Using Infineon's radar baseboard XMC4700 and BGT24LTR11 radar shield with Arduino

Set-up guide

About this document

Scope and purpose

This application note provides a step-by-step guide to setting up Infineon's 24 GHz Sense2GoL Pulse radar system platform, which is made up of the radar baseboard XMC4700 and BGT24LTR11 radar shield, making up the hardware and software for use with the Arduino platform. This guide will then go on to show an application example to demonstrate some of the features of this radar system platform.

Intended audience

This document is intended for anyone interested in using Infineon's 24 GHz radar system platform with the Arduino platform.

Related documents

Additional information can be found in the supplementary documentation provided with the Sense2GoL Pulse Kit in the Infineon Toolbox or from **www.infineon.com/24GHz**:

- 24 GHz Radar Tools and Development Environment User Manual
- Sense2GoL Pulse Software User Manual
- AN 598 – BGT24LTR11 Shield (Pulsed Doppler)
- AN602 – Radar Baseboard XMC4700

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1 Introduction

The radar baseboard XMC4700, which is part of Infineon's 24 GHz radar system platform, is designed with headers compatible with Arduino (Figure 1) to ease prototyping works and integration with other Arduino shields in the market to form a compelling application.

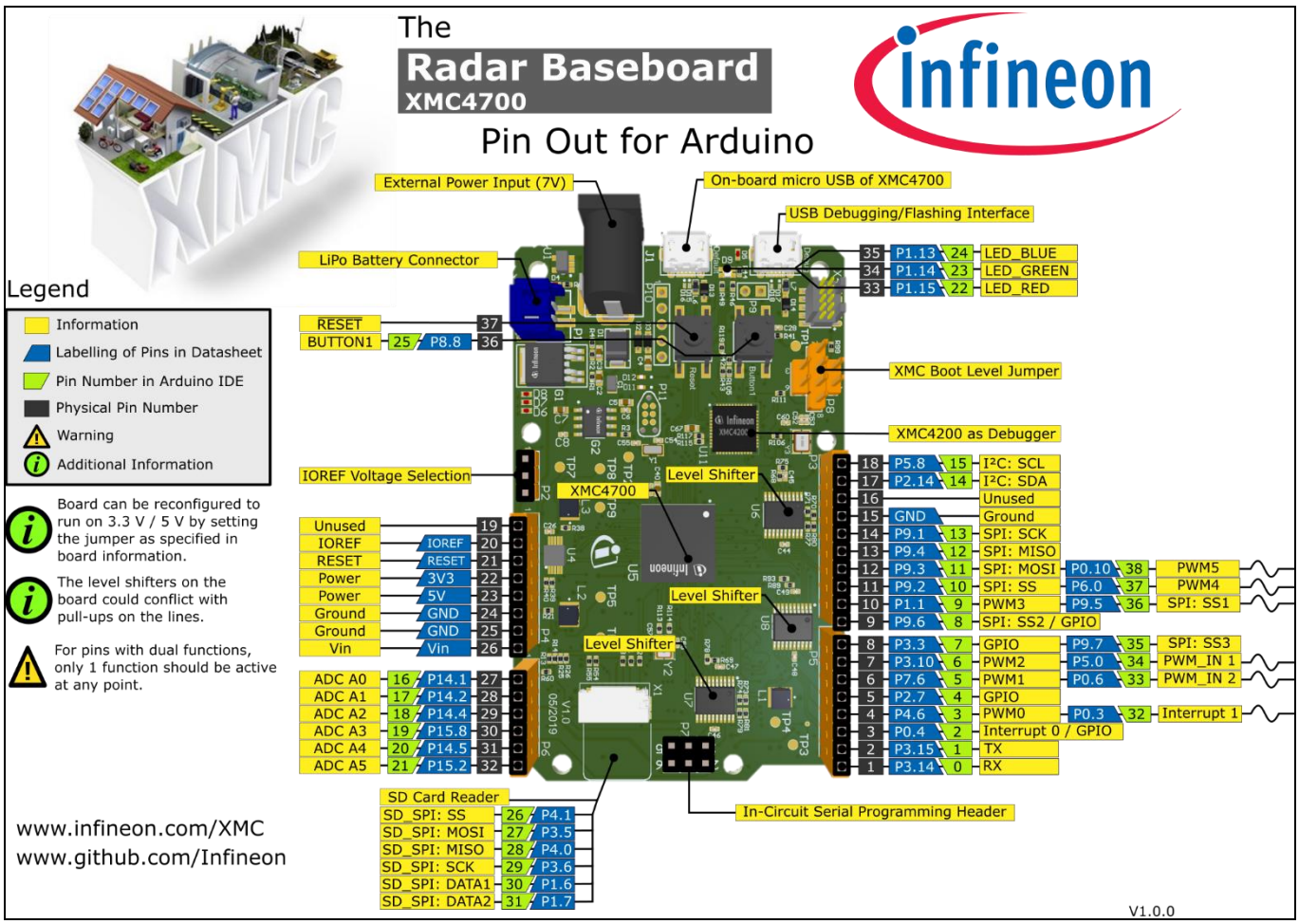

Figure 1 Radar baseboard XMC4700

Currently the 24 GHz radar system platform also offers a BGT24LTR11 radar shield (Figure 2), which is suitable for various applications such as motion detection, presence sensing and proximity sensing.

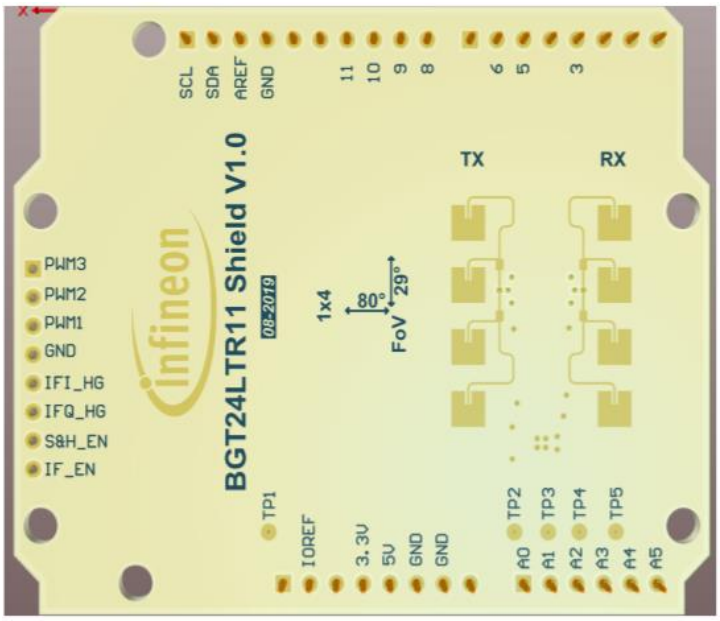

Figure 2 BGT24LTR11 radar shield

For more details on the features of each board, please refer to their respective documents as mentioned on the cover page of this document.

2 Hardware modifications

This section highlights some of the changes required to be made to the hardware before interfacing the radar baseboard XMC4700 with other Arduino shields.

2.1 Removal of resistors

If I^2C communication is intended to be used as the interface to the target Arduino shield, remove the following resistors (Figure 3): R70, R71, R73, R74, R77 and R80.

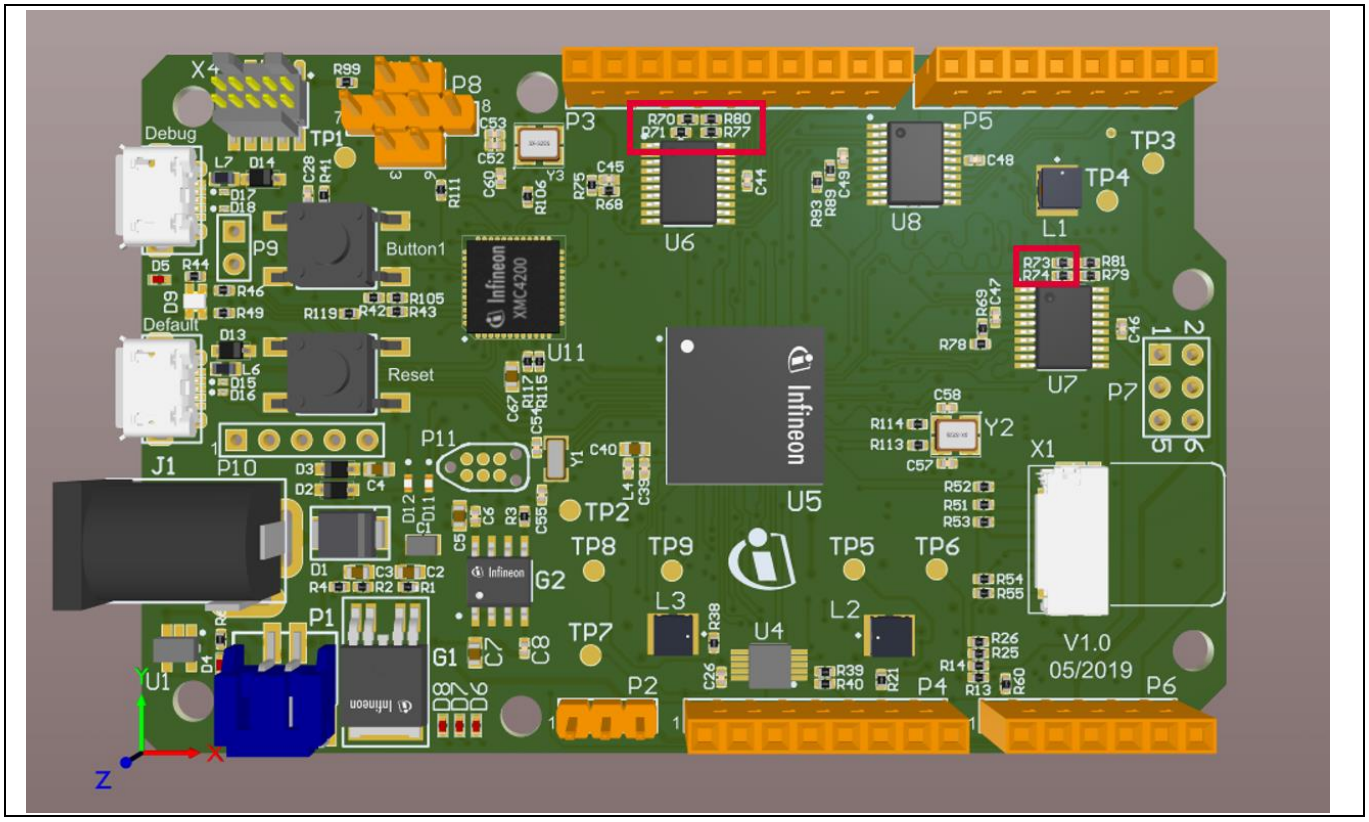

Figure 3 Resistors to be removed for I^2C communication

2.2 Selection of IOREF

XMC4700 operates in the 3.3 V domain. Depending on the target Arduino shield, the IOREF can be configured as 5 V or 3.3 V via a jumper on P2 (Figure 4).

To select 3.3 V as IOREF, short pins 1 and 2 of P2.

To select 5 V as IOREF, short pins 2 and 3 of P2.

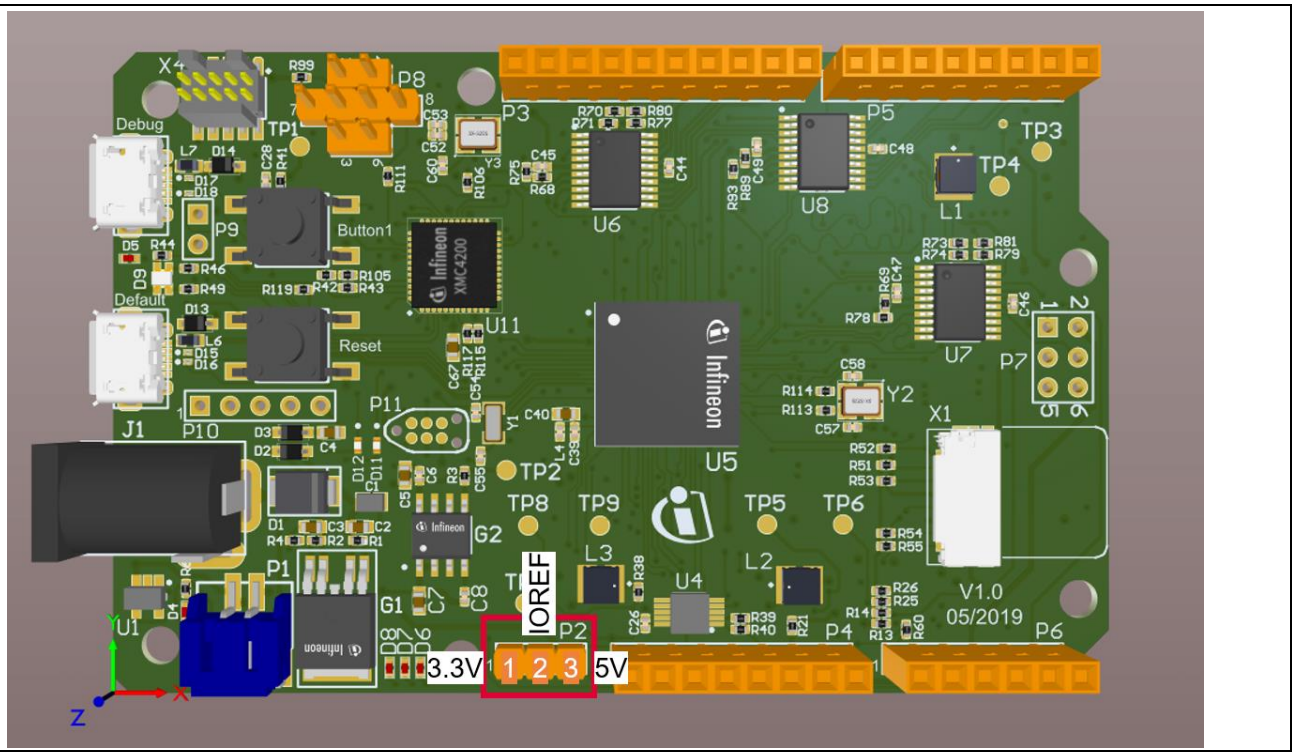

Figure 4 Jumper selection for IOREF

2.3 ISCP header

In case connection via the ISCP header is required to the target Arduino shield, do not use the pins from header P7. Instead, connect the pins via jumper wires from the SPI pins on header P3 (Figure 5).

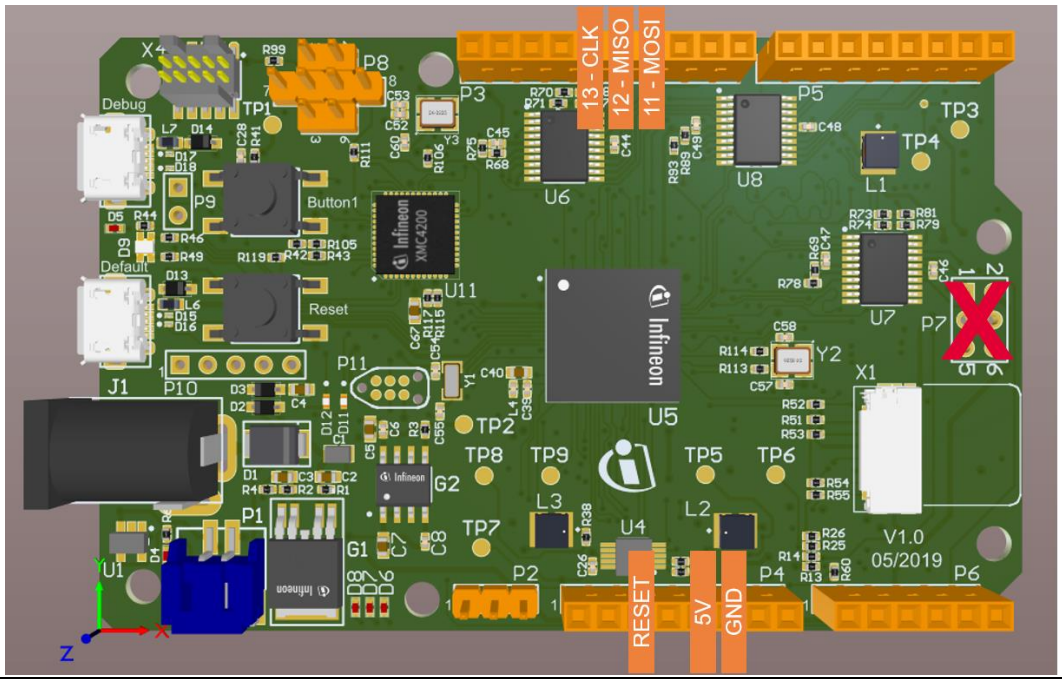

Figure 5 Use SPI pins on P3 instead of P7 (ISCP)

3 Software set-up

This section highlights the steps needed in order to use Infineon's 24 GHz radar system platform with the Arduino IDE.

3.1 Download and install Arduino IDE

The first step is to download the latest Arduino IDE version from https://www.arduino.cc/en/main/software (Figure 6). Select the desired installation type and follow the installation instructions accordingly.

Figure 6 Downloading the Arduino IDE

3.2 Install Infineon's Arduino package

1. Launch the Arduino IDE.
2. Navigate to *File* > *Preferences* (Figure 7).
3. Copy the following URL into the "Additional Boards Manager URLs" field (Figure 8):
   https://github.com/Infineon/Assets/releases/download/current/package_infineon_index.json
   Once done, click "OK".
4. Navigate to *Tools* > *Board* > *Boards Manager* (Figure 9). Type "XMC" into the search field. Select the latest version from the drop-down box and click "Install".
5. Once installation is completed, the XMC-based microcontroller boards can be found and selected under *Tools* > *Board* (Figure 10).

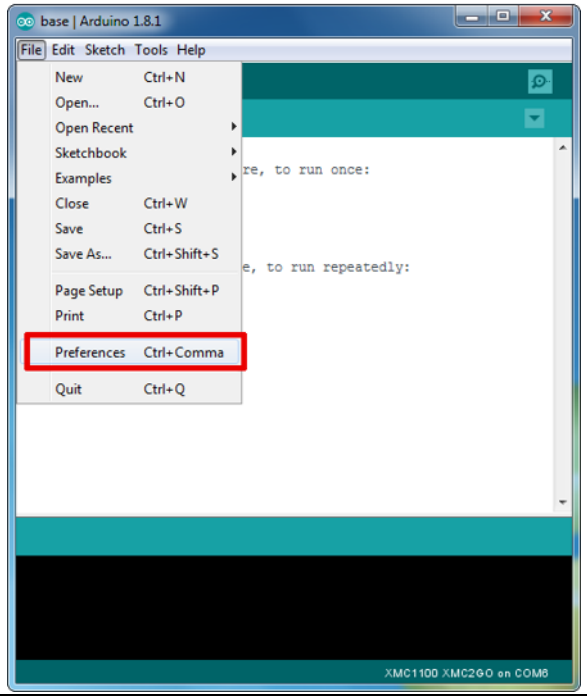

Figure 7 Arduino IDE: File > Preferences

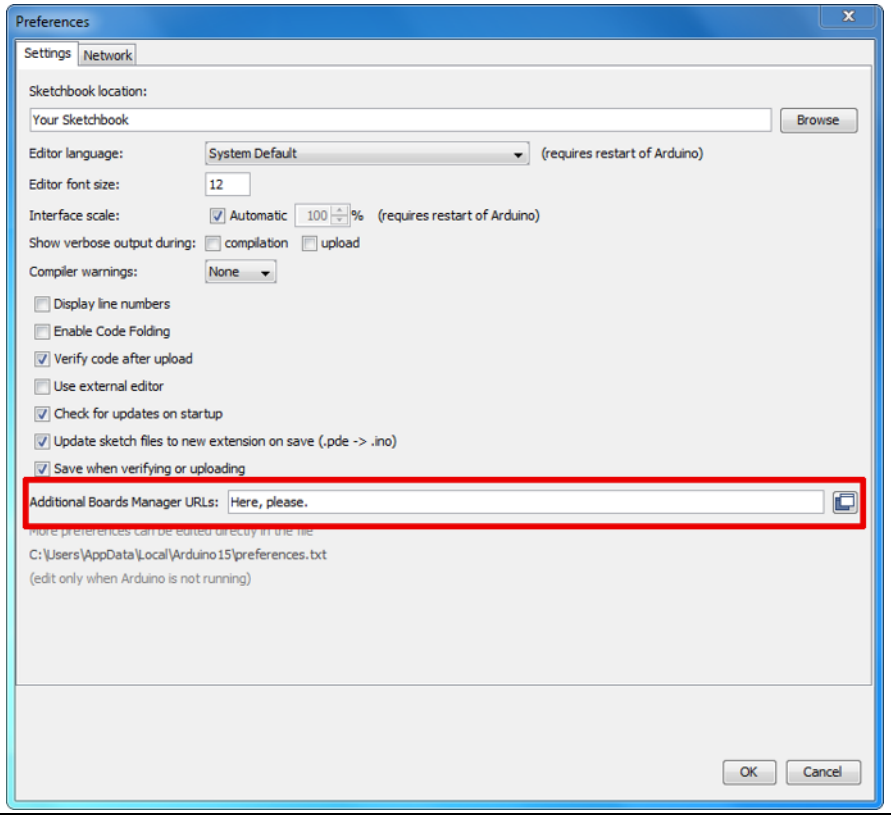

Figure 8 Entering the location from which the package can be downloaded

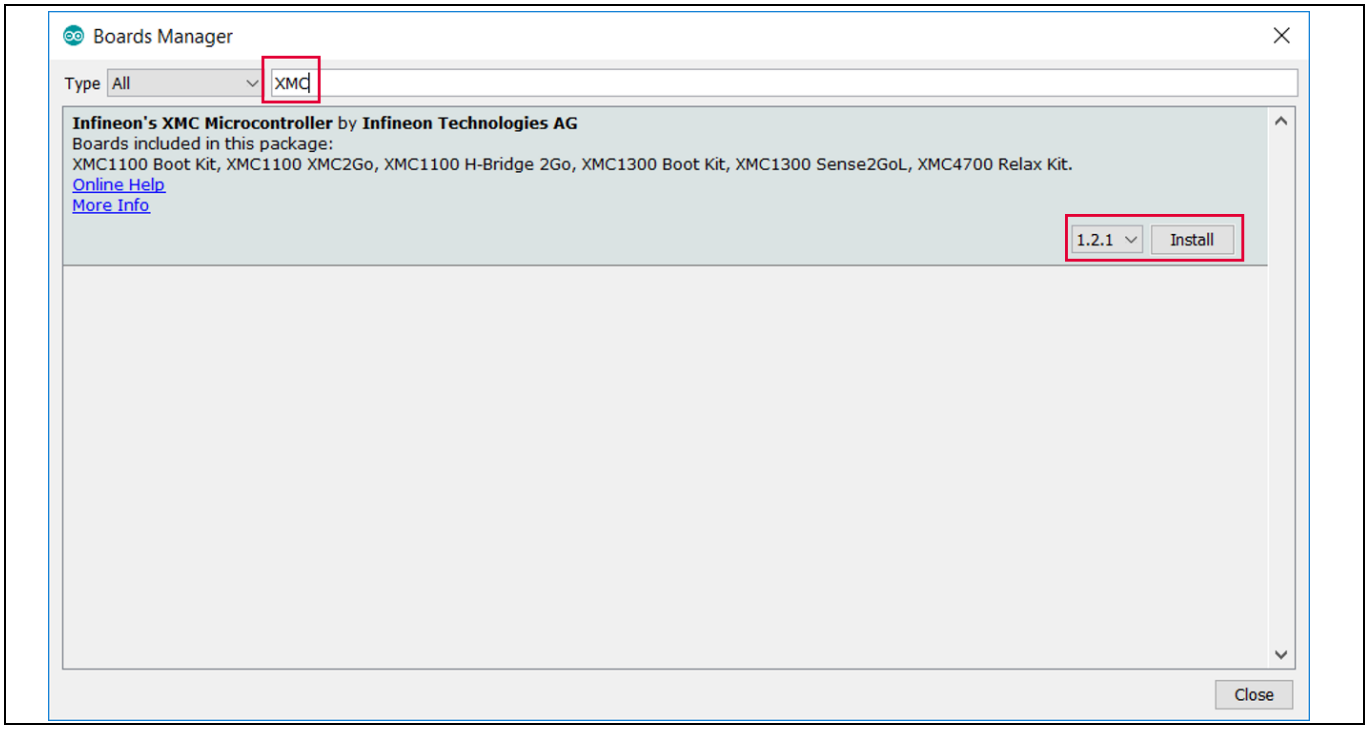

Figure 9 Installing the XMC package

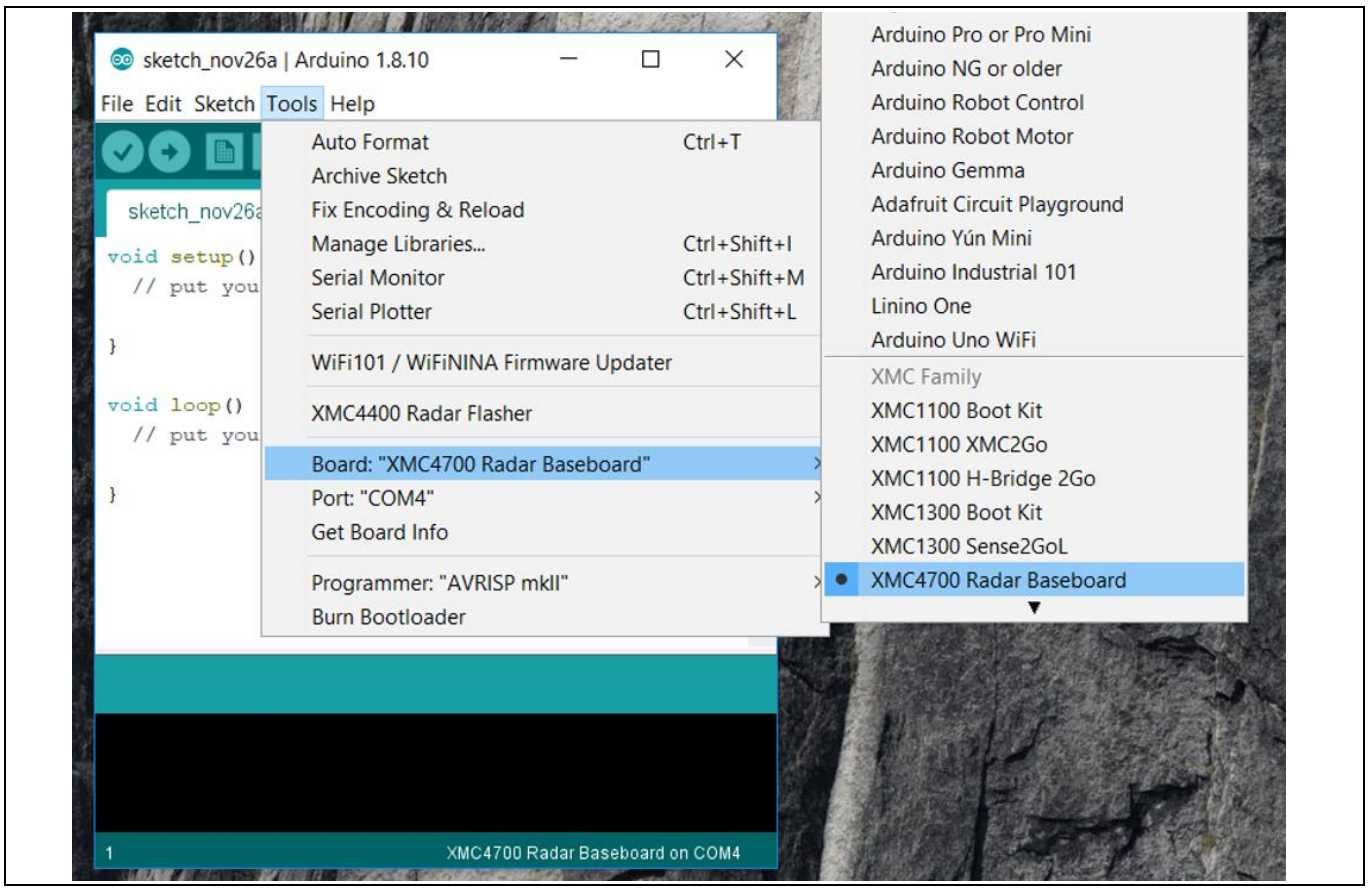

Figure 10 Selecting XMC baseboard

3.3 Using Pulsed Doppler Radar Library

The Pulsed Doppler Radar Library is installed as part of the core libraries for XMC when the XMC Arduino package is installed as shown in Section 3.2.

1. To use the Pulsed Doppler Radar Library in Arduino sketch, it must first be added via *Sketch* > *Include Library* > *IFXRadarPulsedDoppler* (Figure 11).

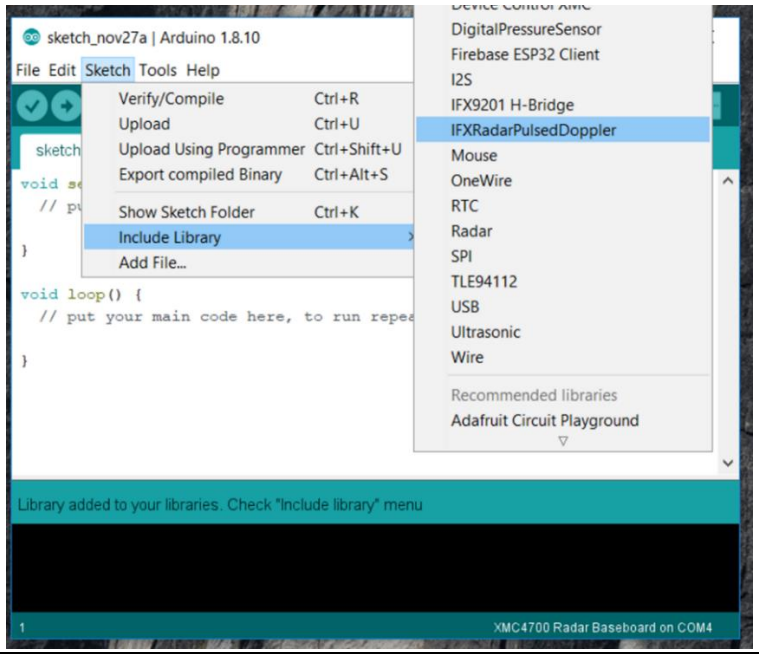

Figure 11 Including and using the Library in Arduino sketch

2. Next, declare a Radar Pulsed Doppler object, such as shown in Figure 12.

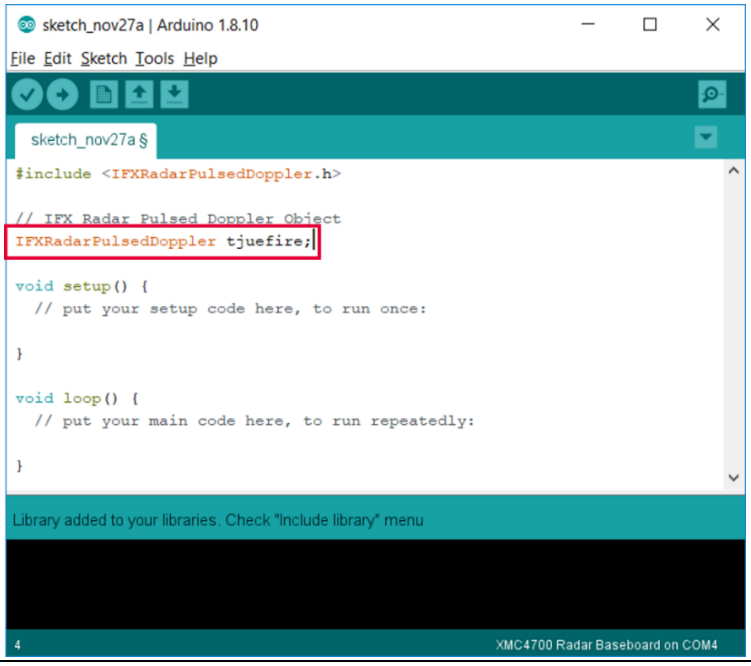

Figure 12 Declaring Pulsed Doppler Radar object

3. Next, some steps are required to initialize the hardware for the Pulsed Doppler Radar and also to configure the parameters. All these are to be done within the setup() routine (Figure 13).

Figure 13 Initializing hardware and parameters for Pulsed Doppler Radar

The lines of code will initialize the software to use the default parameters. In case custom parameters are preferred, the user can call the respective APIs (as listed in Table 1) before calling the begin() function.

Table 1 Configuration APIs

API name	Description
`uint8_t setMinSpeed(float speedMs);`	Set the minimum speed that will be detected
`float getMinSpeed(void);`	Retrieve the minimum speed configured
`uint8_t setMaxSpeed(float speedMs);`	Set maximum speed that will be detected
`float getMaxSpeed(void);`	Retrieve the maximum speed configured
`uint8_t setMotionSensitivity(float threshold);`	Set threshold that will determine motion or not
`float getMotionSensitivity(void);`	Retrieve threshold that will determine motion or not
`uint8_t setDopplerSensitivity(float threshold);`	Set threshold that will determine motion with direction (departing/approaching) or not

API name	Description
`float getDopplerSensitivity(void);`	Retrieve threshold that will determine motion with direction (departing/approaching) or not
`uint8_t setFramePeriod(uint8_t periodUs);`	Set frame period in µs
`uint8_t getFramePeriod(void);`	Retrieve configured frame period in µs
`uint8_t setSampleFreq(uint32_t frequencyHz);`	Set ADC sampling frequency in Hz
`uint32_t getSampleFreq(void);`	Retrieve ADC sampling frequency in Hz
`uint8_t setSkipSamples(uint32_t numSamples);`	Set the number of samples to skip at beginning of frame
`uint32_t getSkipSamples(void);`	Retrieve the number of samples to skip at beginning of frame
`uint8_t setNumSamples(uint32_t numSamples);`	Set size of raw IQ ADC buffer
`uint32_t getNumSamples(void);`	Retrieve configured size of raw IQ ADC buffer
`uint8_t setPulseWidth(uint32_t widthUs);`	Set the pulse width in µs
`uint32_t getPulseWidth(void);`	Retrieve the configured pulse width in µs
`uint32_t getMinFramePeriod(void);`	Get the minimum frame period in µs

4. Next, define the callback function to perform application tasks upon completion of a round of radar processing, for example to turn on or off an LED. In the example shown in Figure 14, different LED colors are used to indicate different radar processing results. Table 2 lists the APIs that can be called to retrieve the result of the radar processing.

Table 2 Result APIs

API name	Description
`bool targetAvailable(void);`	Returns true: motion (with no direction), false: no motion
`float getDopplerLevel(void);`	Retrieve the Doppler level of the detected target
`float getDopplerFreqHz(void);`	Retrieve the Doppler frequency of the detected target
`float getVelocity(void);`	Retrieve the signed velocity value
`uint8_t getDirection(void);`	Returns 0: no direction, 1: departing, 2: approaching
`float getSpeed(void);`	Retrieve the unsigned speed value

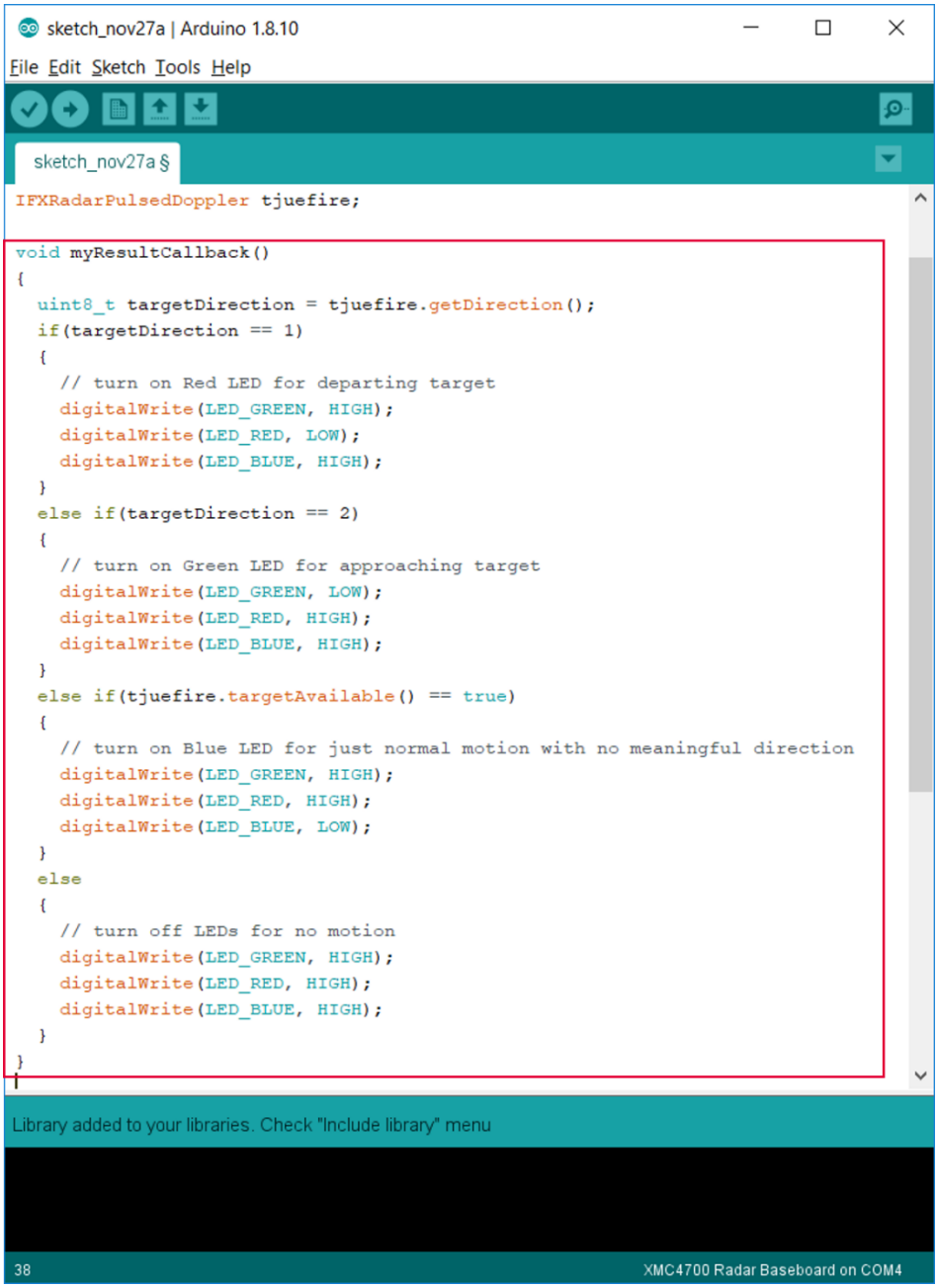

Figure 14 Example for callback function definition

5. Finally, add the run() API in the loop() routine to run the radar processing (Figure 15).

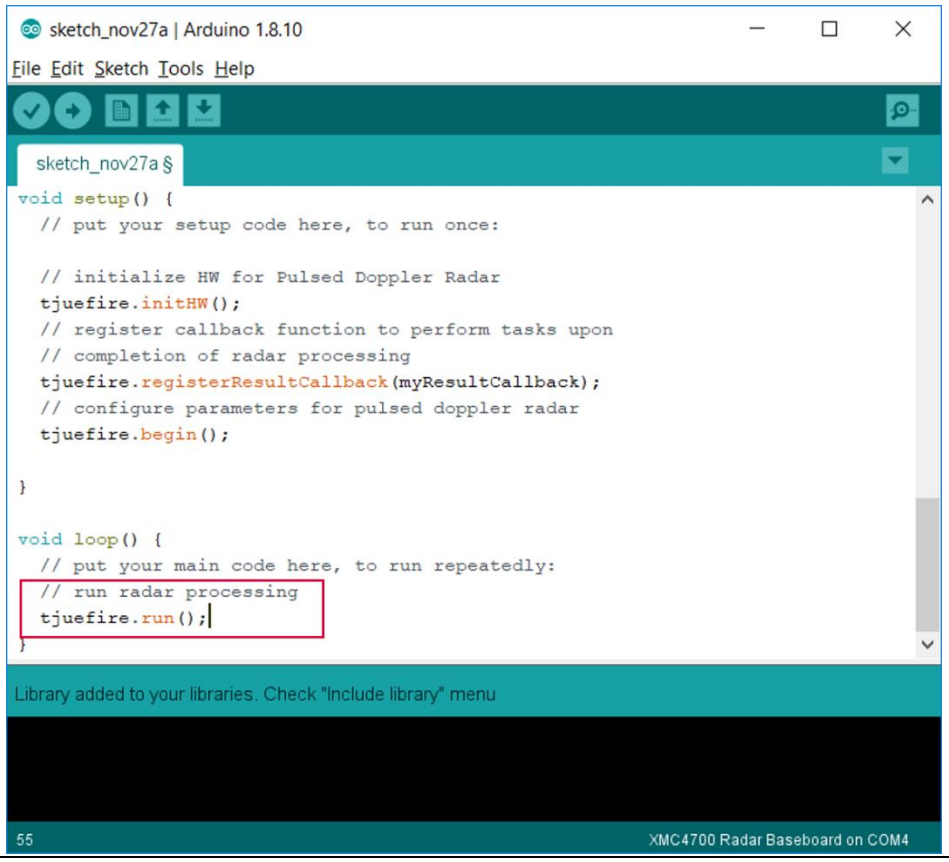

Figure 15 Call run() in main loop()

Table 3 lists the available control APIs for the Pulsed Doppler Radar Library.

Table 3 Control APIs

API name	Description
`void initHW(void);`	To initialize hardware for Pulsed Doppler Radar
`void registerResultCallback(void(*callBackPtr));`	To register function to be called when radar process is done
`void registerErrorCallback(void(*callBackPtr));`	To register function to be called in case of error
`void begin(void);`	To initialize software parameters for Pulsed Doppler Radar
`void end(void);`	To stop radar processing; usually called during runtime before reconfiguring radar parameters
`void run(void);`	To run radar processing

3.4 Example sketches

Two Arduino sketch examples are provided in the current library release. These examples can be accessed from *File* > *Examples* > *IFXRadarPulsedDoppler* (Figure 16). Table 4 provides a brief description of these examples.

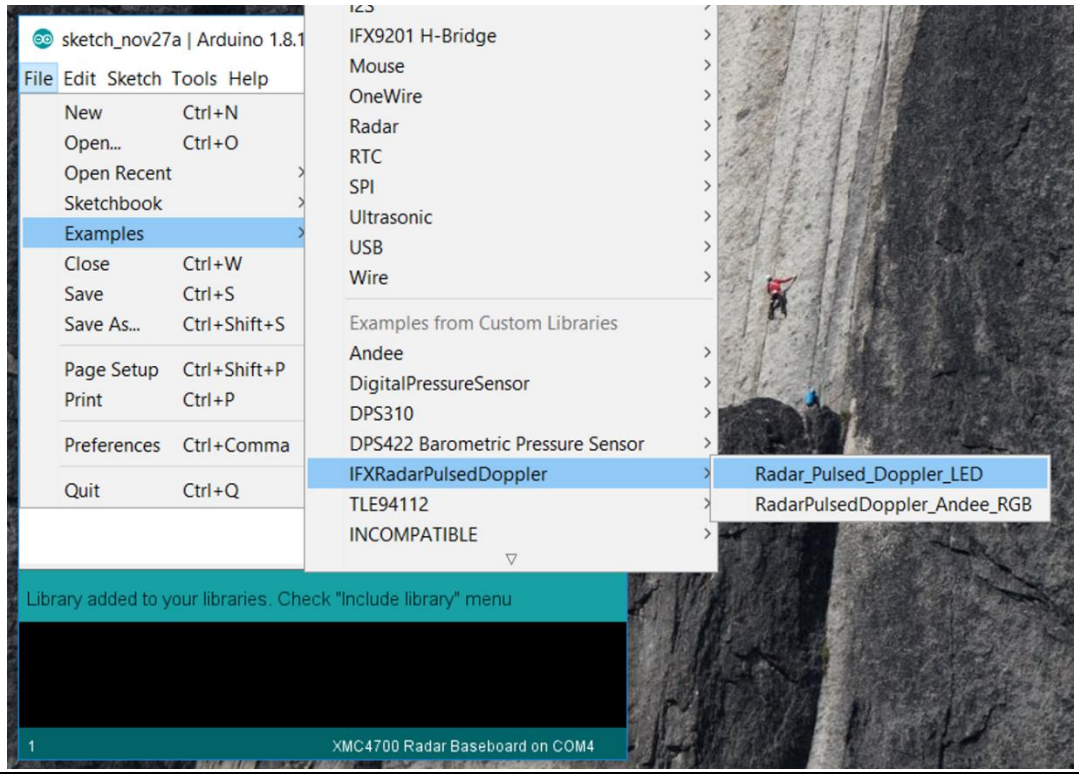

Figure 16 Accessing example sketches from this library

Table 4 Example sketches

Sketch name	Required HW	Description
Radar_Pulsed_Doppler_LED	Radar baseboard XMC4700 and BGT24LTR11 radar shield	Use on-board LED to indicate detection of motion and direction of motion
RadarPulsedDoppler_Andee_RGB	1) Radar baseboard XMC4700 and BGT24LTR11 radar shield 2) Annikken Andee U shield (https://www.annikken.com/andee-u) 3) RGB LED lighting shield with XMC1202 (https://www.infineon.com/cms/en/product/evaluation-boards/kit_led_xmc1202_as_01/)	Project and display the results of radar processing on a smart device (e.g. cell phone/tablet) via Bluetooth, and at the same time using an external RGB LED to indicate motion and direction of motion

3.4.1 Example 1: Radar_Pulsed_Doppler_LED

This section lists the steps to follow to get this example up and running.

1. In Arduino IDE, navigate to *File* > *Examples* > *IFXRadarPulsedDoppler* > *Radar_Pulsed_Doppler_LED* (as shown previously in Figure 16). The sketch will open (Figure 17).

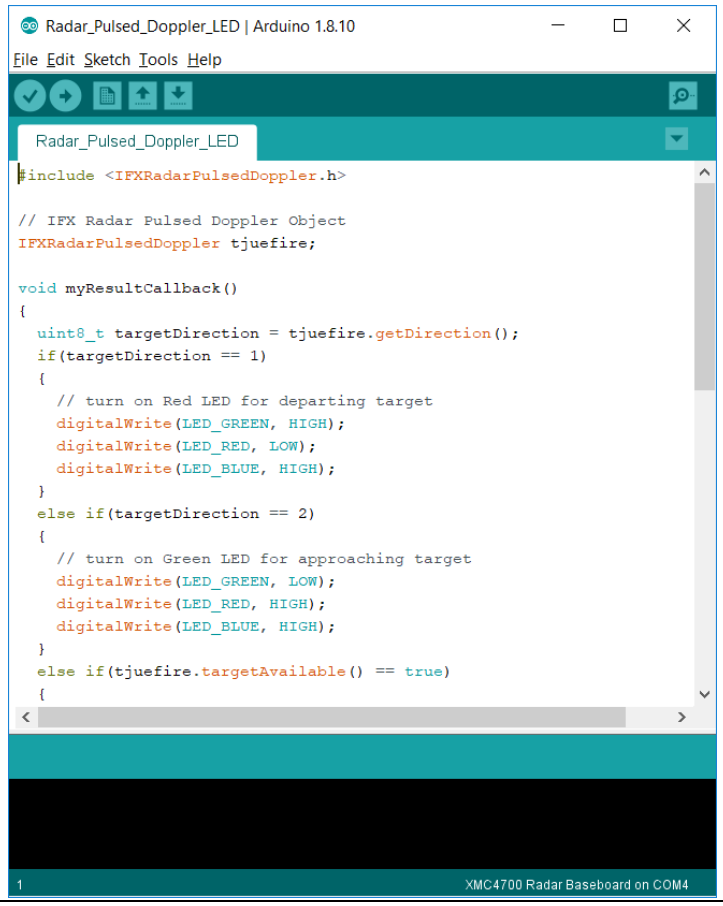

Figure 17 Example sketch: Radar_Pulsed_Doppler_LED

2. Navigate to *Tools* > *Board* > *XMC4700 Radar Baseboard* (as shown previously in Figure 10) to select the radar baseboard as the target kit.
3. Compile the sketch by clicking the "Verify" button (Figure 18). A success message will be displayed on compilation completion (Figure 19).

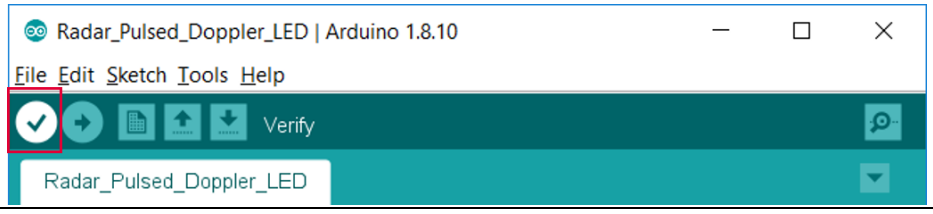

Figure 18 Compiling the sketch

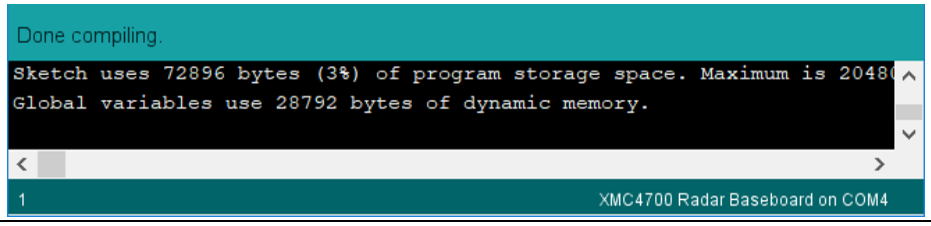

Figure 19 Compilation successful

4. Attach the BGT24LTR11 radar shield to the radar baseboard XMC4700 via the SAMTEC connectors (Figure 20).

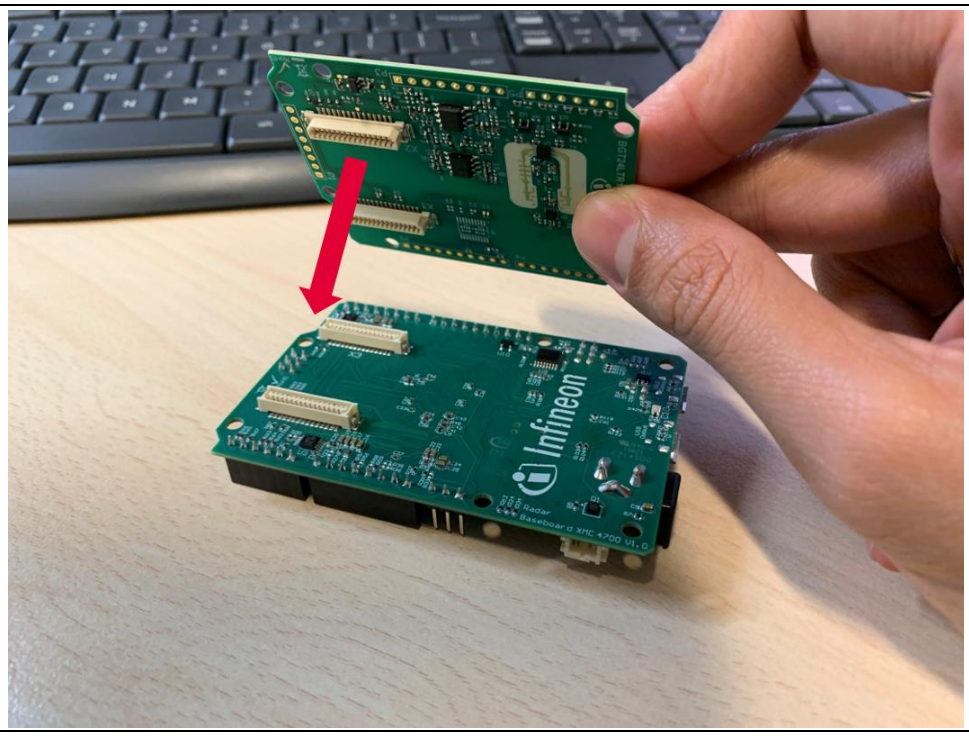

Figure 20 Attach the BGT24LTR11 radar shield to the radar baseboard XMC4700

5. Connect the radar baseboard XMC4700 to the PC via a USB cable onto the "Debug" USB port (Figure 21).

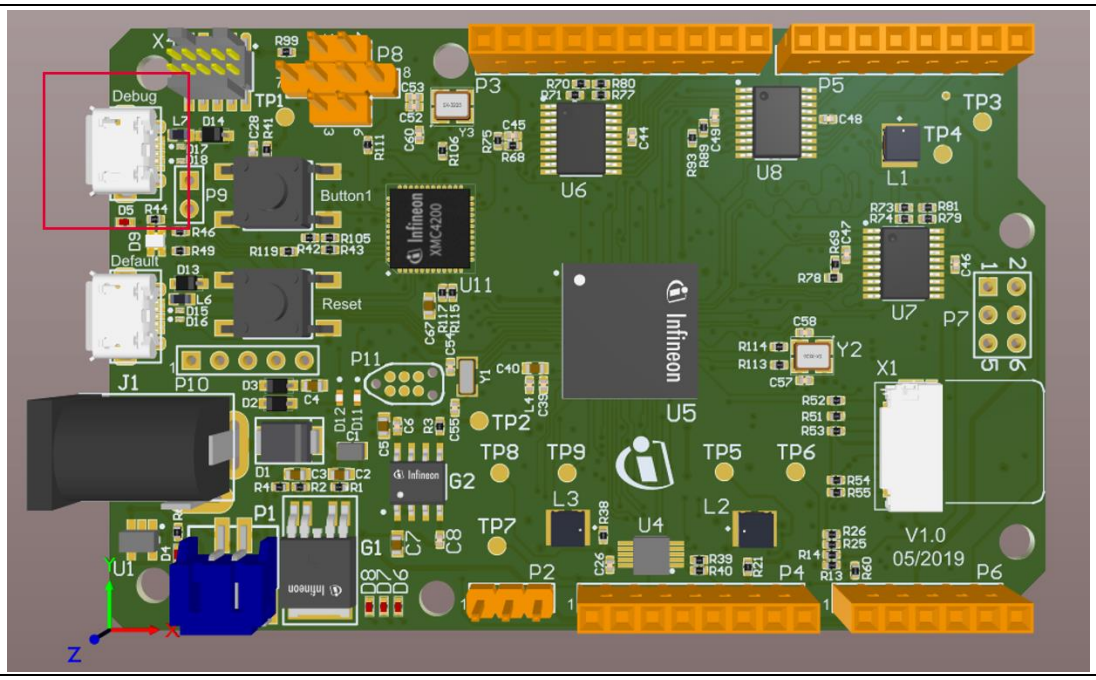

Figure 21 Connect USB cable to debug port

6. Upload the code onto the board by clicking the "Upload" button (Figure 22).

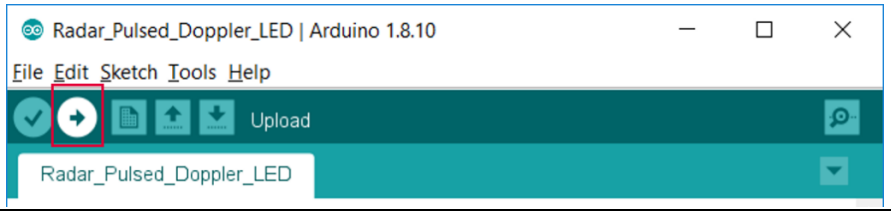

Figure 22 Uploading code onto board

The application can now be tested. Make some movements in front of the radar board and observe the LED colors depending on the motion and its direction (Figure 23).

Table 5 LED color based on motion for Example 1

LED color	Type of motion
Off	No motion
Red	Departing
Green	Approaching
Blue	Motion with no meaningful direction

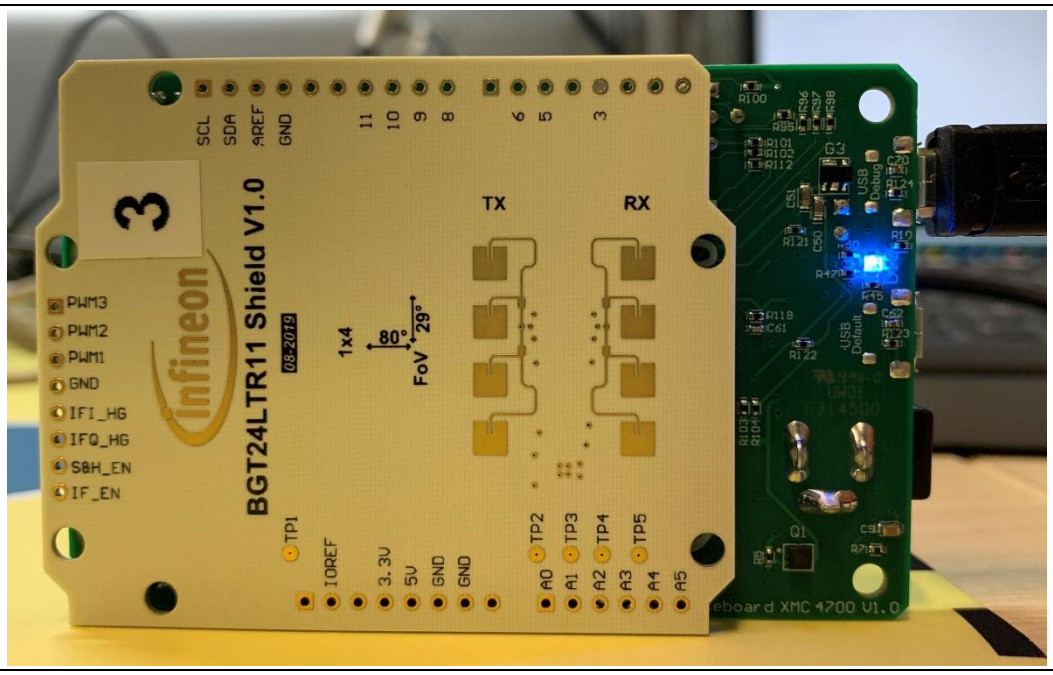

Figure 23 Observe LED color change with motion

3.4.2 Example 2: RadarPulsedDoppler_Andee_RGB

This section lists the steps to follow to get this example up and running.

1. In Arduino IDE, navigate to *File* > *Examples* > *IFXRadarPulsedDoppler* > *RadarPulsedDoppler_Andee_RGB.* The sketch will open (Figure 24).

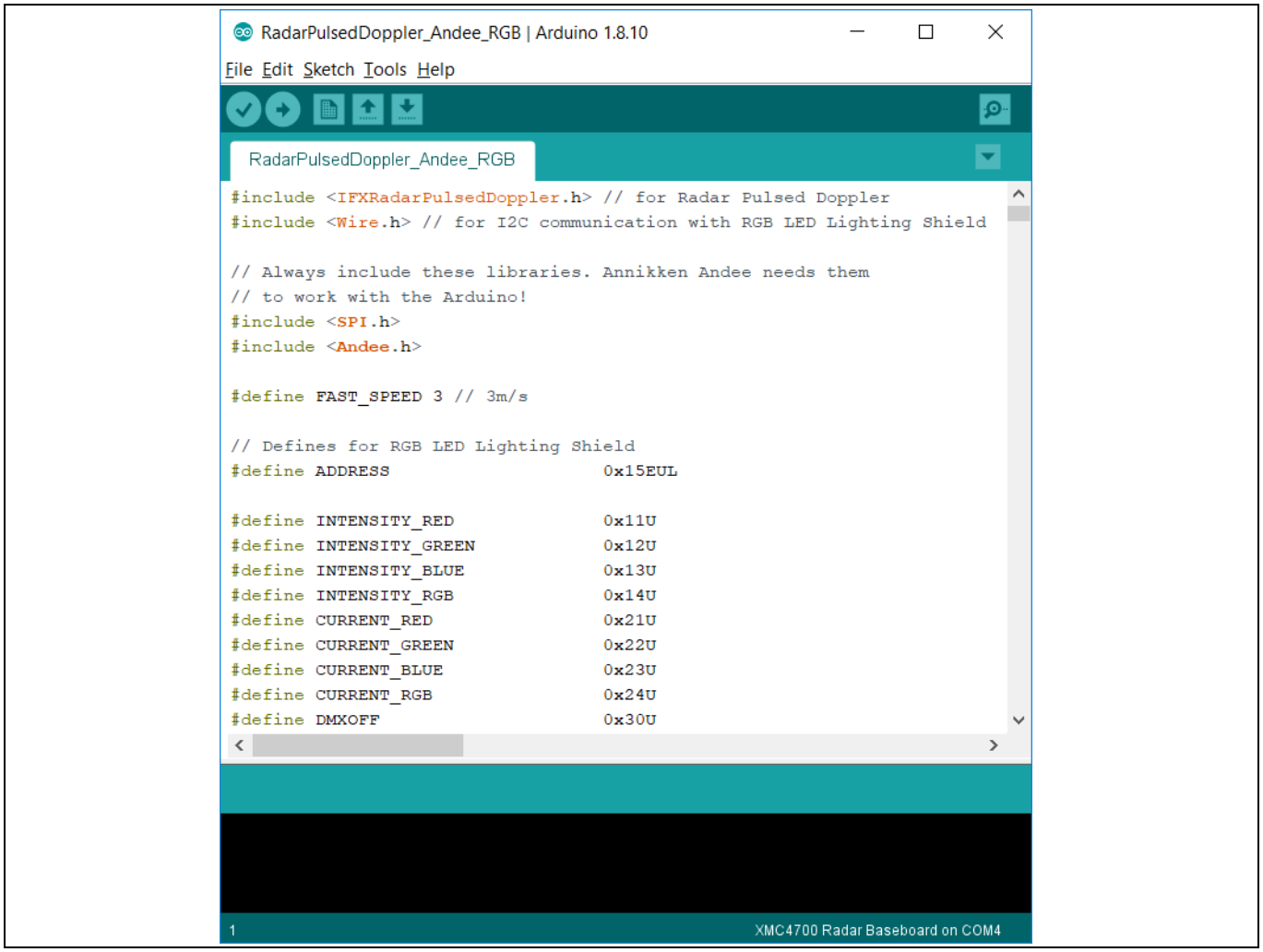

Figure 24 Example sketch: RadarPulsedDopplerLED_Andee_RGB

2. Navigate to *Tools* > *Board* > *XMC4700 Radar Baseboard* (as shown previously in Figure 10) to select the radar baseboard as the target kit.
3. Compile the sketch by clicking the "Verify" button (Figure 25). A success message will be displayed on compilation completion (Figure 26).

Figure 25 Compiling the sketch

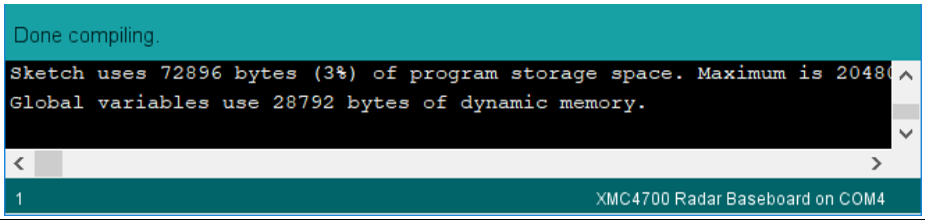

Figure 26 Compilation successful

4. Attach the BGT24LTR11 radar shield to the radar baseboard XMC4700 via the SAMTEC connectors (Figure 27).

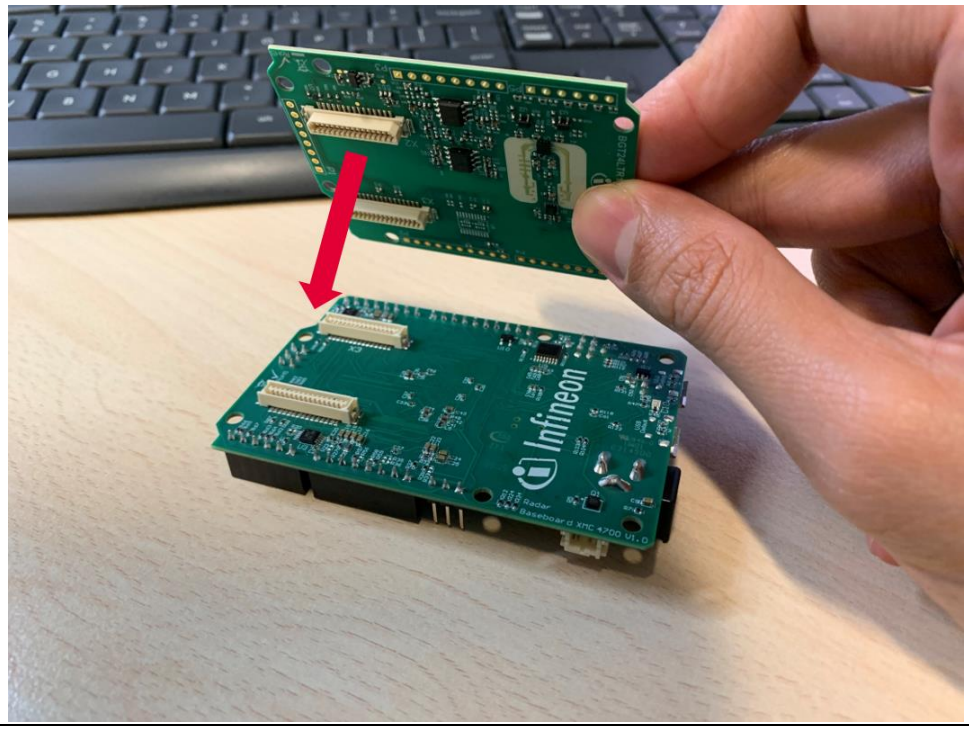

Figure 27 Attach the BGT24LTR11 shield to the radar baseboard XMC4700

5. Stack the RGB LED lighting shield with XMC1202 onto the radar baseboard XMC4700 via the Arduino stack headers (Figure 28). Also connect an RGB LED and a 24 V DC power adapter to the RGB LED lighting shield. **Do not turn the power on yet!** For more information on setting up of the RGB LED lighting shield, please refer to the User Manual for the RGB LED Lighting Shield with XMC1202 (the link can be found in the References section).

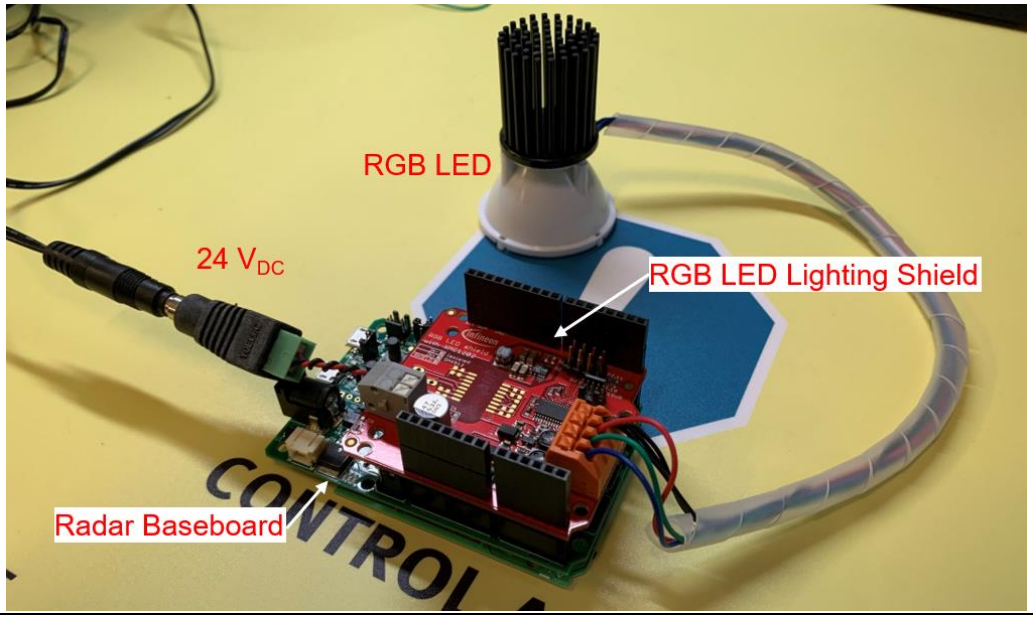

Figure 28 Stacking the RGB LED lighting shield onto the radar baseboard XMC4700

6. Stack the Annikken Andee U shield onto the set-up (Figure 29). Notice that there are several jumper wires on the Annikken Andee U board. This is due to the hardware modifications required on the radar baseboard regarding the ISCP header as mentioned in Section 2.3. Figure 30 illustrates the required connections.

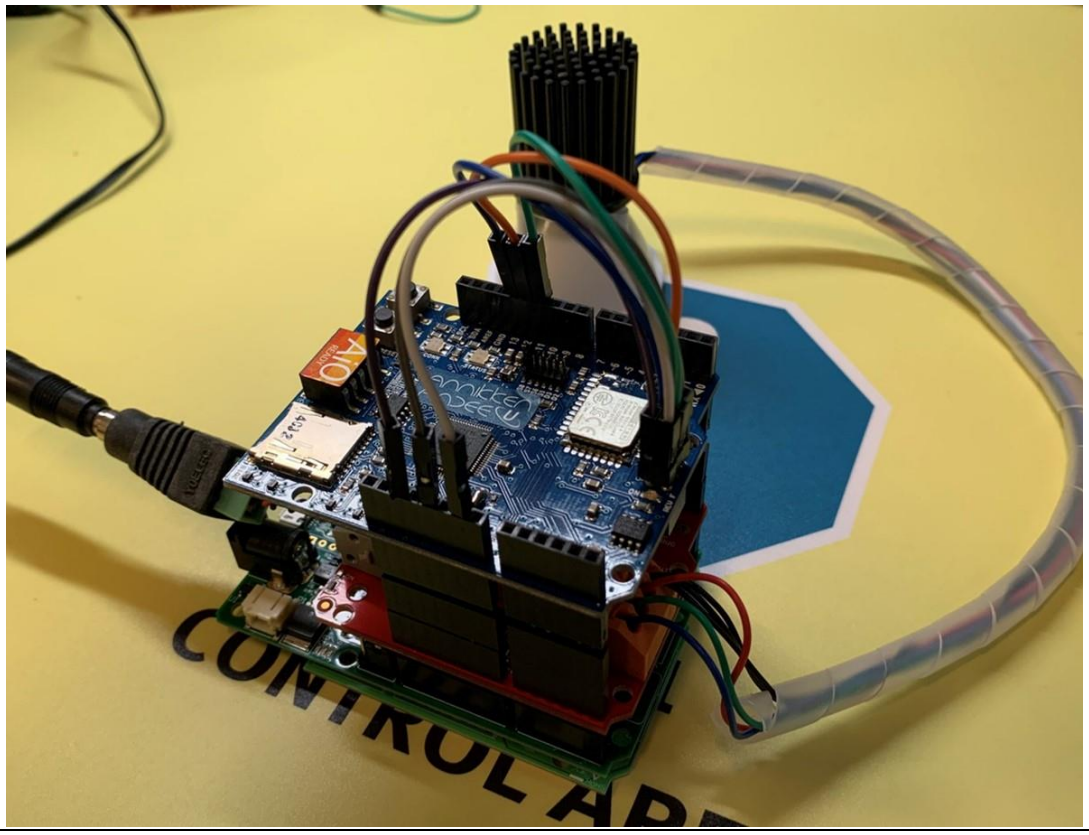

Figure 29 Stacking the Annikken Andee U shield onto the set-up

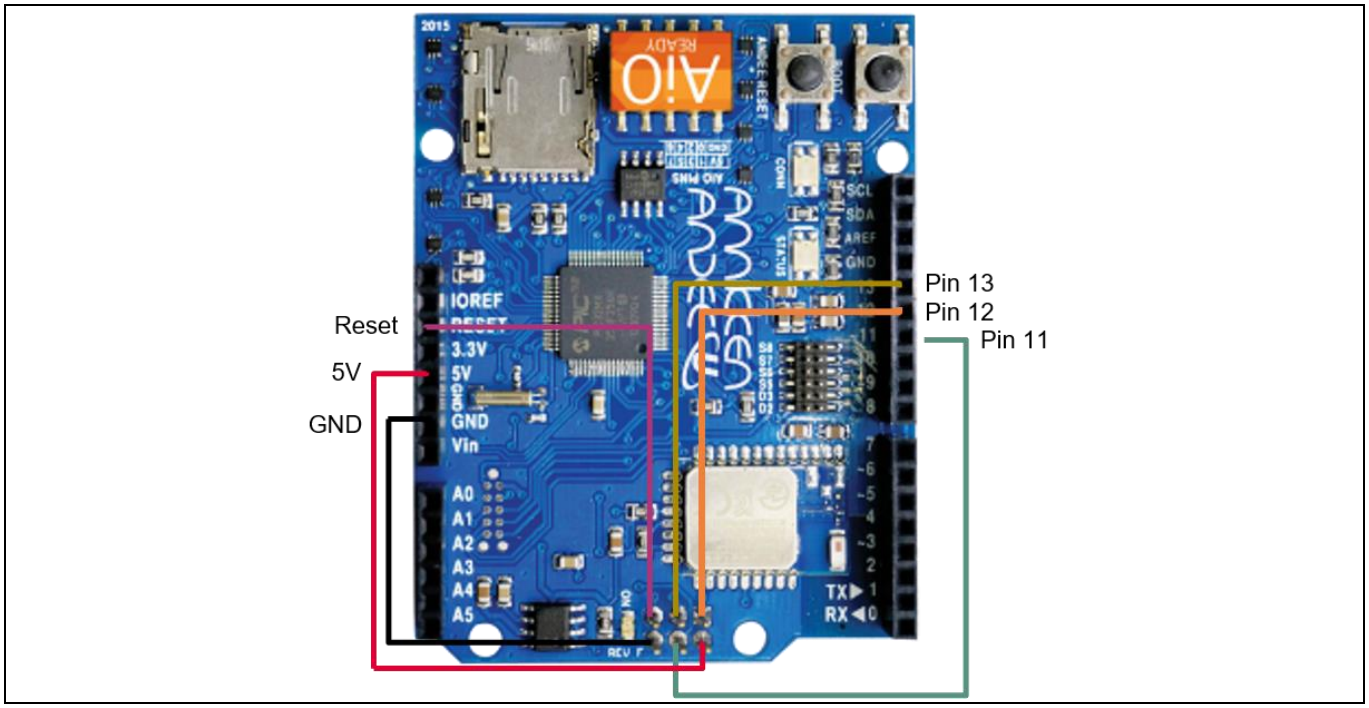

Figure 30 Jumper wire connections on the Andee U

7. Turn on the 24 V DC power supply to the RGB LED lighting shield and connect the radar baseboard XMC4700 to the PC via a USB cable onto the "Debug" USB port (Figure 31).

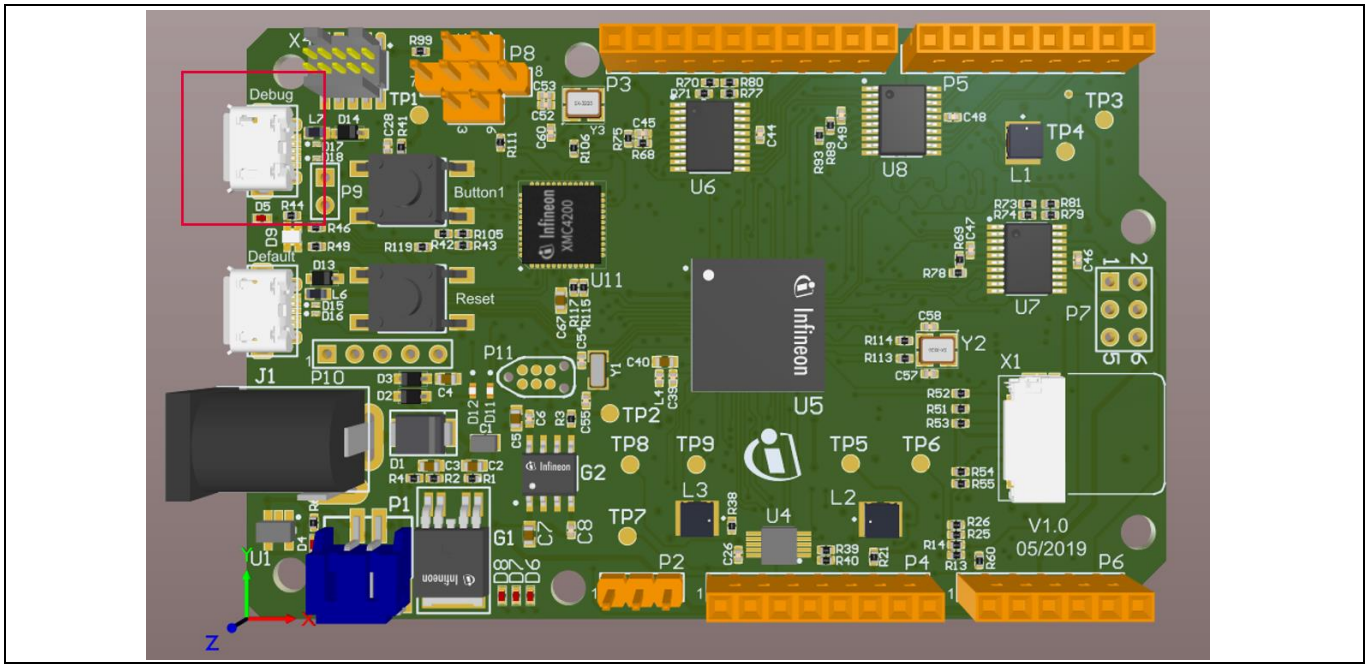

Figure 31 Connect the USB cable onto the debug port

8. Upload the code onto the board by clicking the "Upload" button (Figure 32).

Figure 32 Uploading the code onto the board

The RGB LED should turn on with white light, while the on-board LED will cycle between red, green and blue light to show radar processing is taking place (Figure 33). The application can now be tested.

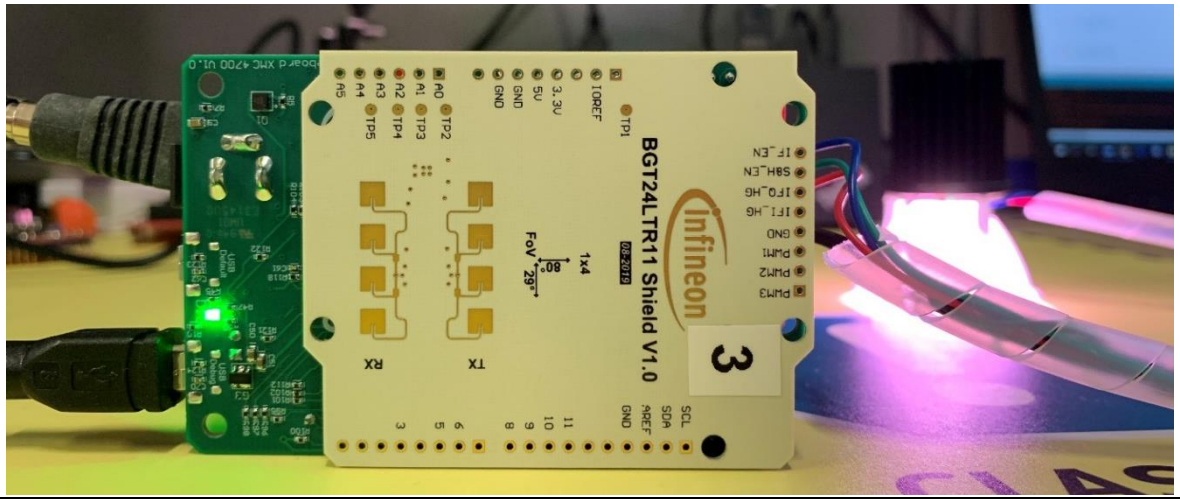

Figure 33 Application starts with white light

9. Launch the Andee app (can be installed for free from the Apple App Store or Google Play Store) on your smart device. In the app, click "Scan for Devices" (Figure 34).

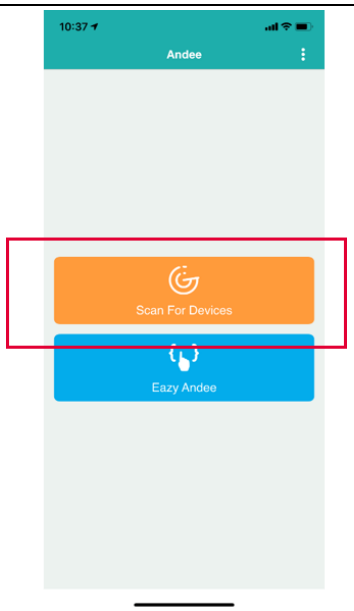

Figure 34 Andee app – scan for devices

10. Click "Tjuefire". When prompted, click "Connect" (Figure 35).

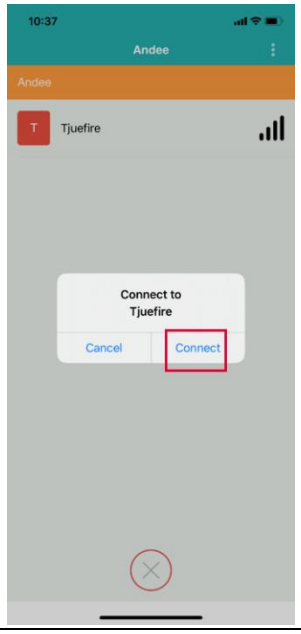

Figure 35 Andee app – connect to device

11. Upon successful connection, the GUI should appear on the app (Figure 36). In case this does not happen, disconnect from the app, press the reset button on the radar baseboard XMC4700 and retry the connection. Make some movement in front of the radar board and observe the measured speed and detected direction on the GUI. You may also observe the light from the RGB LED changing with regard to the motion and its direction (Table 6).

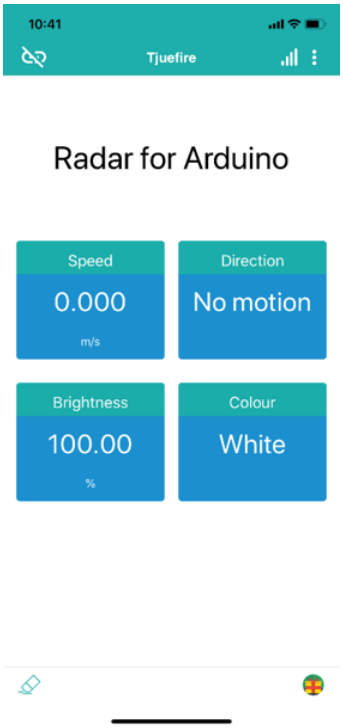

Figure 36 Andee app – GUI upon successful connection

Table 6 LED behavior for Example 2

LED behavior	Type of motion
Dims down	Departing
Brightens	Approaching
Changes color	Motion with speed above pre-defined threshold

The pre-defined fast speed threshold can be changed within the Arduino sketch (Figure 37).

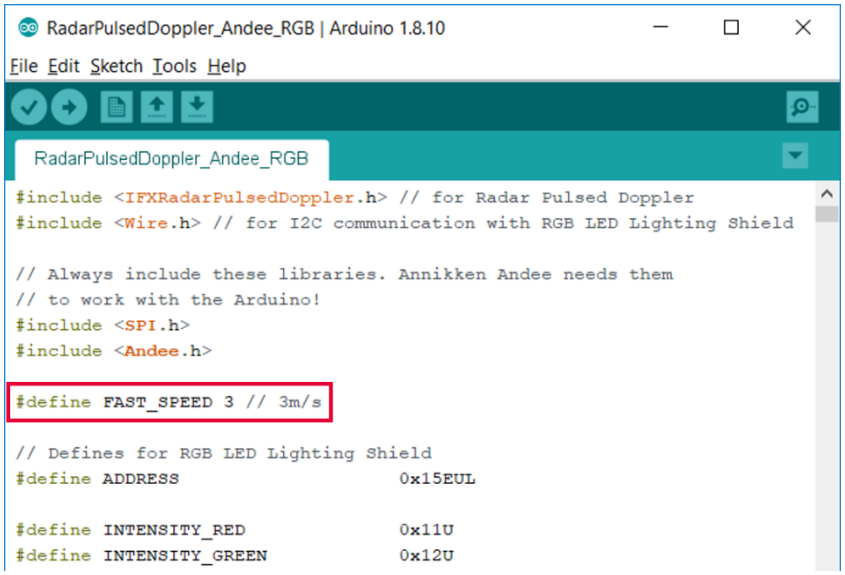

Figure 37 Changing pre-defined fast speed threshold

4 Author

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5 References

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[4] 24 GHz industrial radar – FAQs

[5] ETSI Regulations – EN 300 440 V2.2.1

[6] FCC Regulations – 15.245, 15.249

[7] Infineon RGB LED Lighting Shield with XMC1202 for Arduino - User Manual

[8] Annikken Andee U - Documentation

Revision history

Document version	Date of release	Description of changes
V1.0	02-07-2020	First release

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