



Antenna Composite Gain Test Report

FCC ID	UIDNVG653UX
Equipment	5G NR Fixed Wireless Router
Brand Name	ARRIS
Model Name	NVG653UX
Applicant	ARRIS 3871 Lakefield Drive Suite 300 SUWANEE Georgia United States 30024
Manufacturer	ARRIS 3871 Lakefield Drive Suite 300 SUWANEE Georgia United States 30024
Sample Received	Sep. 12, 2022
Start Test Date	Sep. 22, 2022
Final Test Date	Sep. 22, 2022

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.)



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History of this test report

Report No.	Version	Description	Issued Date
AP282902-02	01	Initial issue of report	Feb. 06, 2023



1. Operation Mode and Antenna Information

Antenna Position	RF Port	Brand Name	Model Name	Ant. Type	Connector	Modes of Operation
Ant1	2	Lynwave	ALX21P-221AA1-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3
Ant2	1	Lynwave	ALX21P-221AA1-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3
Ant3	3	Lynwave	ALX21P-221AA2-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3
Ant4	4	Lynwave	ALX21P-221AA2-A	Dipole	I-PEX	2.4GHz, 5GHz UNII 1~3

Note:

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

Ant1~4 can be used as transmitting/receiving antenna.

Ant1~4 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	23.5-24.5 / 45-55	Sep. 22, 2022

Note:

Testing Site Information

Brand Name: TDK

Dimension: 11m*6m*6m

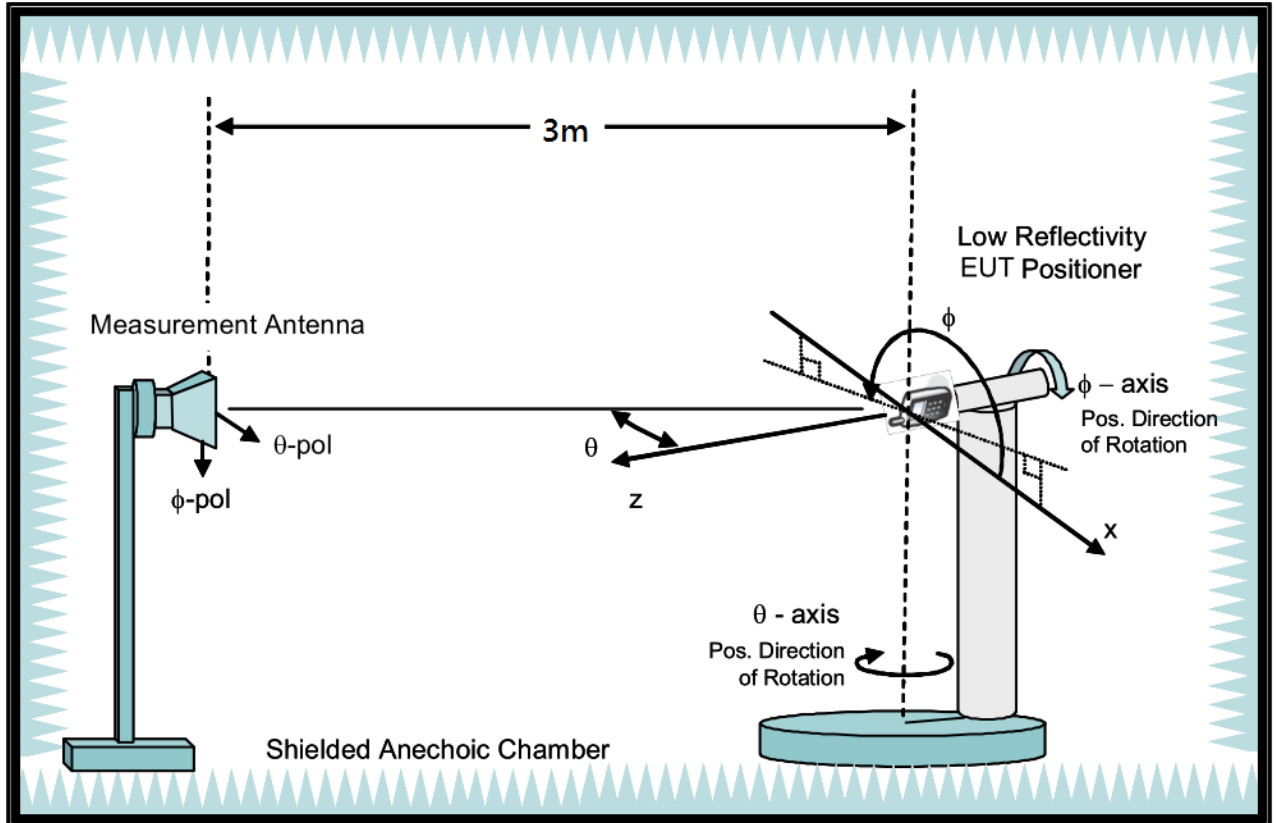
Characteristic: Fully Anechoic Chamber

Reference to Sporton Project No.: 282902

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).

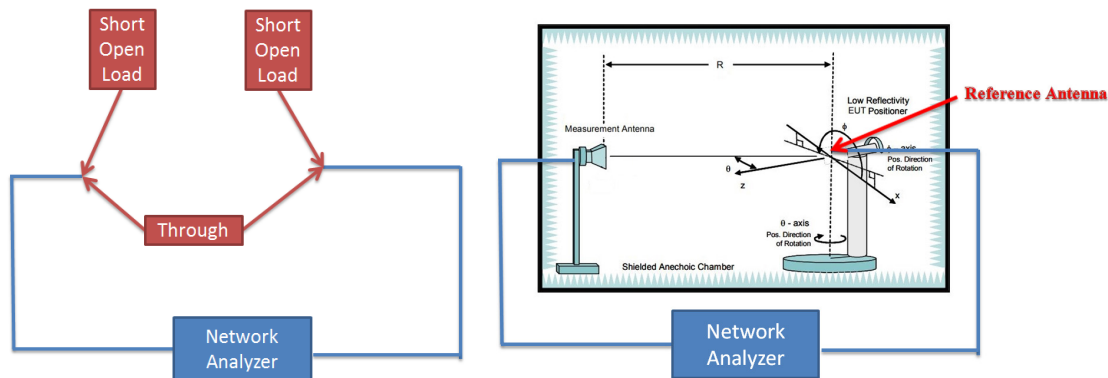
#Reference to CTIA "ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1"



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)	3.18	-8.11	-4.37	-9.66	-3.64
Ant. 2 (dBi)	3.42	-4.97	1.37	4.99	4.79
Ant. 3 (dBi)	-5.85	0.35	3.01	-0.24	-7.59
Ant. 4 (dBi)	-0.54	5.27	-5.12	1.01	2.17
DG [1SS] (dBi)	6.8	5.65	5.45	6.45	6.22
Polarization	Theta	Phi	Theta	Theta	Theta
$\Theta(^{\circ})$	37.5	120	75	60	67.5
$\Phi(^{\circ})$	105	15	337.5	22.5	37.5

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 [$10^{(G/20)}$]	$10^{(3.18/20)}$	$10^{(-8.11/20)}$	$10^{(-4.37/20)}$	$10^{(-9.66/20)}$	$10^{(-3.64/20)}$
Ant. 2 [$10^{(G/20)}$]	$10^{(3.42/20)}$	$10^{(-4.97/20)}$	$10^{(1.37/20)}$	$10^{(4.99/20)}$	$10^{(4.79/20)}$
Ant. 3 [$10^{(G/20)}$]	$10^{(-5.85/20)}$	$10^{(0.35/20)}$	$10^{(3.01/20)}$	$10^{(-0.24/20)}$	$10^{(-7.59/20)}$
Ant. 4 [$10^{(G/20)}$]	$10^{(-0.54/20)}$	$10^{(5.27/20)}$	$10^{(-5.12/20)}$	$10^{(1.01/20)}$	$10^{(2.17/20)}$
Ant. 1 [$10^{(G/20)}$] value	1.442	0.393	0.605	0.329	0.658
Ant. 2 [$10^{(G/20)}$] value	1.483	0.564	1.171	1.776	1.736
Ant. 3 [$10^{(G/20)}$] value	0.51	1.041	1.414	0.973	0.417
Ant. 4 [$10^{(G/20)}$] value	0.94	1.834	0.555	1.123	1.284
Sum All Antenna [Amax]	4.374	3.833	3.744	4.201	4.095
DG [$10^{*log(Amax^2/Nant)}$]	6.8	5.65	5.45	6.45	6.22

Note:

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

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

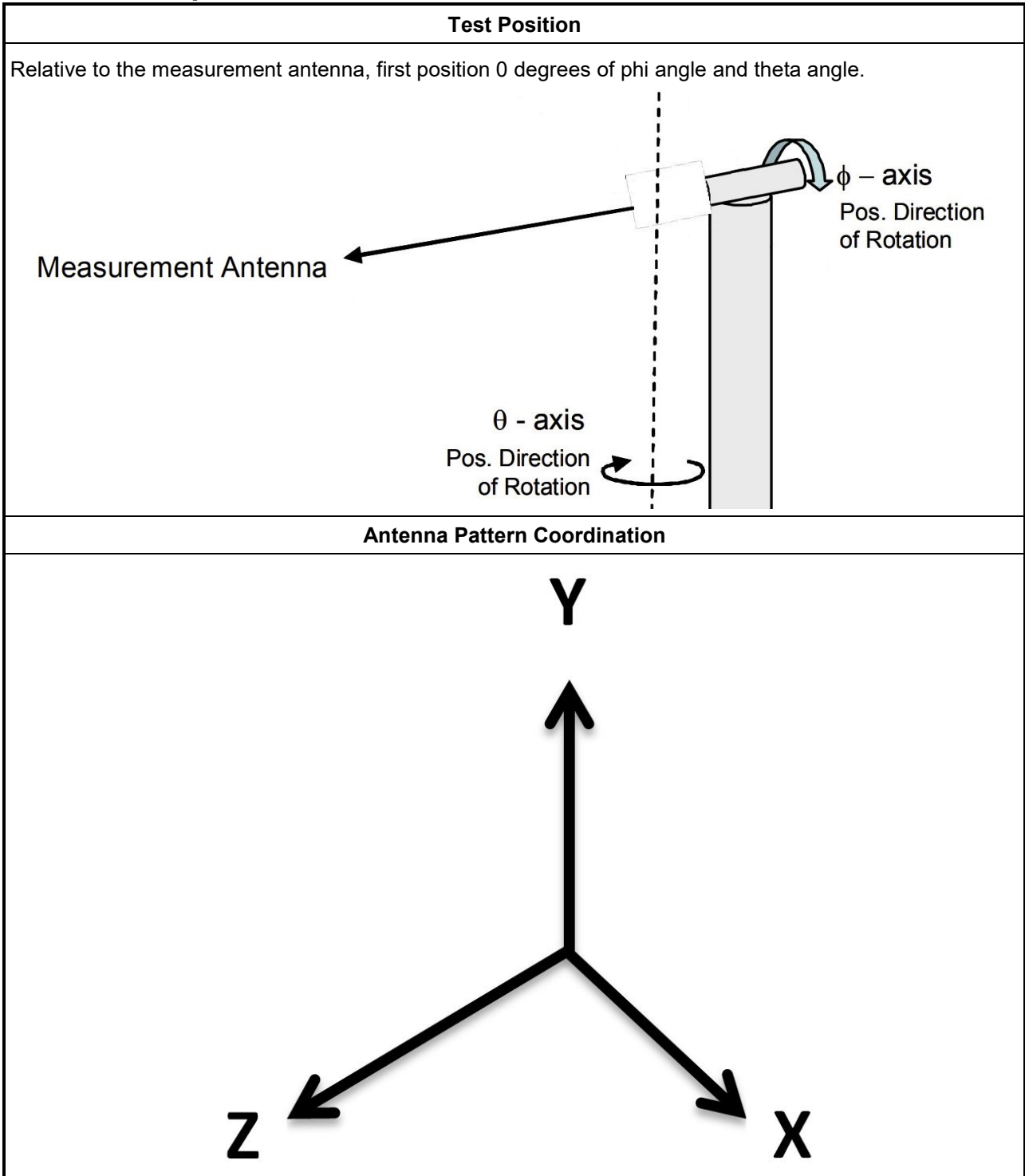
8. Summary of Test Result

Frequency (Hz)	2.45G	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	3.78	3.44	2.93	3.89	4.93
Ant. 2 Max Gain (dBi)	3.54	4.09	4.35	4.99	5.82
Ant. 3 Max Gain (dBi)	2.96	4.48	3.51	2.81	3.46
Ant. 4 Max Gain (dBi)	3.55	5.29	4.52	4.63	5.75
Ant. 1 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/45/120	Theta/60/150	Theta/52.5/150	Theta/112.5/52.5	Theta/112.5/45
Ant. 2 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Phi/37.5/112.5	Theta/112.5/135	Theta/112.5/135	Theta/60/22.5	Theta/112.5/135
Ant. 3 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/75/270	Theta/75/330	Theta/82.5/337.5	Theta/60/0	Theta/82.5/285
Ant. 4 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$	Theta/37.5/52.5	Phi/120/7.5	Phi/120/15	Phi/112.5/15	Phi/127.5/7.5
Max Gain (dBi)	3.78	5.29	4.52	4.99	5.82
DG [1SS] (dBi)	6.8	5.65	5.45	6.45	6.22
DG [2SS] (dBi)	3.79	5.29	4.52	4.99	5.82
DG [4SS] (dBi)	3.78	5.29	4.52	4.99	5.82

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) – 3.01dB. If directional gain is less than max gain, use max gain as directional gain.
4. Directional Gain (4SS) = Directional Gain (1SS) – 6.02dB. 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-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.

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Freq(Hz)	2.45G	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	3.78	3.44	2.93	3.89	4.93
Ant. 2 Max Gain (dBi)	3.54	4.09	4.35	4.99	5.82
Ant. 3 Max Gain (dBi)	2.96	4.48	3.51	2.81	3.46
Ant. 4 Max Gain (dBi)	3.55	5.29	4.52	4.63	5.75
Ant. 1 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/45/120	Theta/60/150	Theta/52.5/150	Theta/112.5/52.5	Theta/112.5/45
Ant. 2 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Phi/37.5/112.5	Theta/112.5/135	Theta/112.5/135	Theta/60/22.5	Theta/112.5/135
Ant. 3 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/75/270	Theta/75/330	Theta/82.5/337.5	Theta/60/0	Theta/82.5/285
Ant. 4 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/37.5/52.5	Phi/120/7.5	Phi/120/15	Phi/112.5/15	Phi/127.5/7.5
Max Gain (dBi)	3.78	5.29	4.52	4.99	5.82
DG [1SS] (dBi)	6.8	5.65	5.45	6.45	6.22
DG [2SS] (dBi)	3.79	5.29	4.52	4.99	5.82
DG [4SS] (dBi)	3.78	5.29	4.52	4.99	5.82



Radiated Composite Gain Data

Appendix A

Theta (°)	-13.07:11.88	-16.31:18.13	-17.89:19.23	-18.31:15.08	-13.17:9.67	-6.46:4.48	-3.34:4.1	-3.36:4.4	-4.17:3.3	-4.54:5.24	-5.91:6.64	-7.66:9.24	-10.88:13.3	-15.14:15.37	-13.22:12.49	-11.71:10.29	-7.66:6.29	-6.63:8.59	-11.21:14.04	-14.09:11.16	-9.05:7.66	-7.66:9.4	-12.78:14.95	-15.05:12.95																								
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	7.5	15	22.5	30	37.5	45	52.5	60	67.5	75	82.5	90	97.5	105	112.5	120	127.5	135	142.5	150	157.5	165	172.5	180	187.5	195	202.5	210	217.5	225	232.5	240	247.5	255	262.5	270	277.5	285	292.5	300	307.5	315	322.5	330	337.5	345	352.5
Gain	-12.76:12.46	-9.06:17.2	-9.41:10.11	-11.16:12.7	-13.45:18.02	-15.86:15.06	-14.01:12.92	-13.31:13.79	-15.03:15.44	-15.79:18.54	-15.55:13.36	-11.88:11.06	-10.13:9.91	-12.11:12.69	-11.91:12.3	-14.14:9	-14.82:14.36	-13.72:13.47	-12.35:11.44	-10.81:10.69	-11.39:11.24	-10.36:9.69	-8.67:8.45	-8.42:8.37																								



Radiated Composite Gain Data

Appendix A

Theta	Phi(75°)	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°)
Theta(7.5°)	-18.37-16.68	-14.37-12.42	-10.59-9.08	-7.87-6.74	-5.91-5.21	-4.69-4.36	-3.61-3.45	-2.73-2.79	-2.00-2.05	-1.50-1.49	-1.11-1.10	-0.80-0.79	-0.56-0.55	-0.38-0.37	-0.25-0.24	-0.17-0.16	-0.12-0.11	-0.08-0.07	-0.05-0.04	-0.03-0.02	-0.01-0.01	0.00-0.00	0.00-0.00	0.01-0.01	0.02-0.02	0.03-0.03	0.05-0.05	0.07-0.07	0.10-0.10	0.14-0.14	0.19-0.19	0.25-0.25	0.32-0.32	0.41-0.41	0.51-0.51	0.62-0.62	0.75-0.75	0.90-0.90	1.07-1.07	1.27-1.27	1.50-1.50	1.76-1.76	2.05-2.05	2.37-2.37		



Total Gain Data

Table with columns for Frequency (Freq/Hz), Polarization (Pol), Total Antenna Gain, and 28 directional gain components (Phi(0) to Phi(35)). Rows represent different frequencies from 0 to 15 degrees.



Antenna Pattern

Appendix B

Theta (°)	-12.77:11.66	-11.22:8.44	-7.94:8.38	-7.44:7.16	-6.34:6.36	-8.11:7.55	-5.16:3.18	-2.40:2.07	-1.57:0.93	-0.82:1.27	-2.10:2.60	-2.64:3.11	-3.95:4.47	-4.04:3.55	-3.28:3.60	-4.39:5.43	-6.38:6.88	-6.54:5.94	-5.41:5.25	-5.37:5.99	-7.05:9.37	-8.98:10.62	-12.29:11.23	-10.79:10.68
Gain	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Theta (°)	0(0°)	1(15°)	2(30°)	3(45°)	4(60°)	5(75°)	6(90°)	7(105°)	8(120°)	9(135°)	10(150°)	11(165°)	12(180°)	13(195°)	14(210°)	15(225°)	16(240°)	17(255°)	18(270°)	19(285°)	20(300°)	21(315°)	22(330°)	23(345°)
Gain	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000



Table with 38 columns (Theta and Phi angles) and 200 rows (Theta and Phi values). It contains numerical data representing antenna patterns across various frequencies and gains.



Antenna Pattern

Appendix B

Table with columns for frequency (Freq), gain, and various antenna pattern angles (Theta) from 0 to 180 degrees. The table contains numerical data for each parameter across the frequency range.

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 $\Theta(0-180)\Phi(270)$

