Antenna Composite Gain Test Report

Equipment	AX5400 Gigabit Wireless Extender
Brand Name	ZYXEL
Model Name	WX3310-B1
Applicant	Zyxel Communications Corporation No.2 Industry East RD. IX, Hsinchu Science Park, Hsinchu 30075, Taiwan, R.O.C
Manufacturer	Zyxel Communications Corporation No.2 Industry East RD. IX, Hsinchu Science Park, Hsinchu 30075, Taiwan, R.O.C
Sample Received	Sep. 21, 2022
Start Test Date	Sep. 27, 2022
Final Test Date	Sep. 27, 2022

Approved by: Jackson Tsai

SPORTON INTERNATIONAL INC. Hsinhua Laboratory

No.52, Huaya 1st Rd., Guishan Dist., Taoyuan City 333411, Taiwan (R.O.C.)

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History of this test report

Report No.	Version	Description	Issued Date
AP292111	01	Initial issue of report	Oct. 24, 2022

1. Operation Mode and Antenna Information

Antenna Position	RF Port	Brand Name	Model Name	Ant. Type	Connector	Modes of Operation
Ant1	1	INPAQ	RFPCA242309IMLB901	PIFA	I-Pex	2.4GHz, 5GHz
Ant2	2	INPAQ	RFPCA242311IMLB901	PIFA	I-Pex	2.4GHz, 5GHz
Ant3	3	INPAQ	RFPCA221116IM5B901	PIFA	I-Pex	5GHz
Ant4	4	INPAQ	RFPCA232007IMLB901	PIFA	I-Pex	5GHz

Note:

2.4GHz Operation Mode (2TX/2RX)

Ant 1~ Ant 2 can be used as transmitting/receiving antenna.

Ant 1~ Ant 2 could transmit/receive simultaneously.

5GHz Operation Mode (4TX/4RX)

Ant 1~ Ant 4 can be used as transmitting/receiving antenna.

Ant 1~ Ant 4 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

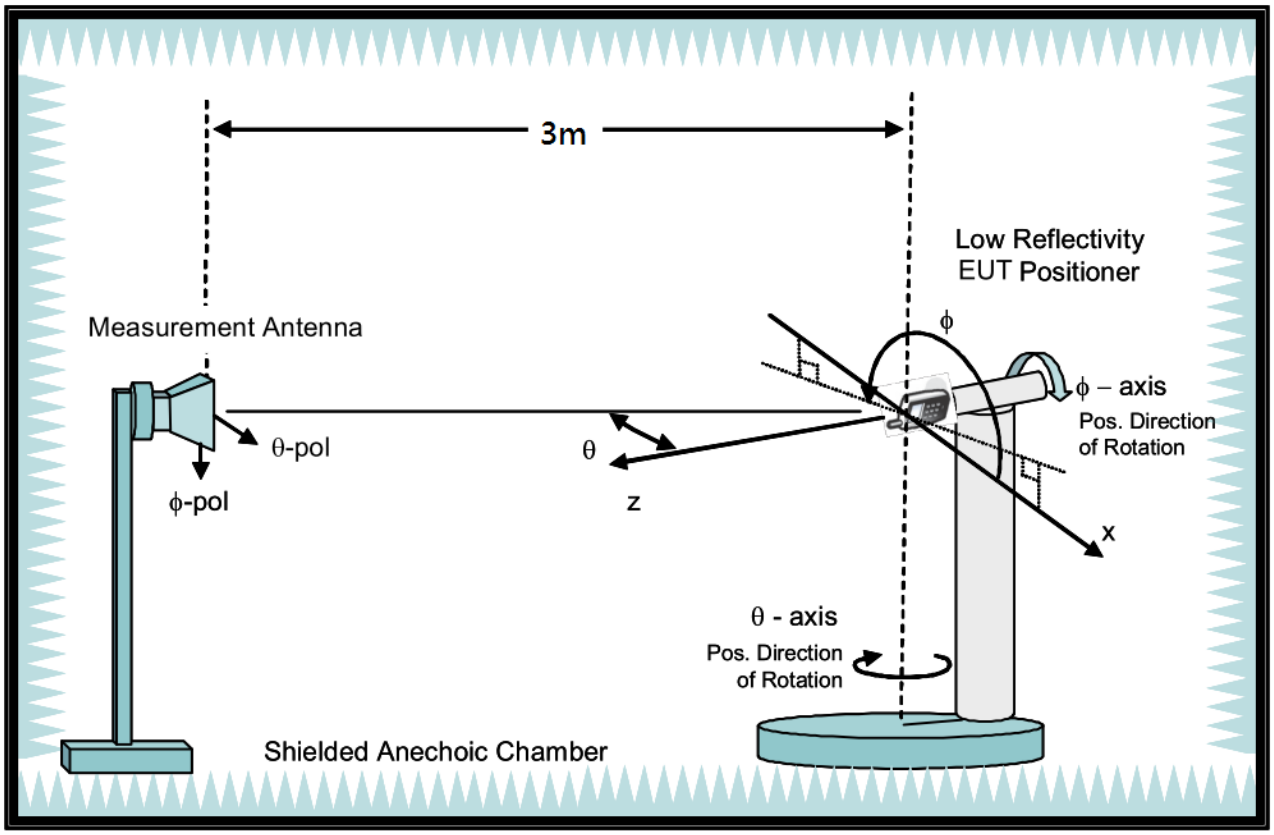
Test Lab. : Sporton International Inc. Hsinhua Laboratory				
☒ Wen 33rd.St.	**ADD:**	No.14-1, Ln. 19, Wen 33rd St., Guishan Dist., Taoyuan City 333010, Taiwan (R.O.C.)		
	TEL: 886-3-318-0787		**FAX:** 886-3-318-0287	
Test Condition	**Test Site No.**	**Test Engineer**	**Test Environment (°C / %)**	**Test Date**
Radiated	05CH03-HY	Rex Liao	23.5~24.5°C / 40~50%	27/Sep/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: Dual Polarization Horn antenna
Turntable: Multi-axis positioner (Theta and Phi angle).

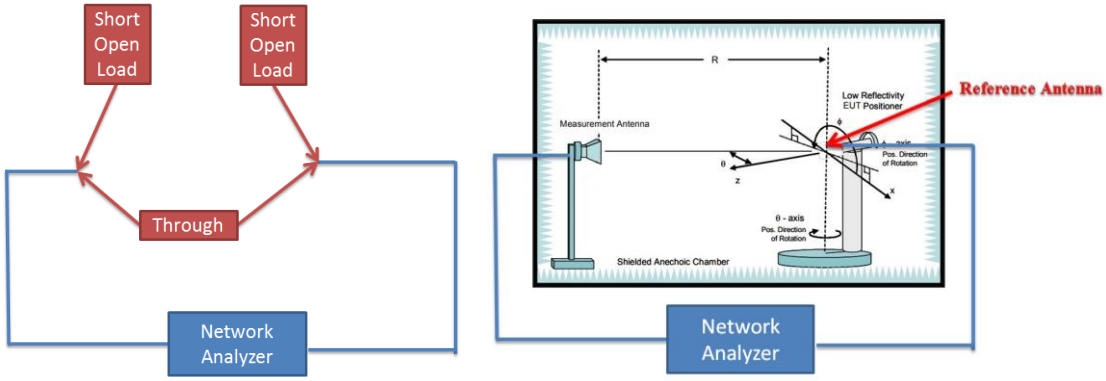
#Reference to CTIA “ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1”



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 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	7200
G(theta) reading (dB)	-33.55	-33.27	-32.92	-32.91	-32.73	-32.02	-32.67	-32.82	-32.98	-33.18	-32.8	-33.92	-34.62	-35.57
G(phi) reading (dB)	-33.15	-32.7	-32.41	-32.61	-32.43	-31.72	-32.37	-32.51	-32.52	-32.66	-32.5	-33.62	-34.32	-35.48
Reference gain (dBi)	10.1	10.4	10.7	12.5	12.7	13.5	13.4	13.3	13.3	13.2	13.4	12.5	12.1	11.4
Factor(theta) (dB)	43.65	43.67	43.62	45.41	45.43	45.52	46.07	46.12	46.28	46.38	46.2	46.42	46.72	46.97
Factor(phi) (dB)	43.25	43.1	43.11	45.11	45.13	45.22	45.77	45.81	45.82	45.86	45.9	46.12	46.42	46.88

Note:

G reading (dB) =20*log(V2/V1)=10*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.

Factor = gain factor + power gain conversion= (Reference antenna gain)-(G 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 7.5 degree from 0 to 352.5 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)	1.57	-18.54	-13.54	-7.87	-4.56
Ant. 2 (dBi)	-0.5	-1.14	0.24	-8.2	-13.58
Ant. 3 (dBi)		3.66	1.3	3.76	1.83
Ant. 4 (dBi)		0.68	1.89	1.53	3.09
DG [1SS] (dBi)	3.61	5.11	5.21	4.93	4.77
Polarization	Phi	Phi	Phi	Phi	Phi
Θ(°)	142.5	150	165	127.5	127.5
Φ(°)	105	180	0	0	0

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^(1.57/20)	10^(-18.54/20)	10^(-13.54/20)	10^(-7.87/20)	10^(-4.56/20)
Ant. 2 [10^(G/20)]	10^(-0.5/20)	10^(-1.14/20)	10^(0.24/20)	10^(-8.2/20)	10^(-13.58/20)
Ant. 3 [10^(G/20)]		10^(3.66/20)	10^(1.3/20)	10^(3.76/20)	10^(1.83/20)
Ant. 4 [10^(G/20)]		10^(0.68/20)	10^(1.89/20)	10^(1.53/20)	10^(3.09/20)
Ant. 1 [10^(G/20)] value	1.198	0.118	0.21	0.404	0.592
Ant. 2 [10^(G/20)] value	0.944	0.877	1.028	0.389	0.209
Ant. 3 [10^(G/20)] value		1.524	1.161	1.542	1.235
Ant. 4 [10^(G/20)] value		1.081	1.243	1.193	1.427
Sum All Antenna [Amax]	2.142	3.601	3.643	3.527	3.463
DG [10*log(Amax^2/Nant)]	3.61	5.11	5.21	4.93	4.77

Note:

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

Directional gain (1SS) = 10*log(10^(G_{ant1}/20)+10^(G_{ant2}/20)+ +10^(G_{ant3}/20) +10^(G_{ant4}/20)+…..)^2/N_{ant})

8. Summary of Test Result

Freq(Hz)	2.45G	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	2.99	2.33	2.99	4.08	4.06
Ant. 2 Max Gain (dBi)	3.28	1.27	1.18	1.51	2.11
Ant. 3 Max Gain (dBi)		5.01	4.1	3.76	3.67
Ant. 4 Max Gain (dBi)		4.09	3.32	2.64	4.21
Ant. 1 Polarization/Θ(°)/Φ(°)	Theta/112.5/232.5	Phi/150/82.5	Phi/135/97.5	Phi/142.5/97.5	Phi/142.5/97.5
Ant. 2 Polarization/Θ(°)/Φ(°)	Phi/75/225	Theta/82.5/240	Theta/82.5/232.5	Theta/105/270	Theta/120/345
Ant. 3 Polarization/Θ(°)/Φ(°)		Phi/127.5/195	Phi/127.5/0	Phi/127.5/0	Phi/157.5/172.5
Ant. 4 Polarization/Θ(°)/Φ(°)		Phi/30/0	Phi/30/352.5	Phi/37.5/352.5	Phi/135/0
Max Gain (dBi)	3.28	5.01	4.1	4.08	4.21
DG [1SS] (dBi)	3.61	5.11	5.21	4.93	4.77
DG [2SS] (dBi)	3.28	5.01	4.1	4.08	4.21
DG [4SS] (dBi)		5.01	4.1	4.08	4.21

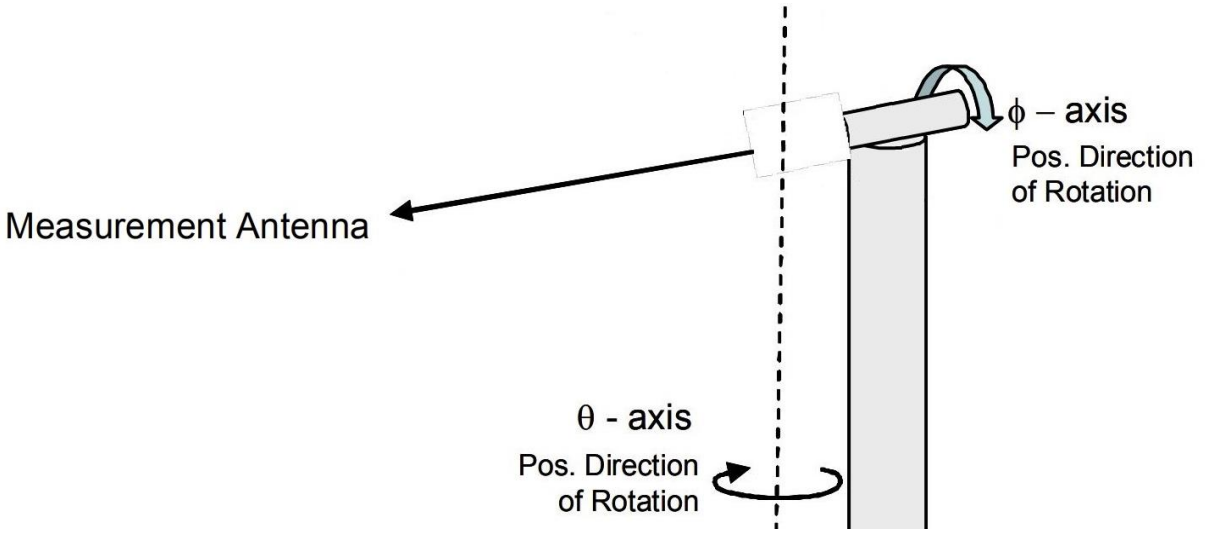
Note:

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.
4. Directional Gain (4SS) = Directional Gain (1SS) – 6dB. If directional gain is less than max gain, use max gain as directional gain.

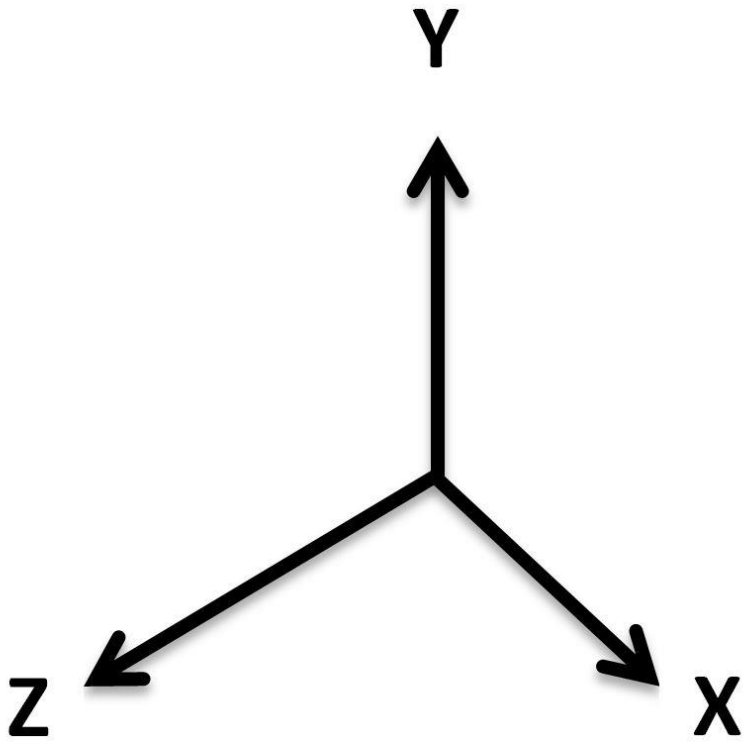
9. Test Setup

Test Position

Relative to the measurement antenna, first position 0 degrees of phi angle and theta angle.



Antenna Pattern Coordination



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-1543	1GHz~18GHz	May. 31, 2022	May. 30, 2023
Dual Polarization Horn Antenna	Sporton	S0209DP	S0209DP-001	2GHz~9GHz	NCR	NCR
ENA Series Network Analyzer	AGILENT	E5071C	MY46419201	100kHz~8.5GHz	Feb. 21, 2022	Feb. 20, 2023
VNA Calibration Kit	TS RF	TS85033E-F	-	DC~9GHz	NCR	NCR
Multi-axis positioner	Sporton	MAPS01	MAPS01-001	Theta / Phi axis	NCR	NCR
Test Software	SPORTON	SENSE-RDG	V1.0.8	-	NCR	NCR

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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