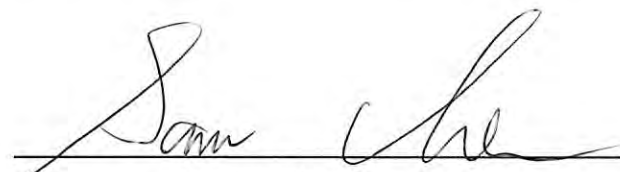




Antenna Composite Gain Test Report

FCC ID	MSQ-RTBE6G00
Equipment	BE19000 Tri-band WiFi Router
Brand Name	ASUS
Model Name	RT-BE96U
Applicant	ASUSTeK COMPUTER INC. 1F., No. 15, Lide Rd., Beitou, 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. Lot D4-5-6, Thang Long Vinh Phuc Industrial Park, Thien Ke Commune, Binh Xuyen District, 15000 Vinh Phuc Province, Vietnam
Sample Received	Dec. 21, 2022
Start Test Date	Dec. 23, 2022
Final Test Date	Jan. 17, 2023



Approved by: Sam Chen

Sporton International Inc. Hsinchu Laboratory
No.8, Ln. 724, Bo'ai St., Zhubei City, Hsinchu County 302010, Taiwan (R.O.C.)



Table of Contents

History of this test report.....	3
1. Operation Mode and Antenna Information	4
2. Test Frequency	4
3. Testing Location.....	4
4. Test Facility and Configuration.....	5
5. Reference Calibration	6
6. Test Method	7
7. Measured Values and Calculation of Maximum Gain Positions.....	8
8. Summary of Test Result	9
9. Test Setup	10
10. Test Equipment and Calibration Data	11
11. Test Results	12



1. Operation Mode and Antenna Information

Antenna Position	RF Port		Brand Name	Model Name	Ant. Type	Connector	Modes of Operation
	WLAN 2.4GHz	WLAN 5GHz					
2G5G Ant1	1	1	WHA Yu	C660-510591-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3
2G5G Ant2	4	4	WHA Yu	C660-510592-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3
2G5G Ant3	3	3	WHA Yu	C660-510593-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3
2G5G Ant4	2	2	WHA Yu	C660-510594-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3

Note:

2.4GHz and 5GHz Operation Mode (4TX/4RX)

2G 5GAnt1~4 can be used as transmitting/receiving antenna.

2G 5GAnt1~4 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

Testing Location		
Sporton International Inc. Hsinhua Laboratory		
<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	23~24 / 40~50	Dec. 23, 2022 ~ Jan. 17, 2023

Note:

Testing Site Information

Brand Name: TDK

Dimension: 11m*6m*6m

Characteristic: Fully Anechoic Chamber

4. Test Facility and Configuration

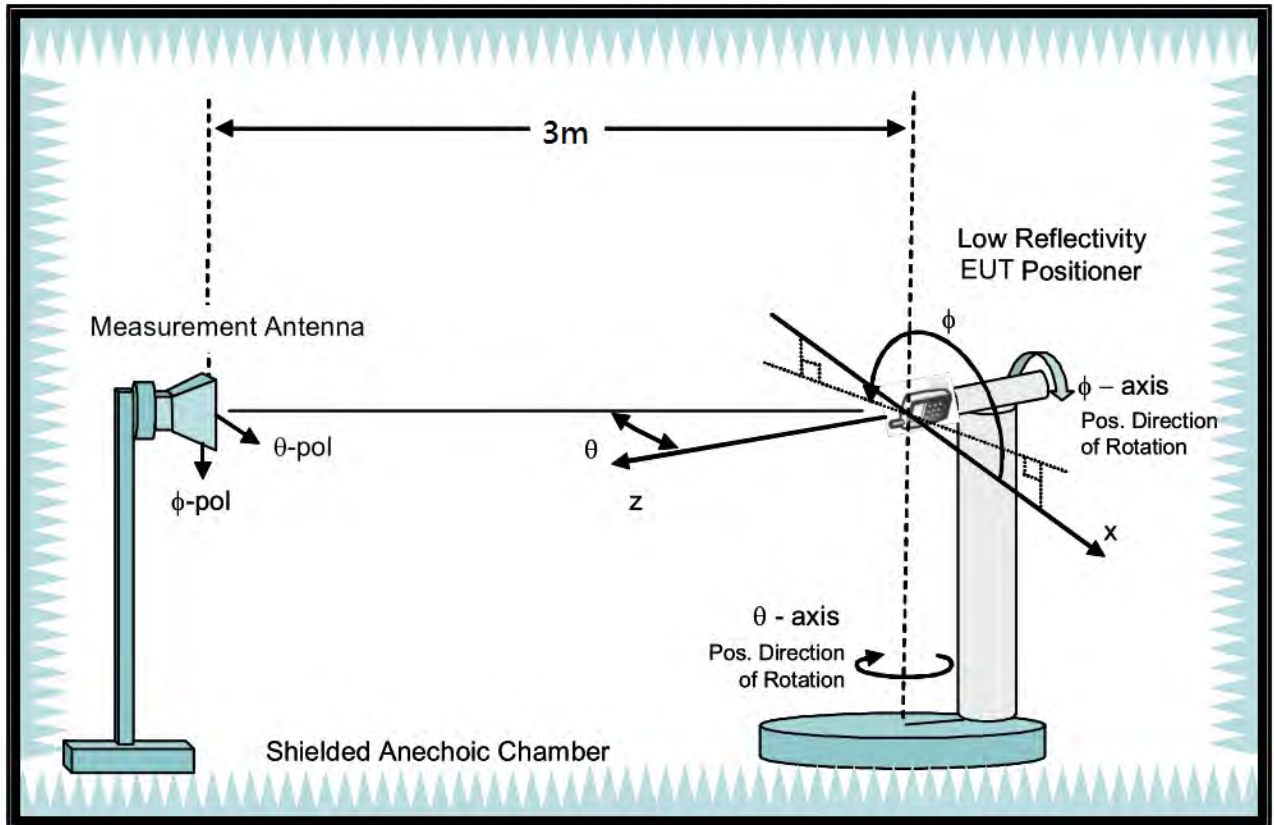
Test configuration: Reference to CITA OTA distributed-axes system configuration.

Chamber: Fully Anechoic Chamber.

Measurement antenna: Dual Polarization Horn antenna

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

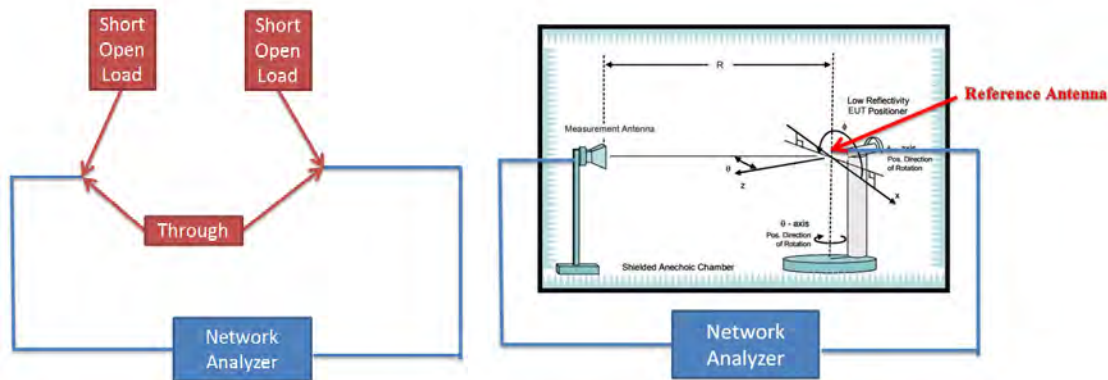
#Reference to CTIA "ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1"



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:

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

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 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)	0.15	-2.37	-4.82	-1.93	-0.82
Ant. 2 (dBi)	-0.56	0.43	0.1	-0.31	-2.03
Ant. 3 (dBi)	0.6	-1.08	2.11	1.39	1.62
Ant. 4 (dBi)	-0.34	-2.5	0.96	-0.66	-0.72
DG [1SS] (dBi)	5.99	4.72	5.97	5.72	5.64
Polarization	Theta	Theta	Theta	Theta	Theta
Θ (°)	90	90	82.5	90	60
Φ (°)	75	127.5	142.5	22.5	195

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 ^(0.15/20)	10 ^(-2.37/20)	10 ^(-4.82/20)	10 ^(-1.93/20)	10 ^(-0.82/20)
Ant. 2 [10 ^(G/20)]	10 ^(-0.56/20)	10 ^(0.43/20)	10 ^(0.1/20)	10 ^(-0.31/20)	10 ^(-2.03/20)
Ant. 3 [10 ^(G/20)]	10 ^(0.6/20)	10 ^(-1.08/20)	10 ^(2.11/20)	10 ^(1.39/20)	10 ^(1.62/20)
Ant. 4 [10 ^(G/20)]	10 ^(-0.34/20)	10 ^(-2.5/20)	10 ^(0.96/20)	10 ^(-0.66/20)	10 ^(-0.72/20)
Ant. 1 [10 ^(G/20)] value	1.017	0.761	0.574	0.801	0.91
Ant. 2 [10 ^(G/20)] value	0.938	1.051	1.012	0.965	0.792
Ant. 3 [10 ^(G/20)] value	1.072	0.883	1.275	1.174	1.205
Ant. 4 [10 ^(G/20)] value	0.962	0.75	1.117	0.927	0.92
Sum All Antenna [Amax]	3.988	3.445	3.978	3.866	3.827
DG [10*log(Amax ² /Nant)]	5.99	4.72	5.97	5.72	5.64

Note:

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

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



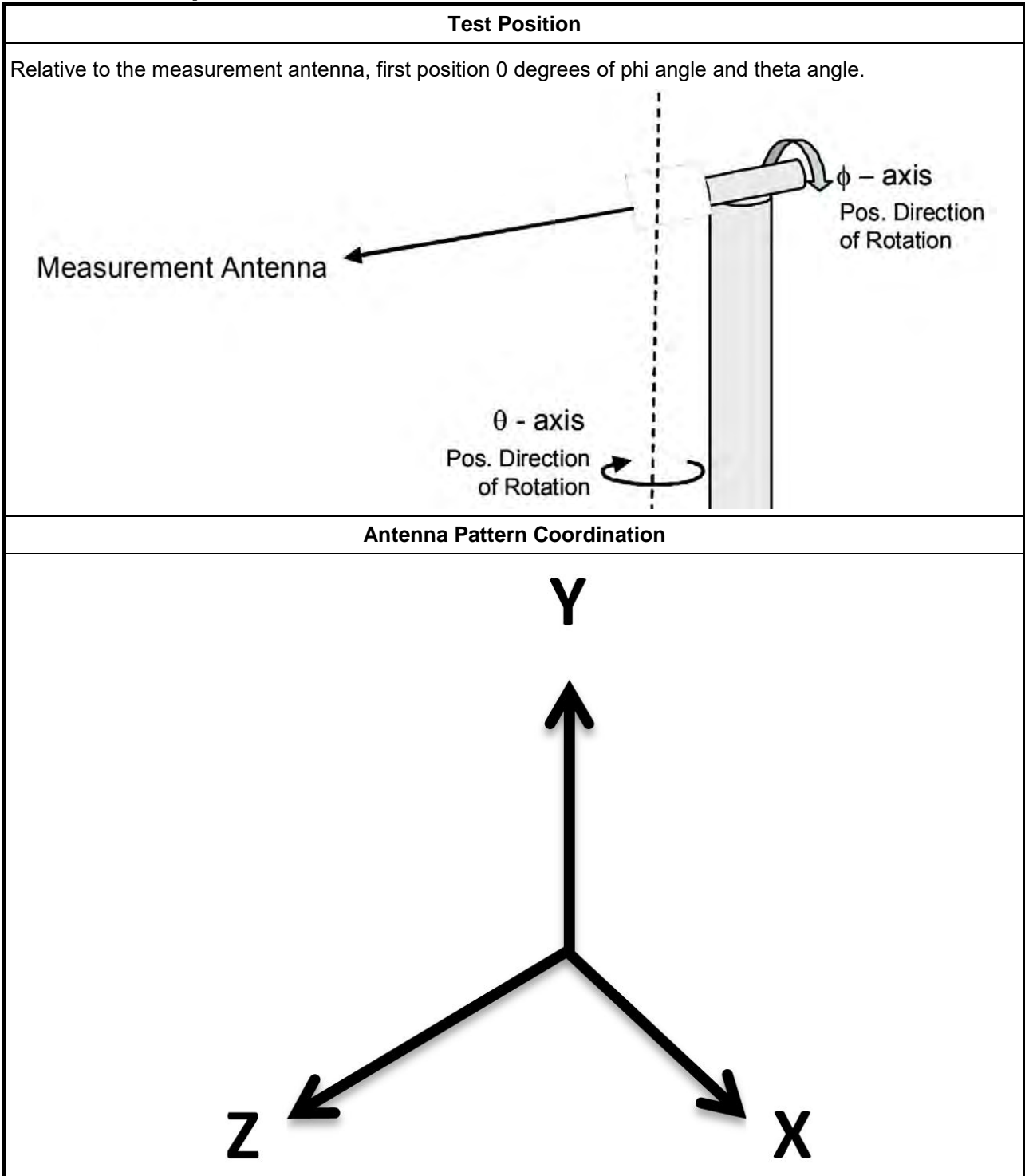
8. Summary of Test Result

Freq(Hz)	2.45G	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	2.09	1.52	1.17	1.98	1.08
Ant. 2 Max Gain (dBi)	1.84	2.29	2.9	3.09	2.51
Ant. 3 Max Gain (dBi)	2.91	2.7	3.04	2.48	3.39
Ant. 4 Max Gain (dBi)	2.14	1.21	1.19	3.23	1.87
Ant. 1 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/97.5/165	Theta/67.5/270	Theta/67.5/270	Theta/97.5/232.5	Theta/82.5/247.5
Ant. 2 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/52.5/262.5	Theta/60/262.5	Theta/90/97.5	Theta/60/247.5	Theta/90/97.5
Ant. 3 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/52.5/180	Theta/60/180	Theta/60/180	Theta/90/37.5	Theta/75/195
Ant. 4 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/60/172.5	Theta/82.5/165	Theta/82.5/157.5	Theta/82.5/180	Theta/67.5/165
Max Gain (dBi)	2.91	2.7	3.04	3.23	3.39
DG [1SS] (dBi)	5.99	4.72	5.97	5.72	5.64
DG [2SS] (dBi)	2.99	2.7	3.04	3.23	3.39
DG [4SS] (dBi)	2.91	2.7	3.04	3.23	3.39

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. Refer to KDB662911D01 (F) (2) (e) (ii)
4. Directional Gain (4SS) = Directional Gain (1SS) – 6dB. If directional gain is less than max gain, use max gain as directional gain. Refer to KDB662911D01 (F) (2) (e) (ii)

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-1543	1GHz~18GHz	May 31, 2022	May. 30, 2023
Dual Polarization Horn Antenna	Sporton	S0209DP	S0209DP-001	2GHz~9GHz	N.C.R.	N.C.R.
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	N.C.R.	N.C.R.
Multi-axis positioner	Sporton	MAPS01	MAPS01-001	Theta / Phi axis	N.C.R.	N.C.R.
Test Software	SPORTON	SENSE-RDG	V1.0.8	-	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.

Appendix A – Radiated Composite Gain	Page 13
Appendix B – Antenna Pattern	Page 27
Appendix C – Test Photos.....	Page 34



Freq(Hz)	2.45G	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	2.09	1.52	1.17	1.98	1.08
Ant. 2 Max Gain (dBi)	1.84	2.29	2.9	3.09	2.51
Ant. 3 Max Gain (dBi)	2.91	2.7	3.04	2.48	3.39
Ant. 4 Max Gain (dBi)	2.14	1.21	1.19	3.23	1.87
Ant. 1 Polarization/ $\theta(^{\circ})/\Phi(^{\circ})$	Theta/97.5/165	Theta/67.5/270	Theta/67.5/270	Theta/97.5/232.5	Theta/82.5/247.5
Ant. 2 Polarization/ $\theta(^{\circ})/\Phi(^{\circ})$	Theta/52.5/262.5	Theta/60/262.5	Theta/90/97.5	Theta/60/247.5	Theta/90/97.5
Ant. 3 Polarization/ $\theta(^{\circ})/\Phi(^{\circ})$	Theta/52.5/180	Theta/60/180	Theta/60/180	Theta/90/37.5	Theta/75/195
Ant. 4 Polarization/ $\theta(^{\circ})/\Phi(^{\circ})$	Theta/60/172.5	Theta/82.5/165	Theta/82.5/157.5	Theta/82.5/180	Theta/67.5/165
Max Gain (dBi)	2.91	2.7	3.04	3.23	3.39
DG [1SS] (dBi)	5.99	4.72	5.97	5.72	5.64
DG [2SS] (dBi)	2.99	2.7	3.04	3.23	3.39
DG [4SS] (dBi)	2.91	2.7	3.04	3.23	3.39



Radiated Composite Gain Data

Appendix A

Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq	Theta	Phi	Gain	Freq												
Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd	Θ(22.5)	Φ(0°)	-18.25/14.36	5.3GPd



Radiated Composite Gain Data

Appendix A

Table with 33 columns (Theta, Gain, etc.) and 24 rows of data. It contains detailed gain data for various frequencies and angles, including sub-headers for Frequency and Theta/Ant 2.



Radiated Composite Gain Data

Appendix A

Freq(Hz)	ThetaAnt 2	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-
Theta(165°)	9.89/8.89	8.47/9.63	-12.19/15.99	-17.86/16.85	-14.18/11.94	-13.99/17.66	-15.56/19.24	-18.83/16.5	-19.04/16.01	-15.09/14.93	-11.87/9.93	-12.86/18.37	-18.9/17.86	-17.76/17.7	-18.92/16.61	-15.35/13.11	-12.56/13.42	-12.79/15.62	-17.7/18.55	-14.6/14.21	-13.68/14.67	-15.22/17.33	-17.77/18.61	-18/16
Theta(172.5°)	-11.42/10.37	-9.53/10.06	-10.26/10.96	-12.26/15.07	-13.97/12.37	-12.29/9.88	-12.49/11.92	-13.74/16.36	-19/18.12	-16.17/15.63	-13.41/12.06	-14.77/18.82	-19.32/19.1	-19.02/18.17	-17.45/16.72	-16.41/14.69	-17.15/14.47	-15.76/15.84	-18.36/18.7	-19.28/18.22	-18.91/17.67	-18.62/18.14	-15.79/16.25	-18.05/17.77
Theta(180°)	-13.45/12.5	-13.91/14.32	-14.39/15.92	-15.36/13.94	-14.06/14.01	-13.71/10.68	-13.13/12.47	-18.83/18.48	-18.92/19.17	-18.73/17.03	-14.64/15.57	-18.67/17.9	-18.53/17.6	-18.22/18.16	-15.12/16.61	-18.13/18.84	-18.63/19.01	-19.13/18.44	-19.13/18.44	-17.35/18.38	-19.18/02	-17.67/17.99	-18.81/18.54	-18.89/17.12
Gain	Phi(0°)/Phi(7.5°)	Phi(15°)/Phi(22.5°)	Phi(30°)/Phi(37.5°)	Phi(45°)/Phi(52.5°)	Phi(60°)/Phi(67.5°)	Phi(75°)/Phi(82.5°)	Phi(90°)/Phi(97.5°)	Phi(105°)/Phi(112.5°)	Phi(120°)/Phi(127.5°)	Phi(135°)/Phi(142.5°)	Phi(150°)/Phi(157.5°)	Phi(165°)/Phi(172.5°)	Phi(180°)/Phi(187.5°)	Phi(195°)/Phi(202.5°)	Phi(210°)/Phi(217.5°)	Phi(225°)/Phi(232.5°)	Phi(240°)/Phi(247.5°)	Phi(255°)/Phi(262.5°)	Phi(270°)/Phi(277.5°)	Phi(285°)/Phi(292.5°)	Phi(300°)/Phi(307.5°)	Phi(315°)/Phi(322.5°)	Phi(330°)/Phi(337.5°)	Phi(345°)/Phi(352.5°)
Theta(0°)	-18.97/18.24	-17.27/18.5	-18.21/17.31	-16.62/17.76	-15.06/13.95	-12.61/12.35	-16.53/14.47	-14.71/14.74	-14.21/18.69	-19.29/17.91	-17.8/18.95	-19.27/17.74	-18.29/16.85	-16.61/17.58	-18.03/15.9	-14.33/13.29	-11.89/14.31	-14.12/13.99	-14.12/14.43	-16.75/16.47	-18.42/18.34	-17.88/17.89	-18.36/17.38	-18.35/16.62