# 60 GHz radar form factor module based on Infineon reference design

## User manual and integration instructions for host product manufacturers

## About this document

### Scope and purpose

This document is the user manual with integration instructions for the radar embedded form factor (FF) module with presence detection software.

### Intended audience

Manufacturers who intend to integrate the Infineon 60 GHz radar (BGT60TR13C) embedded form factor solution into their host product.

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Glossary

**Table 1 Abbreviations**

| Abbreviation | Name | Comment |
|---|---|---|
| CW | Continuous wave | |
| FCC | Federal Communications Commission | |
| FMCW | Frequency-modulated continuous wave | |
| GPIO | General-purpose input/output | |
| LDO | Low dropout | |
| mmWave | Millimeter wave | |
| PIR | Passive infrared sensing | |
| RX | Receiver | |
| SPI | Serial peripheral interface | |
| TX | Transmitter | |
| UART | Universal asynchronous receiver/transmitter | |

# 1 Introduction

Motion sensing is a standard feature present 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 sensing (PIR). As simple as PIR is, there are performance limitations. For example, PIR sensors cannot detect micro motions. In addition, they require a lens, whereas radar sensors can be covered and disguised behind plastic enclosures.

Infineon's presence detection sensor module integrates 60 GHz mmWave technology. The module simplifies the implementation of mmWave sensors in the band of 61.0 to 61.5 GHz, and it includes the ARM® Cortex®-M4F based processor system, 1TX 3RX antennas and onboard regulator. This presence detection sensor module targets low-power and high-resolution presence detection in smart home, office, and diverse other use cases.

## 1.1 General features

- ARM® Cortex®-M4F 150 MHz, 1024 kB Flash, 288 kB RAM
- Built-in antennas (1TX 3RX)
- Built-in regulator
- UART interface and GPIOs
- 3.6~5 V power input
- 26-pin pitch 1.27 mm castellated holes
- Dimensions: 20 x 15 x 2.3 mm

**Figure 1 60 GHz radar form factor module**

## 1.2 Presence detection features

- Low power and high resolution
- Presence sensing for home, office and commercial buildings
- Adjustable detection range
- Field of view of radar: azimuth: ±45 degrees/elevation: ±40 degrees
- Immune to environmental factors such as temperature, wind, sunlight and dust/debris
- Detection range:
    - Detection up to 10 m for macro motion (1)
    - Detection up to 5 m for micro motion (2)

(1) Macro motion: Human movements.
(2) Micro motion: Stationary human (normally breathing and blinking eyes) in sitting or standing position with no active movements for at least 30 s.

# 2 Hardware information

## 2.1 Block diagram

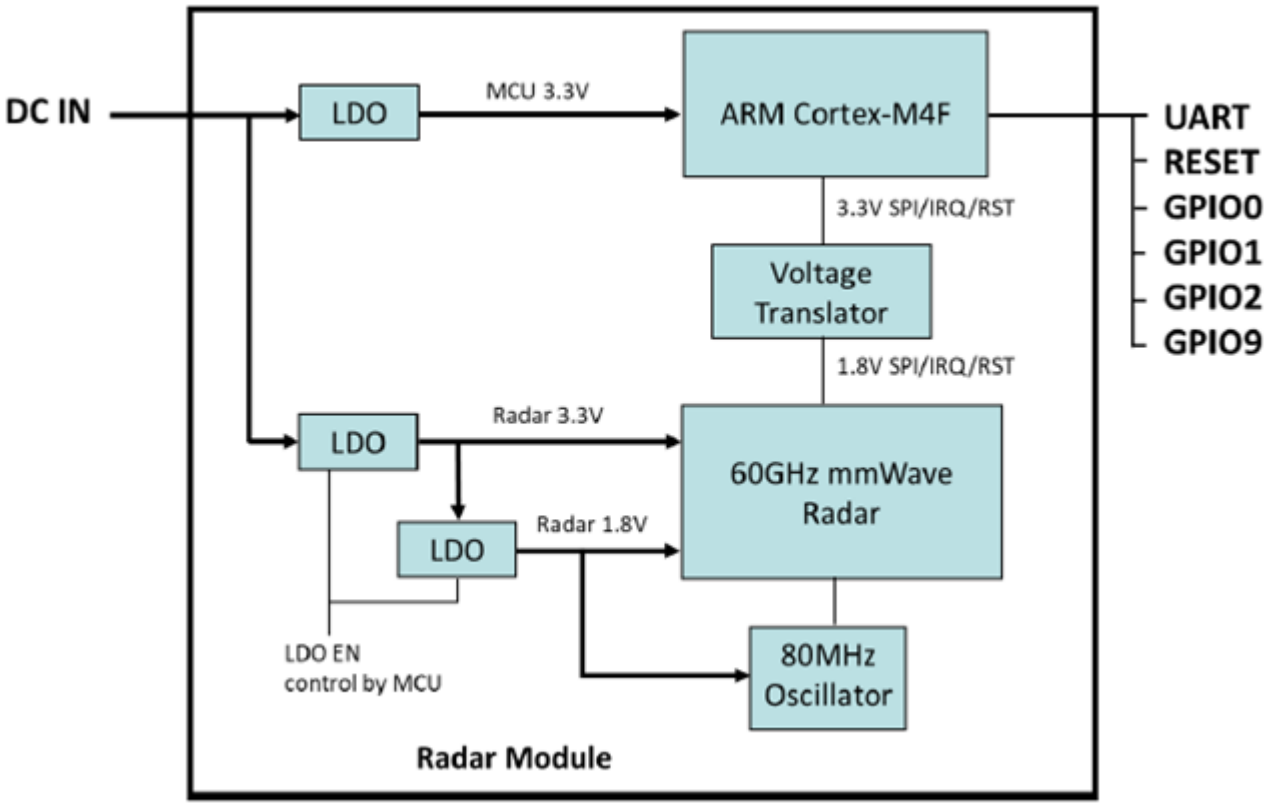



**Figure 2 Module block diagram**

The main components of the module are the 60 GHz radar chip, the ARM® based MCU and the 80 MHz oscillator. The module has its own power supply regulation. UART is the communication interface to the host device.

## 2.2 Module pin definitions

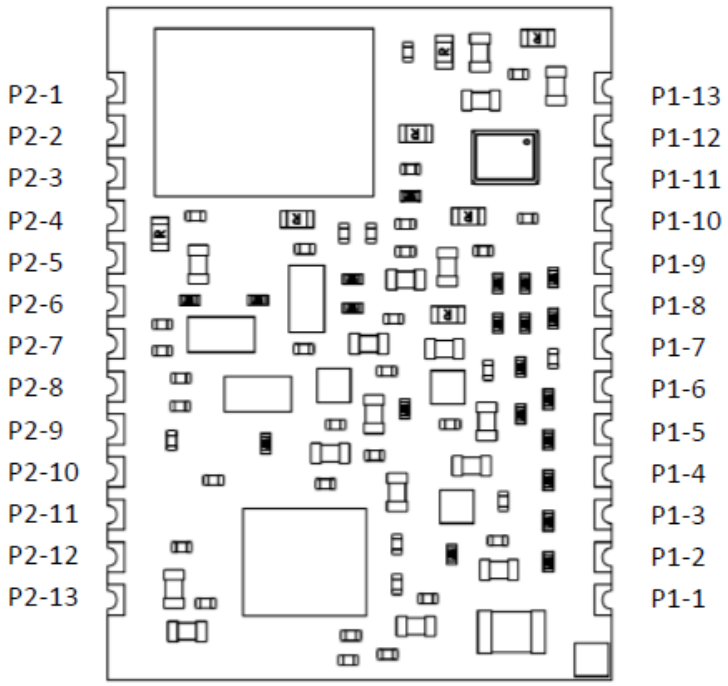



**Figure 3 Components on the module**

**Table 2 P1 pin definitions**

| Pin no. | Signal name | Description |
|---|---|---|
| P1-1 | DC_IN | Power supply input. Range from 3.6 V to 5.5 V. |
| P1-2 | DC_IN | Power supply input. Range from 3.6 V to 5.5 V. |
| P1-3 | NC | Not used |
| P1-4 | NC | Not used |
| P1-5 | NC | Not used |
| P1-6 | NC | Not used |
| P1-7 | NC | Not used |
| P1-8 | nRESET | Reset for radar module. Internal pull high default. Active low. |
| P1-9 | UART_TX | UART transmit. Reserve test point for firmware upgrade. |
| P1-10 | UART_RX | UART receive. Reserve test point for firmware upgrade. |
| P1-11 | NC | Not used |
| P1-12 | NC | Not used |
| P1-13 | GND | Ground |

**Table 3 P2 Pin definitions**

| Pin no. | Signal name | Description |
|---|---|---|
| P2-1 | NC | Not used |
| P2-2 | NC | Not used |
| P2-3 | GPIO0 | GPIO0. Default low, green color for presence indication. |
| P2-4 | GPIO1 | GPIO1. Default low, red color for no presence indication. |
| P2-5 | GPIO2 | GPIO2. Default low, blue color for bootloader mode indication. |
| P2-6 | NC | Not used |
| P2-7 | NC | Not used |
| P2-8 | NC | Not used |
| P2-9 | NC | Not used |
| P2-10 | NC | Not used |
| P2-11 | NC | Not used |
| P2-12 | GPIO9 | GPIO9. Please pull high 1 kΩ to VIO. Executing a hardware reset (using pin P1-8) with this pin pulled to low will trigger the module to enter bootloader mode after reset. Bootloader mode is used for firmware update. |
| P2-13 | GND | Ground |

## 2.3 Recommended operating conditions

| Parameter | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| DC_IN | DC supply input | 3.6 | – | 5.5 | V |
| VIH | IO high-level input voltage | 2.3 | – | – | |
| VIL | IO low-level input voltage | – | – | 1 | |
| Current consumption at DC_IN = 5 V (1) | Presence detect mode on<br>Presence detect mode off<br>Deep sleep mode | | 12.0<br>3.7<br>0.04 | | mA |
| Phase noise | At 100 kHz offset | | -80 | | dBc/Hz |
| Operating temperature (2) | | -10 | | 70 | °C |
| Storage temperature | | -40 | | 85 | °C |

(1) Based on firmware 237a4fe version.
(2) Means ambient temperature when working.

## 2.4 Module RF parameters

| Parameter | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RX_BW, TX_BW | Operating frequency[1] | 61.0 | | 61.5 | GHz |
| Output power | EIRP | | +7.5 | | dBm |
| Antenna gain of single TX | | 2.0 | 3.5 | 5.0 | dBi |
| Antenna gain of single RX | | 2.0 | 3.5 | 5.0 | dBi |
| E-plane of TX and RX antenna | | 25 | 40 | 55 | Deg. |
| H-plane of TX and RX antenna | | 30 | 45 | 60 | Deg. |

[1] Fixed by firmware to comply with granted FCC certification.

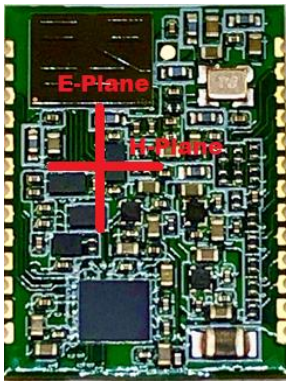



**Figure 4 Module – E- and H-plane**

# 3 UART interface connection

A UART interface is used to communicate with the radar module through binary commands. The UART TX and RX pins operate at TTL 3.3 V level. A detailed configuration of the UART interface is shown in the table below.

| | |
|---|---|
| Baud rate | 115200 |
| Bit width | 8 |
| Parity | None |
| Stop bit | 1 |

## 3.1 Example command

Example command to get firmware version:

Command send to UART_RX

D9 00 00 00 B4 DF

Reply command receive at UART_TX

D9 00 1E 00 50 72 65 73 65 6E 63 65 44 65 74 65 63 74 5F 31 2E 33 2E 30 20 28 31 35 36 61 34 62 63 29 52 EF

The binary command is in the format of header + length + payload + checksum. For detailed information please refer to the “Infineon BGT60TR13C embed MCU4 binary command protocol manual”.

# 4 Radar radiation pattern

## 4.1 Test setup

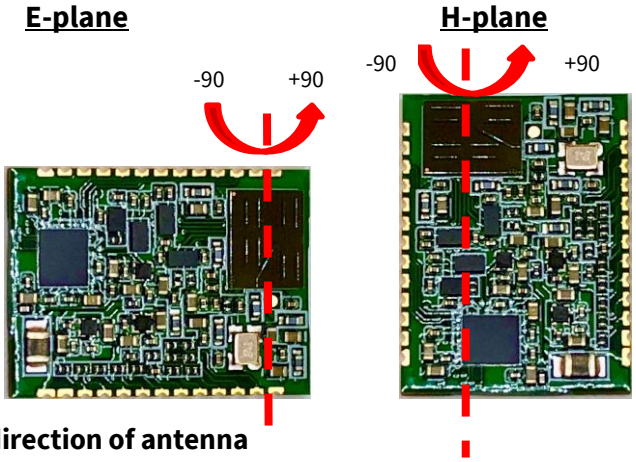



**Figure 5 Turning direction of antenna**

## 4.2 Radiation pattern

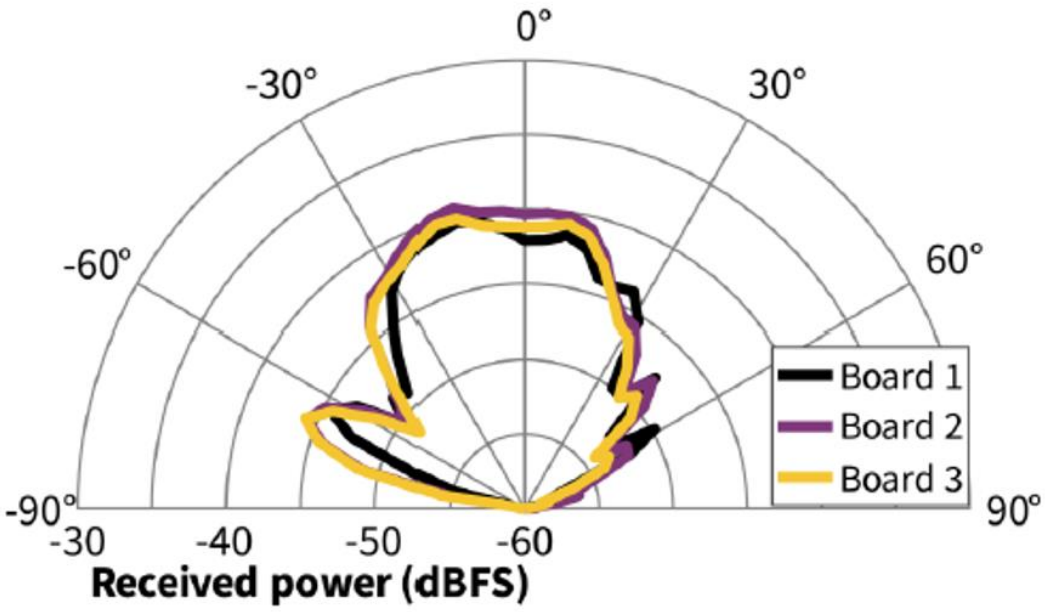



**Figure 6 Radiation pattern of the E-plane**

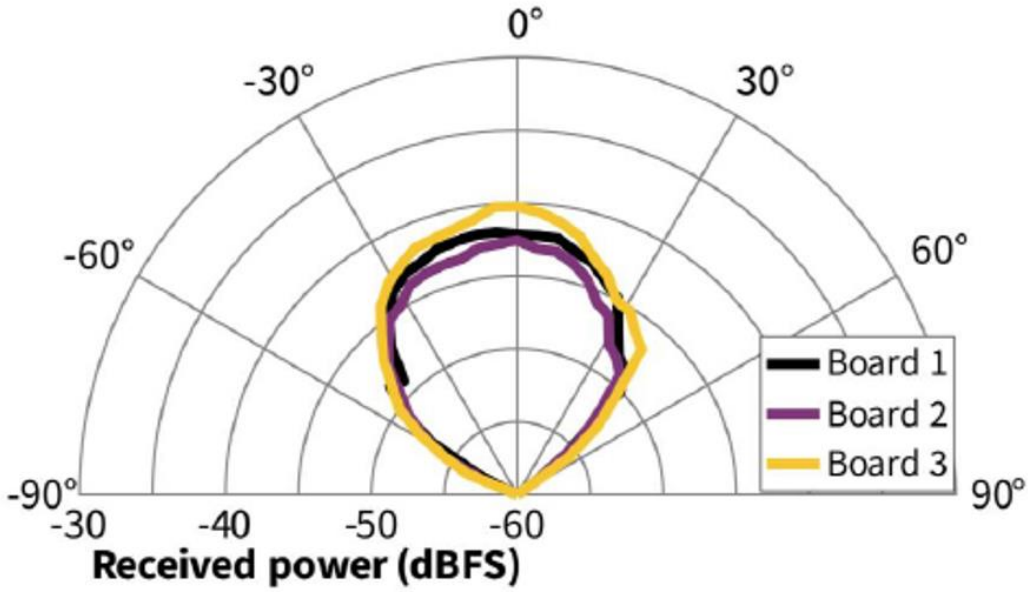



**Figure 7 Radiation pattern of the H-plane**

# 5 FCC considerations

The reference module has been certified at FCC according to the rules as stated in chapter 5.1.

Host product manufacturers must immediately file a 2.933 Change-in-ID application to obtain their own FCC ID for the module, and then a C2P application to authorize the module in their specific host device(s).

Host product manufacturers are advised to carefully read the whole of chapter 5 and follow the guidelines according to KDB 996369 D04, or the latest updates of it.

## 5.1 List of applicable FCC rules

The modular transmitter was tested according to the following rules:

- FCC Rules and Regulations Part 15, Subpart A – General (September 2019)
- Part 15, Subpart A, Section 15.31 Measurement standards
- FCC Rules and Regulations Part 15, Subpart C – Intentional Radiators (September 2019)
- Part 15, Subpart C, Section 15.203 Antenna requirements
- Part 15, Subpart C, Section 15.204 External radio frequency power amplifiers and antenna modifications
- Part 15, Subpart C, Section 15.205 Restricted bands of operation
- Part 15, Subpart C, Section 15.207 Conducted limits
- Part 15, Subpart C, Section 15.209 Radiated emission limits, general requirements
- Part 15, Subpart C, Section 15.255 Operation within the band 57 to 71 GHz.

The modular transmitter is **only** FCC authorized for the specific rule parts listed on the grant. The host product manufacturer is responsible for compliance with any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

## 5.2 Specific operational use conditions

- The module is classified for use in fixed equipment, refer to chapter 5.5.
- The module is FCC- certified for the operating frequency range 61 to 61.5 GHz.
- The application software (SW) has the firmware (FW) ID 1.0.0.

## 5.3 Limited module procedures

The modular transmitter is approved by FCC as a “limited module” due to the following limitations:

- The module does not have its own RF shielding.
- The module does not have an FCC ID label attached to it. FCC ID: 2AYSQ-6011

Notes:

- See also chapter 5.5 for human exposure considerations.
- The module has not been tested for simultaneous transmission operations.
- Refer to chapter 6.2 for integration methods that address the limitation due to RF shielding.

## 5.4 Trace antenna design

Not applicable.

## 5.5 RF exposure considerations

- The performed human exposure evaluation is described in the *"Human exposure RF test report" No. : T46134-04-00HS*
- The module is classified for use in fixed equipment.
    - The host product operating conditions must be such that there is a minimum separation distance of 20 cm (or possibly greater than 20 cm) between the module and nearby persons.
    - The host product manufacturer is required to provide the following text in its end user manual: "In order to comply with FCC RF Exposure requirements this device must be operated with a minimum separation distance of 20 cm between the equipment and a person's body."

## 5.6 Antennas

The antenna is integrated into the radar chip (on-chip antenna).

Type: Linear polarized strip patch array antenna; gain 5 dBi.

## 5.7 Label and compliance information

The module does not have a FCC label attached to it. The host product manufacturer is advised to provide a physical or e-label stating "Contains FCC ID: …." with the finished product. The manufacturer is advised to read "Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748."

## 5.8 Information on test modes and additional testing requirements

Infineon provides software that enables the host module manufacturer to operate the module in certain test modes, including the modes that have been used for FCC certification of the module:

- CW low frequency: Operates the module in CW at 61.019 GHz.
- CW mid frequency: Operates the module in CW at 61.249 GHz.
- CW high frequency: Operates the module in CW at 61.479 GHz.
- FMCW: Chirp mode V 1.0.0 (presence detection SW) according to FW version 1.0.0.

The SW also provides additional options that might be useful in testing the host system – e.g. a mode that puts the module into sleep mode. See the next chapter for information on initializing and using the SW.

## 5.9 Test mode command

The UART interface can be used to set up the module in test mode. The following table show the commands for entering different test modes. After power-up or reset, the module will be in presence detection mode, which is sending FMCW chirps. An acknowledge command will be sent from the module after a valid command is received.

| Command name | Binary command |
|---|---|
| Enable presence detection | D9 0A 01 00 01 28 C1 |
| Disable presence detection | D9 0A 01 00 00 09 D1 |
| Enable RFCW output at 61.019 GHz (low) | D9 0B 01 00 01 9C B7 |
| Enable RFCW output at 61.249 GHz (mid) | D9 0B 01 00 02 FF 87 |
| Enable RFCW output at 61.479 GHz (high) | D9 0B 01 00 03 DE 97 |
| Disable RFCW output | D9 0B 01 00 00 BD A7 |
| Deep sleep mode | D9 0E 01 00 01 D9 0B |

To enable RFCW mode, please follow the below command sequence:

Disable presence detection → Enable RFCW output (low/mid/high)

To resume chirp mode from RFCW mode, please follow the below command sequence:

Disable RFCW output → Enable presence detection

## 5.10 Important notes

The host product manufacturer must provide the below text to the end-user:

a) Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

b) This device complies with Part 15 of the FCC rules. Operation is subject to the following conditions:

- This device may not cause interference.
- This device must accept any interference, including interference that may cause undesired operation of the device.

# 6 Reference design

## 6.1 Design recommendation

- Please reserve the test points of the UART for FW upgrade in the future.
- Please keep the module solder layer free of ground plane/trace rout in the “keep-out area” (shown in Figure 12).
- The power trace for DC_IN must be at least 20 mm wide.

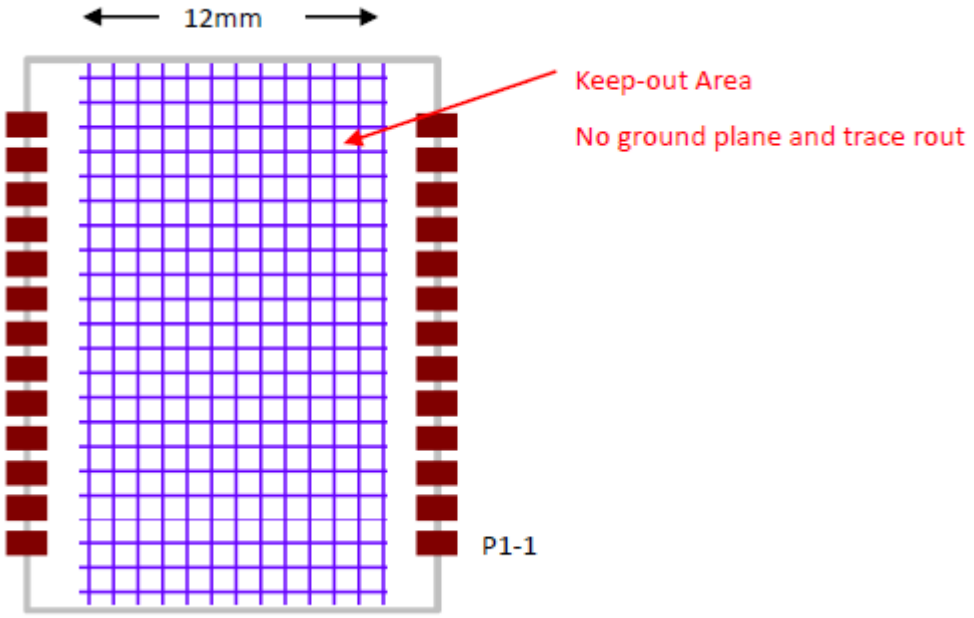



**Figure 8 Recommended layout of radar module**

## 6.2 Integration of radar module into host product

Considerations when integrating are to ensure that the emissions from the host electronics are not advertently impacting the module and preventing proper operation. Conversely, the module emissions shall not prevent the rest of the host from operating properly. The complete host must still comply with applicable FCC regulations.

Therefore, a verification of the final product must be done, by at least spot-checking emissions from the device while operating the host as a complete system. This testing should be performed with the host product configured in typical operational modes to check the fundamental frequency and spurious emissions for compliance with all applicable rules.

To reduce the impact of the module on emissions, the host product manufacturer is advised to follow these guidelines:

- Ensure that the maximum amount of the radar signal is indeed leaving the host device by ensuring that the signal is not unnecessarily reflected inside the host. See the Infineon “*60 GHz radar radome design guide*” for proper distances to housing surfaces and recommended housing materials.
- Place the radar module inside the host as far away as technically feasible from other electronics that have been identified as susceptible to RF emissions, or identified to be a potential source of such

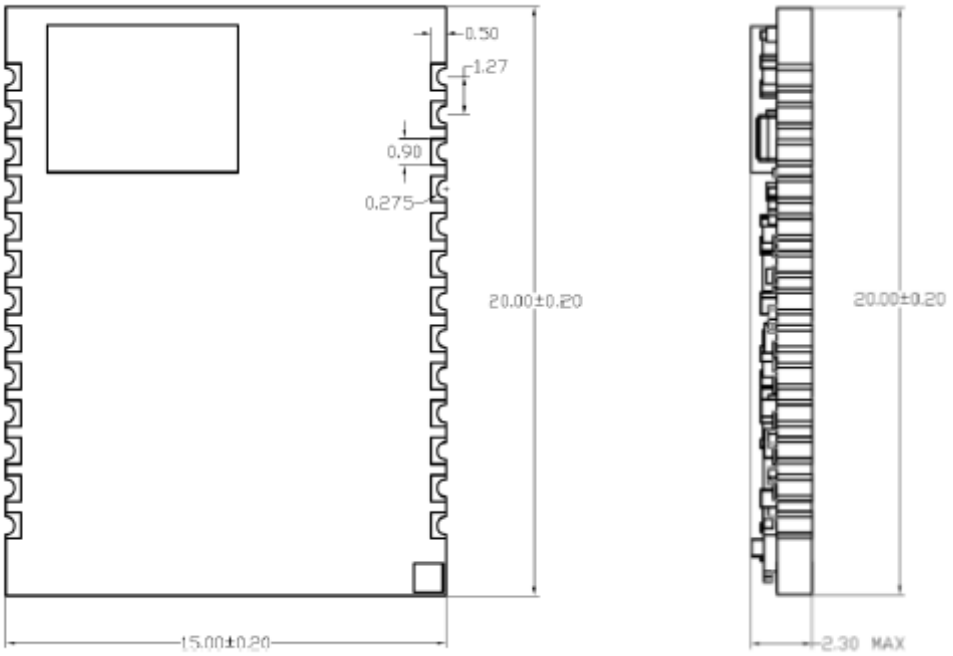
emissions. Such potential sources include other intentional transmitters or digital electronics operating at MHz clock rates.

- Put the PCB with the radar module soldered onto it within a separate section of the host, where it can be shielded from other host electronics. The shielding should be made of sheet metal, metal mesh or a metallic ink-coated material expressly designed as an effective shield. Any holes in the shield must be significantly smaller than the wavelength of the radiation that is being blocked. For 60 GHz radar that would mean maximum 0.5 mm.

Whereas the first item should always be followed by the host manufacturer, the manufacturer can evaluate whether items two or three are suitable for the product and take measures to keep overall emissions below regulatory limits.

# 7 Module information

## 7.1 Module dimensions




Top view

Side view

Bottom view

**Figure 9 Module dimensions**

## 7.2 Recommended land pattern

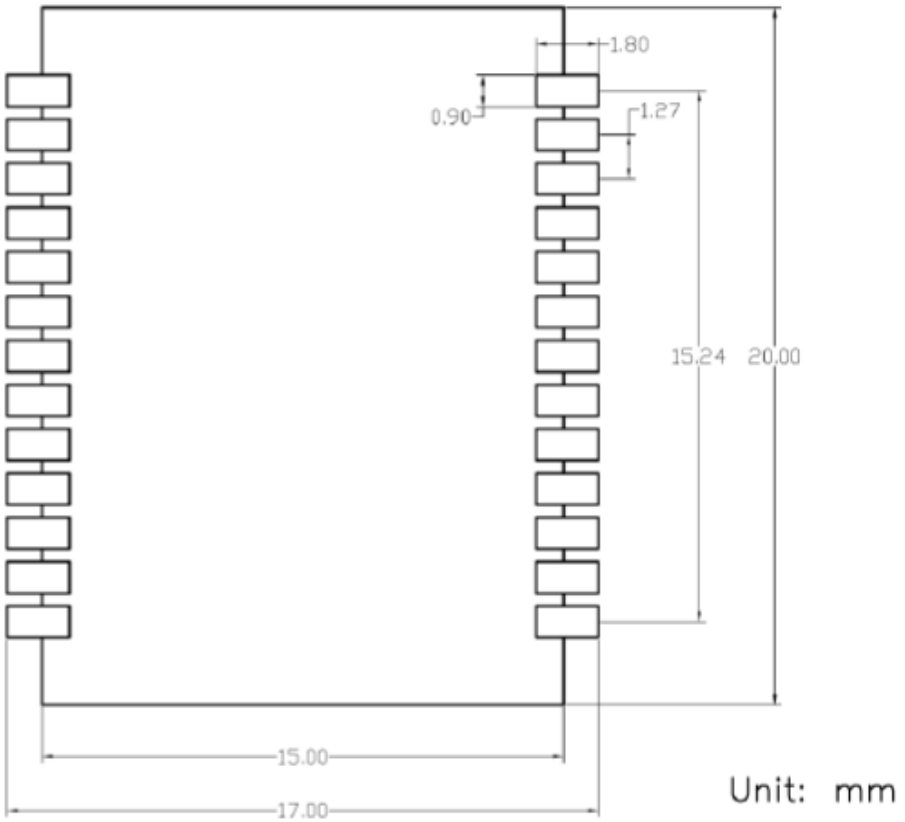



**Figure 10 Recommended land pattern dimensions**

# 8 SMT/baking information

## 8.1 Baking recommendations

Baking conditions:

- Follow MSL Level 4 to carry out the baking process.
- After the bag is opened, devices that will be subjected to reflow solder or other high-temperature processes must be:
  - mounted within 72 hours of factory conditions at less than 30°C/60 percent RH
  - stored at less than 10 percent RH.
- Devices require baking before mounting if the humidity indicator card reads more than 10 percent.
- If baking is required, devices may be baked for 8 hours at 125°C.

## 8.2 SMT recommendations

Recommended reflow profile:

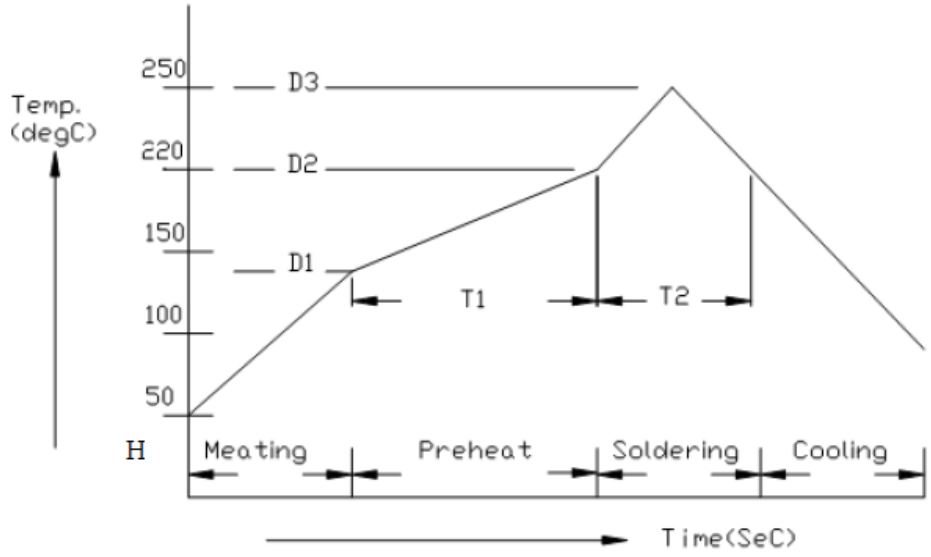



**Figure 11 Reflow profile of module**

**Table 4 Description of parameters in reflow profile**

| | | | |
|---|---|---|---|
| 1 | Pre-heat | D1: 140 ~ D2: 200 | T1: 80~120 |
| 2 | Soldering | D2: 220 | T2: 60 +/-10 |
| 3 | Peak temperature | D3: 250°C max. | |

Note: Reflow soldering is recommended a maximum of twice.

Note: Add nitrogen during the reflow process to improve SMT solderability.

- **Stencil thickness:** 0.1~0.13 mm (recommended)
- **Soldering paste (without Pb):** SENJU N705-GRN3360-K2-V for best soldering effects.

# 9 Revision history

| Date of release | Document version | Description of changes |
|---|---|---|
| 03. 03. 2021 | 0.3 | Reviewed version |
| 29. 06. 2021 | 1.0 | Updates in chapter 5.0 / 5.5 / 5.10 |
| | | |
| | | |

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