

## PVS6

Passive Measurement Report

Date: Jul 24, 2018

Prepared By: Macy Zhang

Airgain ))

#### **Table of Contents**

- Airgain Solution
- Return Loss and Isolation
- Efficiency and Peak Gain
- Azimuth and Elevation Patterns
- System Coverage
- Summary



#### Introduction

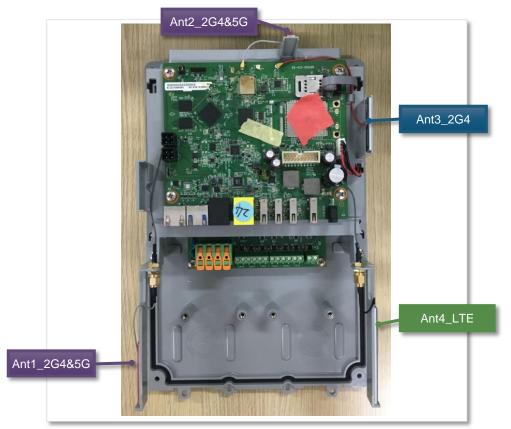
- Airgain proposes an embedded antenna solution for PVS6
- There are two 2.4GHz & 5GHz Wifi antennas, one 2.4GHz Zigbee antenna and one LTE antenna
- All antennas are mounted on the plastic enclosure and connect to the radio through coaxial cable and U.FL. Connector
- Antennas are measured in the hardware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



Airgain antenna solutions



## Airgain Solution



Antenna #	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		

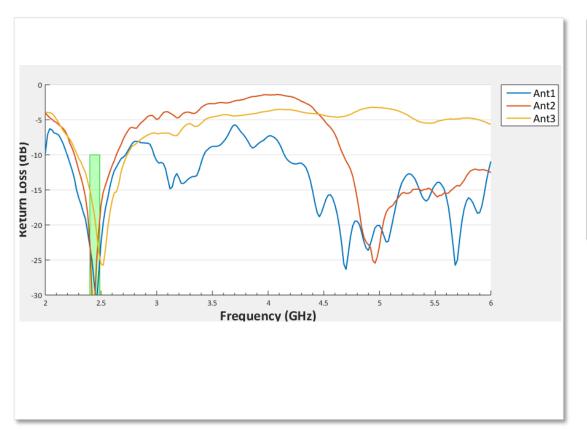
Antenna placement for PVS6

**Return Loss and Isolation** 



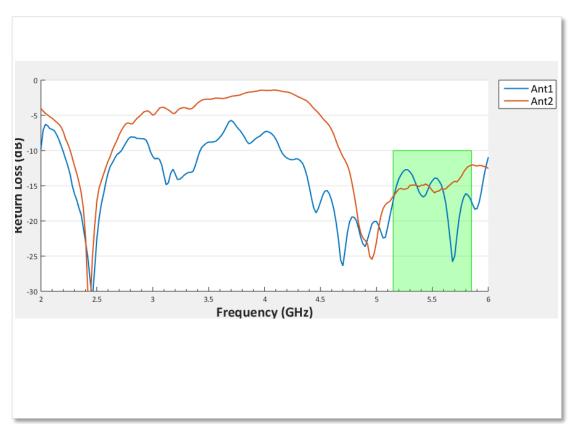
7/24/2018

#### S-Parameter – Return Loss for All 2.4GHz Antennas



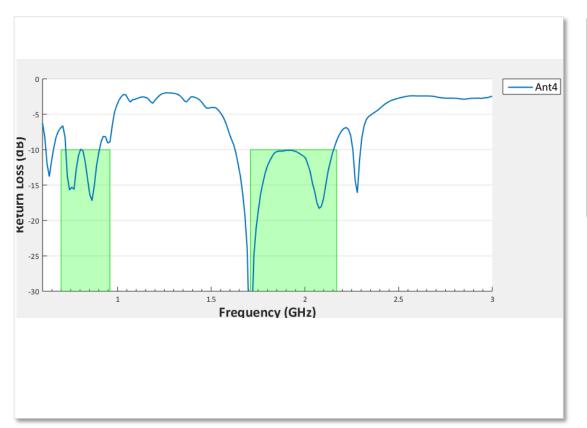
KEY OBSERVATIONS			
Antonno	Return Lo	oss (dB)	
Antenna	2.4G	2.49G	
Ant1_2G4	-22.4	-23.8	
Ant2_2G4	-22.4	-20.8	
Ant3_2G4	-15.0	-25.6	

#### S-Parameter – Return Loss for All 5GHz Antennas



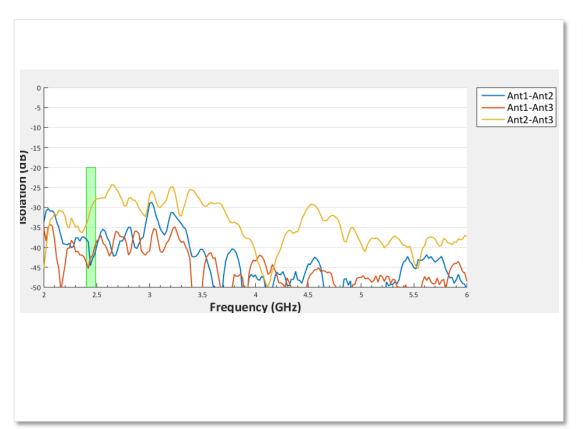
KEY OBSERVATIONS			
Return Loss (dB)			
5.15G	5.85G		
-17.4	-17.4		
-16.7	-12.1		
	Return Lo 5.15G -17.4		

#### S-Parameter – Return Loss for All LTE Antennas



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

#### S-Parameter – Isolation for All 2.4GHz Antennas

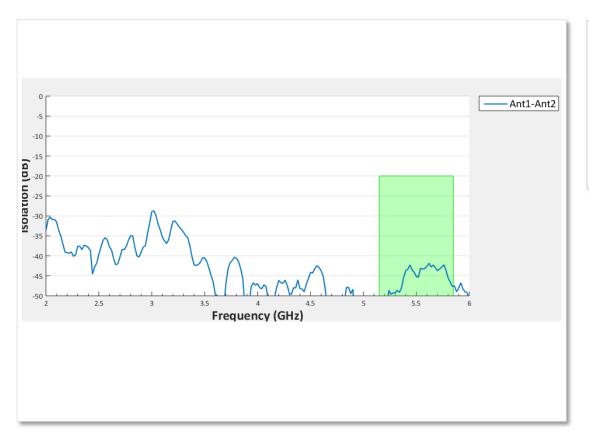


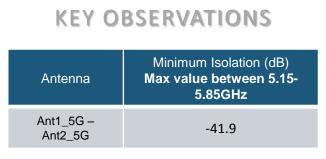
#### **KEY OBSERVATIONS**

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





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

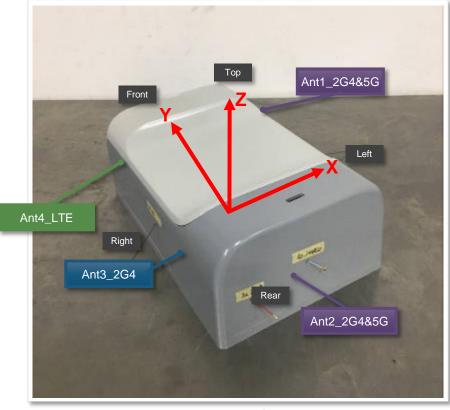


## Antenna Efficiency & Peak Gain – LTE Antenna

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** 



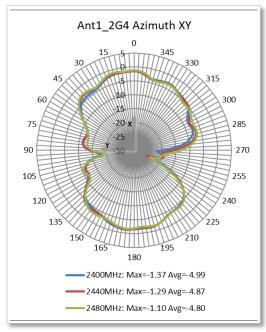
....

Azimuth and Elevation Patterns, and System Coverage 2.4 GHz plots



#### Radiation Pattern at 2.4GHz –Ant1





Ant1\_2G4 Elevation XZ 60 75 285 270 105 255 120 165 195 180 2400MHz: Max=1.52 Avg=-0.89 ----2440MHz: Max=1.42 Avg=-0.99 ----2480MHz: Max=1.35 Avg=-1.14

Ant1\_2G4 Elevation YZ 330 315 75 285 270 105 255 120 195 165 180 2400MHz: Max=1.10 Avg=-2.91 --- 2440MHz: Max=0.82 Avg=-2.74 -----2480MHz: Max=0.51 Avg=-2.90

Azimuth (XY)

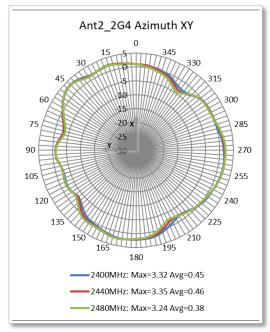
Side to Side (XZ)

Front to Back (YZ)



#### Radiation Pattern at 2.4GHz –Ant2





Ant2\_2G4 Elevation XZ 2400MHz: Max=2.19 Avg=-1.74 ----2440MHz: Max=2.10 Avg=-1.75 ----2480MHz: Max=1.93 Avg=-1.87

2400MHz: Max=1.78 Avg=-3.13 ----2440MHz: Max=2.12 Avg=-2.91 ----2480MHz: Max=2.29 Avg=-2.66

Ant2\_2G4 Elevation YZ

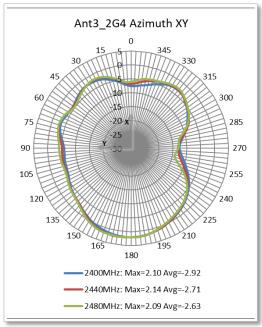
Azimuth (XY)

Side to Side (XZ)

Front to Back (YZ)

#### Radiation Pattern at 2.4GHz –Ant3



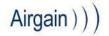


Ant3\_2G4 Elevation XZ 2400MHz: Max=4.22 Avg=0.58 --- 2440MHz: Max=4.26 Avg=0.71 ----2480MHz: Max=4.59 Avg=0.89

Ant3\_2G4 Elevation YZ 2400MHz: Max=4.37 Avg=-2.44 2440MHz: Max=4.39 Avg=-2.18 -----2480MHz: Max=4.32 Avg=-2.07

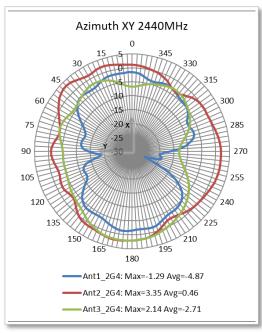
Azimuth (XY) Side to Side (XZ)

Front to Back (YZ)



## System Coverage: Radiation Pattern at 2.44GHz





Elevation XZ 2440MHz 285 105 255 120 165 195 180 Ant1 2G4: Max=1.42 Avg=-0.99 Ant2\_2G4: Max=2.10 Avg=-1.75 ——Ant3 2G4: Max=4.26 Avg=0.71

Elevation YZ 2440MHz 75 285 270 105 255 120 165 195 180 Ant1 2G4: Max=0.82 Avg=-2.74 Ant2\_2G4: Max=2.12 Avg=-2.91 Ant3 2G4: Max=4.39 Avg=-2.18

Azimuth (XY)

Side to Side (XZ)

Front to Back (YZ)

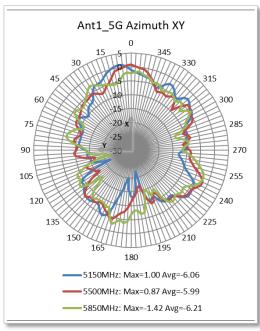


Azimuth and Elevation Patterns, and System Coverage 5 GHz plots



#### Radiation Pattern at 5GHz -Ant1





Ant1\_5G Elevation XZ ----5150MHz: Max=2.59 Avg=-2.22 5500MHz: Max=3.40 Avg=-1.30 -----5850MHz: Max=3.74 Avg=-1.89

Ant1\_5G Elevation YZ -5500MHz: Max=4.29 Avg=-3.02 --- 5850MHz: Max=2.30 Avg=-3.31

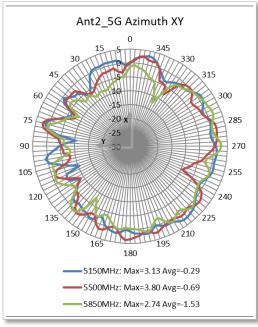
Azimuth (XY) Side to Side (XZ)

Front to Back (YZ)



#### Radiation Pattern at 5GHz –Ant2





Ant2\_5G Elevation XZ 75 285 270 105 120 165 195 180 -----5150MHz: Max=3.07 Avg=-1.70 5500MHz: Max=5.15 Avg=-0.82 ----5850MHz: Max=3.19 Avg=-1.30

Ant2\_5G Elevation YZ 285 270 105 255 120 195 165 180 --- 5500MHz: Max=2.02 Avg=-2.93 --- 5850MHz: Max=2.78 Avg=-2.86

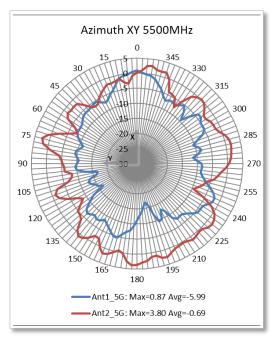
Azimuth (XY) Side to Side (XZ)

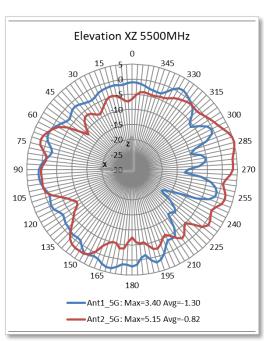
Front to Back (YZ)

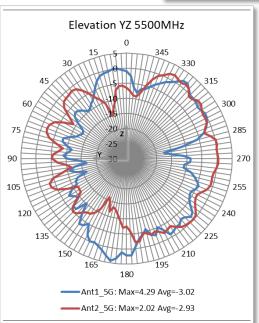


## System Coverage: Radiation Pattern at 5.5GHz









Azimuth (XY)

Side to Side (XZ)

Front to Back (YZ)

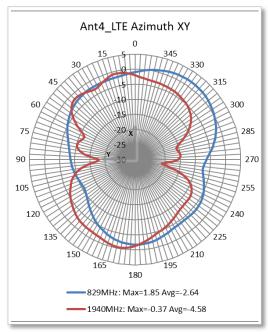


Azimuth and Elevation Patterns, and System Coverage LTE plots



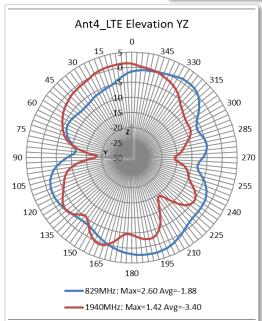
#### Radiation Pattern at LTE -Ant4





Ant4\_LTE Elevation XZ 315 285 90 270 105 255 135 180 -----829MHz: Max=2.45 Avg=-0.71 1940MHz: Max=1.86 Avg=-0.55

Side to Side (XZ)



Front to Back (YZ)

Airgain)))

Azimuth (XY)

PROPRIETARY AND CONFIDENTIAL

#### 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





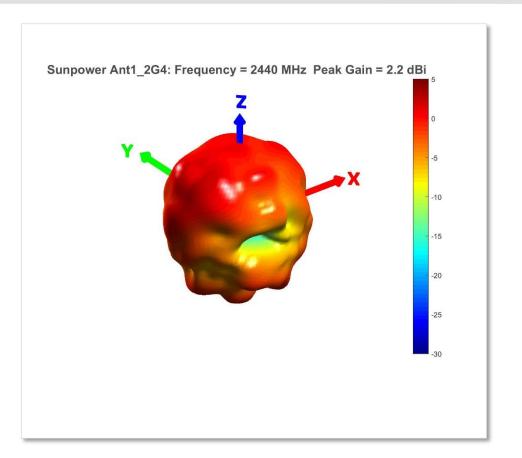
# Appendix

Airgain ))

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



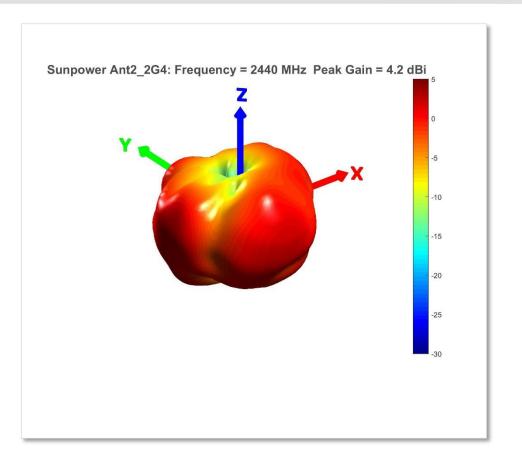
## 3D Antenna Pattern – [Ant1\_2G4 at 2.44GHz]







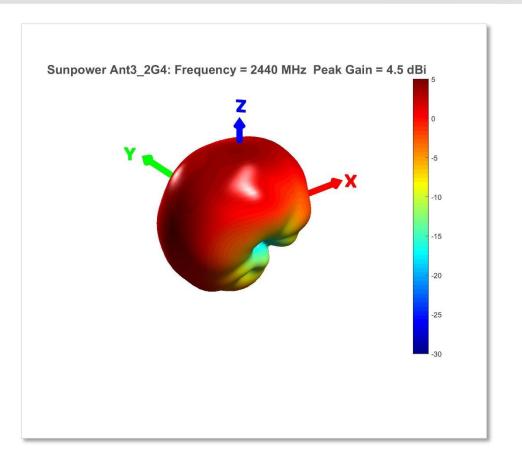
## 3D Antenna Pattern – [Ant2\_2G4 at 2.44GHz]







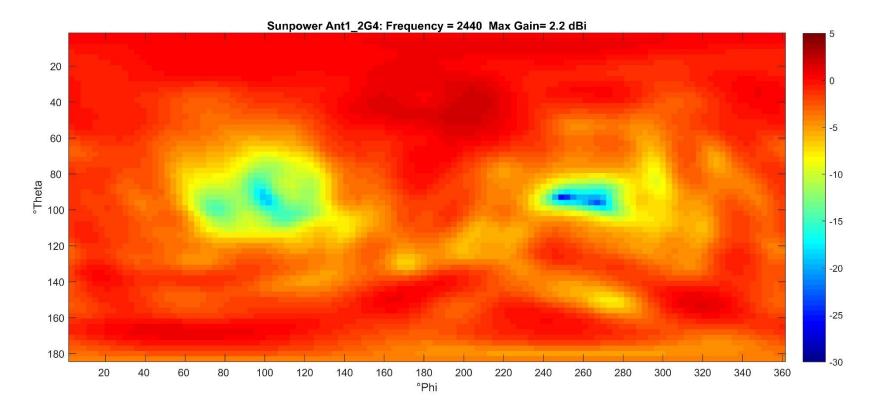
## 3D Antenna Pattern – [Ant3\_2G4 at 2.44GHz]





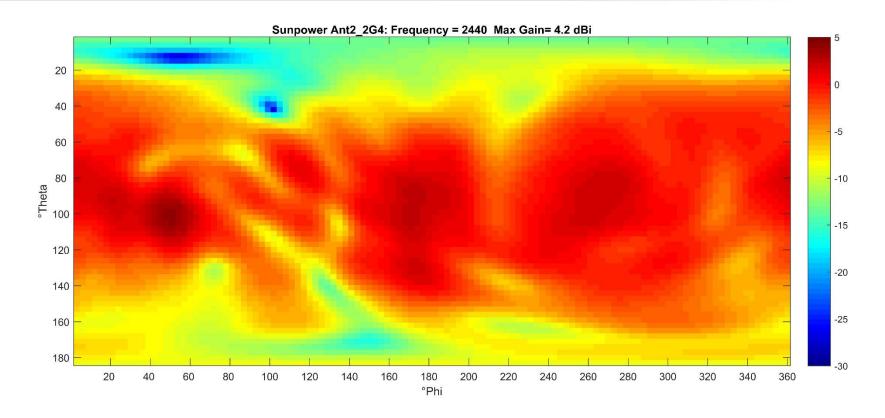


## Heatmaps Antenna Pattern – [Ant1\_2G4 at 2.44GHz]



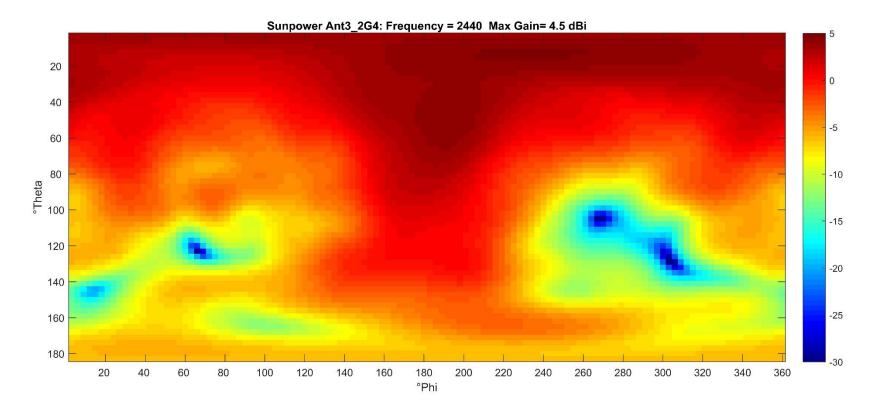


## Heatmaps Antenna Pattern – [Ant2\_2G4 at 2.44GHz]



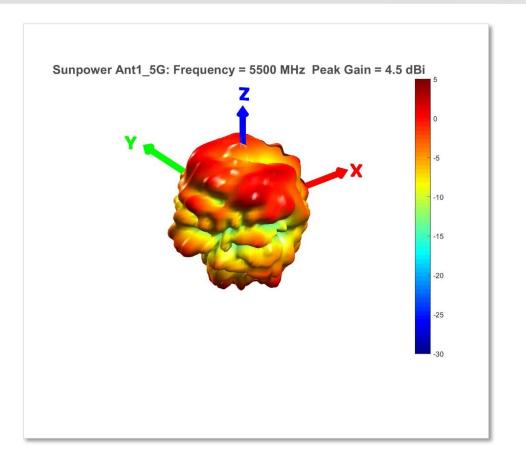


## Heatmaps Antenna Pattern – [Ant3\_2G4 at 2.44GHz]





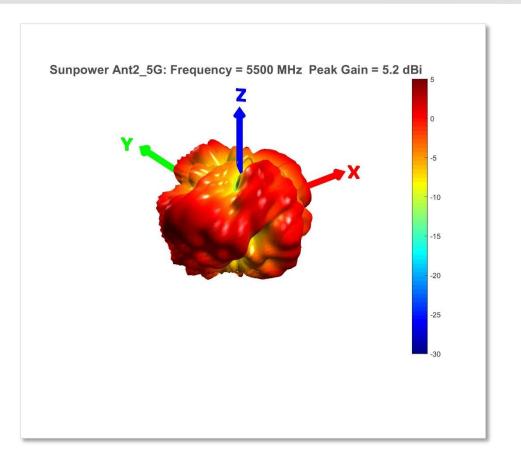
## 3D Antenna Pattern – [Ant1\_5G at 5.5GHz]

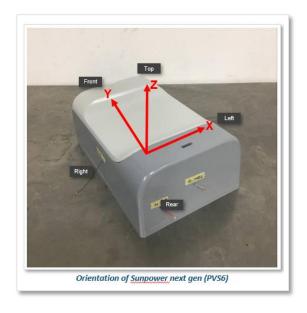






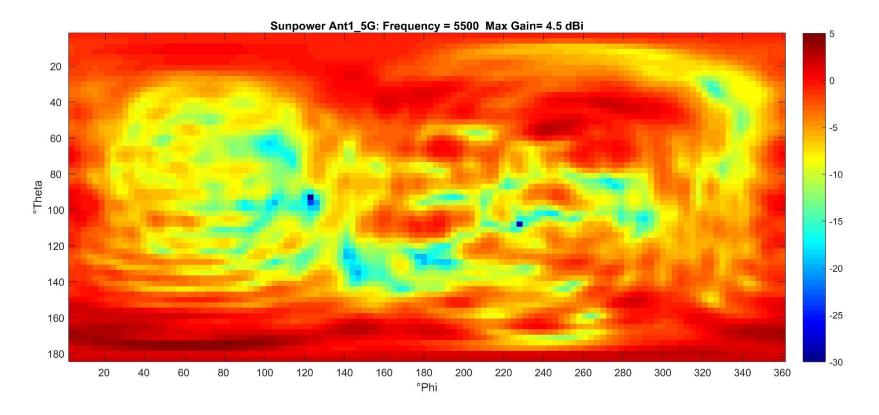
## 3D Antenna Pattern – [Ant2\_5G at 5.5GHz]





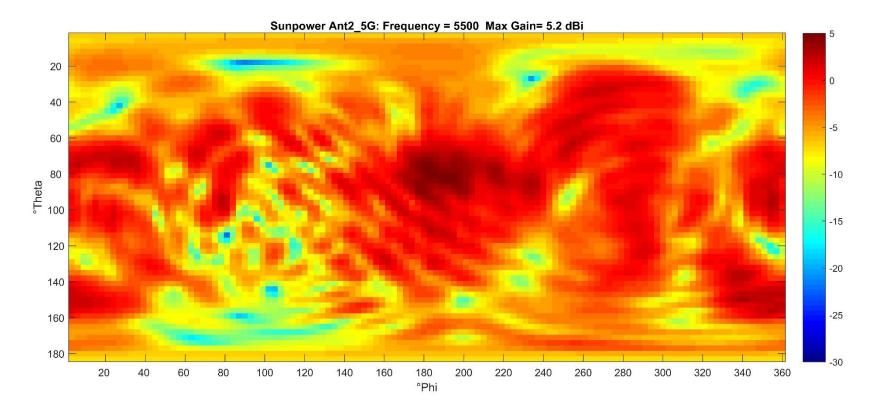


## Heatmaps Antenna Pattern – [Ant1\_5G at 5.5GHz]



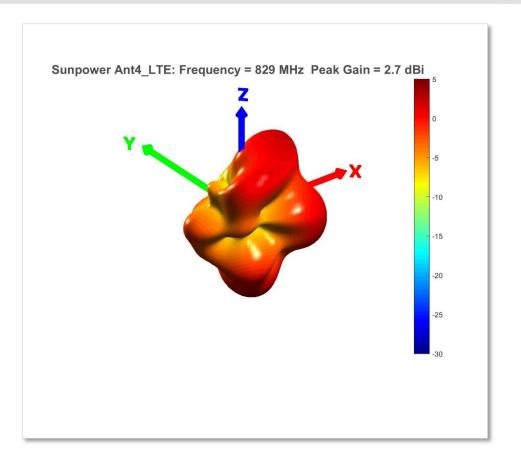


## Heatmaps Antenna Pattern – [Ant2\_5G at 5.5GHz]





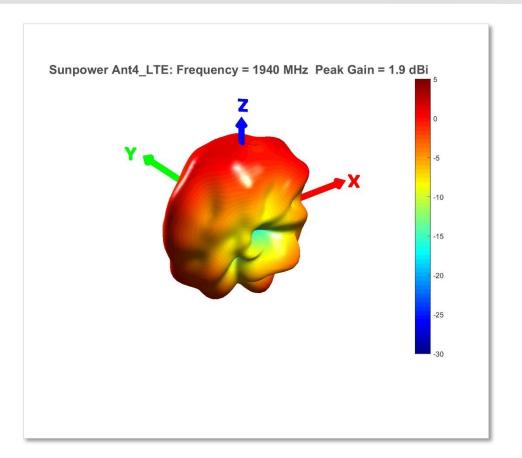
## 3D Antenna Pattern – [Ant4\_LTE at 829MHz]







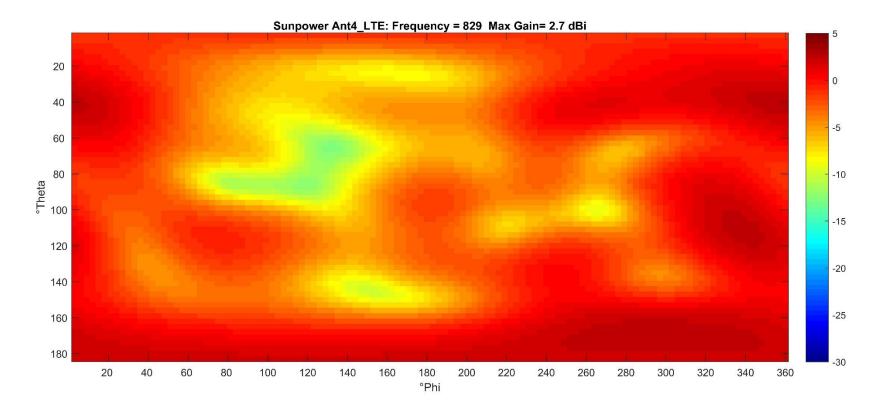
## 3D Antenna Pattern – [Ant4\_LTE at 1940MHz]







## Heatmaps Antenna Pattern – [Ant4\_LTE at 829MHz]





## Heatmaps Antenna Pattern – [Ant4\_LTE at 1940MHz]

