



# PVS6

## Passive Measurement Report

Date: Jul 24, 2018

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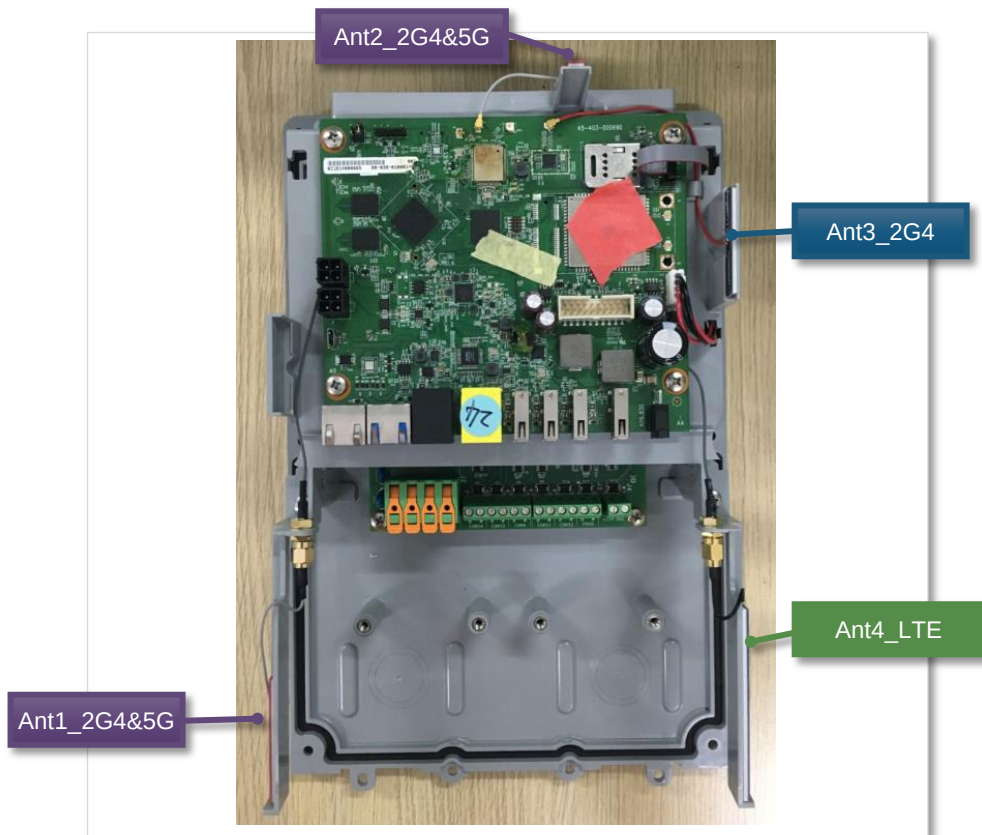
- Airgain Solution
- Return Loss and Isolation
- Efficiency and Peak Gain
- Azimuth and Elevation Patterns
- System Coverage
- Summary

# 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

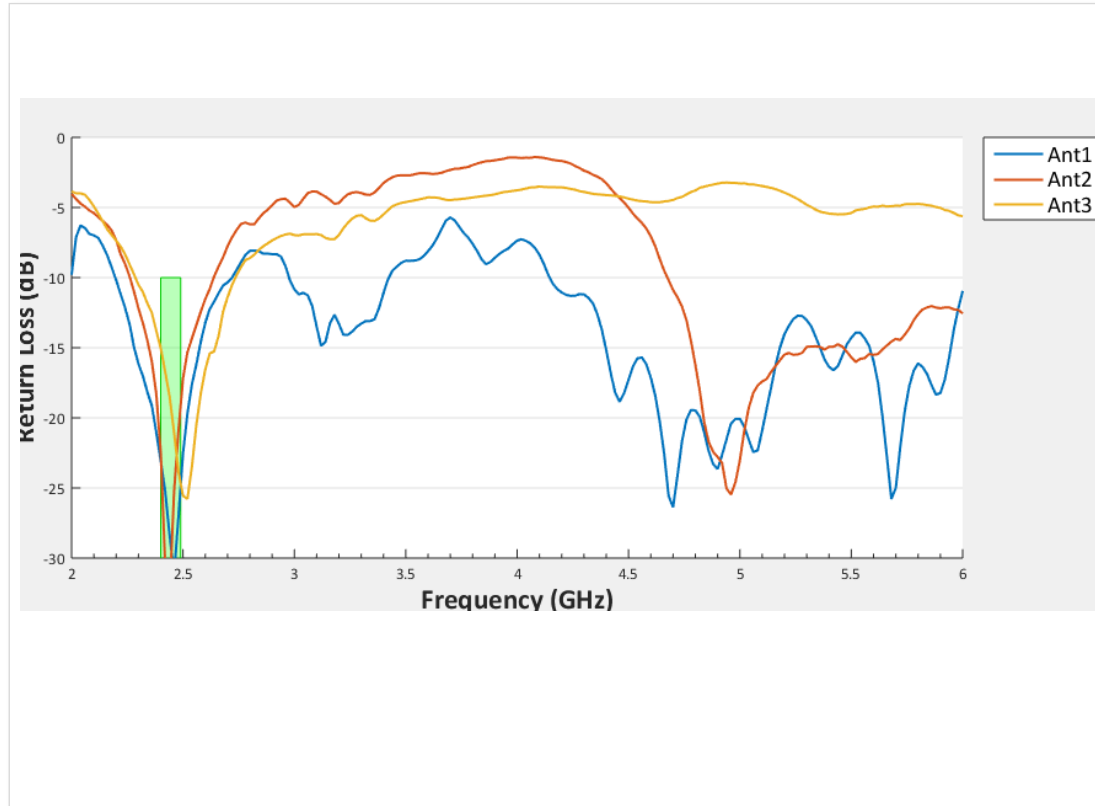


| Antenna #   | Part Number                |
|-------------|----------------------------|
| Ant1_2G4&5G | N2420DGLCORE3-T-PK1-W90SMA |
| Ant2_2G4&5G | N2420DGST2-T-PK1-A50U      |
| Ant3_2G4    | N2420GSST-T-PK1-R130U      |
| Ant4_LTE    | N815DMST-T-PK1-B55SMA      |

***Antenna placement for PVS6***

## Return Loss and Isolation

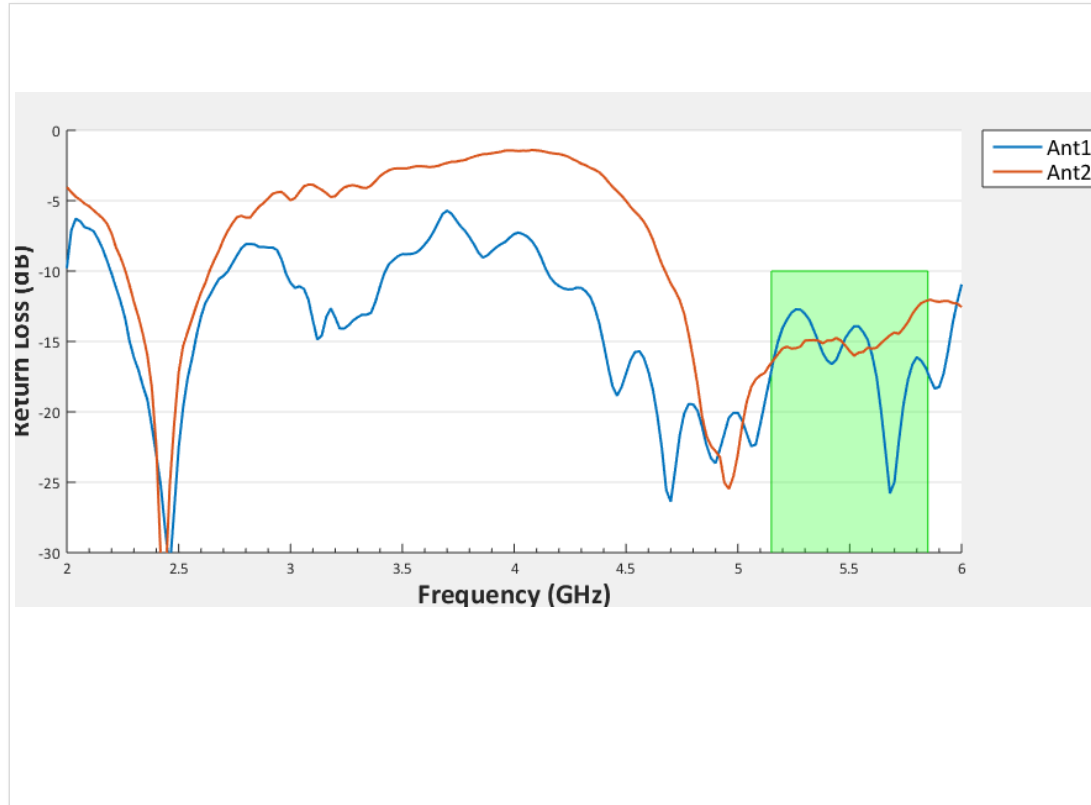
# S-Parameter – Return Loss for All 2.4GHz Antennas



## 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 |

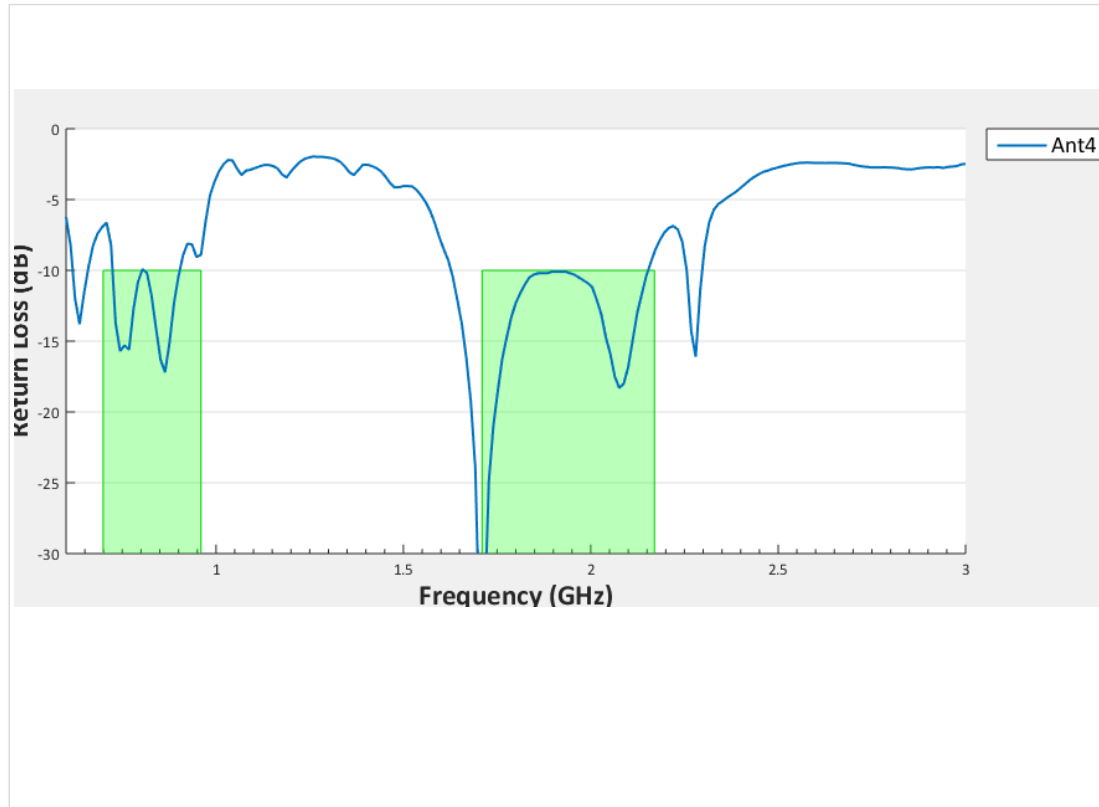
# S-Parameter – Return Loss for All 5GHz Antennas



## KEY OBSERVATIONS

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

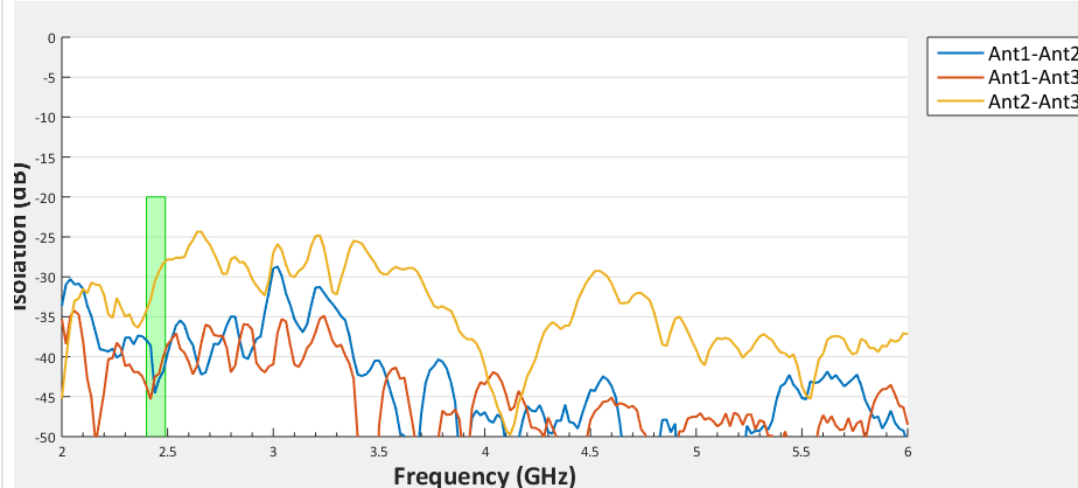
# S-Parameter – Return Loss for All LTE Antennas



## KEY OBSERVATIONS

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

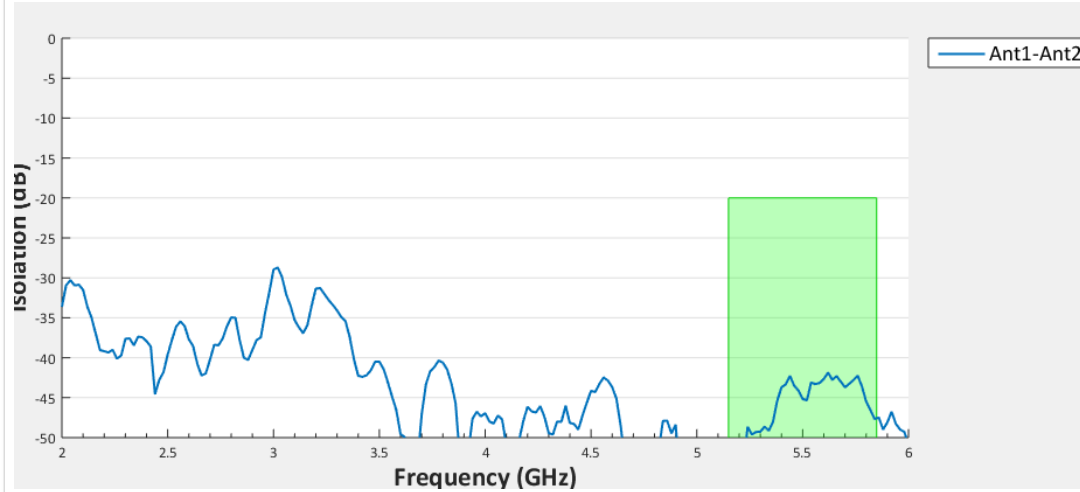
# S-Parameter – Isolation for All 2.4GHz Antennas



## KEY OBSERVATIONS

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

# S-Parameter – Isolation for All 5GHz Antennas



## KEY OBSERVATIONS

| Antenna           | Minimum Isolation (dB)<br>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            |

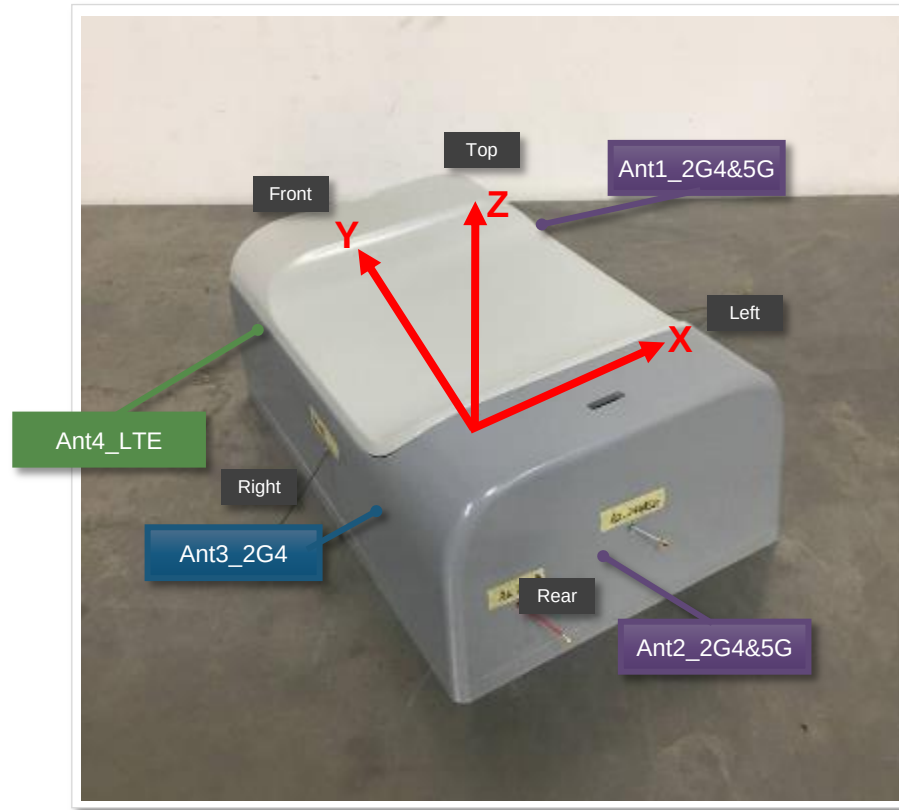
## Antenna Peak Gain – 5GHz Antennas

| 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<br>Ant4_LTE (dBi) | Efficiency<br>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                       |

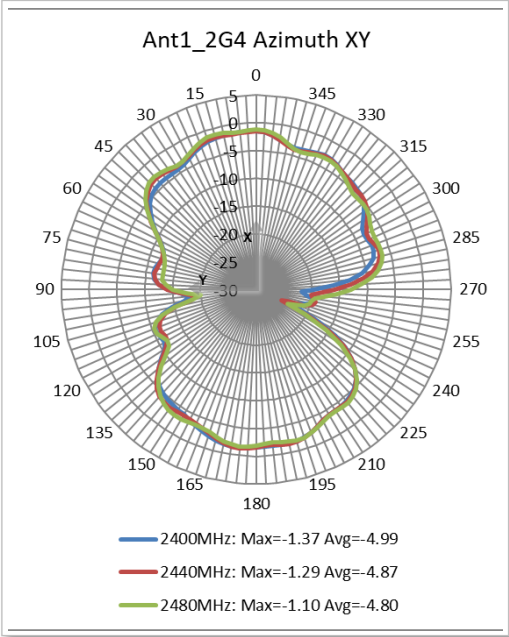
# Orientation



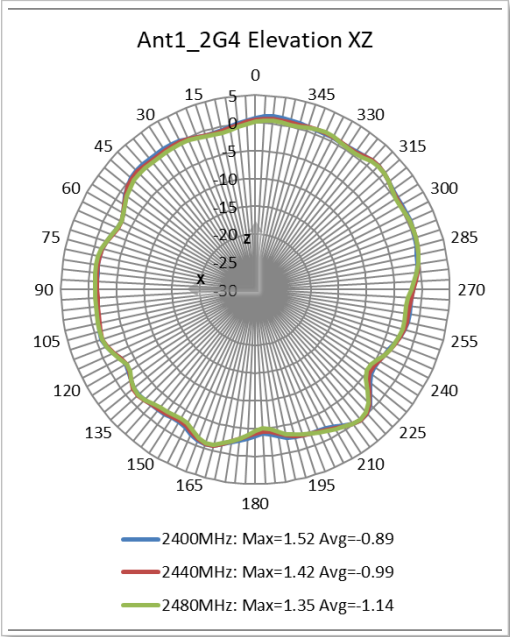
***Orientation of PVS6***

## Azimuth and Elevation Patterns, and System Coverage 2.4 GHz plots

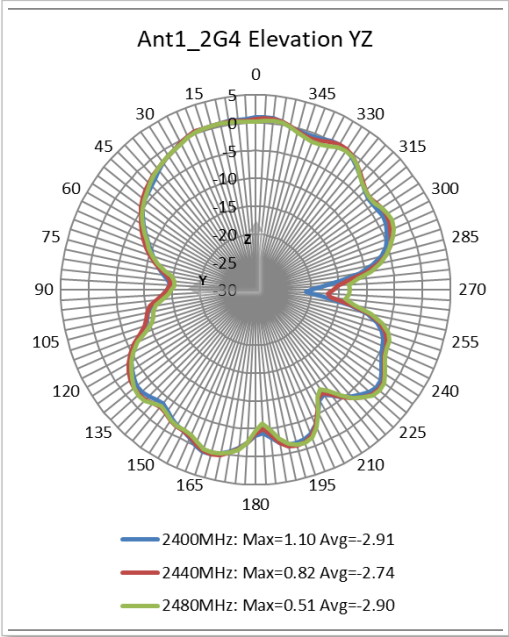
# Radiation Pattern at 2.4GHz –Ant1



Azimuth (XY)



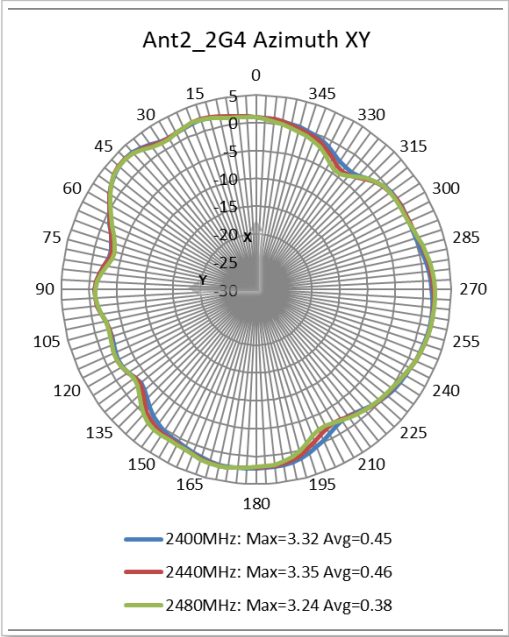
Side to Side (XZ)



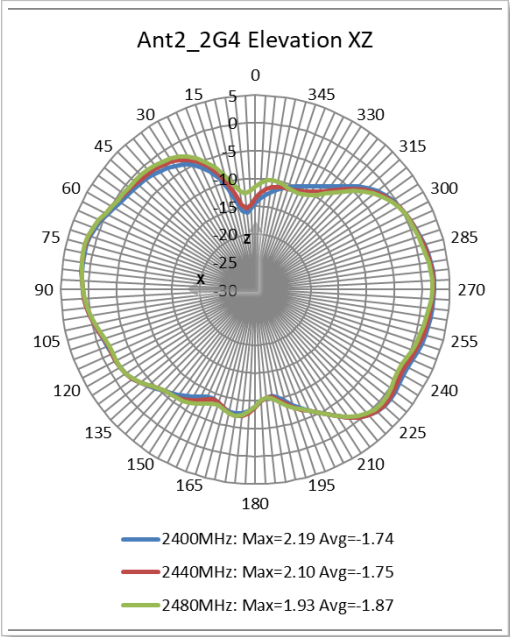
Front to Back (YZ)

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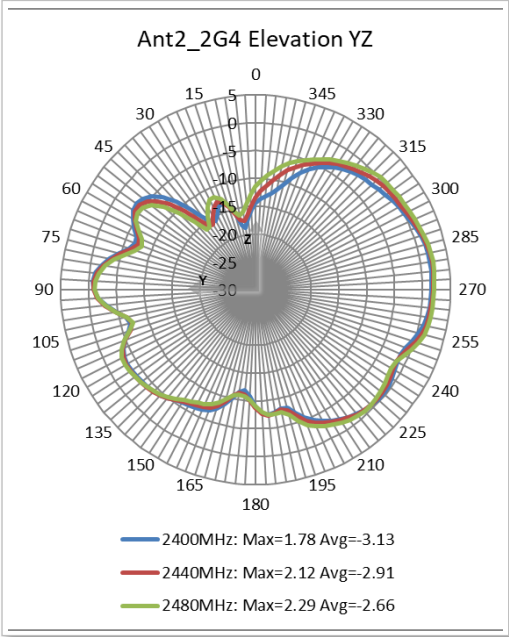
# Radiation Pattern at 2.4GHz –Ant2



Azimuth (XY)



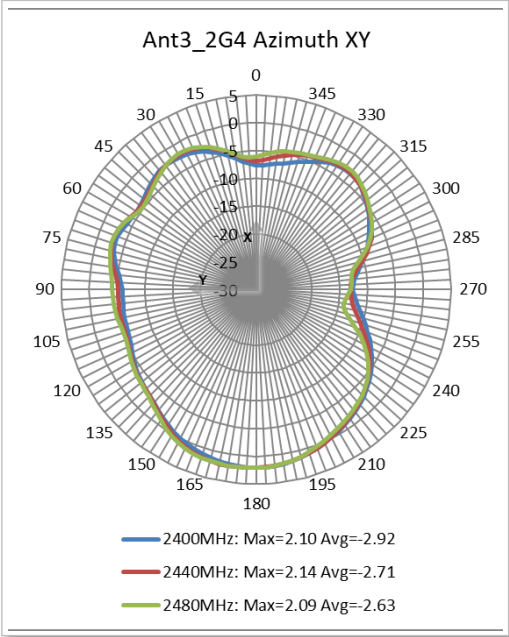
Side to Side (XZ)



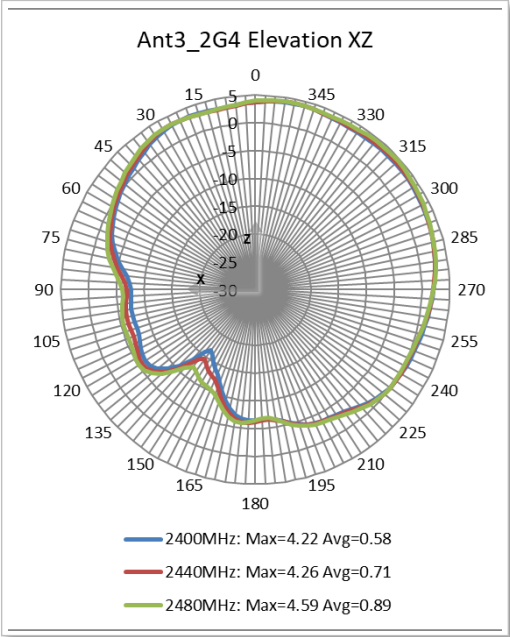
Front to Back (YZ)



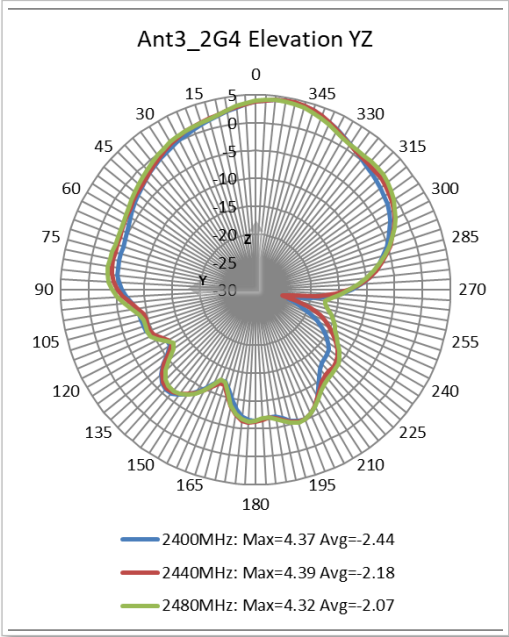
# Radiation Pattern at 2.4GHz –Ant3



Azimuth (XY)



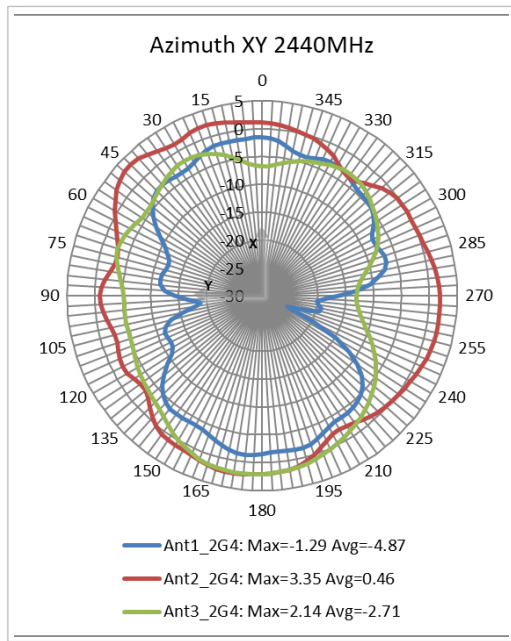
Side to Side (XZ)



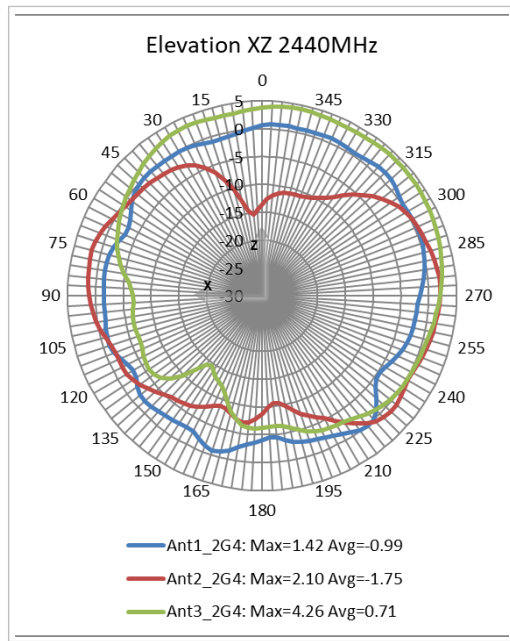
Front to Back (YZ)

Airgain )))

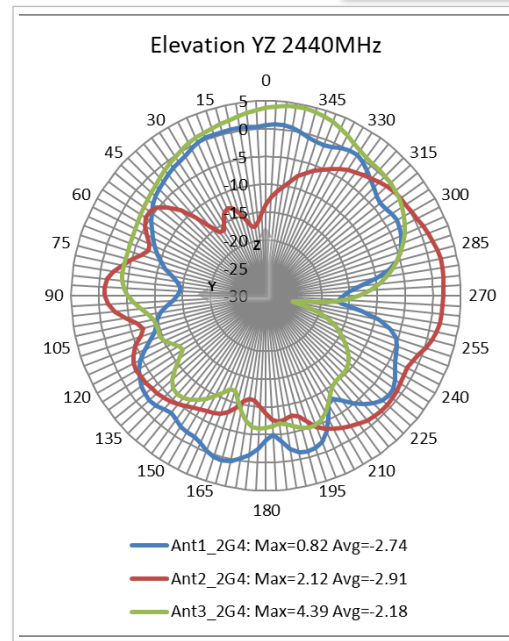
# System Coverage: Radiation Pattern at 2.44GHz



Azimuth (XY)



Side to Side (XZ)

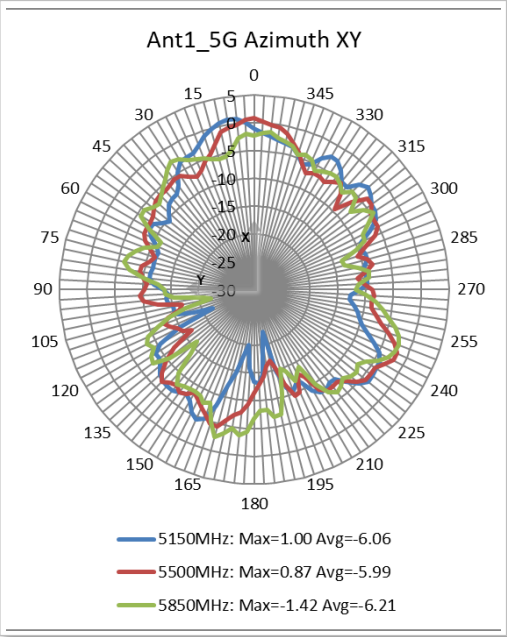


Front to Back (YZ)

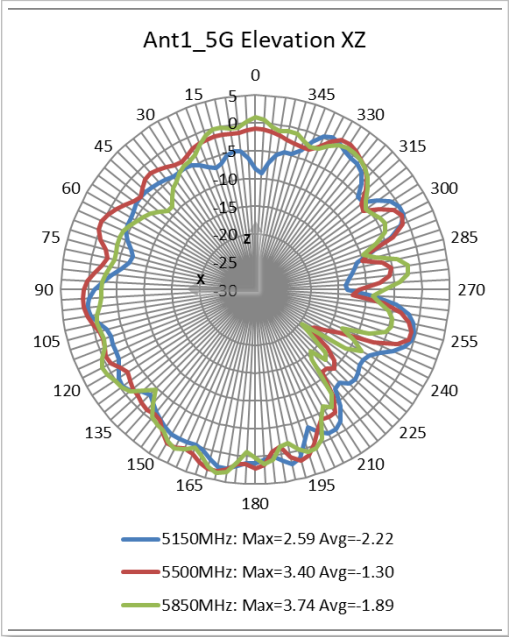
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## Azimuth and Elevation Patterns, and System Coverage 5 GHz plots

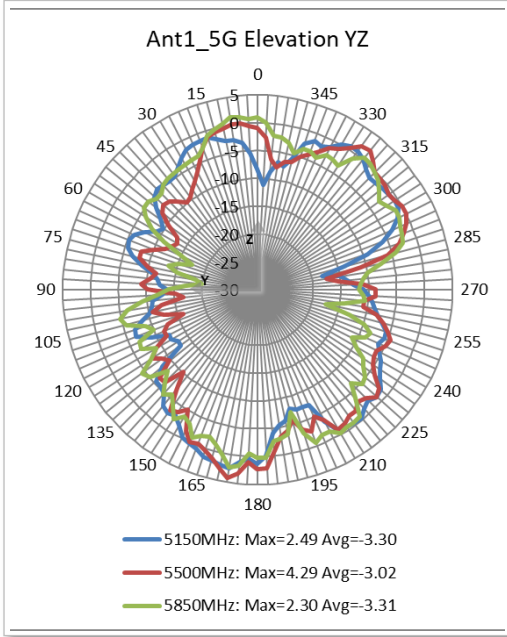
# Radiation Pattern at 5GHz –Ant1



Azimuth (XY)



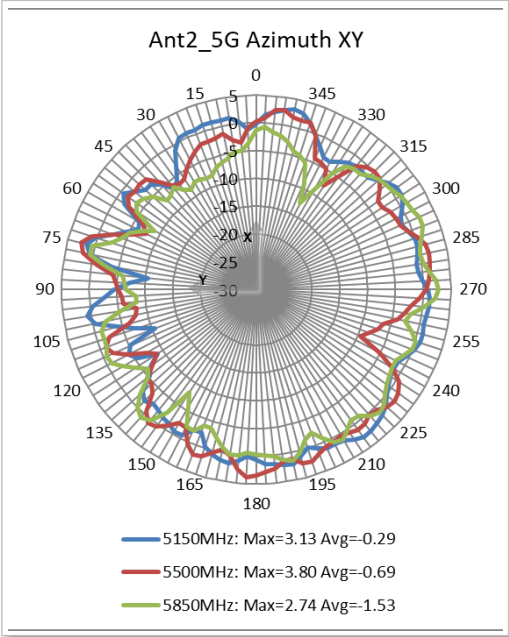
Side to Side (XZ)



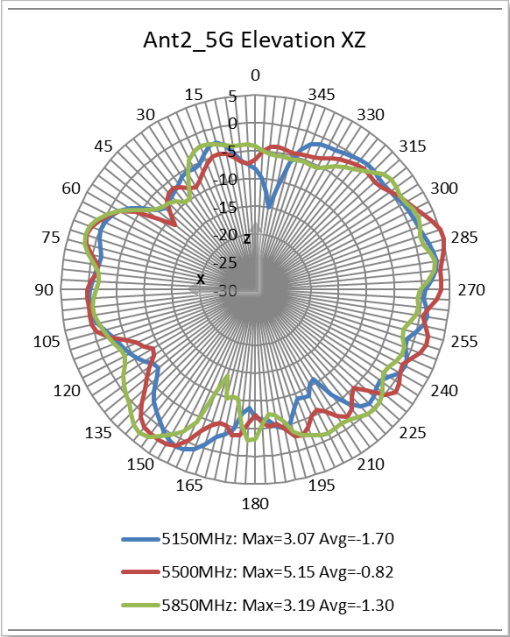
Front to Back (YZ)



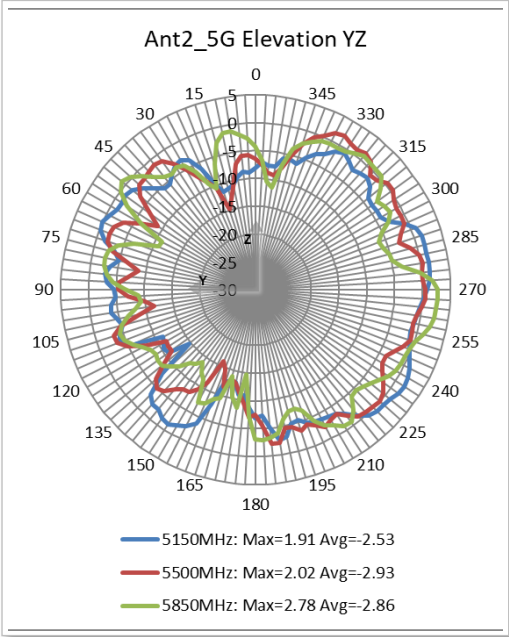
# Radiation Pattern at 5GHz –Ant2



Azimuth (XY)



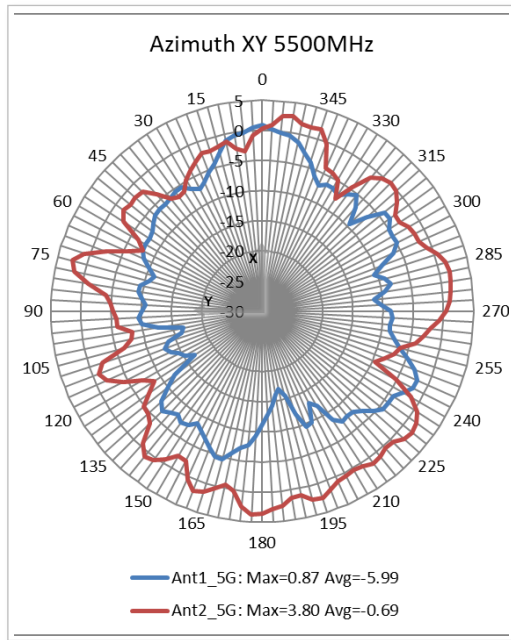
Side to Side (XZ)



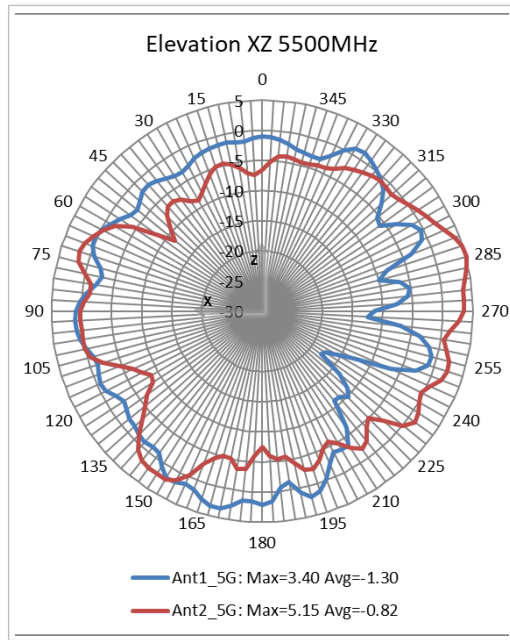
Front to Back (YZ)



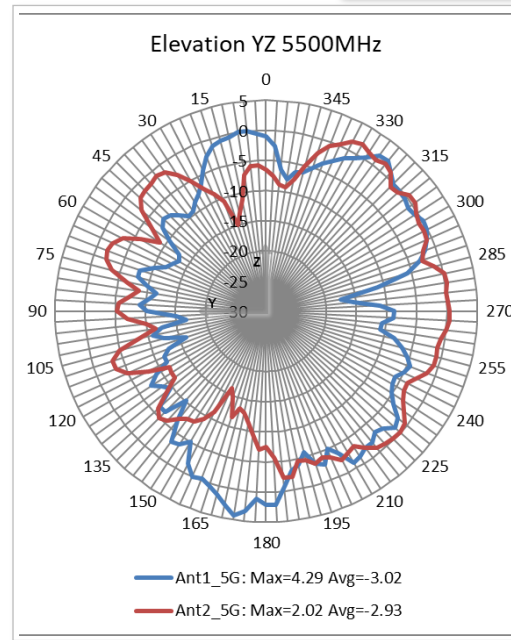
# System Coverage: Radiation Pattern at 5.5GHz



Azimuth (XY)



Side to Side (XZ)

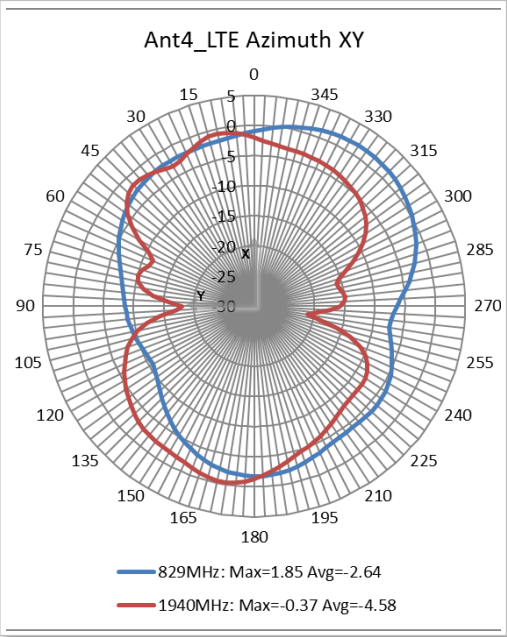


Front to Back (YZ)

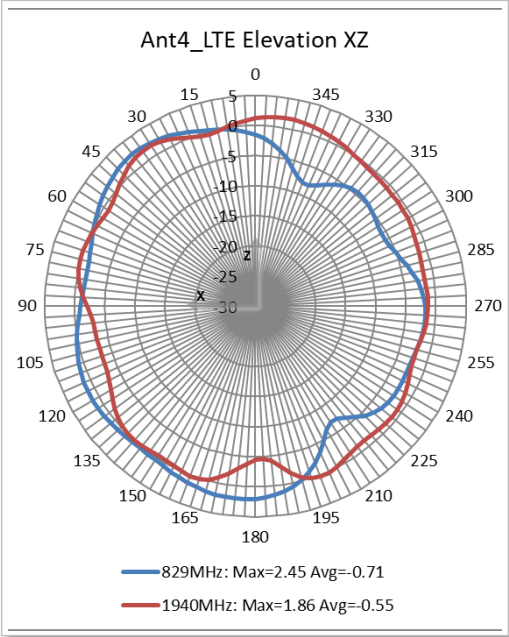
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## Azimuth and Elevation Patterns, and System Coverage LTE plots

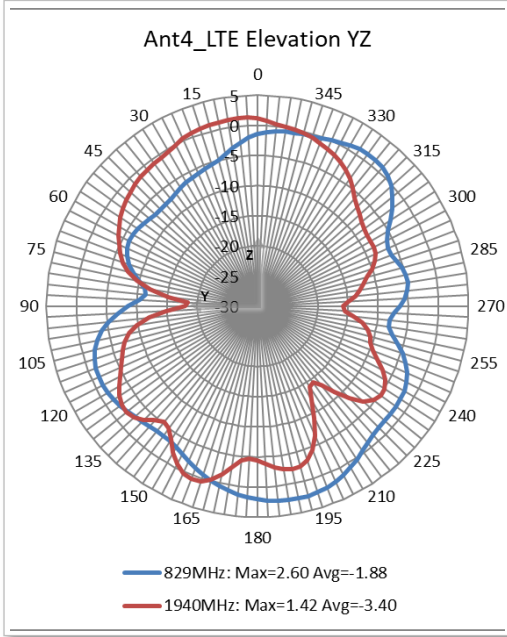
# Radiation Pattern at LTE –Ant4



Azimuth (XY)



Side to Side (XZ)



Front to Back (YZ)

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## 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



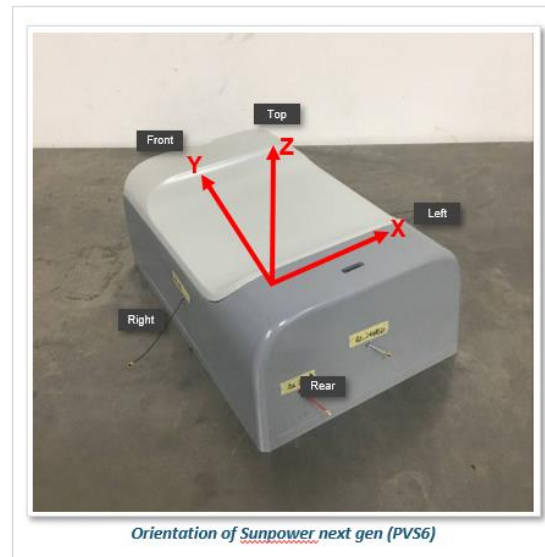
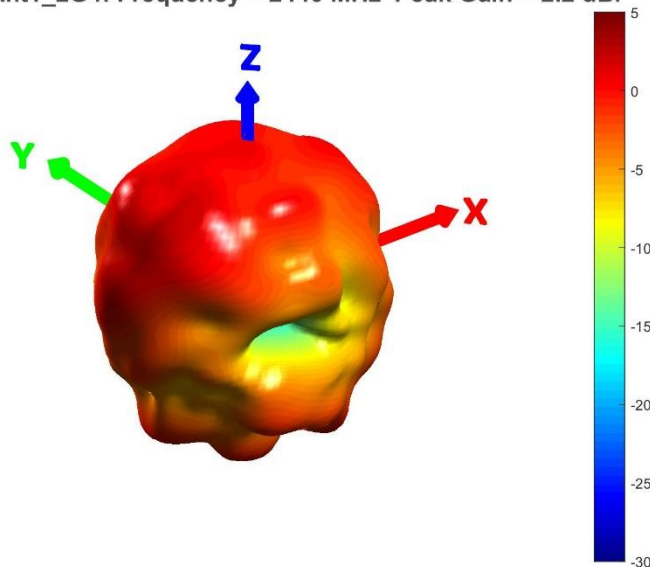
# Appendix

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

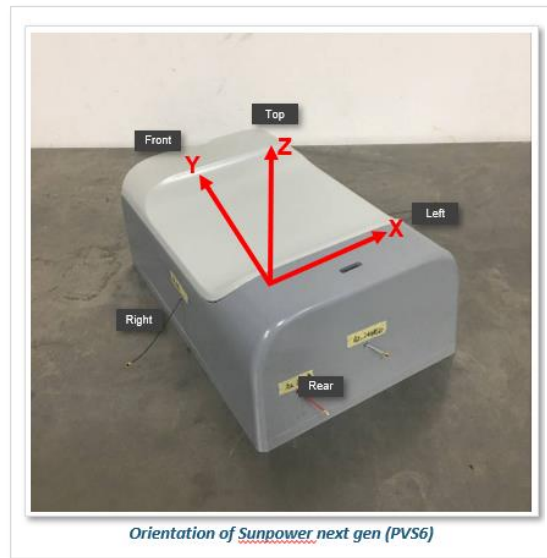
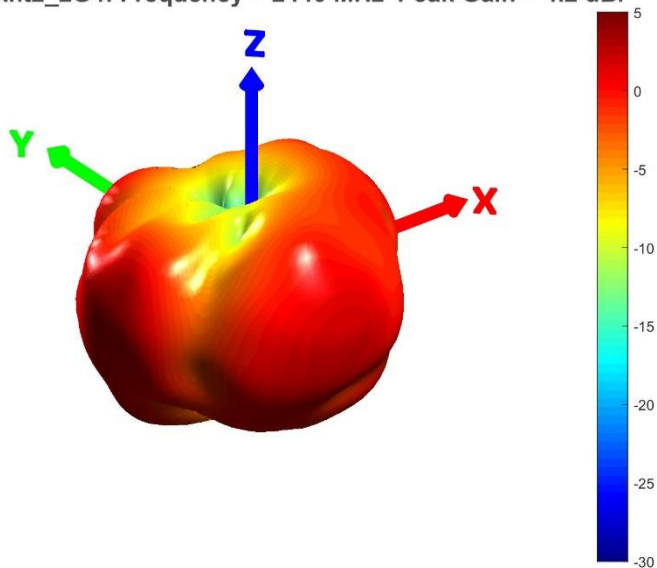
## 3D Antenna Pattern – [Ant1\_2G4 at 2.44GHz]

Sunpower Ant1\_2G4: Frequency = 2440 MHz Peak Gain = 2.2 dBi



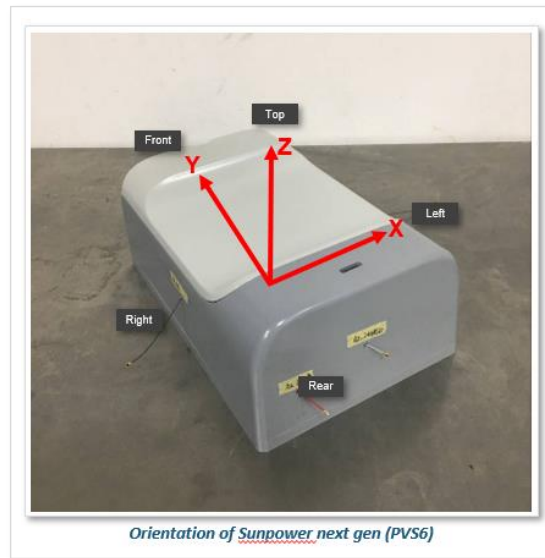
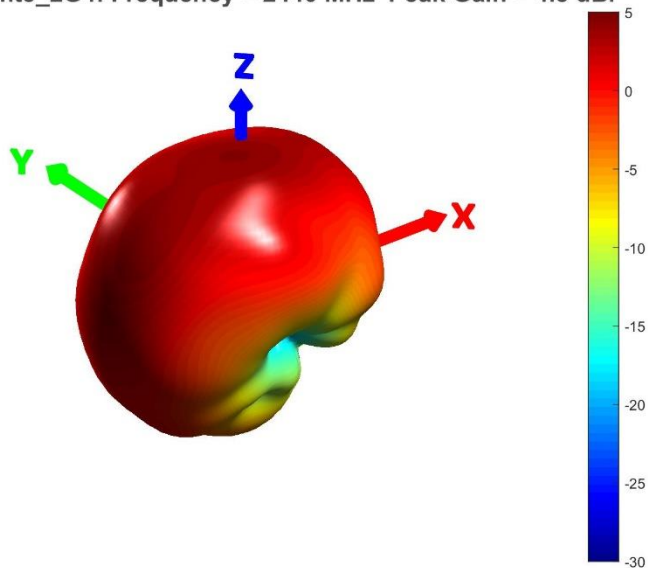
## 3D Antenna Pattern – [Ant2\_2G4 at 2.44GHz]

Sunpower Ant2\_2G4: Frequency = 2440 MHz Peak Gain = 4.2 dBi

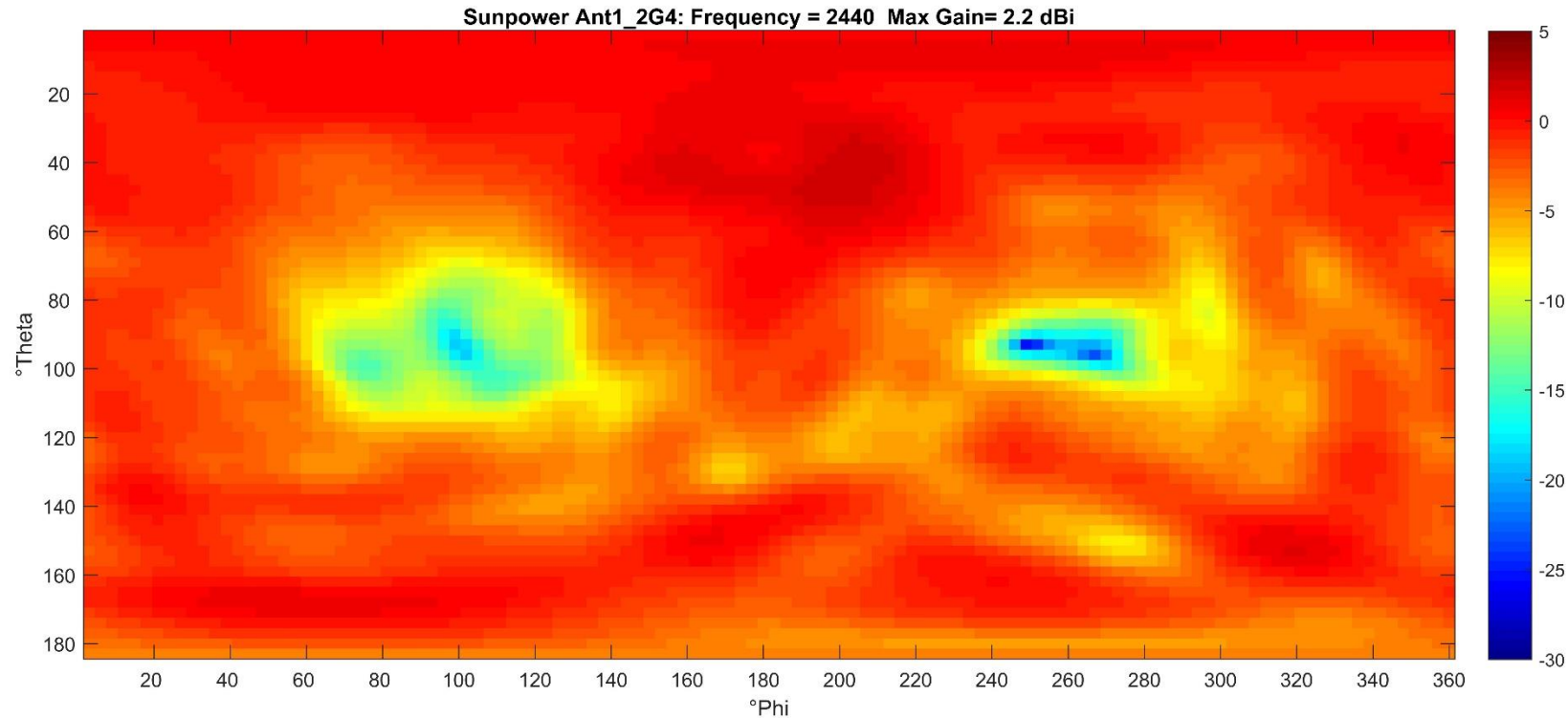


## 3D Antenna Pattern – [Ant3\_2G4 at 2.44GHz]

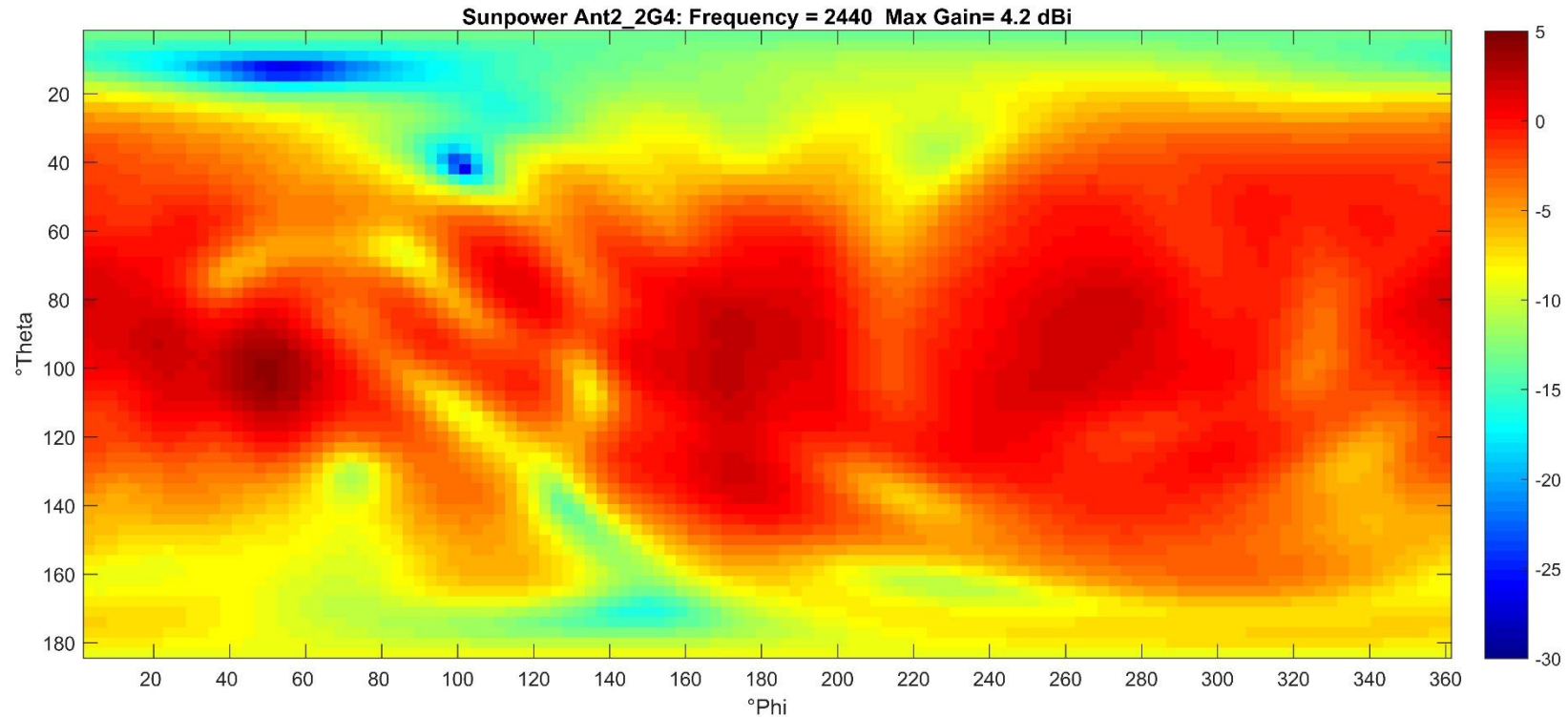
Sunpower Ant3\_2G4: Frequency = 2440 MHz Peak Gain = 4.5 dBi



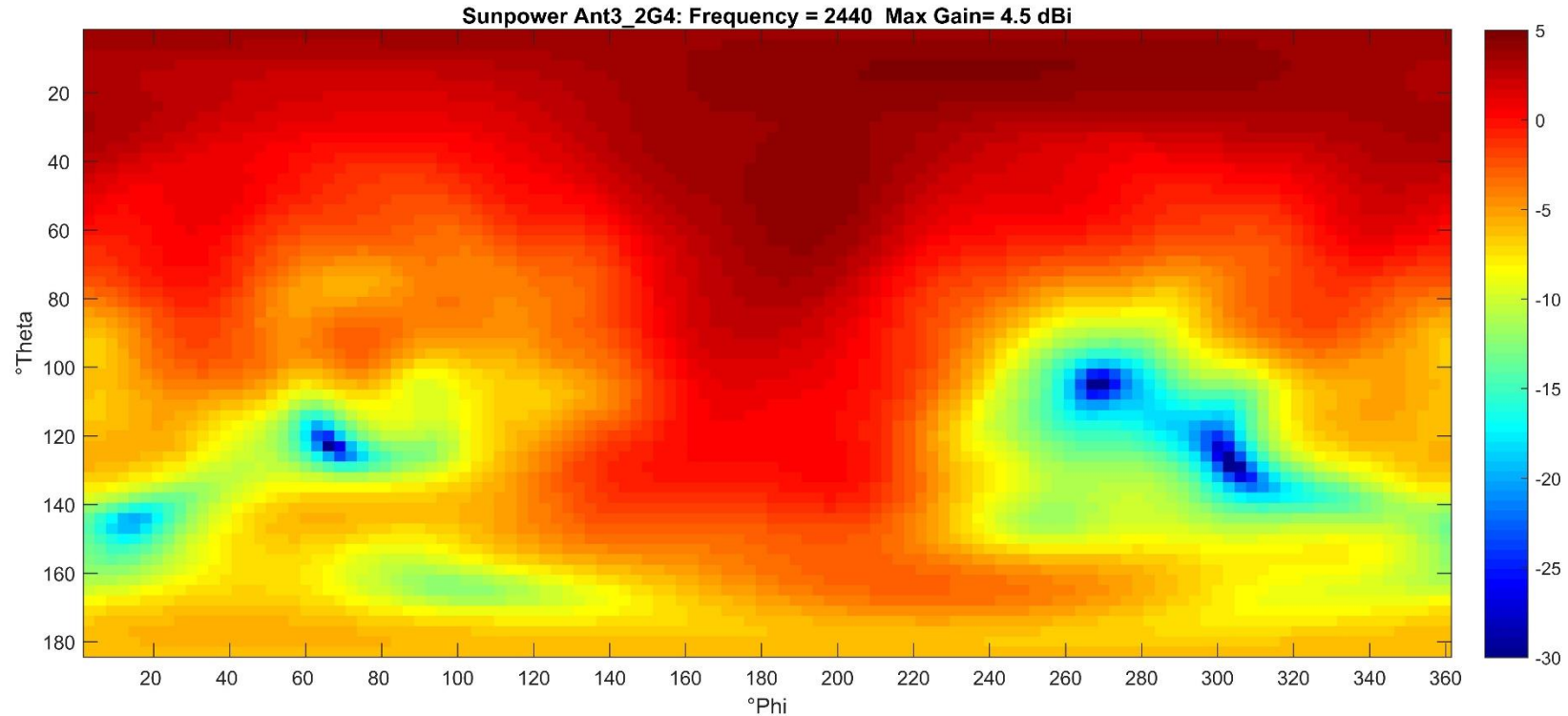
## Heatmaps Antenna Pattern – [Ant1\_2G4 at 2.44GHz]



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

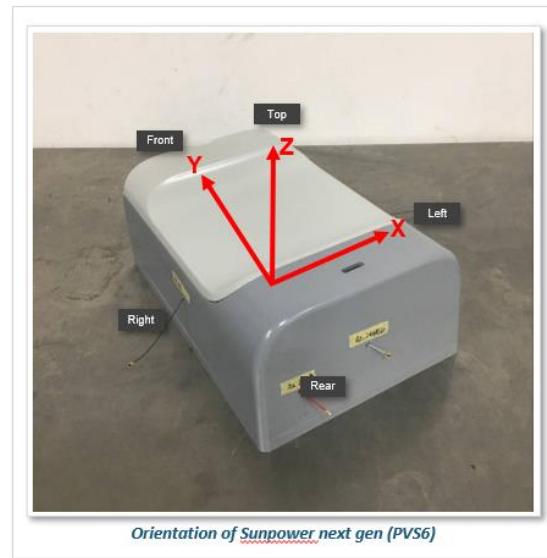
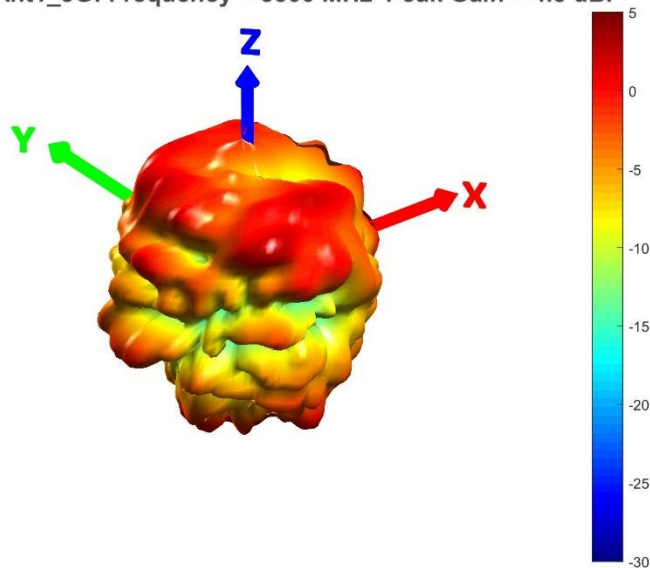


## Heatmaps Antenna Pattern – [Ant3\_2G4 at 2.44GHz]



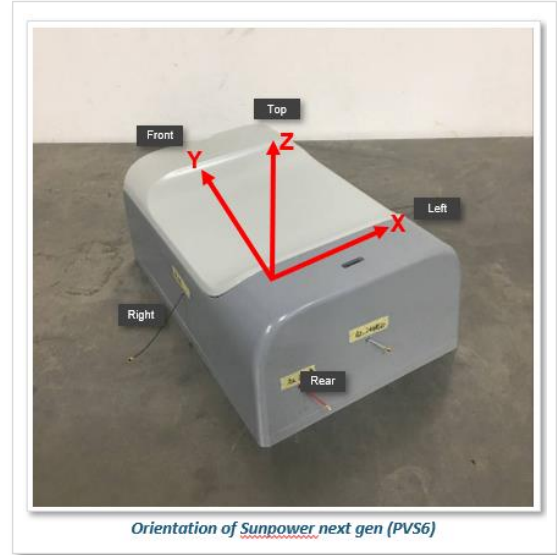
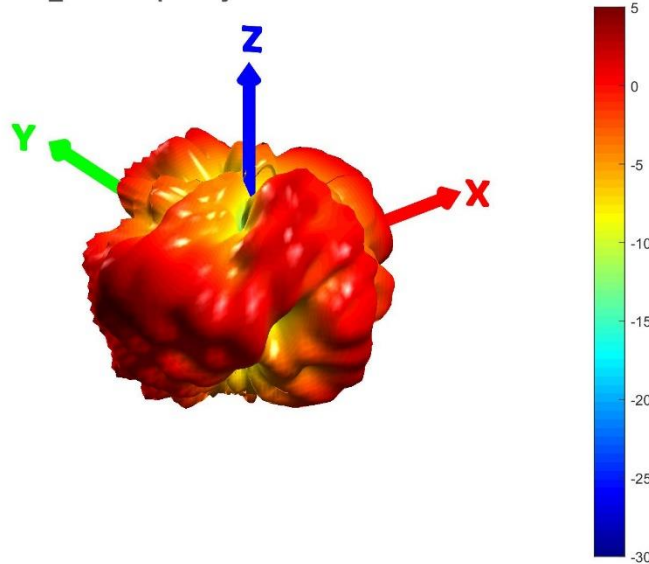
## 3D Antenna Pattern – [Ant1\_5G at 5.5GHz]

Sunpower Ant1\_5G: Frequency = 5500 MHz Peak Gain = 4.5 dBi

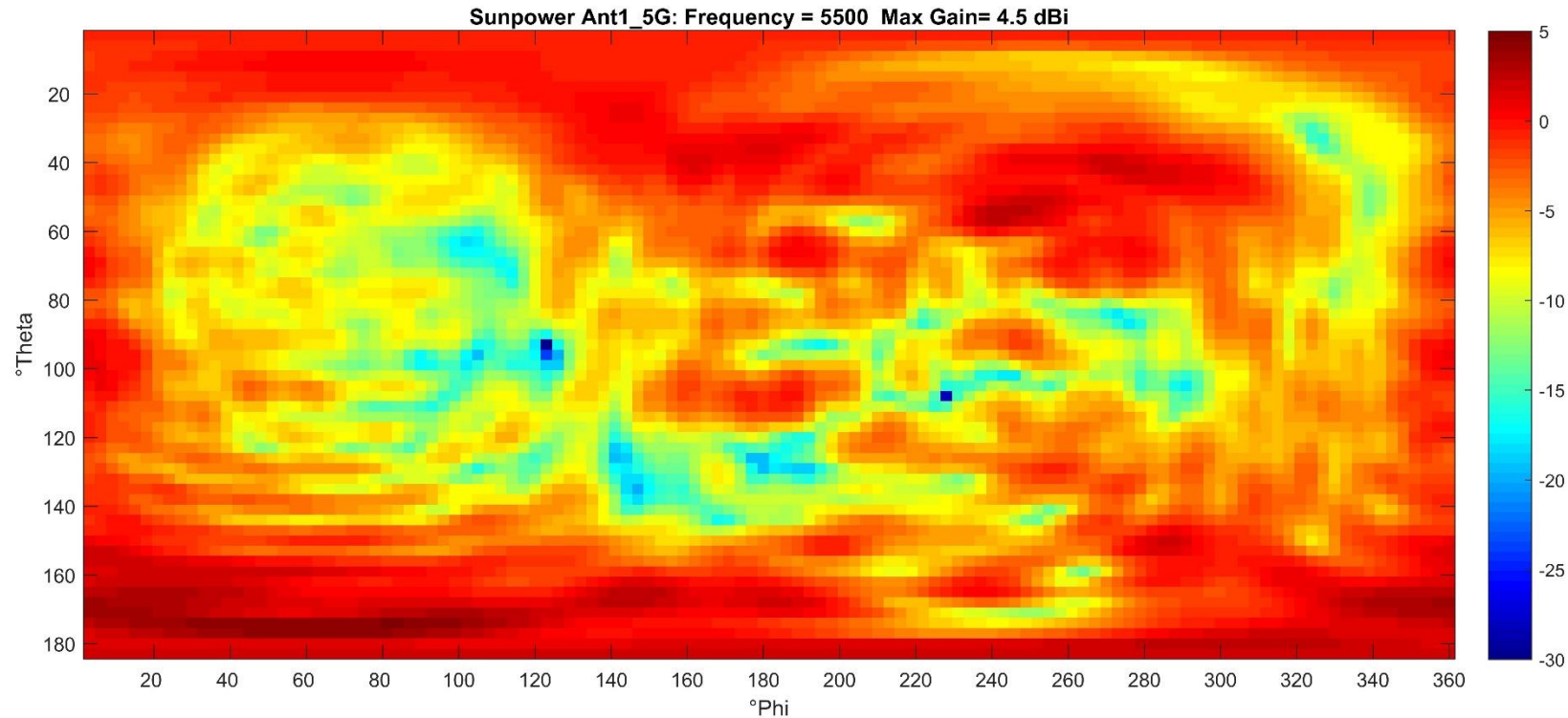


## 3D Antenna Pattern – [Ant2\_5G at 5.5GHz]

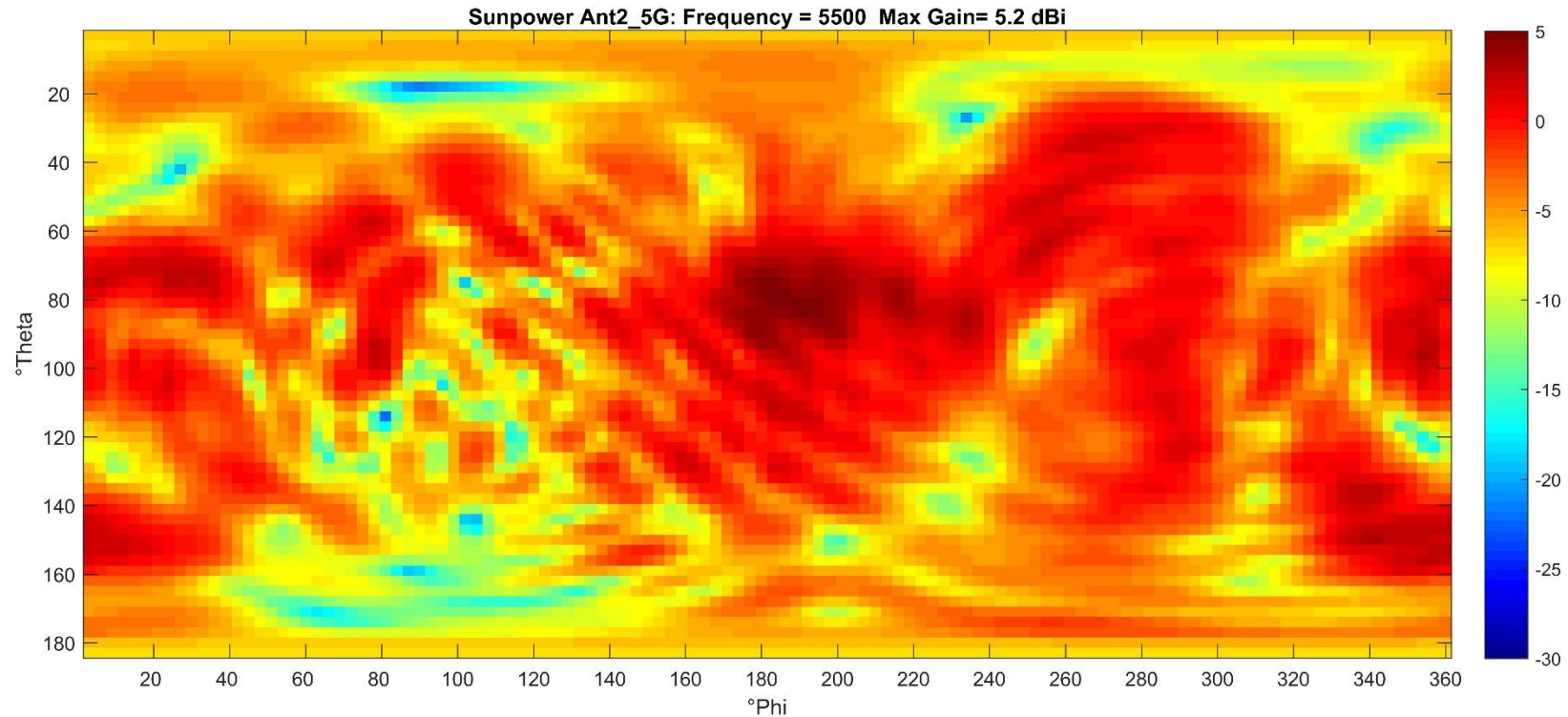
Sunpower Ant2\_5G: Frequency = 5500 MHz Peak Gain = 5.2 dBi



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

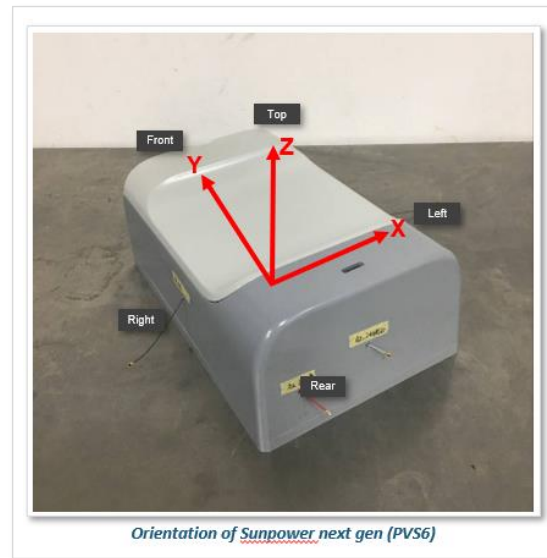
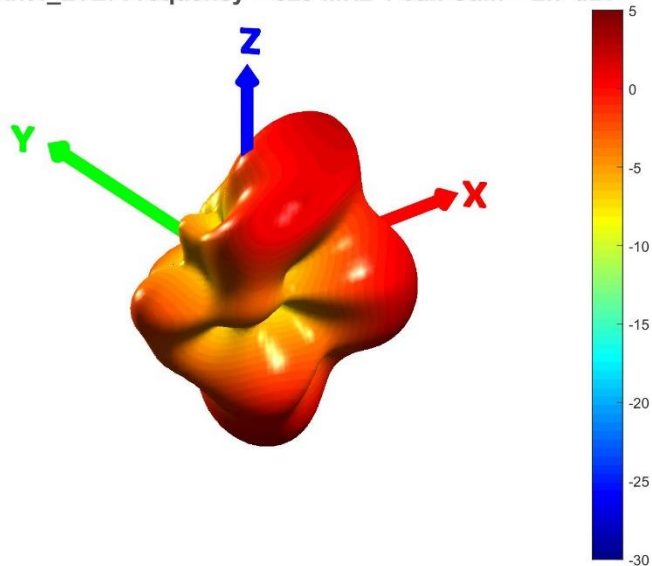


## Heatmaps Antenna Pattern – [Ant2\_5G at 5.5GHz]



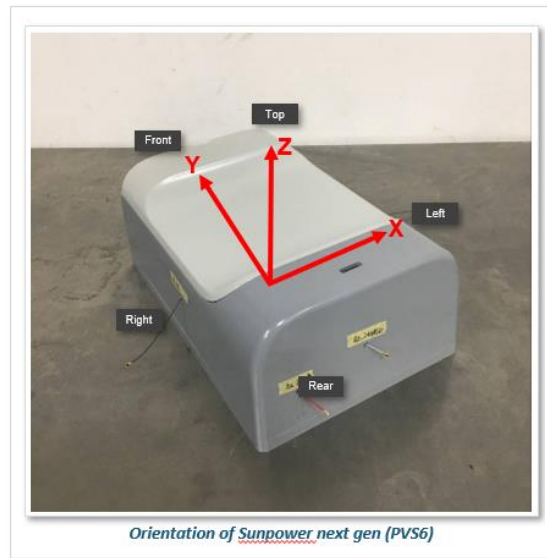
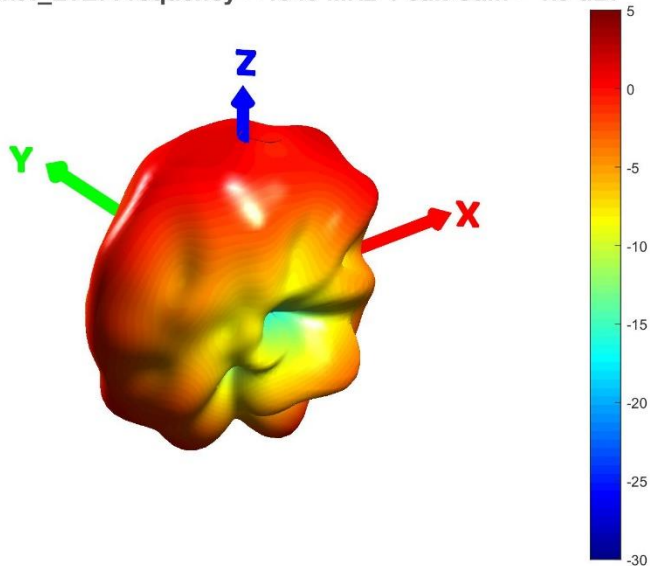
## 3D Antenna Pattern – [Ant4\_LTE at 829MHz]

Sunpower Ant4\_LTE: Frequency = 829 MHz Peak Gain = 2.7 dBi

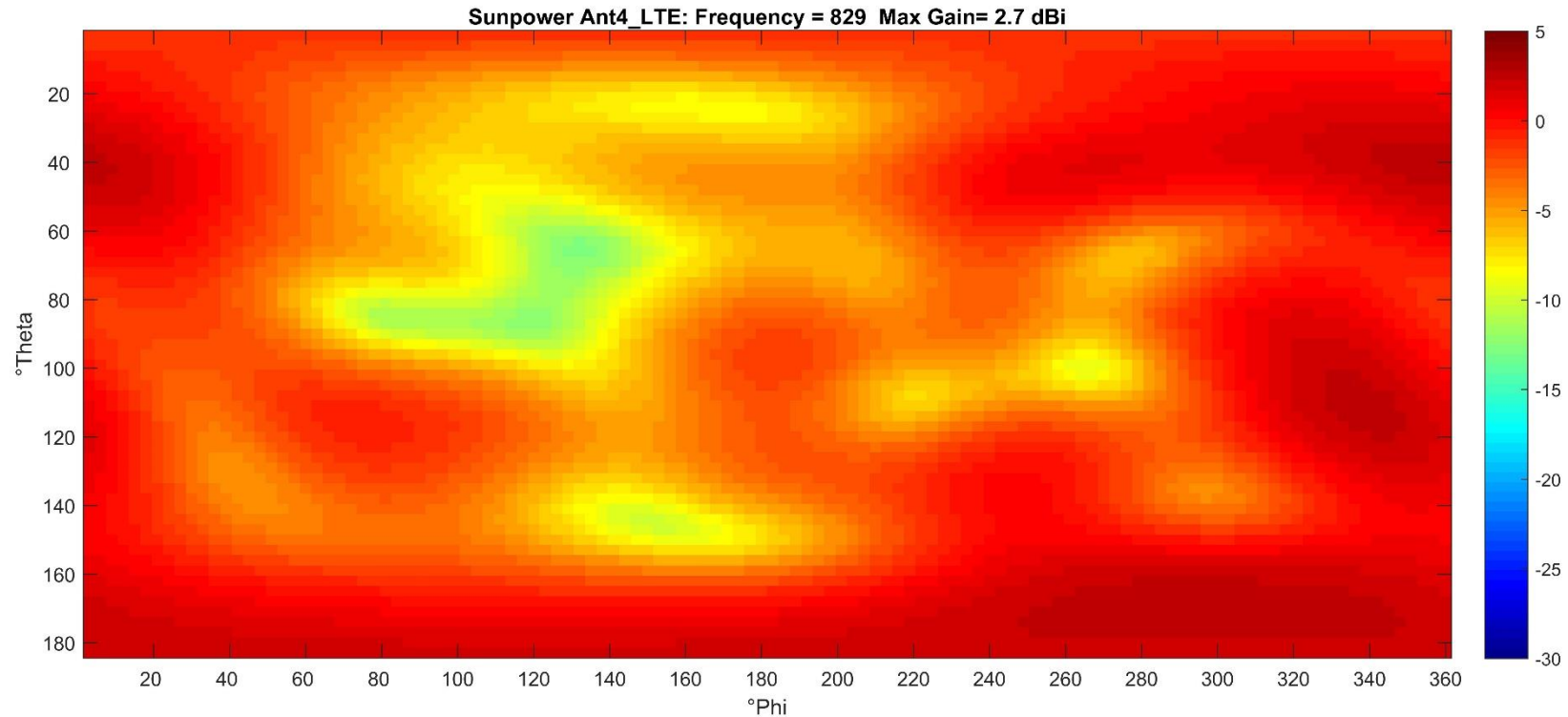


## 3D Antenna Pattern – [Ant4\_LTE at 1940MHz]

Sunpower Ant4\_LTE: Frequency = 1940 MHz Peak Gain = 1.9 dBi



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



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

