



Antenna Composite Gain Test Report

FCC ID	VW3FAST399V2
Equipment	Wireless Home Router
Brand Name	SAGEMCOM
Model Name	FAST 399
Applicant	SAGEMCOM BROADBAND SAS 250 Route de l'Empereur - 92848 RUEIL MALMAISON CEDEX- FRANCE
Manufacturer	SAGEMCOM BROADBAND SAS 250 Route de l'Empereur - 92848 RUEIL MALMAISON CEDEX- FRANCE
Sample Received	Nov. 07, 2022
Start Test Date	Nov. 23, 2022
Final Test Date	Nov. 23, 2022

Approved by: Sam Chen

Sporton International Inc. Hsinchu Laboratory

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Table of Contents

History of this test report.....	3
1. Operation Mode and Antenna Information	4
2. Test Frequency	4
3. Testing Location.....	5
4. Test Facility and Configuration.....	6
5. Reference Calibration	7
6. Test Method	8
7. Measured Values and Calculation of Maximum Gain Positions.....	9
8. Summary of Test Result	10
9. Test Setup	11
10. Test Equipment and Calibration Data	12
11. Test Results	13



History of this test report

Report No.	Version	Description	Issued Date
AP170737-06	01	Initial issue of report	Jan. 11, 2023



1. Operation Mode and Antenna Information

Table with 9 columns: Antenna Position, RF Port (WLAN 2.4GHz, WLAN 5GHz, WLAN 6GHz), Brand Name, Model Name, Ant. Type, Connector, Modes of Operation. Rows include 2G5G Ant1-3, 5G Ant4, and 6G Ant1-4.

Note:

2.4GHz Operation Mode (3TX/3RX)

2G5G Ant1~3 can be used as transmitting/receiving antenna.

2G5G Ant1~3 could transmit/receive simultaneously.

5GHz Operation Mode (4TX/4RX)

2G5G Ant1~5G Ant4 can be used as transmitting/receiving antenna.

2G5G Ant1~5G Ant4 could transmit/receive simultaneously.

6GHz Operation Mode (4TX/4RX)

6G Ant1~4 can be used as transmitting/receiving antenna.

6G Ant1~4 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 (2400-2483.5, 5150-5250, 5250-5350, 5470-5725, 5725-5850) and their corresponding test frequencies (2450, 5200, 5300, 5600, 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 / 50-55	Nov. 23, 2022

Note:

Testing Site Information

Brand Name: TDK

Dimension: 11m*6m*6m

Characteristic: Fully Anechoic Chamber

4. Test Facility and Configuration

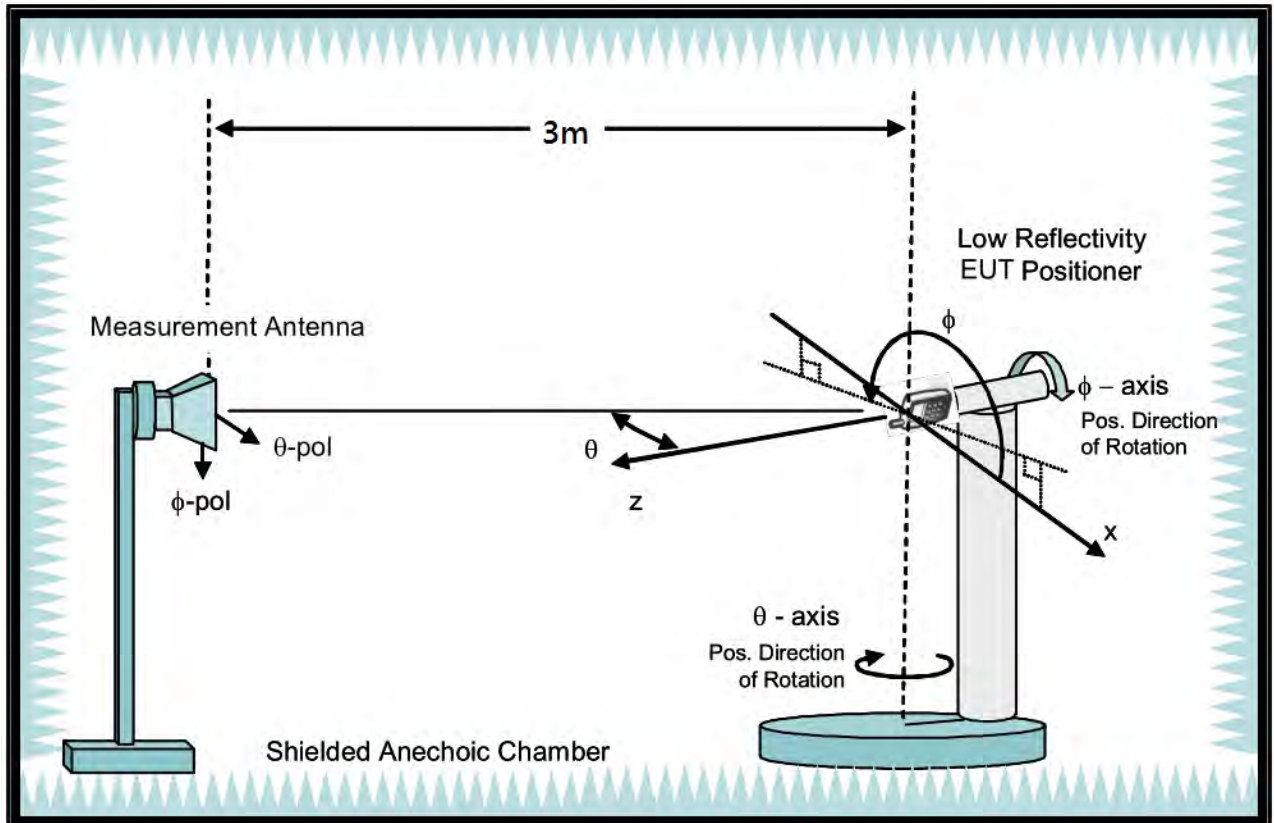
Test configuration: Reference to CITA OTA distributed-axes system configuration.

Chamber: Fully Anechoic Chamber.

Measurement antenna: Dual Polarization Horn antenna

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

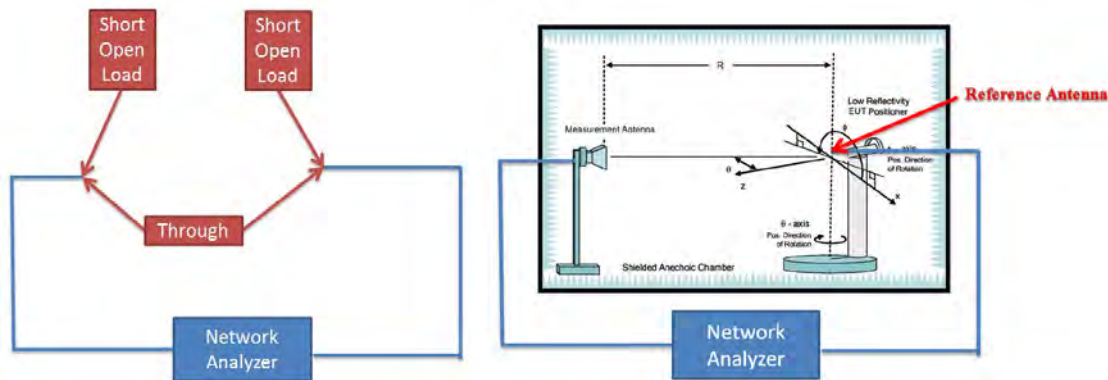
#Reference to CTIA “ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1”



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:

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

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)	2	2.76	-10.68	1.45	2.07
Ant. 2 (dBi)	-1.25	1.3	-6.3	0.06	-0.12
Ant. 3 (dBi)	-7.13	-3.33	1.25	-9.2	-6.81
Ant. 4 (dBi)	-	-8.15	1.93	-3.92	-4.22
DG [1SS] (dBi)	3.41	5.13	4.03	4.01	4.42
Polarization	Theta	Theta	Phi	Theta	Theta
$\Theta(^{\circ})$	97.5	82.5	67.5	97.5	97.5
$\Phi(^{\circ})$	210	22.5	187.5	187.5	187.5

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 [$10^{(G/20)}$]	$10^{(2/20)}$	$10^{(2.76/20)}$	$10^{(-10.68/20)}$	$10^{(1.45/20)}$	$10^{(2.07/20)}$
Ant. 2 [$10^{(G/20)}$]	$10^{(-1.25/20)}$	$10^{(1.3/20)}$	$10^{(-6.3/20)}$	$10^{(0.06/20)}$	$10^{(-0.12/20)}$
Ant. 3 [$10^{(G/20)}$]	$10^{(-7.13/20)}$	$10^{(-3.33/20)}$	$10^{(1.25/20)}$	$10^{(-9.2/20)}$	$10^{(-6.81/20)}$
Ant. 4 [$10^{(G/20)}$]	-	$10^{(-8.15/20)}$	$10^{(1.93/20)}$	$10^{(-3.92/20)}$	$10^{(-4.22/20)}$
Ant. 1 [$10^{(G/20)}$] value	1.259	1.374	0.292	1.182	1.269
Ant. 2 [$10^{(G/20)}$] value	0.866	1.161	0.484	1.007	0.986
Ant. 3 [$10^{(G/20)}$] value	0.44	0.682	1.155	0.347	0.457
Ant. 4 [$10^{(G/20)}$] value	-	0.391	1.249	0.637	0.615
Sum All Antenna [Amax]	2.565	3.608	3.18	3.172	3.327
DG [$10 \cdot \log(Amax^2/N_{ant})$]	3.41	5.13	4.03	4.01	4.42

Note:

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

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



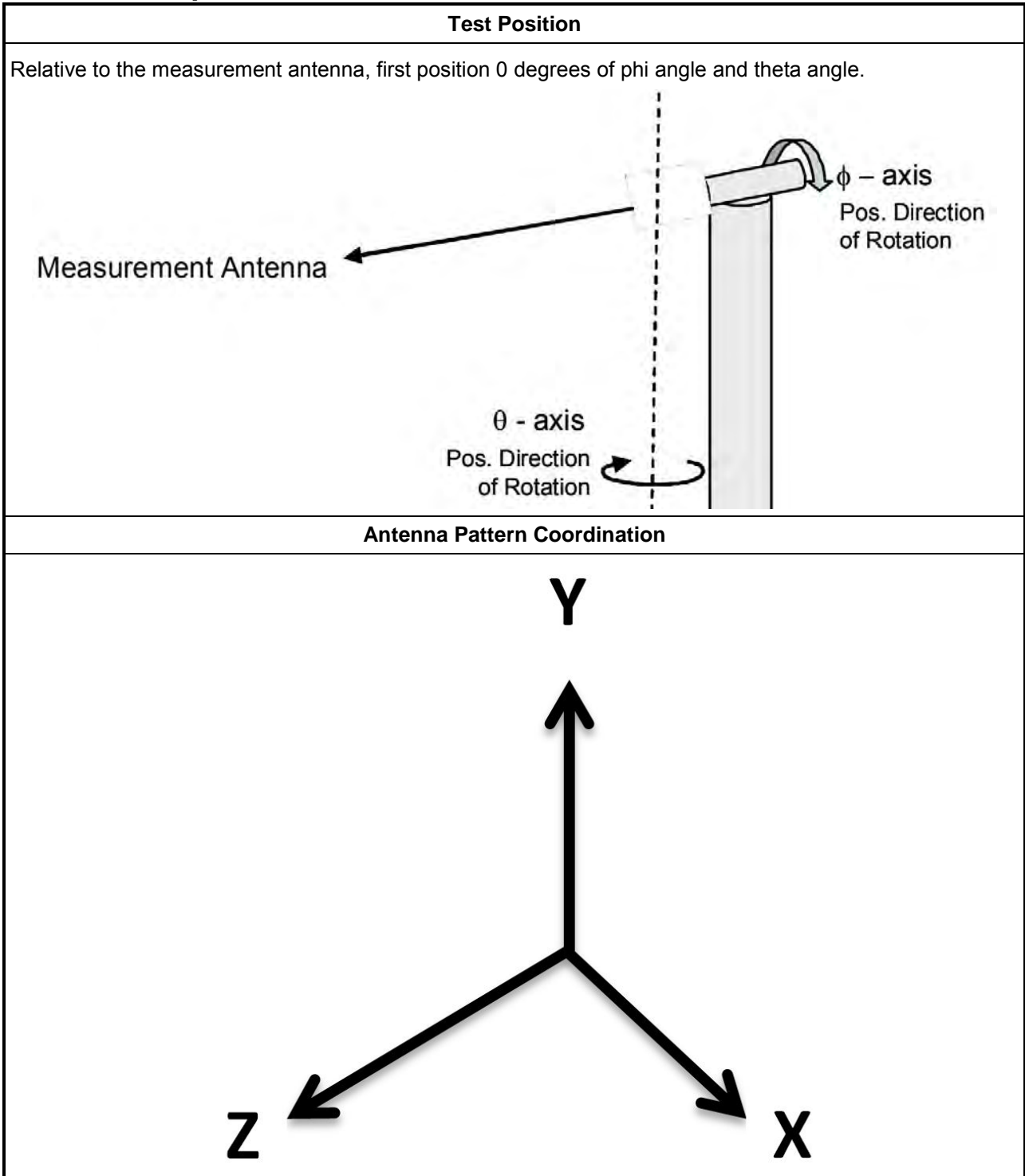
8. Summary of Test Result

Table with 6 columns: Freq(Hz), 2.45G, 5.2G, 5.3G, 5.6G, 5.785G. Rows include Max Gain (dBi), Polarization/Theta/Phi, DG [1SS/2SS/4SS] (dBi) for Antennas 1-4.

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 (3SS) = Directional Gain (1SS) - 4.77dB. If directional gain is less than max gain, use max gain as directional gain. Refer to KDB662911D01 (F) (2) (e) (ii)
5. 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 14
Appendix B – Antenna Pattern.....	Page 28
Appendix C – Test Photos.....	Page 35



Freq(Hz)	2.45G
Ant. 1 Max Gain (dBi)	3.12
Ant. 2 Max Gain (dBi)	1.24
Ant. 3 Max Gain (dBi)	3.18
Ant. 1 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Phi/142.5/150
Ant. 2 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/90/112.5
Ant. 3 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Phi/30/172.5
Max Gain (dBi)	3.18
DG [1SS] (dBi)	3.41
DG [2SS] (dBi)	3.18
DG [3SS] (dBi)	3.18

Freq(Hz)	5.2G	5.3G	5.6G	5.785G
Ant. 1 Max Gain (dBi)	3.32	3.31	2.65	3.66
Ant. 2 Max Gain (dBi)	2.27	1.97	2.31	2.46
Ant. 3 Max Gain (dBi)	3.33	2.68	2.36	2.01
Ant. 4 Max Gain (dBi)	4.9	3.67	3.24	3.22
Ant. 1 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/105/22.5	Theta/105/22.5	Theta/90/15	Theta/90/30
Ant. 2 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Theta/105/52.5	Theta/112.5/67.5	Theta/67.5/75	Theta/82.5/60
Ant. 3 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Phi/30/7.5	Phi/30/0	Phi/30/172.5	Phi/52.5/315
Ant. 4 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$	Phi/165/195	Phi/105/202.5	Phi/172.5/180	Phi/60/180
Max Gain (dBi)	4.9	3.67	3.24	3.66
DG [1SS] (dBi)	5.13	4.03	4.01	4.42
DG [2SS] (dBi)	4.9	3.67	3.24	3.66
DG [4SS] (dBi)	4.9	3.67	3.24	3.66



DG 1SS Result

Table with columns for Frequency (MHz), Polarization (Pol), and various Gain (dB) and Phase (Phi) values for different antenna configurations. The table is organized into multiple sections based on frequency bands (2.45G, 5.2G) and polarization types (Theta, Phi).



Table with 30 columns and 200 rows of numerical data representing radiated composite gain. The table includes headers for frequency (MHz) and gain (dB) for various antenna configurations and directions. Data points are organized in a grid with alternating positive and negative values, and some cells are highlighted in red (e.g., 3.074, 3.028, 3.413).



Table with columns for elevation angles (Theta) and azimuth angles (Phi) and corresponding gain values. The table contains 20 rows of elevation angles and 20 columns of azimuth angles, with a total of 400 data points.



Gain Result

Table with columns for Frequency (MHz), Polarization, and various Gain values (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(105), Phi(120), Phi(135), Phi(150), Phi(165), Phi(180), Phi(195), Phi(210), Phi(225), Phi(240), Phi(255), Phi(270), Phi(285), Phi(300), Phi(315), Phi(330), Phi(345)).



Table with columns for Frequency (MHz), Polarization (Theta/Ant), and Gain (Phi/Theta) for various angles (0 to 180 degrees) and frequencies (5.30 to 5.85 GHz). The table contains numerical gain values for each combination of parameters.



Table with columns for Frequency (Freq/Hz), Gain, and various antenna configurations (Theta/Ant 1 to 2). Rows represent different antenna types and frequencies, with numerical gain values for each configuration.



Radiated Composite Gain

Appendix A

Large data table with columns for frequency (5.2, 5.3, 5.6 GHz), antenna types (Theta, Phi), and gain values for various composite configurations. Includes a highlighted cell with value 0.46227.



Radiated Composite Gain

Appendix A

Table with 20 columns representing frequencies from 30° to 180° and 20 rows representing gains for various antenna configurations. Includes sub-headers for 5.2G Pol, Phi Ant 3, and Gain.



Large table with columns for frequency (MHz), antenna configurations, and gain values. Rows are labeled by frequency (e.g., 82.5, 90, 97.5, 105, 112.5, 120, 127.5, 135, 142.5, 150, 157.5, 165, 172.5, 180, 187.5, 195 MHz) and antenna pairs (e.g., Phi Ant 3, Phi Ant 4, etc.). Each cell contains a numerical gain value.



Radiated Composite Gain

Appendix A

Table with columns for Frequency (Freq), Gain, and various Phi angles (Phi(0) to Phi(345)). The table contains numerical data for each combination of frequency and angle.



Table with columns for Freq(Hz), 5.3GPol, Phi(Ant 4), and Gain. It contains multiple rows of data for various frequencies and polarizations, with values ranging from -15.51 to 15.51.



Table with columns for frequency (Freq(Hz)), gain (Gain), and various radiation angles (Theta) from 37.5 to 180 degrees. The table contains numerical data for each combination of frequency and angle.



Total Gain Data

Table with columns for Frequency (MHz), Polarization, and Gain (dBi) for various antenna configurations. The table is organized into multiple sections, each with a 'Freq(Hz)' and 'TotalAnt. 1' header. Each section contains 20 rows of gain data for different antenna types, such as Phi(0°)Phi(7.5°), Phi(15°)Phi(22.5°), etc. The gain values are listed in decibels (dBi).



Table with columns for Frequency (MHz), Total Ant 2, and Gain (dBi) for various antenna configurations. The table contains numerical data for each configuration across a range of frequencies.



Table with columns for Frequency (Freq(Hz)), Total Ant. 2, and Gain for various antenna configurations (Theta and Phi angles). The table contains numerical data for each configuration, with some cells highlighted in red.



Table with 28 columns representing elevation angles from 0 to 165 degrees and 28 rows representing gain values in dBi. The table contains numerical data for various antenna configurations and frequencies.



Table with columns for frequency (172.5 to 180 MHz), gain, and various antenna pattern parameters (Phi(0) to Phi(345)).

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

