



Antenna Composite Gain Test Report

Equipment	AX3000 Dual Band WiFi Router
Brand Name	ASUS
Model Name	XD5, XD4 Pro
Applicant	ASUSTeK COMPUTER INC. 1F., No. 15, Lide Rd., Beitou, Taipei 112, Taiwan
Manufacturer (1)	GEMTEK TECHNOLOGY CO., LTD. No. 15-1, Zhonghua Road, Hsinchu Industrial Park, Hukou, Hsinchu 30352, Taiwan, R.O.C.
Manufacturer (2)	GEMTEK VIETNAM CORPORATION LIMITED. Dong Van II Industrial Zone, Duy Minh Ward, Duy Tien Town, Ha Nam Province, Vietnam (ZIP 400000)
Manufacturer (3)	GEMTEK ELECTORNICS (CHANGSHU) CO., LTD. No. 1, Zheng Wen Road, New & High Tech Industrial Park, Changshu Economic Development Zone, Jiangsu Province 215500, P.R.China
Manufacturer (4)	GEMTEK ELECTRONICS (KUNSHAN) CO., LTD. No. 88, Xin Zhu Road, Comprehensive Bonded Zone, Kun Shan, Jiangsu Province 215300, P. R. China
Manufacturer (5)	Lih Rong Electronic Enterprise Co.,Ltd. 3F, No. 1, Gaoxia Rd., Zhongli Dist., 32061 Taoyuan City, TAIWAN
Manufacturer (6)	Lukisen Electronic Corp. 3F.,No.236,Bo"ai St., Shulin Dist., New Taipei City 23845, Taiwan
Manufacturer (7)	Datamax Electronics(DongGuan) Co., Ltd. Niu Shan Foreign Economic Industrial Park,Dong Cheng District,Dong Guan City,Guang Dong,China
Sample Received	May 07, 2021
Start Test Date	Sep. 07, 2021
Final Test Date	Sep. 07, 2021



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1. Operation Mode and Antenna Information

Antenna Position	RF Port	Brand Name	Model Name	Ant. Type	Connector	Modes of Operation
Ant1	1	Airgain	N03ASAFc-PH-LB1X85BUI	PCB	I-PEX	2.4GHz, 5GHz UNII 1~3
Ant2	2	Airgain	N03ASAFc-PH-LG1X120BUI	PCB	I-PEX	2.4GHz, 5GHz UNII 1~3

Note:

2.4GHz and 5GHz Operation Mode (2TX/2RX)

Ant1~2 can be used as transmitting/receiving antenna.

Ant1~2 could transmit/receive simultaneously.

2. Test Frequency

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

Band [MHz]	Test Frequency [MHz]
2400-2483.5	2450
5150-5250	5200
5250-5350	5300
5470-5725	5600
5725-5850	5785



3. Testing Location

Testing Location	
<input checked="" type="checkbox"/>	HWA YA ADD : No.13-1 & 14-1, Ln. 19, Wen 33rd St., Guishan Dist., Taoyuan City 333, Taiwan R.O.C.

Test Condition	Test Site No.	Test Engineer	Test Environment (°C / %)	Test Date
Radiated	05CH03-HY	Rex Liao	23.5-24.5 / 45-55	Sep. 07, 2021

Note:

Testing Site Information

Brand Name: TDK

Dimension: 11m*6m*6m

Characteristic: Fully Anechoic Chamber

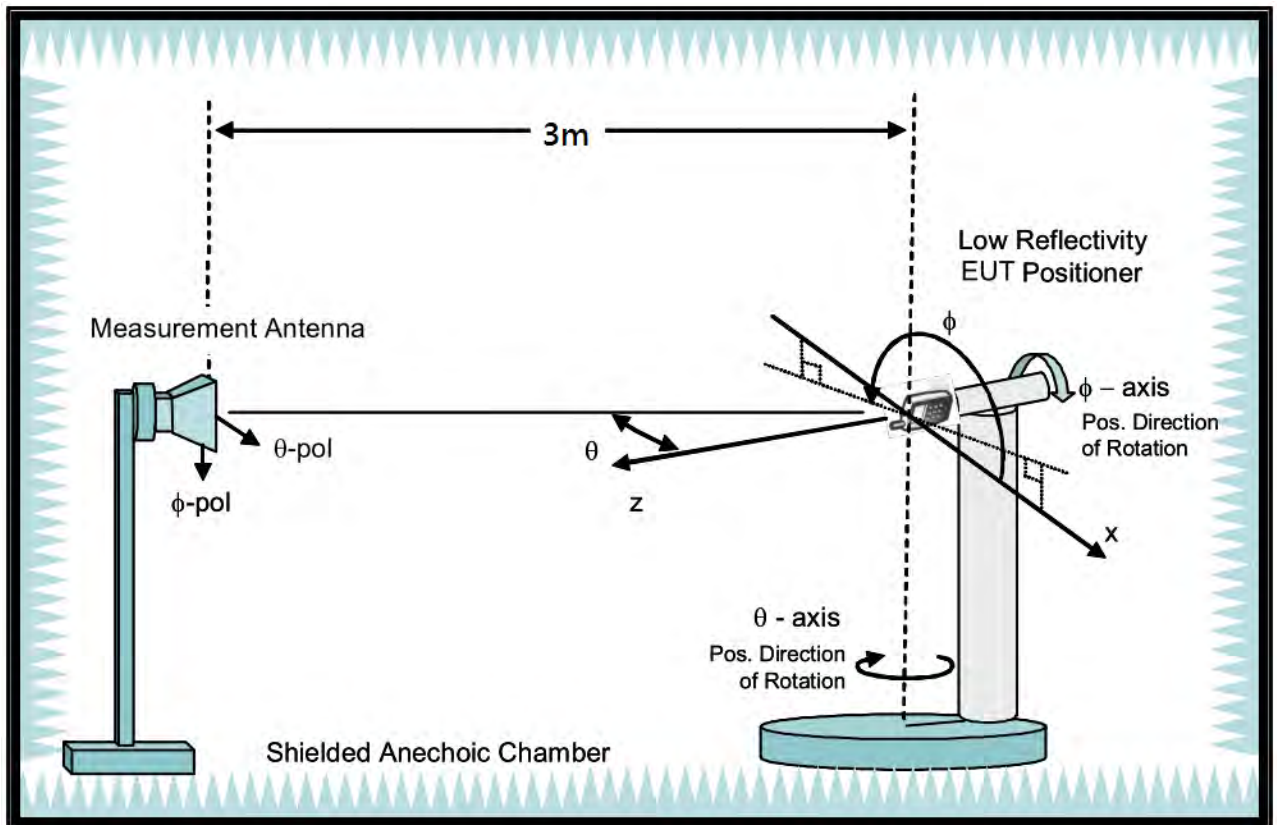
4. Test Facility and Configuration

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.

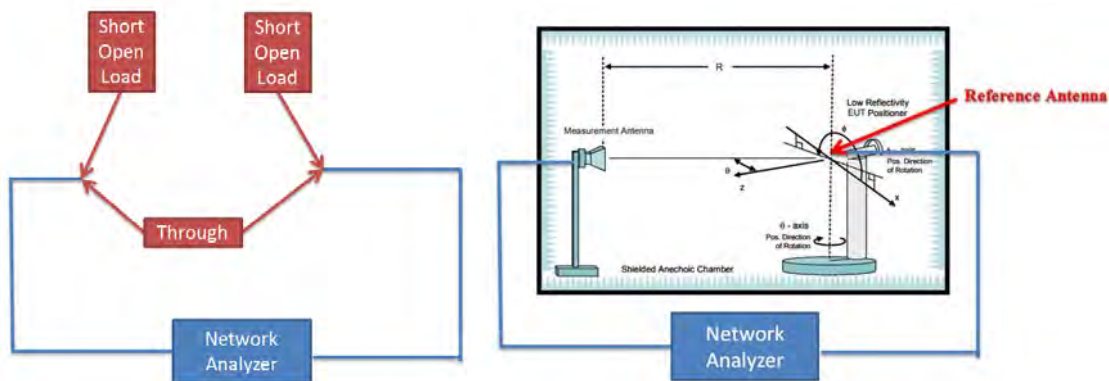
#Reference to CTIA "ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1"



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 G 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 G 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
G reading (dB)	-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)	41.34	41.55	41.68	43.24	43.56	43.68	43.79	43.91	43.99	44.43	44.49	45.24	46.12	46.31

Note:

$$G \text{ reading (dB)} = 20 \cdot \log(V2/V1) = 10 \cdot \log(P2/P1)$$

V2 is the voltage of VNA port2 is measured, V1 is the voltage of VNA port1 is the reference source.

P2 is the power of VNA port2 is measured, P1 is the power of VNA port1 is the reference source.

$$\text{Factor} = \text{gain factor} + \text{power gain conversion} = (\text{Reference antenna gain}) - (G \text{ reading})$$



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 G 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 d) (i) and 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.

Note: Antenna gain = G reading + factor, The factor of chapter five includes reference antenna gain factor and power gain conversion.



7. Measured Values and Calculation of Maximum Gain Positions

DG_1SS Max Value Position

Frequency (Hz)	2.45G	5.2G	5.3G	5.6G	5.785G
Ant. 1 (dBi)	2.47	2.46	3.1	2.7	2.69
Ant. 2 (dBi)	2.25	1.62	1.71	1.91	3.37
DG [1SS] (dBi)	5.37	5.06	5.44	5.32	6.05
Polarization	Theta	Theta	Theta	Theta	Theta
Θ (°)	105	90	90	90	90
Φ (°)	225	285	255	240	240

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	5.6G	5.785G
Ant. 1 [10 ^{^(G/20)}]	10 ^{^(2.47/20)}	10 ^{^(2.46/20)}	10 ^{^(3.1/20)}	10 ^{^(2.7/20)}	10 ^{^(2.69/20)}
Ant. 2 [10 ^{^(G/20)}]	10 ^{^(2.25/20)}	10 ^{^(1.62/20)}	10 ^{^(1.71/20)}	10 ^{^(1.91/20)}	10 ^{^(3.37/20)}
Ant. 1 [10 ^{^(G/20)}] value	1.329	1.327	1.429	1.365	1.363
Ant. 2 [10 ^{^(G/20)}] value	1.296	1.205	1.218	1.246	1.474
Sum All Antenna [Amax]	2.625	2.532	2.646	2.611	2.837
DG [10*log(Amax ² /Nant)]	5.37	5.06	5.44	5.32	6.05

Note:

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

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



8. Summary of Test Result

Frequency (Hz)	2.45G
Ant. 1 Max Gain (dBi)	2.72
Ant. 2 Max Gain (dBi)	3.6
Ant. 1 Polarization/ Θ (°)/ Φ (°)	Theta/90/195
Ant. 2 Polarization/ Θ (°)/ Φ (°)	Theta/105/255
Max Gain (dBi)	3.6
DG [1SS] (dBi)	5.37
DG [2SS] (dBi)	3.6

Note:

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

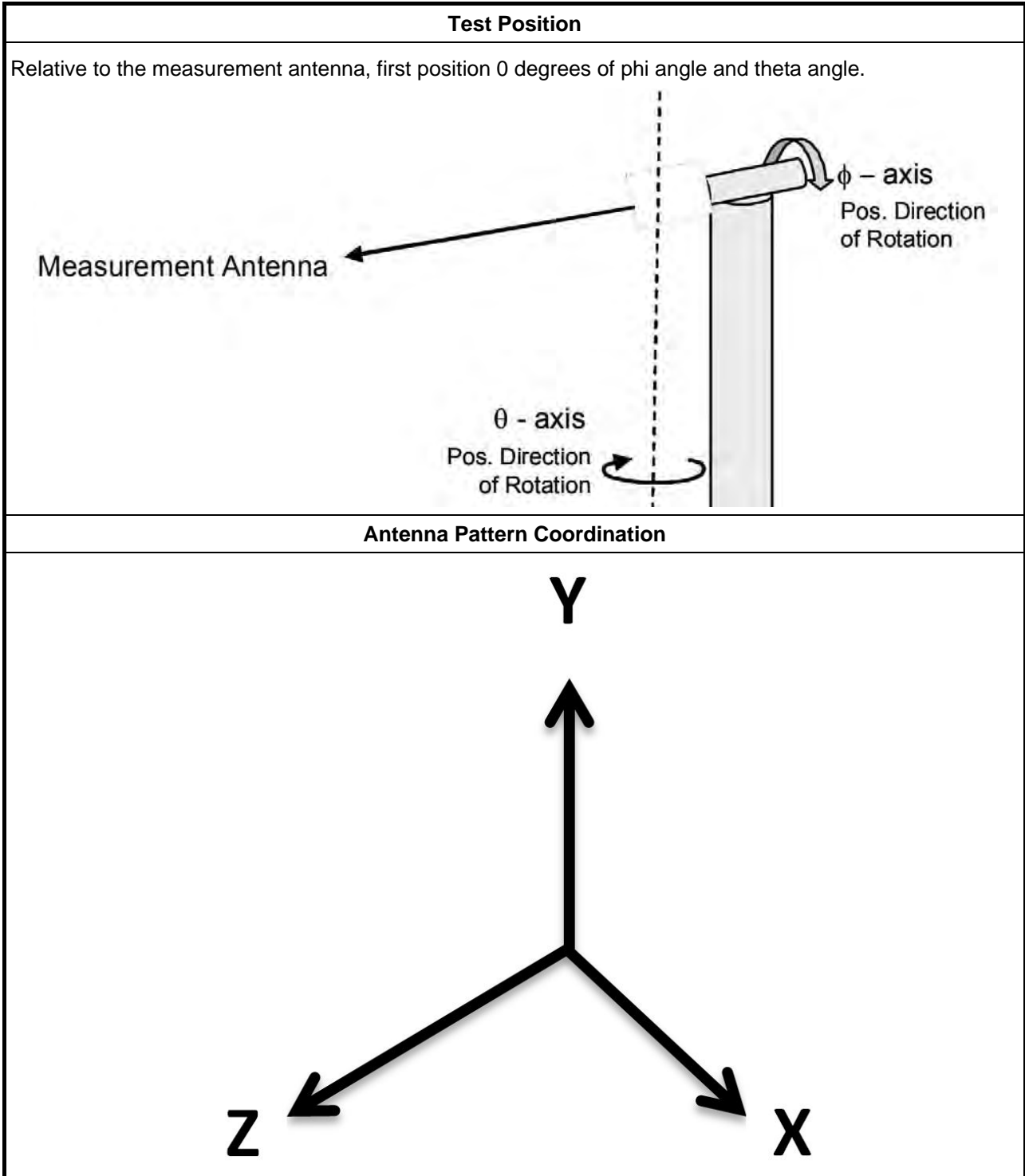


Frequency (Hz)	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	2.52	3.1	3.38	3.11
Ant. 2 Max Gain (dBi)	2.13	2.98	2.6	3.37
Ant. 1 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/90/255	Theta/90/255	Theta/105/255	Theta/105/255
Ant. 2 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/105/120	Theta/105/120	Theta/75/240	Theta/90/240
Max Gain (dBi)	2.52	3.1	3.38	3.37
DG [1SS] (dBi)	5.06	5.44	5.32	6.05
DG [2SS] (dBi)	2.52	3.1	3.38	3.37

Note:

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

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	Oct. 04, 2020	Oct. 03, 2021
Test Software	SPORTON	SENSE-RDG	V1.0.6	-	N.C.R.	N.C.R.

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

N.C.R. means Non-Calibration required.



11. Test Results

Please refer to the appendix.

Appendix A – Radiated Composite Gain of 2.4GHz, 5GHz U-NII 1~U-NII 3.....	Page 15
Appendix B – Antenna Pattern of 2.4GHz, 5GHz U-NII 1~U-NII 3.....	Page 21
Appendix C – Test Photos.....	Page 24



Freq(Hz)	2.45G	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	2.72	2.52	3.1	3.38	3.11
Ant. 2 Max Gain (dBi)	3.6	2.13	2.98	2.6	3.37
Ant. 1 Polarization/ θ (°)/ ϕ (°)	Theta/90/195	Theta/90/255	Theta/90/255	Theta/105/255	Theta/105/255
Ant. 2 Polarization/ θ (°)/ ϕ (°)	Theta/105/255	Theta/105/120	Theta/105/120	Theta/75/240	Theta/90/240
Max Gain (dBi)	3.6	2.52	3.1	3.38	3.37
DG [1SS] (dBi)	5.37	5.06	5.44	5.32	6.05
DG [2SS] (dBi)	3.6	2.52	3.1	3.38	3.37



DG 1SS Result

Table with columns for Freq(Hz), DG(dB), and various Phi angles (0 to 345 degrees) for frequencies 2.45G, 5.2G, and 5.3G. The table contains multiple rows of data for each frequency, showing gain values in dB.



Table with 25 columns and 100 rows of data. Columns include frequency (5.6G, 5.785G), polarization (Pol., Theta), and various gain values (DG(dB)) for angles from 0 to 180 degrees. Values range from -15.59 to 6.05.



Gain Result

Table with columns for Freq(Hz), Gain, and various Phi and Theta angles (0 to 180 degrees) for frequencies 2.45G, 5.2G, and 5.3G. The table contains multiple rows of numerical data for each frequency and angle combination.



Radiated Composite Gain

Appendix A

Table with columns for frequency (5.6G, 5.785G, 2.45G, 5.2G, 5.2G) and gain/loss values for various angles (Theta and Phi) from 0 to 180 degrees. Includes sub-headers for Gain, Pol., and Theta/Ant. 1/2.



Radiated Composite Gain

Appendix A

Table with columns for frequency (5.3G, 5.6G, 5.785G), polarization (Pol.), phase (Phi), and gain for various angles (Theta and Phi) from 0 to 180 degrees. The table contains numerical values for each combination of frequency, polarization, and angle.



Total Gain Data

Table with columns for Freq(Hz), Pol., Total, Ant. 1, and various Phi angles (0 to 345 degrees) for frequencies 2.45G, 5.2G, 5.3G, 5.6G, 5.785G, and 5.2G. Each cell contains a numerical gain value.

E1(XY plane) – $\Theta(90)\Phi(0-360)$
 E2(XZ plane) – $\Theta(0-180)\Phi(0)$ and $\Theta(0-180)\Phi(180)$
 E3(YZ plane) – $\Theta(0-180)\Phi(90)$ and $\Theta(0-180)\Phi(270)$

