PVS6

Passive Measurement Report

Date: Jul 24, 2018

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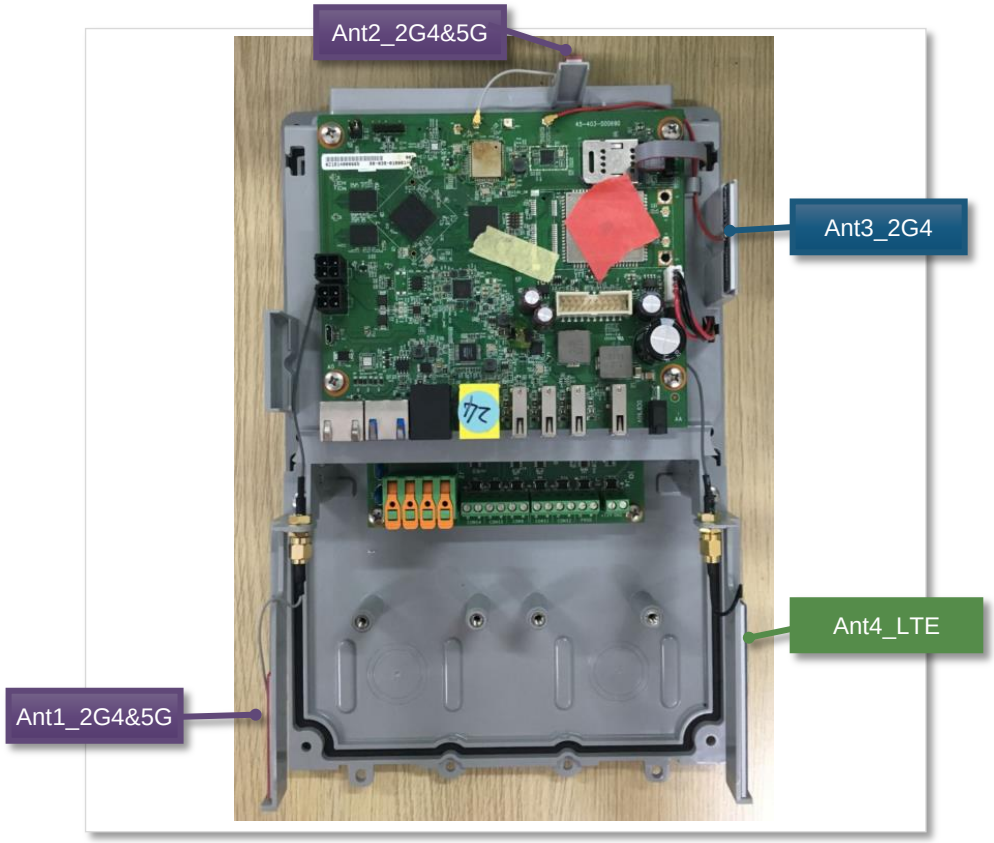
Introduction

- Airgain proposes an embedded antenna solution for PVS6
- There are two 2.4GHz & 5GHz Wifi antennas ,one 2.4GHz Zigbee antenna and one LTE antenna
- All antennas are mounted on the plastic enclosure and connect to the radio through coaxial cable and U.FL. Connector
- Antennas are measured in the hardware provided
- Passive measurement results are presented

Airgain antenna solutions

Airgain Solution

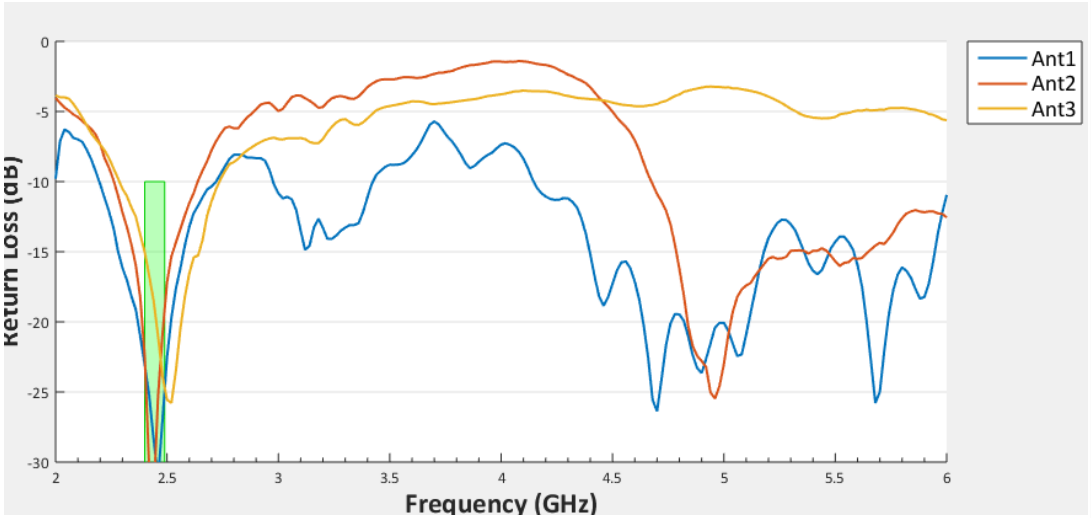


Antenna placement for PVS6

Antenna #	Part Number
Ant1_2G4&5G	N2420DGLCORE3-T-PK1-W90SMA
Ant2_2G4&5G	N2420DGST2-T-PK1-A50U
Ant3_2G4	N2420GSST-T-PK1-R130U
Ant4_LTE	N815DMST-T-PK1-B55SMA

Return Loss and Isolation

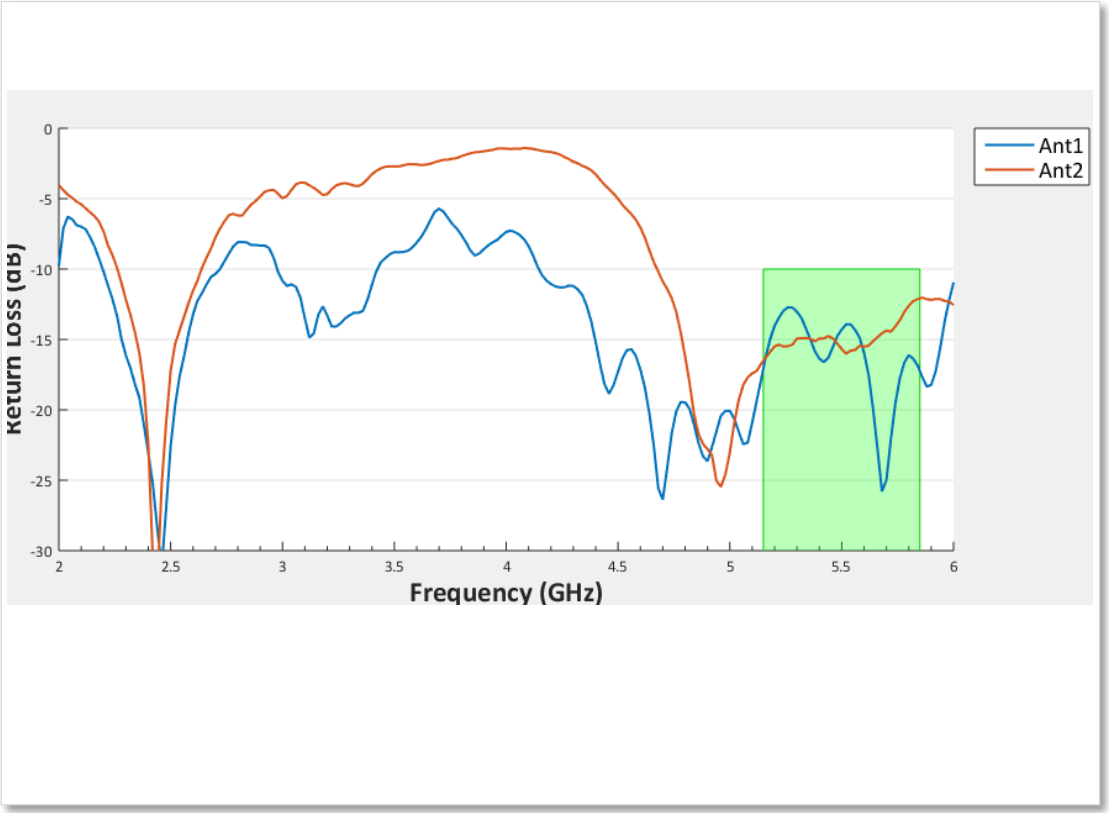
S-Parameter – Return Loss for All 2.4GHz Antennas



KEY OBSERVATIONS

Antenna	Return Loss (dB)	
	2.4G	2.49G
Ant1_2G4	-22.4	-23.8
Ant2_2G4	-22.4	-20.8
Ant3_2G4	-15.0	-25.6

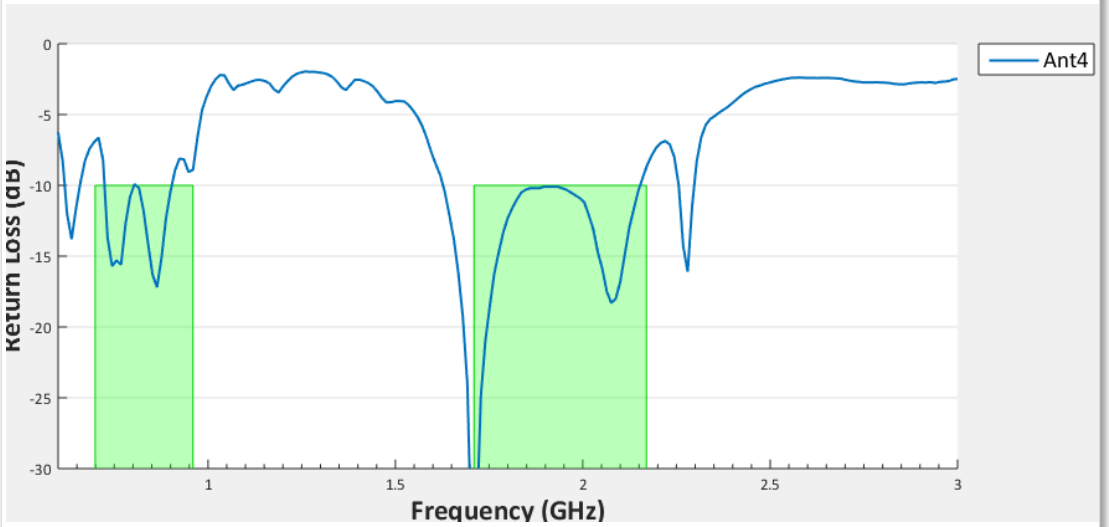
S-Parameter – Return Loss for All 5GHz Antennas



KEY OBSERVATIONS

Antenna	Return Loss (dB)	
	5.15G	5.85G
Ant1_5G	-17.4	-17.4
Ant2_5G	-16.7	-12.1

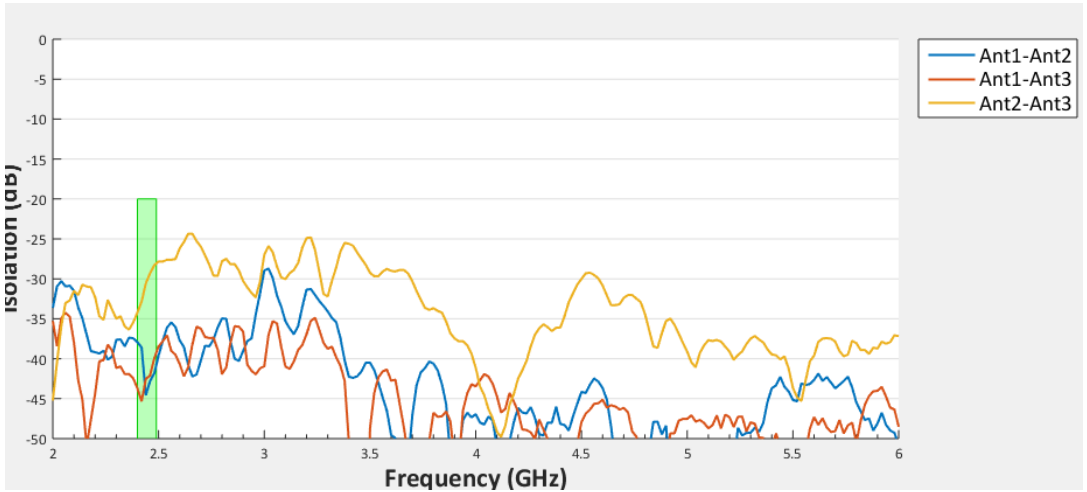
S-Parameter – Return Loss for All LTE Antennas



KEY OBSERVATIONS

Antenna	Return Loss (dB)			
	699M	960M	1710M	2170M
Ant4_LTE	-6.9	-8.6	-30.0	-8.8

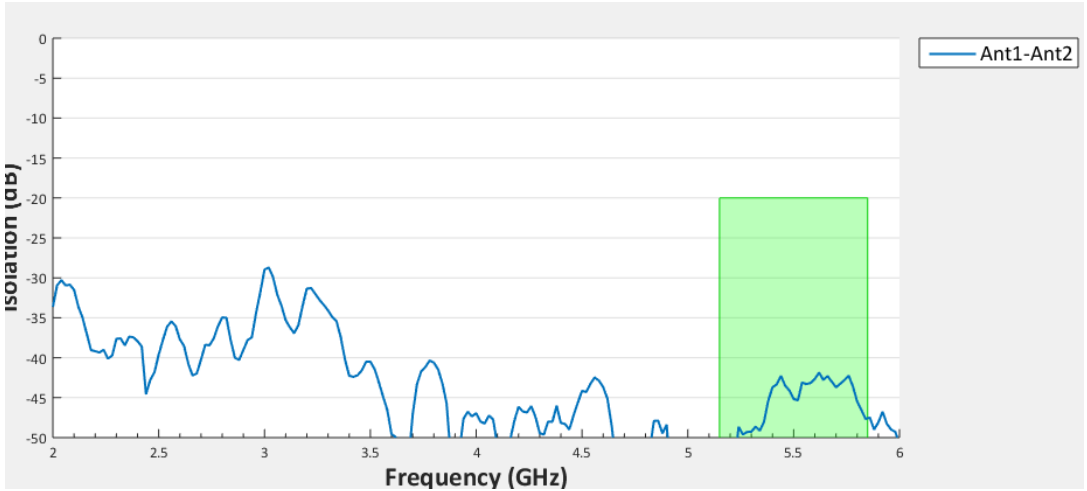
S-Parameter – Isolation for All 2.4GHz Antennas



KEY OBSERVATIONS

Antenna	Minimum Isolation (dB) **Max value between 2.4-2.49GHz**
Ant1_2G4 – Ant2_2G4	-37.9
Ant1_2G4 – Ant3_2G4	-38.5
Ant2_2G4 – Ant3_2G4	-27.8

S-Parameter – Isolation for All 5GHz Antennas



KEY OBSERVATIONS

Antenna	Minimum Isolation (dB) **Max value between 5.15-5.85GHz**
Ant1_5G – Ant2_5G	-41.9

Antenna Efficiency and Peak Gain

Antenna Efficiency – 2.4GHz Antennas

Frequency (MHz)	Ant1_2G4 (%)	Ant2_2G4 (%)	Ant3_2G4 (%)
2400	55.8	67.3	70.0
2410	57.0	68.1	72.8
2420	57.0	68.0	72.6
2430	56.5	67.8	72.3
2440	57.0	68.1	73.5
2450	56.9	68.2	73.3
2460	56.3	67.5	73.1
2470	56.8	68.0	74.2
2480	56.6	67.9	74.2
2490	56.7	67.7	74.6
Average	56.7	67.9	73.1

Antenna Efficiency – 5GHz Antennas

Frequency (MHz)	Ant1_5G (%)	Ant2_5G (%)
5150	55.9	70.8
5200	52.5	69.0
5300	52.6	67.4
5400	54.3	66.3
5500	51.5	64.0
5600	53.8	64.6
5700	52.2	62.6
5800	51.9	62.8
5850	50.8	61.1
Average	52.8	65.4

Antenna Peak Gain – 2.4GHz Antennas

Frequency (MHz)	Ant1_2G4 (dBi)	Ant2_2G4 (dBi)	Ant3_2G4 (dBi)
2400	2.1	4.0	4.5
2410	2.2	4.1	4.6
2420	2.1	4.1	4.5
2430	2.1	4.1	4.5
2440	2.2	4.2	4.5
2450	2.2	4.2	4.5
2460	2.1	4.1	4.6
2470	2.1	4.1	4.7
2480	2.1	4.1	4.7
2490	2.1	4.1	4.8

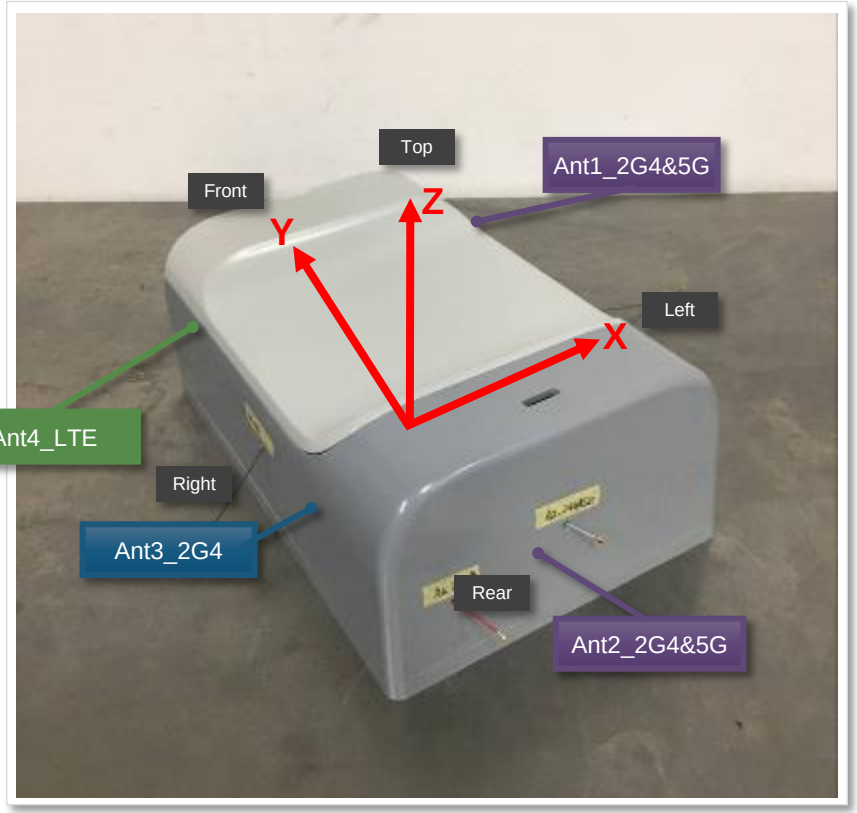
Antenna Peak Gain – 5GHz Antennas

Frequency (MHz)	Ant1_5G (dBi)	Ant2_5G (dBi)
5150	3.8	4.1
5200	3.5	4.1
5300	4.2	4.4
5400	4.3	5.0
5500	4.5	5.2
5600	4.5	4.9
5700	4.2	4.8
5800	4.2	4.0
5850	4.0	3.6

Antenna Efficiency & Peak Gain – LTE Antenna

Frequency (MHz)	Peak Gain Ant4_LTE (dBi)	Efficiency Ant4_LTE (%)
699	0.5	45.6
829	2.7	64.2
960	2.2	52.4
1710	2.6	66.1
1940	1.9	53.1
2170	1.8	53.9

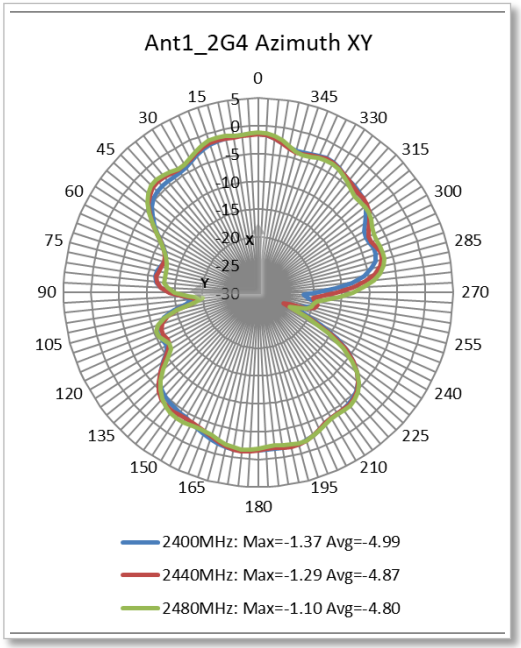
Orientation



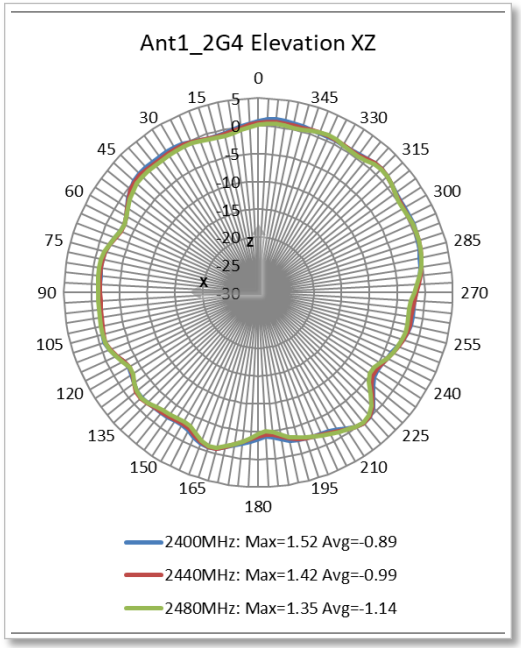
Orientation of PVS6

Azimuth and Elevation Patterns, and System Coverage
2.4 GHz plots

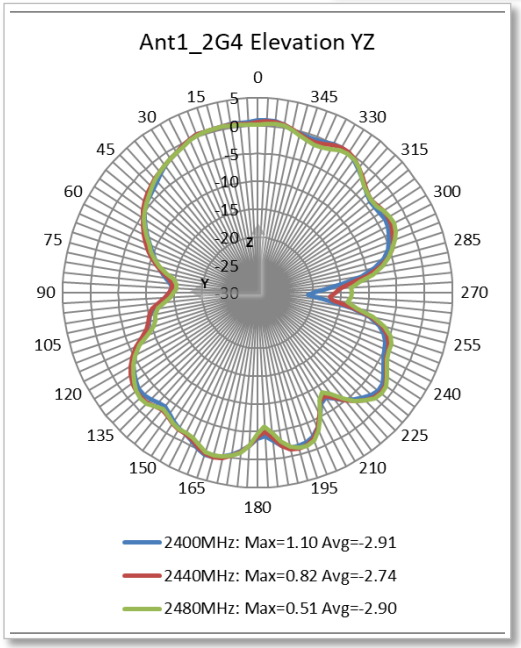
Radiation Pattern at 2.4GHz –Ant1



Azimuth (XY)

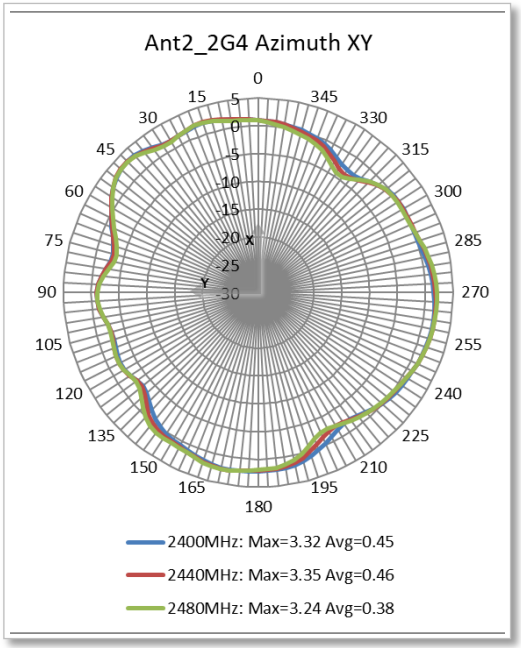


Side to Side (XZ)

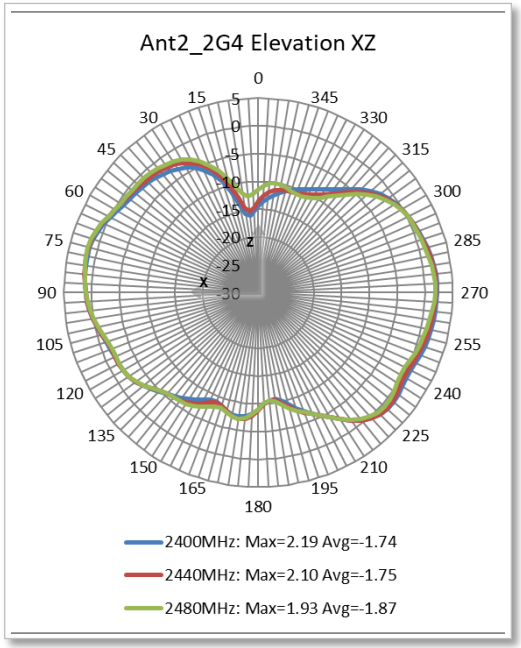


Front to Back (YZ)

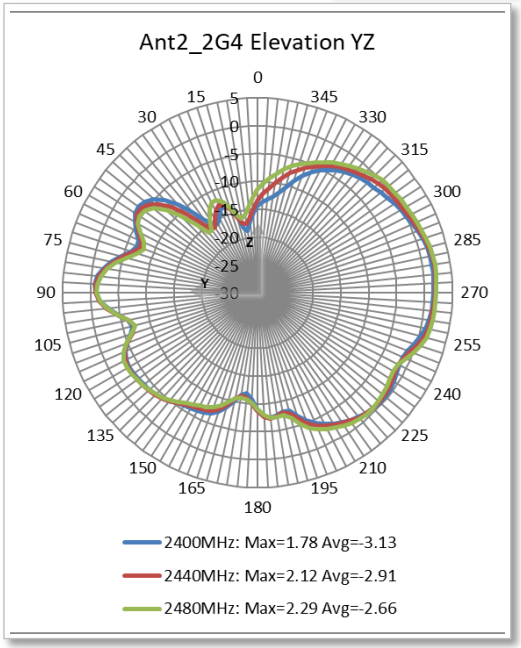
Radiation Pattern at 2.4GHz –Ant2



Azimuth (XY)

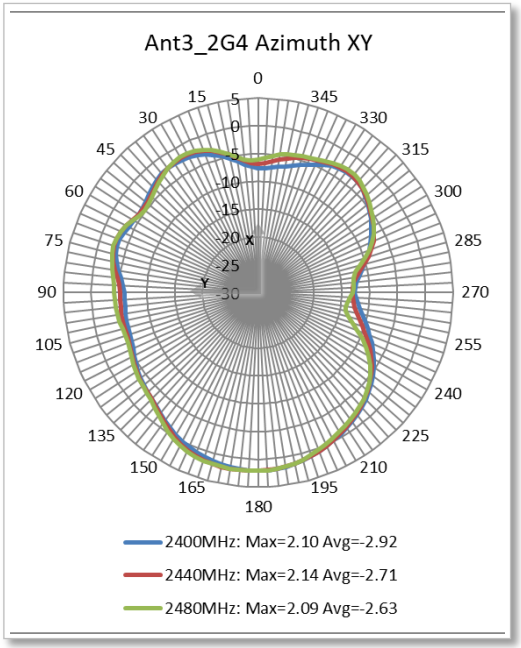


Side to Side (XZ)

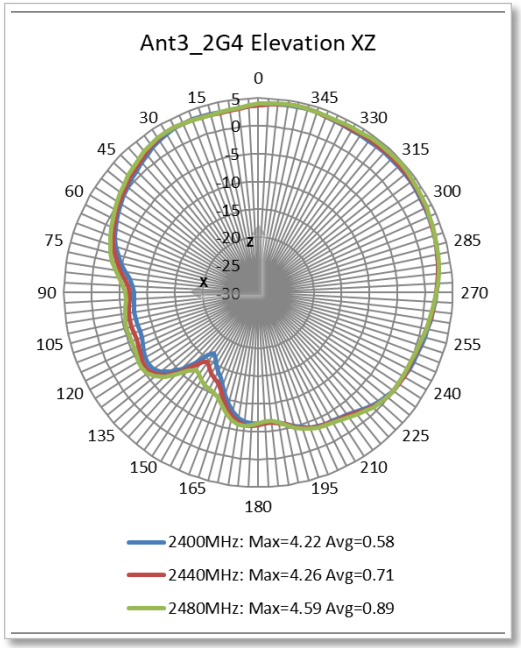


Front to Back (YZ)

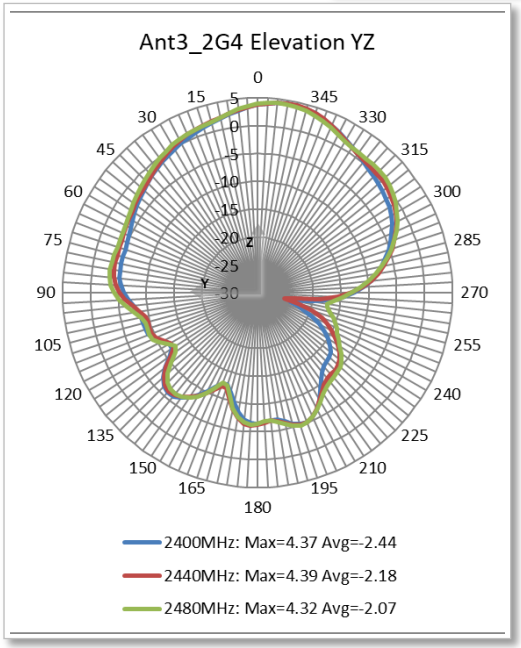
Radiation Pattern at 2.4GHz –Ant3



Azimuth (XY)

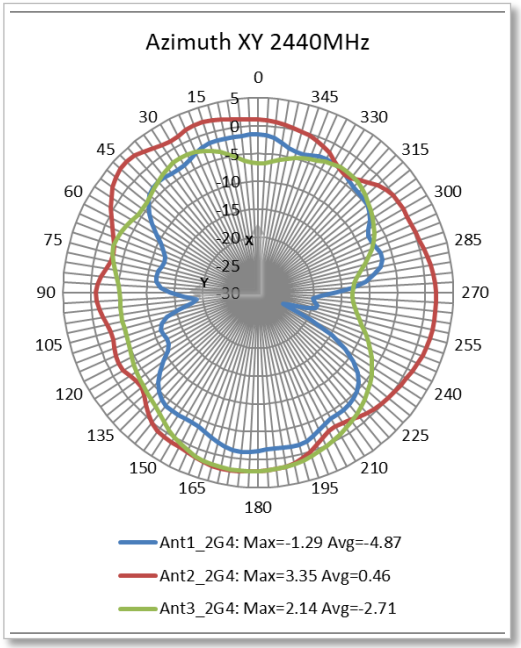


Side to Side (XZ)

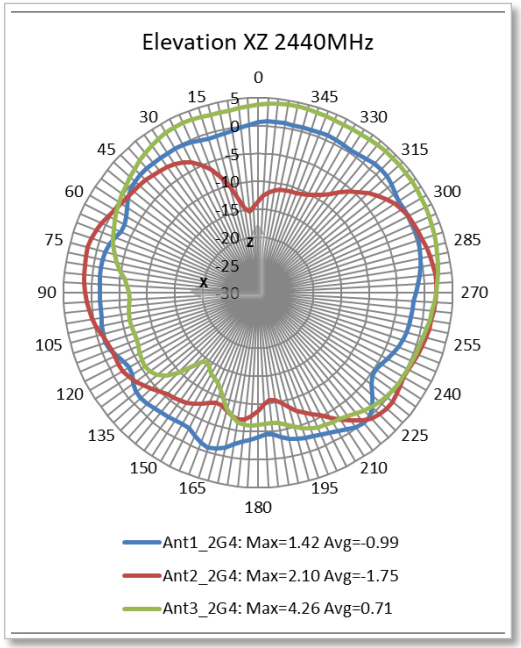


Front to Back (YZ)

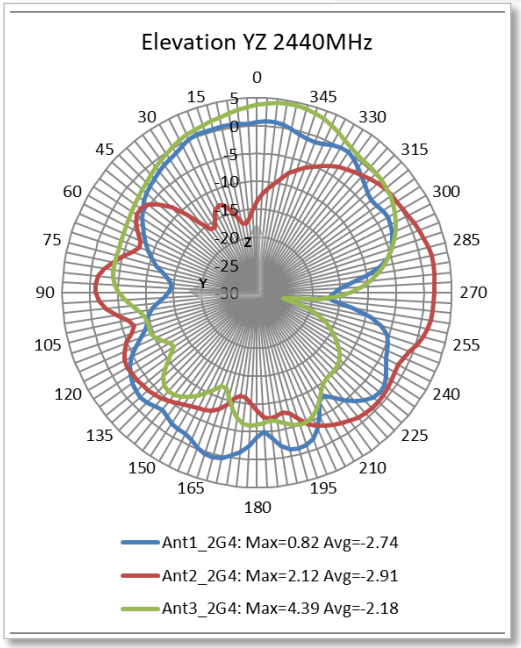
System Coverage: Radiation Pattern at 2.44GHz



Azimuth (XY)



Side to Side (XZ)

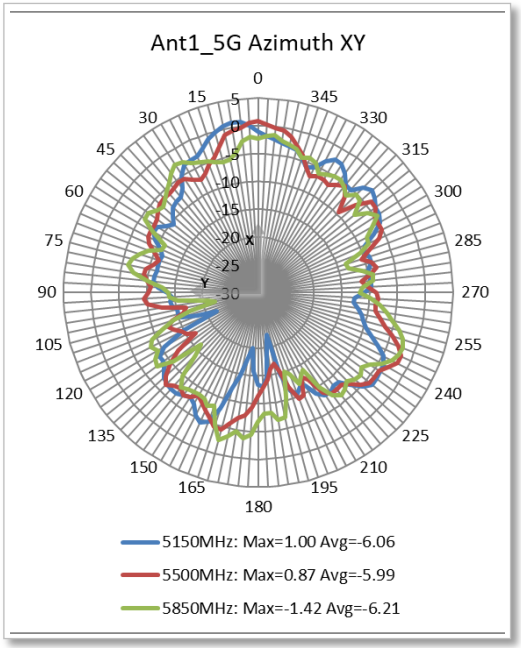


Front to Back (YZ)

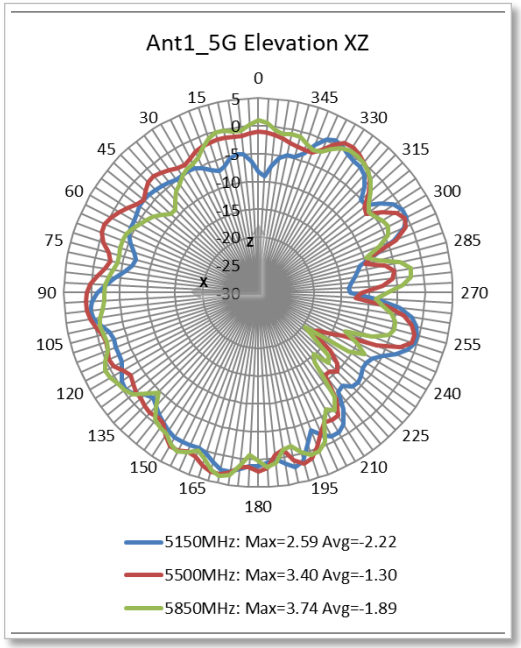
Airgain

Azimuth and Elevation Patterns, and System Coverage
5 GHz plots

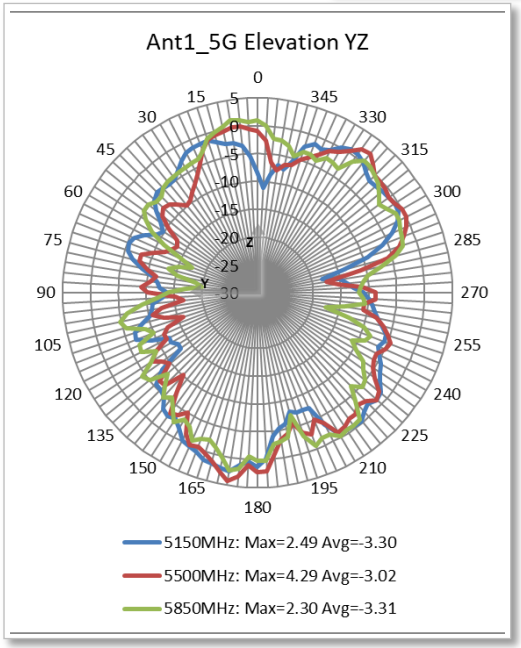
Radiation Pattern at 5GHz –Ant1



Azimuth (XY)

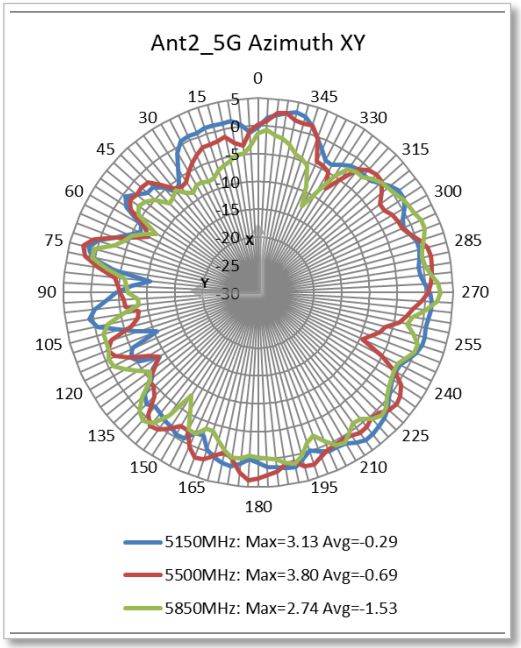


Side to Side (XZ)

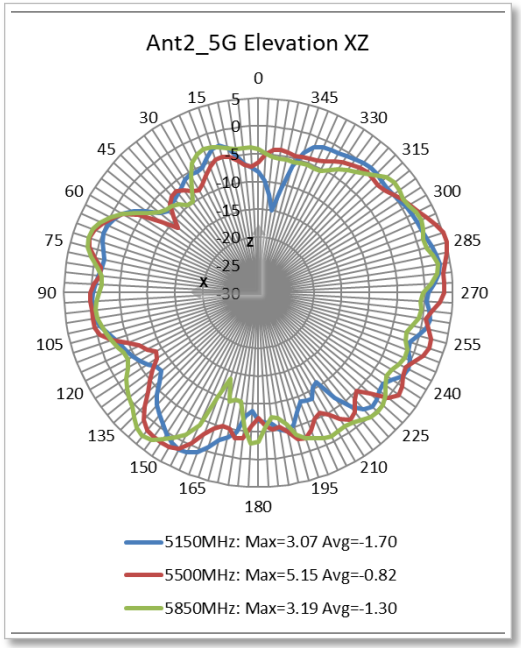


Front to Back (YZ)

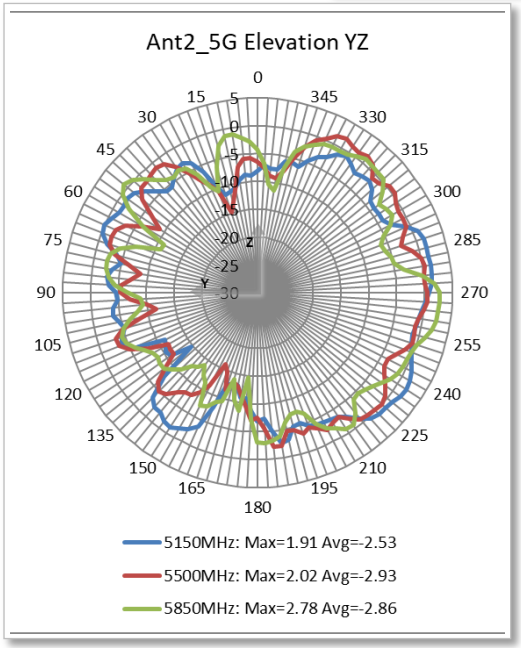
Radiation Pattern at 5GHz –Ant2



Azimuth (XY)

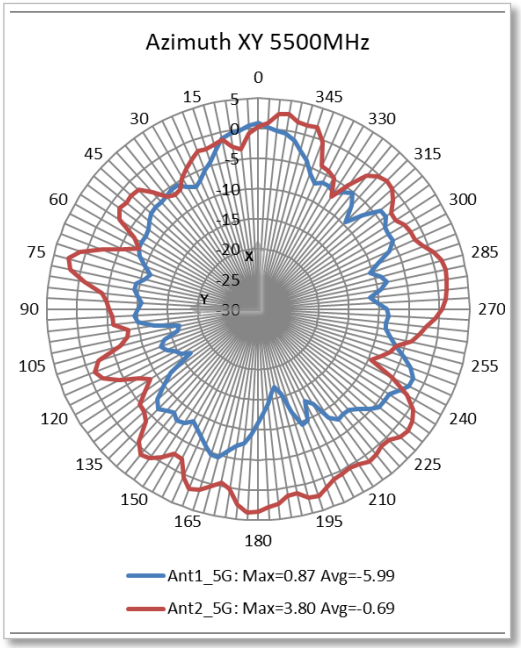


Side to Side (XZ)

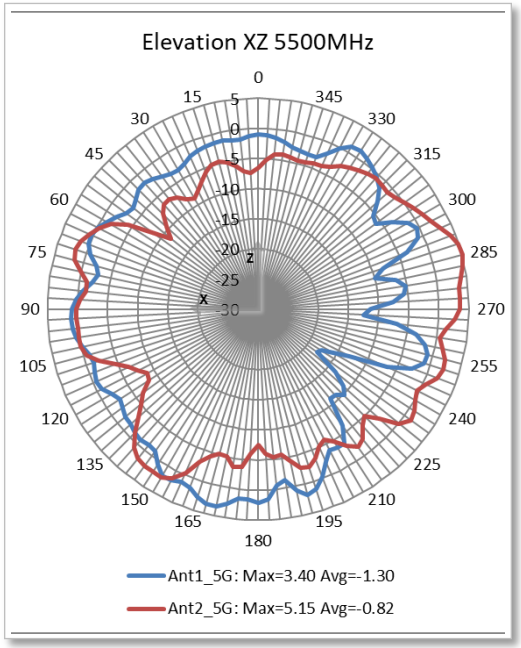


Front to Back (YZ)

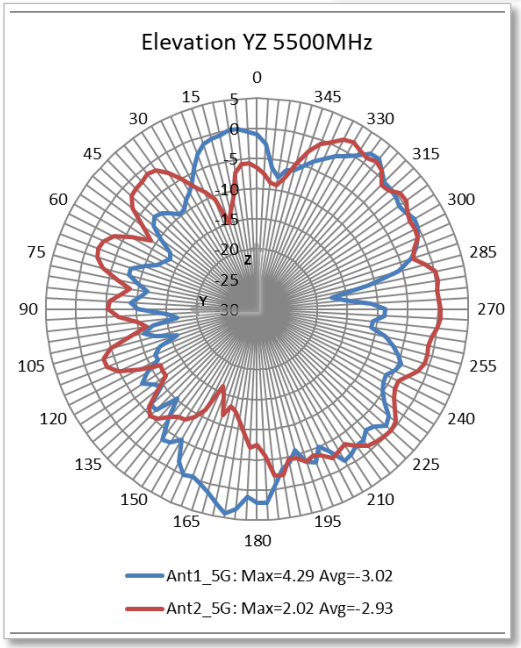
System Coverage: Radiation Pattern at 5.5GHz



Azimuth (XY)



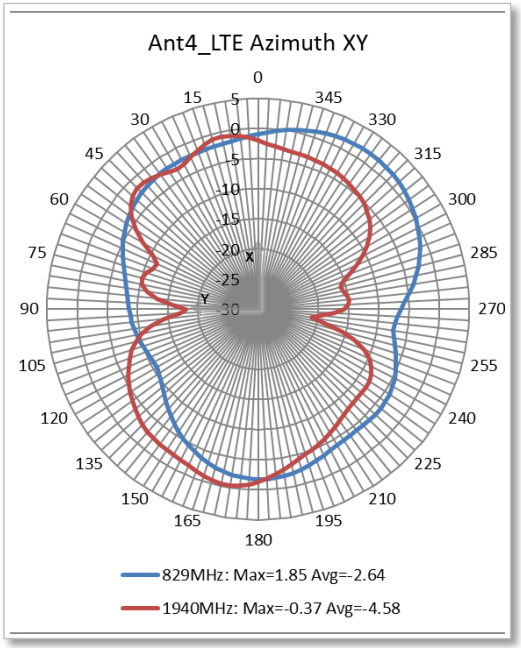
Side to Side (XZ)



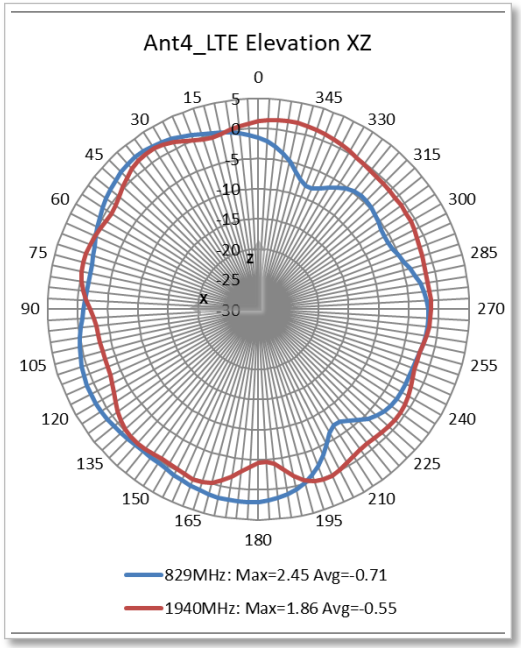
Front to Back (YZ)

Azimuth and Elevation Patterns, and System Coverage LTE plots

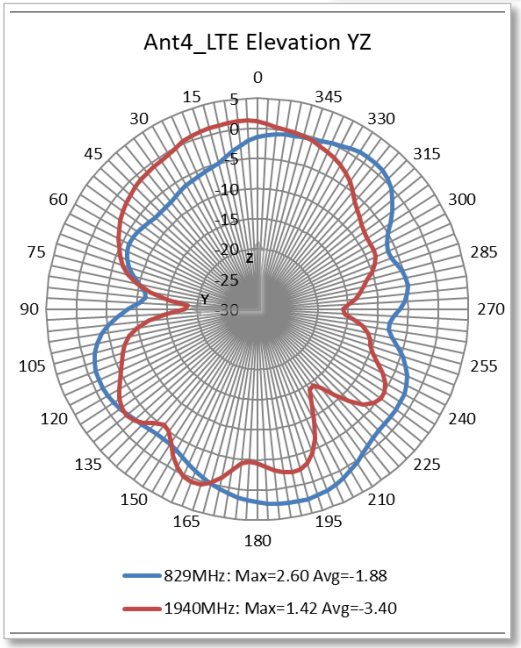
Radiation Pattern at LTE –Ant4



Azimuth (XY)



Side to Side (XZ)



Front to Back (YZ)

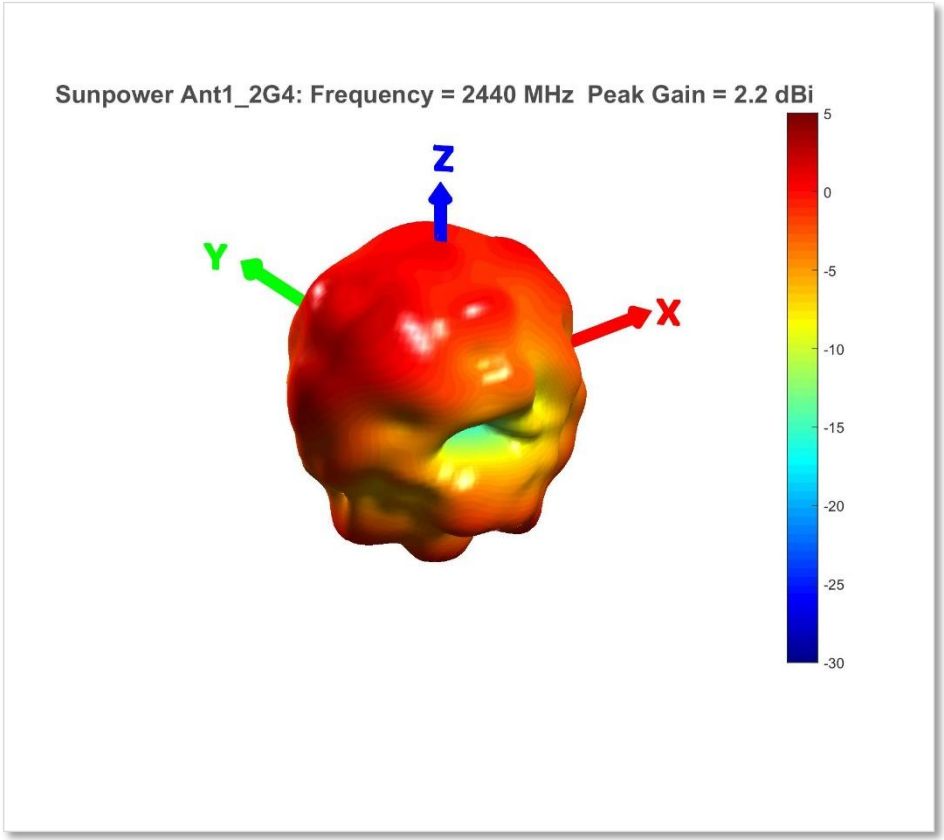
Summary

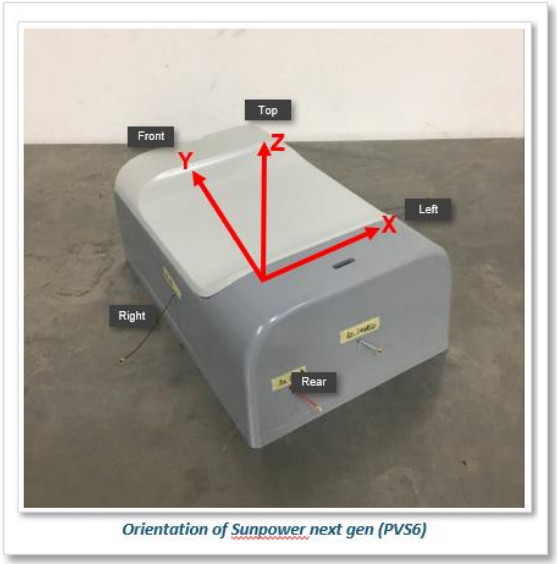
- Airgain evaluated embedded antenna passive performance
- Isolation is better than 25dB between 2.4GHz antennas and 40dB between 5GHz
- All antennas have good efficiency
- Wifi antennas offer good system coverage with polarization and pattern diversity to support in-housing MIMO

Appendix

3-D radiotin patterns & 2-D Radaition Heat-map

3D Antenna Pattern – [Ant1_2G4 at 2.44GHz]

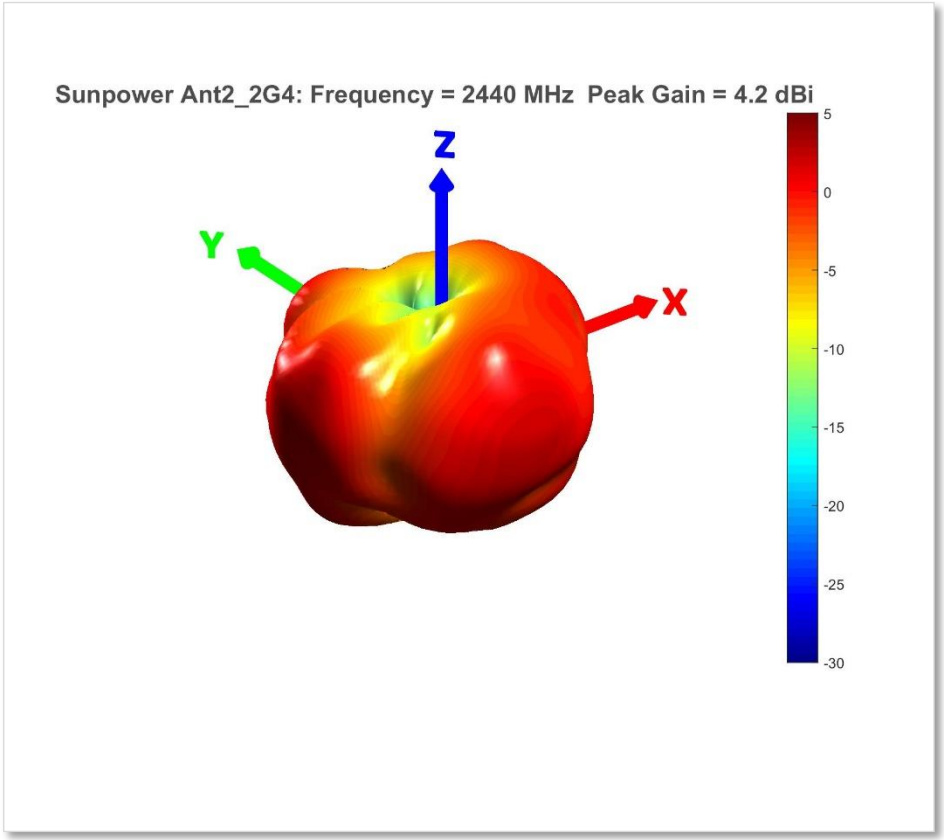


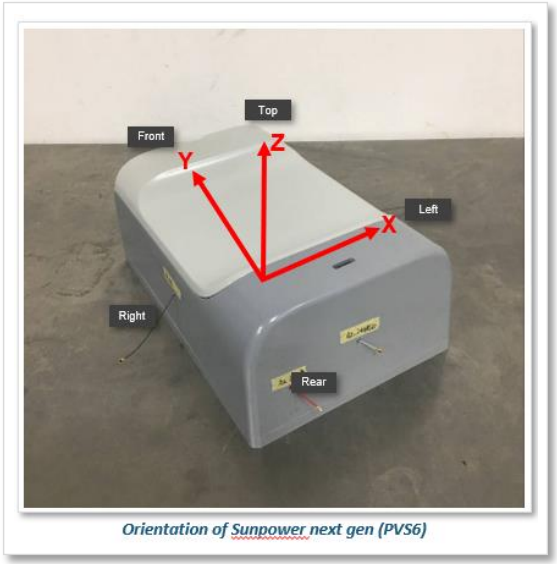


Orientation of Sunpower next gen (PVS6)

Airgain

3D Antenna Pattern – [Ant2_2G4 at 2.44GHz]

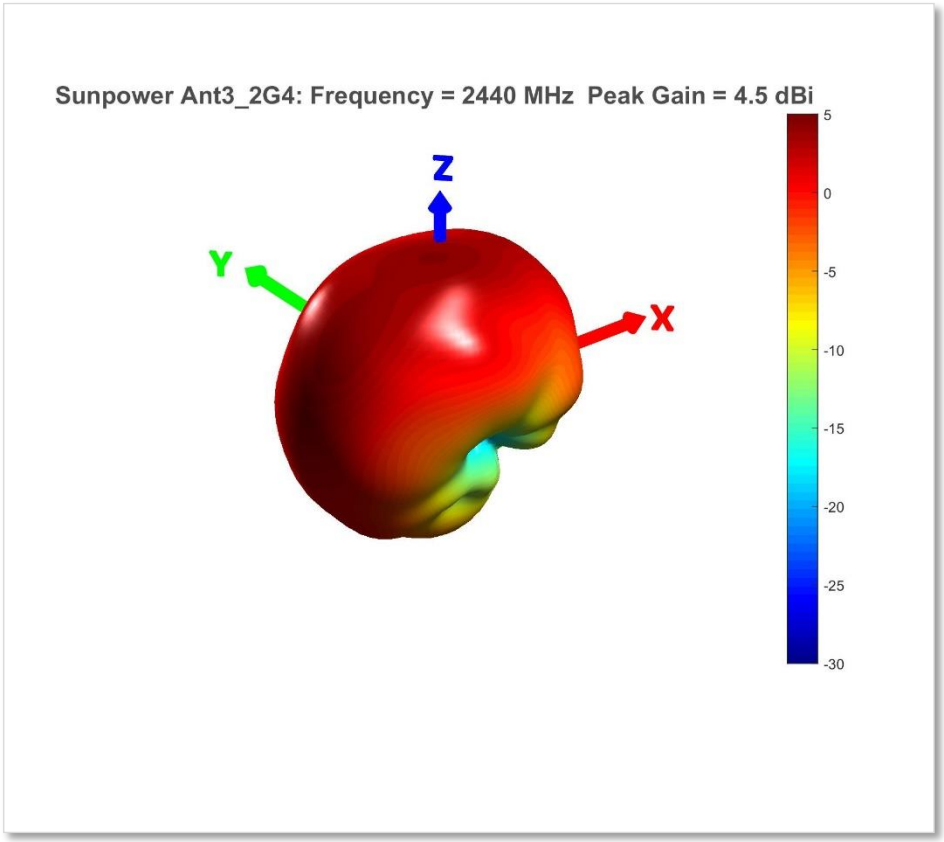


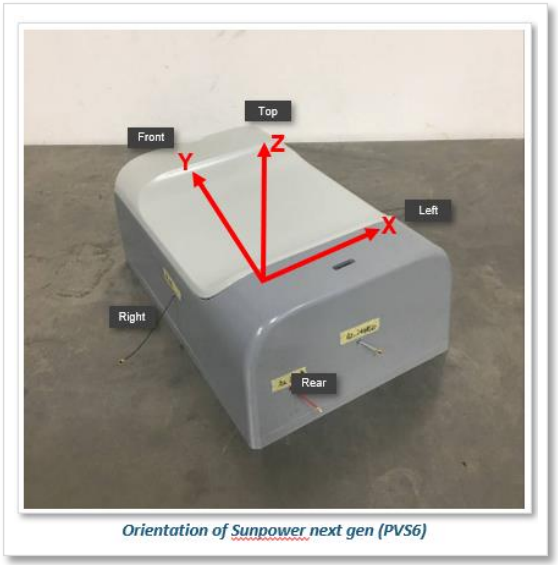


Orientation of Sunpower next gen (PVS6)

Airgain

3D Antenna Pattern – [Ant3_2G4 at 2.44GHz]

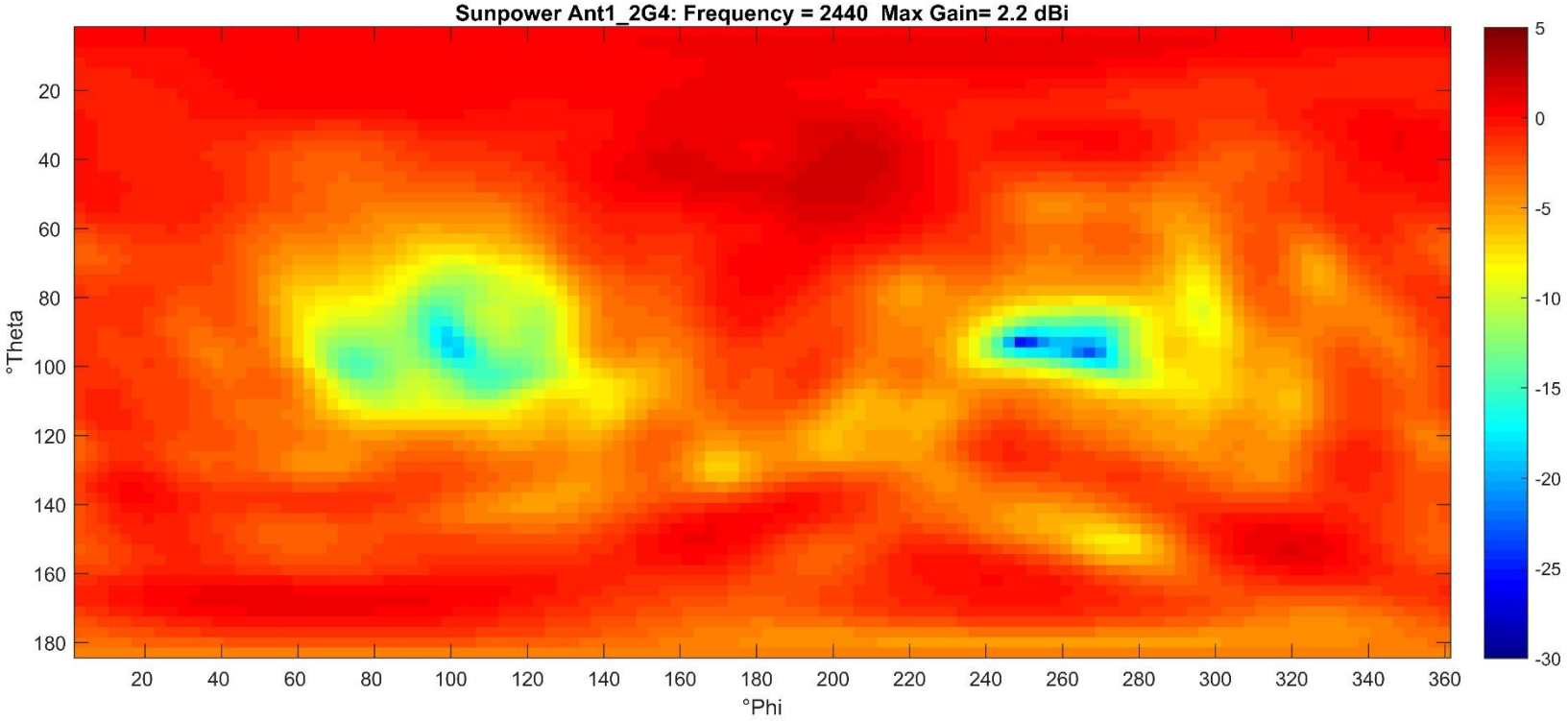




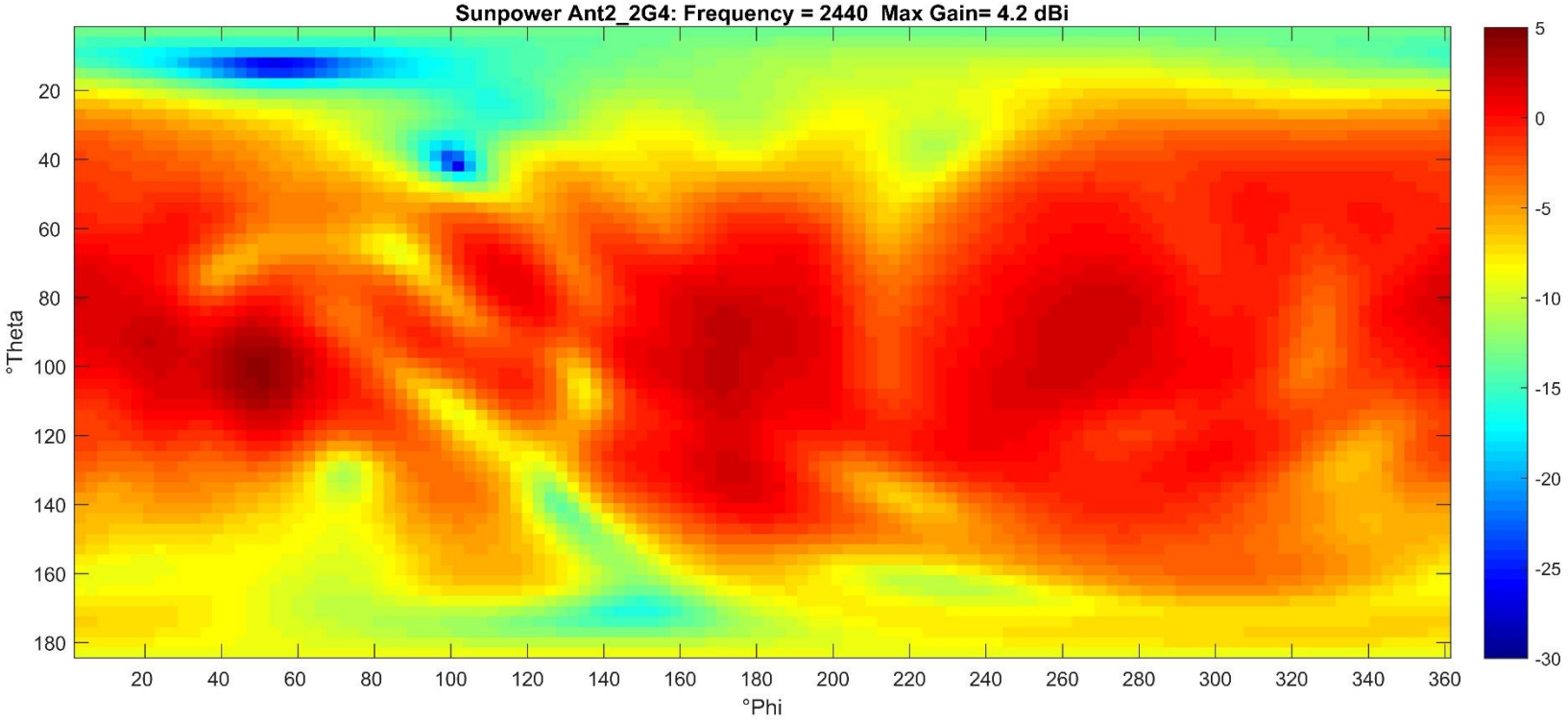
Orientation of Sunpower next gen (PVS6)

Airgain

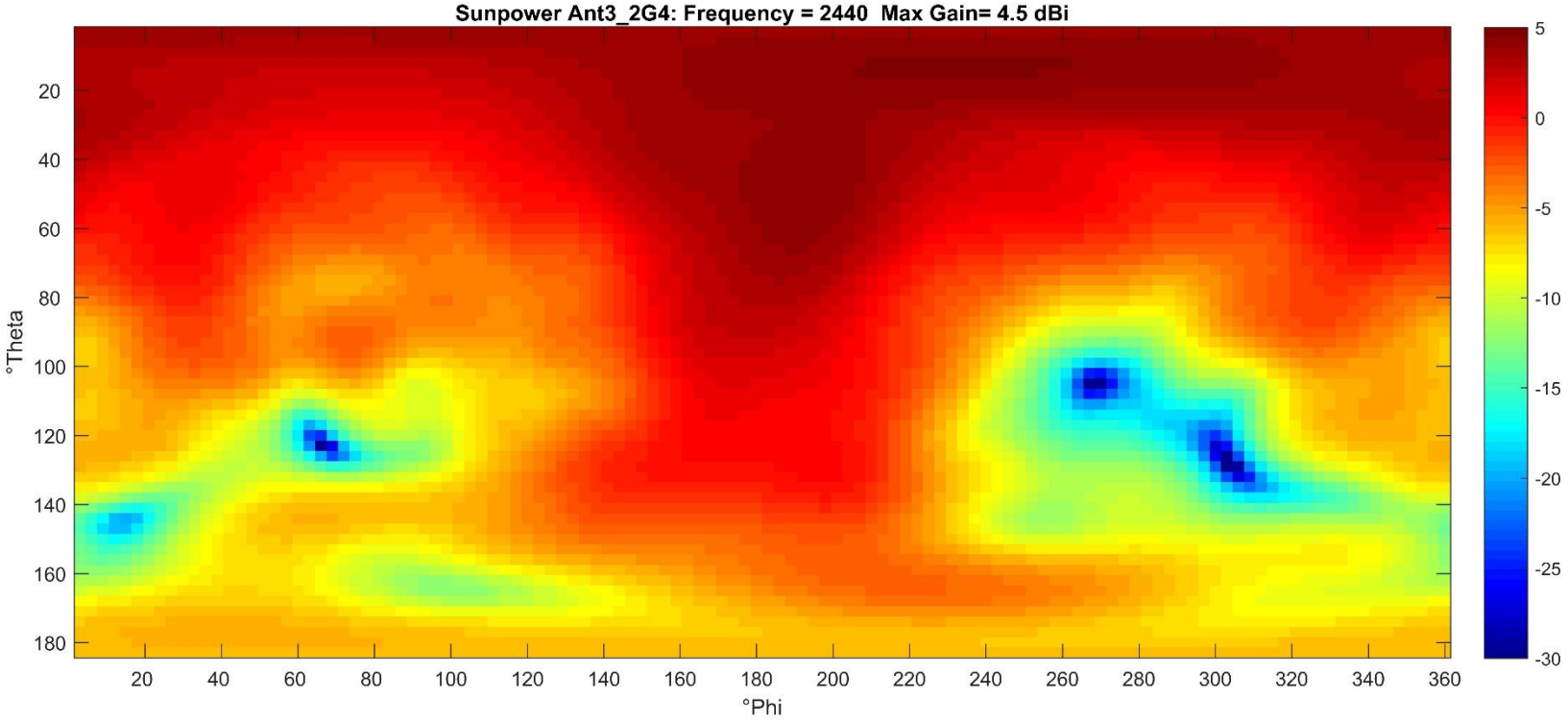
Heatmaps Antenna Pattern – [Ant1_2G4 at 2.44GHz]



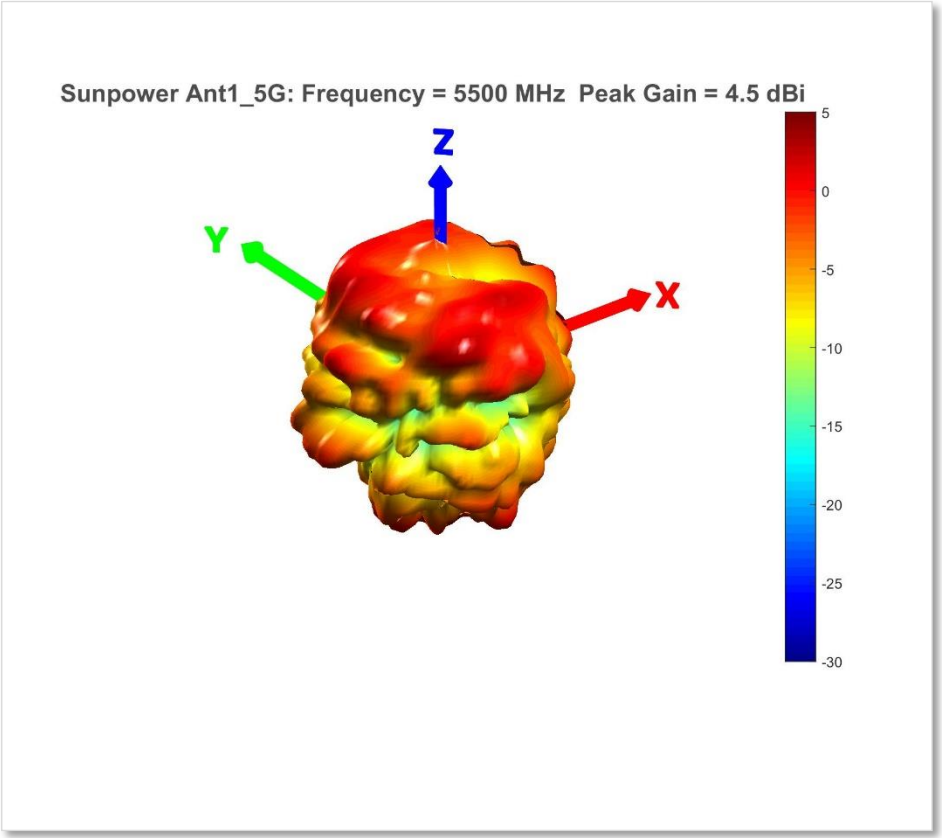
Heatmaps Antenna Pattern – [Ant2_2G4 at 2.44GHz]

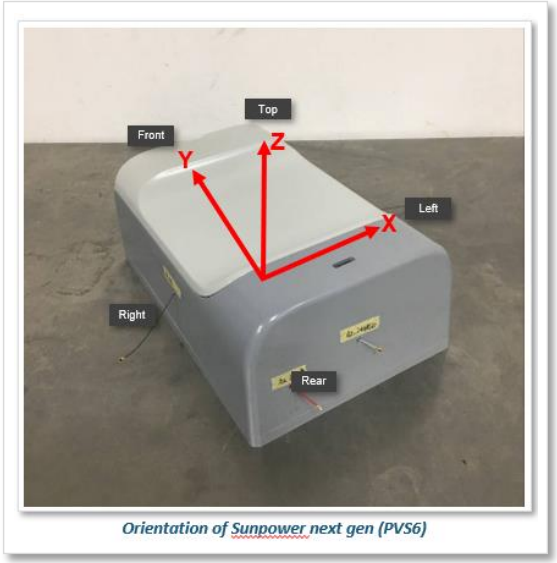


Heatmaps Antenna Pattern – [Ant3_2G4 at 2.44GHz]



3D Antenna Pattern – [Ant1_5G at 5.5GHz]

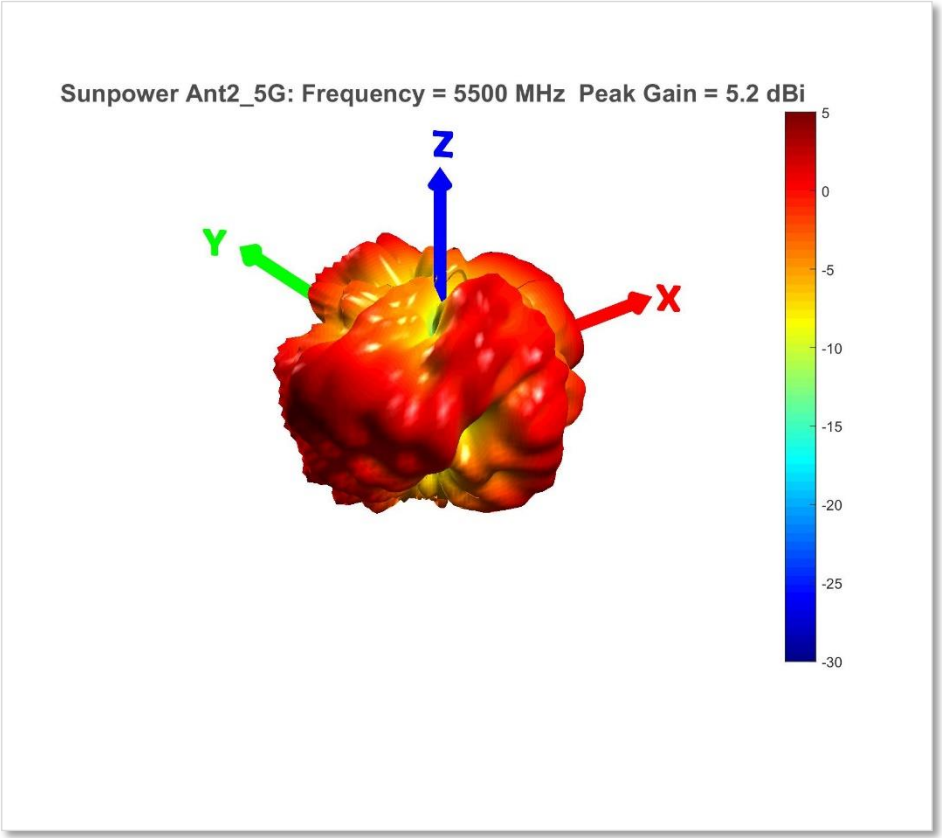


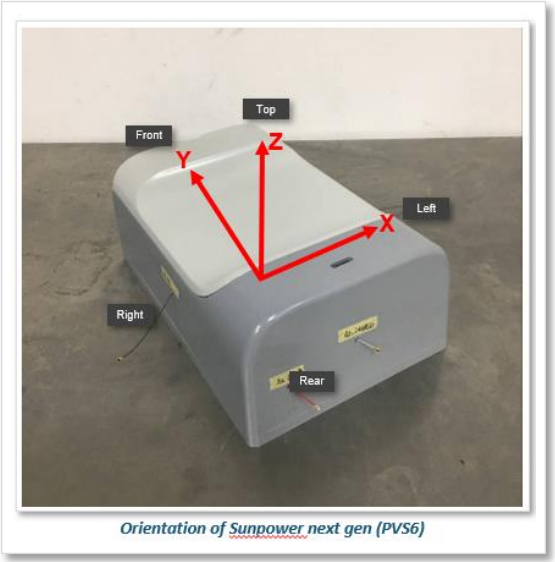


Orientation of Sunpower next gen (PVS6)

Airgain

3D Antenna Pattern – [Ant2_5G at 5.5GHz]

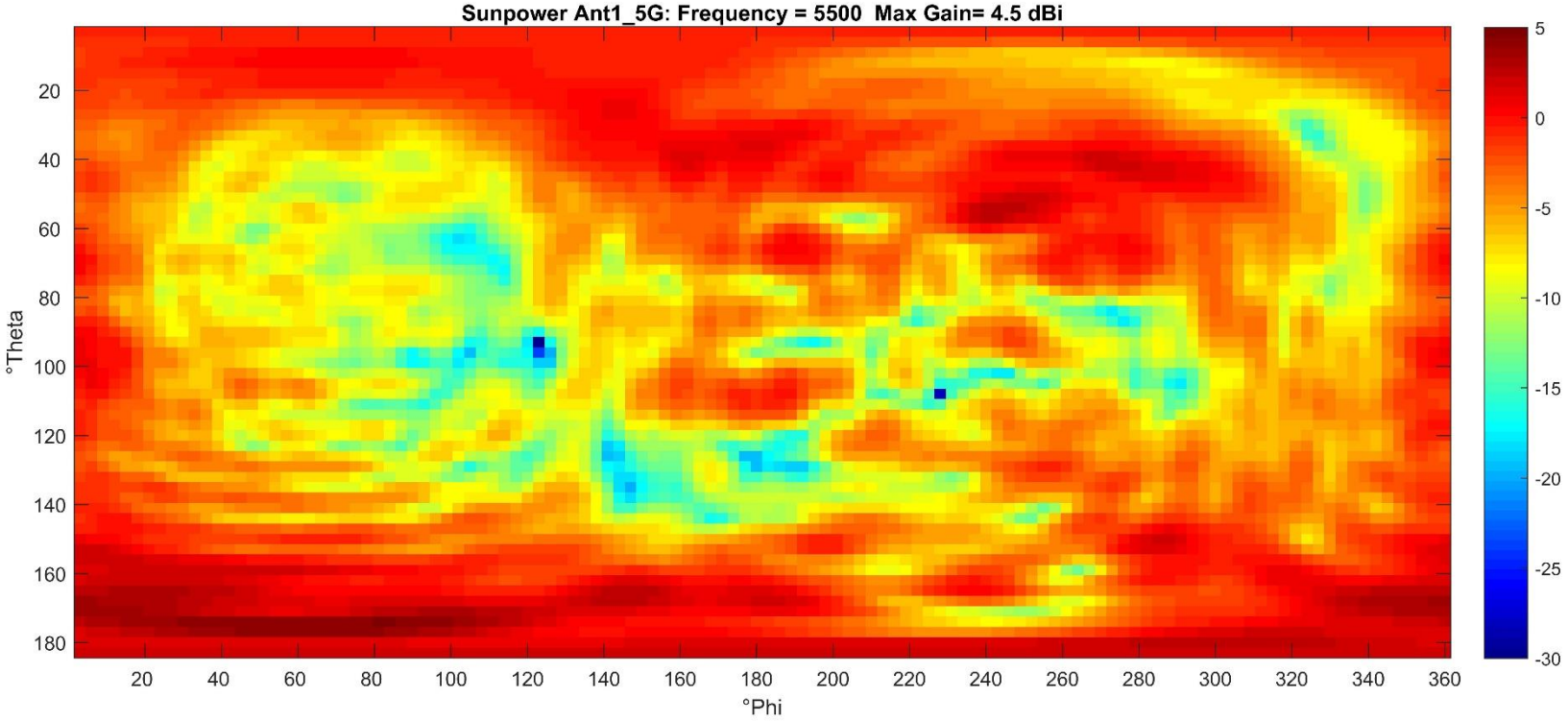




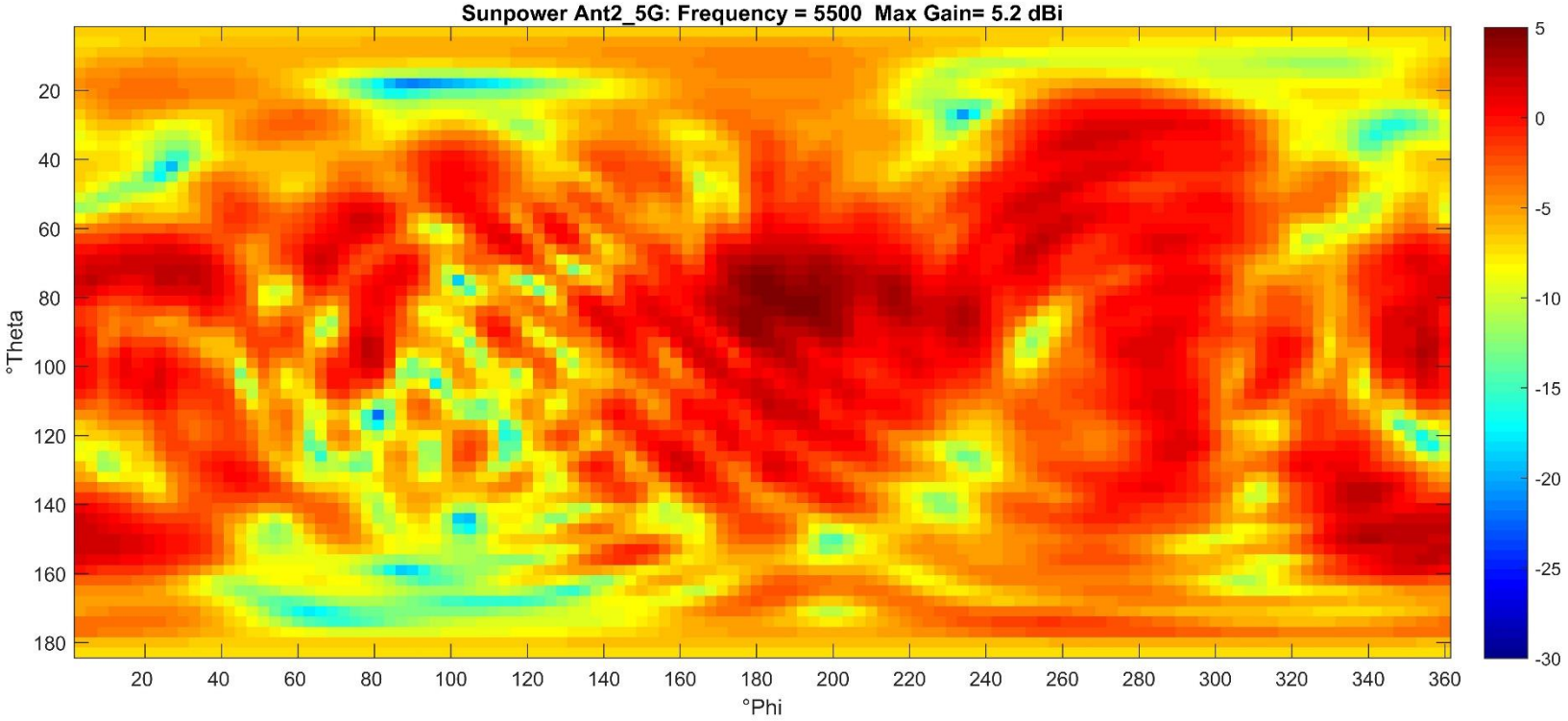
Orientation of Sunpower next gen (PVS6)

Airgain

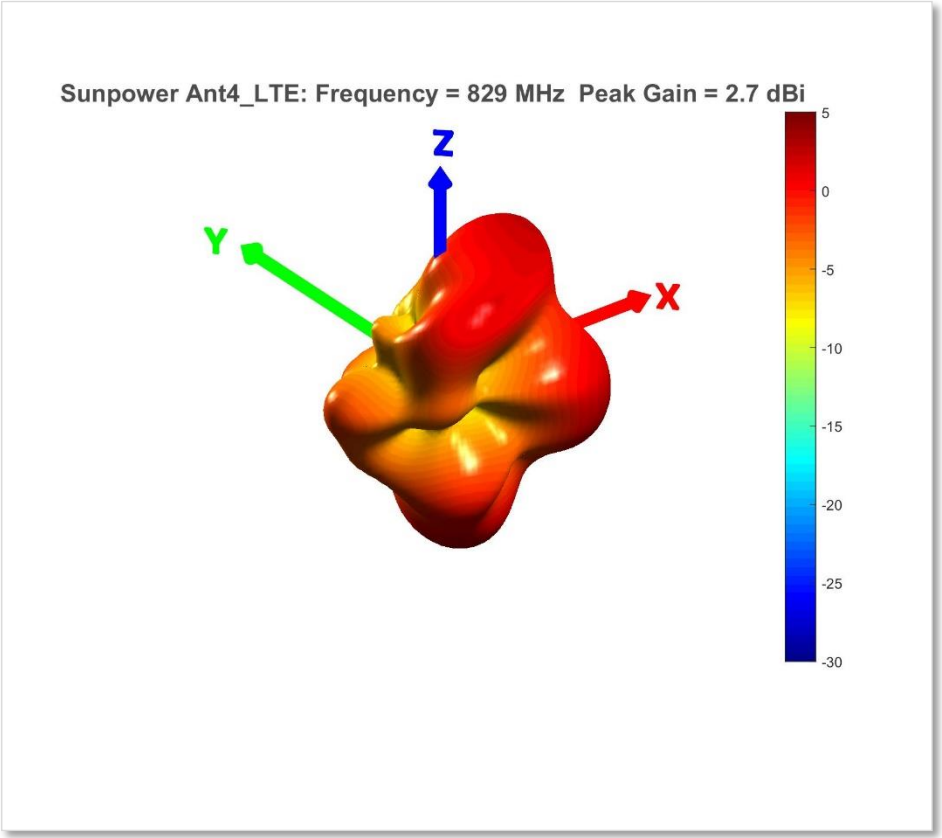
Heatmaps Antenna Pattern – [Ant1_5G at 5.5GHz]

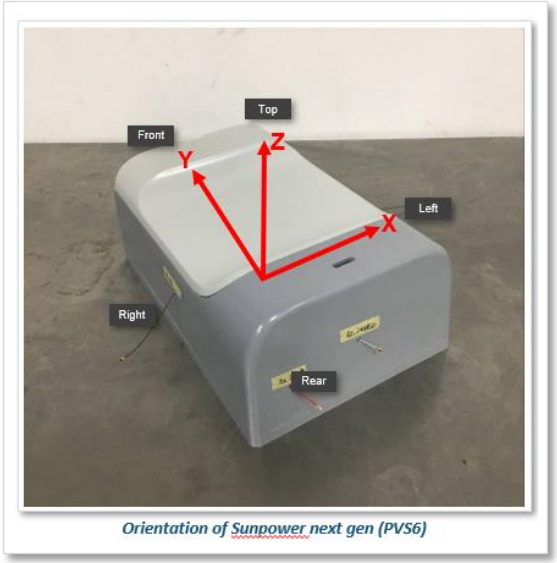


Heatmaps Antenna Pattern – [Ant2_5G at 5.5GHz]



3D Antenna Pattern – [Ant4_LTE at 829MHz]

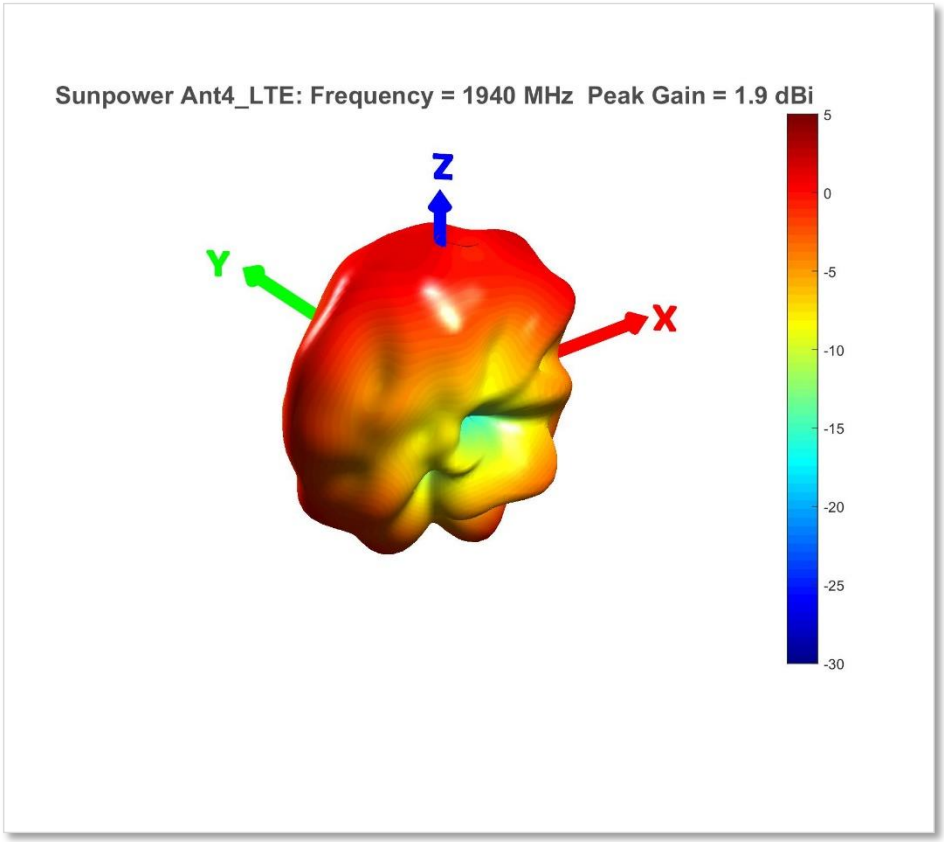


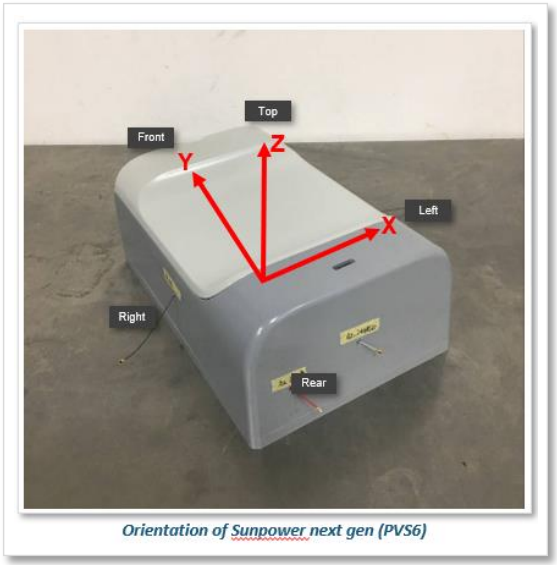


Orientation of Sunpower next gen (PVS6)

Airgain

3D Antenna Pattern – [Ant4_LTE at 1940MHz]

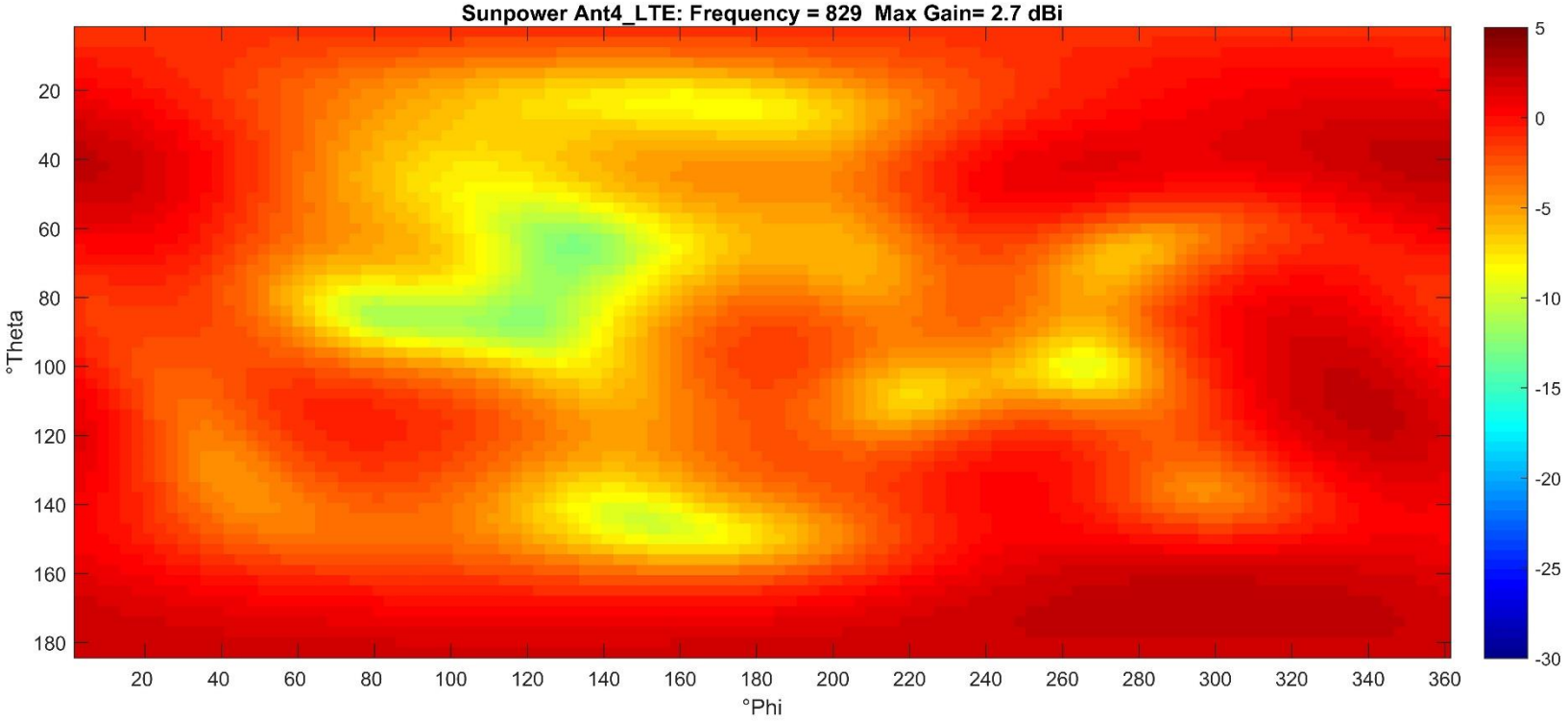




Orientation of Sunpower next gen (PVS6)

Airgain

Heatmaps Antenna Pattern – [Ant4_LTE at 829MHz]



Heatmaps Antenna Pattern – [Ant4_LTE at 1940MHz]