

MM5D91-00

60GHz mmWave Radar

Presence Detection Sensor Module

Datasheet

Revision 3.0

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1. INTRODUCTION

The MM5D91-00 is the presence detection sensor module which integrates 60GHz mmWave technology. The module simplifies the implementation of mmWave sensors in the band of 61.0 to 61.5GHz, and it includes the ARM Cortex-M4F based processor system, 1Tx 3Rx antenna and onboard regulator. This presence detection sensor module targets low power and high resolution presence detection in smart home, office, security and diverse applications.

1.1. General Features

- ARM Cortex-M4F 150MHz, 1024KB Flash, 288KB RAM
- Built-in Antenna (1Tx, 3Rx)
- Built-in Regulator
- UART interface and GPIOs
- 3.6~5.5V Power input
- 26pin pitch 1.27mm Castellated Holes
- Dimensions: 20 x 15 x 2.3 mm

1.2. Presence Detection Features

- Presence sensing for home, office and commercial buildings
- Adjustable detection range
- Field of View of Radar : Azimuth: $\pm 45^\circ$ / Elevation: $\pm 40^\circ$
- Supported moving object speed (m/sec): up to 2.0 m/sec
- Static objects (non-living) are not detected
- Able to detect presence ($\leq 1\text{sec}$) when at least one moving object is present
- Absence is declared in around 3sec (both macro and micro modes enabled).
Configurable up to 30sec
- Detection Range :

※ Detection up to 10m for macro motion ⁽¹⁾

※ Detection up to 5m for micro motion ⁽²⁾

(1) Macro motion: human movements

(2) Micro motion:

Stationary human (normally breathing and blinking eyes) in sitting or standing positions with no active movements for at least 30 sec.

2. HARDWARE INFORMATION

2.1. Block Diagram

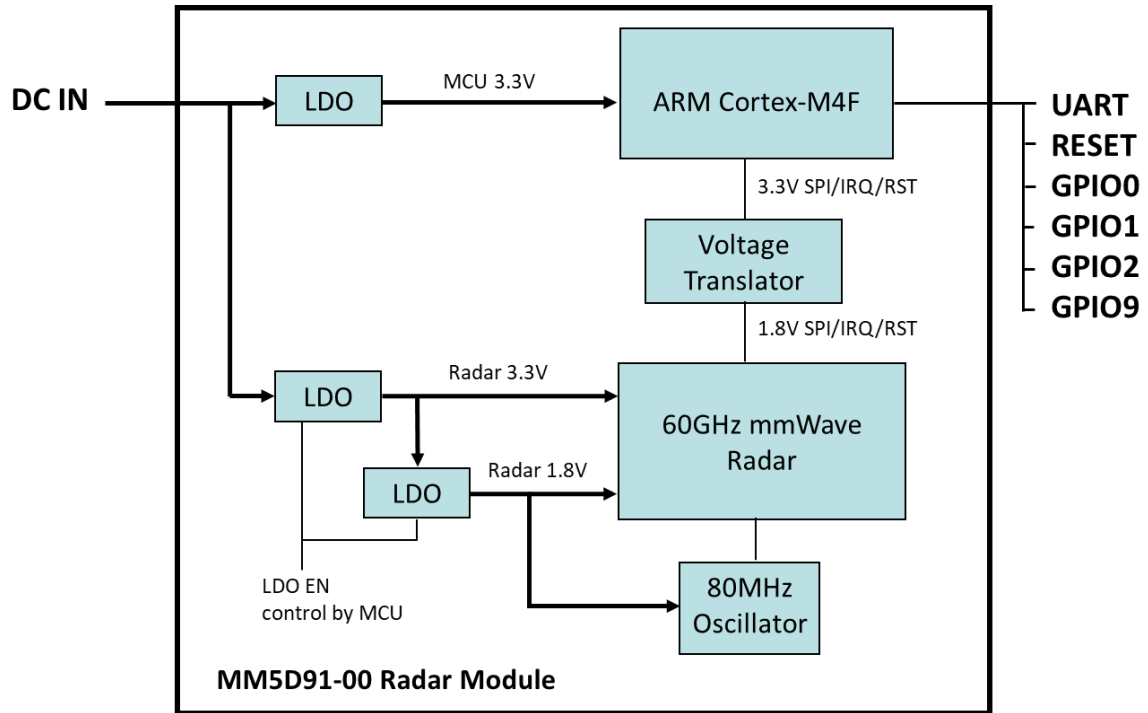


Figure 2-1. MM5D91-00 Block Diagram

2.2. Module Pin Define

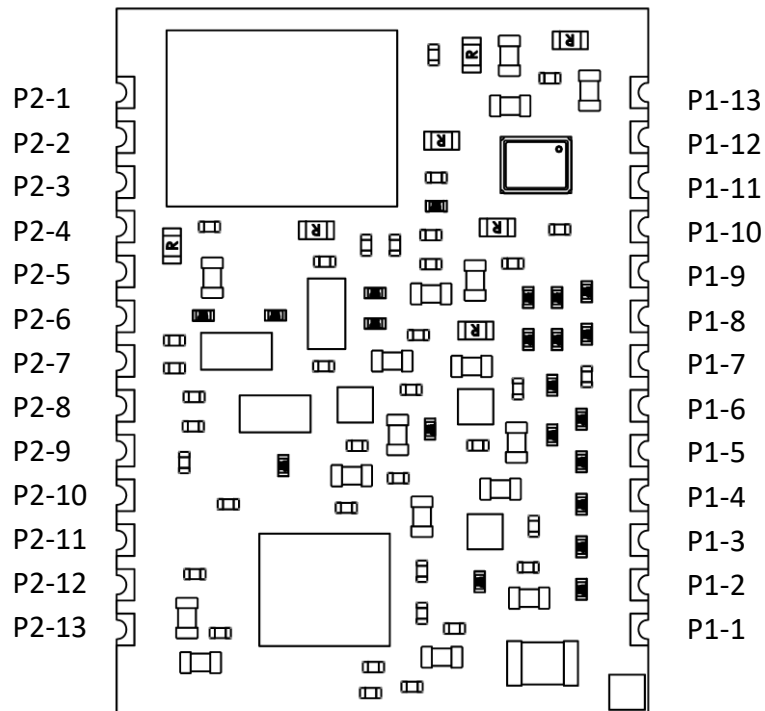


Figure 2-2. MM5D91-00 Module View

P1 Pin define:

Pin No.	Signal Name	Description
P1-1	NC	No Used.
P1-2	NC	No Used.
P1-3	NC	No Used.
P1-4	NC	No Used.
P1-5	NC	No Used.
P1-6	NC	No Used.
P1-7	NC	No Used.
P1-8	nRESET	Reset for radar module. Internal pull high default.
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	No Used.
P1-12	NC	No Used.
P1-13	GND	Ground.

P2 Pin define:

Pin No.	Signal Name	Description
P2-1	NC	No Used.
P2-2	NC	No Used.
P2-3	GPIO0	GPIO0. Default low, green color for not presence indication.
P2-4	GPIO1	GPIO1. Default low, red color for presence detected indication.
P2-5	GPIO2	GPIO2. Default low, blue color for bootloader mode indication.
P2-6	NC	No Used.
P2-7	NC	No Used.
P2-8	NC	No Used.
P2-9	NC	No Used.
P2-10	NC	No Used.
P2-11	NC	No Used.
P2-12	GPIO9	GPIO9. Please Pull high 1K ohm to VIO.
P2-13	DC_IN	Power supply input. Range from 3.6V to 5.5V.

2.3. Recommended Operating

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 @ DC_IN=5V ⁽¹⁾	Presence detect mode on Presence detect mode off Deep sleep mode		12.0 3.7 0.04		mA
Phase noise	At 100KHz offset		-80		dBc/Hz
Operating Temperature ⁽²⁾		-20		70	°C
Storage Temperature		-40		85	°C

(1) Based on firmware 237a4fe version.

(2) Means ambient temperature when working.

2.4. Built-in Antenna Specifications

Parameter		Min	Typ	Max	Units
RX_BW, TX_BW	Antenna bandwidth	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
Field of View of Azimuth		70	90	110	Deg
Field of View of Elevation		60	80	100	Deg

3. RADAR RADIATION PATTERN

3.1. Test Setup

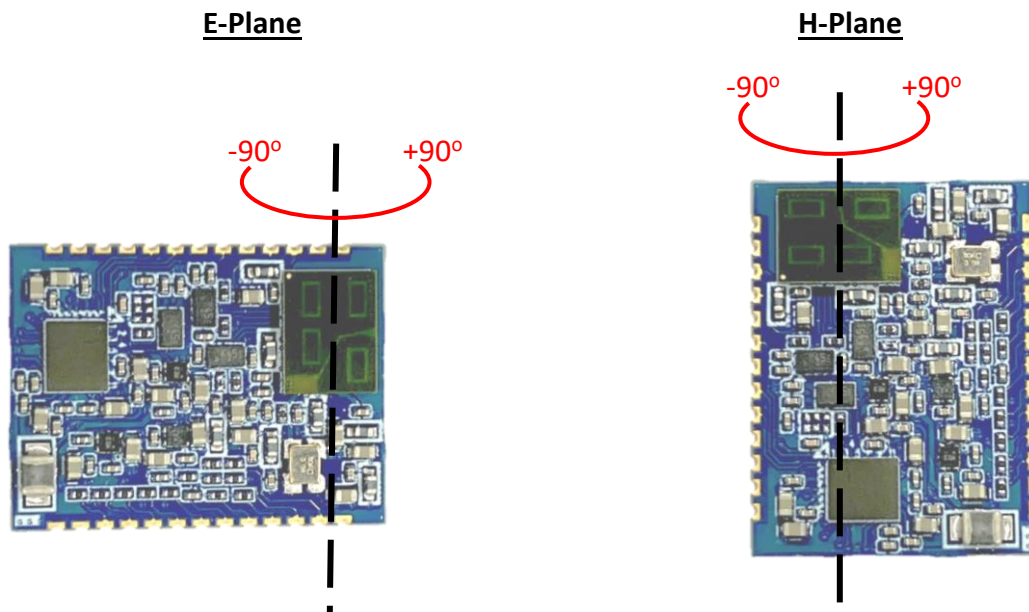


Figure 3-1. Antenna Setup

3.2. Radio Pattern

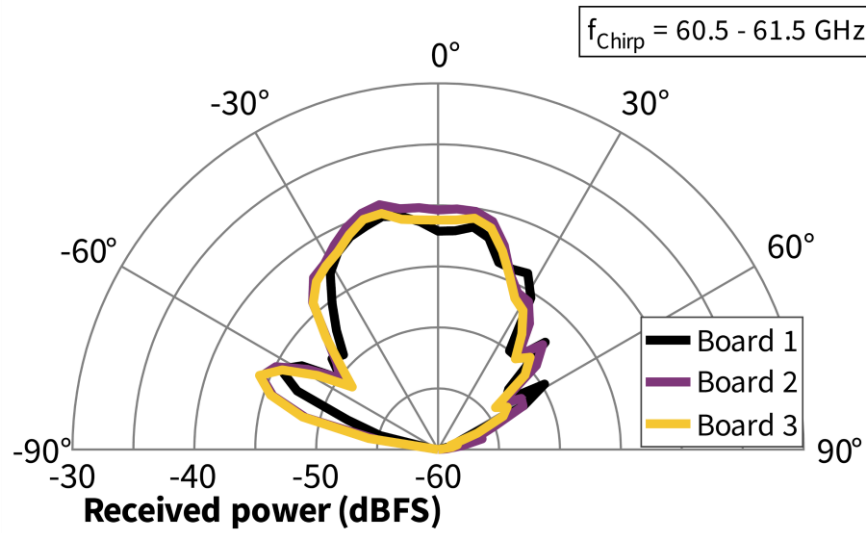


Figure 3-2. Radiation Pattern of the E-Plane

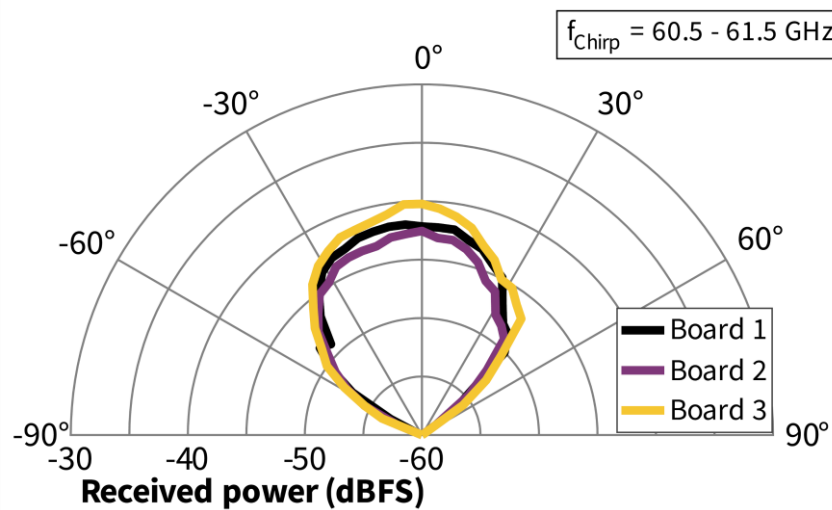


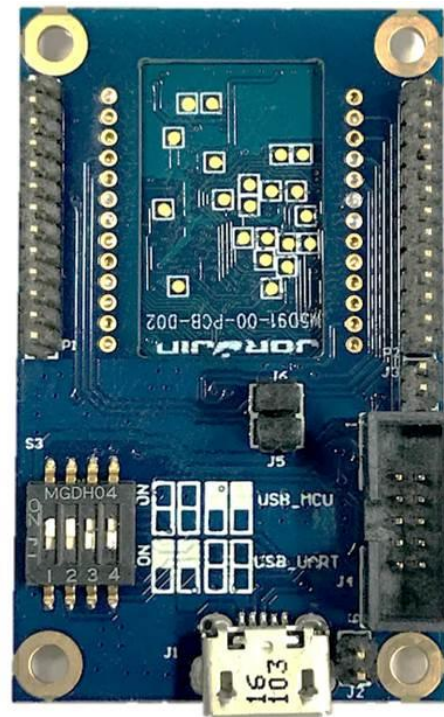
Figure 3-3. Radiation Pattern of the H-Plane

4. EVALUATION KIT

The Jorjin mmWave Radar sensor evaluation kit MM5D91E00 show as below. Based on the MM5D91-00 Radar sensor module, evaluation board is built to demonstrate the function of presence detection of the 60 GHz radar sensor with its sophisticated radar presence detection algorithms. This evaluation kit easy to demo and development for customer.



TOP side



Bottom side

Figure 4-1. MM5D91E00 mmWave Radar Evaluation Kit

4.1. Evaluation Hardware Description

The following figure and table describe physical sections of the board.

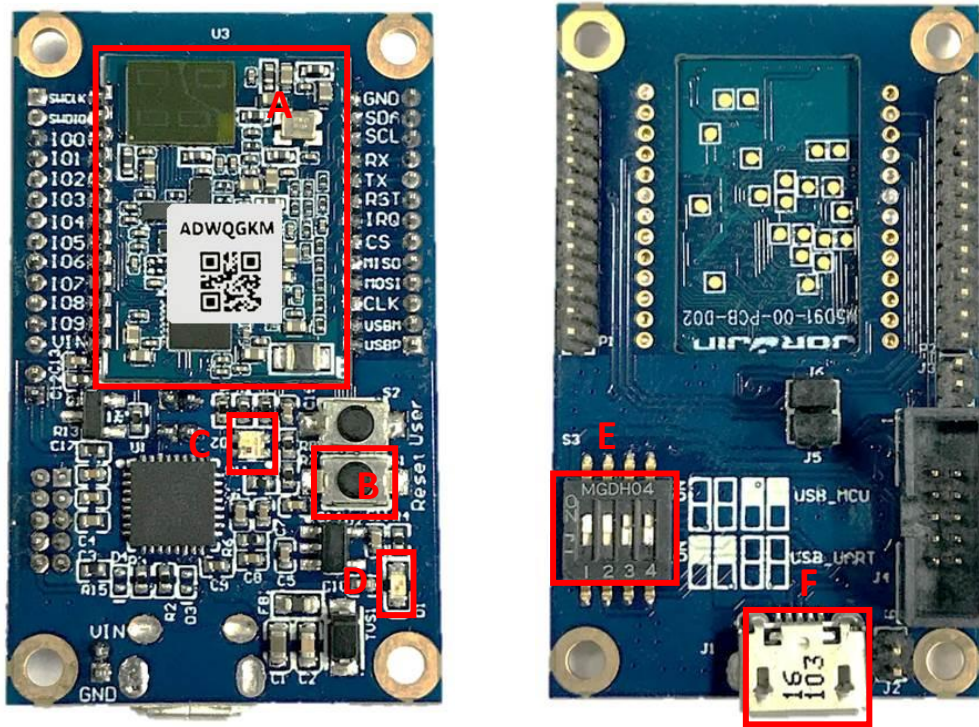


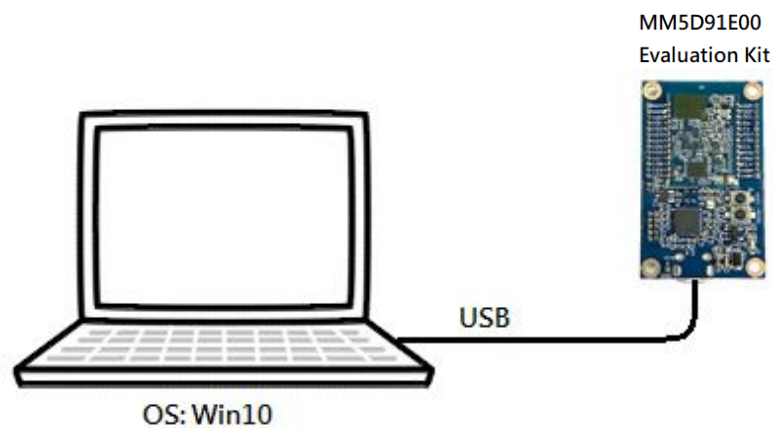
Figure 4-2. Hardware description of Evaluation Kit

Table 4-1. Evaluation Kit component descriptions list

Region	Description
A	Jorjin mmWave Radar sensor module.
B	Radar sensor module reset switch.
C	Red LED light when the evaluation kit is power on.
D	LED of radar detect status: - Green color : No presence. - Red color : Presence detected.
E	Interface setting: Turn up of left two / Turn down of right two. Please keep the setting always.
F	Micro USB connector. Connected to PC (config tool) or power bank to demo.

5. CONFIGURABILITY

- Easy Configuration UART port for the end user to change parameters
- Standard mode: Detection range, sensitivity, reset etc.
- Expert mode: macro/micro modes, thresholds etc.
- The detection range, sensitivity and status settings are stored in the flash and remain set after power reboot.



If the OS is win7 or lower , please find the USB driver as [the link](#).

Figure 5-1. Radar module connect to PC

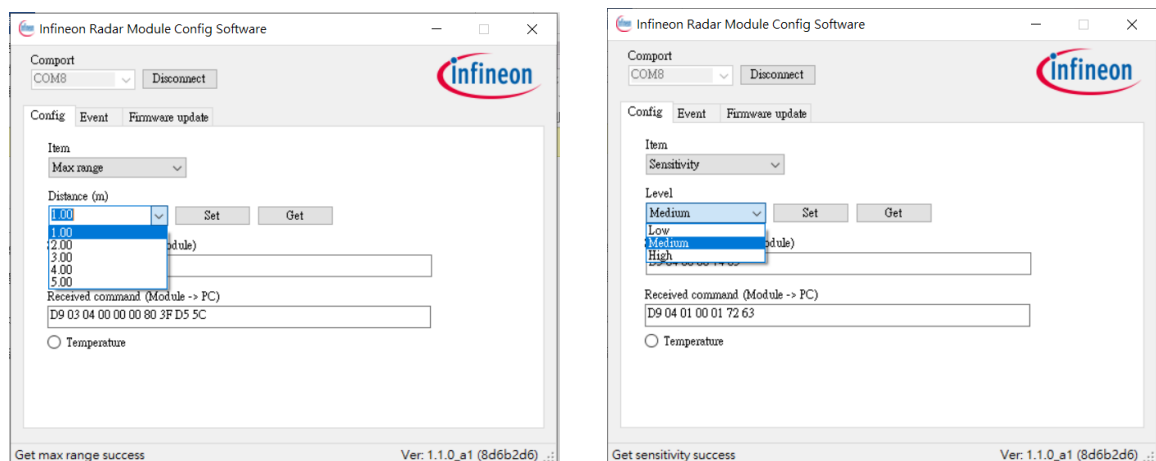


Figure 5-2. Radar Module Configuration software

6. REFERENCE OF MODULE DESIGN

6.1. Reference Schematic

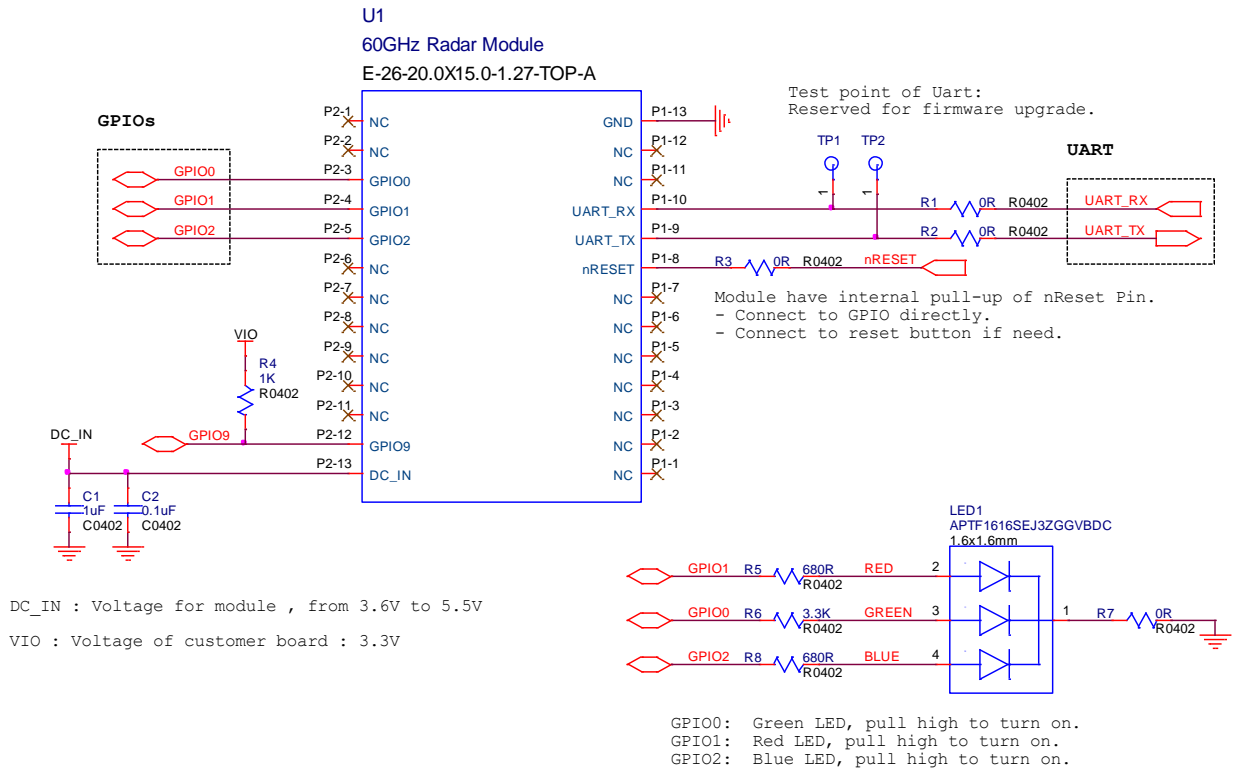


Figure 6-1. MM5D91-00 Radar Module Reference Circuit

6.2. Design Recommendation

1. Please reserve the test points of UART for firmware upgrade in the future.
2. Please keep the module solder layer that no ground plane and trace rout in the keep-out area. Show in Figure 6-2.
3. The power trace for DC_IN must be at least 20-mil wide.

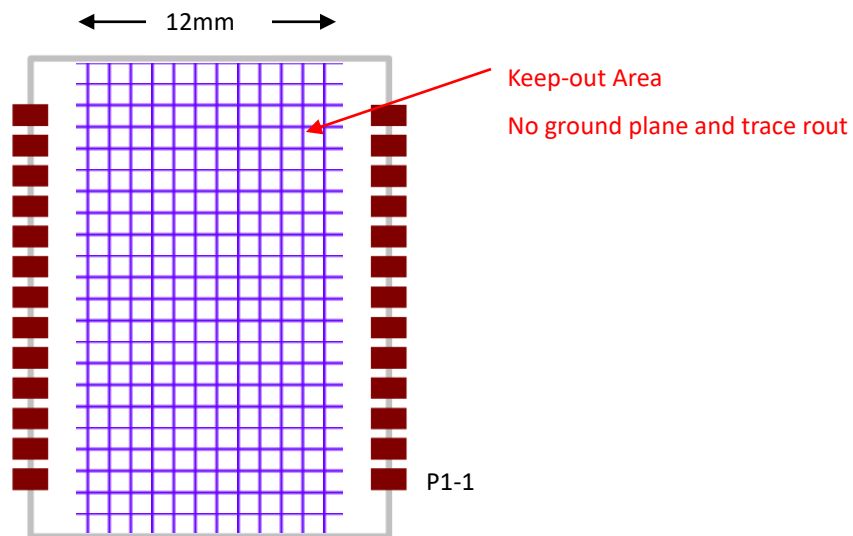


Figure 6-2. Recommend Layout of Radar module

7. RADOME DESIGN GUIDE

7.1. Radome Material

In order to minimize 60 GHz signal attenuation at the radome, we need to minimize the dielectric loss at the radome. Materials with low dielectric constant (ϵ_r) and low tangent loss ($\tan\delta$) value, will have smaller dielectric losses.

Without going into the technical details, low permittivity would enhance transmittance and lower the reflection at the radome, and lower the loss due to the rotation of polarization. On the other hand, low tangent loss would lower the amount of signal absorption.

The following are common plastic materials that have acceptable permittivity and loss tangent properties.

Material	Dielectric constant (ϵ_r)	Loss tangent ($\tan\delta$)
Polypropylene (PP)	2.2	0.0005
ABS	2.48	0.008
Polyethylene (PE)	2.3	0.0003
Polycarbonate (PC)	2.9	0.012
Polystyrene (PS)	2.5	0.0004
Teflon	2.2	0.0002

Note:

1. Only the pure plastic materials as shown in the table, would exhibit such dielectric constants and tangent losses. In the market, for example, plastic might be called ABS, but it could contain additives (e.g. fire retardants) that mean its characteristics deviates from the ideal parameters shown in the table.
2. Additives could cause changes in the dielectric constant because in chemical terms they are polar materials, and these polar materials will cause an increase in dielectric constant.

7.2. Radome Design

7.2.1. Radome Shape

A simple, flat design is the recommended shape for a radome. However, if curvature is unavoidable, it is best to use a design that maintains a constant thickness to avoid any lensing effect, which could change the antenna pattern or field of view of your 60 GHz product.

For example, design (a) below is an example of a curved radome with constant thickness, and it does not change the direction of the wave, thus producing no lensing effect. On the other hand, design (b) is not recommended as it has non-constant thickness, so it changes the wave's direction of travel and thus produces a lensing effect.

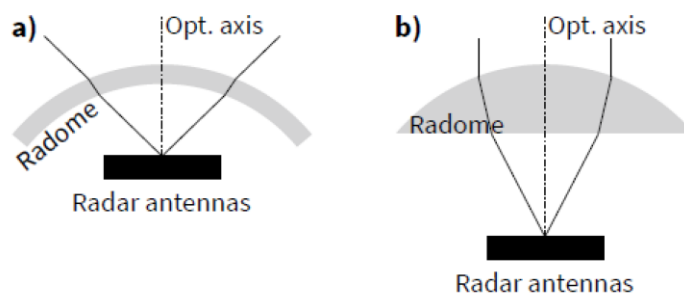


Figure 7-1. Shape for radome

7.2.2. Radome Thickness

As illustrated in the cross section diagram below, we assume your product has a planar flat surface above the radar. In this case, the following radome thickness would give a good signal. In this case, the following radome thickness would give a good signal.

- Radome thinness: 1.5mm (if ABS for radome)
- Air Gap: 2.5mm or a multiple of 2.5mm.

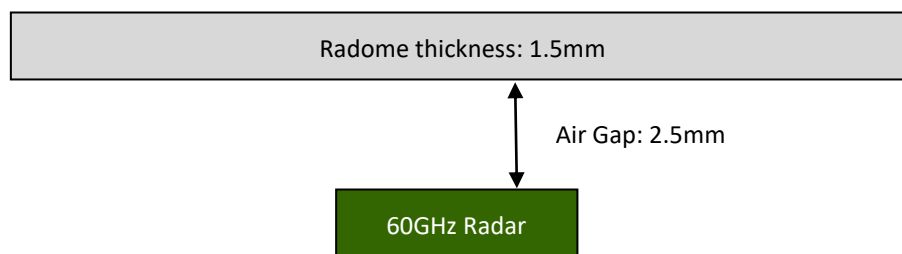


Figure 7-2. Distance between radar sensor and radome

8. PACKAGE INFORMATION

8.1. Module Dimension

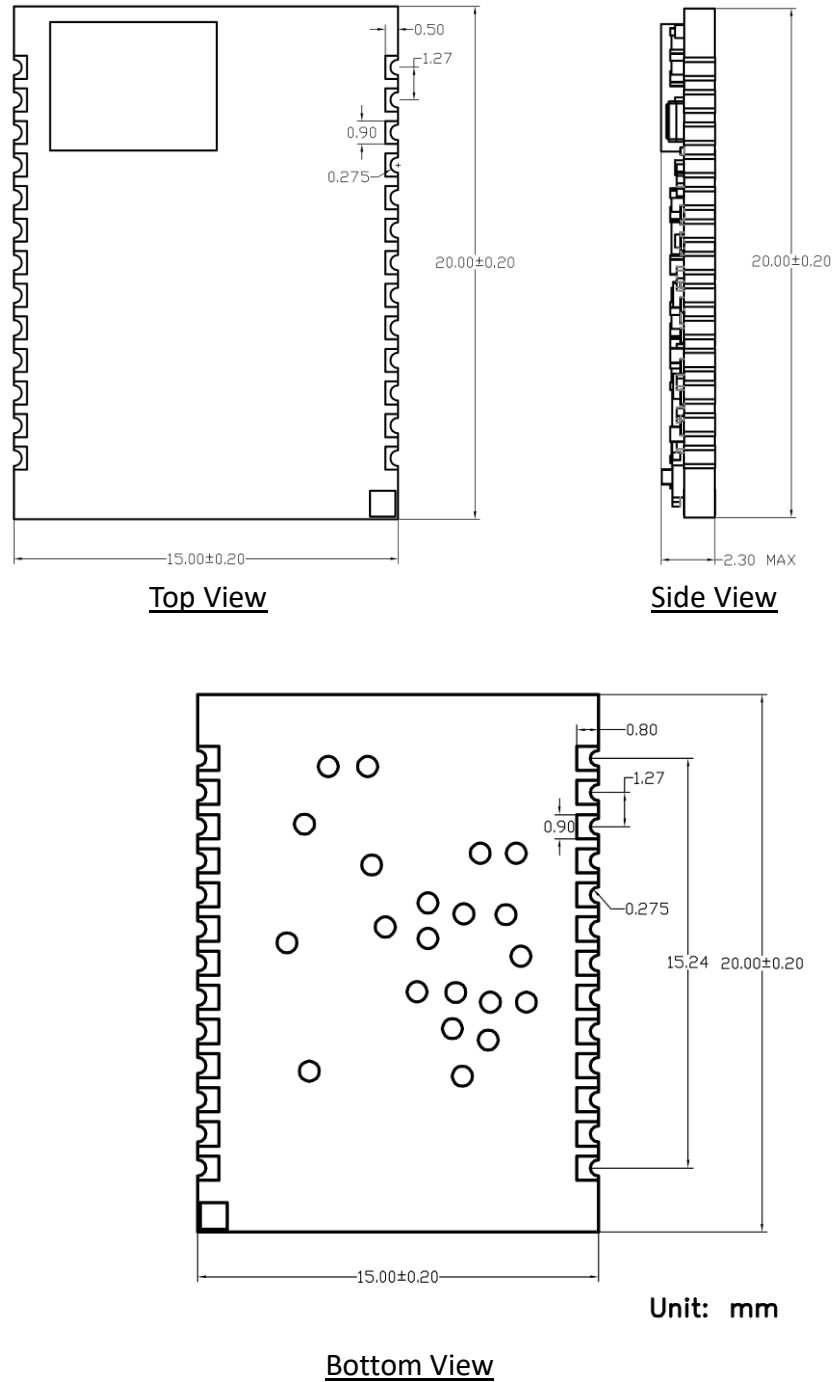


Figure 8-1. MM5D91-00 Module Dimension

8.2. Recommended Land Pattern

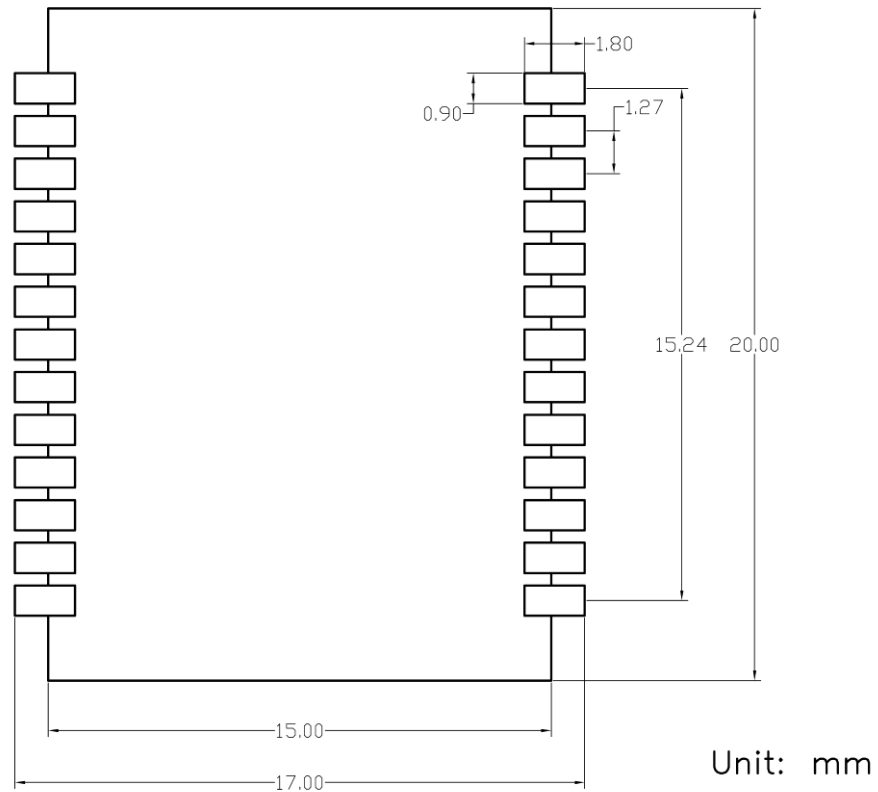
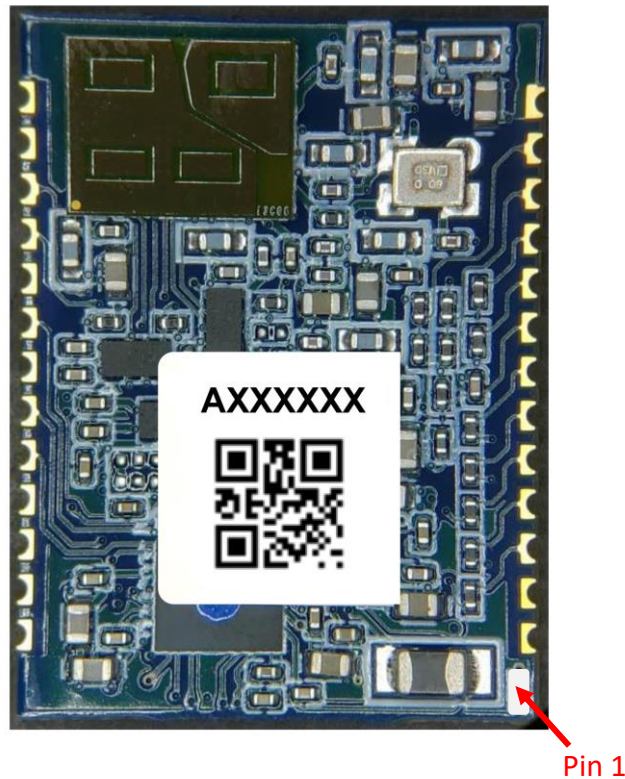


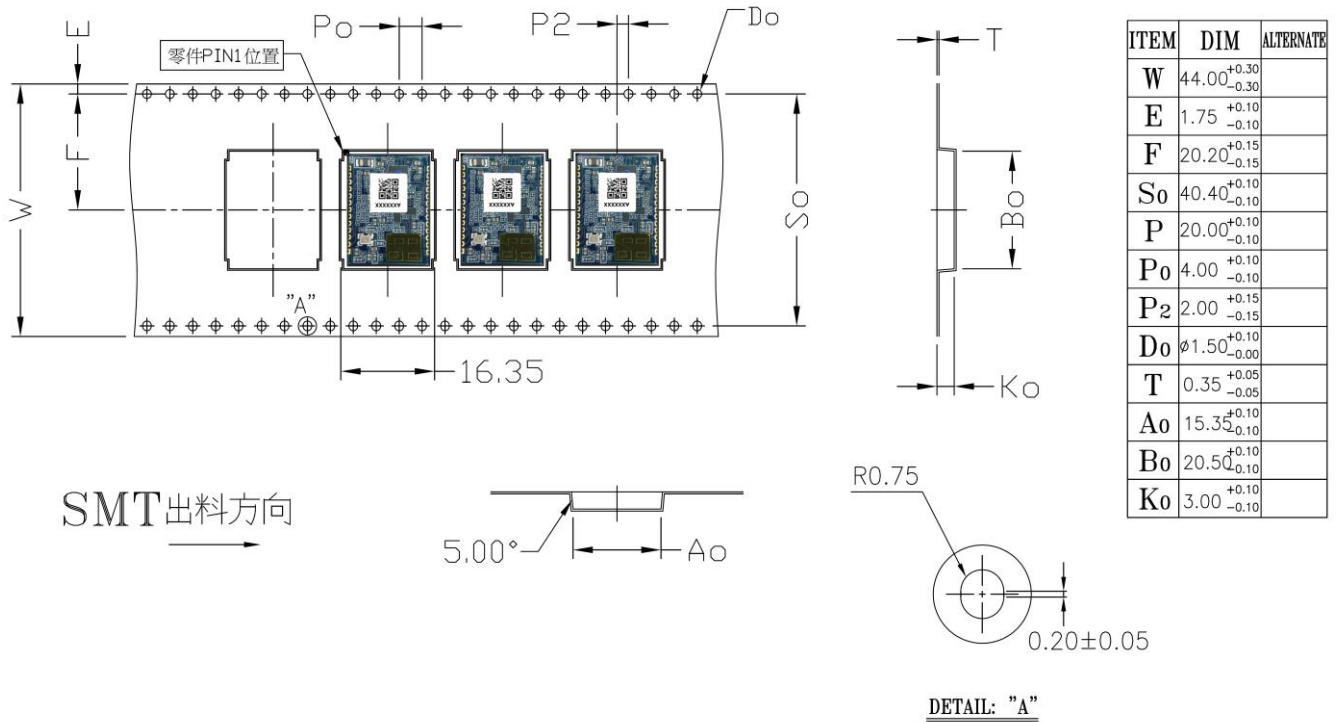
Figure 8-2. Recommended Land Pattern Dimension

8.3. Device Label



Marking	Description
QR Code : YYWW,AXXXXXX	YY : Digit of the year, ex: 2019=19 WW : Week (01~52) A : Product Number, ex: A=MM5D91-00 XXXXXX : Series number.

8.4. Tape Reel information



Reel : 1000 pcs per reel



Pizza Box : 1 reel per pizza box

9. SMT / BAKING INFORMATION

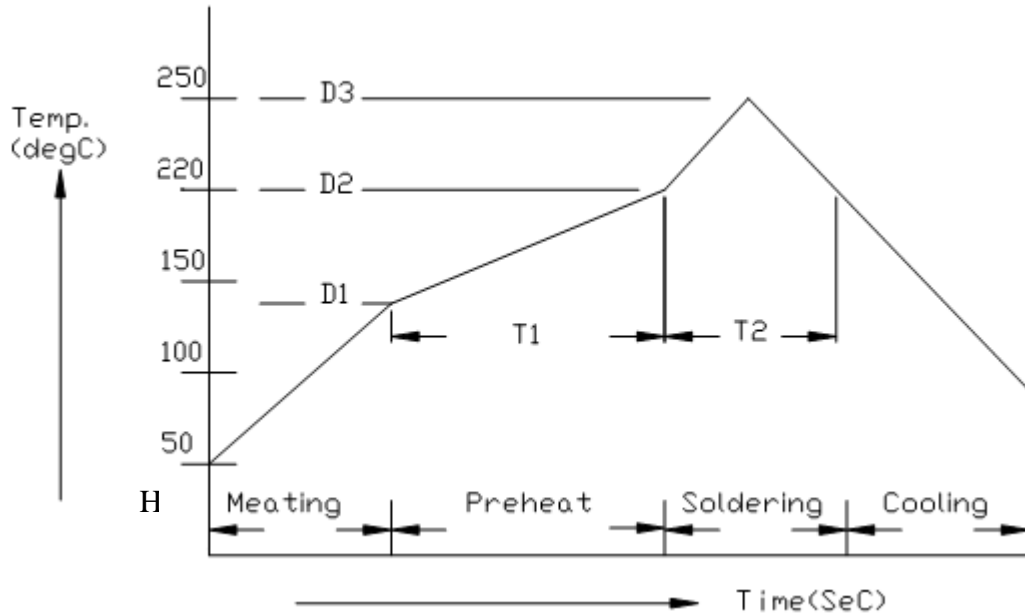
9.1. Baking Recommendation

Baking condition:

- Follow MSL Level 4 to do baking process.
- After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be
 - a. Mounted within 72 hours of factory conditions <30°C / 60% RH
 - b. Stored at <10% RH.
- Devices require bake, before mounting, if Humidity Indicator Card reads >10%
- If baking is required, Devices may be baked for 8 hrs at 125 °C.

9.2. SMT Recommendation

Recommended Reflow profile:



No.	Item	Temperature (°C)	Time (sec)
1	Pre-heat	D1: 140 ~ D2: 200	T1: 80 ~ 120
2	Soldering	D2: = 220	T2: 60 +/- 10
3	Peak-Temp.	D3: 250 °C max	

Note-1: Reflow soldering is recommended two times maximum.

Note-2: Add Nitrogen while Reflow process: SMT solder ability will be better.

- **Stencil thickness:** 0.1~ 0.13 mm (Recommended)
- **Soldering paste (without Pb):**
Recommended SENJU N705-GRN3360-K2-V can get better soldering effects.

10. ORDERING INFORMATION

Order number	Description
MM5D91-00A	Presence Detection Sensor module
MM5D91E00	Evaluation kit of MM5D91-00

11. HISTORY CHANGE

Revision	Date	Description
Revision 1.0	2020-12-03	Official version release.
Revision 2.0	2021-03-18	Correct GPIO0 / GPIO1 description
Revision 3.0	2021-10-06	Add Radome design guide.