FCC Composite Gain Test Report

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Basic Information

EUT Description:	AX5400 Ceiling Mount Wi-Fi 6 Access Point		
Brand Name:	tp-link		
Model Name:	EAP670		
Tested By:	Yangjunyu Yang Junyu	Date:	2025/11/24

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7.2 DG_NSSmax Test Data .... 错误!未定义书签。

1 Operation Mode and Antenna Information

1.1 EUT Operation Mode

The EAP670(MODEL NUMBER) is the dualr-band wireless router of 4 internal antennas, of which 3 were 2.4G & 5G Dual-Band antennas and 1 were 5G antennas

1.2 Antenna Information

The Antennas are internal , the Locations of Antennas are shown below:

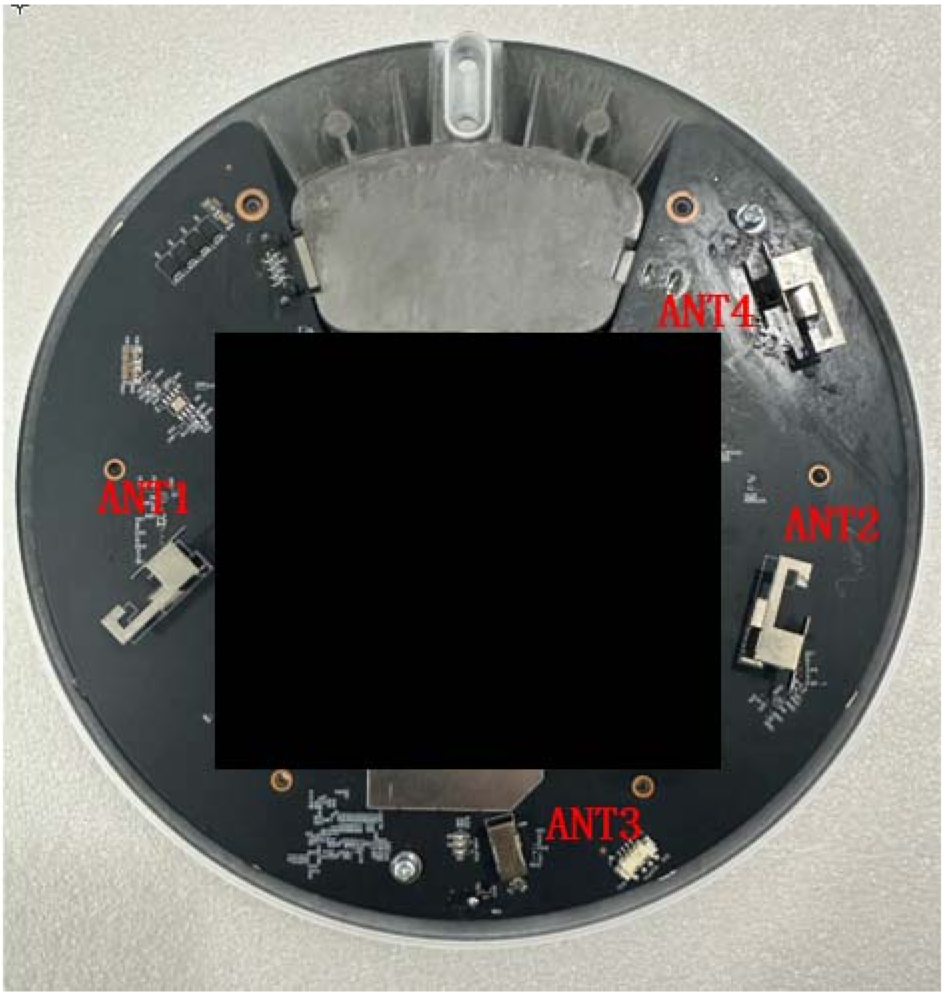

Figure 1-1 Locations of Antennas

The Antenna Information was shown below:

Table 1-1 Antenna Information

Antenna Position	Antenna Type	Connector	Mode of operation
Ant1	Pifa	Microstrip line	2.4G&5G
Ant2	Pifa	Microstrip line	2.4G&5G
Ant3	Pifa	Microstrip line	5G

Ant4	Pifa	Microstrip line	2.4G&5G

1.3 Test Frequency

Test frequency bands are shown in *Table 1-2*.

Table 1-2 Test Frequency

Frequency Band(MHz)
2400-2500
5150-5250
5250-5350
5470-5725
5725-5925

2 Test System

2.1 Test Equipment

Table 2-1Test System

Equipment	Model	Manufacturer	S/N	Cali. Interval	Cali. Due Date
Chamber	Rayzone2800	GTS	MY53470435	12months	2026/04/15
Vector Network Analyzer	E5071C	Keysight	MY46315238	24months	2026/05/27

2.2 Test Software

Table 2-2 Test Software

Software	Version	Function
GTS MaxSign100	V2.1	Passive Antenna Measurements

3 Test Summary

3.1 Measurement Environment

This measurement experiment adopted an antenna near-field measurement system, and the diagram of the measurement system was shown in Figure 3-1. The excitation signal was generated by the Keysight E5071C (300kHz-20GHz). Under the control of the central computer, the probe rotated in the θ direction, and the EUT rotated in the φ direction with the turntable. The probe sampling frame received and collected signals in the near-field range of the EUT. The software system which was controlled by the central computer completed the processing, output and display of the test data.

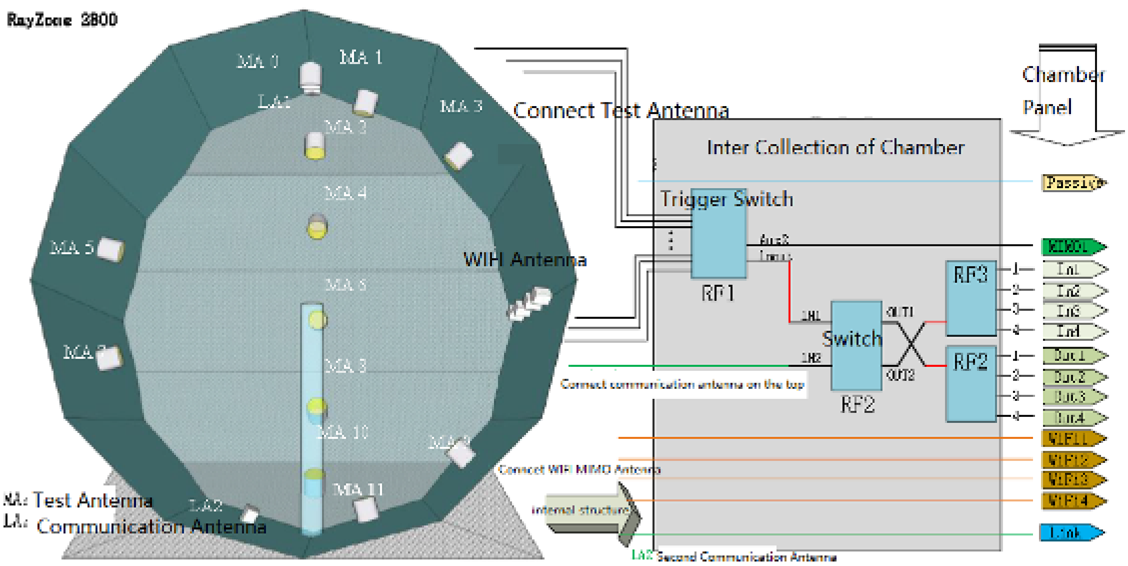

Figure 3-1 Schematic diagram of antenna near-field measurement system

The test site was a full anechoic chamber with a size of 3.0m×3.1m×2.97m, which was built by GTS Rayzone2800. All six surfaces of the anechoic chamber were pasted with absorbing materials. And the chamber was calibrated by the authoritative third-party lab every year. The antenna anechoic chamber measurement system adopted a 13-probe multi-probe system. The probe antennas were evenly distributed on the spherical surface surrounding the EUT, and theirs operating frequency was 600MHz~8.5GHz.

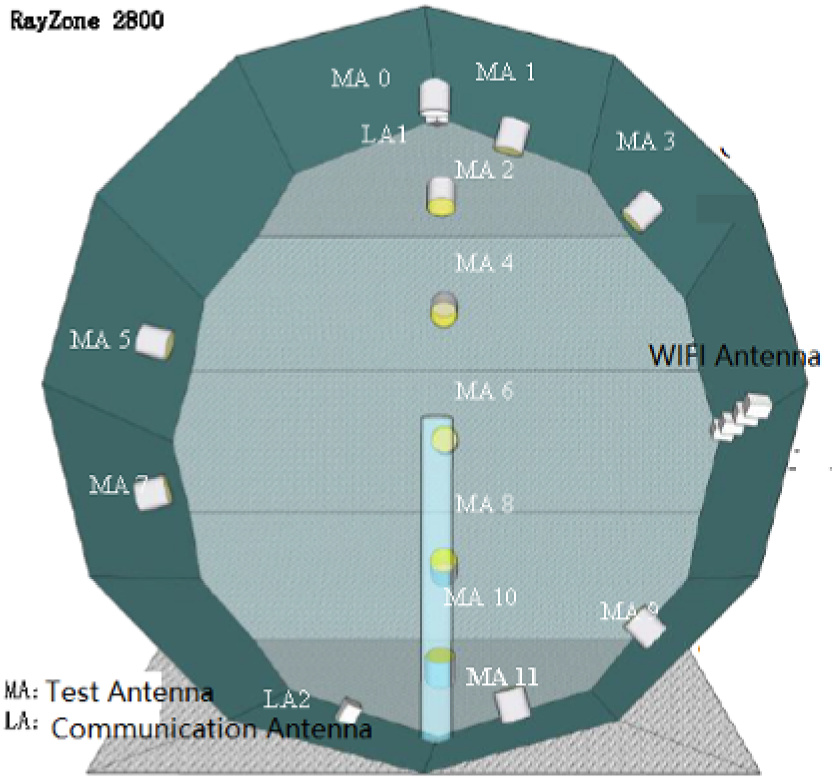

Figure 3-2 Antenna anechoic chamber for near-field measurement

During the measurement, the probe antennas were rotated in the θ direction under the control of the probe holder to sample the near-field data at the θ angle. At the same time, the EUT rotated with the turntable in the φ direction to sample the near field data at the φ angle. The system diagram was shown in Figure 3-3. From the sampling results, the EUT's near-field test data of θ component, φ component and total component could be obtained.

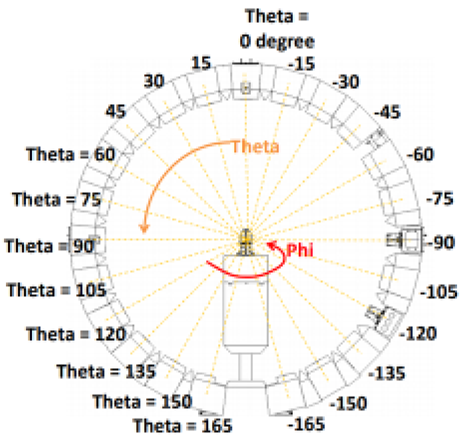

Figure 3-3 System diagram

Before the measurement, calibrated the vector network analyzer, and then connected the input end of each antenna to the output end of the vector network analyzer, and evenly the antennas to be measured. The Calibration information was shown in table 2-1.

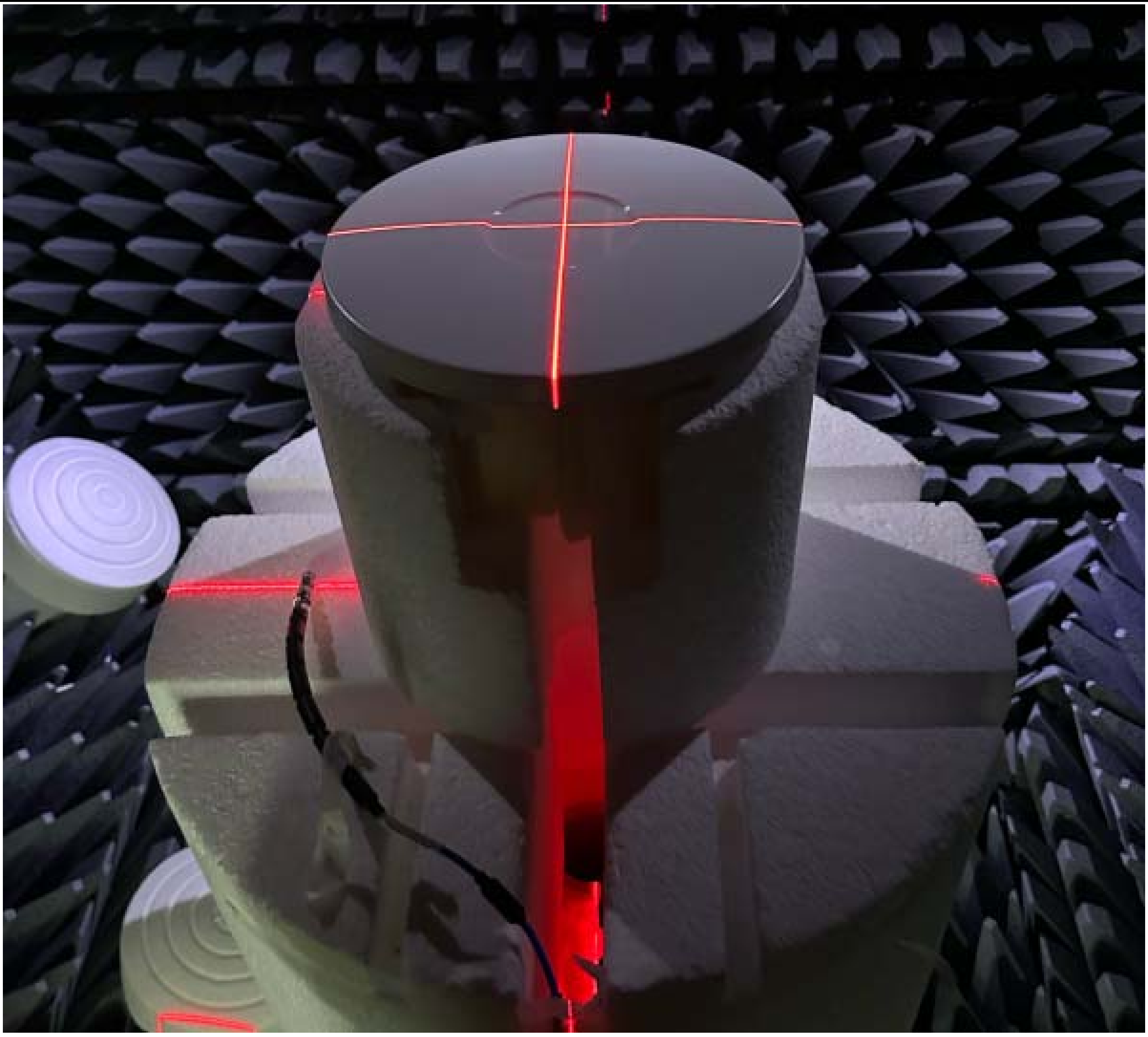

Figure 3-4 Antennas measurement diagram

Table 3-1 Calibration information

Measurement Class	Standard
Cal Type	2p/1-2
Cal Kit	N4691B

3.2 Measurement Quantity

In this measurement experiment, the Directional Gain was measured at a certain frequency interval within the whole frequency range. The measurement frequency interval of the 2.4G antennas was 10MHz, while the 5GL and 5GU and 6G antennas was 50MHz.

3.3 Test Method

During the measurement, the probe antennas were rotated in the θ direction under the control of the probe holder to sample the near-field data at the θ angle. At the same time, the EUT rotated with the turntable in the φ direction to sample the near field data at the φ angle. The sampling accuracy was 15°. The system diagram was shown in Figure 2-6. From the sampling results, the EUT's near-field test data of θ component, φ component and total component could be obtained.

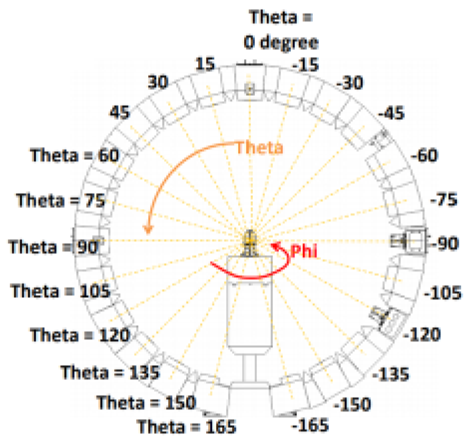

Figure 3-5 Test angle

3.4 Directional Gain Calculations

Multiple antennas system, each of which has one of two (or three) polarizations that are orthogonal to one another (i.e., cross polarized), The total gain—including array gain—is computed separately for each of the two (or three) polarizations using the procedures presented in this document. The highest of the total gains shall apply.

Theoretical Directional Gain represented the theoretical value calculated by formula 2-1. As we all know, the effect of array gain must be included in the calculation of overall directional antenna gain for devices that transmit on multiple outputs simultaneously in the same band, in the same or in overlapping frequency ranges. Therefore, in formula 2-1, the directional gain calculation needs to include all directions and all Frequencies and all Polarizations, and then take the maximum value as the final directional gain value. Therefore, the calculation formula of theoretical directional gain value can be modified as formula 2-2

$$\text{Directional Gain} = 10\log\left[\frac{\sum_{j=1}^{N_{SS}}\left\{\sum_{k=1}^{N_{ANT}} g_{j,k}\right\}^2}{N_{ANT}}\right] \quad (2\text{-}1)$$

Where

Nss = the number of independent spatial streams of data; NSS =1.

Nant = the total number of antennas: NANT =4 for 2.4G & 5G antennas

$g_{j,k} = 10^{G_k/20}$ if the kth antenna is being fed by spatial stream j, or zero if it is not;

G_k is the gain in dBi of the kth antenna .

$$\text{Directional Gain} = \text{Maximum}\left[10\log\left[\frac{\sum_{j=1}^{N_{SS}}\left\{\sum_{k=1}^{N_{ANT}} g_{j,k}\right\}^2}{N_{ANT}}\right]\right] \quad (2\text{-}2)$$

Maximum function is the max directional gain overall directions and all frequency all polarizations.

3.5 Directional Gain (Nss=N_{ant}) Calculations

Multiple antennas system, each of which has one of two (or three) polarizations that are orthogonal to one another (i.e., cross polarized), The total gain—including array gain—is computed separately for each of the two (or three) polarizations using the procedures presented in this document. The highest of the total gains shall apply.

Theoretical Directional Gain represented the theoretical value calculated by formula 2-1. As we all know, the effect of array gain must be included in the calculation of overall directional antenna gain for devices that transmit on multiple outputs simultaneously in the same band, in the same or in overlapping frequency ranges. Therefore, in formula 2-1, the directional gain calculation needs to include all directions and all Frequencies and all Polarizations, and then take the maximum value as the final directional gain value. Therefore, the calculation formula of theoretical combined gain value can be modified as formula 2-2

$$\text{Directional Gain} = 10\log\left[\frac{\sum_{j=1}^{N_{ANT}} g_{j,k}}{N_{ANT}}\right] \tag{2-3}$$

Where

Nss = the number of independent spatial streams of data; NSS =Nant.

Nant = the total number of antennas: NANT =4 for 2.4G & 5G & 6G antennas

$g_{j,k} = 10^{G_k/10}$ if the kth antenna is being fed by spatial stream j, or zero if it is not;

G_k is the gain in dBi of the kth antenna .

$$\text{Directional Gain} = \text{Maximum}\left[10\log\left[\frac{\sum_{j=1}^{N_{ANT}} g_{j,k}}{N_{ANT}}\right]\right] \tag{2-4}$$

Maximum function is the max directional gain overall directions and all frequency all polarizations.

3.6 Test Procedure

The calculation method of DG (Directional Gain) in this scheme is summarized as follows:

1) The antenna anechoic chamber is used to measure the gain of each antenna, the gain of each antenna at this angle is taken every 15° to calculate the Directional Gain;

2) Use formula below to calculate and the DG_Nss=1 of the system at this angle is obtained

$$\text{Directional Gain} = 10\log\left[\frac{\sum_{j=1}^{N_{SS}}\left\{\sum_{k=1}^{N_{ANT}} g_{j,k}\right\}^2}{N_{ANT}}\right] \tag{2-5}$$

3) Use formula below to calculate and the DG_Nssmax of the system at this angle is obtained

$$\text{Directional Gain} = 10\log\left[\frac{\sum_{j=1}^{N_{ANT}} g_{j,k}}{N_{ANT}}\right] \tag{2-6}$$

4) For each frequency point, the Directional Gain value under 24 different angles can be obtained, and finally the maximum value is taken as the system Directional Gain value.

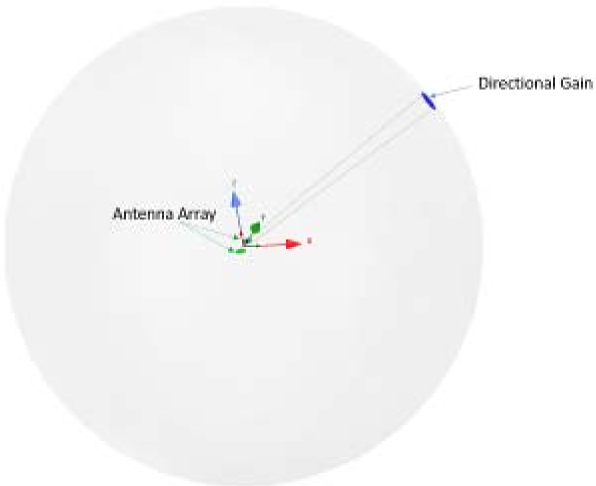

Figure 3-6 Directional Gain Calculation Sketch Map

4 Measured Value and Maximum Gain Positions

4.1 Antenna Number

The Antennas number for measured in the following section was shown below:

Table 4-1 Antennas number

Antenna Number	Antenna Position	
	2G	5G
Ant1	Ant1	Ant1
Ant2	Ant2	Ant2
Ant3		Ant3
Ant4		Ant4

4.2 2G

4.2.1 DG_1SS Max Value Position

Table 4-2 DG_1SS Max Value Position

Frequency(GHz)	2.40~2.50
Ant1(dBi)	4.36
Ant2(dBi)	1.54
Polarization	Theta
Φ (°)	150
θ (°)	45

4.2.2 DG_1SS Max Value Position Calculation

Table 4-3 DG_1SS Max Value Position Calculation

Frequency(GHz)	2.40~2.50
Ant1[10^(G/20)]	10^(4.36/20)
Ant2[10^(G/20)]	10^(1.54/20)
Ant1[10^(G/20)] value	1.652
Ant2[10^(G/20)] value	1.194
Sum of Ants Value(Antmax)	2.846
DG[10*Log(Antmax^2/Nant)] (dBi)	6.07

4.2.3 DG_NSSmax Max Value Position

Table 4-4 DG_NSSmax Max Value Position

Frequency(GHz)	2.40~2.50
Ant1(dBi)	4.44
Ant2(dBi)	1.39
Polarization	Theta
Φ (°)	150
θ (°)	45

4.2.4 DG_NSSmax Max Value Position Calculation

Table 4-5 DG_NSSmax Max Value Position Calculation

Frequency(GHz)	2.40~2.50
Ant1[10^(G/10)]	10^(4.44/10)
Ant2[10^(G/10)]	10^(1.39/10)
Ant1[10^(G/10)] value	2.78
Ant2[10^(G/10)] value	1.377
Sum of Ants Value(Antmax)	4.157
DG[10*Log_{10}(Antmax/Nant)] (dBi)	3.18

4.3 5G

4.3.1 DG_1SS Max Value Position

Table 4-6 DG_1SS Max Value Position

Frequency(GHz)	5.15~5.25	5.25~5.35	5.47~5.725	5.725~5.925
Ant1(dBi)	4.02	3.96	2.19	2.13
Ant2(dBi)	4.02	3.84	1.57	2.01
Ant3(dBi)	0.55	0.27	3.72	3.59
Ant4(dBi)	5.64	5.63	5.88	5.72
Polarization	Theta	Theta	Theta	Theta
Φ (°)	180	180	225	225
θ (°)	60	60	45	45

4.3.2 DG_1SS Max Value Position Calculation

Table 4-7 DG_1SS Max Value Position Calculation

Frequency(GHz)	5.15~5.25	5.25~5.35	5.47~5.725	5.725~5.925
Ant1[10^(G/20)]	10^(4.02/20)	10^(3.96/20)	10^(2.19/20)	10^(2.13/20)

Ant2[10^(G/20)]	10^(4.02/20)	10^(3.84/20)	10^(1.57/20)	10^(2.01/20)
Ant3[10^(G/20)]	10^(0.55/20)	10^(0.27/20)	10^(3.72/20)	10^(3.59/20)
Ant4[10^(G/20)]	10^(5.64/20)	10^(5.63/20)	10^(5.88/20)	10^(5.72/20)
Ant1[10^(G/20)] value	1.589	1.578	1.287	1.278
Ant2[10^(G/20)] value	1.589	1.556	1.198	1.26
Ant3[10^(G/20)] value	1.065	1.032	1.535	1.512
Ant4[10^(G/20)] value	1.914	1.912	1.968	1.932
Sum of Ants Value(Antmax)	6.157	6.077	5.987	5.982
DG[10*Log(Antmax^2/Nant)] (dBi)	9.77	9.65	9.52	9.52

4.3.3 DG_NSSmax Max Value Position

Table 4-8 DG_NSSmax Max Value Position

Frequency(GHz)	5.15~5.25	5.25~5.35	5.47~5.725	5.725~5.925
Ant1(dBi)	4.02	3.96	2.19	2.13
Ant2(dBi)	4.02	3.84	1.57	2.01
Ant3(dBi)	0.55	0.27	3.72	3.59
Ant4(dBi)	5.64	5.63	5.88	5.72
Polarization	Theta	Theta	Theta	Theta
Φ (°)	180	180	225	225
θ (°)	60	60	45	45

4.3.4 DG_NSSmax Max Value Position Calculation

Table 4-9 DG_NSSmax Max Value Position Calculation

Frequency(GHz)	5.15~5.25	5.25~5.35	5.47~5.725	5.725~5.925
Ant1[10^(G/10)]	10^(4.02/10)	10^(3.96/10)	10^(2.19/10)	10^(2.13/10)
Ant2[10^(G/10)]	10^(4.02/10)	10^(3.84/10)	10^(1.57/10)	10^(2.01/10)
Ant3[10^(G/10)]	10^(0.55/10)	10^(0.27/10)	10^(3.72/10)	10^(3.59/10)
Ant4[10^(G/10)]	10^(5.64/10)	10^(5.63/10)	10^(5.88/10)	10^(5.72/10)
Ant1[10^(G/10)] value	2.523	2.489	1.656	1.633
Ant2[10^(G/10)] value	2.523	2.421	1.435	1.589
Ant3[10^(G/10)] value	1.135	1.064	2.355	2.286
Ant4[10^(G/10)] value	3.664	3.656	3.873	3.733
Sum of Ants Value(Antmax)	9.846	9.63	9.319	9.24
DG[10*Log_{10}(Antmax/Nant)] (dBi)	3.91	3.82	3.67	3.64

5 Test and Calculate Result

5.1 Peak Antenna Gain（Single）

Table 5-1 Antenna Test Result

Frequency Band(MHz)	Ant1	Ant2	Ant3	Ant4
2400-2500	4.44dBi	4.99dBi		
5150-5250	5.41dBi	5.21dBi	5.68dBi	5.77dBi
5250-5350	5.57dBi	5.08dBi	5.52dBi	5.63dBi
5470-5725	6.02dBi	4.45dBi	5.86dBi	5.88dBi
5725-5925	5.41dBi	4.26dBi	4.21dBi	5.72dBi

5.2 DG_1SS Calculate Result

Table 5-2 Test & Calculate Result

Frequency Band(MHz)	Max Combined Gain	Polarization/Φ (°) / θ (°)
2400-2450	6.07dBi	Theta/150/45
5150-5250	9.77dBi	Theta/180/60
5250-5350	9.65dBi	Theta/180/60
5470-5725	9.52dBi	Theta/225/45
5725-5925	9.52dBi	Theta/225/45

5.3 DG_NSSmax Calculate Result

Table 5-3Test & Calculate Result

Frequency Band(MHz)	Max Combined Gain	Polarization/Φ (°) / θ (°)
2400-2450	3.18dBi	Theta/150/45
5150-5250	3.91dBi	Theta/180/60
5250-5350	3.82dBi	Theta/180/60
5470-5725	3.67dBi	Theta/225/45
5725-5925	3.64dBi	Theta/225/45

6 Test Pattern

6.1 Antenna Pattern

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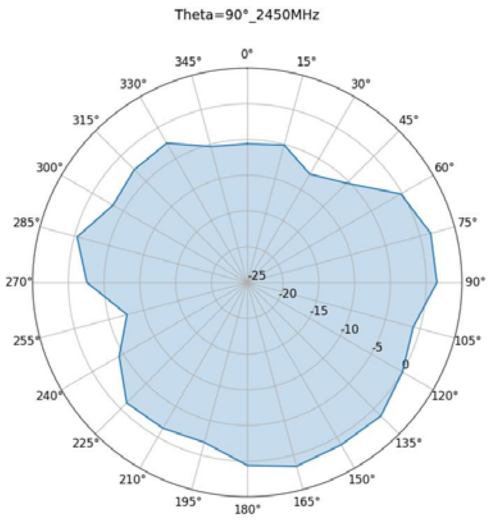
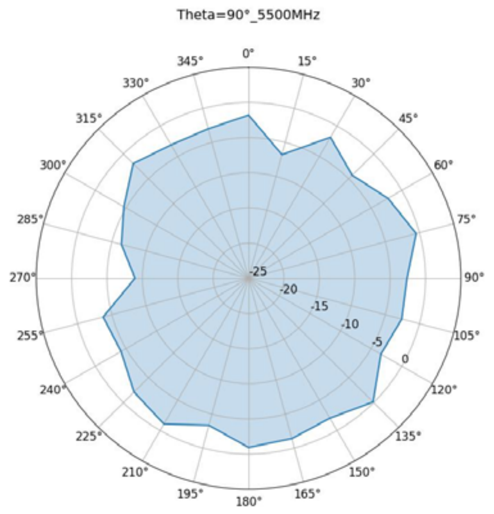
<tr><td>
</td><td>
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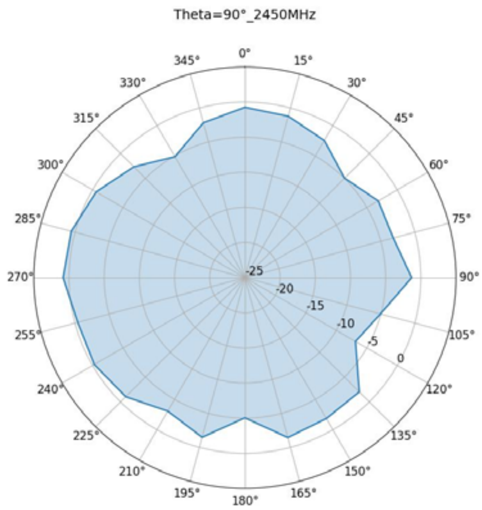
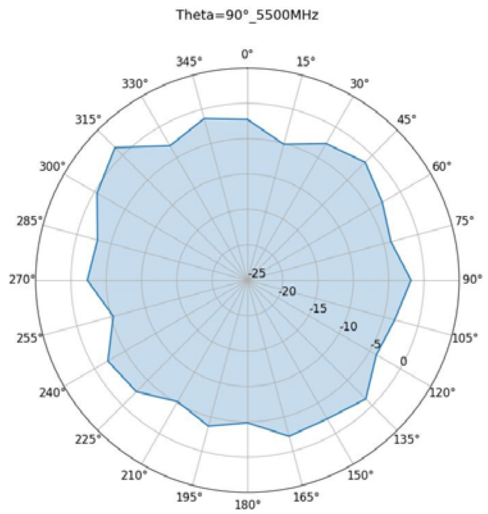
<tr><td>
</td><td>
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<tr><th colspan="2">Ant3</th></tr>
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	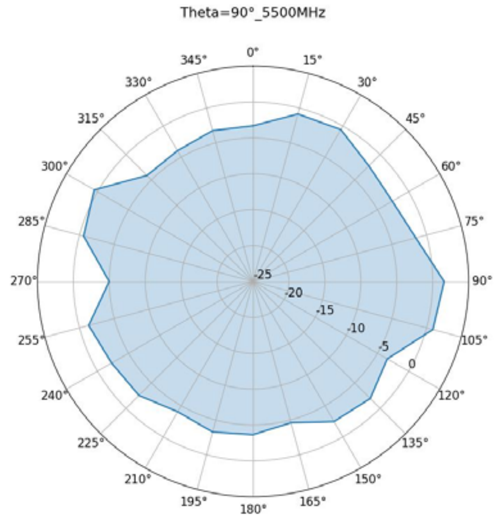
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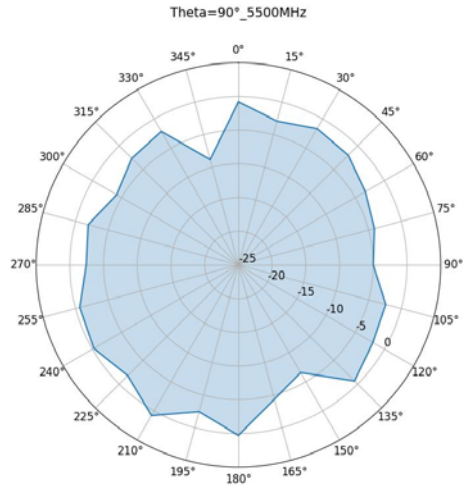
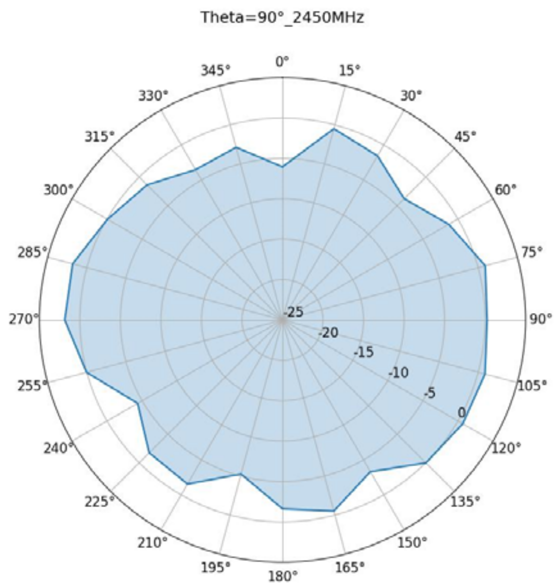
	
Ant4（BLE）	
	

7 Test Pattern

7.1 DG_1SS Test Data