SIM8300G_M2 Antenna Port Mapping and Design Guide

5G Module

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Version History

Data	Version	Description of change	Author
2019-09-27	1.00	The original version	
2019-10-30	1.01	Added QTM527 design reference	
2019-10-30	1.01	IF naming and alignment adjustments	
2019-11-04	1.01	Antenna port mapping changes	
2019-11-06	1.02	The connection correction between the QTM IF connector and the SIM8300GGPIO port in Table 7	
2019-12-24	1.03	MMW connector model update	
2020-05-21	1.04		
Data	Version	Description of change	

Contents

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1 Introduction

This document describes the SIM8300G_M2 5G module antenna port mapping, design guide and millimeter wave design guide to customer to refer.

2 Definitions, symbols and abbreviations

Table 1：Abbreviations and description

Abbreviations	Description
LB	Low Frequency Band [1]
MHB	Middle and High Frequency Band[2]
UHB	Ultra High Frequency Band[3]
LAA	Limited Access Authorization
TRX	Transmit and Receive signal
DIV	The Diversity Receive signal
UL-MIMO	Uplink- Multiple Input Multiple Output
DL-MIMO	Downlink- Multiple Input Multiple Output
GNSS	Global Navigation Satellite System

※ NOTE

[1] Frequency is from 600MHz to 960MHz, such as LTE B5/B8/B12/B20/B28 and so on;
[2] Frequency is from 1710MHz to 2690MHz, such as LTE B1/B2/B3/B7/B25/ B38/B40/B41 and so on;
[3] Frequency is from 3300MHz to 4200MHz, such as LTE B48.

3 Antenna Interfaces

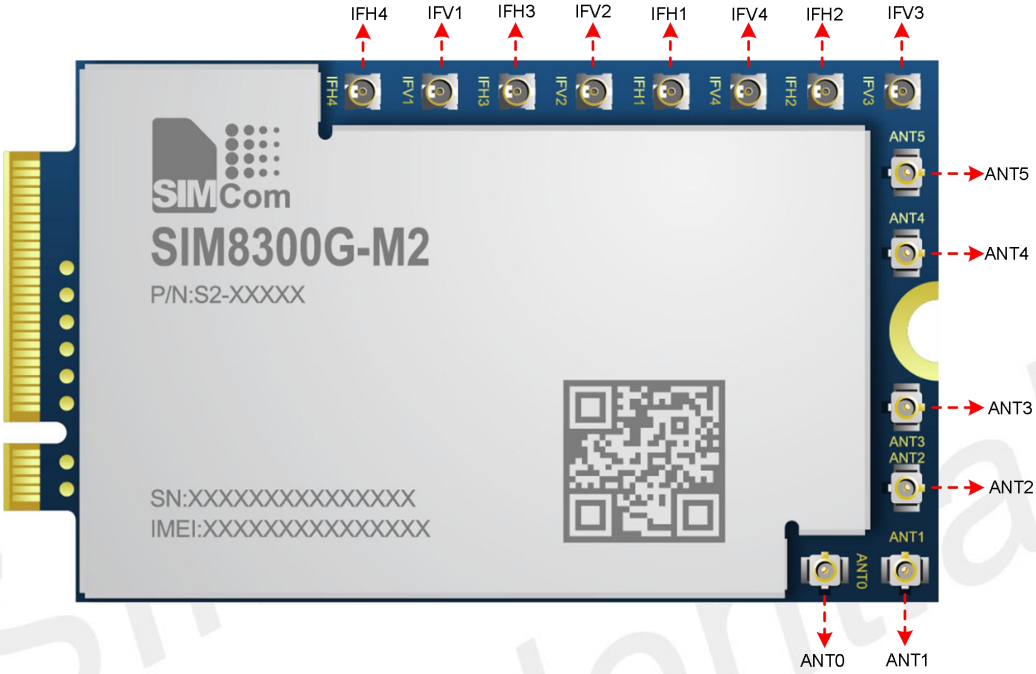

Figure 1: Antenna interfaces

4 LTE and Sub6 5G Antenna Port Mapping and Design Guide

4.1 Antenna Port Mapping

SIM8300G_M2 provides six antennas for sub-6G bands. Module and antenna connector is shown in figure1. The Bands and the Antenna port mapping are shown in table2.

4.1.1 Full function with 6 antennas

In this design, it can reach the maximum performance of SIM8300G_M2——4*4 DL-MIMO and 2*2 UL-MIMO———that data rate of NR Sub-6 is 4Gbps (DL) and 1Gbps(UL), data rate of TDD/FDD LTE CAT20 is 2Gbps (DL) and 400Mbps (UL).

Table 2: Frequency Band and Antenna Port Mapping

ANTENNAS / BANDS / FUNCTIONS			ANT0	ANT1	ANT2	ANT3	ANT4	ANT5
GNSS			✓					
5G	n79	DIV						
3G/4G/5G	MHB	DL-MIMO2		✓				
4G	LAA	DL-MIMO1						
4G/5G	UHB/n77/n78/n79	TRX						
5G	n41	DIV						
3G/4G/5G	MHB/UHB/n77/n78	UL/DL-MIMO1			✓			
4G	LAA	PRX						
5G	n41	TRX						
4G/5G	UHB/LAA/n77/n78	DL-MIMO2				✓		
3G/4G/5G	LB/MHB	TRX						
4G/5G	UHB/LAA/n77/n78	DIV					✓	
5G	n41	UL/DL-MIMO1						
5G	n79	DL-MIMO2						
3G/4G/5G	LB/n79	UL/DL-MIMO1						✓
3G/4G/5G	MHB	DIV						

5G	n41	DL-MIMO2

NOTE

4G LB only support 2*2 DL-MIMO

4.1.2 Antenna Reduction with 3 Antennas

In this design, it can support the base function of SIM8300G_M2, but with performance and function reduction:

1. no GNSS
2. For 5G n79, it reduces two paths of DL and one path of UL. Its data rate becomes 2Gbps (DL) , 500Mbps(UL)
3. For 5G n77/n78, it reduces one path of DL. Its data rate becomes 3Gbps (DL), 1Gbps(UL)
4. For 5G n41, it reduces one paths of DL. Its data rate becomes 3Gbps (DL), 1Gbps(UL)
5. For 4G MHB/UHB/LAA, it reduces one path of DL. Its data rate becomes 1.5Gbps (DL), 400Mbps(UL)
6. For 4G LB, it reduces one path of DL. Its data rate becomes 500Mbps (DL), 200Mbps(UL).

Table 3：Frequency Band and Antenna Port Mapping with 3 antennas

ANTENNAS / BANDS / FUNCTIONS			ANT0	ANT1	ANT2	ANT3	ANT4	ANT5
3G/4G/5G	MHB	DL-MIMO2						
4G	LAA	DL-MIMO1						
4G/5G	UHB/n77/n78/n79	TRX						
5G	n41	DIV						
3G/4G/5G	MHB/UHB/n77/n78	UL/DL-MIMO1						
4G	LAA	PRX						
5G	n41	TRX						
3G/4G/5G	LB/MHB	TRX						
4G/5G	UHB/LAA/n77/n78	DIV						
5G	n41	UL/DL-MIMO1						
5G	n79	DL-MIMO2						

4.1.3 Antenna Reduction with 2 Antennas

If there is a requirement for minimum two antennas, it is recommended to combine ANT1 and ANT2 with a diplexer, it recommends LFD182G50MPAE246 from Murata. The referenced design is below:

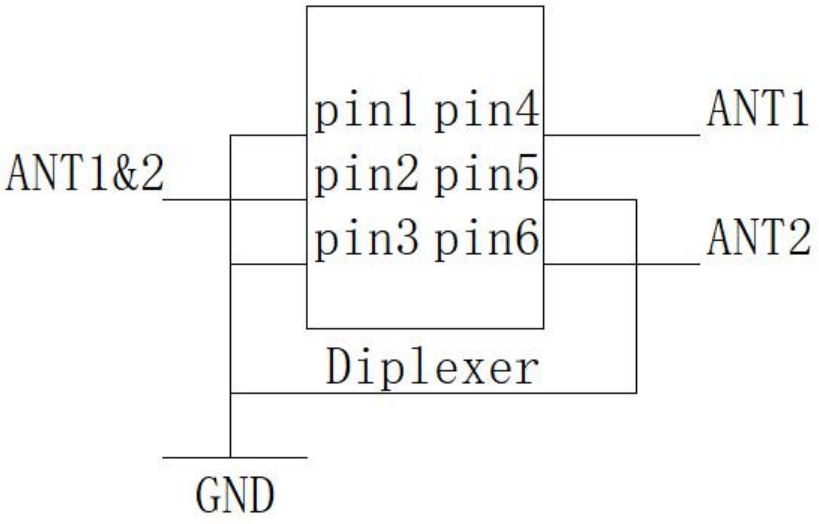

Figure 2：Diplexer referenced design with LFD182G50MPAE246

In this design, the performance and function reduction includes:

1. no GNSS
2. For 5G n79/n77/n78, it reduces two paths of DL and one path of UL. Its data rate becomes 2Gbps (DL) , 500Mbps(UL)
3. For 5G n41, it reduces one paths of DL. Its data rate becomes 3Gbps (DL), 1Gbps(UL)
4. For 4G MHB/LAA, it reduces two path of DL. Its data rate becomes 1Gbps (DL), 500Mbps(UL)
5. For 4G UHB, it reduces two paths of DL and one path of UL. Its data rate becomes 1Gbps (DL), 200Mbps(UL)
6. For 4G LB, it reduces one path of DL. Its data rate becomes 500Mbps (DL), 200Mbps(UL)

Table 4：Frequency Band and Antenna Port Mapping with 2 antennas

ANTENNAS BANDS FUNCTIONS			ANT0	ANT1&ANT2	ANT3	ANT4	ANT5
4G	LAA	DL-MIMO1					
4G/5G	UHB/n77/n78/n79	TRX					
3G/4G/5G	MHB	UL/DL-MIMO1					
5G	n41	TRX					
5G	n41	DIV					
3G/4G/5G	LB/MHB	TRX					
4G/5G	UHB/LAA/n77/n78	DIV					
5G	n41	UL/DL-MIMO1					
5G	n79	DL-MIMO2					

4.2 Antenna Reference Design

The space isolation of each antenna should be larger than 15dB. The isolation between LTE and 5GNR an tennas is at least 20dB for the ENDC or UL-MIMO combo which two antennas transmit simultaneously.

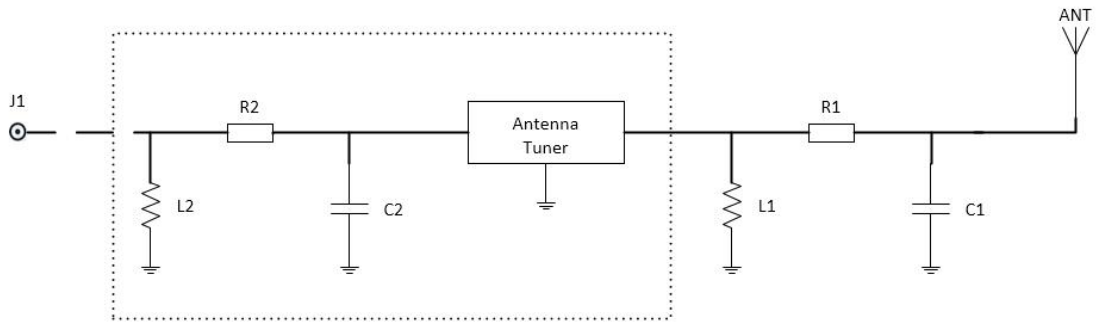

Figure 3: Antenna reference design

J1 is the coaxial cable connection. For most of customers, above match-components (R1/R2,L1/L2,C1/C2 and Tuner) are not needed to meet the requirements. But for the high-level requirements or some bad antenna design conditions, it is recommended. What's more, antenna tuner design in the dotted line may be considered for some customers to enhance the low frequency band performance.

NOTE

Customer should submit request to SIMcom for tuner support if needed.

4.3 RF Plug Recommendation

When selecting antenna, customer should pay attention to the match between the antenna connector and the RF connector of the module. SIM8200EA_M2 uses Murata connectors, size is 2.0mm*2.0mm*0.6mm, model is MM4829-2702B/RA4/RB0. The size and specification are shown as below.

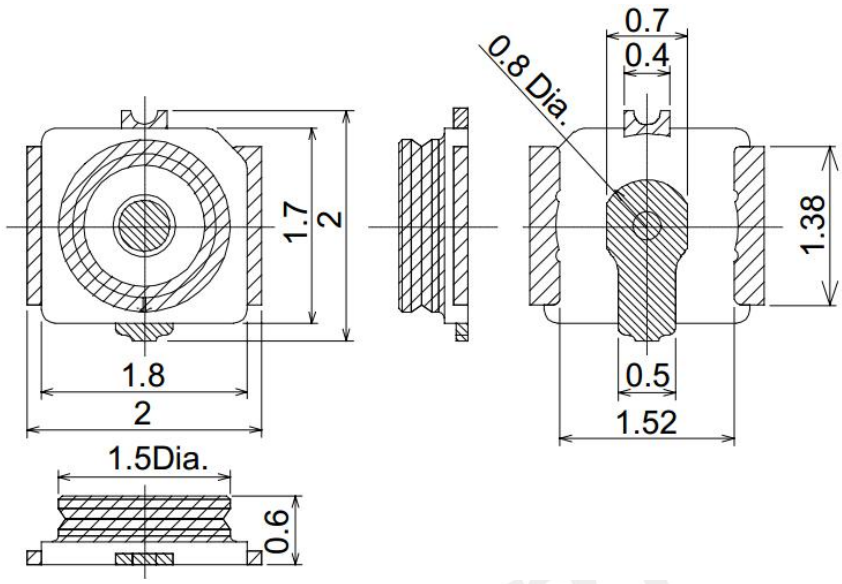

Figure 4: 3D view of MM4829-2702B/ RA4/ RBO

The recommended coaxial model to match is Murata's MXHJD3HJ1000. The size and specification are shown as below.

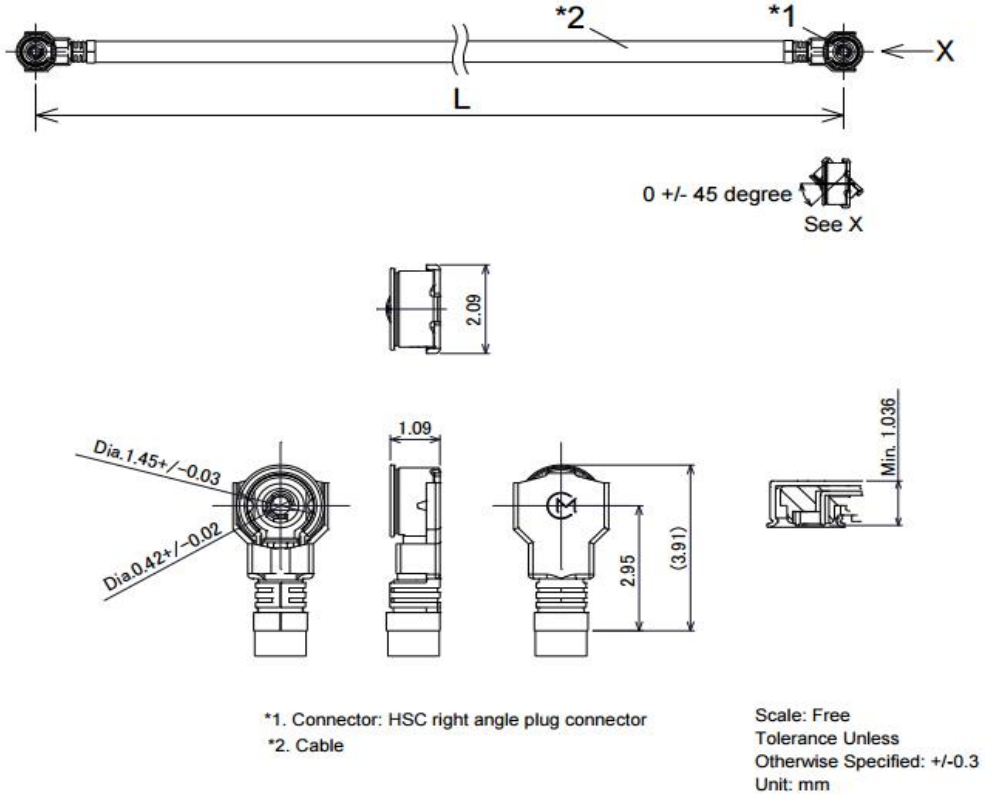

Figure 5: 3D view of MXHJD3HJ1000

4.4 Antenna Requirements

The following table shows the requirements on 3G/4G/5G antennas and GNSS antenna.

Table 5：3G/4G/5G antennas

Parameter	Requirement
Operating Frequency	See Table 2 for each antenna
Direction	Omni Directional
Gain	1dBi (Avg)
Impedance	50 Ω
Max. Input Power	50W
VSWR	< 2
Polarization Type	Vertical
Isolation	20dB is preferred
Cable Insertion Loss (<1GHz)	<1dB
Cable Insertion Loss (1GHz~2.2GHz)	<1.5dB
Cable Insertion Loss (2.3GHz~2.7GHz)	<2dB
Cable Insertion Loss (3.3GHz~6GHz)	<2.5dB

Table 6：GNSS antenna (for dedicated GNSS antenna only)*

Parameter	Requirement
Operating Frequency	L1: 1559~1609MHZ L5: 1166~1187MHz
Direction	Hemisphere, face to sky
Impedance	50 Ω
Max. Input Power	50W
VSWR	< 2
Polarization	RHCP or Linear
Passive antenna gain	0dBi
Active antenna gain	-2dBi
Noise Figure for Active Antenna	< 1.5
Active antenna embedded LNA gain	20dB(Typ.)
Total Gain for Active Antenna	< 18 dB
Cable Insertion Loss	<1.5dB

NOTE

*: These recommendations are for dedicated GNSS antenna which application need best of class GNSS tracking performance.

5 MM Wave Antenna Design Guide

This section provides reference designs for QTM525 and QTM527 millimeter wave antennas.

5.1 QTM525 Design

5.1.1 QTM525 mmW Antenna Specification

Key Features

1. Include an integrated RFIC, power management IC, and phased antenna array.
2. QTM525-2 – two dual-band module variants supporting n257 and n258.
3. QTM525-5 – two dual-band module variants supporting n258 and n260.
4. QTM525-2/ QTM525-5 Size – 23 mm × 4.2 mm × 1.86 mm (1.97 mm max) rectangular.

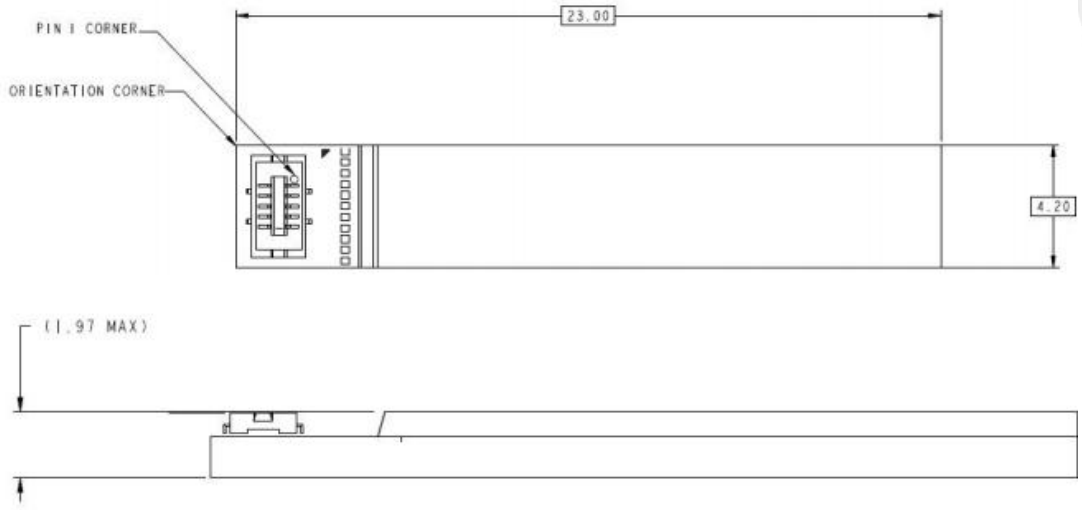

Figure 6: QTM525-2/QTM525-5 variant package drawing

Each module has a board-to-board connector to provide electrical power, grounding, and IF signal connections. It's a receptacle one which pin assignments as follow, while there are eight additional ground pins (11–18) that provide connector mechanical support.

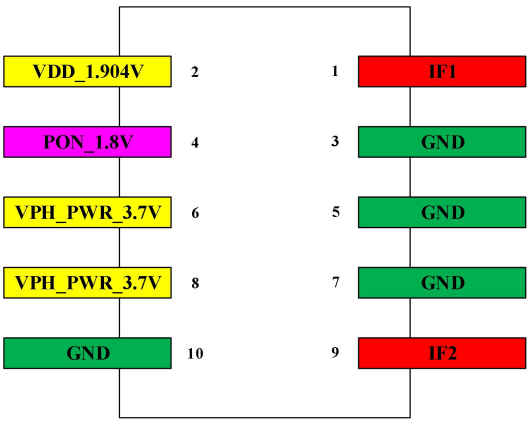

Figure 7: Pin assignments of B2B connector

NOTE

1. Recommended receptacle part is IPEX MPN 20865-010E-01: 2.1 × 3.5 × 0.585 mm, (receptacle mounted on module QTM525).
2. Recommended Plug part is IPEX MPN 20864-010E-01: 2.1 × 4.2 × 0.655 mm.

	PART NO.	Pos.	A	B	C	D	E
	20865-010E-01	10	3.50	1.40	1.05	3.70	3.68

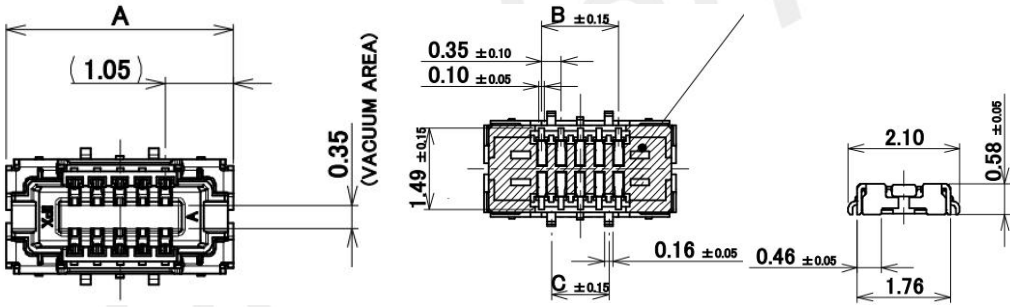

Figure 8: Package size of IPEX MPN 20865-010E-01

PART NO.	Pos.	A	B	C	D	E	F
20864-010E-01	10	1.40	4.15	1.05	3.85	4.10	3.75

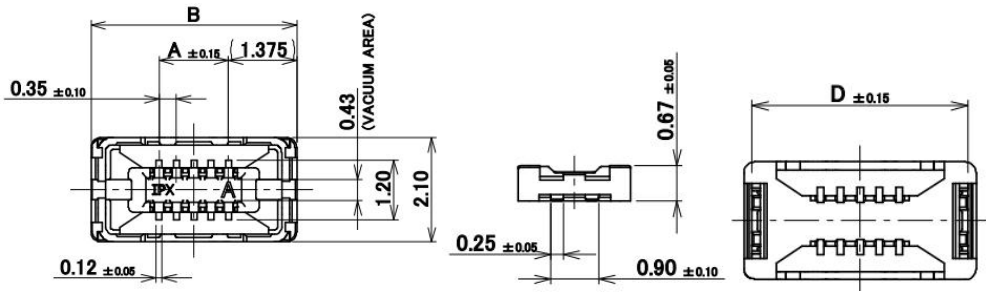

Figure 9: Package size of IPEX MPN 20864-010E-01

5.1.2 QTM525 IF connector and GPIO Port Mapping

There are 8 IF Connectors in SIM8300G design, need coaxial cables mating with the RF connector. Cable specification refers to the next chapter.

Table 7: the connection of QTM with IF connector and GPIO port of SIM8300G

QTM525 Module	QTM IF1 PORT	QTM IF2 PORT	QTM525 PON
0	IFH1	IFV1	QTM0_PON
1	IFH4	IFV4	QTM1_PON
2	IFH2	IFV2	QTM2_PON
34	IFH3	IFV3	QTM3_PON

5.1.3 QTM525 Reference Design

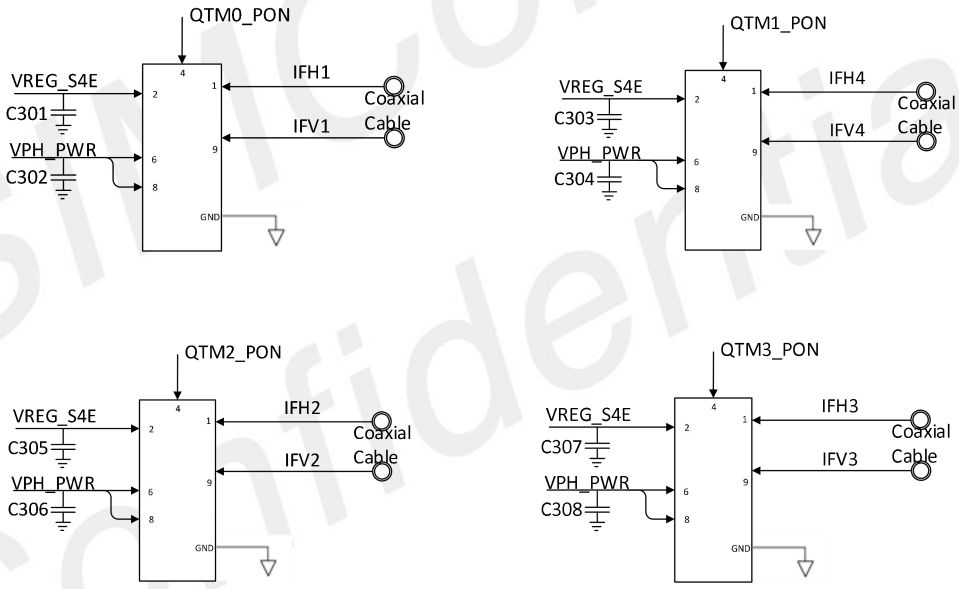

Figure 10: QTM525 reference Schematic Design with SIM8300G

NOTE

see the parts list for the parts value.
6
/93

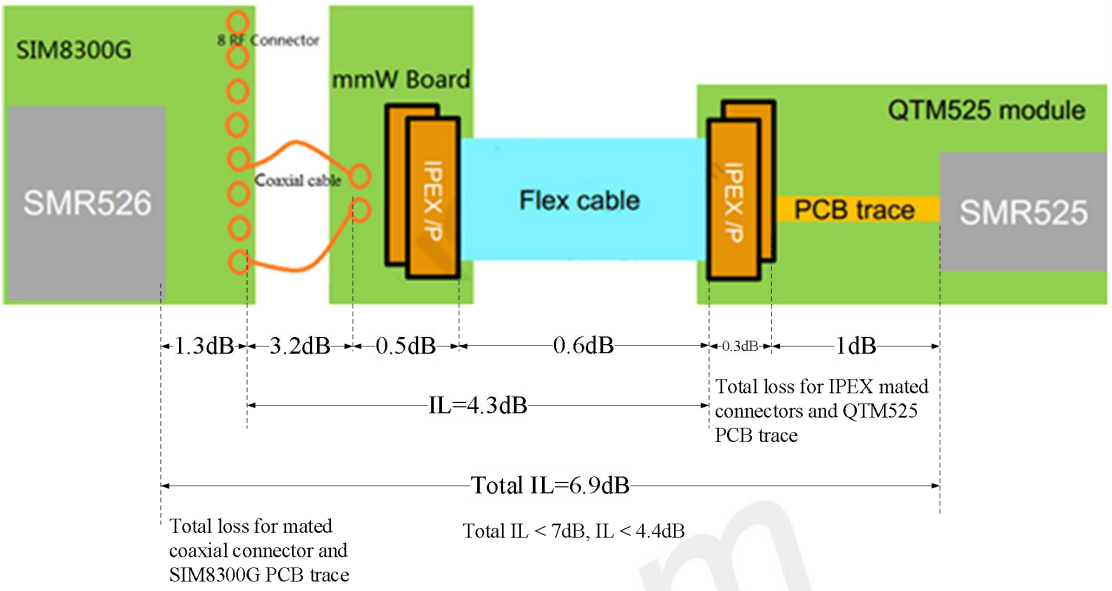

Figure 11: mmW Connection Design and IF Loss Example

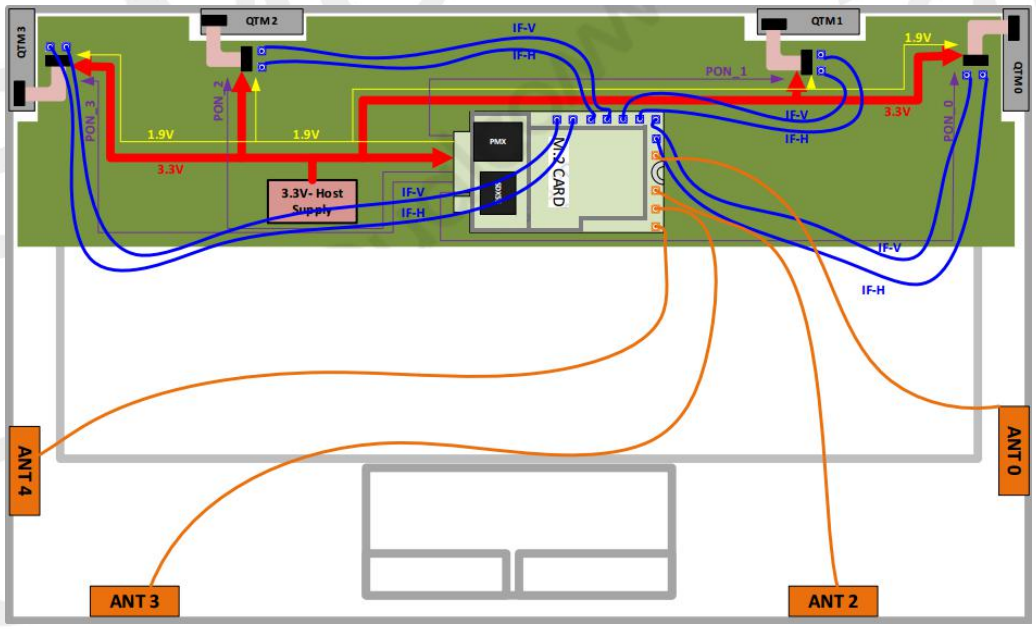

Figure 12: the Whole Design with 4 QTM525

Table 8: Power Supply Requriements

	QTM525 Voltage			QTM525 Current
Power Supply	MIN.	TYP.	MAX.	MAX.
VPH_PWR	2.5V	3.7V	4.8V	700mA
VDD_1P9	1.85V	1.9V	2.0V	100mA

Table 9: IF path VSWR requirements

Range	VSWR requirement
10 MHz–1.2 GHz	< 1.2:1
1.2 GHz–3.6 GHz	< 2:1
6–10 GHz	< 2:1. variation over 1.4GHz＜0.5

Table 10: IF path insertion loss requirements

Range	Insertion loss requirement
10 MHz–1.2 GHz	< 2 dB (recommended)
1.2 GHz–3.6 GHz	< 4 dB (recommended)
6–10 GHz	< 7 dB (from the IFIC pin to the RFIC pin)

NOTE

1. IF signal traces must be in accordance with 50 ohm strictly.
2. Minimize routing IF lines too deep into the PCB stack-up.
3. Route IF lines as striplines with the highest priority. Shield each IF trace with via fences to achieve high isolation.
4. Total system isolation between IF paths (combined PCB, cables, connectors, and so on) to the same module should be > 40 dB from 6 GHz to 10 GHz for proper operation. Different modules, the isolation specification can be relaxed to >25dB.
5. Preferred IF trace FPC Vendors: Forewin and Sunway, IF IL < 2.3 dB/100 mm.

5.2 QTM527 Design

5.2.1 QTM527 mmW Antenna Specification

Key Features

1. QTM527-1—two dual-band module variants supporting n260 and n261.
2. QTM527-2—two dual-band module variants supporting n257 and n258.
3. QTM527-1 size:16.8mm×16.8mm×1.89mm rectangular.
4. QTM527-2 size:21.2mm×21.2mm×2.19mm rectangular.

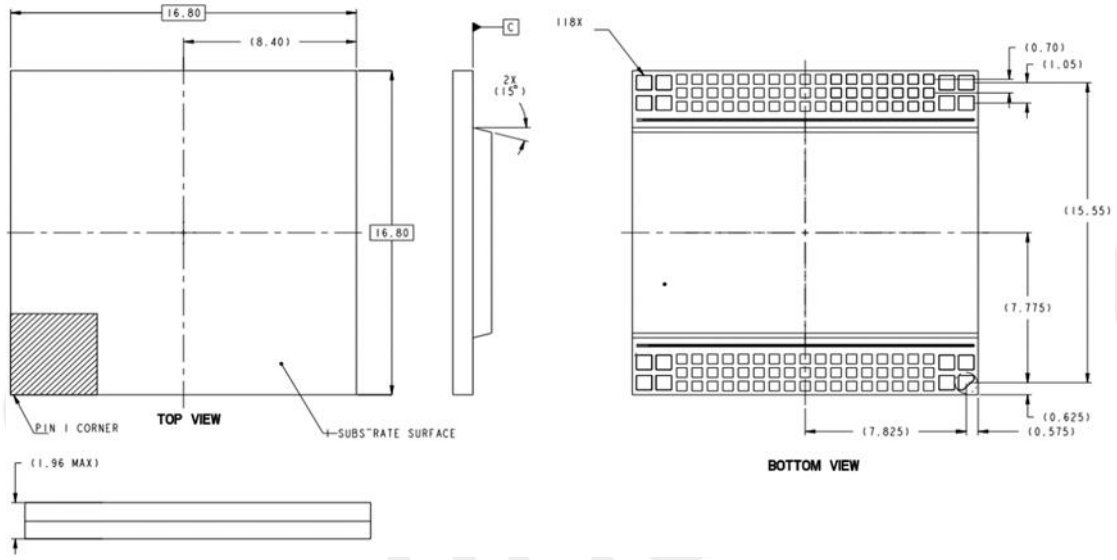

Figure 13: QTM527-1 variant pakage drawing

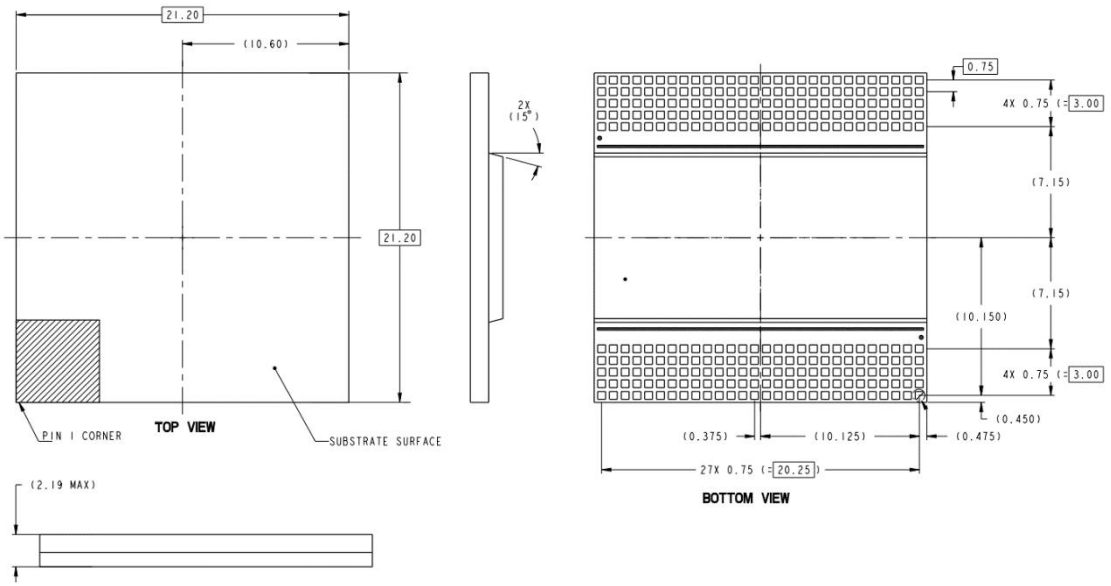

Figure 14: QTM527-2 variant pakage drawing

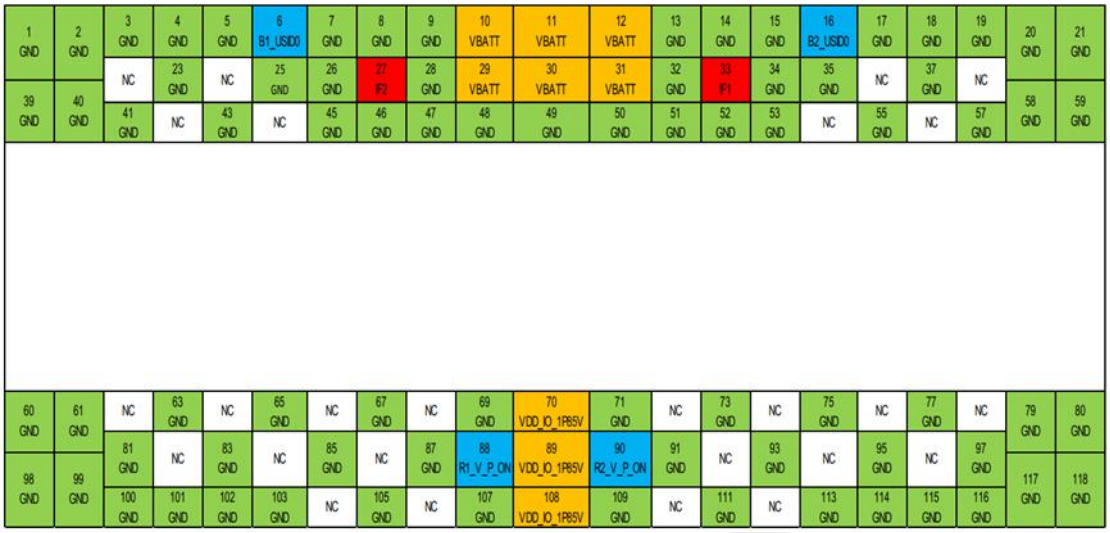

Figure 15: Pin assignments of QTM527-1(bottom view)

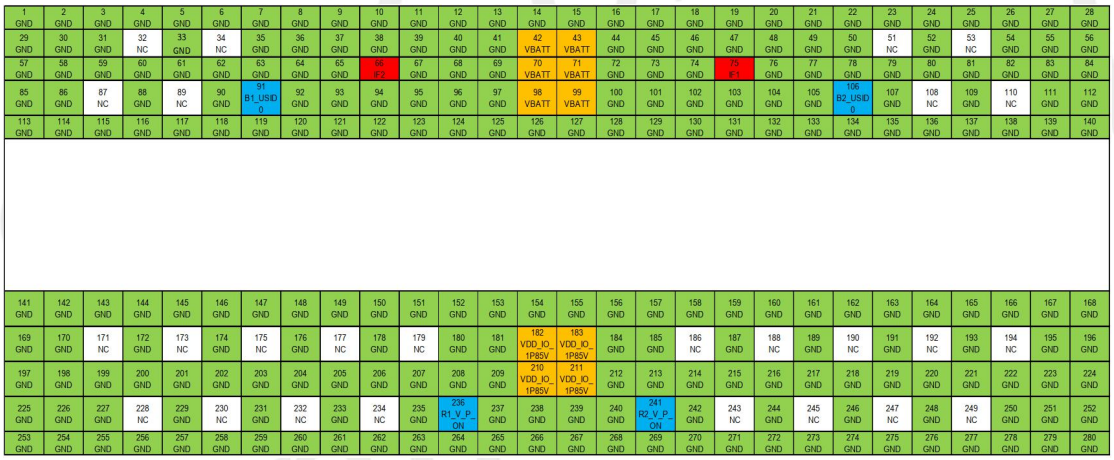

Figure 16: Pin assignments of QTM527-2（bottom view）

Every two modules have a board-to-board connector to provide electrical power and grounding connections,two in total. It's a receptacle one which pin assignments as follow, while there are twelve additional ground pins (31–42) that provide connector mechanical support.

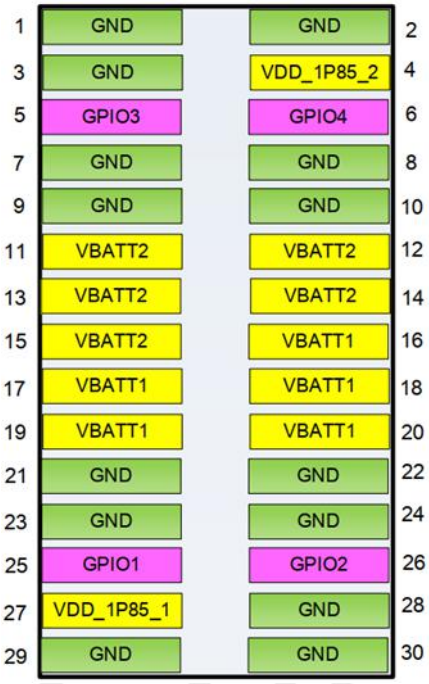

Figure 17: Pin assignments of B2B connector

NOTE

1. Recommended receptacle part is IPEX MPN 20865-030E-01: 7.2mm × 2.1mm × 0.585 mm (receptacle mounted on carrier board of QTM527).
2. Recommended Plug part is IPEX MPN 20864-030E-01: 7.9mm × 2.1mm × 0.675 mm.

PART NO.	Pos.	A	B	C	D	E
20865-030E-01	30	7.20	4.90	3.15	7.40	7.38

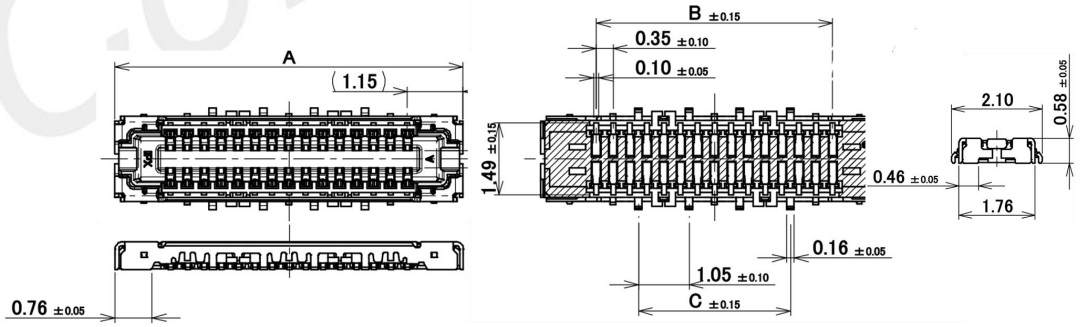

Figure 18: Package size of IPEX MPN20865-030E-01

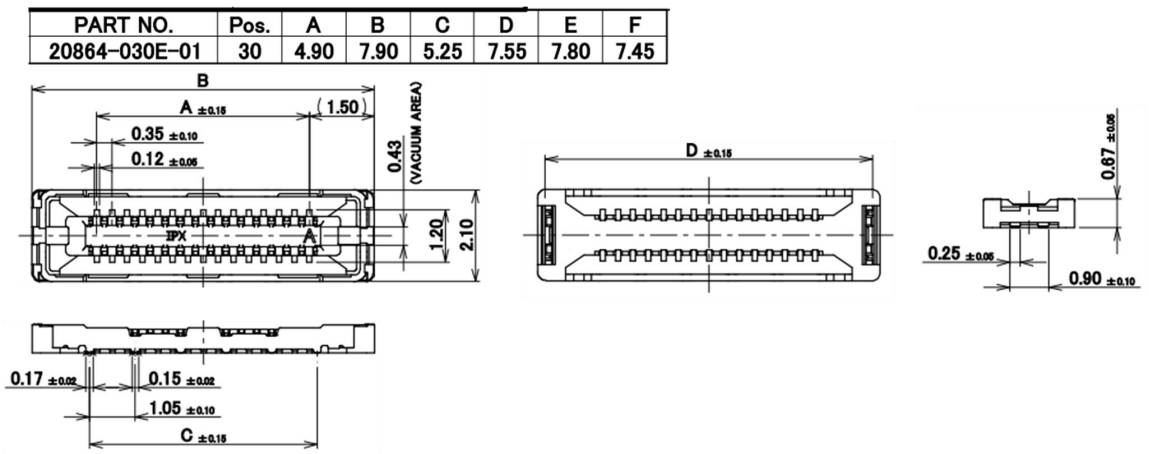

Figure 19: Package size of IPEX MPN20864-030E-01

5.2.2 QTM527 IF connector and GPIO Port Mapping

There are 8 IF Connectors in SIM8300G design, need coaxial cables mating with the RF connector. Cable specification refers to the next chapter.

Table 11: the connection of QTM with IF connector and GPIO port of SIM8300G

QTM527 Module	QTM IF1 PORT	QTM IF2 PORT	QTM527 PON
1#	IFH1	IFV1	QTM3_PON
2#	IFH2	IFV2	QTM0_PON
3#	IFH3	IFV3	QTM1_PON
4#	IFH4	IFV4	QTM2_PON

5.2.3 QTM527 Reference Design

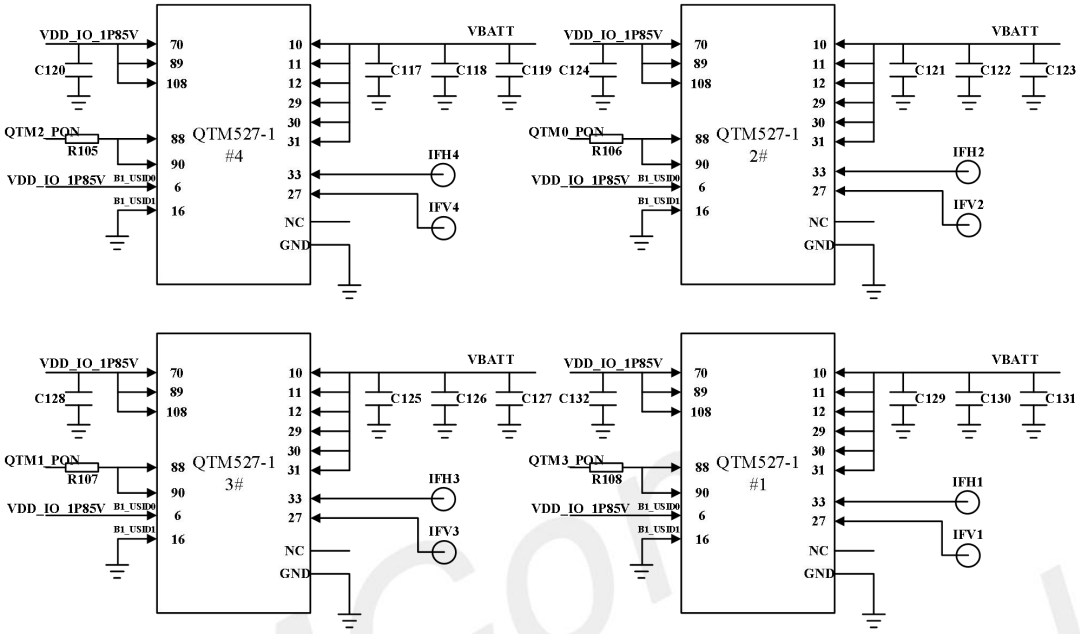

Figure 20: QTM527-1 reference Schematic Design

NOTE

see the parts list for the parts value.

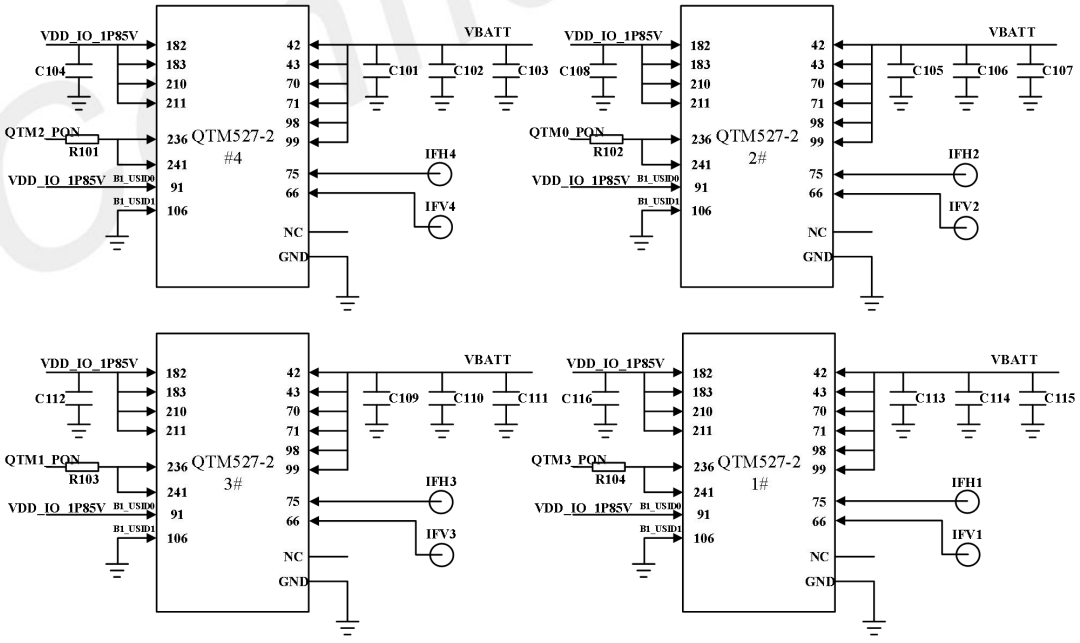

Figure 21: QTM527-2 reference Schematic Design

NOTE

see the parts list for the parts value.

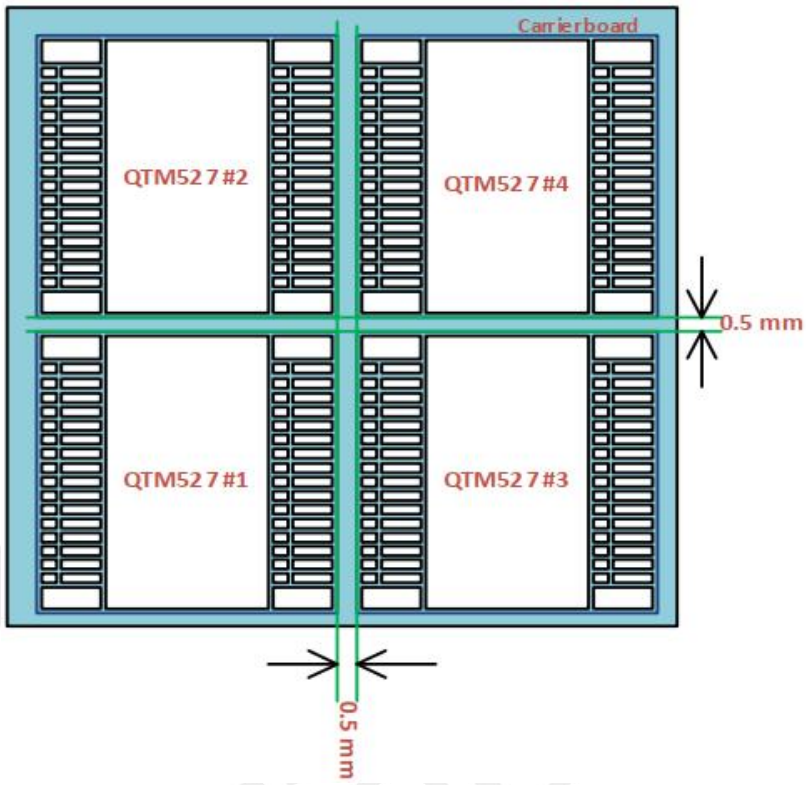

Figure 22: Recommended placement of QTM527

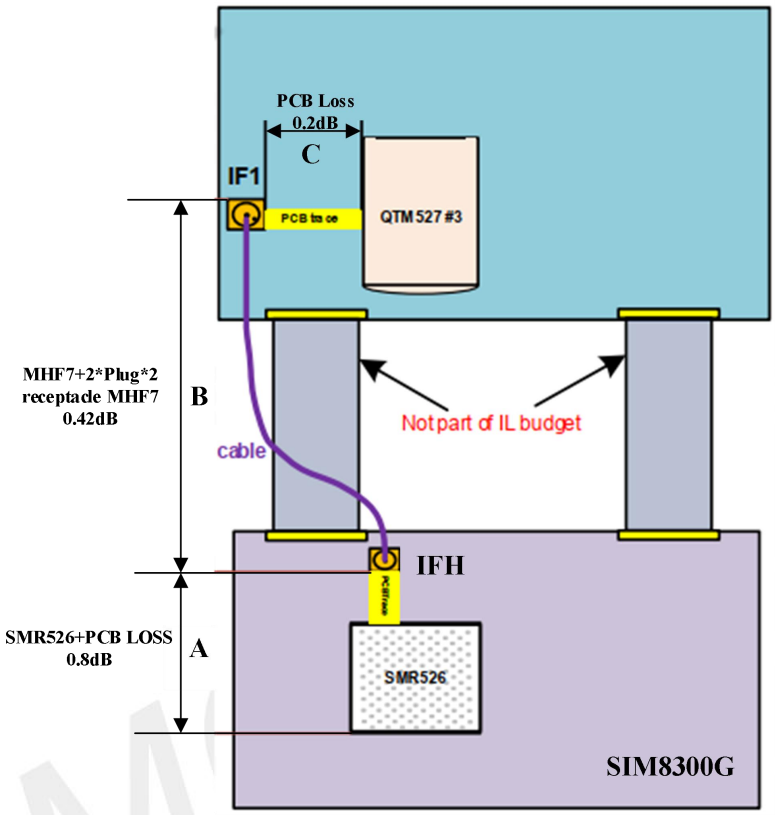

Figure 23: mmW Connection Design and IF Loss Example of QTM527

NOTE

1. IF signal path insertion loss A+B+C should be less than 2dB.
2. Total insertion loss (including internal loss of SMR526 and QTM527) is required to be less than 7dB.

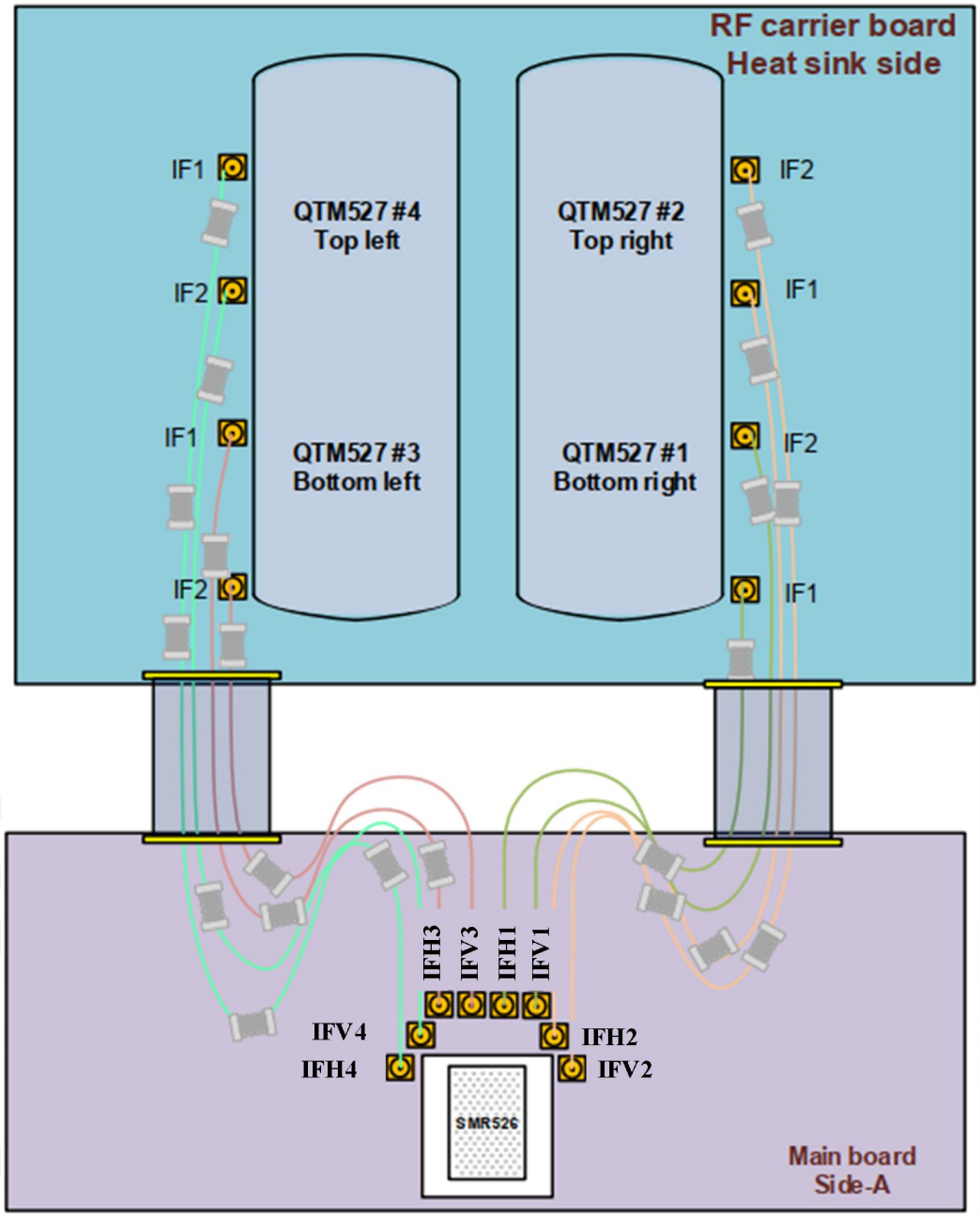

Figure 24: the Whole Design with 4 QTM527

NOTE

1. The length of each QTM527 and the two coaxial cables connected to the main board must be equal.
2. Unequal coaxial lines will lead to performance degradation.
3. The picture is the back of the board (cooling surface).

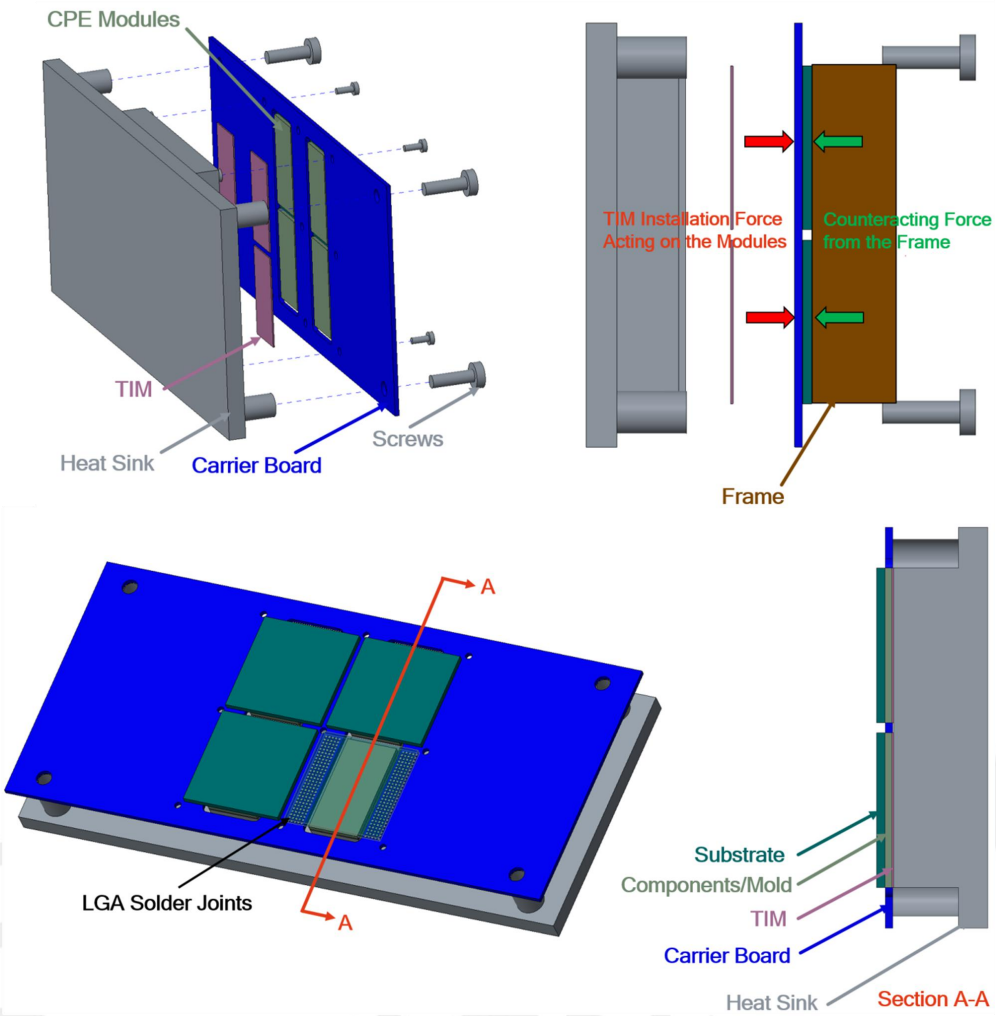

Figure 25: Thermal Design

Figure 26: Radome Design

NOTE

1. It can be changed according to different scanning angles.
2. The dielectric constant of the radome must be determined during design.
3. The thickness of the radome shall not be more than 1/2 wavelength.
4. The radome should be as far away from the antenna as possible, preferably with a gap of 5-10 wavelengths.

Table 12: Power Supply Requriements

	QTM527 Voltage			QTM527 Current
Power Supply	MIN.	TYP.	MAX.	MAX.
VPH_PWR	determined	3.7V	determined	2.1A
VDD_1P9	determined	1.904V	determined	200mA

Table 13: IF Isolation Requriements

Isolation Requriements (dB)	IFV1	IFV2	IFV3	IFV4	IFH1	IFH2	IFH3	IFH4
IFV1		20	20	20	40	35	35	35
IFV2	20		20	20	35	40	35	35
IFV3	20	20		20	35	35	40	35
IFV4	20	20	20		35	35	35	40
IFH1	40	35	35	35		20	20	20
IFH2	35	40	35	35	20		20	20
IFH3	35	35	40	35	20	20		20
IFH4	35	35	35	40	20	20	20	

NOTE

1. IF signal traces must be in accordance with 50 ohm strictly.
2. Route IF lines as striplines with the highest priority. Shield each IF trace with via fences to achieve high isolation.

5.3 Parts List

Table 14: Recommended BOM list of Reference Design

Item	Ref des	Part description	Qty	Recommedation
1	C101 C102 C104 C105 C106 C108 C109 C110 C112 C113 C114 C116 C117 C118 C120 C121 C122 C124 C125 C126 C128 C129 C130 C132	CAP 22PF±5% 50V CH0402	24	
2	C103 C107 C111 C115 C119 C123 C127 C131	CAP 10UF±20% 10V CH0402	8	
3	R101 R102 R103 R104 R105 R106 R107 R108	RES 0R +/-5% 1/20W CH0402	8	
4	C301 C302 C303 C304 C305 C306 C307 C308	CAP 100PF +/-5% 50V CH0402	8	

5.4 RF Plug Recommendation

When choosing antennas, user should pay attentions to the connector on antenna which should match with the connector on the module. The dimension of the connector on SIM8300G is 2.0*2.0*0.53mm, which is from IPEX, and the Part Number is 20981-001E-01.

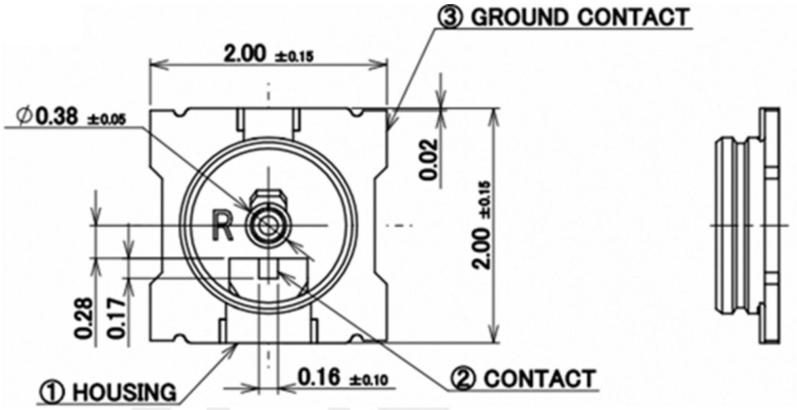

Figure 27: Antenna connector

Table 15: the major specifications of the RF connector

Item	Specification
Nominal Frequency Range	DC ~ 15 GHz
Nominal Impedance	50Ω
Temperature Rating	-40˚C ~ + 90˚C
Initial Contact Resistance (without conductor resistance)	Center contact 20.0mΩmax. Outer contact 20.0mΩmax.
Voltage Standing Wave Ratio (V.S.W.R.)	≤1.30(DC~3GHz) ≤1.35(3GHz~6GHz) ≤1.40(3GHz~9GHz) ≤1.45(9GHz~12GHz) ≤1.50(12GHz~15GHz)

Coaxial cables matching the RF connector in SIM8300G, that SIMCom recommends to use, is 20980-001R-13 from IPEX, shown as follows.

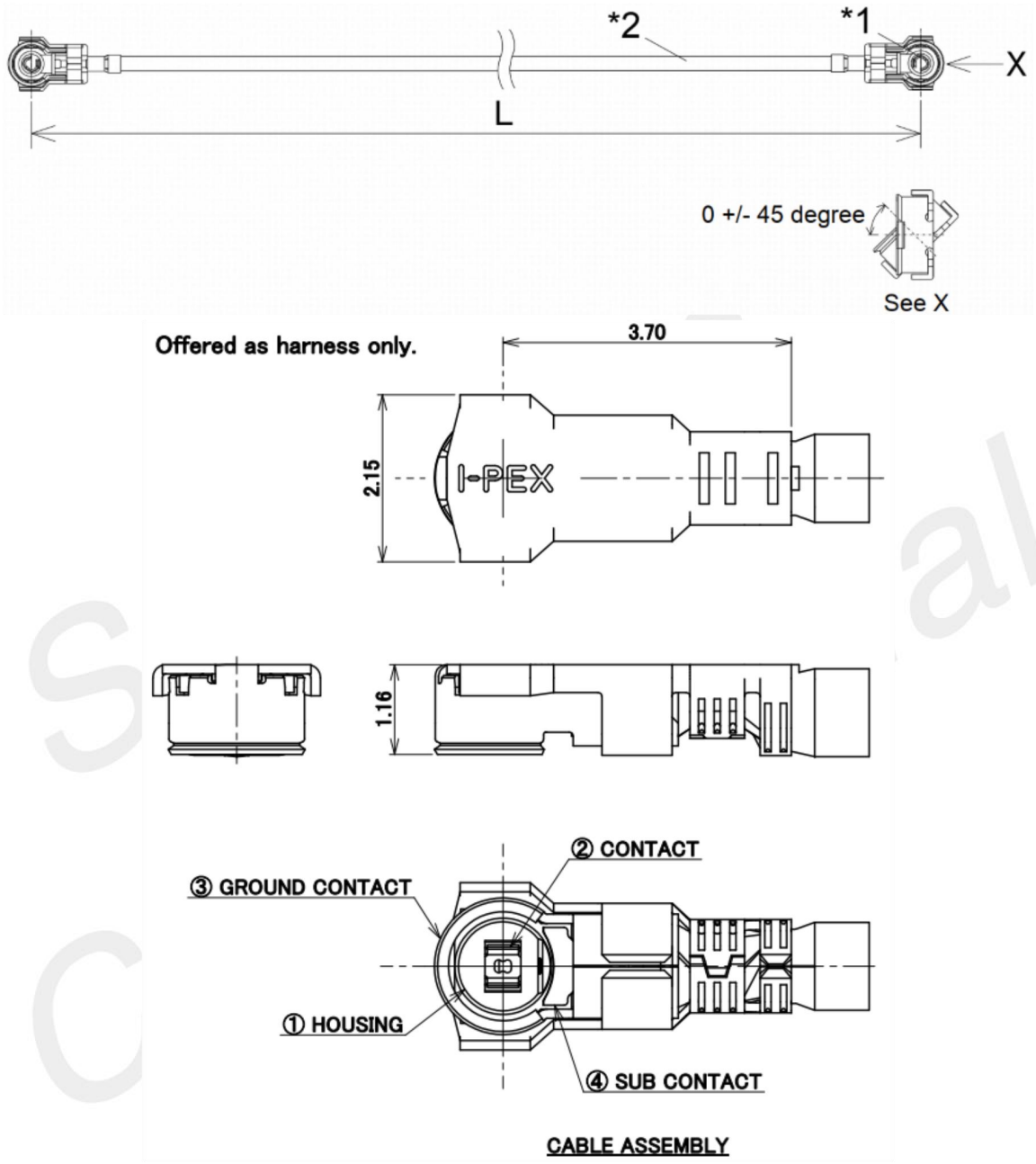

Figure 28: Dimension Spec of 20980-001R-13