CE Combined Gain Test Report

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Basic Information

EUT Description：	5GHz 867Mbps Long-range Indoor/Outdoor Wireless Bridge		
Brand Name：	tp-link		
Model Name：	EAP220-Bridge		
Tested By：	Yang Yuxiu Yang Yuxiu	Date：	2025/05/16

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1 Operation Mode and Antenna Information

1.1 EUT Operation Mode

The EAP220-Bridge is the Long-range Indoor/Outdoor Wireless Bridge of 2 internal antennas, which were 5G antennas.

1.2 Antenna Information

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

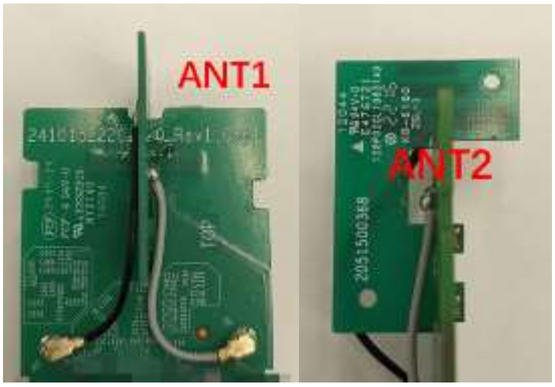


Figure 1-1 Locations of Antennas

The Antenna Information was shown below:

Table 1-1 Antenna Information

Antenna Position	Antenna Type	Connector	Mode of operation
Ant1	Dipole	ipex	5G
Ant2	Dipole	ipex	5G

1.3 Test Frequency

The Listed frequency of each bands are selected to represent each frequency bands.

Table 1-2 Test Frequency

Frequency Band(MHz)	Test Frequency(MHz)
5150-5250	5200
5250-5350	5300
5470-5725	5600
5725-5850	5800

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.

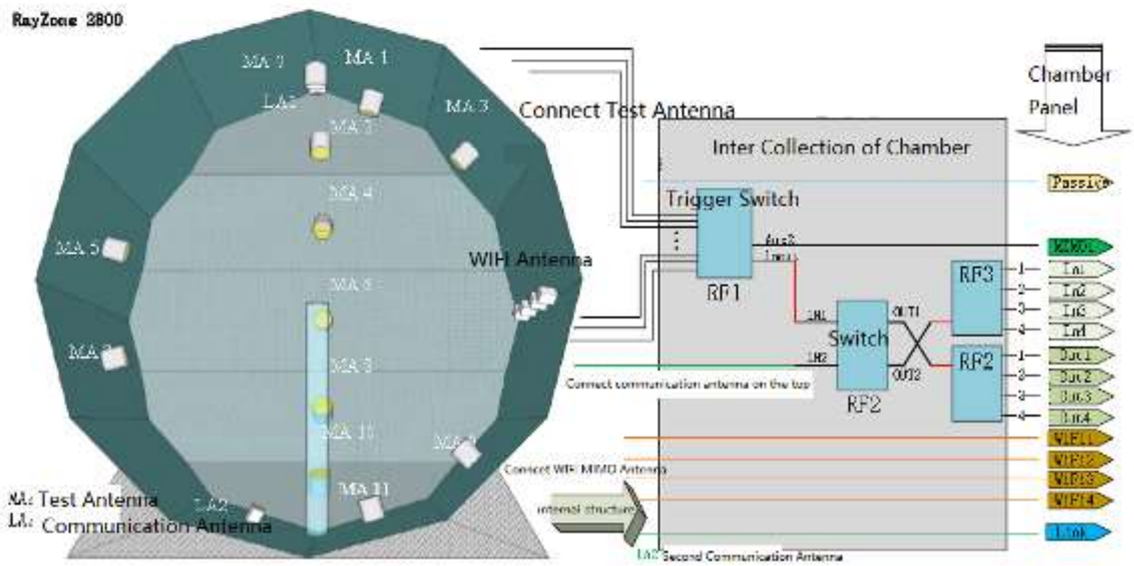


Figure 3-1 Schematic diagram of antenna near-field measurement system

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.

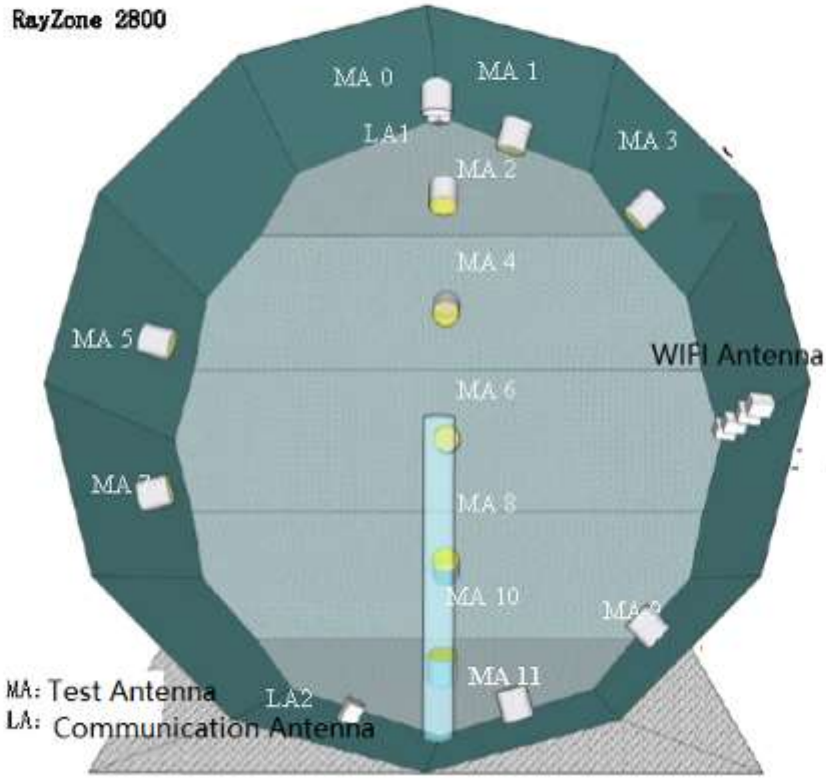


Figure 3-2 Antenna anechoic chamber for near-field measurement

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.

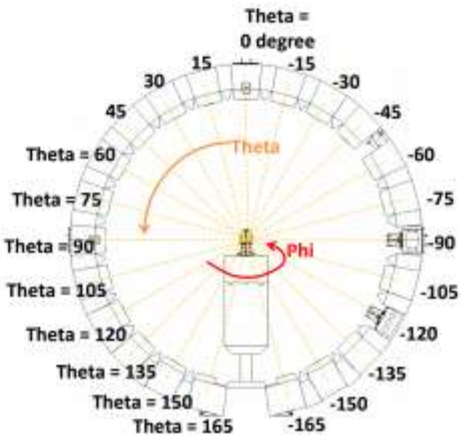


Figure 3-3 System diagram

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.

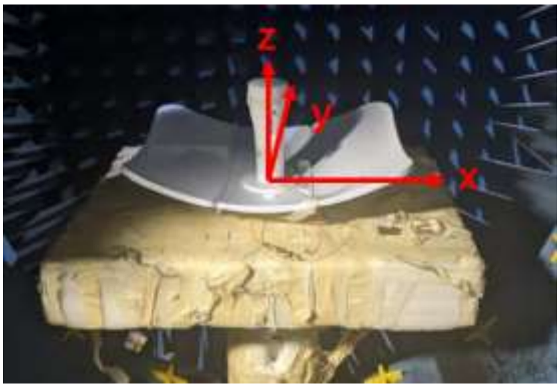


Figure 3-4 Antennas measurement diagram

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.

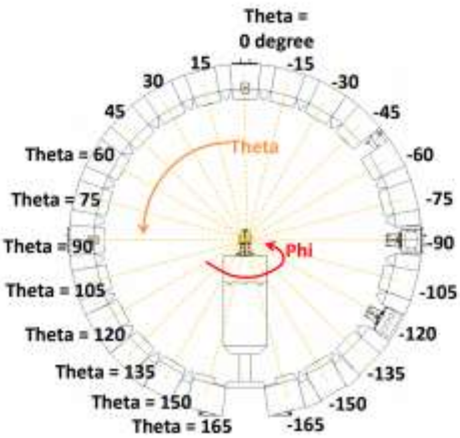


Figure 3-5 Test angle

3.4 Combined 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 Combined 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 combined 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

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

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 .

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

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

3.5 Test Procedure

The calculation method of CG (Combined 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 Combined Gain;

2) Use formula below to calculate and the Combined Gain of the system at this angle is obtained

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

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

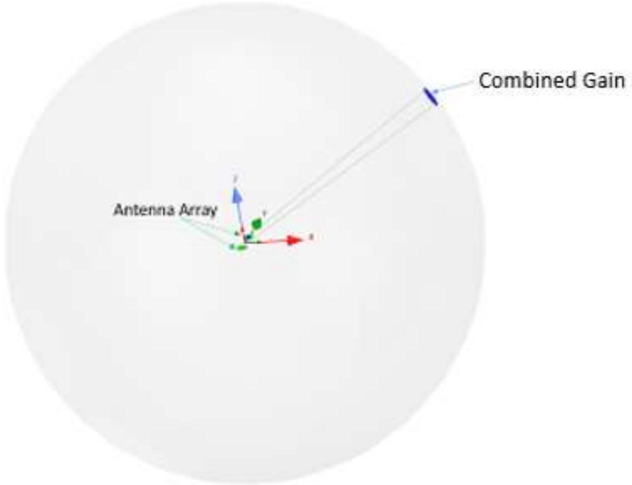


Figure 3-6 Combined Gain Calculation Sketch Map

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
	5G
Ant1	Ant1
Ant2	Ant2

4.2 5G

4.2.1 Combined Gain Max Value Position

Table 4-2 Combined Gain Max Value Position

Frequency(GHz)	5.20	5.30	5.60	5.80
Ant1(dBi)	15.20	15.84	17.19	16.76
Ant2(dBi)	18.00	18.21	17.88	18.95
Polarization	Phi	Phi	Phi	Phi
Φ (°)	79	76	76	73
θ (°)	0	0	0	0

4.2.2 Combined Gain Value Position Calculation

Table 4-3 Combined Gain Max Value Position Calculation

Frequency(GHz)	5.20	5.30	5.60	5.80
Ant1[10^(G/10)]	10^(6.74/10)	10^(7.9/20)	10^(5.04/20)	10^(6.17/20)
Ant2[10^(G/10)]	10^(17.62/10)	10^(17.87/20)	10^(17.6/20)	10^(18.65/20)
Ant1[10^(G/10)] value	4.72	6.16	3.19	4.14
Ant2[10^(G/10)] value	57.76	61.24	57.51	73.36
Sum of Ants Value(Antmax)	62.48	67.4	60.7	77.5
DG[10*Log_{10}(Antmax/Nant)] (dBi)	14.95	15.28	15.50	15.88

5 Test and Calculate Result

5.1 Antenna Test Result

Table 5-1 Antenna Test Result

Frequency(GHz)	5.20	5.30	5.60	5.80
Ant1 MaxGain(dBi)	15.97	16.53	17.19	17.64
Ant2 MaxGain(dBi)	18.04	18.25	18.59	18.96
Max Gain(dBi)	18.04	18.25	18.59	18.96

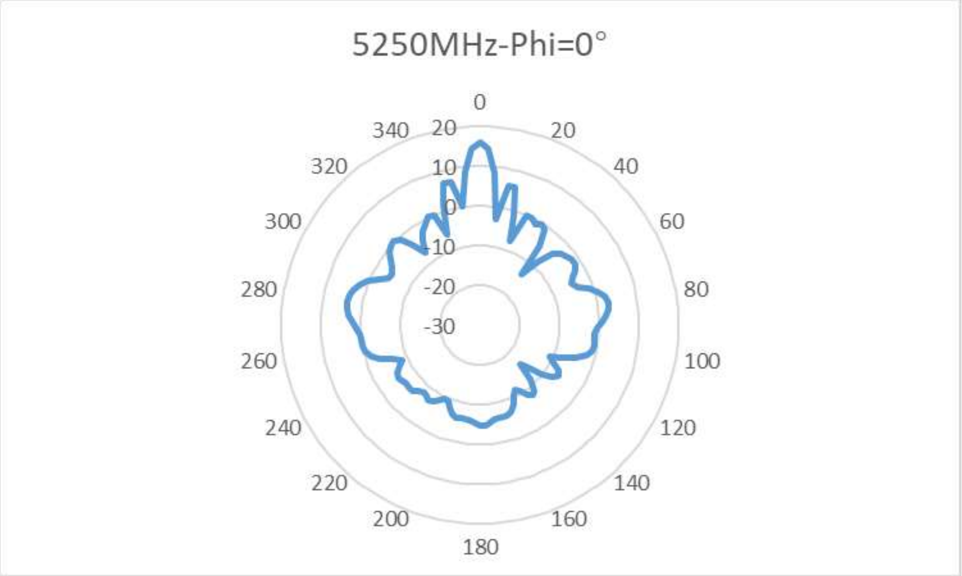
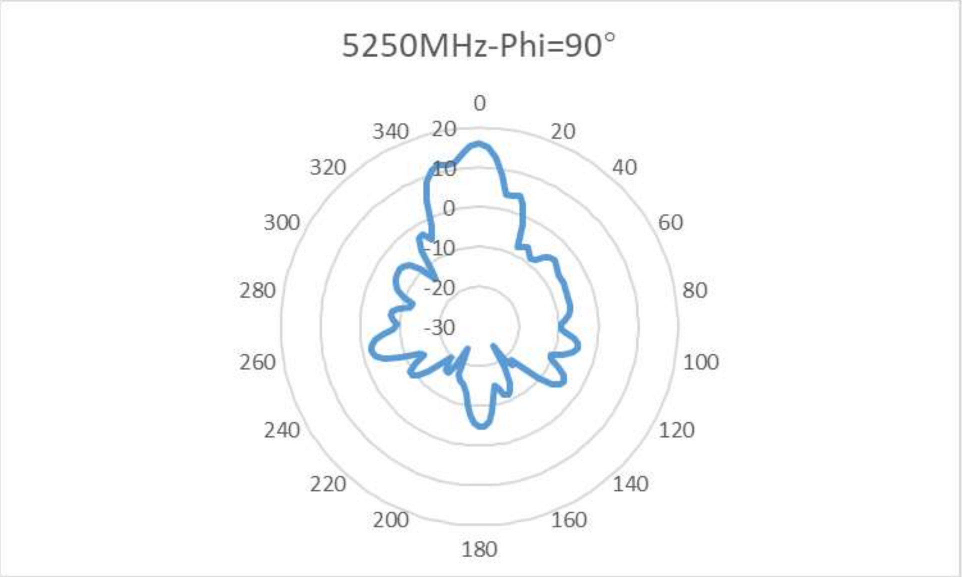
5.2 Combined Gain Calculate Result

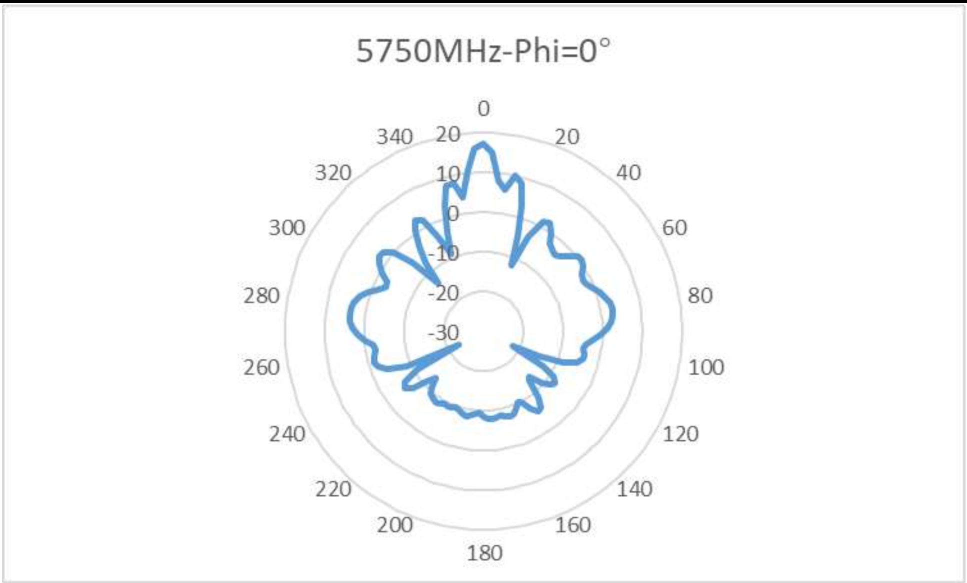
Table 5-2 Test & Calculate Result

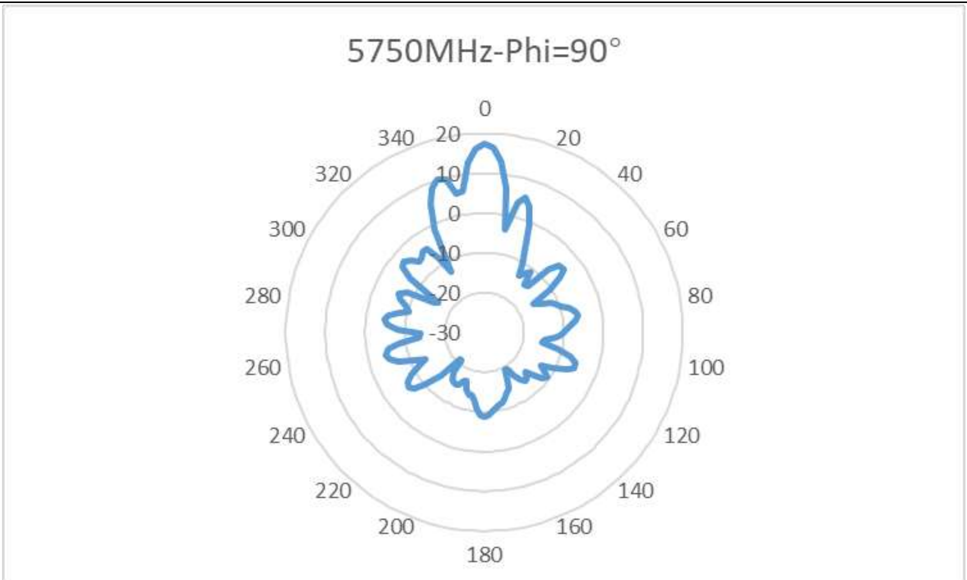
Frequency Band(MHz)	Max Antenna Gain	Max Combined Gain	Polarization/Φ (°) / θ (°)
5150-5250(5200)	18.04dBi	14.95dBi	Phi/79/0
5250-5350(5300)	18.25dBi	15.28dBi	Phi/76/0
5470-5725(5600)	18.59dBi	15.50dBi	Phi/76/0
5725-5850(5800)	18.96dBi	15.88dBi	Phi/73/0

Test Pattern

5.3 Antenna Pattern

Ant1


Ant2





6 Test Pattern

EAP220-Bridge data-6.27.xlsx