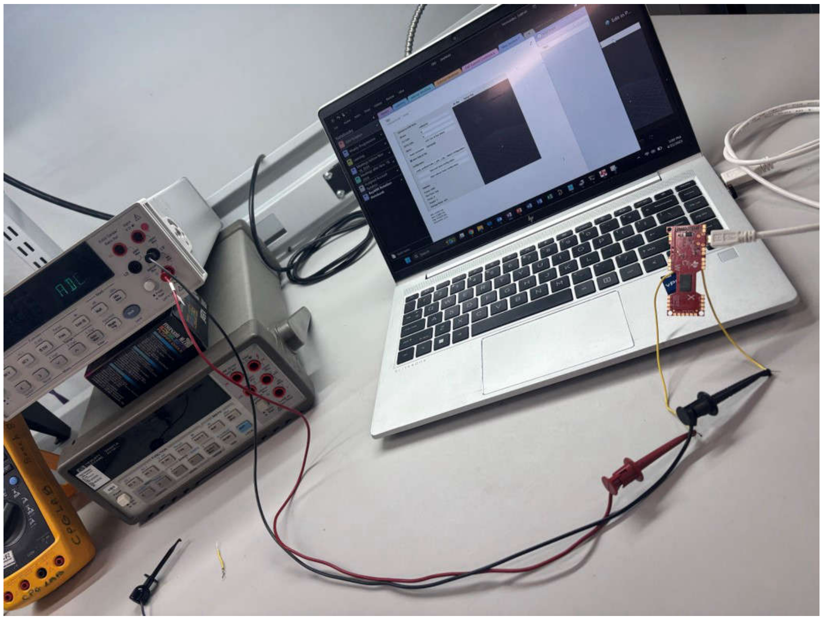

Figure 3-18. Test Device Setup

Following specially developed cfg file has been used, Visualizer GUI software from mmWave-Radar Toolbox on the PC and start the demonstration.

```
channelCfg 3 2 0
chirpComnCfg 50 0 1 64 0 38 1
chirpTimingCfg 6 8 0 8 62.8
frameCfg 4 0 300 1 333 0
guiMonitor 0 0 0 0 0 1 0 0 0 0 0
sigProcChainCfg 16 2 1 0 2 1 0 15
cfarCfg 2 8 4 3 0 70.0 0 0.9 0 1 1 1
aoaFovCfg -80 80 -40 40
rangeSelCfg 0.5 15
clutterRemoval 1
antGeometryCfg 1 1 1 0 0 1 1 3 1 2 0 3 2.5 2.5
compRangeBiasAndRxChanPhase 0.0 1.00000 0.00000 1.00000 0.00000 1.00000 0.00000 1.00000 0.00000
1.00000 0.00000 1.00000 0.00000
adcDataSource 0 adcData_1_000.bin
adcLogging 0
lowPowerCfg 1
factoryCalibCfg 1 0 40 0 0x1ff000
sensorPosition 0 0 1.44 0 0
majorStateCfg 30 2 8 300 100 1000 4 15
mpdBoundaryBox 1 0 1.48 0 1.95 0 3
mpdBoundaryBox 2 0 1.48 1.95 3.9 0 3
mpdBoundaryBox 3 -1.48 0 0 1.95 0 3
mpdBoundaryBox 4 -1.48 0 1.95 3.9 0 3
clusterCfg 0 1 2
sensorStart 0 0 0 0
```

Table 3-2 lists the results of the power measurements. The current is measured at the input power REG_3V3 of the design module.

Table 3-2. Power Consumption

MEASURE DEVICE	MINIMUM CURRENT	AVERAGE CURRENT	MAXIMUM CURRENT
TIDA-010967[(1)]	0.450mA	1.94mA at 3.3VDC	396.42mA

(1) The current drawn by this design module can be decreased significantly depending on the configuration sent to xWRL6432AOP. See also the *xWRL6432 Low Power Radar - Power Optimization Techniques* application note.

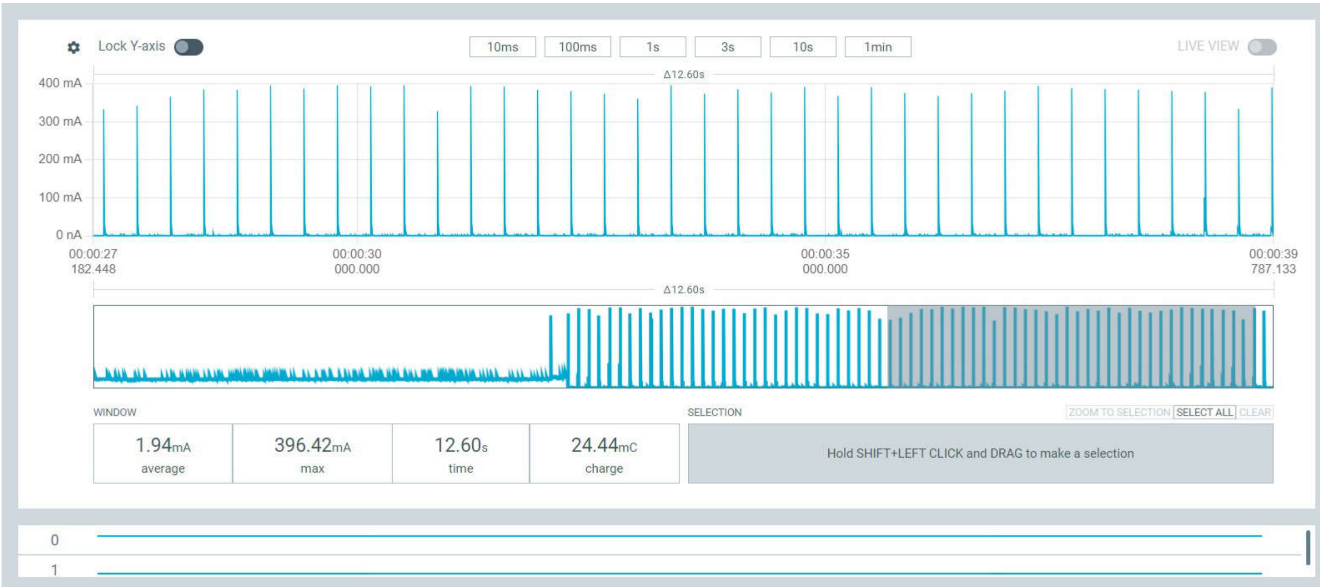

Figure 3-19. Module Current Waveframe

Figure 3-20. Module Minimum Current Waveframe

4 Design and Documentation Support

4.1 Design Files

4.1.1 Schematics

To download the schematics, see the design files at TIDA-010967.

4.1.2 BOM

To download the bill of materials (BOM), see the design files at TIDA-010967.

4.1.3 PCB Layout Recommendations

This design module uses ultra-low-cost FR4 PCB material with two layers.

	Top Overlay		Overlay			
	Top Solder	Solder Resist	Solder Mask		0.4mil	4.5
1	Top Layer		Signal	1oz	1.401mil	
	Dielectric 1	FR-4 High Tg135	Core		41.929mil	4.5
2	Bottom Layer		Signal	1oz	1.401mil	
	Bottom Solder	Solder Resist	Solder Mask		0.4mil	4.5
	Bottom Overlay		Overlay			

Figure 4-1. PCB Layer Stackup

4.1.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-010967.

4.2 Tools and Software

Tools

Visualizer GUI   Radar Toolbox for mmWave Sensors

Software

MMWAVE-L-SDK   mmWave software development kit (SDK) for xWRL1432 and xWRL6432

4.3 Documentation Support

1. Texas Instruments, *IWRL6432AOP Single-Chip 57 to 64GHz Industrial Radar Sensor with Antenna On Package (AOP) Data Sheet*
2. Texas Instruments, *TPS62850x 2.7V to 6V, 1A / 2A / 3A Step-Down Converter in SOT583 Package Data Sheet*

4.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

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