FCC KDB inquiry
In KDB 388624 D02 & KDB 662911 D03
DRGAIN PAG-02

We provide the test plan and result.

checklist

1. Test dates, names of test engineers that performed the testing, table of contents, A table of calibrated test equipment used, and Names of any commercial test software used
2. Antenna system specification, configuration and description, including RF Chains and operating modes,
3. Antenna gain measurement setup, photos, units and conversions, test method and environment, calibration method and corrections.
4. Radiations plots viewable without magnification and are annotated with values of interest. Raw test data are not required.
5. DG composite gain formulas to be used, justification, calculations and summary tables for each in-band RF Chain or Operating Mode
6. For radiated out-of-band limits, DG must be determined and summarized for the entire frequency range of investigation.
7. Complex composite antenna gain systems require detail description and justification for an alternative DG determination method for consideration.

History :

DRgain PAG-01	Original
DRgain PAG-02	Add chamber description to P.6

Equipment	:	Home Gateway
Brand Name	:	Comtrend
Model Name	:	PBL-6201v2

Antenna Information

Equipment :

Antenna	Frequency band	Model	Type	connector
Ant1	2.4G, 5G UNII1~3	907X00747X67	copper Tube antenna	MHF
Ant2	2.4G, 5G UNII1~3	907X00747X67	copper Tube antenna	MHF
Ant3	2.4G, 5G UNII1~3	907X00747X66	copper Tube antenna	MHF
Ant4	2.4G, 5G UNII1~3	907X00747X66	copper Tube antenna	MHF

DGain supported band and Test Frequency

Band (MHz)	Test Frequency (MHz)
2400 – 2483.5	2450
5150 -5250	5200
5250 - 5350	5300
5470 - 5730	5600
5730 - 5850	5800

Test Item	Test Site	Test period	Environmental Conditions	Tested By
Antenna Gain	OTA01	2022/11/11~ 2022/11/12	24℃~26℃/ 50%~59%	Saul Wang

Measuring software :
ETS-Lindgren, L.P , EMQuest V1.14

For radiated out-of-band limits, we follow the method. In ANSI C63.10 clause 6.6 DRGain will not use.

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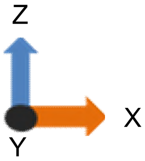
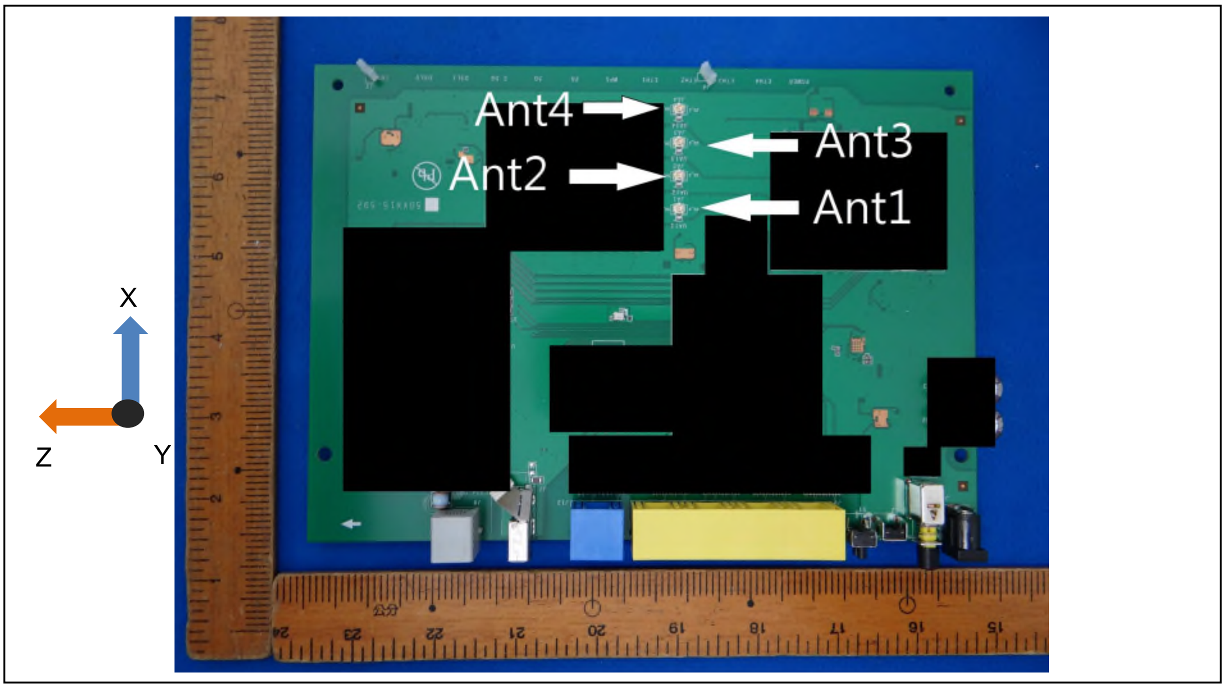


Back side :

Front: side of PCB board:



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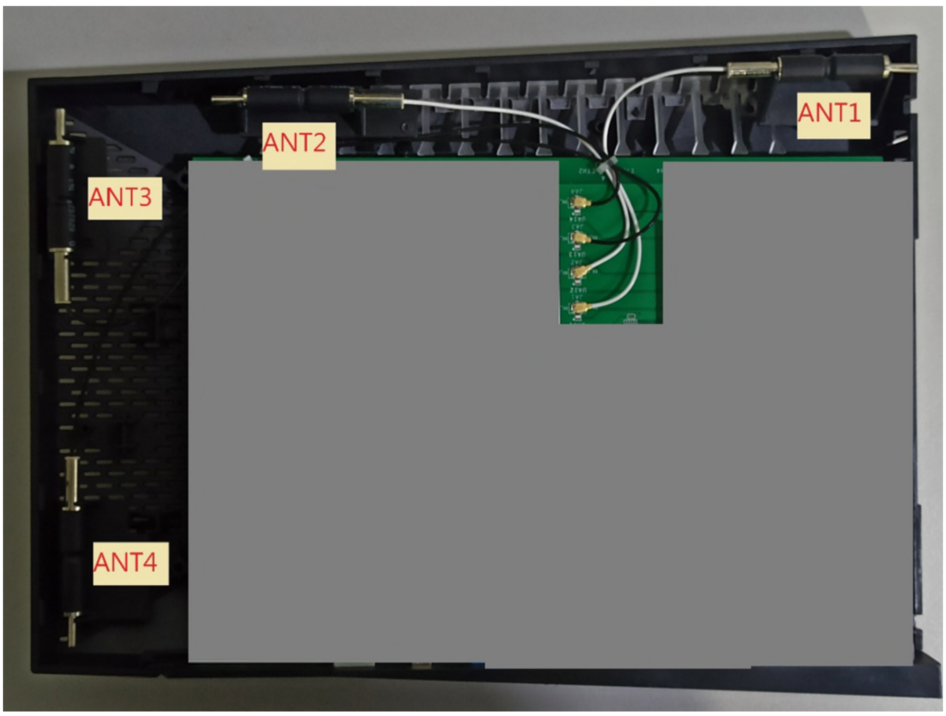

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	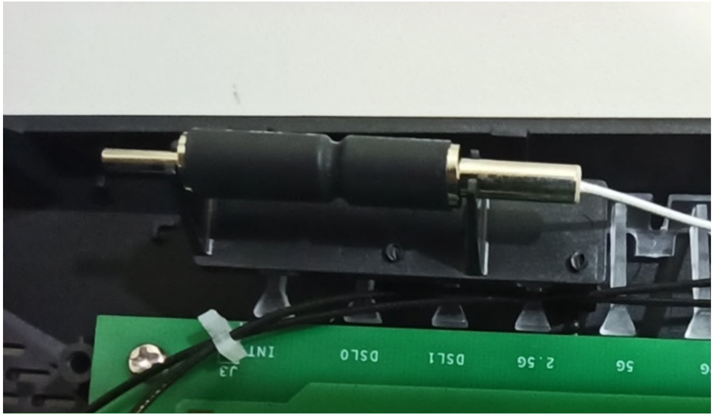
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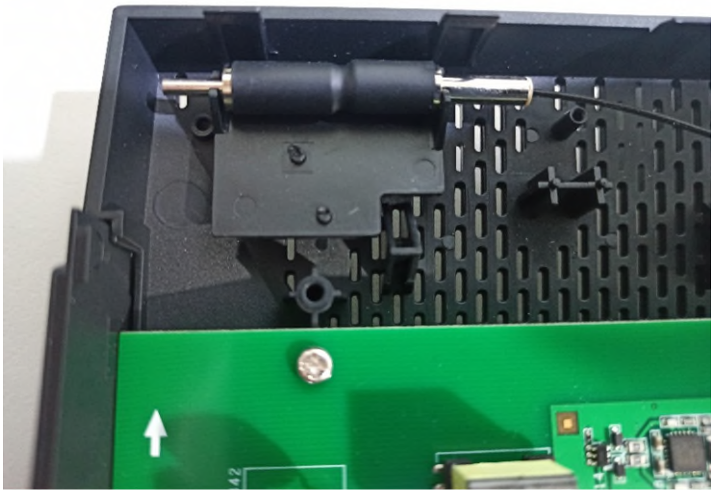
	

OTA Chamber Description

Dimensions：

The anechoic chamber is an AMS-8500 anechoic chamber designed and built by ETS-Lindgren with the following nominal dimensions：

Chamber inner dimensions	
Length	7.32m(24ft)
Width	3.66m(12ft)
Height	3.66m(12ft)

Chamber Passive Frequency Range：

700MHz～7.125GHz

Refer to
https://www.ets-lindgren.com/datasheet/absorbers/rf-absorbers/1006/100601

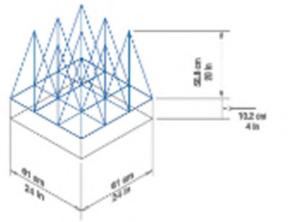
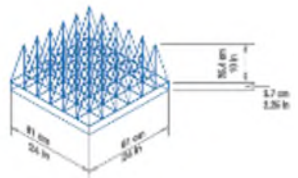
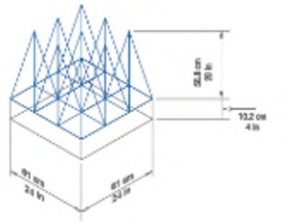
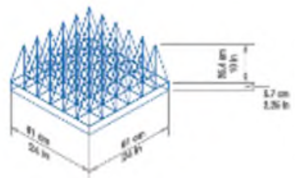
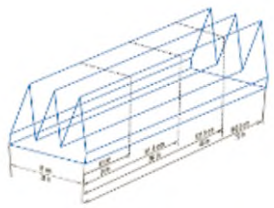
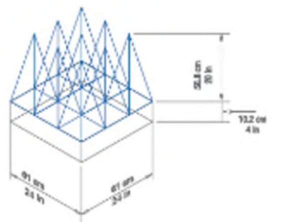
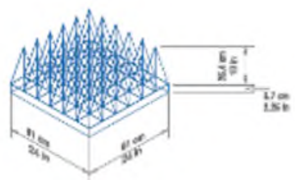
Frequency Range by Model

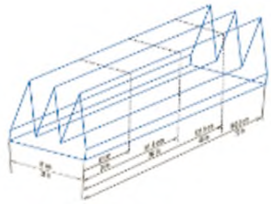
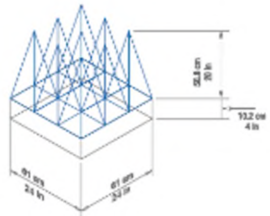
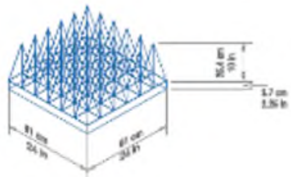
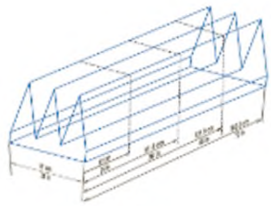
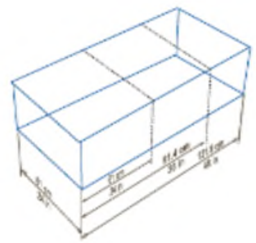
Model	Frequency Minimum	Frequency Maximum
EHP-3PCL	4 GHz	40 GHz
EHP-5PCL	2 GHz	40 GHz
EHP-8PCL	1 GHz	40 GHz
EHP-12PCL	1 GHz	40 GHz
EHP-18PCL	500 MHz	40 GHz
EHP-24PCL	200 MHz	40 GHz

Maximum Reflections at Normal Incidence

	80 MHz	120 MHz	200 MHz	300 MHz	500 MHz	1-2GHz	2-4 GHz	4-8 GHz	8-12 GHz	12-18 GHz	18-40 GHz
EHP3PCL								-30 dB	-40 dB	-45 dB	-45 dB
EHP5PCL							-30 dB	-40 dB	-45 dB	-50 dB	-50 dB
EHP8PCL						-30 dB	-40 dB	-45 dB	-50 dB	-50 dB	-50 dB
EHP12PCL						-35 dB	-40 dB	-45 dB	-50 dB	-50 dB	-50 dB
EHP18PCL					-30 dB	-40 dB	-45 dB	-50 dB	-50 dB	-50 dB	-50 dB
EHP24PCL			-20 dB	-30 dB	-35 dB	-40 dB	-50 dB	-50 dB	-50 dB	-50 dB	-50 dB

Absorbers installation

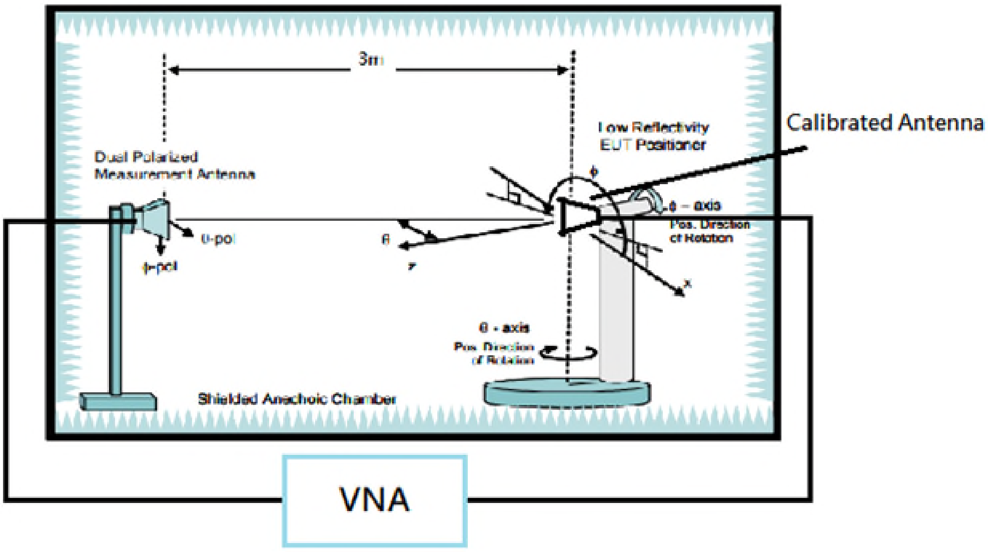
Location	Type	Photo
Receiving Wall	EHP-24PCL Pyramidal Absorber	
Transmitting Wall	EHP-12PCL Pyramidal Absorber	
Ceiling	EHP-24PCL Pyramidal Absorber	
	EHP-12PCL Pyramidal Absorber	
	EHP-24WGCL Wedge Absorber	
Floor	EHP-24PCL Pyramidal Absorber	
	EHP-12PCL Pyramidal Absorber	

	EHP-24WGCL Wedge Absorber	
Sidewalls	EHP-24PCL Pyramidal Absorber	
	EHP-12PCL Pyramidal Absorber	
	EHP-24WGCL Wedge Absorber	
Walkways	WW-12PCL Rigid Walkway Absorber	

Test Configuration and Calibration process

4.1 Test configuration
Test configuration refers to “CTIA Certification Program Test Plan”

4.2 Reference Calibration
Calibrate with Vector Network Analyzer (VNA) using SOLT calibration method.
Then we connected between VNA and chamber system, the measurement Antenna with cable connected to port 1 of VNA, and the calibrated Antenna connected to port 2. Record S21 to calculate path factor.



Frequency (MHz)	2400	2450	2500	5200	5300	5500	5600	5700	5800
Path Factor (dB)	-76.8	-77.1	-77.6	-89.1	-89.2	-90.0	-90.2	-90.7	-90.8

Test Procedures

1. EUT set on positioner, align the center reference point of the measuring antenna.
2. The one of Antenna of EUT connect to Port 1 of VNA. Select one frequency.
3. Start with the Thera of the measuring antenna, the positioner is from 0 degrees to 345 degrees on Phi angle and 0 to 180 degree on Theta angle and the S21 value is recorded every 5 degrees.
4. Repeat different frequency points, and the Phi angle of the measuring antenna.
5. Replace another antenna of EUT and repeat the measurement until all antennas are completed.
6. Composite every angle of Theta and Phi antenna gain by KDB 662911 D01 d)(i) and (ii).
7. Check the composite antenna gain for all angles to determine maximum gain and Directional gain.

using the formulas:

- $$DirectionalGain = 10 \cdot \log \left[\frac{\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} g_{j,k} \right\}^2}{N_{ANT}} \right]$$

where

Each antenna is driven by no more than one spatial stream;
N_{SS} = the number of independent spatial streams of data;
N_{ANT} = the total number of antennas
$g_{j,k} = 10^{G_k/20}$ if the kth antenna is being fed by spatial stream j, or zero if it is not;
G_k is the gain in dBi of the kth antenna.

- $$DirectionalGain = 10 \cdot \log \left[\frac{\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} g_{j,k} \sqrt{P_{j,k}} \right\}^2}{N_{ANT}} \right]$$

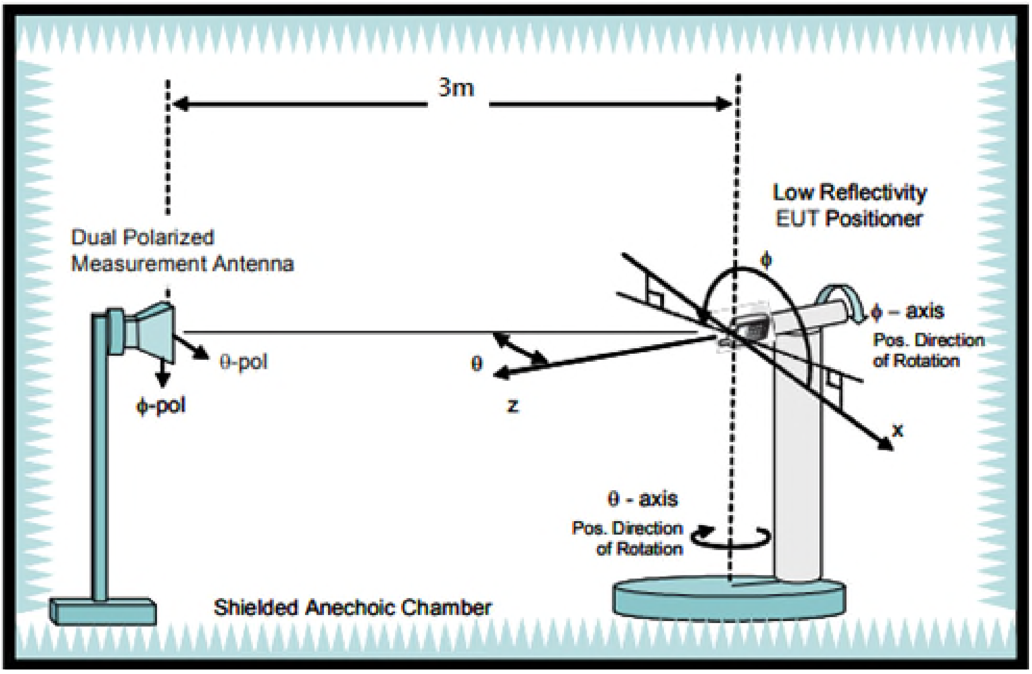
where

N_{SS} = the number of independent spatial streams of data;
N_{ANT} = the total number of antennas;
$g_{j,k} = 10^{G_k/20}$ if the kth antenna is being fed by spatial stream j, or zero if it is not;
G_k is the gain in dBi of the kth antenna;
$P_{j,k}$ is the relative normalized power (in linear terms, not decibels) of spatial stream j feeding the kth antenna, normalized such that

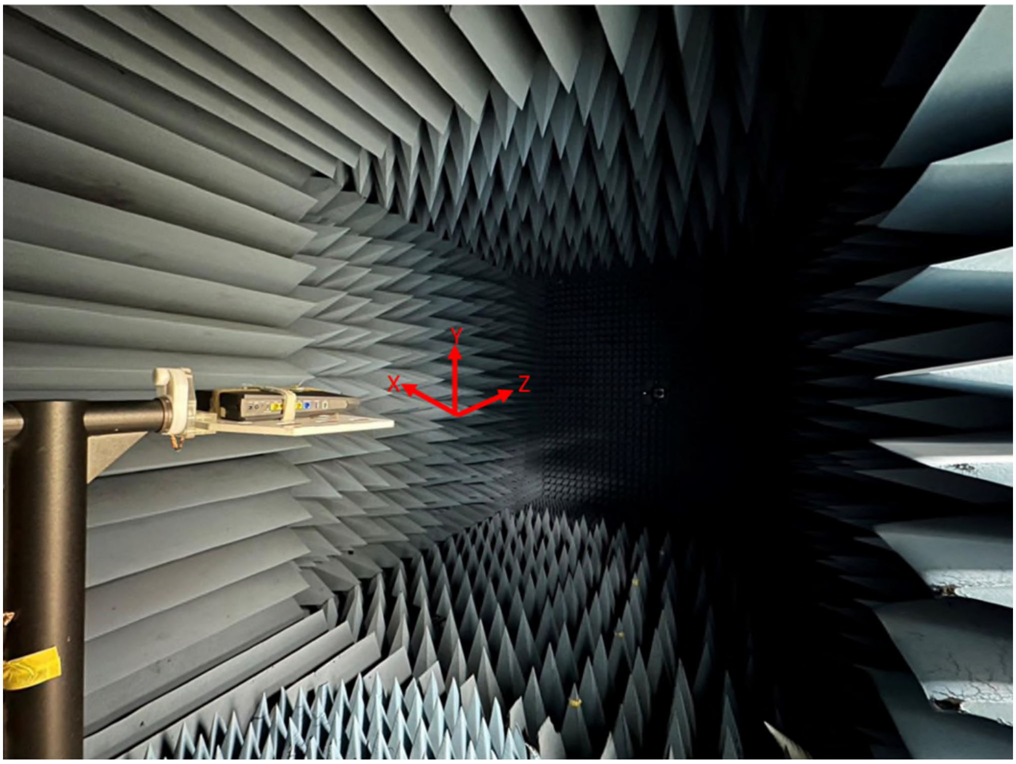
$$\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} P_{j,k} \right\} = N_{ANT}$$

Note: $P_{j,k} = 0$ if spatial stream j does not feed the kth antenna.

Test setup



3m
Low Reflectivity
EUT Positioner
Dual Polarized
Measurement Antenna
ϕ
ϕ – axis
Pos. Direction
of Rotation
θ-pol
θ
ϕ-pol
z
x
θ - axis
Pos. Direction
of Rotation
Shielded Anechoic Chamber



Y
X
Z

Test result

Refer to Appendix A Radiated Composite Gain & composite Excel

Max gain of each antenna :

Frequency Band (MHz)		Max Gain (Measurement)			
		Ant 1	Ant 2	Ant 3	Ant 4
2450	Gain (dBi)	3.72	3.54	3.74	3.14
	Pol. (θ / Φ)°	Theta 110/310	Theta 70/270	Phi 90/320	Phi 115/80
5200	Gain (dBi)	3.45	3.13	2.22	1.44
	Pol. (θ / Φ)°	Theta 115/85	Theta 45/295	Phi 75/85	Phi 155/130
5300	Gain (dBi)	4.59	4.47	2.2	1.98
	Pol. (θ / Φ)°	Theta 110/75	Theta 60/40	Phi 85/70	Phi 115/130
5600	Gain (dBi)	5.18	6.46	2.81	3.15
	Pol. (θ / Φ)°	Theta 100/65	Theta 65/40	Phi 105/70	Phi 160/120
5800	Gain (dBi)	5.68	6.34	2.36	3.33
	Pol. (θ / Φ)°	Theta 100/70	Theta 65/40	Phi 130/295	Phi 160/120

Note : Each antenna max gain is the max value of measurement S21 of theta and phi through all measurement angles.

Directional Gain :

Frequency Band	Final DG(dBi)		
	4T1S	4T2S	4T4S
2450	5.13	3.74	3.74
5200	4.39	3.45	3.45
5300	4.39	4.59	4.59
5600	5.51	6.46	6.46
5800	5.38	6.34	6.34

Note :

1. Follow KDB 662911 D01 F) 2) e) (ii), (iii) method.
2. If directional gain is less than max gain, use max gain as directional gain.

Antenna Pattern

2450MHz

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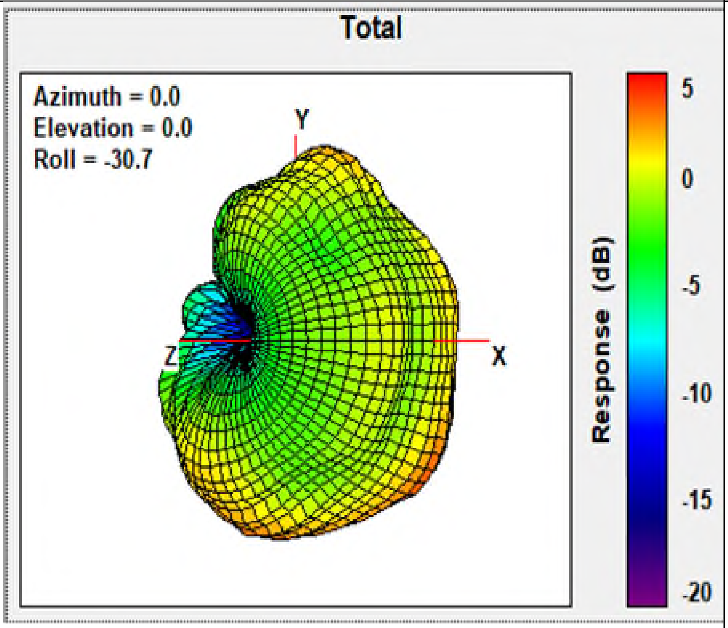

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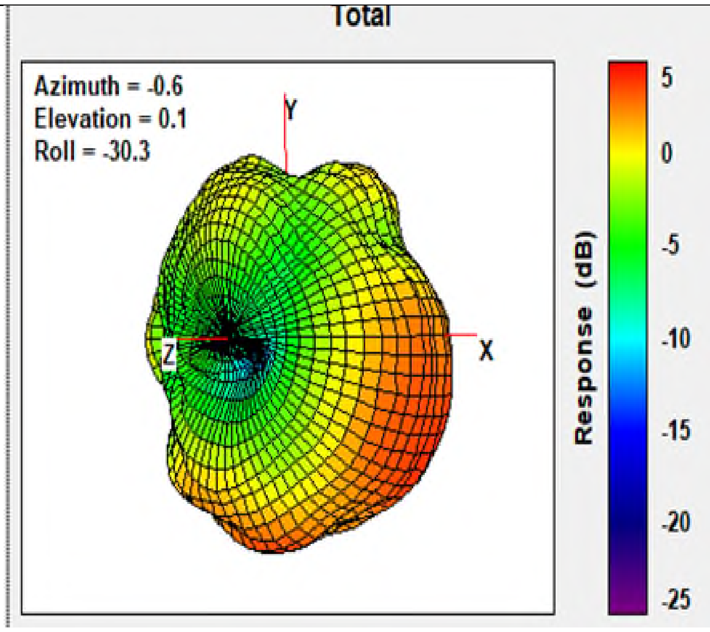

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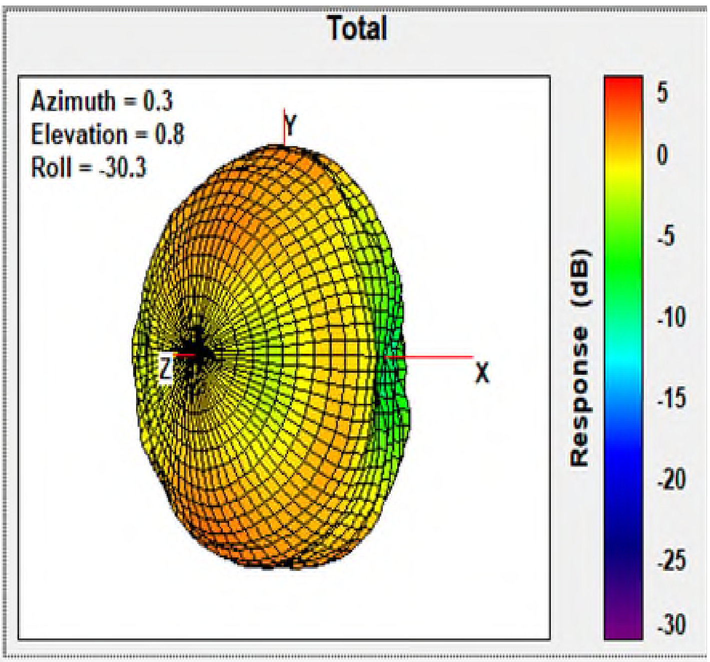

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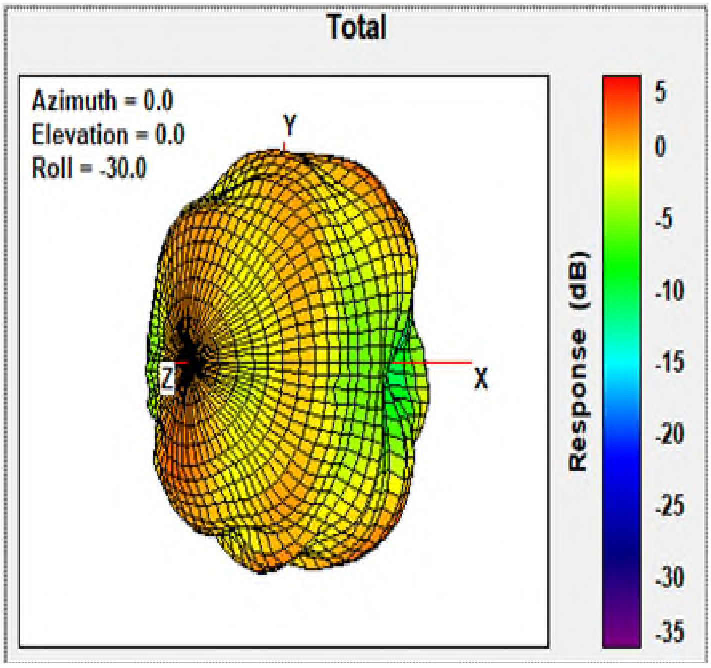

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52000MHz

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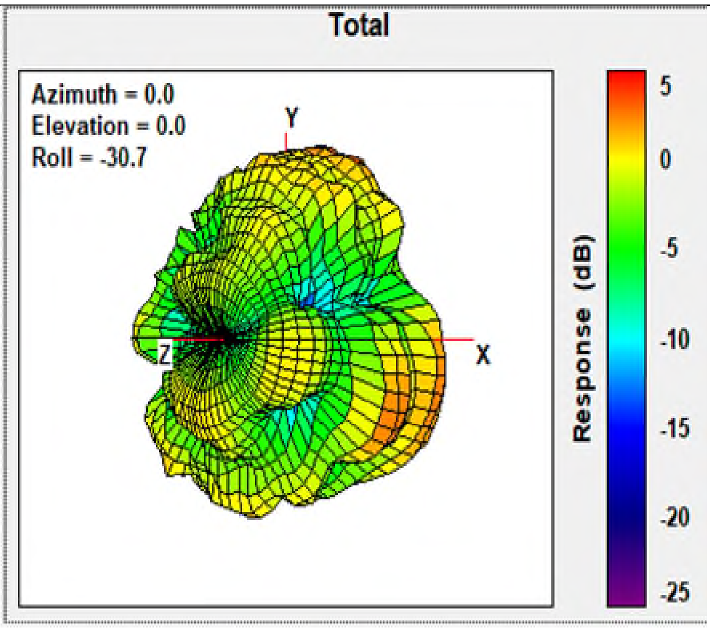
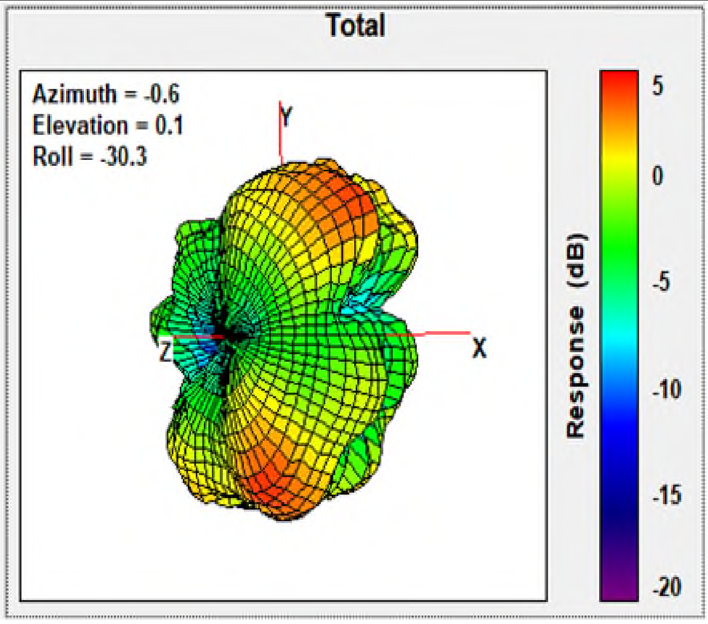
<tr><td>
</td><td>
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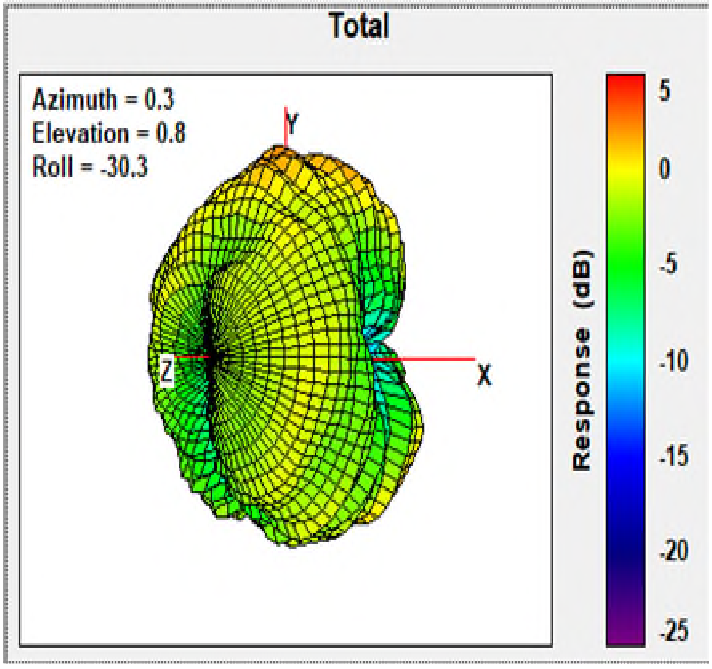
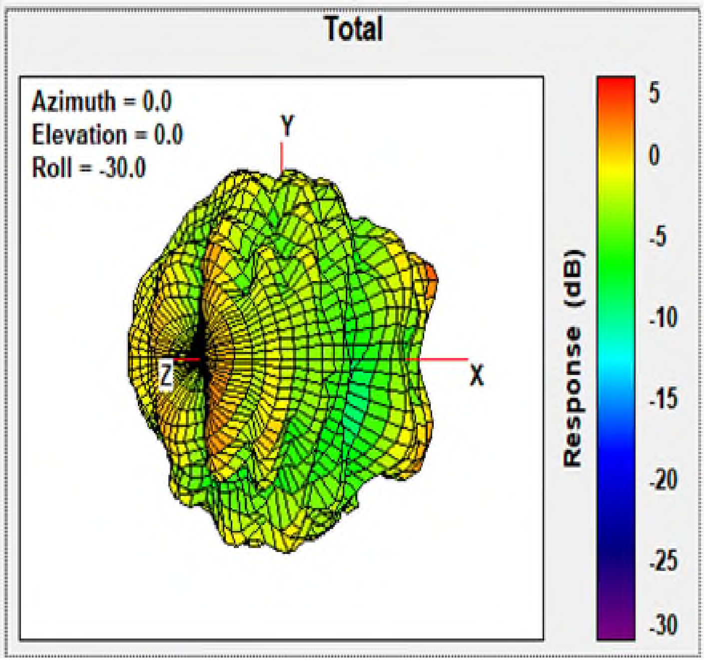
<tr><td>
</td><td>
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5300MHz

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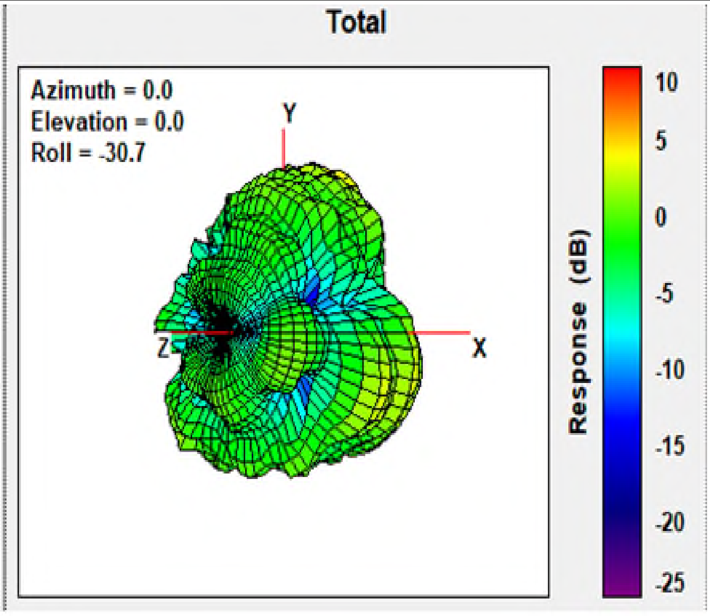	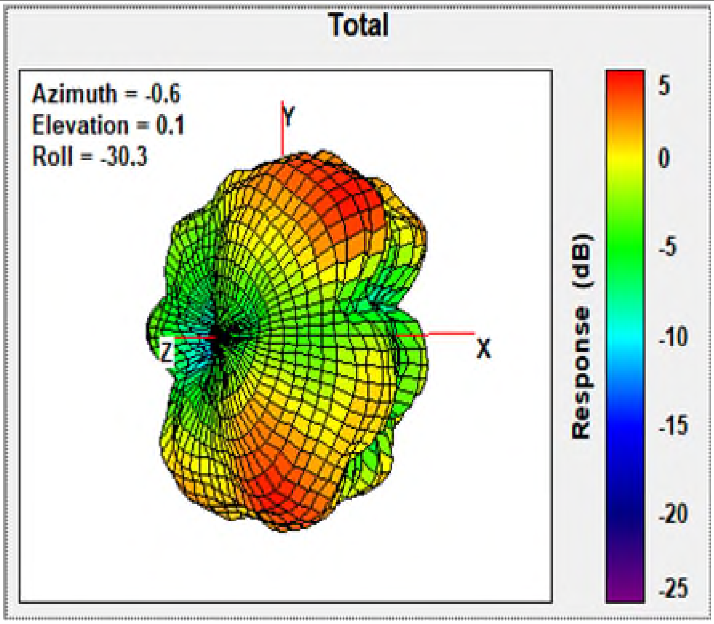
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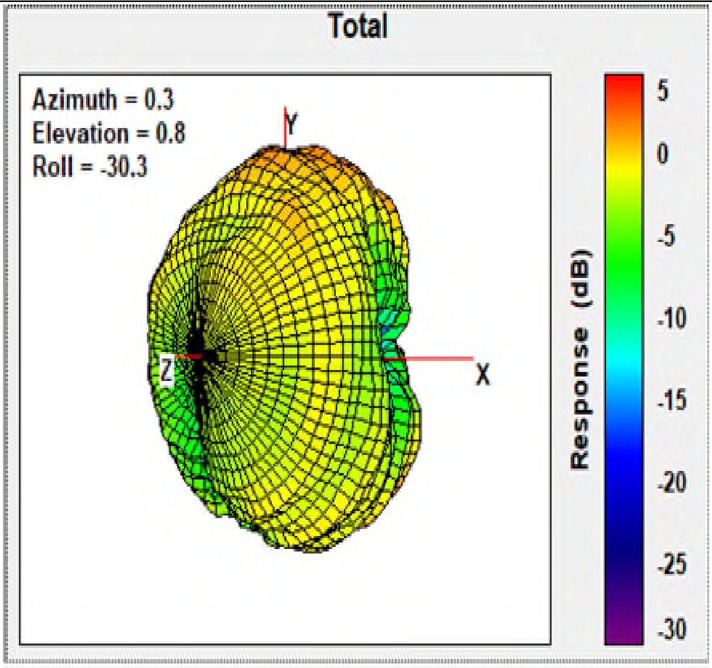	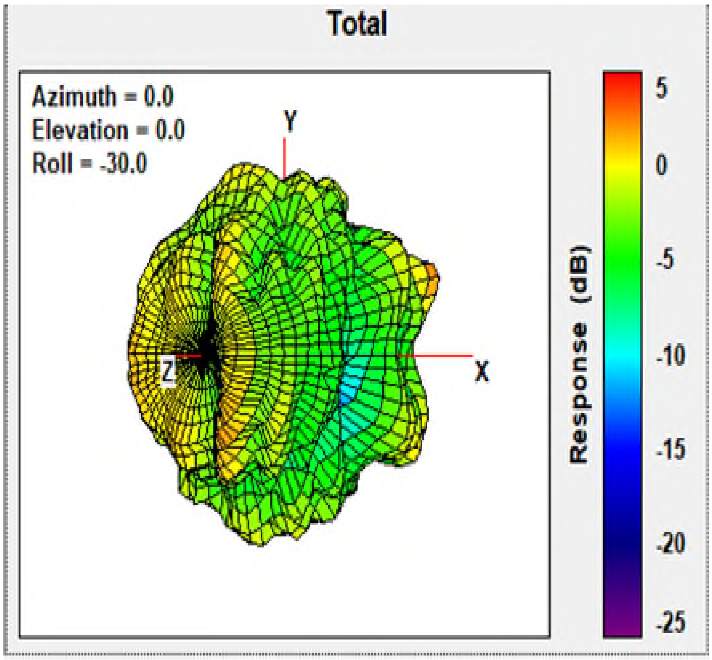

5600MHz

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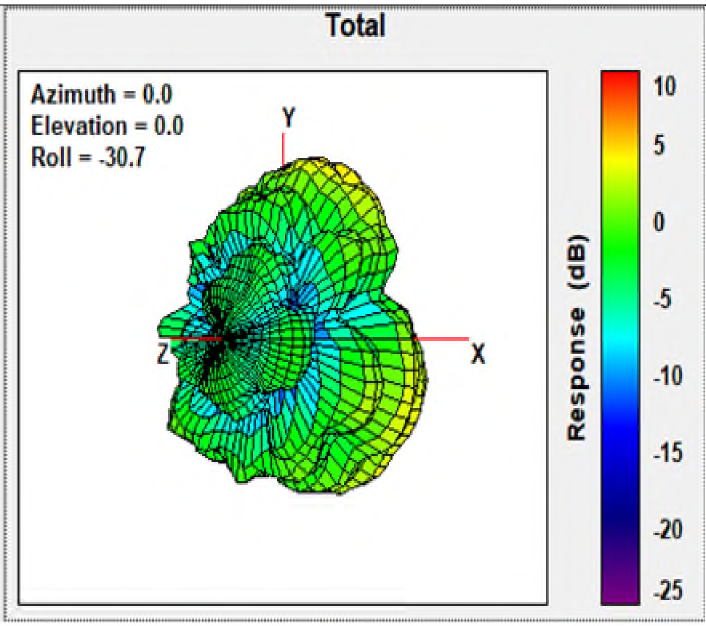	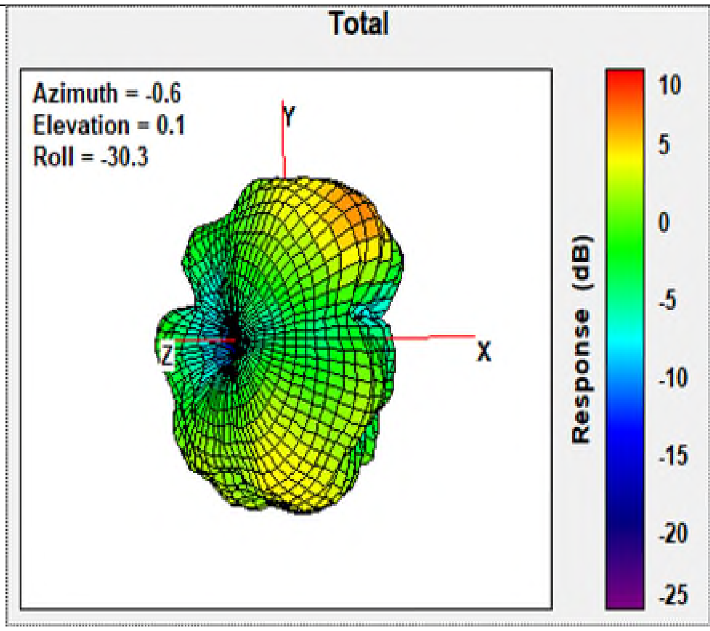
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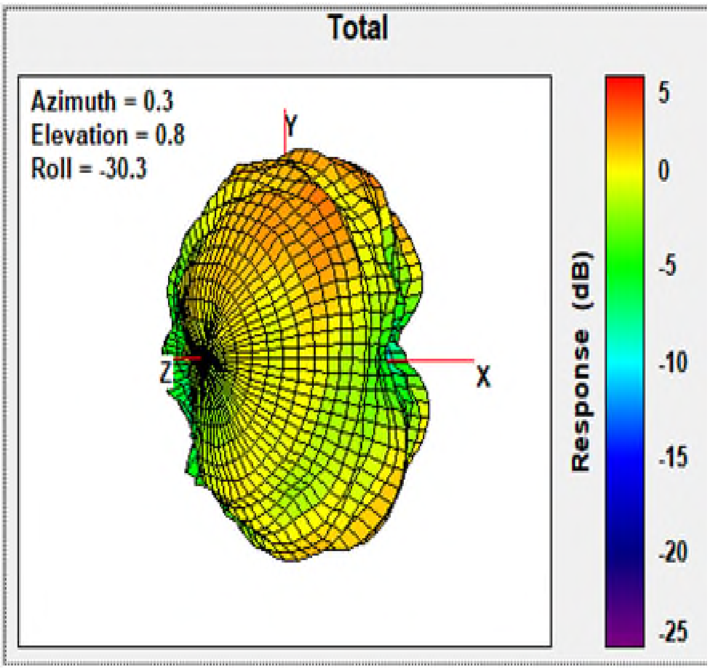	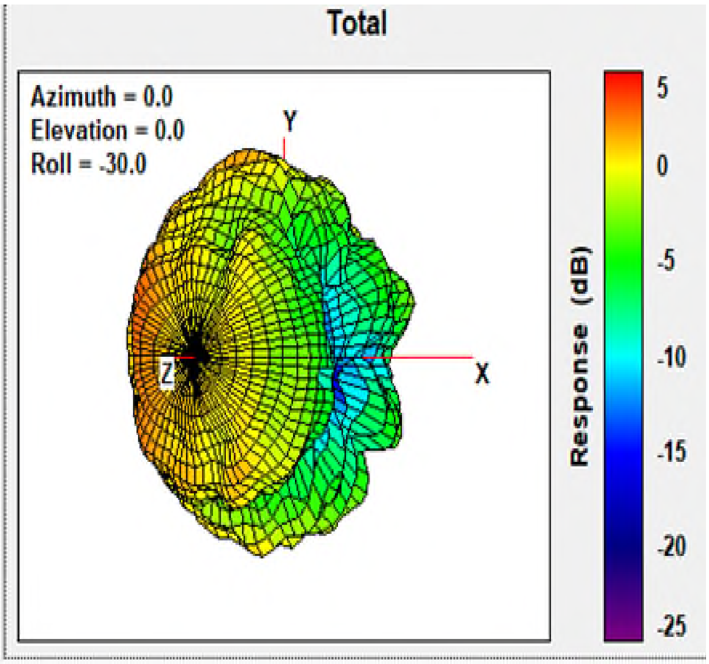

5800MHz

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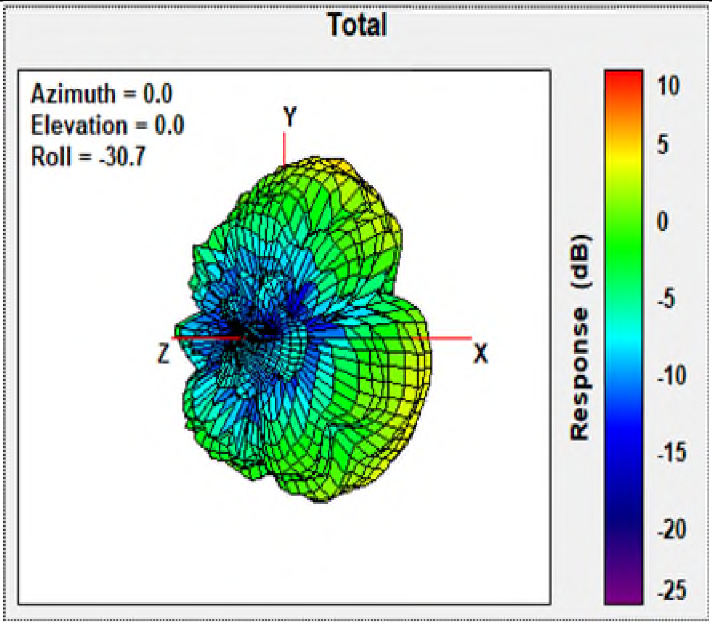	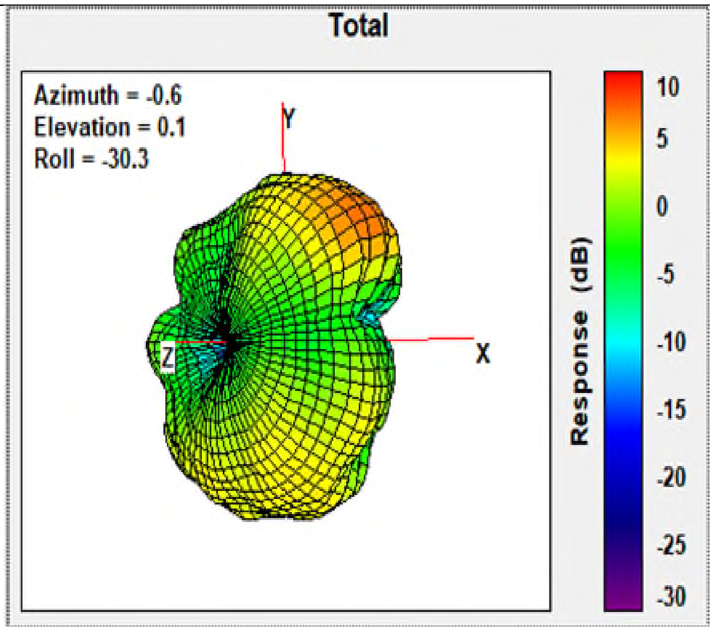
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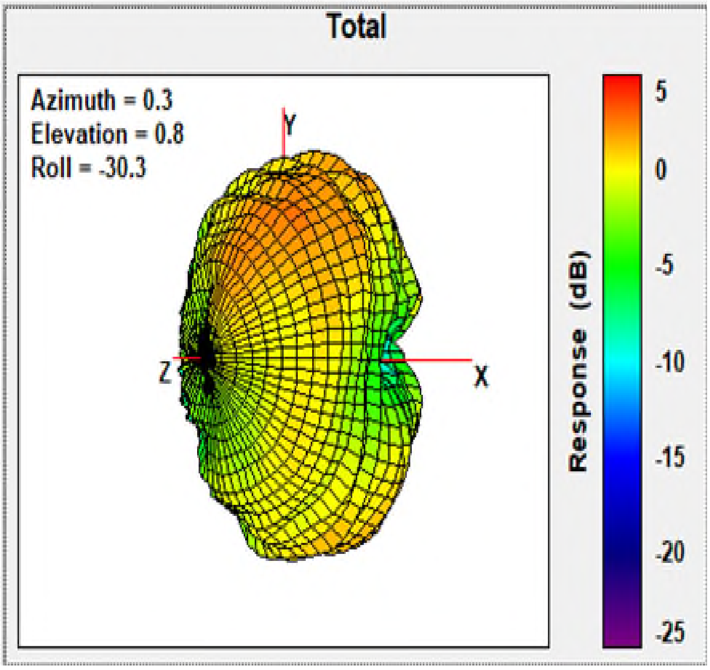	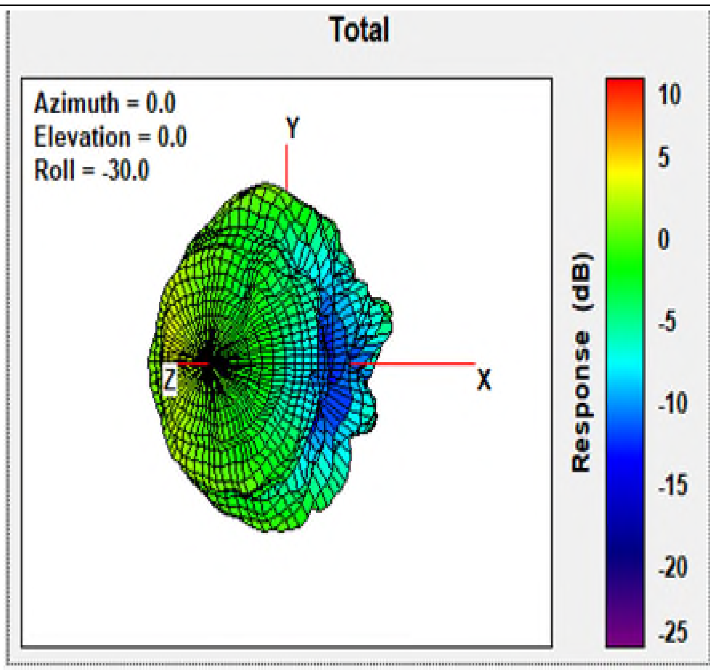

4. Test Equipment and Calibration Data

Instrument	Brand	Model	Serial No.	Calibration date	Calibration Due Date
Vector Network Analyzer	Rohde&Schwarz	ZNB8	106333	2022/5/16	2023/5/15
Horn Antenna	EMCO	3115	31589	2022/10/12	2023/10/11
Dual Polarized Antenna	ETS-LINDGREN	3164-08	161340	2022/4/20	2023/4/19

- **Please comment and approval**