



Antenna Composite Gain Test Report

Equipment	AX7800 Tri Band WiFi Router AX6600 Tri Band WiFi Router
Brand Name	ASUS
Model Name	ZenWiFi XT9/ASUS ZenWiFi XT9/XT8/BR-XT9/ZenWiFi Business BR-XT9/XT9
Applicant	ASUSTeK COMPUTER INC. 1F., No. 15, Lide Rd., Beitou Dist., Taipei City 112, Taiwan
Manufacturer (1)	Compal Networking(KunShan) CO., LTD. No.520,Nan Bang RD., Economic & Technical Development Zone, KunShan,JiangSu,China
Manufacturer (2)	ARCADYAN TECHNOLOGY (VIETNAM) CO., LTD. No. D4-5-6, Thang Long Industrial Park (Vinh Phuc), Thien Ke Commune, Binh Xuyen District, Vinh Phuc Province, Vietnam
Sample Received	Oct. 19, 2021
Start Test Date	Mar. 18, 2022
Final Test Date	Mar. 18, 2022



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1. Operation Mode and Antenna Information

Table with 7 columns: Antenna Position, RF Port, Brand Name, Model Name, Ant. Type, Connector, Modes of Operation. Rows include 2G 5GL Ant1-2, 5GH 5.9G Ant1-4.

Note:

Operation Mode (2TX/2RX):

2G 5GL Ant1~2G 5GL Ant2 can be used as transmitting/receiving antenna.

2G 5GL Ant1~2G 5GL Ant2 could transmit/receive simultaneously.

Operation Mode (4TX/4RX):

5GH 5.9G Ant1~5GH 5.9G Ant4 can be used as transmitting/receiving antenna.

5GH 5.9G Ant1~5GH 5.9G Ant4 could transmit/receive simultaneously.

2. Test Frequency

The listed frequency of each bands are selected to represent each frequency bands

Table with 2 columns: Band [MHz], Test Frequency [MHz]. Rows show frequency ranges like 2400-2483.5 and corresponding test frequencies like 2450.

3. Testing Location

Table with 1 row: Testing Location. Content: HWA YA, ADD : No.13-1 & 14-1, Ln. 19, Wen 33rd St., Guishan Dist., Taoyuan City 333, Taiwan R.O.C.

Table with 5 columns: Test Condition, Test Site No., Test Engineer, Test Environment (°C / %), Test Date. Row: Radiated, 05CH03-HY, Rex Liao, 23.5-24.5 / 50-55, Mar. 18, 2022.

Note:

Testing Site Information

Brand Name: TDK

Dimension: 11m*6m*6m

Characteristic: Fully Anechoic Chamber

4. Test Facility and Configuration

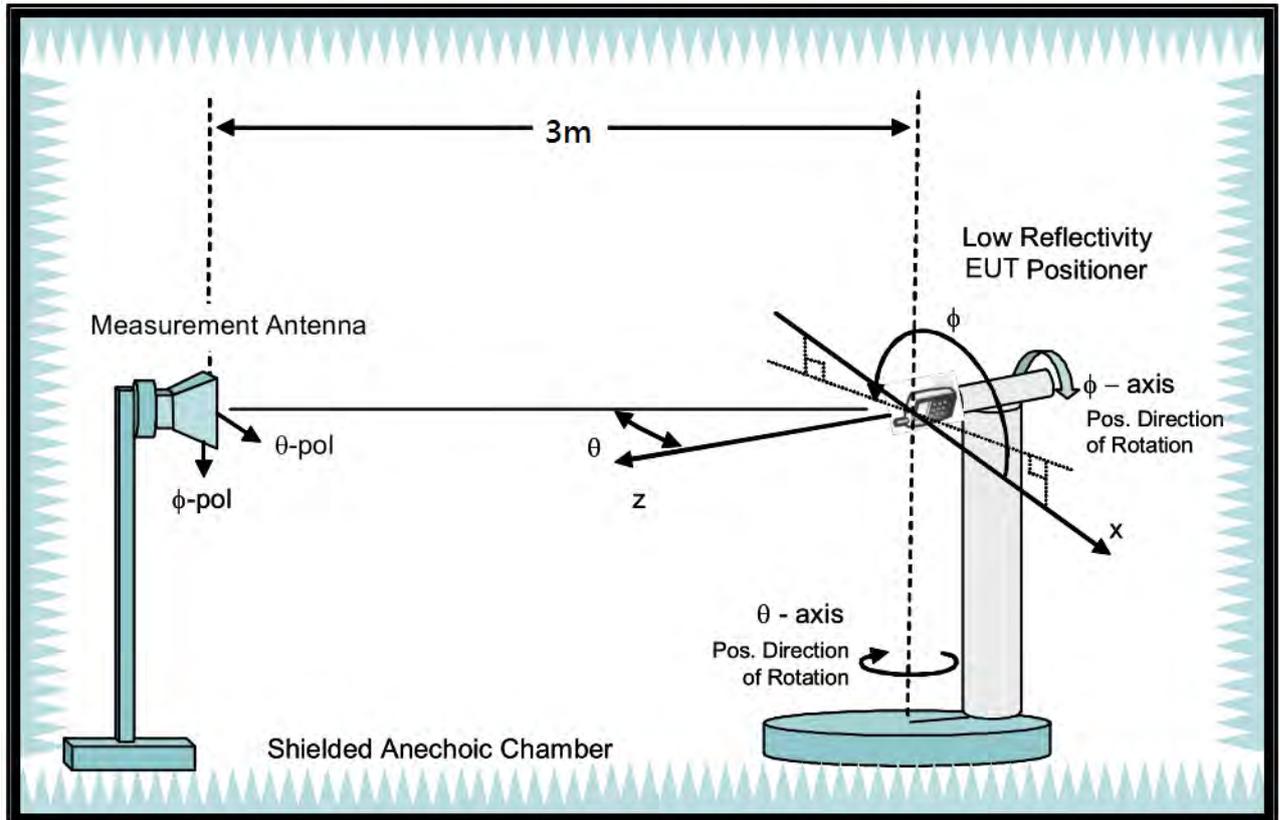
Test configuration: Reference to CITA OTA distributed-axes system configuration.

Chamber: Fully Anechoic Chamber.

Measurement antenna: Single Polarization Horn antenna calibrated according to ANSI C63.5.

Turntable: Multi-axis positioner (Theta and Phi angle).

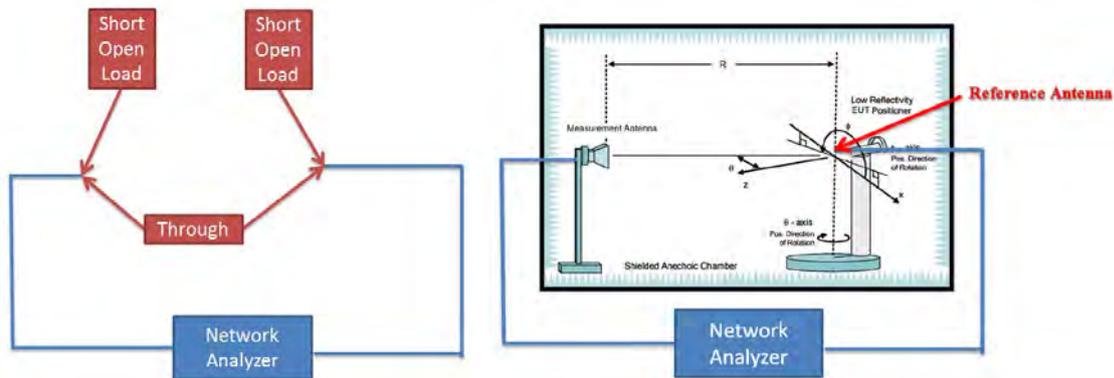
#Reference to CTIA “ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1”



5. Reference Calibration

Connected cables to VNA calibration kit and use network analyzer internal function to do calibration. Do short, open and load to each side. Then connect through to both side and calibrate S21 values. The cable loss is calibrated and set inside the network analyzer.

Measurement Antenna is connected to port1 of Network analyzer and reference antenna connected to port 2 of Network Analyzer. Record S21 values and used with reference antenna gain to calculate gain factor.



Frequency (MHz)	2400	2450	2500	5150	5200	5300	5600	5750	5800	5900	6000	6500	7000	7500
S21 values (dBi)	-31.4	-31.4	-31.3	-31.3	-31	-30.7	-30.1	-30.5	-30.5	-30.8	-31.3	-32.8	-34.4	-35.4
Reference gain (dBi)	10.2	10.4	10.6	12.4	12.8	13.4	13.4	13.3	13.3	13.1	13.2	12.3	11.7	11.1
Factor (dB)	41.63	41.81	41.89	43.72	43.78	44.12	43.5	43.78	43.76	43.88	44.45	45.14	46.08	46.51



6. Test Method

EUT set on multi-axis positioner and adjust EUT's physical center to measurement reference center. Measurement antenna set at phi polarization and 1.5 meter height. Port 1 of Network analyzer connect to antenna 1 of EUT. Record S21 value every 15 degree from 0 to 345 degree on Phi angle and 0 to 180 on theta angle of multi-axis positioner. Then set measurement antenna to theta polarization and repeat process. Repeat process to each antenna of EUT.

DG steps:

1. Each Phi and Theta polarization antenna gain are measured for all test angles.
2. Composite Phi and Theta antenna gain are computed, using formula in KDB662911 D01 F. 2) e) (ii), for all angles.
3. Composite antenna gain are examined for all angles to determine max gain and Phi/Theta position. Max gain and phi/theta position are listed in section 7 tables.



7. Measured Values and Calculation of Maximum Gain Positions

For 2G 5GL Ant1~2G 5GL Ant2

DG_1SS Max Value Position

Frequency (Hz)	2.45G	5.2G	5.3G
Ant. 1 (dBi)	3.29	2.91	4.45
Ant. 2 (dBi)	1.33	2.73	0.12
DG [1SS] (dBi)	5.38	5.83	5.56
Polarization	Theta	Theta	Theta
$\Theta(^{\circ})$	80	90	90
$\Phi(^{\circ})$	90	250	180

Note: The DG 1SS max value position is the maximum value of section 11 table DG 1SS Result.

DG_1SS Max Value Position Calculation

Frequency (Hz)	2.45G	5.2G	5.3G
Ant. 1 [10^(G/20)]	10^(3.29/20)	10^(2.91/20)	10^(4.45/20)
Ant. 2 [10^(G/20)]	10^(1.33/20)	10^(2.73/20)	10^(0.12/20)
Ant. 1 [10^(G/20)] value	1.46	1.398	1.669
Ant. 2 [10^(G/20)] value	1.165	1.369	1.014
Sum All Antenna [Amax]	2.626	2.767	2.683
DG [10*log(Amax^2/Nant)]	5.38	5.83	5.56

Note:

Directional Gain (1SS) is the max value of every look angle. Each position value is calculated by KDB662911 D01 d) (i).

$$\text{Directional gain (1SS)} = 10 \cdot \log(10^{(G_{ant1}/20)} + 10^{(G_{ant2}/20)} + 10^{(G_{ant3}/20)} + 10^{(G_{ant4}/20)} + \dots)^2 / N_{ant}$$



DG_2SS Max Value Position

Frequency (Hz)	2.45G	5.2G	5.3G
Ant. 1 (dBi)	3.86	2.91	4.45
Ant. 2 (dBi)	0.38	2.73	0.12
DG [4SS] (dBi)	2.46	2.82	2.8
Polarization	Theta	Theta	Theta
$\Theta(^{\circ})$	90	90	90
$\Phi(^{\circ})$	230	250	180

Note: The DG 2SS max value position is the maximum DG 2SS value calculated from section 11 table Gain Result.

DG_2SS Max Value Position Calculation

Frequency (Hz)	2.45G	5.2G	5.3G
Ant. 1 $((10^{(G/20)})^2)$	2.4322	1.9543	2.7861
Ant. 2 $((10^{(G/20)})^2)$	1.0914	1.875	1.028
Sum All Antenna	3.5236	3.8293	3.8141
DG $[10*\log(\text{sum all}/N_{\text{ant}})]$	2.46	2.82	2.8

Note: Directional Gain (2SS) is the max value of all position. Each position value is calculated by KDB662911 D01 (e) (ii).

$g_{j,k} = 10^{(G/20)}$

Directional Gain (2SS) = $10*\log((10^{(G_{\text{ant}1}/20)})^2+(10^{(G_{\text{ant}2}/20)})^2+ (10^{(G_{\text{ant}3}/20)})^2 +(10^{(G_{\text{ant}4}/20)})^2+.....)/N_{\text{ant}})$



For 5GH 5.9G Ant1~5GH 5.9G Ant4

DG_1SS Max Value Position

Frequency (Hz)	5.6G	5.785G	5.885G
Ant. 1 (dBi)	-0.8	-0.81	-0.41
Ant. 2 (dBi)	2.02	1.53	1.96
Ant. 3 (dBi)	-0.19	1.35	2.24
Ant. 4 (dBi)	1.97	2.02	2.66
DG [1SS] (dBi)	6.86	7.11	7.71
Polarization	Theta	Theta	Theta
$\Theta(^{\circ})$	80	90	90
$\Phi(^{\circ})$	270	230	230

Note: The DG 1SS max value position is the maximum value of section 11 table DG 1SS Result.

DG_1SS Max Value Position Calculation

Frequency (Hz)	5.6G	5.785G	5.885G
Ant. 1 [$10^{(G/20)}$]	$10^{(-0.8/20)}$	$10^{(-0.81/20)}$	$10^{(-0.41/20)}$
Ant. 2 [$10^{(G/20)}$]	$10^{(2.02/20)}$	$10^{(1.53/20)}$	$10^{(1.96/20)}$
Ant. 3 [$10^{(G/20)}$]	$10^{(-0.19/20)}$	$10^{(1.35/20)}$	$10^{(2.24/20)}$
Ant. 4 [$10^{(G/20)}$]	$10^{(1.97/20)}$	$10^{(2.02/20)}$	$10^{(2.66/20)}$
Ant. 1 [$10^{(G/20)}$] value	0.912	0.911	0.954
Ant. 2 [$10^{(G/20)}$] value	1.262	1.193	1.253
Ant. 3 [$10^{(G/20)}$] value	0.978	1.168	1.294
Ant. 4 [$10^{(G/20)}$] value	1.255	1.262	1.358
Sum All Antenna [Amax]	4.407	4.534	4.86
DG [$10 \cdot \log(A_{max}^2/N_{ant})$]	6.86	7.11	7.71

Note:

Directional Gain (1SS) is the max value of every look angle. Each position value is calculated by KDB662911 D01 d) (i).

$$\text{Directional gain (1SS)} = 10 \cdot \log(10^{(G_{ant1}/20)} + 10^{(G_{ant2}/20)} + 10^{(G_{ant3}/20)} + 10^{(G_{ant4}/20)} + \dots)^2 / N_{ant}$$



DG_4SS Max Value Position

Frequency (Hz)	5.6G	5.785G	5.885G
Ant. 1 (dBi)	-28.3	-0.81	-0.41
Ant. 2 (dBi)	0.43	1.53	1.96
Ant. 3 (dBi)	3.66	1.35	2.24
Ant. 4 (dBi)	2.6	2.02	2.66
DG [4SS] (dBi)	1.18	1.15	1.76
Polarization	Theta	Theta	Theta
$\Theta(^{\circ})$	100	90	90
$\Phi(^{\circ})$	190	230	230

Note: The DG 4SS max value position is the maximum DG 4SS value calculated from section 11 table Gain Result.

DG_4SS Max Value Position Calculation

Frequency (Hz)	5.6G	5.785G	5.885G
Ant. 1 $((10^{(G/20)})^2)$	0.0015	0.8299	0.9099
Ant. 2 $((10^{(G/20)})^2)$	1.1041	1.4223	1.5704
Ant. 3 $((10^{(G/20)})^2)$	2.3227	1.3646	1.6749
Ant. 4 $((10^{(G/20)})^2)$	1.8197	1.5922	1.845
Sum All Antenna	5.248	5.209	6.0002
DG $[10 \cdot \log(\text{sum all}/N_{\text{ant}})]$	1.18	1.15	1.76

Note: Directional Gain (4SS) is the max value of all position. Each position value is calculated by KDB662911 D01 (e) (ii).

$$g_{j,k} = 10^{(G/20)}$$

$$\text{Directional Gain (4SS)} = 10 \cdot \log\left(\frac{10^{(G_{\text{ant}1}/20)} + 10^{(G_{\text{ant}2}/20)} + 10^{(G_{\text{ant}3}/20)} + 10^{(G_{\text{ant}4}/20)} + \dots}{N_{\text{ant}}}\right)$$



8. Summary of Test Result

For 2G 5GL Ant1~2G 5GL Ant2

Freq(Hz)	2.45G	5.2G	5.3G
Ant. 1 Max Gain (dBi)	3.86	4.25	4.45
Ant. 2 Max Gain (dBi)	3.94	4.53	4.52
Ant. 1 Polarization/ Θ ($^{\circ}$)/ Φ ($^{\circ}$)	Theta/90/230	Theta/90/180	Theta/90/180
Ant. 2 Polarization/ Θ ($^{\circ}$)/ Φ ($^{\circ}$)	Theta/100/70	Theta/100/50	Theta/100/50
Max Gain (dBi)	3.94	4.53	4.52
DG [1SS] (dBi)	5.38	5.83	5.56
DG [2SS] (dBi)	2.46	2.82	2.8

Note:

1. Each antenna max gain is the max value of measurement S21 of theta and phi through all measurement angles.
2. The max gain is the max value of all antennas.

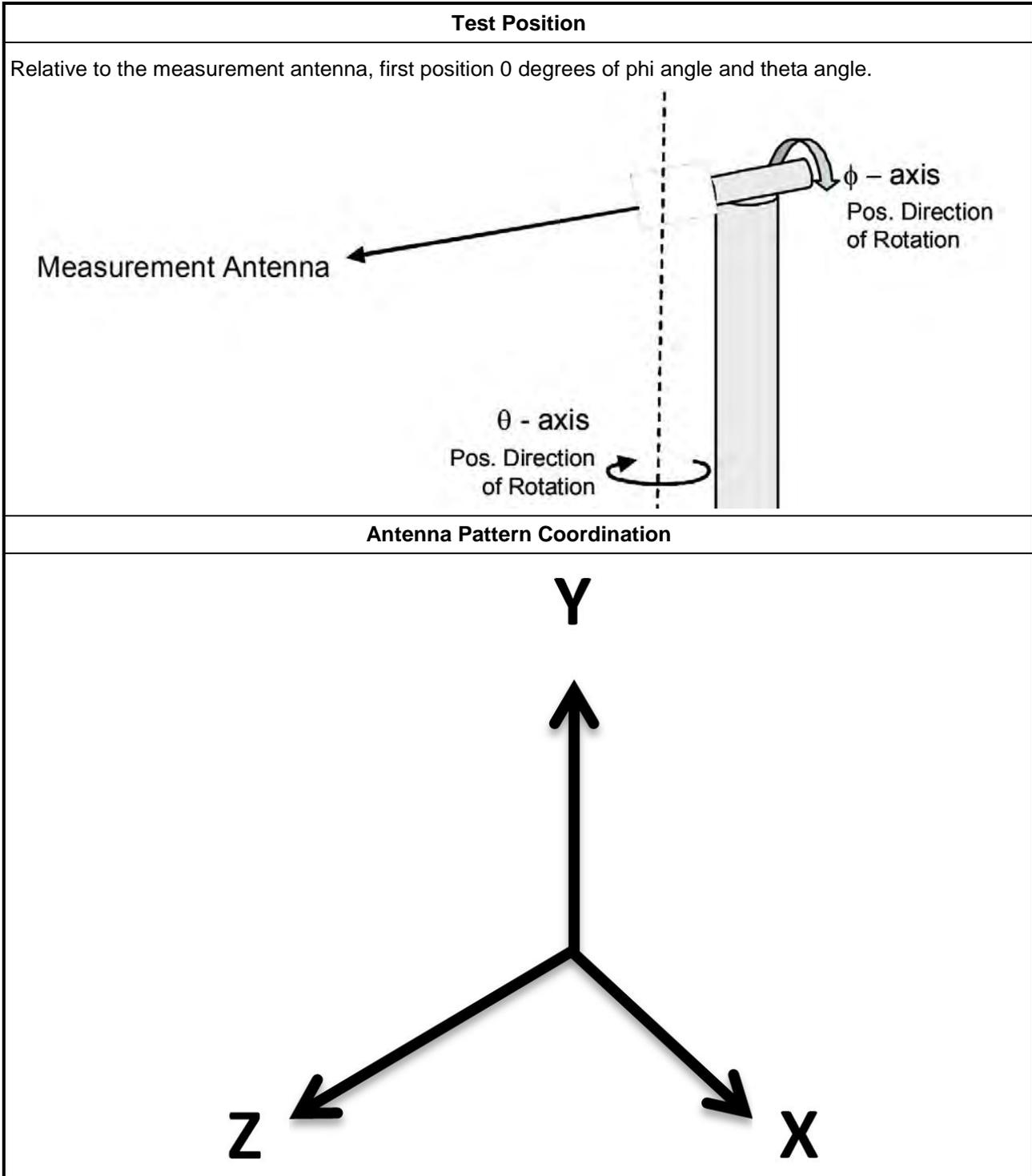
For 5GH 5.9G Ant1~5GH 5.9G Ant4

Freq(Hz)	5.6G	5.785G	5.885G
Ant. 1 Max Gain (dBi)	3.8	4.05	4.73
Ant. 2 Max Gain (dBi)	4.06	4.23	4.23
Ant. 3 Max Gain (dBi)	3.66	3.65	4.78
Ant. 4 Max Gain (dBi)	4.32	4.76	5.08
Ant. 1 Polarization/ Θ ($^{\circ}$)/ Φ ($^{\circ}$)	Theta/100/40	Theta/100/40	Theta/100/40
Ant. 2 Polarization/ Θ ($^{\circ}$)/ Φ ($^{\circ}$)	Theta/90/250	Theta/90/160	Theta/130/80
Ant. 3 Polarization/ Θ ($^{\circ}$)/ Φ ($^{\circ}$)	Theta/100/190	Theta/60/340	Theta/60/350
Ant. 4 Polarization/ Θ ($^{\circ}$)/ Φ ($^{\circ}$)	Theta/90/260	Theta/130/290	Theta/130/290
Max Gain (dBi)	4.32	4.76	5.08
DG [1SS] (dBi)	6.86	7.11	7.71
DG [2SS] (dBi)	4.32	4.76	5.08
DG [4SS] (dBi)	1.18	1.15	1.76

Note

1. Directional Gain (2SS) = Directional Gain (1SS) – 3dB. If directional gain is less than max gain, use max gain as directional gain.
2. Each antenna max gain is the max value of measurement S21 of theta and phi through all measurement angles.
3. The max gain is the max value of all antennas.

9. Test Setup



Note:

Photos of Test Position: Please refer to the test photos in the appendix.



10. Test Equipment and Calibration Data

Instrument	Brand	Model No.	Serial No.	Characteristics	Calibration Date	Calibration Due Date
Horn Antenna	SCHWARZBECK	BBHA9120D	BBHA 9120D-1292	1GHz~18GHz	Aug. 04, 2021	Aug. 03, 2022
ENA Series Network Analyzer	AGILENT	E5071C	MY46419201	100kHz~8.5GHz	Feb. 21, 2022	Feb. 20, 2023
Test Software	SPORTON	SENSE-RDG	V1.0.6	-	N.C.R.	N.C.R.

Note: Calibration Interval of instruments listed above is one year.

NCR means Non-Calibration required.



11. Test Results

Please refer to the appendix.

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Radiated Composite Gain of 2G 5GL Ant1~2G 5GL Ant2

Freq(Hz)	2.45G	5.2G	5.3G
Ant. 1 Max Gain (dBi)	3.86	4.25	4.45
Ant. 2 Max Gain (dBi)	3.94	4.53	4.52
Ant. 1 Polarization/ θ (°)/ ϕ (°)	Theta/90/230	Theta/90/180	Theta/90/180
Ant. 2 Polarization/ θ (°)/ ϕ (°)	Theta/100/70	Theta/100/50	Theta/100/50
Max Gain (dBi)	3.94	4.53	4.52
DG [1SS] (dBi)	5.38	5.83	5.56
DG [2SS] (dBi)	2.46	2.82	2.8



Freq(Hz)	5.6G	5.785G	5.885G
Ant. 1 Max Gain (dBi)	3.8	4.05	4.73
Ant. 2 Max Gain (dBi)	4.06	4.23	4.23
Ant. 3 Max Gain (dBi)	3.66	3.65	4.78
Ant. 4 Max Gain (dBi)	4.32	4.76	5.08
Ant. 1 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/100/40	Theta/100/40	Theta/100/40
Ant. 2 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/90/250	Theta/90/160	Theta/130/80
Ant. 3 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/100/190	Theta/60/340	Theta/60/350
Ant. 4 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/90/260	Theta/130/290	Theta/130/290
Max Gain (dBi)	4.32	4.76	5.08
DG [1SS] (dBi)	6.86	7.11	7.71
DG [2SS] (dBi)	4.32	4.76	5.08
DG [4SS] (dBi)	1.18	1.15	1.76

