XENSIV™ 60GHz BGT60TR13C Radar System on Module MCU4 Presence Detection

User guide

About this document

Scope and purpose

This document is a user guide for the presence detection software qualified on the XENSIV™ 60GHz BGT60TR13C system-on-module (SoM) MCU4 board as a reference hardware platform.

Intended audience

Customers interested in using the Infineon XENSIV™ 60GHz BGT60TR13C SoM solution for presence detection in various consumer applications.

Table of contents

About this document **1**
Table of contents **2**
1 Introduction **3**
1.1 What is radar for presence detection? 3
1.2 Key benefits 3
2 Prerequisites **4**
2.1 Hardware 4
2.2 Software 5
3 Module configuration software setup **6**
4 Set and get configuration **7**
5 Presence event output **11**
6 Macro and micro threshold tuning **12**
6.1 Reading the macro and micro level 12
6.2 Increase Sensitivity by parameter adjustment 13
7 Signal verification mode **14**
7.1 Measurement setup 15
8 Anti-interference **16**
9 Firmware update **17**
10 Additional documents **18**
Revision history **19**

1 Introduction

The Infineon radar presence detection solution detects both macro- and micro-movements in a configurable range using the XENSIV™ 60GHz BGT60TR13C radar sensor. This user guide for the Infineon radar presence detection solution describes the required software and hardware, and how to set up and use the module configuration software to configure and update the system. In an accompanying mounting recommendations guide, the user can see how to mount the presence solution in indoor environments. Additional user guides are available and are listed at the end of this document.

1.1 What is radar for presence detection?

Motion sensing is a standard feature in many devices. Today's devices become smarter by knowing if the user is around or not. Traditionally motion sensors have been designed using passive infrared (PIR) sensing. As simple as PIR is, there are performance limitations. For example, PIR sensors cannot detect micro movements. In addition, they require a lens, while radar sensors can be covered and disguised behind plastic enclosures.

What if there were a solution that could detect the tiniest movements without requiring an opening in the product housing?

Infineon's radar presence detection solution enables the detection of human presence within a configured range. Enabled by our XENSIV™ 60 GHz BGT60TR13C radar with its sophisticated radar presence detection algorithms, this solution provides extremely high accuracy in detecting both macro and micro movements.

1.2 Key benefits

- Ready-to-use radar solution for presence sensing with adjustable detection range
- Ability to detect micro-movements
- Radar sensor immune to environmental factors such as temperature, wind, sunlight and dust/debris
- A fully tested and verified solution for presence sensing for home, office and commercial buildings

2 Prerequisites

2.1 Hardware

Figure 1 Reference hardware platform – XENSIV™ 60 GHz BGT60TR13C SoM board (mounted on motherboard for development/evaluation purposes)

The module can be connected with a UART serial interface (baud rate 115200, 8N1) for command communication. There is a converter chip on the motherboard to convert the UART interface to USB for PC connection. Set the dip switch as follows to enable USB_UART connection.

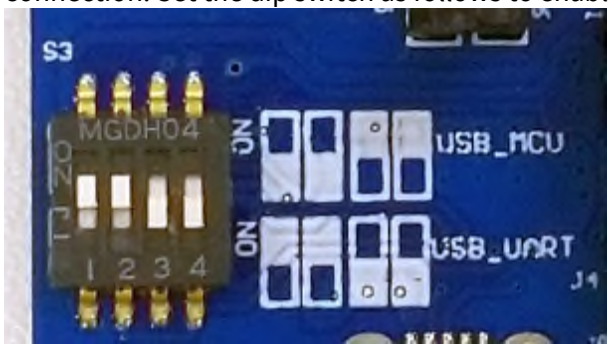


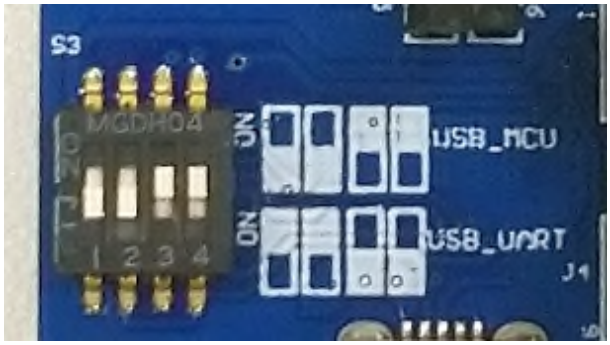
Figure 2 USB_UART selection

The user must download and install the driver at the following link to ensure the USB- to- UART converter chip can work at on a PC.

https://www.cypress.com/documentation/software-and-drivers/microsoft-certified-usb-uart-driver

Prerequisites

The following dip switch setting can directly route the USB connection to the module. The module will then become a USB device, acting as VCOM at the PC.



USB_MCU selection

2.2 Software

Infineon_ XENSIV™ 60 GHz BGT60TR13C SoM _Presence_v1.3.0_build-xxxxxxx.zip is part of the above software release package.

This archive contains the following files after extraction to the folder MCU4_SoM:

- IFX_B XENSIV™ 60GHz BGT60TR13C SoM _MCU4_Module_Config_v1.3.1_build-xxxxxxx.exe
- IFX_ XENSIV™ 60GHz BGT60TR13C SoM _MCU4_Presence_v1.3.0_build-xxxxxxx.bin

The “xxxxxxx” stands for the build and version number of the firmware and should match the number in the archive filename.

3 Module configuration software setup

Connect the radar board to the PC through USB, and open the file “IFX_ XENSIV™ BGT60TR13C SoM _MCU4_Module_Config.exe”. Select the correct comport number (COM8 in this example) and press “Connect”.

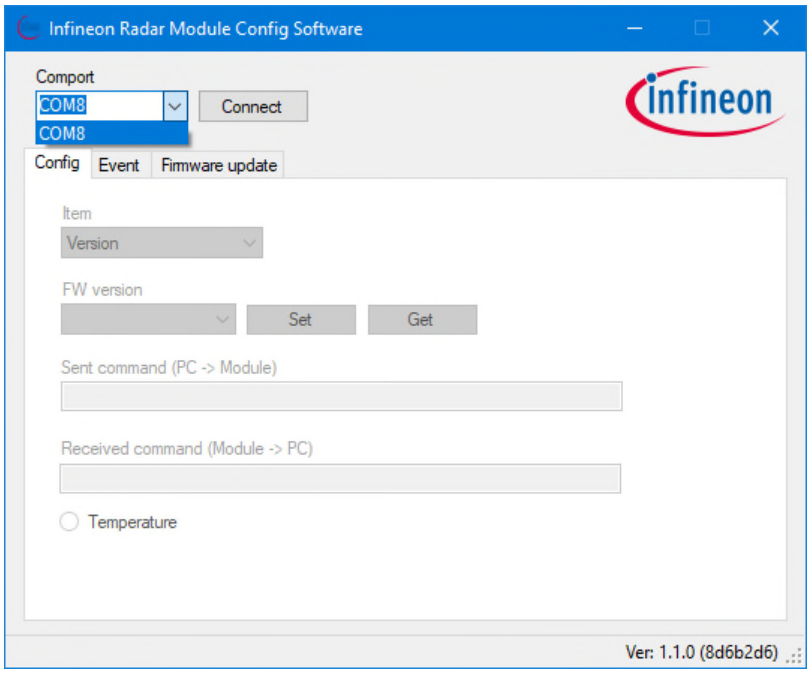


Figure 4 Com port selection

If the board is connected successfully, a firmware version will show in the box. Otherwise a fail message will be shown at the bottom.

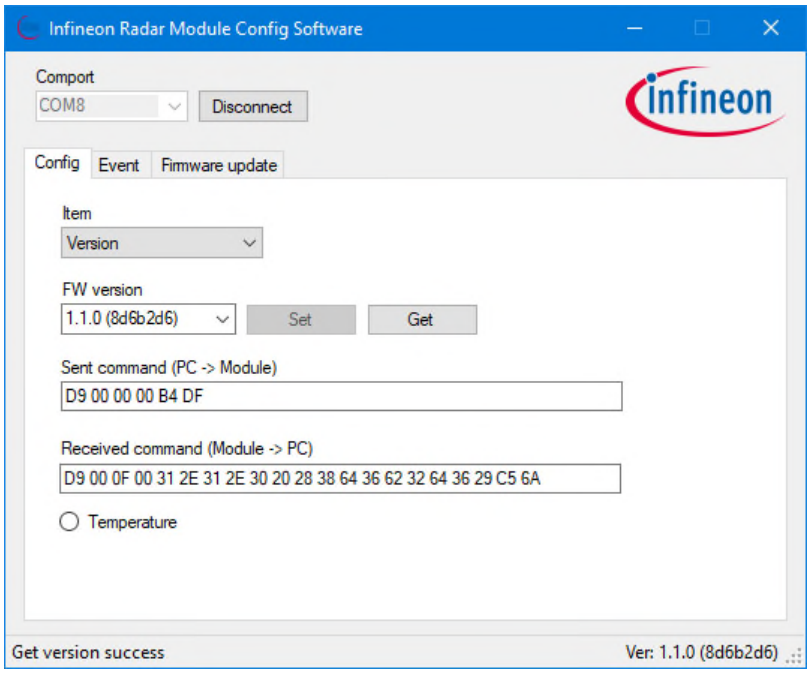


Figure 5 Firmware version get success

4 Set and get configuration

The user can set or get the configuration of the radar under the “Parameter” tab. The following items are currently available:

Item	Description
Version	Get the firmware version in MCU.
Max. range [0.66 to 10.2]	Get or set the maximum detection distance for presence detection. The setting would be stored in Flash; default is 1.00 m.
Sensitivity	Get or set the sensitivity level presence detection; higher sensitivity means more sensitivity to small movements. Changing the sensitivity would change the macro and micro threshold values. “Max” sensitivity is a special setting that will extend the observation time to 10 s, which means the response of changing from presence to absence will have a delay of 10 s. The setting would be stored in Flash; default is high. *Note: The user is recommended to use a “max” sensitivity setting for optimal performance at angles and for use cases such as a person sitting on a chair behind a table.*
Event control	Enable/disable active output command of presence or absence event change. The setting would be stored in Flash; default is on.
Get presence event	Get current presence detection result.
Presence detect on/off	Set presence detection to on or off. Default is on. When set to off, radar chip power would also be set to off.
RFCW mode	Enable or disable the RF continuous wave mode for FCC test. Presence detection needs to be off before enabling this mode. Disable: Disable RFCW mode. Low: Set RFCW output at 61.02 GHz. Mid: Set RFCW output at 61.25 GHz. High: Set RFCW output at 61.48 GHz. Low TX off: Set RFCW test at 61.02 GHz with TX off. Mid TX off: Set RFCW test at 61.25 GHz with TX off. High TX off: Set RFCW test at 61.48 GHz with TX off.
Self-test	Perform tests related to the radar chip. Presence detection needs to be off before enabling this mode. Self-test covers SPI checking and RF test utilizes internal test hardware. Please run the self-test in an environment where there is an empty space of 50 cm in front of the radar.
Temperature	Get temperature on the radar chip (°C).
Sleep mode	Set the radar module to deep sleep mode. The module will wake up again when data is received at the UART RX pin. A preamble byte such as 0x00 is needed to add in the next command so the command is correctly received at the module (to compensate for wake-up delay time).
Calibration mode	Enable/disable active output command of calibration message. A calibration message would output periodically when enabled. The message would contain the activity level used to compare with the macro/micro threshold value at that time. This mode is mainly used for measuring the background noise of macro and micro detection, to tune for an optimum threshold value for the environment.

Calibration rate [1 to 4]	Set the update rate of the calibration message output. Selection is 1 to 4. For example, setting the value to 4 would change the output message rate to 4 Hz.
Detect mode	Set presence detection detect mode. The setting would be stored in Flash; default is macro then micro. Macro then micro: The radar would first detect macro motion for presence, and enter micro motion detect mode when the object movement is smaller. Macro only: Radar would only detect macro movement. Micro only: Radar would only detect micro movement. Macro and micro: Radar would always detect both macro and micro movement; either kind of motion exceeding the threshold would be treated as a presence.
Signal verify mode	Enable/disable active output command of range bin profile. A range bin profile would output periodically (1 s) when enabled. The range bin profile is an array of floating numbers showing the received signal level (in dB) at different distances. This feature can be used to measure the RF attenuation due to plastic casing.
Min. range [0.00 to 10.2]	Get or set the minimum detection distance for presence detection. The user needs to ensure this value is smaller than the maximum range. The setting would be stored in Flash; default is 0.00 m.
Macro threshold [more than 0.0]	Threshold value used in macro movement detection. After changing this value, the sensitivity would be customized. The setting would be stored in Flash; default is 1.00.
Micro threshold [more than 0.0]	Threshold value used in micro movement detection. After changing this value, the sensitivity would be customized. The setting would be stored in Flash; default is 25.00.
Macro valid [0.5 to 30.0]	Time-out value (s) used to judge motion is no longer macro movement. For example, if the value is 1, it means a detected value below the macro threshold for 1 s continuous would be treated as no macro movement. The setting would be stored in Flash; default is 1.
Micro valid [1.5 to 1800.0]	Time-out value (s) used to judge the motion is no longer micro movement. The judging criteria are the same as for a valid macro value. The setting would be stored in Flash; default is 4.
Macro trigger range [1 to 64]	Get or set the macro trigger range for macro movement detection. When setting a higher value, the user needs to enter the inner detection zone to trigger a presence. The value is a multiple of 0.33 m. The setting would be stored in Flash; default is 1.
Macro trigger delay [0 to 255]	Get or set the trigger delay for macro movement detection. Input value is multiple of 0.25 s. For example, by setting the value to 3, the radar will determine the motion as macro movement for a continuous 0.75 s of major motion. The setting would be stored in Flash; default is 0.
Chirp per frame [1 to 16]	Get or set the number of chirps per frame for coherent integration. Setting a higher value, radar will send out more chirps in a frame and use them for coherent integration and interference checking, resulting in a better signal-to-noise ratio. Note that power consumption will increase for setting a higher value, as the RF active time will also increase. The setting would be stored in Flash; default is 16.

Unique ID	Get the unique ID of the module.
Reset config.	Reset all settings stored in Flash to default.

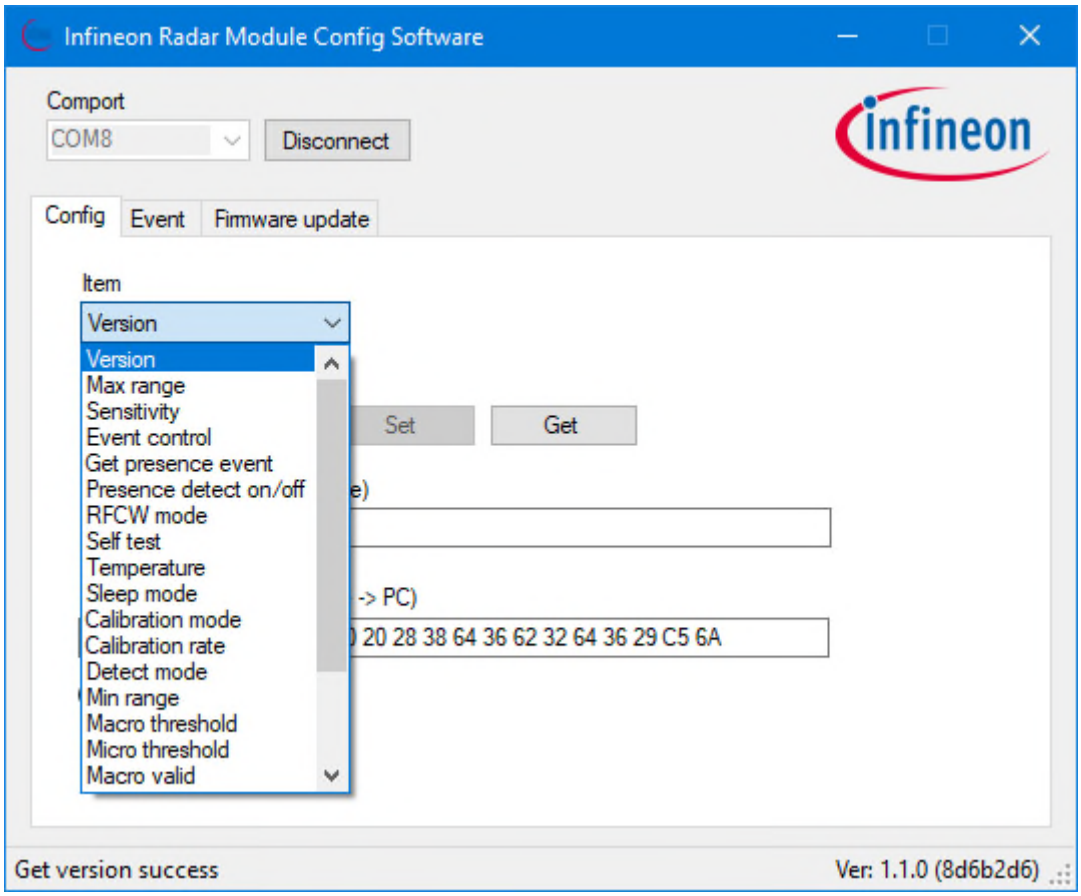


Figure 6 Configuration item list

Set and get configuration

After pressing the “Set” or “Get” button, the relevant binary command would be shown in the command text box. The developer can use that command for reference or checking. The temperature button enables periodic polling of the radar chip temperature.

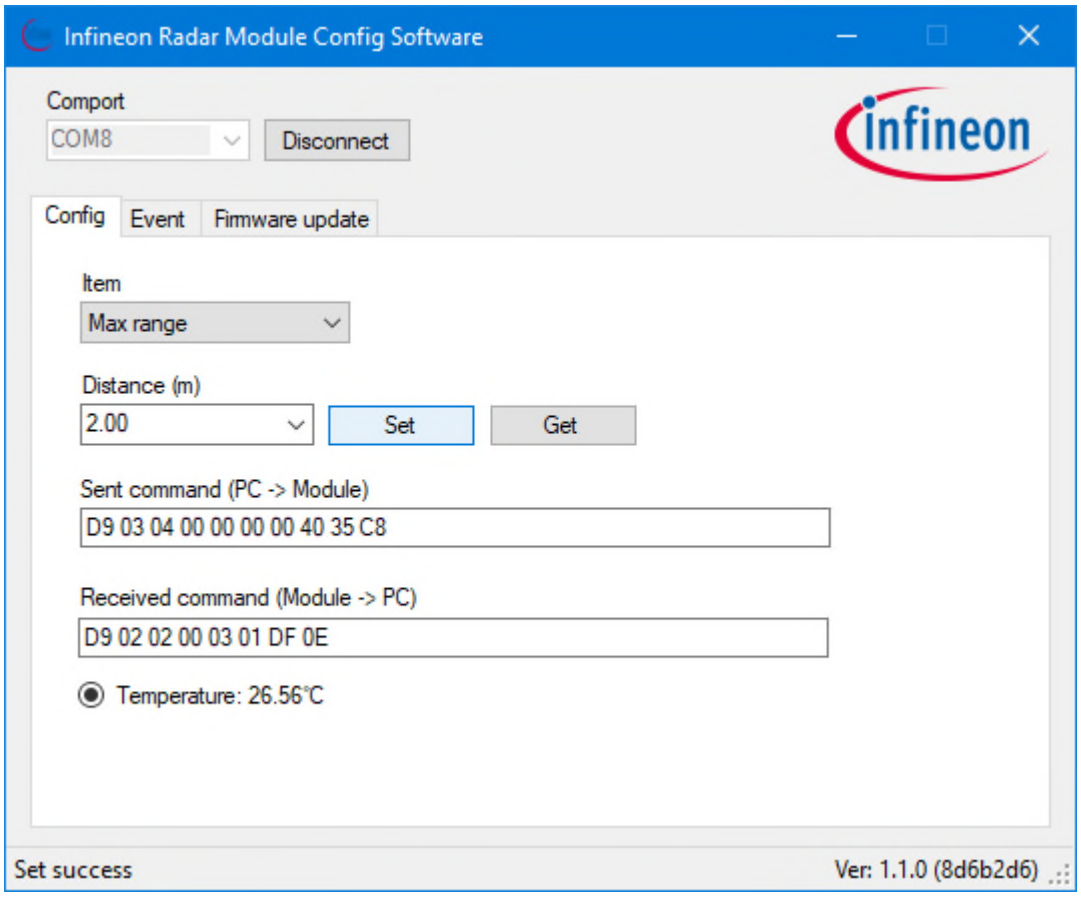


Figure 7 Configuration set or get example

5 Presence event output

When event control is turned on, the presence detection result would be shown under the “Event” tab.

Item	Description
Presence event	Presence detection result. In: Moving object detected in the zone. Out: No moving object detected in the zone.
Distance (m)	Detected distance range of the closest moving object, in meters.
Time (s)	Relative event time, in seconds. The time starts from power on; it is not an absolute time.

The received event command would be shown in the command text box for reference. When calibration mode is enabled, a calibrate message box would also be shown.

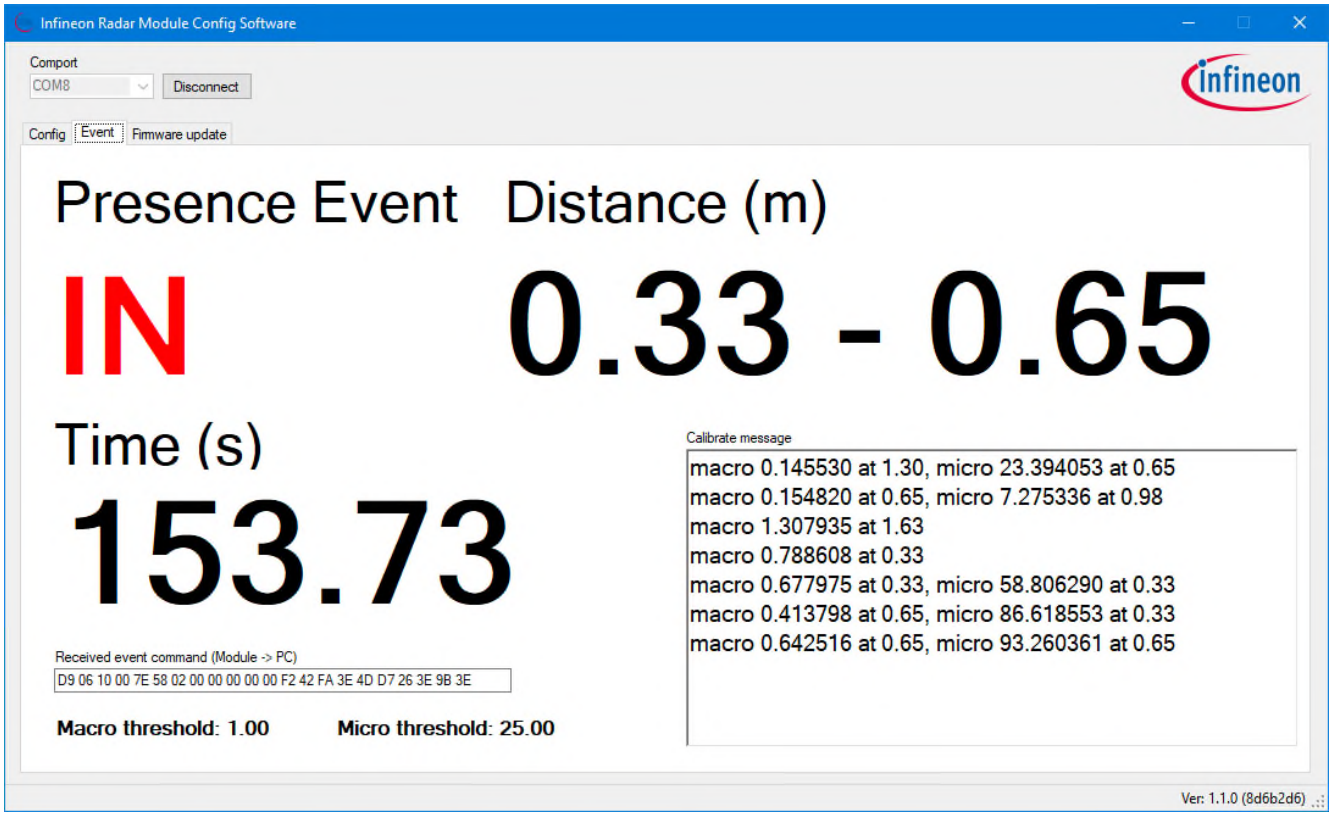


Figure 8 Presence detect event page

6 Macro and micro threshold tuning

In the presence detection solution, there is a macro and micro mode concept. The macro then micro detection mode can be illustrated using a state machine.

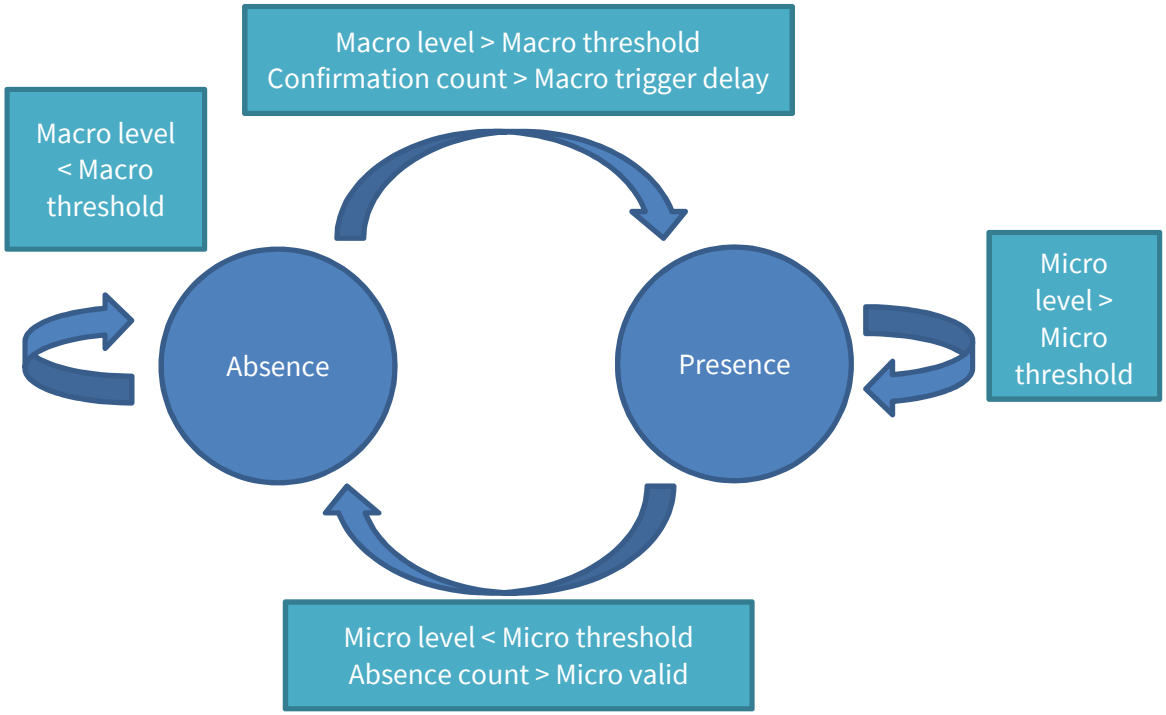


Figure 9 Presence detect state diagram

When the detection is in absence state, it will check the macro level. If the macro level is higher than the macro threshold, the macro trigger confirmation count will increase by 1. If the confirmation count exceeds the macro trigger delay, the state will transit from absence to presence. For presence state, the state remains in presence when the micro level is higher than the micro threshold. When the micro level is lower than the micro threshold, the absence count will increase by 1. If the absence count exceeds micro valid, the state will return to absence.

Sensitivity settings (high, medium and low) have pre-defined macro and micro threshold values. If the user finds the sensitivity is not enough even with high sensitivity, they can manually set the micro and macro threshold value to fit their use case.

6.1 Reading the macro and micro level

The following steps are used to enable macro- and micro-level tuning.

1. Turn “Calibration mode” to “On”.
2. Set “Detection mode” to “macro and micro”.
3. Set “Calibration rate” to 4, so the solution will report the update rate as fast as possible.

With these settings, the presence detection solution would report the macro- and micro-level readings. An example is shown below (macro level 1.155, micro level 219.1):

macro 1.155223 at 0.33, micro 219.102509 at 0.33

6.2 Increase sensitivity by parameter adjustment

To increase the sensitivity further, the user must:

1. Find out the noise floor value of the system
2. Set the threshold above the noise floor

To find out the noise floor value, the user must empty the detection area so no one is inside. Put the radar module into a product casing so it will have a temperature similar to the product environment, as temperature can affect the noise floor. Record the macro and micro level for a period of time, and take the maximum reading as macro and micro noise level. The threshold level can then be set to 15 to 20 percent above noise level.

7 Signal verification mode

The radar SoM provides a feature called signal verification mode to check the RF attenuation due to the plastic material. Signal verification mode is a feature to output range bin profile. For a basic explanation of how FMCW radar measures distance, see the following link.

https://www.infineon.com/dgdl/Infineon-Radar%20FAQ-PI-v02_00-EN.pdf?fileId=5546d46266f85d6301671c76d2a00614

The range bin profile is an array of floating numbers showing the received signal level (in dB) at different distances. An example of a range bin profile is shown below. This feature can be used to measure the RF attenuation due to the plastic casing.

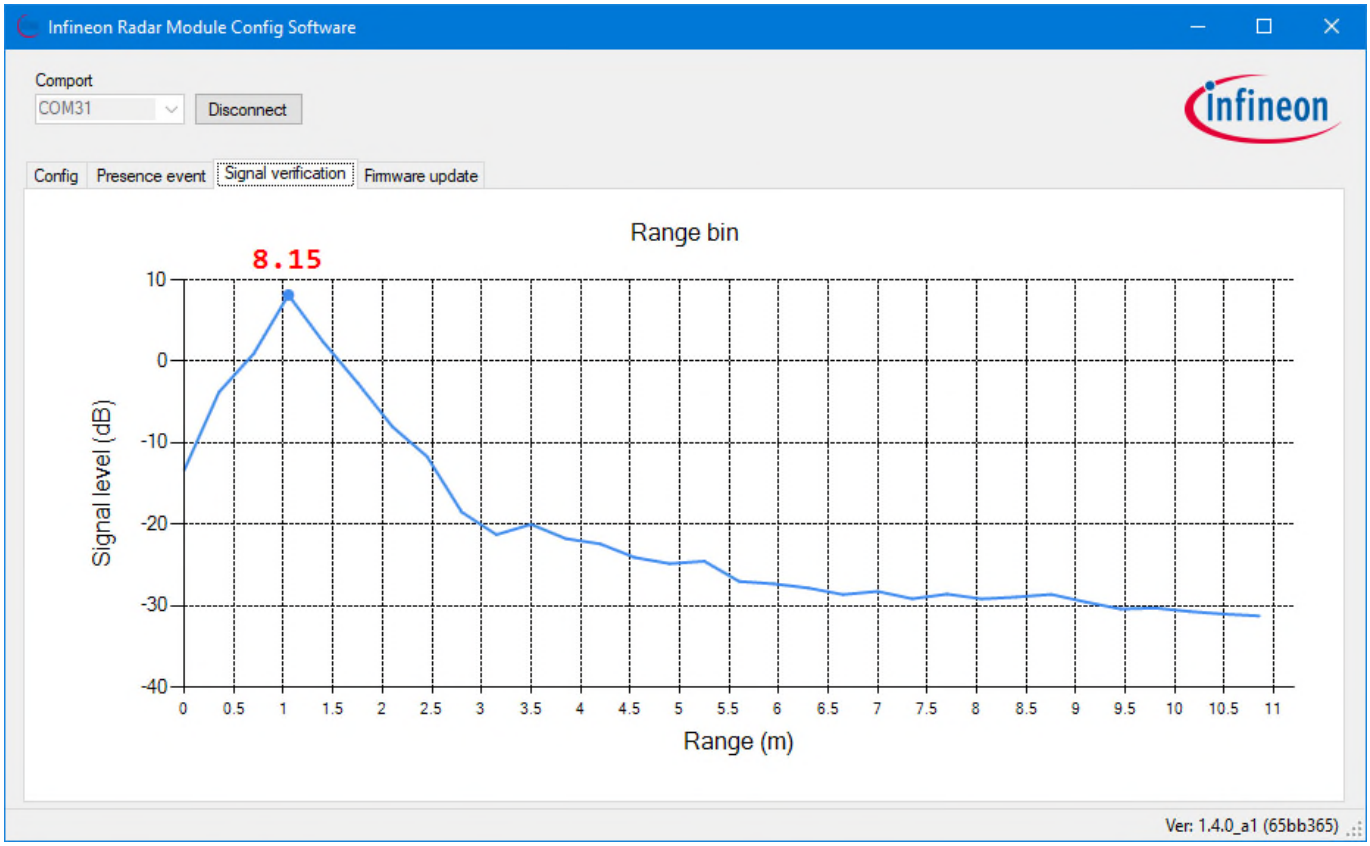


Figure 10 Range bin profile

7.1 Measurement setup

Put the radar in an open area, to minimize the reflected signal due to other static objects. At 1 m distance, place a corner reflector to maximize the reflected signal at 1 m. The user can then look at the signal level at 1 m to compare the difference with and without plastic casing. If the difference is smaller than 2 dB, it can be considered a good plastic casing that does not attenuate the RF signal too much.

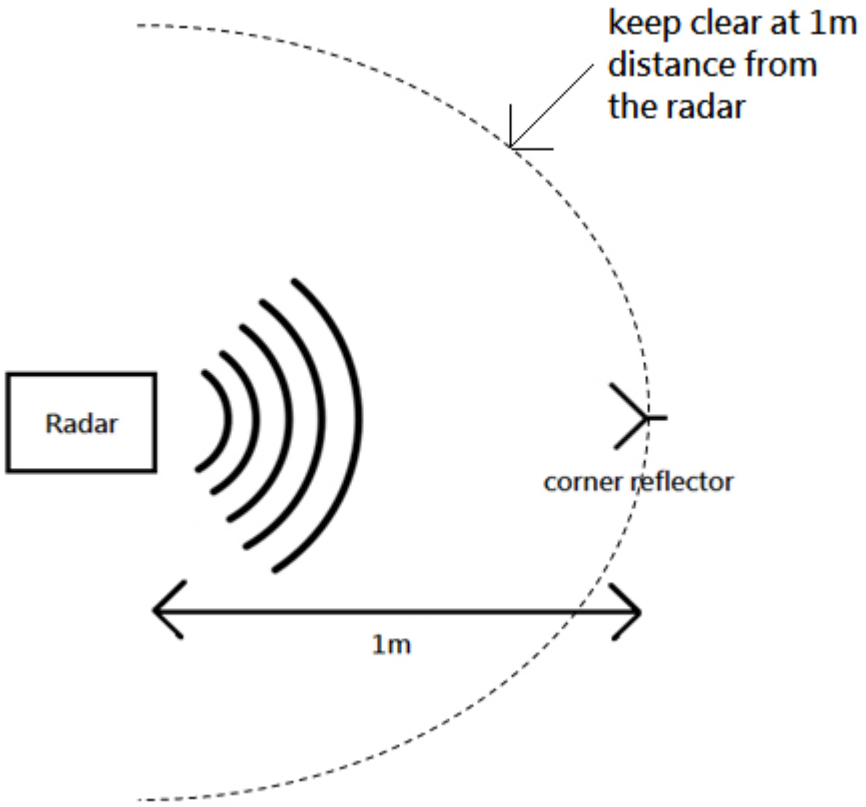


Figure 11 Measurement setup

Recommended corner reflector size (a: 50 mm; L: 70 mm).

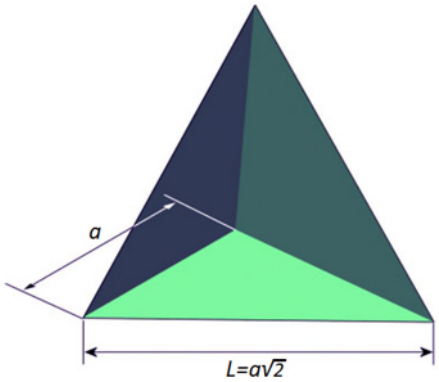


Figure 12 Corner reflector

8 Anti-interference

When an environment is using more than one radar module for presence detection, interference may occur and result in a false alarm. The radar module may report a presence event even inside a detection zone. To avoid this issue, the user can set the chirps-per-frame parameter to a higher value (e.g., 16) to enable the radar to check whether interference has occurred or not.

When using the 16 chirps-per-frame setting, the radar can filter out interference with up to 20 radar modules operating at the same time.

9 Firmware update

A firmware update can be done under the “Firmware update” tab. Select the target .bin file by pressing the “Select” button. Bootloader mode will be entered automatically during the update process. In case non-working firmware is loaded, the user can manually force the module to enter bootloader mode by pressing the user button on the motherboard after power-up or reset. The LED will change to blue when bootloader mode is entered.

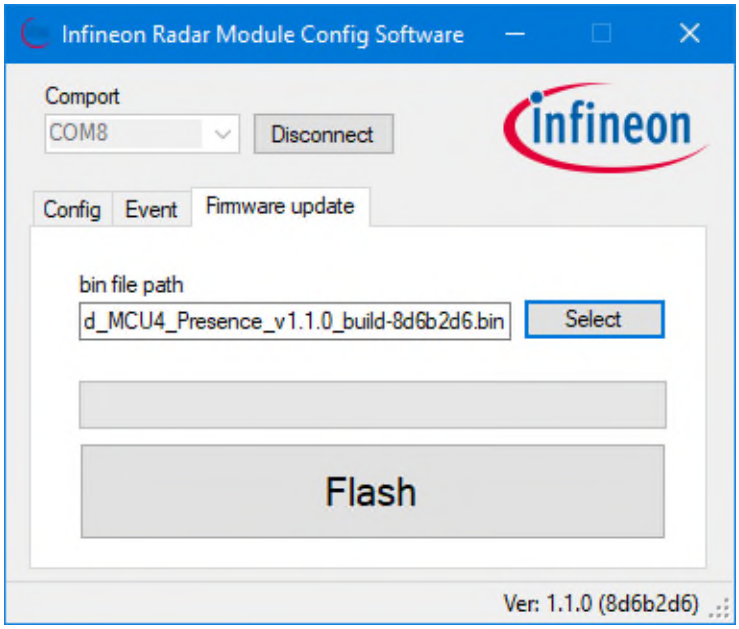


Figure 13 Firmware update tab page

Press the “Flash” button to start the firmware update. The whole update process should take around 20 s. Although a protection mechanism is included in the update process, it is recommended not to unplug the USB or power off the board to prevent any unexpected errors.

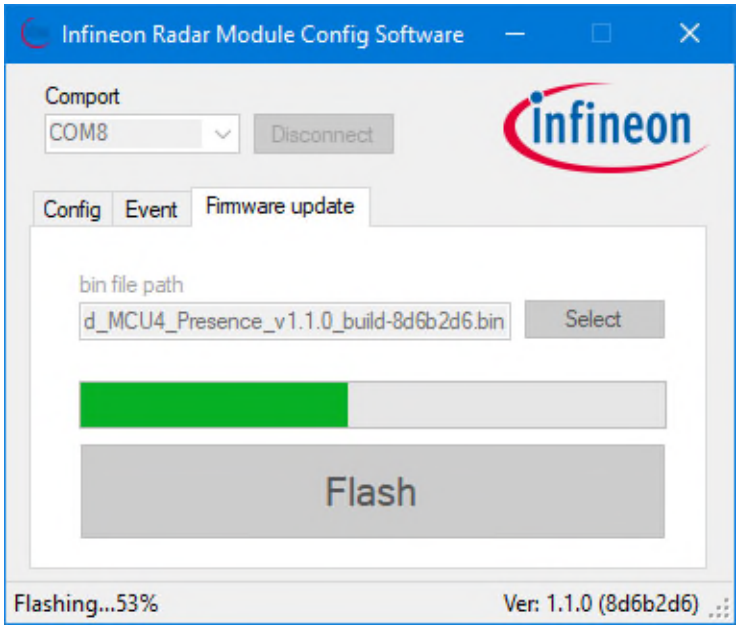


Figure 14 Firmware update in process

10 Additional documents

Specific user guides are available, including the following:

- **Infineon XENSIV™ 60GHz BGT60TR13C SoM solution for presence detection user guide:** Board specification, GPIO indication for presence event detection, hardware description and start-up, schematics and layout.
- **Infineon XENSIV™ 60GHz BGT60TR13C SoM MCU4 binary command protocol manual:** Describes the binary command protocol for integration of the module with a serial connection.

Revision history

Document version	Date of release	Description of changes
06/02/2020	1.0	Engineering samples release version
21/04/2020	1.1	Productive release version (updated introduction and firmware update contents)
19/06/2020	1.2	Maintenance release version (updated configuration table content)
30/09/2020	1.3	Maintenance release version (updated configuration table content)
15/01/2021	1.4	Updated hardware description and signal verification mode
18/02/2021	1.5	Updated threshold tuning method
31/05/2021	1.6	Added chapter for anti-interference
13/07/2021	1.7	Updated sensitivity description

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