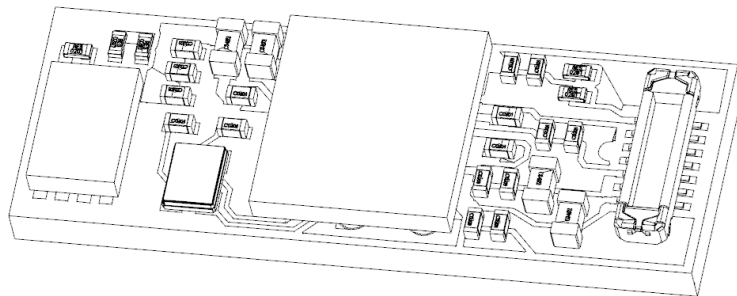




MT5C01-02R1

TI IWRL6432 WCSP

60GHz mmWave AoM



Datasheet

Reversion 1.0

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1. INTRODUCTION

The MT5C01-02R1 module is an Antenna-on-Module (AoM) Radar device which integrate Texas Instruments mmWave FMCW single chip sensor and Jorjin high field of View (FoV) Antenna design. This module is designed for low power and small form factor radar sensor in the personal electronics space for applications such as TV, ear buds, monitors, PC, wearables etc.

1.1. Features

● Antenna on Module

- AoM include Single Chip Radar 、Antenna 、Crystal 、16M-bit Flash 、Board to Board Connector
- Board to Board Connector: Pitch 0.35mm / 14pins / Stacking Height 0.8mm
- Module Interface: UART 、SPI 、I2C 、GPIOs
- Module dimensions: 15.5x5.5 mm
- Operating temperature: -40°C to 85°C

● Single Chip Radar

- Arm® M4F® Core with Single Precision FPU (160 MHz)
- TI Radar Hardware Accelerator (HWA 1.2) for FFT, Log Magnitude, and CFAR Operations (80MHz)
- 1MB of On-Chip RAM

● Radar Transceiver

- Integrated PLL, Transmitter, Receiver, Baseband and ADC
- 57 to 64GHz coverage with 7-GHz
- 3 Receive and 2 Transmit Channels
- FMCW Operation
- Single transmitter EIRP: 15dBm typical

● Supports Multiple Low-power Modes

- Idle Mode
- Deep Sleep Mode

● Power Management

- 1V8 and 3V3 VIO support
- Power-Optimized design

● Support Algorithm from TI

- Presence detection
- Motion detection
- People Tracking
- Human vs non-human classification

● Applications

- Smart Television
- Monitoring Device
- Home Theater
- Personal Computer

1.2. Block Diagram

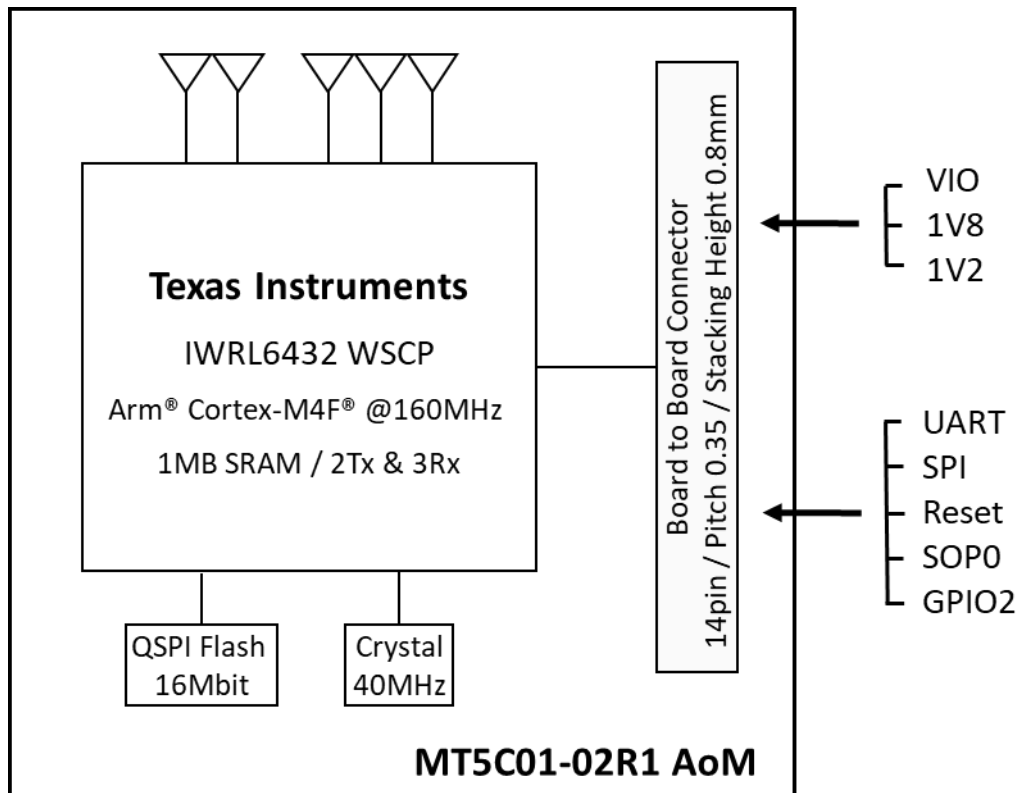
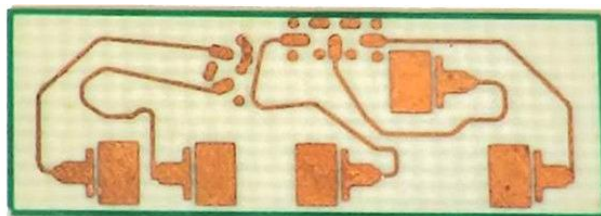


Figure 1-1. MT5C01-02R1 Block Diagram



Top View



Bottom View

Figure 1-2. MT5C01-02R1 Drawing

1.3. Module Pin Define

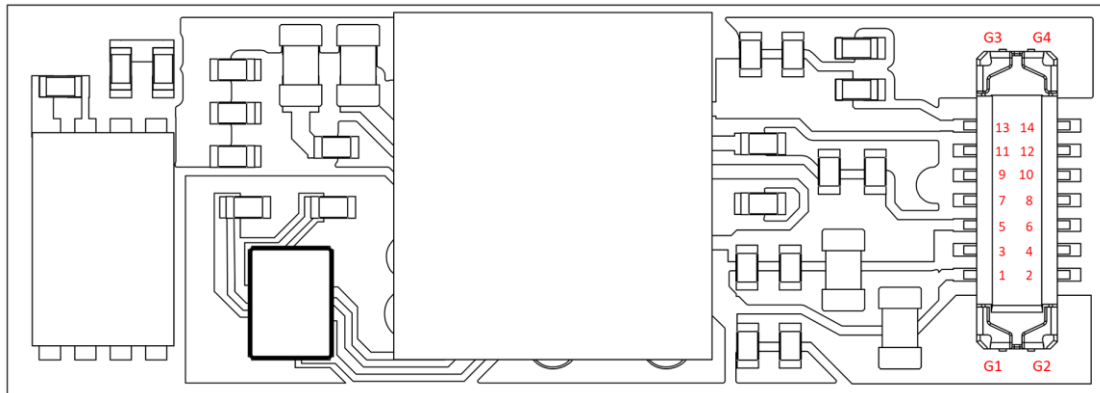


Figure 1-3. MT5C01-02R1 Bottom View

Pin define of Board to Board Connector

Pin No.	Signal Name	Description
1	GND	Ground.
2	RADAR_SPI_MOSI	SPI Master Out Slave In.
3	RADAR_1V8	Module 1V8 Supply.
4	RADAR_SPI_MISO	SPI Master In Slave Out.
5	RADAR_1V8	Module 1V8 Supply.
6	RADAR_SPI_CS	SPI Chip Select.
7	RADAR_Nrst	Power on reset for chip. Active low.
8	RADAR_SPI_CLK	SPI Clock.
9	RADAR_HOST_INTR	Out of Band Interrupt to an external host communicating over SPI.
10	RADAR_RS232_RX	Debug UART (Operates as Bus Main) – Receive Signal.
11	RADAR_GPIO2	General purpose I/O.
12	RADAR_RS232_TX	Debug UART (Operates as Bus Main) – Transmit Signal.
13	RADAR_VIO	Module VIO Supply. Support 1.8V or 3.3V.
14	RADAR_SOP0	Module functional mode default. Pull-down if need to set to flash mode.
G1	RADAR_1V2	Module 1V2 Supply.
G2	RADAR_1V2	Module 1V2 Supply.
G3	GND	Ground.
G4	GND	Ground.

2. SPECIFICATIONS

2.1. Recommended Operating Conditions

PARAMETER		Min	Typ	Max	Units
RADAR_1V8	1.8V power supply input	1.71	1.8	1.89	V
RADAR_1V2	1.2V power supply input	1.14	1.2	1.26	
RADAR_VIO	3.3V power supply input for module IO	3.135	3.3	3.465	
	1.8V power supply input for module IO	1.71	1.8	1.89	
V _{IH}	Voltage Input High (VIO=3.3V)	2.25			
	Voltage Input High (VIO=1.8V)	1.17			
V _{IL}	Voltage Input Low (VIO=3.3V)			0.62	
	Voltage Input Low (VIO=1.8V)			0.57	
RADAR_NRST	V _{IH} (VIO=3.3V)	1.57			
	V _{IL} (VIO=3.3V)			0.3	
RADAR_SOP0	V _{IH} (VIO=1.8V)	0.96			
	V _{IL} (VIO=1.8V)			0.2	
Operating temperature		-40		85	°C

2.2. RF and Antenna Specification

PARAMETER	Min	Typ	Max	Unit
RF frequency range ⁽¹⁾	57		63.9	GHz
Single transmitter output power EIRP ⁽²⁾		+15		dBm
Antenna gain of single transmitter			6	dBi
Field of View of Azimuth		140		degree
Field of View of Elevation		120		degree
Detection Range ⁽³⁾		6		meters
Phase noise at 1-MHz offset (57 to 63.9GHz)		-89		dBc/Hz

(1) The module RF frequency range is 57-64GHz. Based on application and certification of end product, the use range will be changed.

(2) Certification regulatory constraints limit the module output power to the following: 10dB Tx back off .

(3) Based on Presence and Motion detection application, the typical detection range is 6m at Boresight.

2.3. Typical Power Consumption Numbers

Below table lists the typical power consumption for each power save modes in different power topologies and antenna configurations.

Estimated Power Consumed in 3V3 IO Mode

Power Mode		Power Consumption (mW)
		Power Optimized Mode
Active (2TX, 3RX)	Sampling: 12.5 MSps, CW Mode Freq = 60 GHz, BW= 2 GHz RX gain = 30 dB TX back off = 0 dB	960
Active (2TX, 2RX)		870
Active (1TX, 3RX)		803
Active (1TX, 2RX)		720
Active (1TX, 1RX)		690
Processing	Major motion SDK OOB chain is used for measurement.	80
Idle	APPSS CM4 = 20MHz, FECSS, HWA powered off, SPI active	11.2
Deep sleep	Memory Retained = 114KB	0.66

Estimated Power Consumed in 1V8 IO Mode

Power Mode		Power Consumption (mW)
		Power Optimized Mode
Active (2TX, 3RX)	Sampling: 12.5 MSps, CW Mode Freq = 60 GHz, BW= 2 GHz RX gain = 30 dB TX back off = 0 dB	960
Active (2TX, 2RX)		870
Active (1TX, 3RX)		803
Active (1TX, 2RX)		720
Active (1TX, 1RX)		690
Processing	Major motion SDK OOB chain is used for measurement.	80
Idle	APPSS CM4 = 20MHz, FECSS, HWA powered off, SPI active	10.9
Deep sleep	Memory Retained = 114KB	0.48

Use Case Power Consumed in 3.3V IO Power Optimized mode

Parameter		Condition	mW
Average Power Consumption (Presence and Motion detection)	RF Front End Configuration: 2TX, 3RX ADC Sampling Rate = 5.556Msps Ramp End time = 30us Chirp Idle Time = 6us Chirp Slope = 50MHz/us Number of chirps per burst = 2 Burst Periodicity = 220us Number of bursts per frame = 64 Device configured to go to deep sleep state after active operation.	10Hz Update Rate	11

2.4. Peak Current Requirement per Voltage Rail

Mode ⁽¹⁾	IO Voltage ⁽³⁾	Maximum Current (mA) ⁽²⁾		
		1.2V Total Current	1.8V Total Current	3.3V Total Current
Power Optimized	3.3V	1100	270	90
	1.8V	1100	360	NA

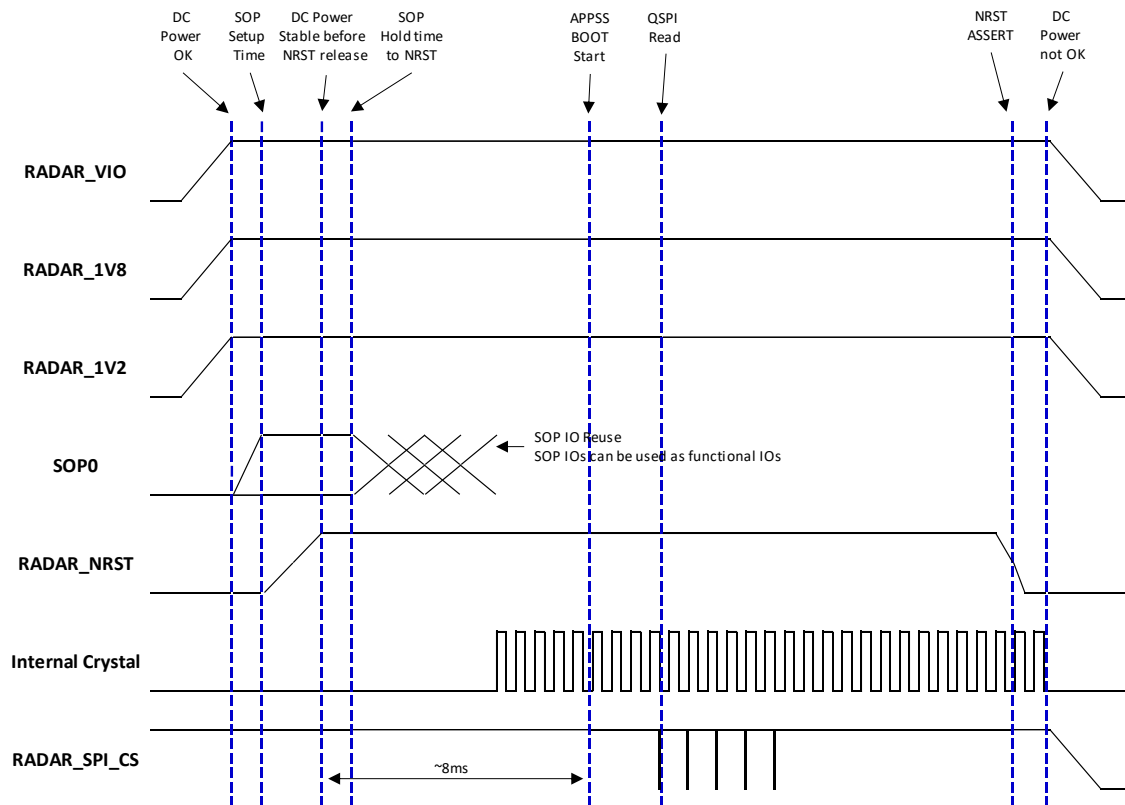
(1) Exercise full functionality of device, including 2TX, 3RX simultaneous operation, HWA, M4F and various host comm/interface peripherals active (CAN, I2C, GPADC), test across full temperature range.

(2) The specified current values are at typical supply voltage level.

(3) The exact VIOIN current depends on the peripherals used and their frequency of operation.

2.5. Power Sequencing and Rest Timing

The device expects all external voltage rails to be stable before reset is deasserted. The device wake-up sequence describe as below.



3. ANTENNA RADIATION PATTERNS

3.1. Antenna Positions

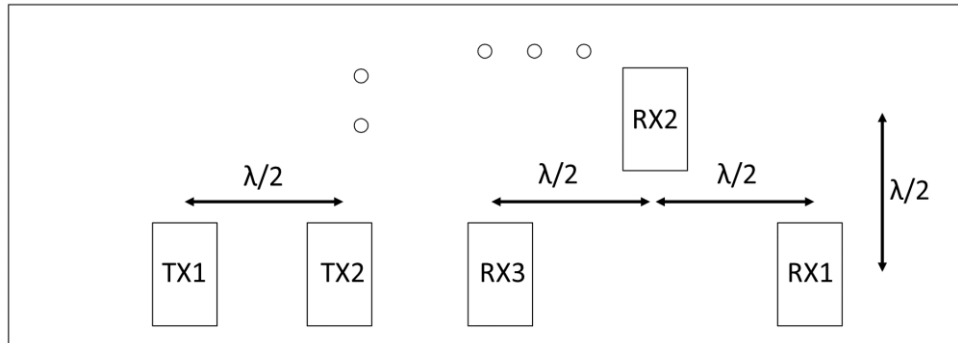


Figure 3-1. Antenna position of module

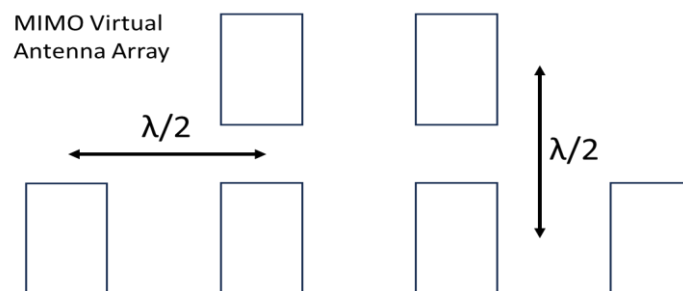


Figure 3-2. MIMO 2x4 Virtual Antenna Array

3.2. Antenna Radiation Patterns

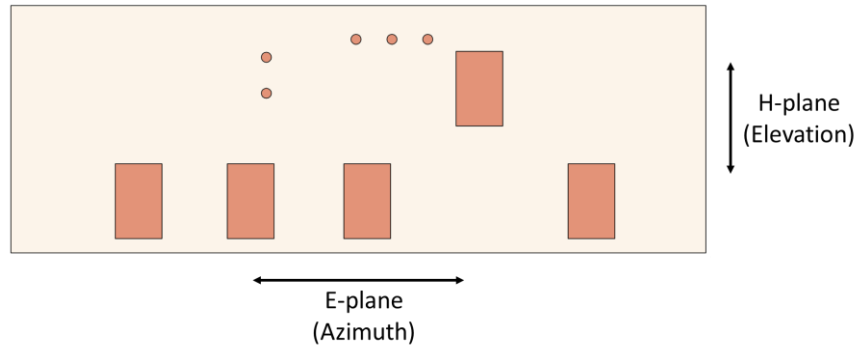
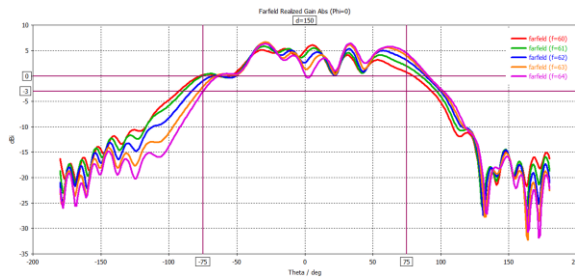
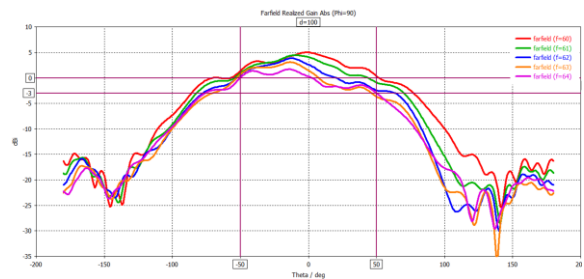


Figure 3-3. Azimuth and Elevation of module

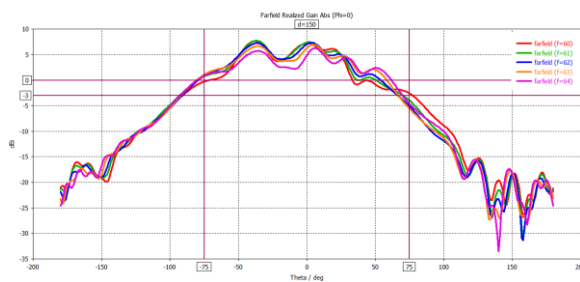
TX1 E-Plane



TX1 H-plane



TX2 E-Plane



TX2 H-plane

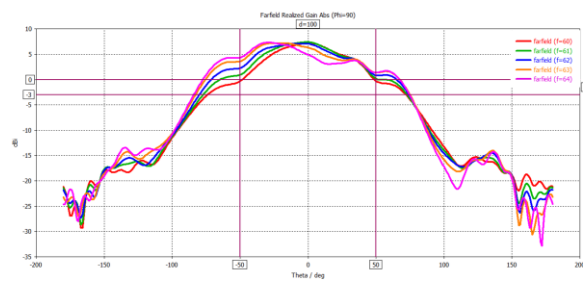
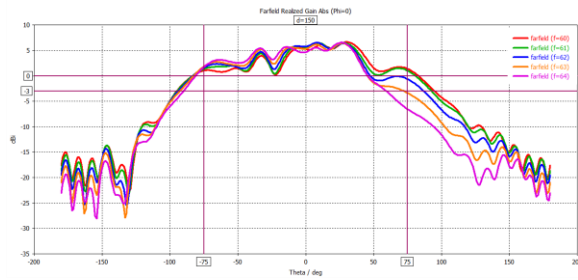
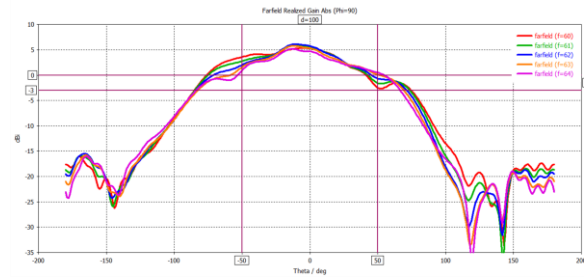


Figure 3-4. Transmitter Antenna Radiation Pattern Simulation

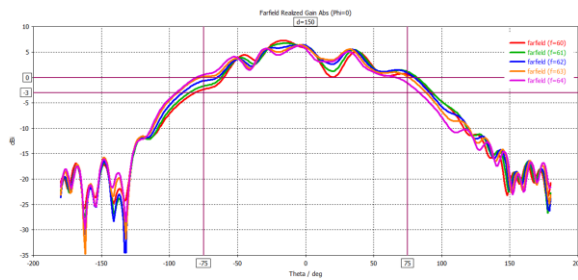
RX1 E-Plane



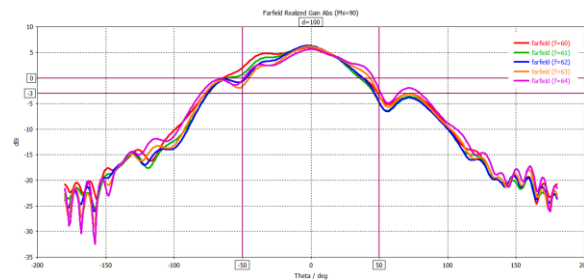
RX1 H-plane



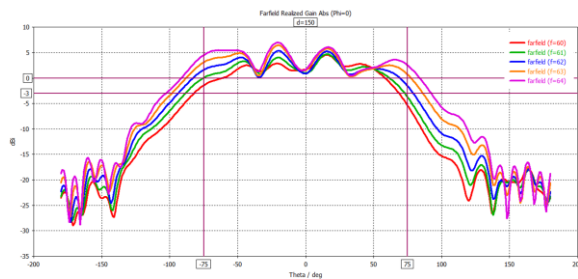
RX2 E-Plane



RX2 H-plane



RX3 E-Plane



RX3 H-plane

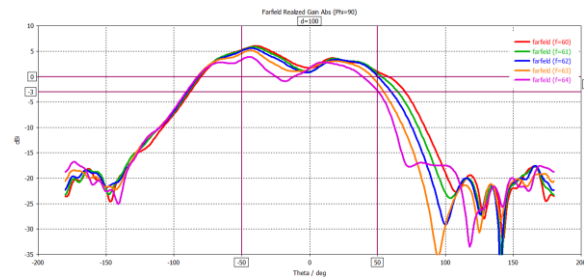


Figure 3-5. Receiver Antenna Radiation Pattern Simulation

4. MMWAVE RADOME DESIGN GUIDE

4.1. 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 (D_k , ϵ_r) and low tangent loss (D_f , $\tan\delta$) value, will have smaller dielectric losses.

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

Material	Dielectric constant (ϵ_r)	Loss tangent ($\tan\delta$)
ABS ⁽¹⁾	2.0-3.5	0.005-0.019
Teflon (PTFE)	2.0	< 0.0002
Polypropylene (PP)	2.2	0.0005
Polyethylene (PE)	2.3	0.0003
Polystyrene (PS)	2.5	0.0004
Polycarbonate (PC)	2.9	0.012

Note:

1. In the market, plastic might be called ABS, but it could contain additives. (e.g. fire retardants)

The 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.

4.2. Radome simulations

In general, radome performance depends mainly on the frequency of use, thickness, Dk/Df, air gap, shape and size. This section used radome designs and simulations performed with the Jorjin antenna using a rectangular radome as a case. And compared the far-field antenna radiation patterns with and without radome.

The setting of the simulation:

- TX2 E-plan at 62GHz
- DK=2.7 / Df=0.003
- Air Gap 2.5mm ($\lambda/2$ at 60GHz)
- Thickness from 1.1 to 2.5mm

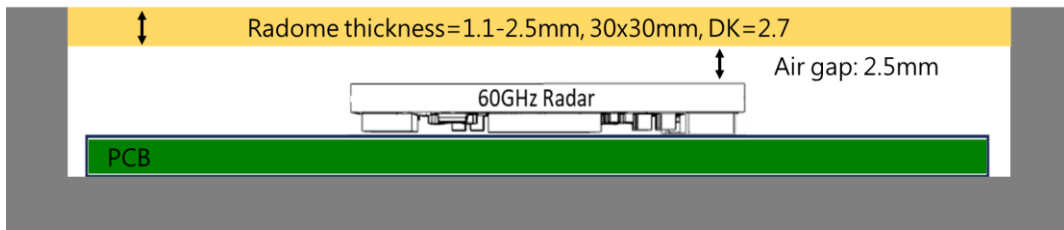


Figure 4-1. Simulation model of Radome

TX1+RX3 E-plan at 62GHz / Air Gap of Radome=2.5mm

Radome thickness (mm)	Gain difference between with Radome and no Radome (dBm)					Notes
	-70°	-60°	0°	+60°	+70°	
1.1mm	-0.5	-0.3	+2.7	-1.7	+0.2	
1.5mm	+3.1	-0.4	-2.8	-1.5	+3.1	
1.8mm	+3.2	+1.0	-1.1	+1.5	+4.0	Width FOV
2.5mm	+0.8	+2.9	+3.1	-7.7	-3.2	

TX2+RX3 E-plan at 62GHz / Air Gap of Radome=2.5mm

Radome thickness (mm)	Gain difference between with Radome and no Radome (dBm)					Notes
	-70°	-60°	0°	+60°	+70°	
1.1mm	-0.2	+0.3	+2.2	+0.8	+1.7	
1.5mm	+2.1	-0.4	+0.5	+0.9	+6.1	
1.8mm	+3.2	+0.7	+1.6	+2.7	+6.8	Width FOV
2.5mm	-1.8	0	+1.7	+0.1	+5.6	

Figure 4-2. FOV simulation with difference radome thickness

4.3. Clearance Area Recommendation of Module

Recommended clear area of MT5C01-02R1 AoM module with no components over the module as below.

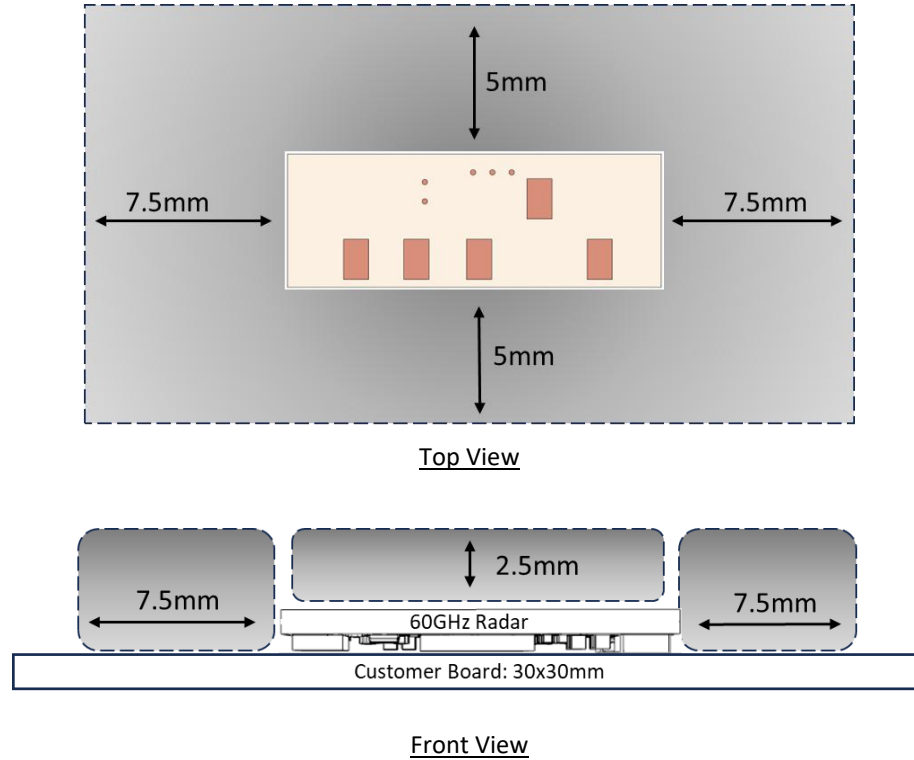


Figure 4-3. Recommend Clear Area of Radar module

4.4. Radome Recommendation of Module

According to Radome simulation in section 4-2, we assume your product has a planar flat surface above the radar. In this case, the radome thickness would give a good signal.

- **Radome thickness:** 1.8mm, if used PC ($D_k=2.7$, $D_f=0.003$) for radome.
- **Air Gap:** 2.5mm ($\lambda/2$ at 60GHz)
- **Radome size:** 30x30mm (for example)

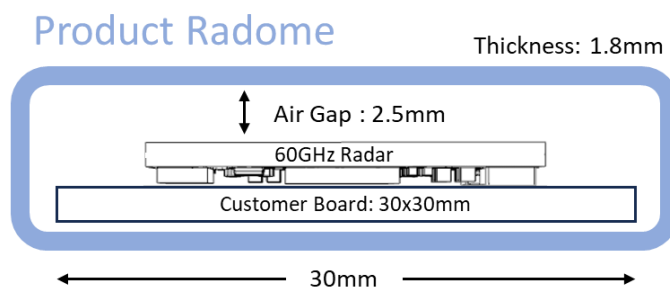


Figure 4-4 . Recommend design of Radome

5. MODULE REFERENCE DESIGN

5.1. Reference Schematic

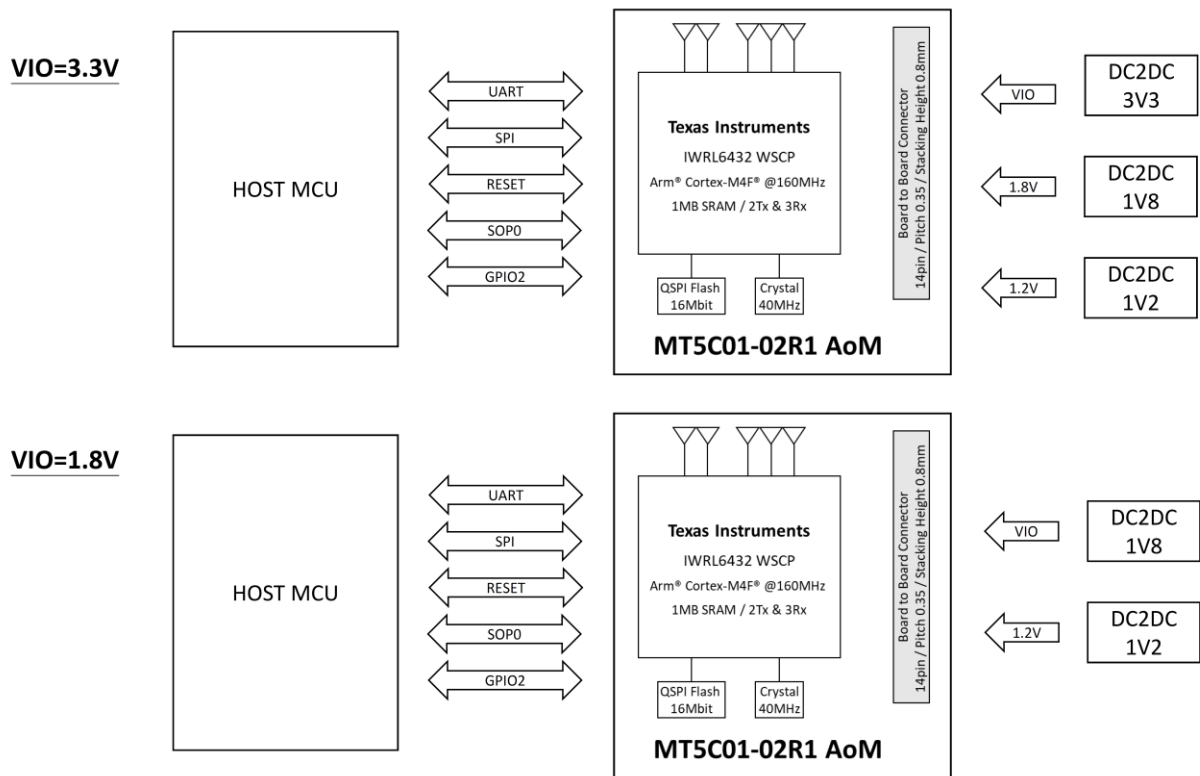
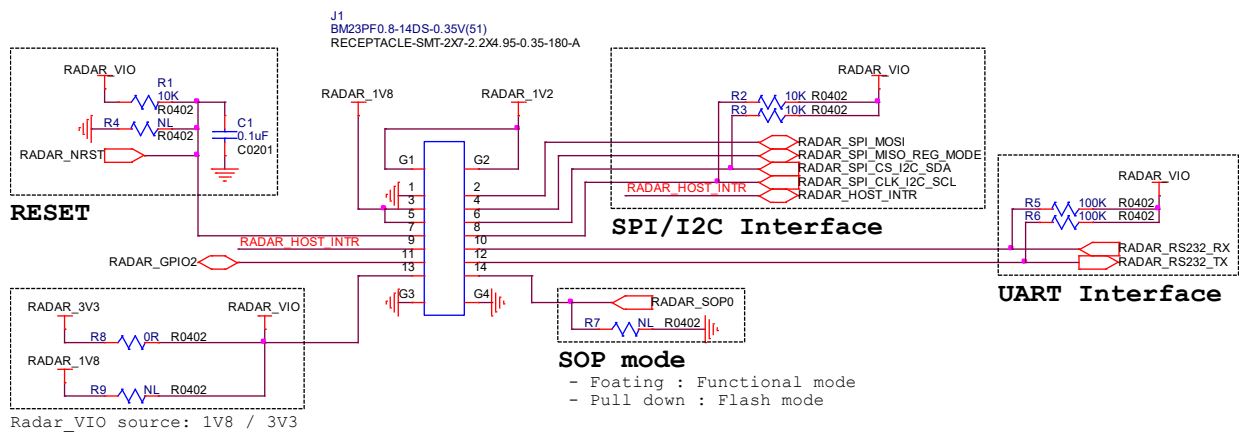


Figure 5-1. System Hardware Topology

Board to Board Connector



DCDC Circuit

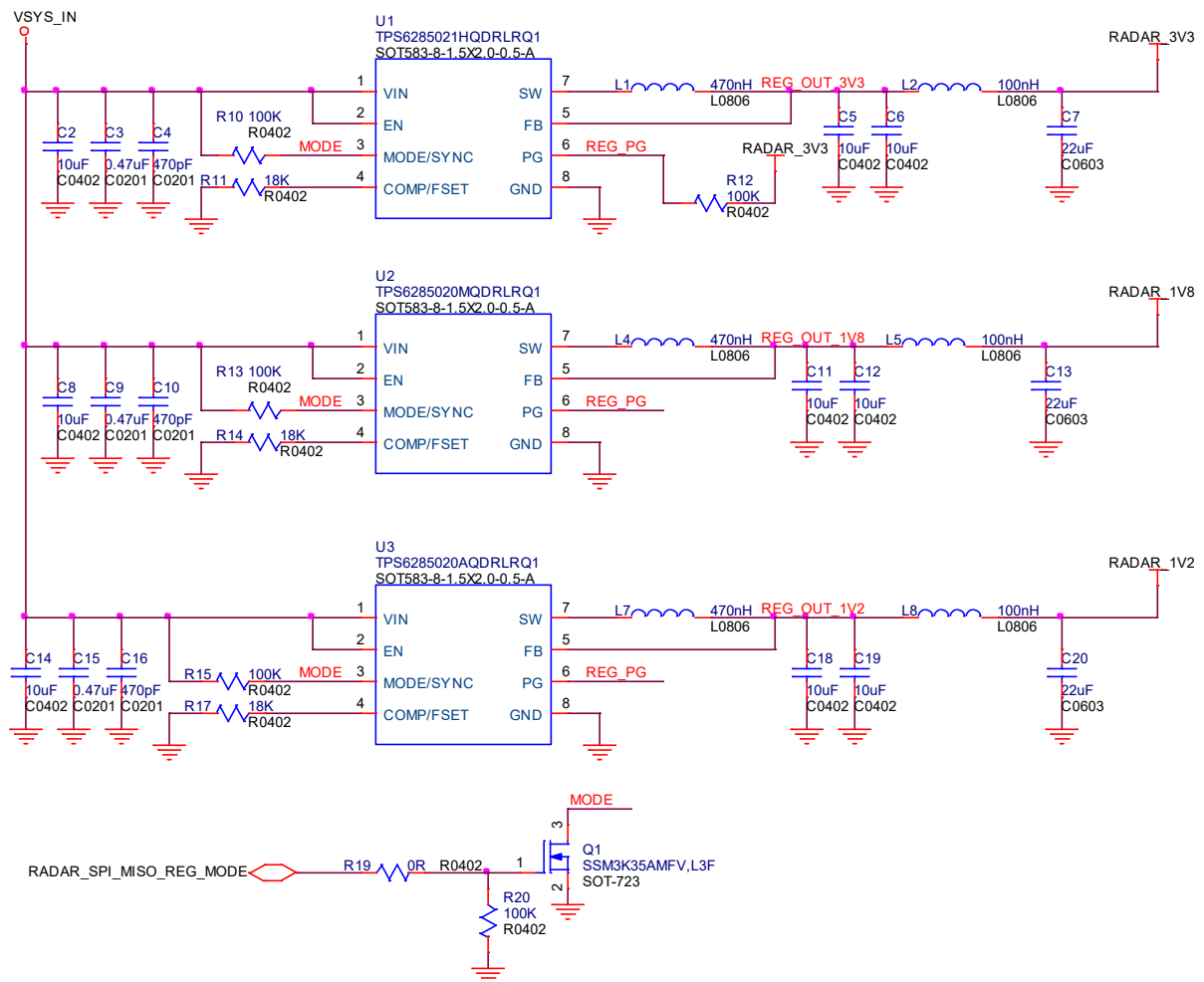


Figure 5-2. Reference Schematic

DESCRIPTION	PART NO.	PACKAGE	REFERENCE	MFR
Board to Board / 2x7 pin / pitch 0.35mm / H=0.8mm / Receptacle	BM23PF0.8-14DS-0.35V (51)	4.19 x 1.5 x 0.64 mm	J1	Hirose
Buck / Vin 2.7~6V / Vout 3.3V / 2A	TPS6285021HQDRLRQ1	2.1 x 1.6 x 0.6 mm	U1	TI
Buck / Vin 2.7~6V / Vout 1.8V / 2A	TPS6285020MQDRLRQ1	2.1 x 1.6 x 0.6 mm	U2	TI
Buck / Vin 2.7~6V / Vout 1.2V / 2A	TPS6285020AQDRLRQ1	2.1 x 1.6 x 0.6 mm	U3	TI
Inductor / 0806 / 470nH / ±20% / 4.7A	TFM201610GHM-R47MTAA	0806	L1, L4, L7	TDK
Inductor / 0806 / 0.1uH / ±20% / 4A	LQM2MPZR10MJHL	0806	L2, L5, L8	Murata
N-MOS / SOT-723 / VDS=20V / ID=250mA	SSM3K35AMFV, L3F	SOT-723	Q1	Toshiba

Table 5-1. Bill of Materials

5.2. Connector Recommendation for Customer

The Board to Board Connector plug of Hirose BM23PF0.8-14DP-0.35V(51) is be used in the MT5C01-02R1 Module. Please ensure that must be used Receptacle type of [Hirose BM23PF0.8-14DS-0.35V\(51\)](#) to correct positioning the module on board.

B2B Connector – Receptacle for Customer used

Vendor: Hirose

P/N: BM23PF0.8-14DS-0.35V(51)

Pitch: 0.35mm

Mated Height: 0.6mm

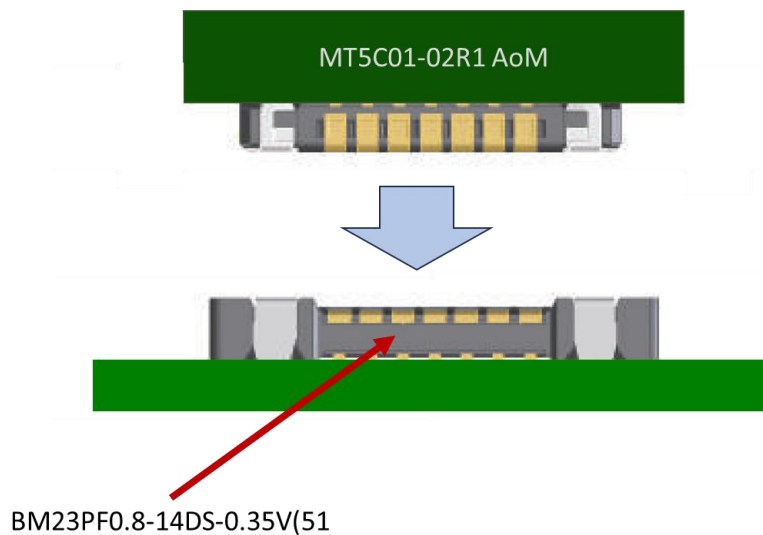
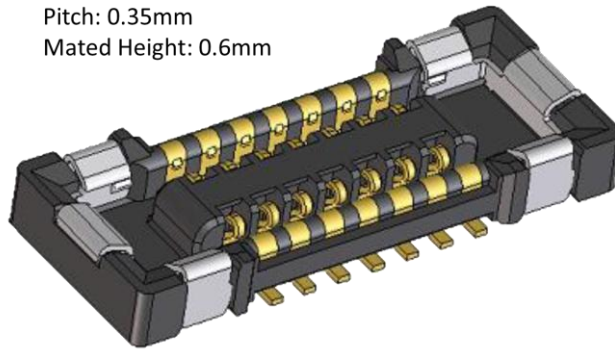
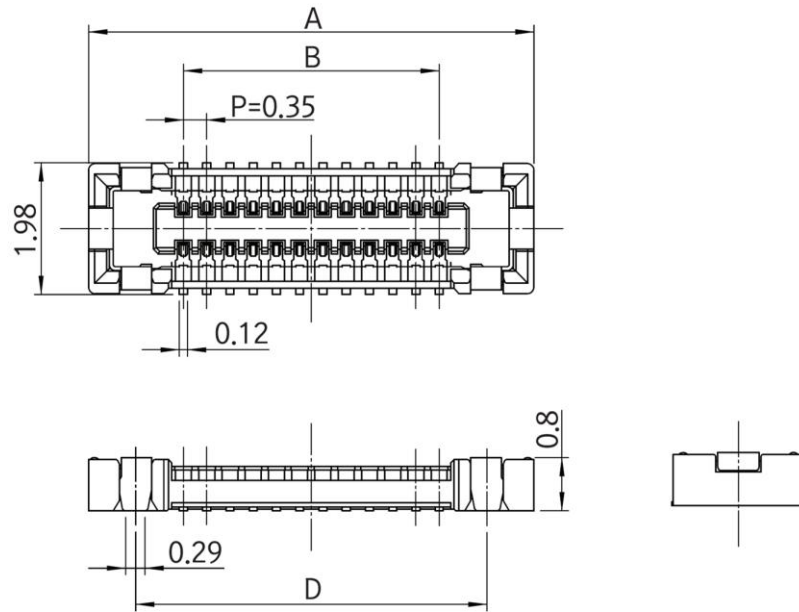


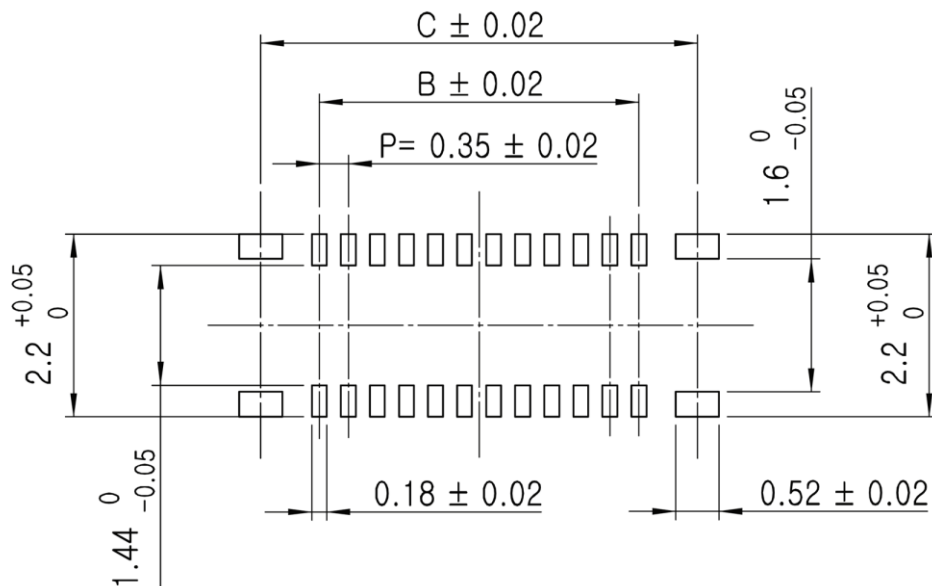
Figure 5-5. Board to Board Connector for Customer



Unit : mm

Part No.	HRS No.	No. of contacts	A	B	C	D
BM23PF0.8-14DS-0.35V(***)	480-0367-0 **	14	4.95	2.10	3.51	3.54

Figure 5-6. Connector Dimensions of Hirose BM23PF series



Unit : mm

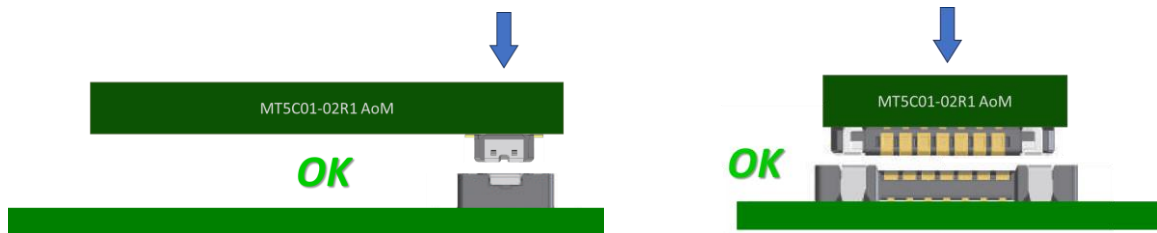
Part No.	HRS No.	No. of contacts	A	B	C	D
BM23PF0.8-14DS-0.35V(***)	480-0367-0 **	14	4.95	2.10	3.51	3.54

Figure 5-7. Recommended PCB Layout of Hirose BM23PF series

Notice for Connector Handling

When aligning, look for the guide port without applying excessive force.

When guided, the connectors are aligned parallel to each other with longitudinal and lateral movements restricted. Mate them parallel to each other.



Un-mate connectors parallel to each other.

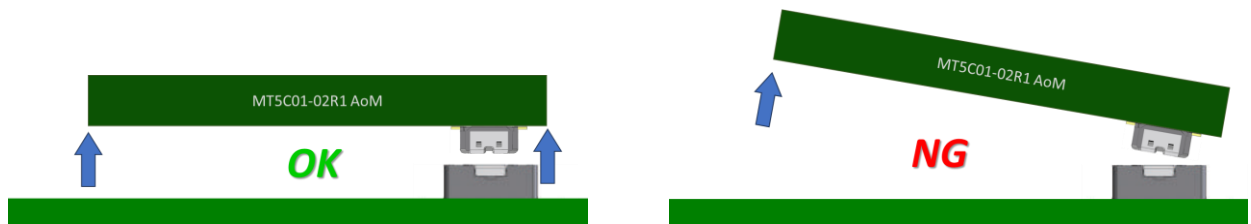


Figure 5-8. Correct Handle when mating a connector

6. PACKAGE INFORMATION

6.1. Module Dimension

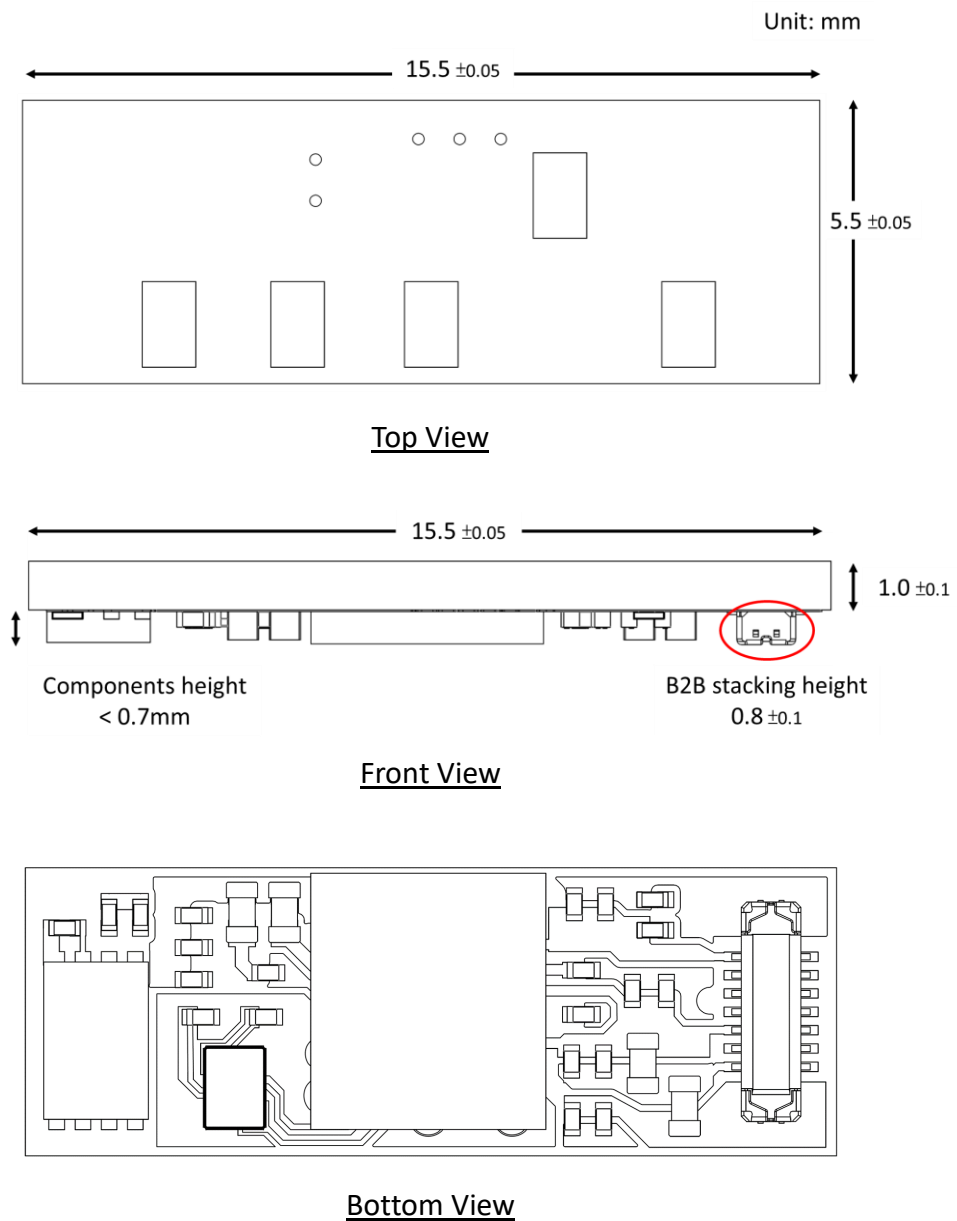
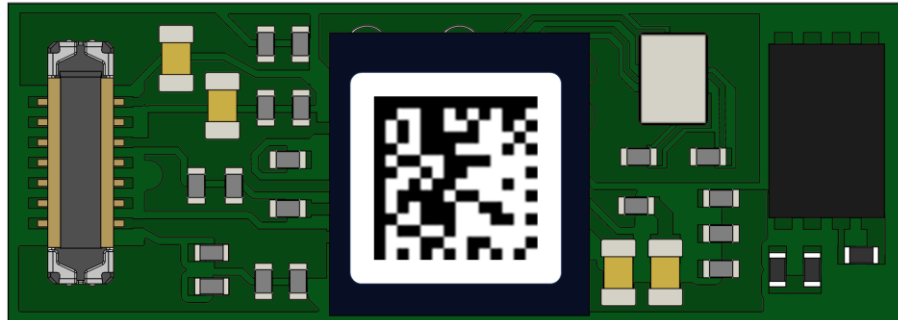


Figure 6-1. MT5C01-02R1 Module Dimension

6.2. Device Label

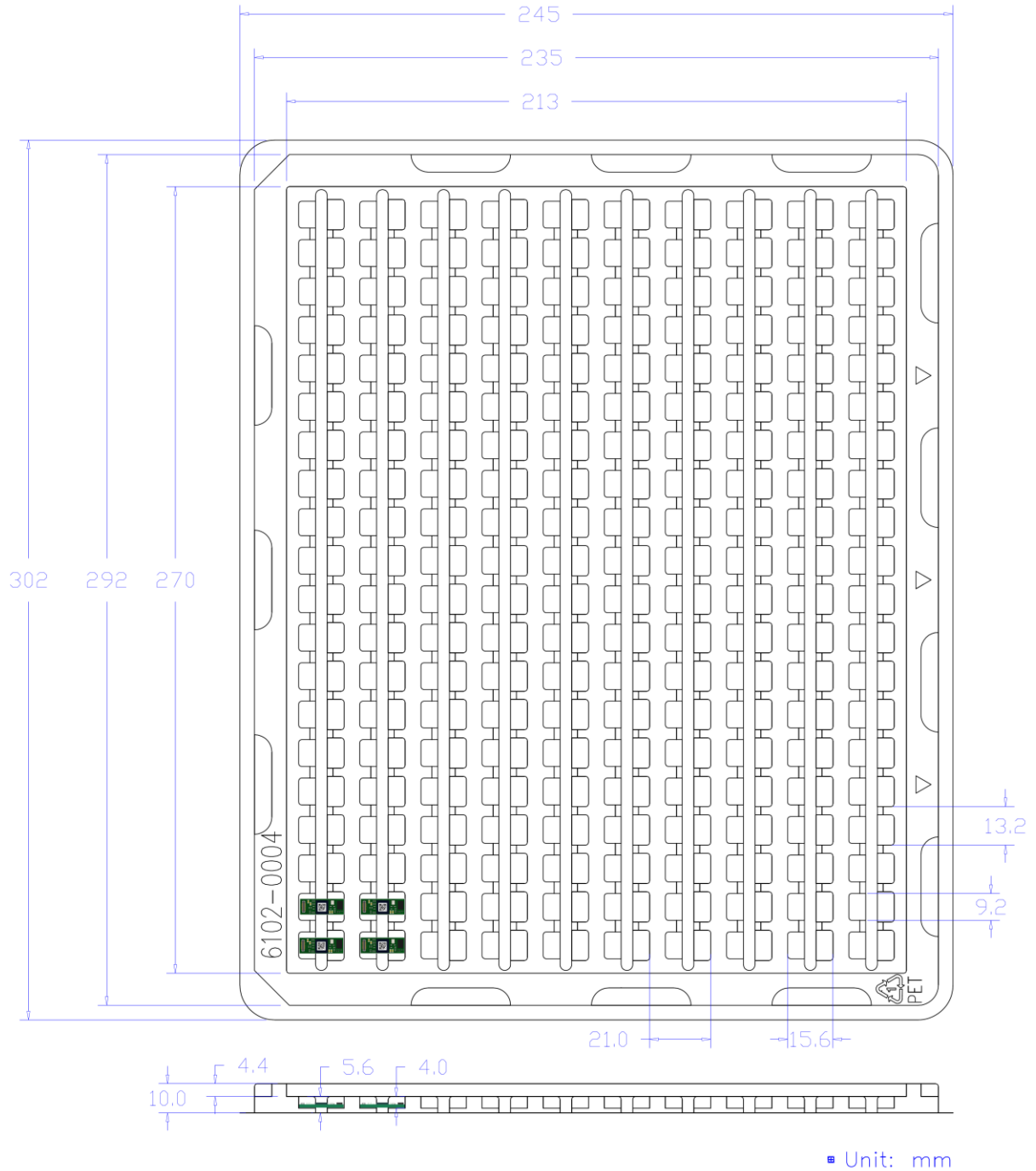


Code information	Description
Date code and module ID	YYWWCSSSSS YY : Digit of the year, ex: 2025=25 WW : Week (01~52) C : MT5C01-02R1 SSSSSS : Serial number from 000001-999999

Figure 6-2. Code label on Bottom of module

6.3. Packaging information

Tray Drawing



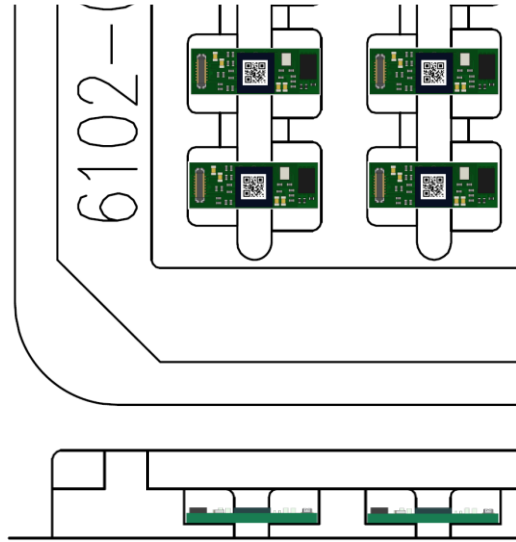
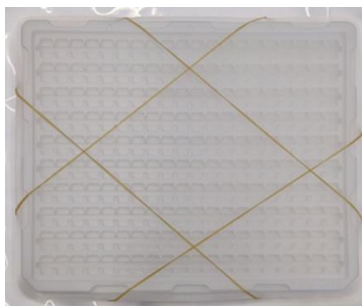


Figure 6-3. Dimensions for Tray Specification



200pcs module per tray



5-trays per pizza box



5-pizza boxes per carton



Figure 6-4. Package Information

7. EVALUATION KIT

The Jorjin mmWave Radar evaluation kit MT5C01E02R1 show as below. Based on the MT5C01-02R1 Radar sensor module. This evaluation kit easy to demo and development for customer.

7.1. Evaluation Hardware Description

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

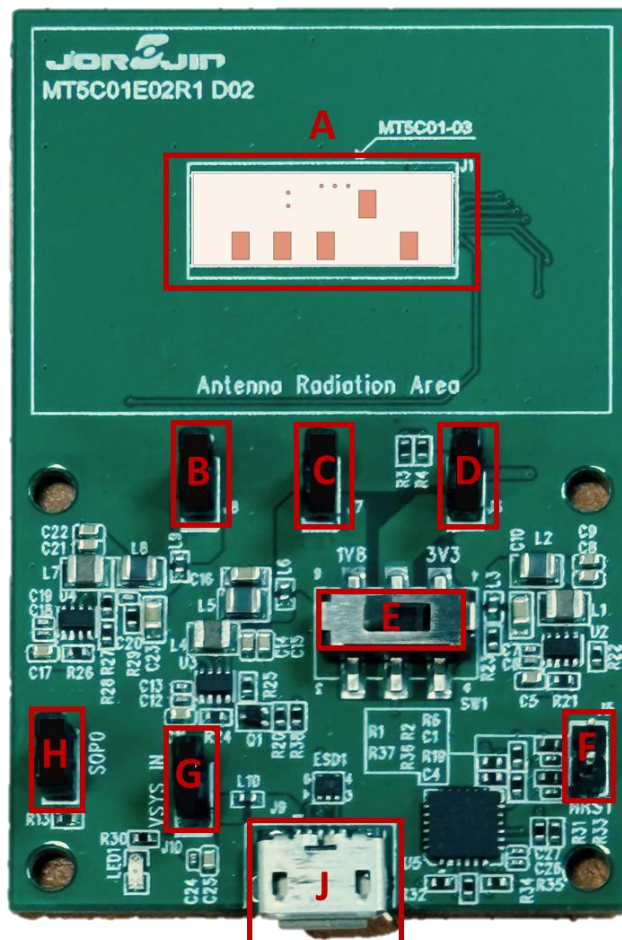


Table 7-1. Evaluation Kit component descriptions list

Region	Description
A	Jorjin MT5C01-02R1 mmWave Radar module.
B	1V2 power source of Module.
C	1V8 power source of Module.
D	VIO power source of Module
E	Slide Switch of VIO power source selection: <ul style="list-style-type: none">- 3.3V: Slide to right. (Default)- 1.8V: Slide to left.
F	Reset pin of Radar module: <ul style="list-style-type: none">- Module working: Jumper open. (Pull-up)- Module reset: Jumper short. (Pull-down)
G	5V Power source to Radar DCDC form micro-USB.
H	SOP0 selection: <ul style="list-style-type: none">- Functional mode: Jumper open. (Pull-up)- Flash mode: Jumper short. (Pull-down)
J	Micro-USB for function demo and power supply of module.

8. ORDERING INFORMATION

Order number	Description
MT5C01-02R1	60GHz mmWave Radar AoM Module
MT5C01E02R1	AoM mmWave Radar Evaluation Kit

9. REGULATORY INFORMATION

This radar module does not need to link an addition external antenna due to Jorjin has designed in the antenna on this module.

This section outlines the regulatory information for the following countries:

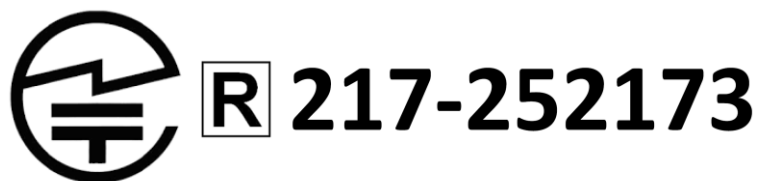
- United States / Canada (Only pre-tested)
- Japan
- Europe
- Taiwan

9.1. United States / Canada

This device has been pre-tested and found to comply with Part 15 of the FCC Rules.

9.2. Japan

The MT5C01-02R1 is certified as a module with type certification number 217-252173. End products that integrate this module do not need additional MIC Japan certification for the end product. End product can display the certification label of the embedded module.



9.3. Europe

Jorjin Technologies Inc. declares that the radio equipment type RF module is in compliance with Directive 2014/53/EU.

The compliance has been verified in the operating frequency band of 60.1GHz to 61.75GHz. Developers and integrators that incorporate the MT5C01-02R1 Module in any end products are responsible for obtaining applicable regulatory approvals for such end product.

The MT5C01-02R1 has been tested in the 60GHz to 64GHz ISM frequency band at 5V across the temperature range -40°C to +85°C and tolerance.

Labeling and User Information Requirements

As a result of the conformity assessment procedure described in Annex III of the Directive 2014/53/EU, the end-customer equipment should be labeled as follows:



9.4. NCC 警語

本產品取得審驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。低功率射頻器材之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前述合法通信，指依電信管理法規定作業之無線電通信。低功率射頻器材須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

本模組於取得認證後將依規定於模組本體標示審驗合格標籤，並要求平台廠商於平台上標示「本產品內含射頻模組 **CCAF25Y20030T4**」。

10. HISTORY CHANGE

Revision	Date	Description
Draft 0.1	2023-12-19	Draft version.
Draft 0.2	2024-02-01	Modify Radome information in Section 4.2~4.4.
Rev. 1.0	2025-05-16	<ol style="list-style-type: none">1. Update RF and Antenna Specification in Section 2.2.2. Update Power Consumption Data in Section 2.3.3. Add Peak Current Requirement per Voltage Rail in Section 2.4.4. Add Power Sequencing and Reset Timing in Section 2.5.5. Remove BOM optimized mode information of AoM.6. Update Reference Schematic and BOM in Section 5.1.7. Update Package information in Section 6.2 & 6.3.8. Update Evaluation board drawing and description in Section 7.1.9. Add Certification information in Section 9.