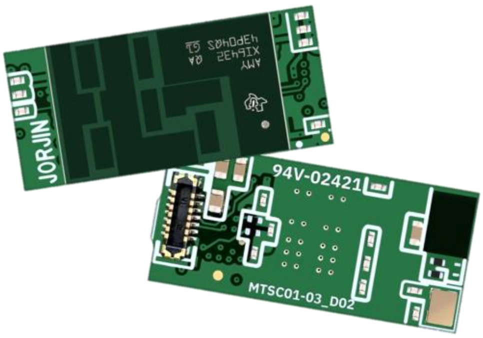
MT5C01-03

TI IWRL6432 AOP

60GHz mmWave AoM



Datasheet

Draft 0.1

Index

1. INTRODUCTION

The MT5C01-03 module is an Radar device which integrate Texas Instruments mmWave Radar sensor Antenna-on-Package (AoP) design. This module is designed for low power radar systems in the industrial and Smart home for applications such as air conditioning, lighting, smart home, video doorbell applications.

1.1. Features

- **Antenna on Module**
  - 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: 15.5x7.0 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
  - Gesture Recognition
- **Applications**
  - Video doorbell
  - Lighting
  - IP network camera
  - Air conditioning
  - Smart home

1.2. Block Diagram

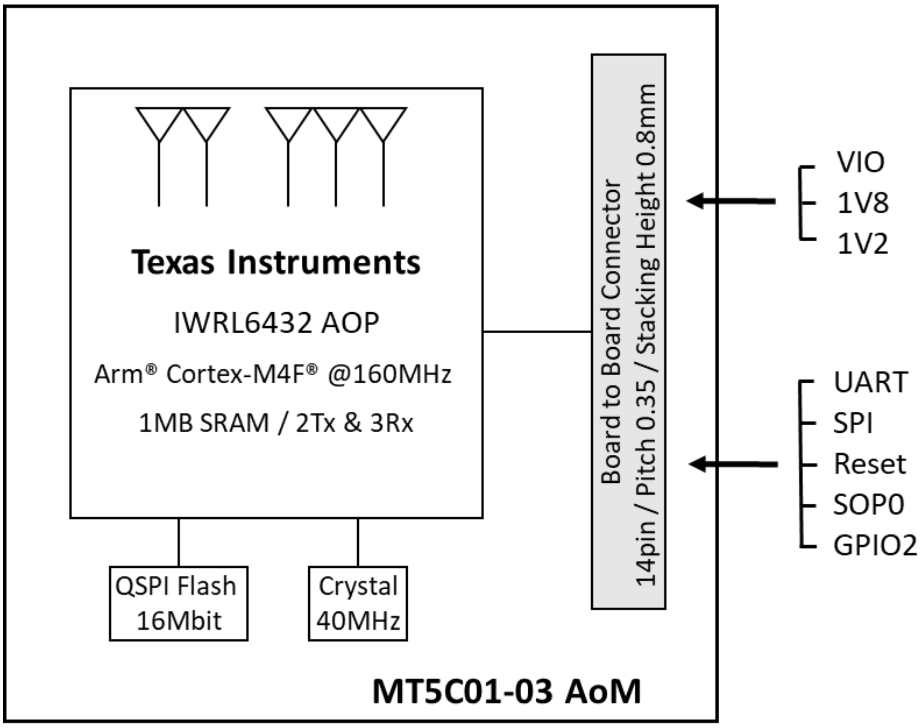
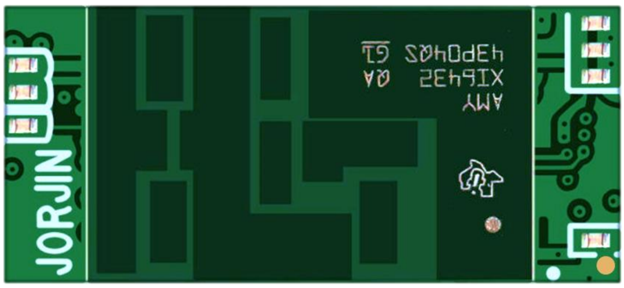
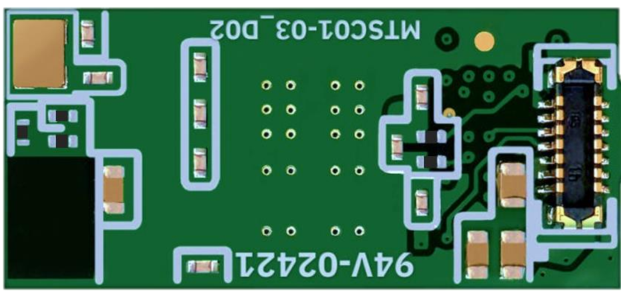


Figure 1-1. MT5C01-03 Block Diagram



Top View



Bottom View

Figure 1-2. MT5C01-03 Drawing

1.3. Module Pin Define

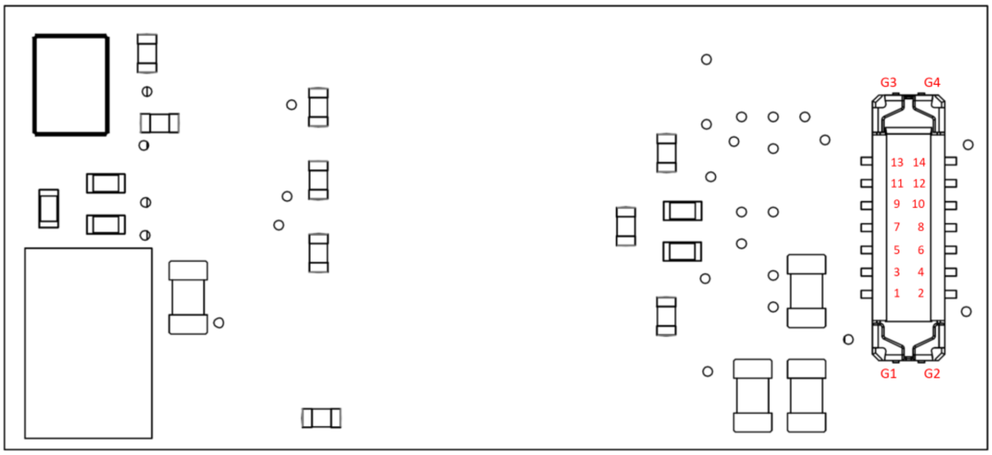


Figure 1-3. MT5C01-03 Bottom View

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 RADAR_SOP0	V_{IH} (VIO=3.3V)	1.57			
	V_{IL} (VIO=3.3V)			0.3	
	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		+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 (2)		15		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) Based on Presence detection application, the typical detection range is 15m at Boresight and 7m at FOV Edges.

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 Detection -Major Motion)	RF Front End Configuration: 1TX, 1RX ADC Sampling Rate = 12.5Msps Ramp End time = 25us Chirp Idle Time = 6us Chirp Slope = 35MHz/us Number of chirps per burst = 10 Burst Periodicity = 300us Number of bursts per frame = 1 Device configured to go to deep sleep state after active operation. Memory Retained in deep sleep = 114KB	1Hz Update Rate	1.2

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

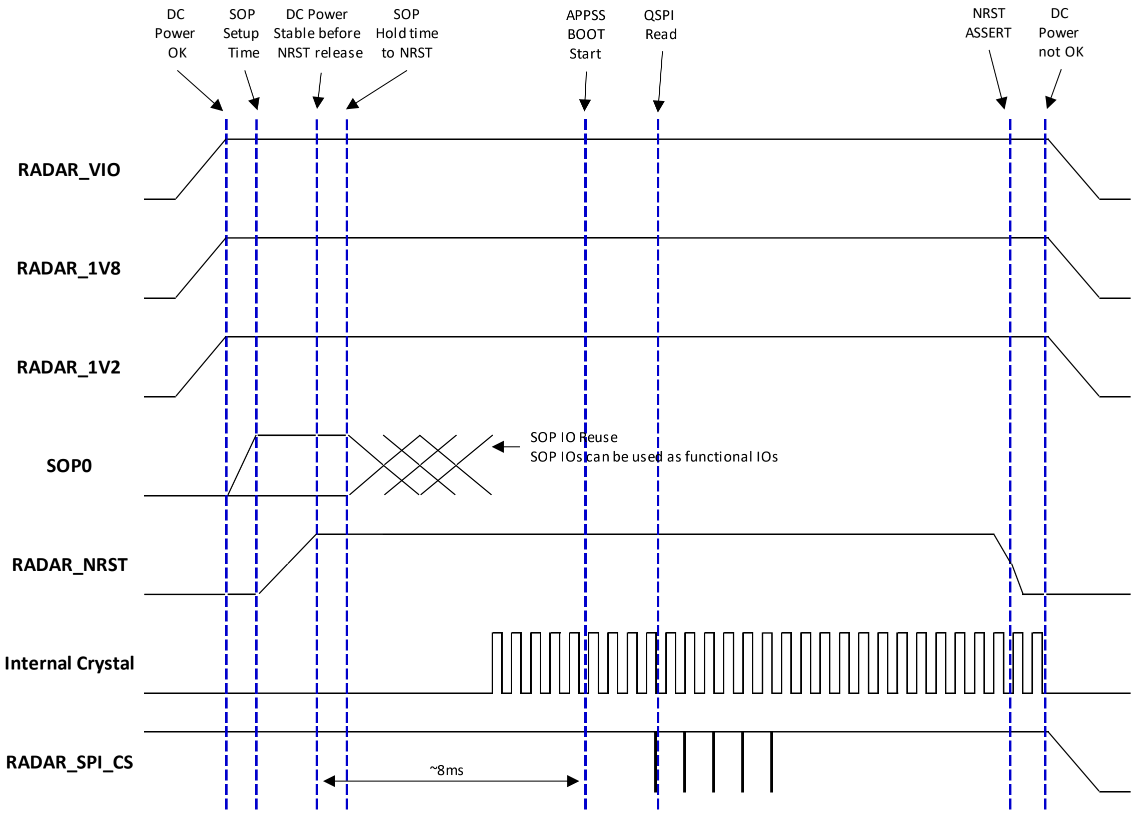
(1) Exercise full functionality of device, including 2TX, 3RX simultaneous operation, HWA, M4F and various host comm/interface peripherals active (CAN, I2C, GPADC), test across full temperature range.

(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

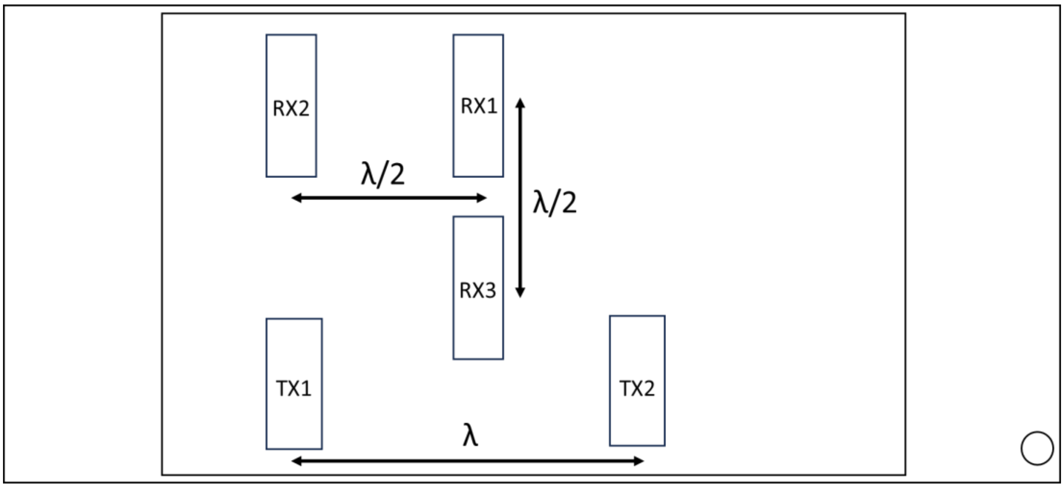


Figure 3-1. Antenna position of module

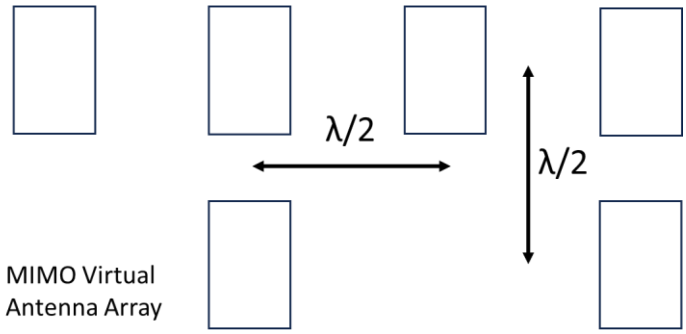


Figure 3-2. MIMO 2x4 Virtual Antenna Array

3.2. Antenna Radiation Patterns [1]

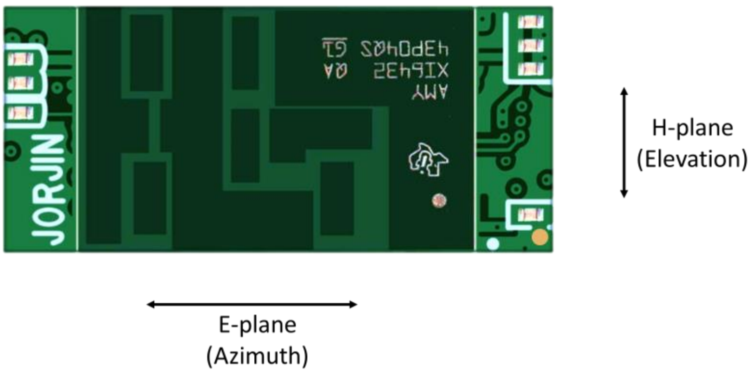
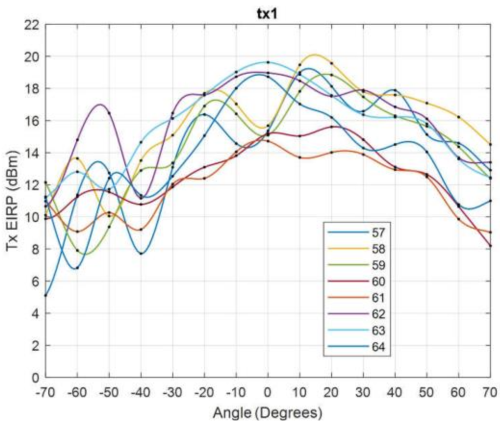


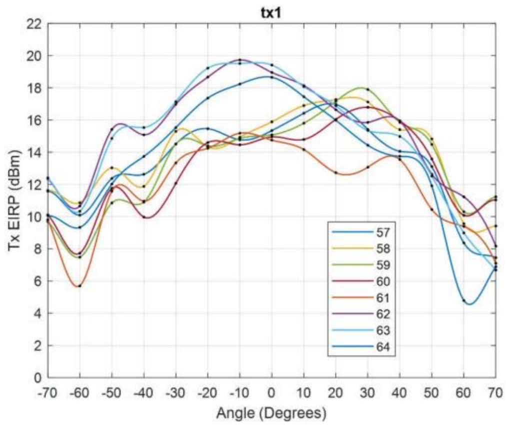
Figure 3-3. Azimuth and Elevation of module

(1) The Antenna radiation patterns data refer to TI IWRL6432AOP datasheet.

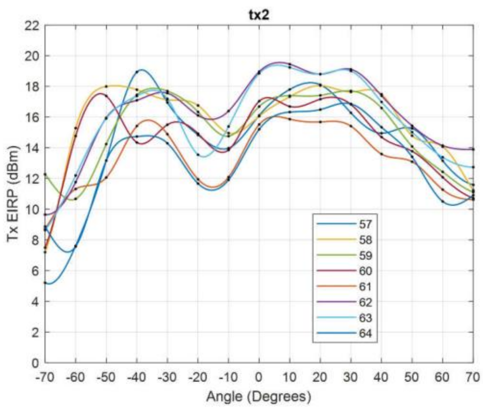
TX1 E-Plane



TX1 H-plane



TX2 E-Plane



TX2 H-plane

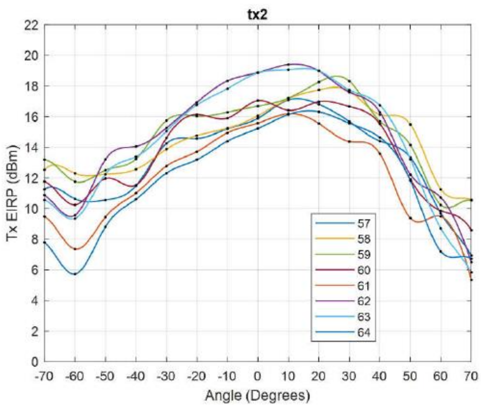
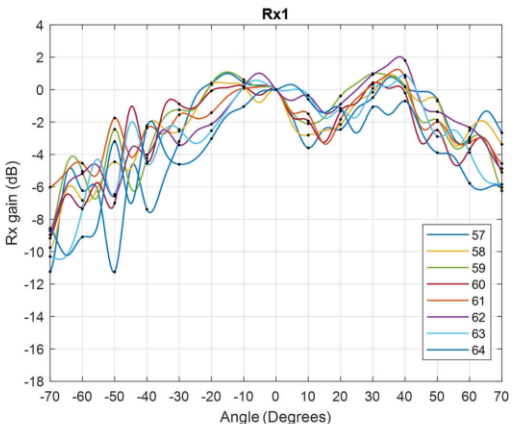
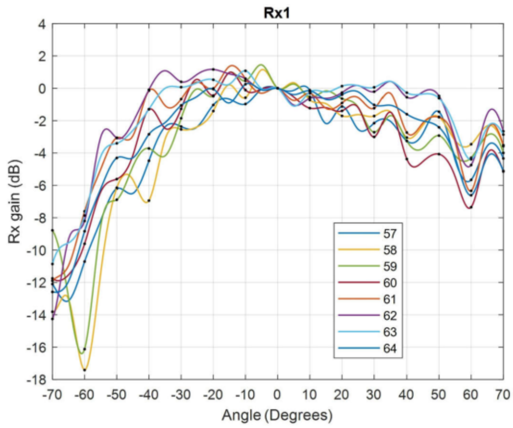


Figure 3-4. Transmitter Antenna Radiation Pattern

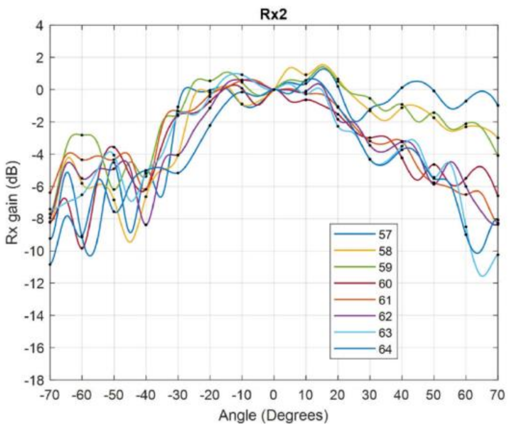
RX1 E-Plane



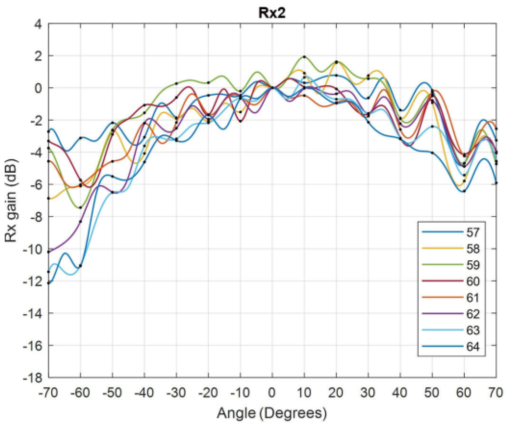
RX1 H-plane



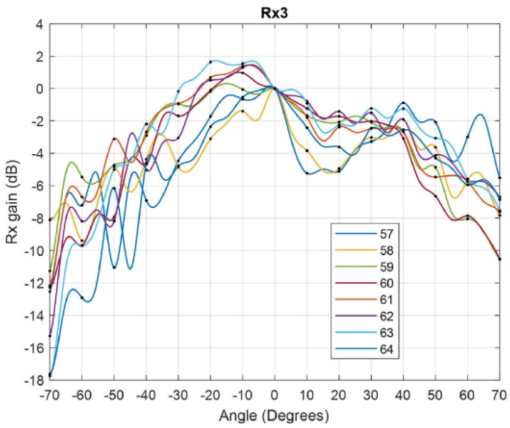
RX2 E-Plane



RX2 H-plane



RX3 E-Plane



RX3 H-plane

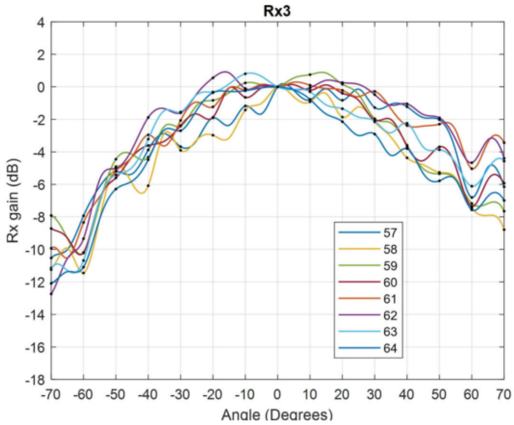


Figure 3-5. Receiver Antenna Radiation Pattern

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 (Dk, εr) and low tangent loss (Df, tanδ) value, will have smaller dielectric losses.

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

Material	Dielectric constant (εr)	Loss tangent (tanδ)
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

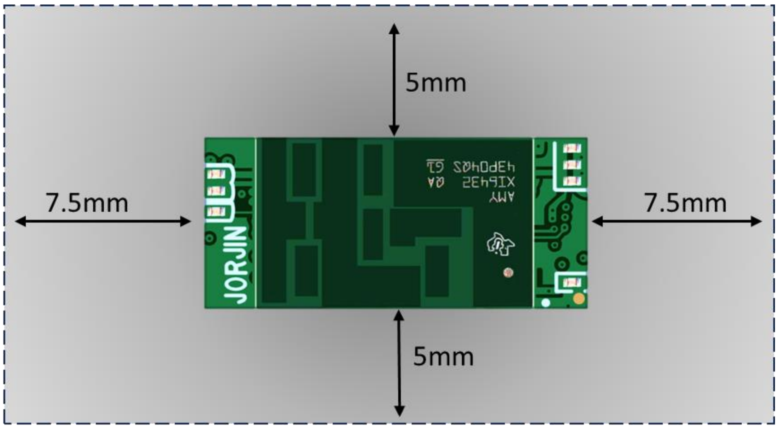
Note:

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

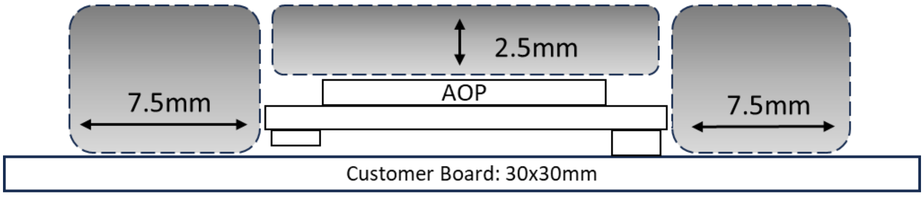
The additives could cause changes in the dielectric constant because in chemical terms they are **polar materials**, and these polar materials will cause an increase in dielectric constant.

4.2. Clearance Area Recommendation of Module

Recommended clear area of MT5C01-03 AoM module with no components over the module as below.



Top View



Front View

Figure 4-3. Recommend Clear Area of Radar module

4.3. Radome Recommendation of Module

Assumed your product has a planar flat surface above the radar. In this case, the recommend radome thickness and air gap would give a good signal.

- **Radome thickness:** 1.8mm, if used PC (Dk=2.7, Df=0.003) for radome.
- **Air Gap:** 2.5mm (λ/2 at 60GHz)
- **Radome size:** 30x30mm (for example)

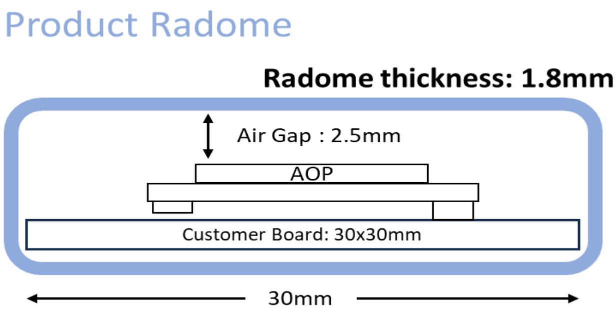


Figure 4-4. Recommend design of Radome

5. MODULE REFERENCE DESIGN

5.1. Reference Schematic

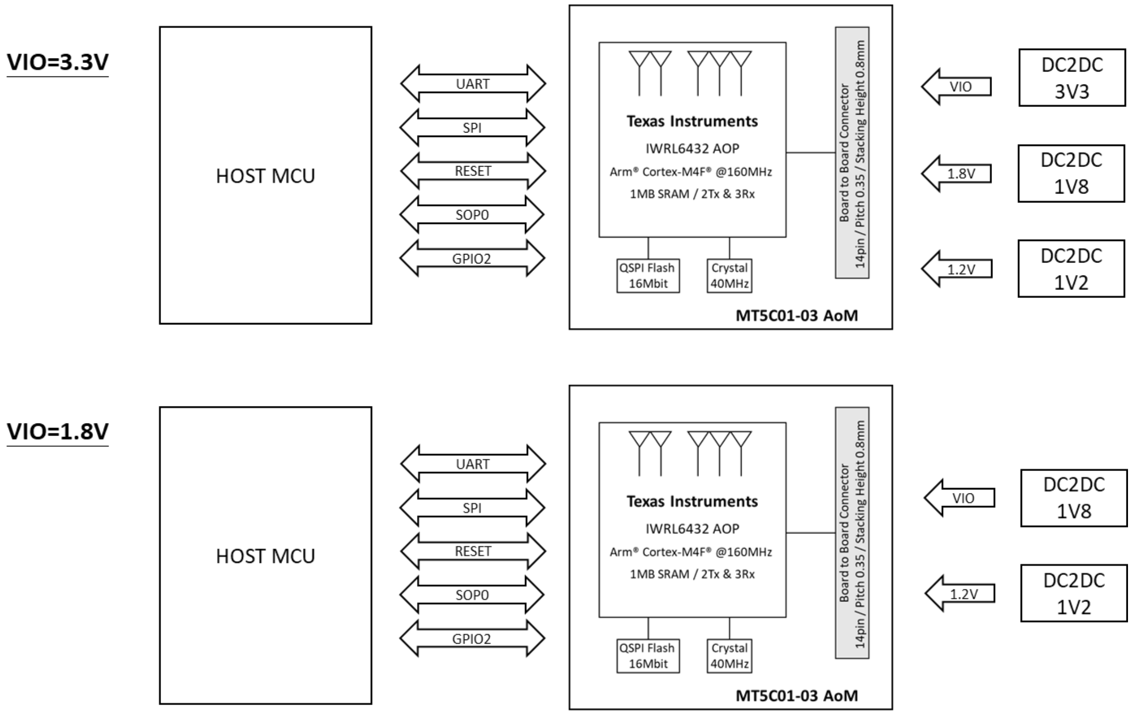
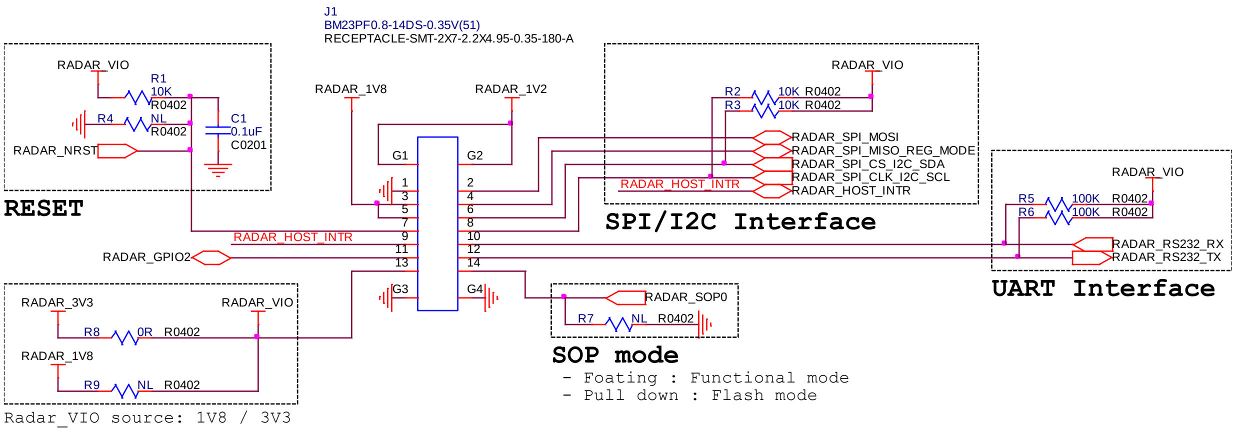


Figure 5-1. System Hardware Topology

Board to Board Connector



DCDC Circuit

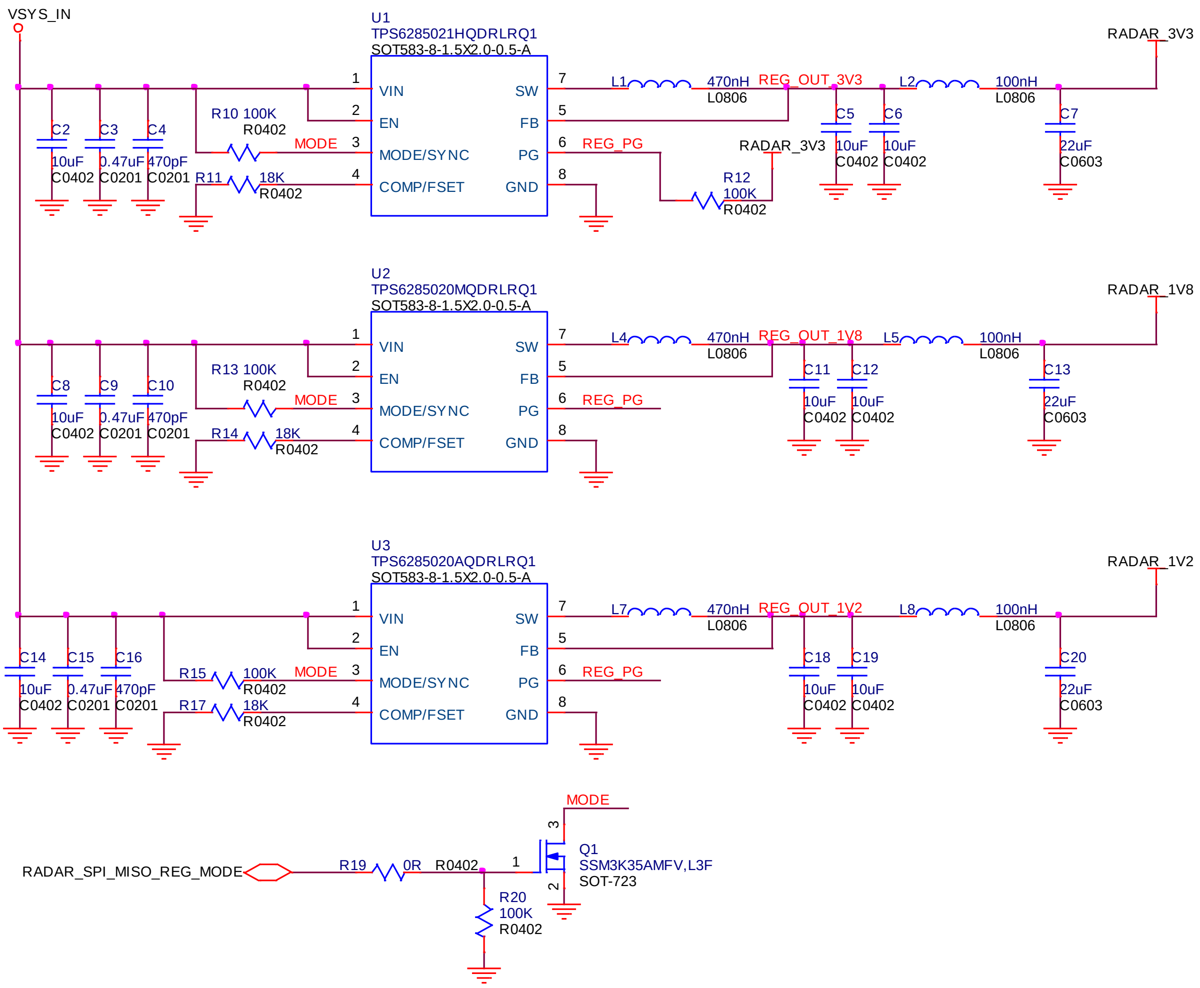


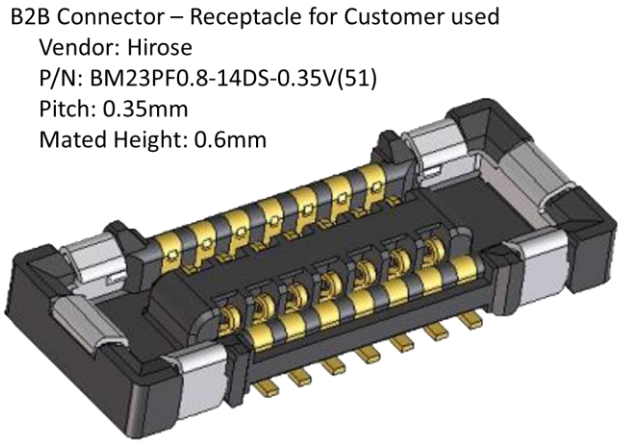
Figure 5-2. Reference Schematic

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 × 1.6 × 0.6 mm	U1	TI
Buck / Vin 2.7~6V / Vout 1.8V / 2A	TPS6285020MQDRLRQ1	2.1 × 1.6 × 0.6 mm	U2	TI
Buck / Vin 2.7~6V / Vout 1.2V / 2A	TPS6285020AQDRLRQ1	2.1 × 1.6 × 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 MT5C01-03 Module. Please ensure that must be used Receptacle type of Hirose BM23PF0.8-14DS-0.35V(51) to correct positioning the module on board.



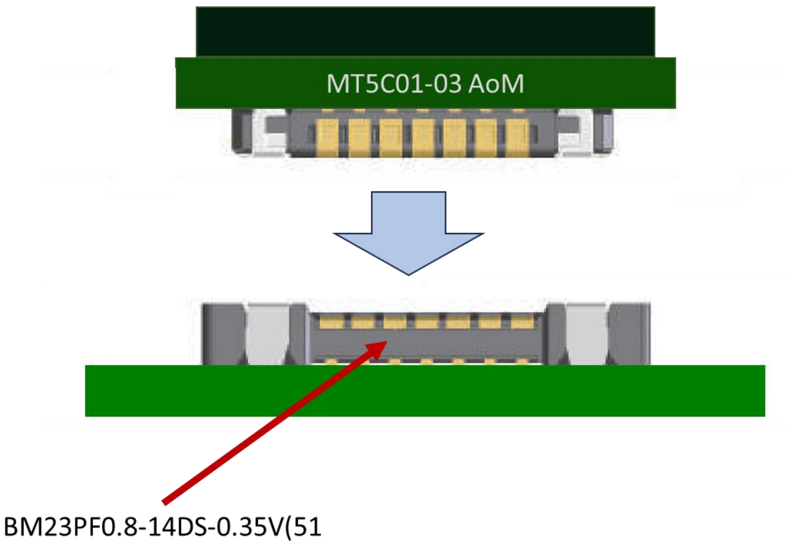
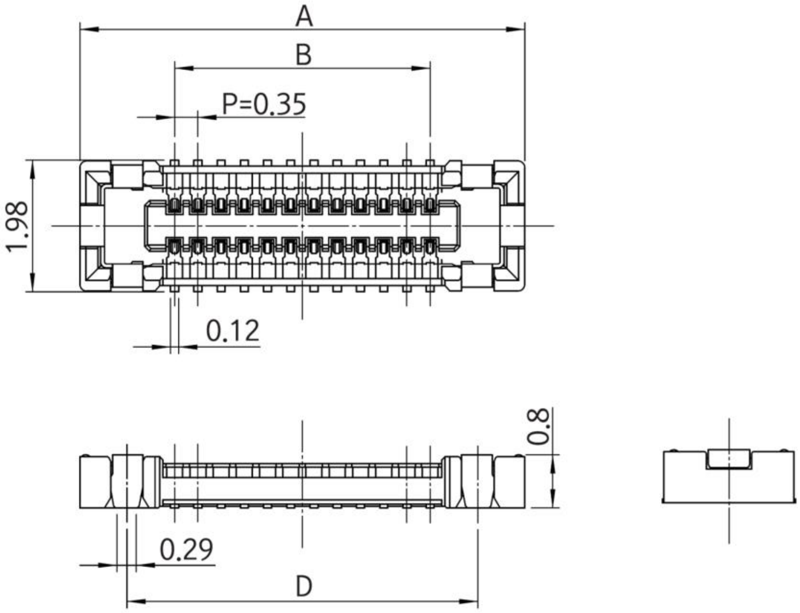


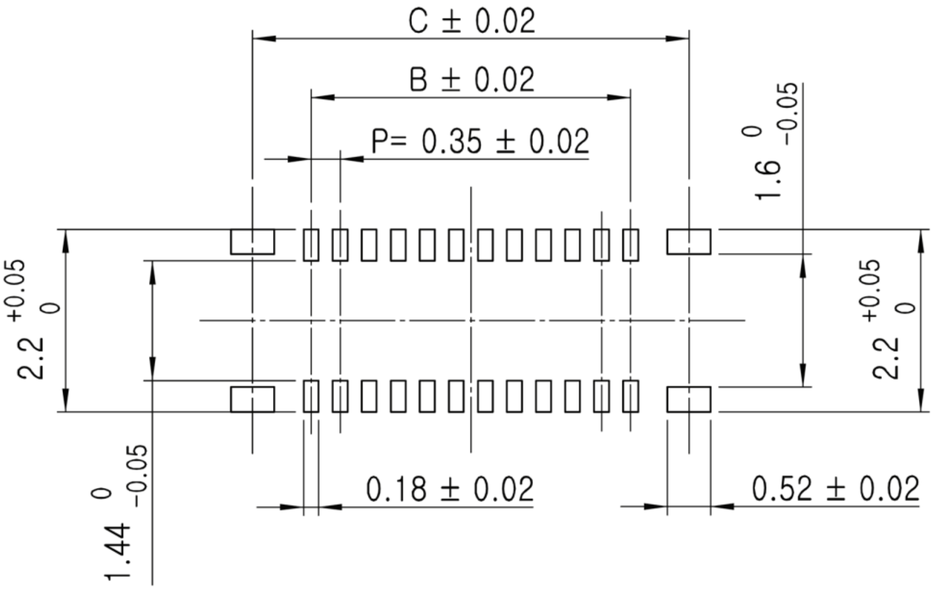
Figure 5-5. Board to Board Connector for Customer



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



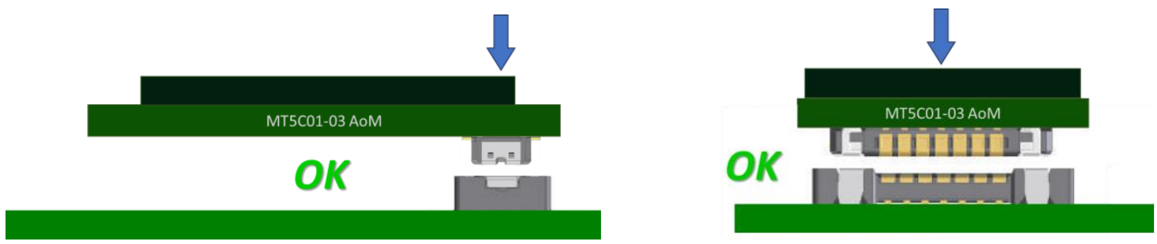
Unit : mm

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.

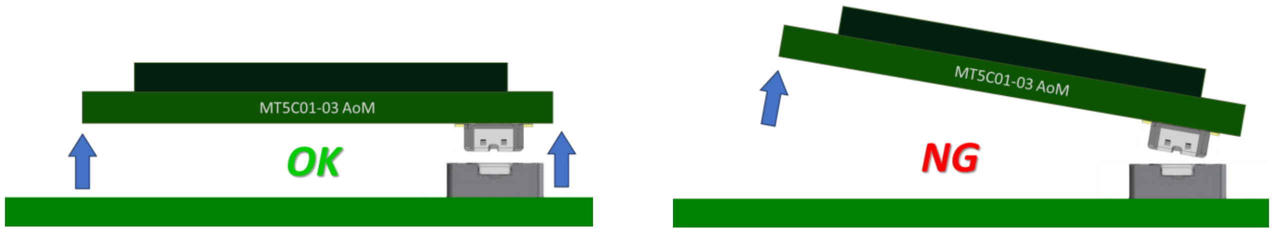
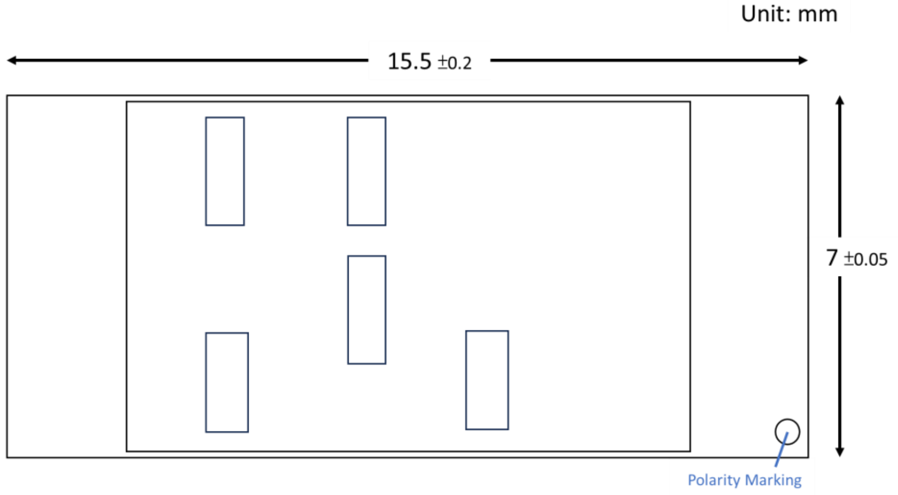


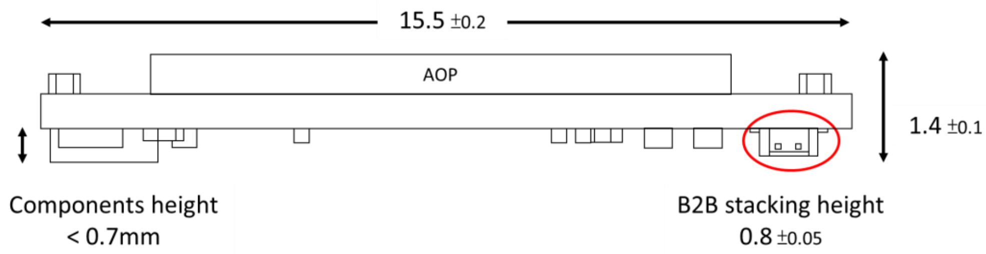
Figure 5-8. Correct Handle when mating a connector

6. PACKAGE INFORMATIION

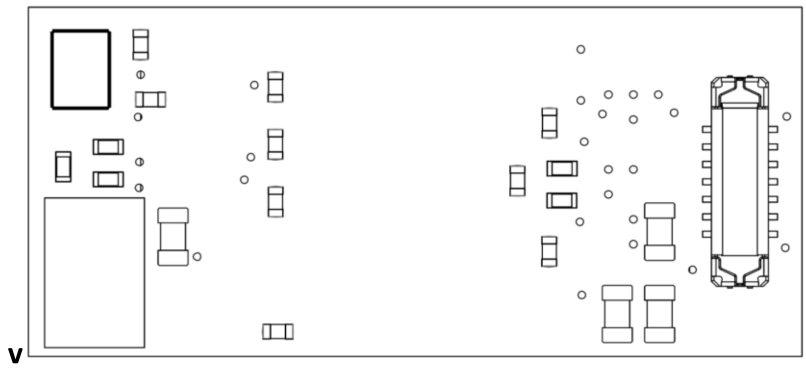
6.1. Module Dimension



Top View



Front View



Bottom View

Figure 6-1. MT5C01-03 Module Dimension

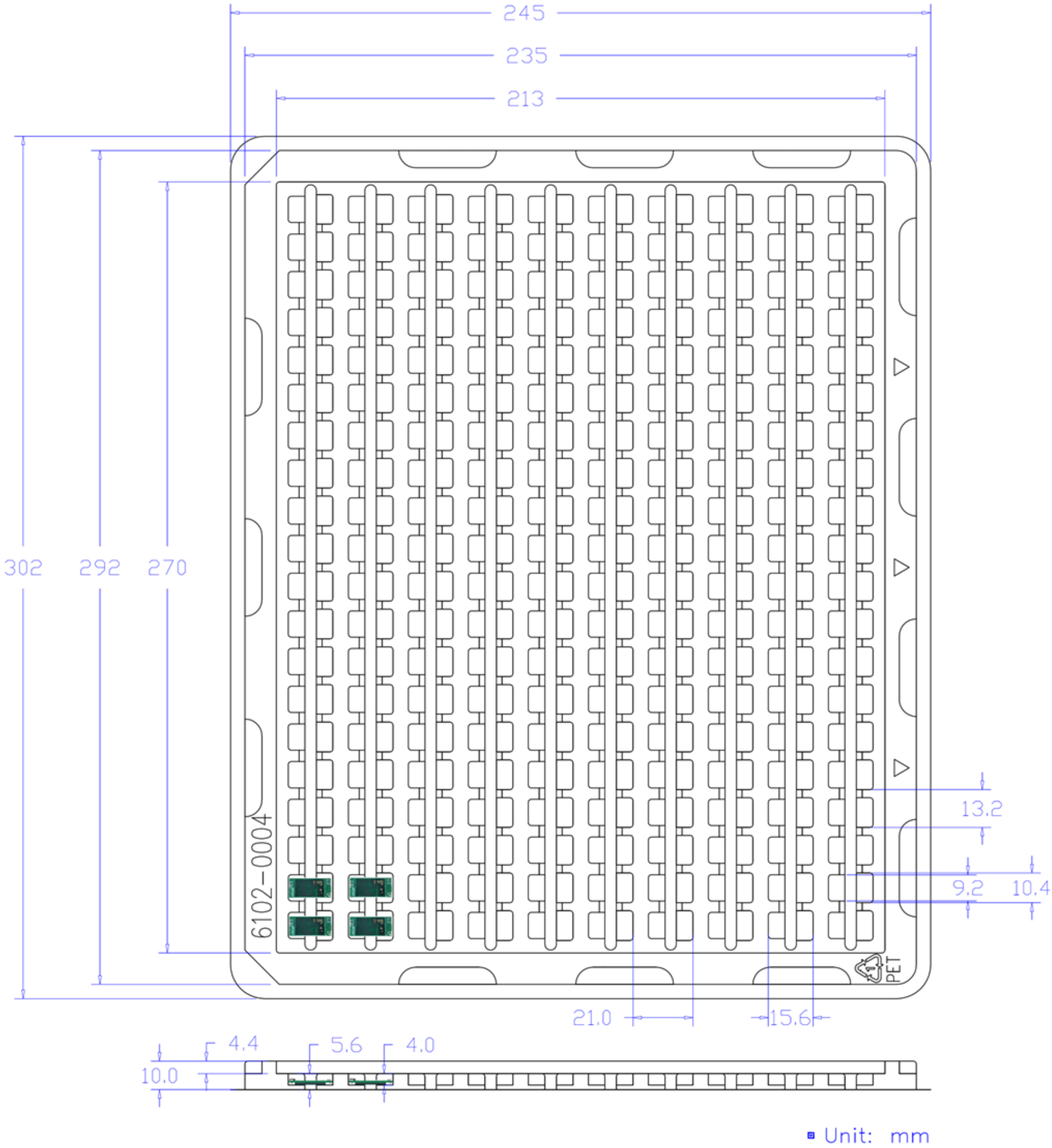
6.2. Device Label

Code information	Description
Date code and module ID	YYWW,CXXXXXX YY : Digit of the year, ex: 2024=24 WW : Week (01~52) D : Product Number, ex: D=MT5C01-03 XXXXXX : module ID.
Certification ID	TBD

Figure 6-2. Code label on Bottom of module

6.3. Packaging information

Tray Drawing



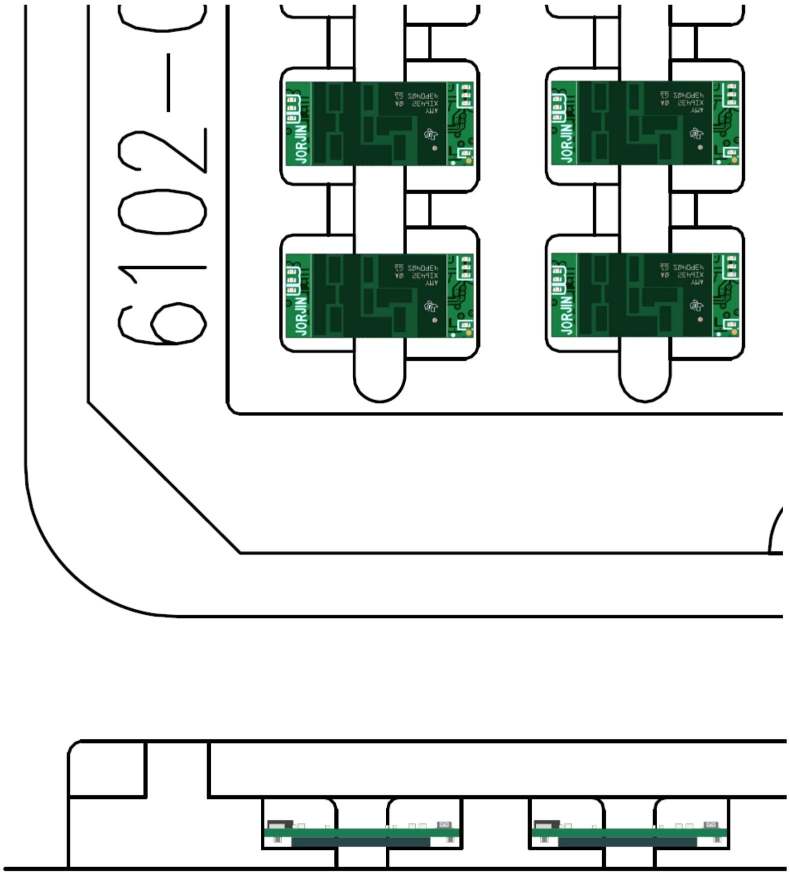


Figure 6-3. Dimensions for Tray Specification

7. EVALUATION KIT

The Jorjin mmWave Radar evaluation kit show as below. Based on the MT5C01-03 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.

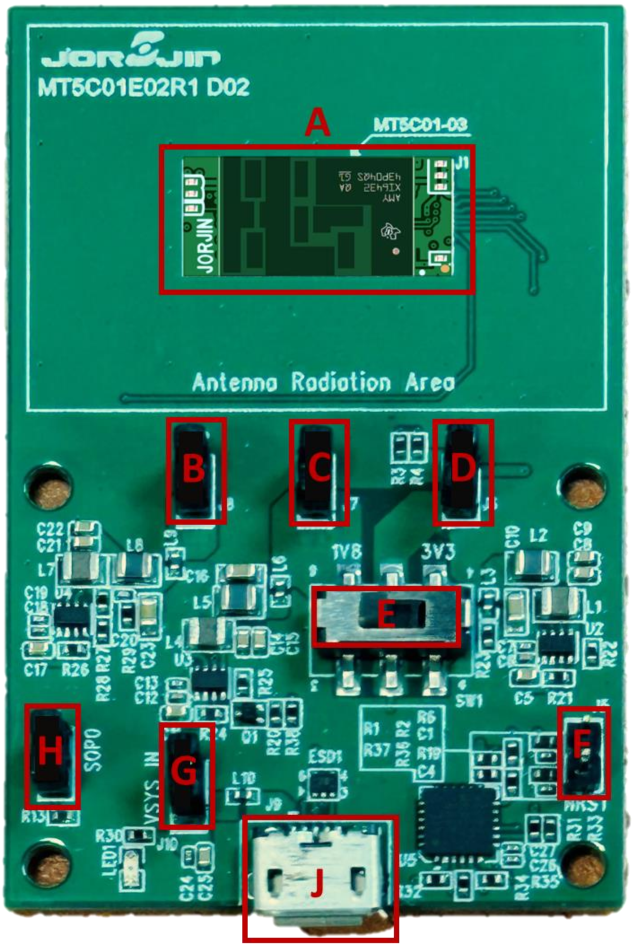


Figure 7-1. MT5C01-03 mmWave Radar Evaluation Kit

Table 7-1. Evaluation Kit component descriptions list

Region	Description
A	Jorjin MT5C01-03 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: - 3.3V: Slide to right. (Default) - 1.8V: Slide to left.
F	Reset pin of Radar module: - 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: - 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
MT5C01-03	60GHz mmWave Radar AoM Module

9. HISTORY CHANGE

Revision	Date	Description
Draft 0.1	2024-07-04	Draft version.