Customer Name & Project: Sercomm _IP6846A

Prepared By: Angela

Date: 28th Oct 2022

Airgain Project Code:

Introduction

- Airgain proposes an embedded antenna solution for Sercomm _IP6846A
  - **The antenna solution is updated based upon the latest device provided by Oct 21st, 2022**
    - **Update heat sink and hoder**

DUT Description

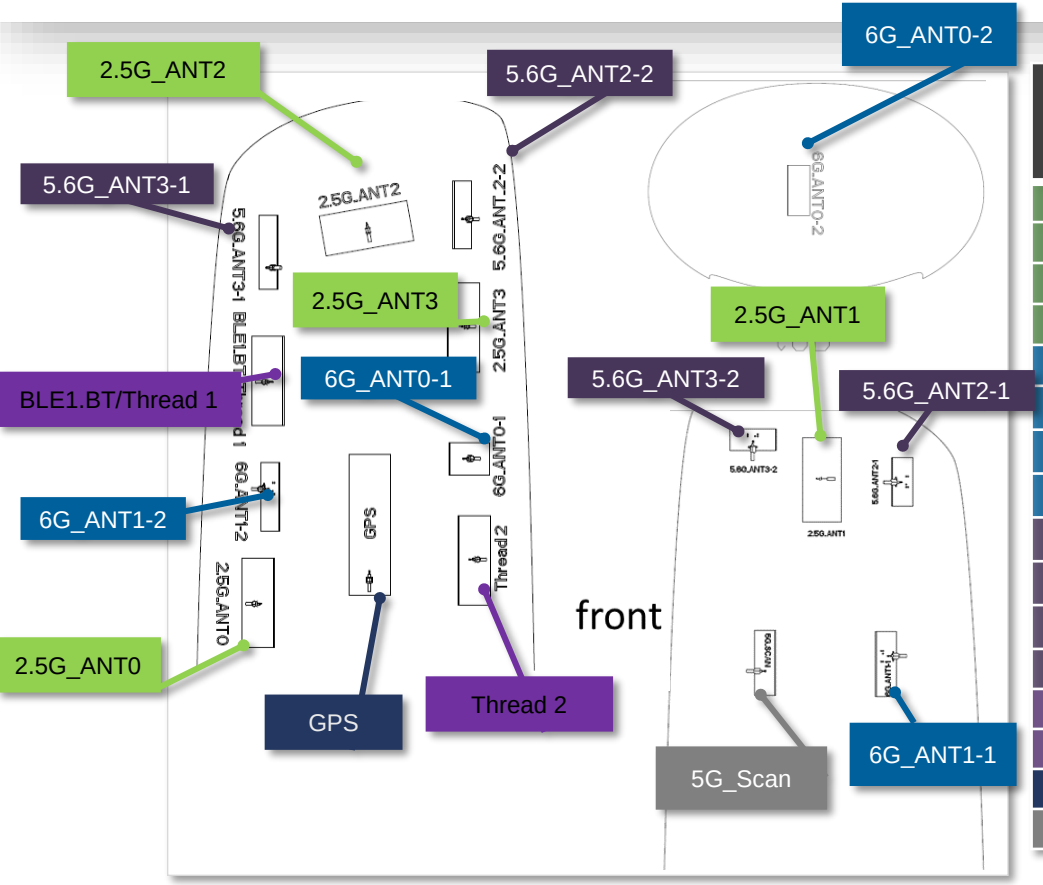
- The solution for this device is as follows:
  - **Cable-fed Antennas:**
    - **4 pcs 2.4G&5G Antennas(2.4GHz-2.49GHz,5.15GHz-5.925GHz)**
    - **4 pcs 6G Antennas(5.925GHz-7.125GHz)**
    - **4 pcs 5G&6G Antennas(5.15GHz-7.125GHz)**
    - **1 pcs 5G Antenna (5.15GHz-5.925GHz)-RX only**
    - **2 pcs BT/Thread Antenna (2.4GHz-2.49GHz)**
    - **1 pcs GPS Antenna (1575.42MHz)**
- The antenna is mounted on the plastic enclosure and connect to the radio through coaxial cable and U.FL. Connector.
- Passive measurement results are presented

Summary of Requirements

- Return Loss :
  All band <-10dB
- Isolation:
  Isolation between antennas <-20dB
- Efficiency:
  WiFi antenna (4 pcs, 2G&5G band) → 2.4G>60%, 5G>60%
  WiFi antenna (4 pcs, 6G band) → 6G>60%
  WiFi antenna (4 pcs, 5G&6G band) → 5G>60% , 6G>60%
  WiFi antenna (1 pcs, 5G band) → 5G>60%
  BT/Thread antenna (2 pcs, 2G4 band) → 2.4G>60%
  GPS antenna (1 pcs, 1575.42MHZ band) → 1575.42MHZ >60%
- Gain:
  All band < 6dBi

Airgain Antenna System Proposal

Antenna System Proposal



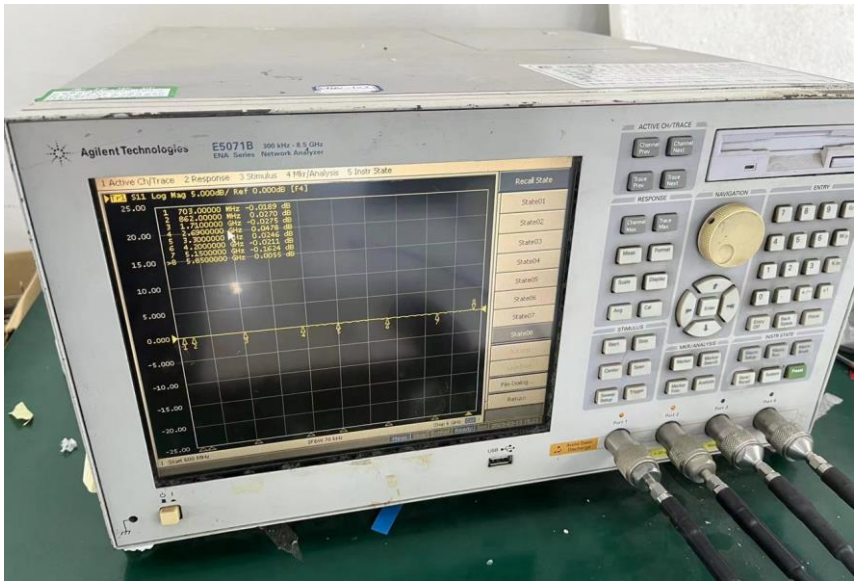
Antenna #	Part Number	Type
2.5G_ANT0	N03SMAGA-PK1-LG203U	FR4, Low Loss Cable fed
2.5G_ANT1	N03SMAGB-PK1-B60U	FR4, Cable fed
2.5G_ANT2	N03SMAGC-PK1-W80U	FR4, Cable fed
2.5G_ANT3	N03SMAGD-PK1-A75U	FR4, Cable fed
6G_ANT0-1	N06SMAGG-PK1-LK165U	FR4, Low Loss Cable fed
6G_ANT0-2	N06SMAGF-PK1-LB257U	FR4, Low Loss Cable fed
6G_ANT1-1	N06SMAGE-PK1-LG215U	FR4, Low Loss Cable fed
6G_ANT1-2	N06SMAGH-PK1-LP250U	FR4, Low Loss Cable fed
5.6G_ANT2-1	N05SMAGJ-PK1-LW160U	FR4, Low Loss Cable fed
5.6G_ANT2-2	N05SMAGK-PK1-LE105U	FR4, Low LossCable fed
5.6G_ANT3-1	N02SMAGT-PK1-R135U	FR4, Cable fed
5.6G_ANT3-2	N05SMAGN-PK1-A130U	FR4, Cable fed
Thread 2	N01SMAGP-PK1-LY195U	FR4, Low Loss Cable fed
BLE1.BT/Thread1	N01SMAGR-PK1-LE200U	FR4, Low Loss Cable fed
GPS	N73SMAGS-PK1-Y135U	FR4, Cable fed
5G_Scan	N05SMAGM-PK1-R150U	FR4, Cable fed

S-Parameters

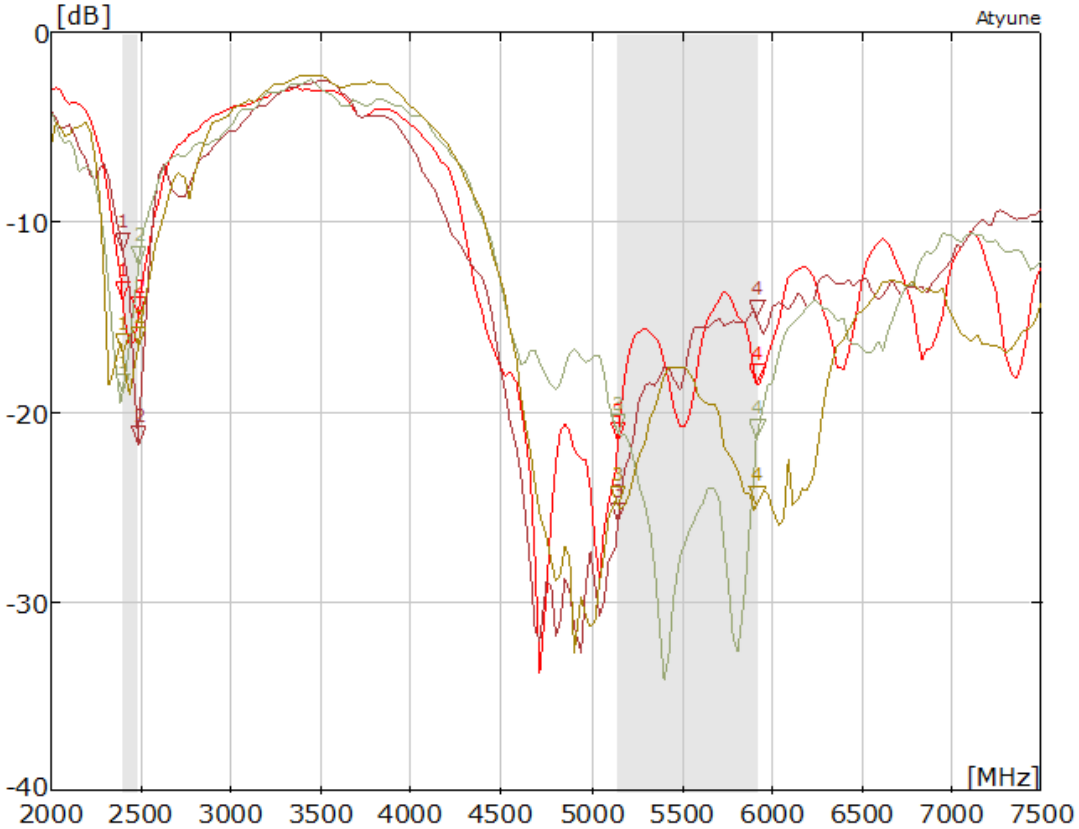
Actual Equipment List and Calibration Information

Vendor	Model	Calibrated Date	Calibrated Until
Agilent Technologies	E5071B	2022/8/26	2023/8/25

Test personnel	Test date
Angela	2022/10/08

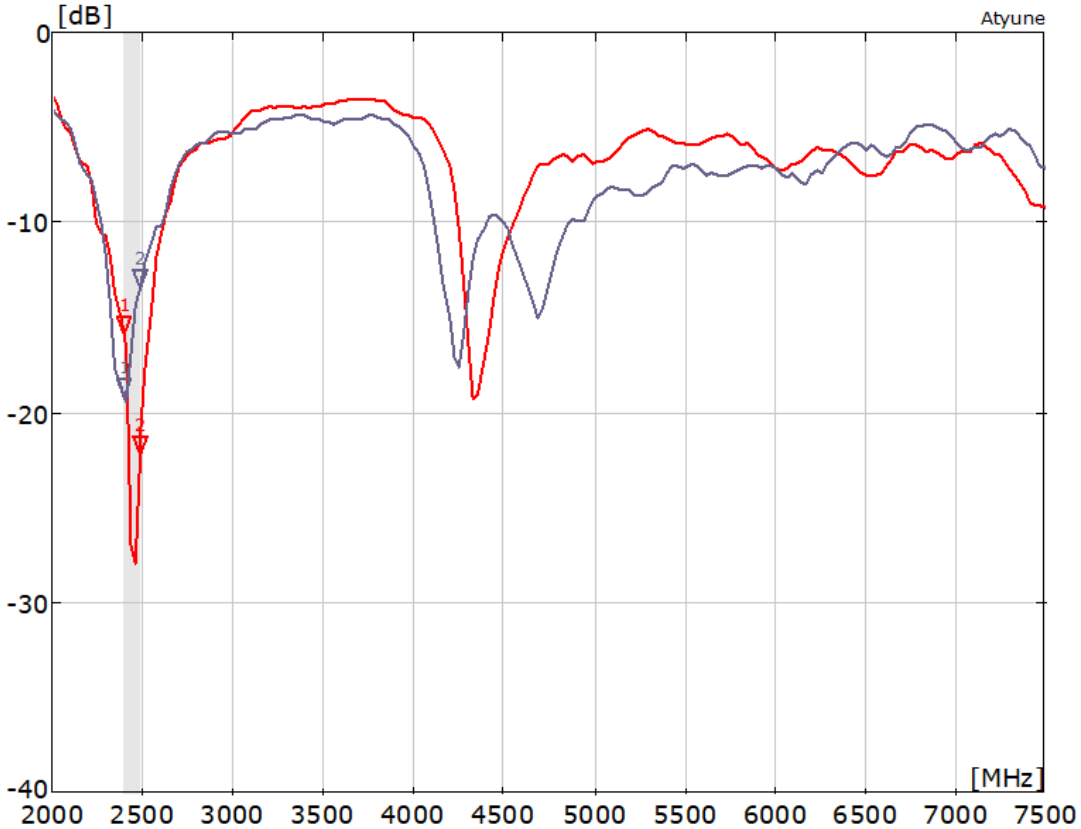


S-Parameter – Return Loss for 2G&5G Antennas



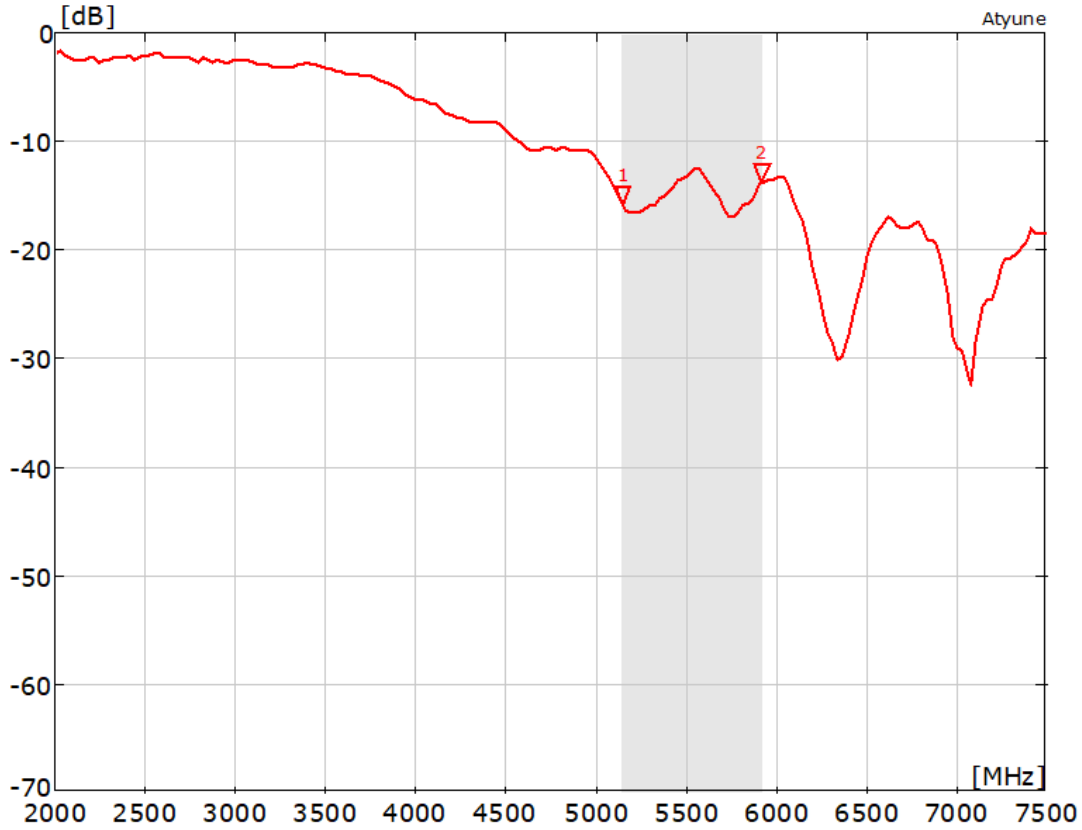
MARKERS:	MHz	dB	MHz	dB
2.5G_A0				
	1: 2400	-14.01	3: 5150	-21.38
	2: 2490	-14.87	4: 5925	-18.38
2.5G_A1				
	1: 2400	-11.45	3: 5150	-25.70
	2: 2490	-21.61	4: 5925	-14.99
2.5G_A2				
	1: 2400	-18.86	3: 5150	-21.06
	2: 2490	-12.19	4: 5925	-21.27
2.5G_A3				
	1: 2400	-16.83	3: 5150	-24.76
	2: 2490	-16.41	4: 5925	-24.75

S-Parameter – Return Loss for BT/Thread Antennas



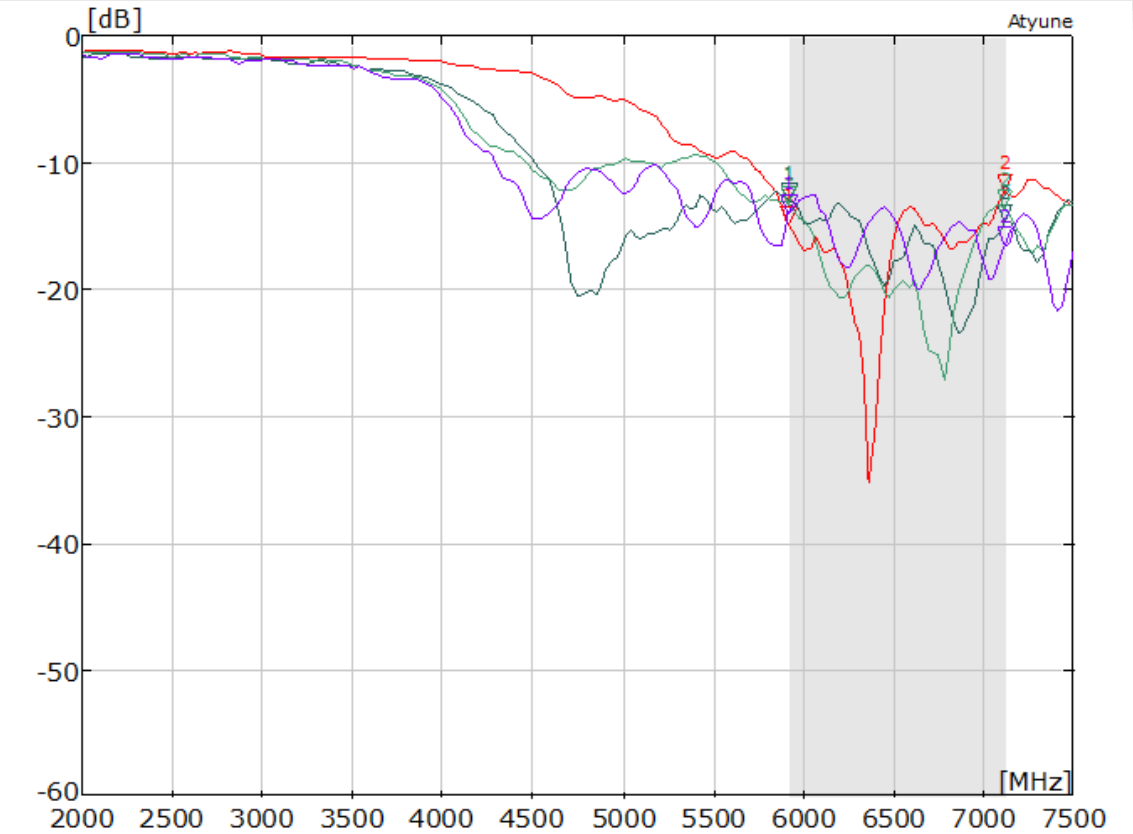
MARKERS:	MHz	dB
BLE_A1		
	1: 2400	-15.86
	2: 2490	-22.10
BLE_A2		
	1: 2400	-19.15
	2: 2490	-13.38

S-Parameter – Return Loss for 5G Antennas



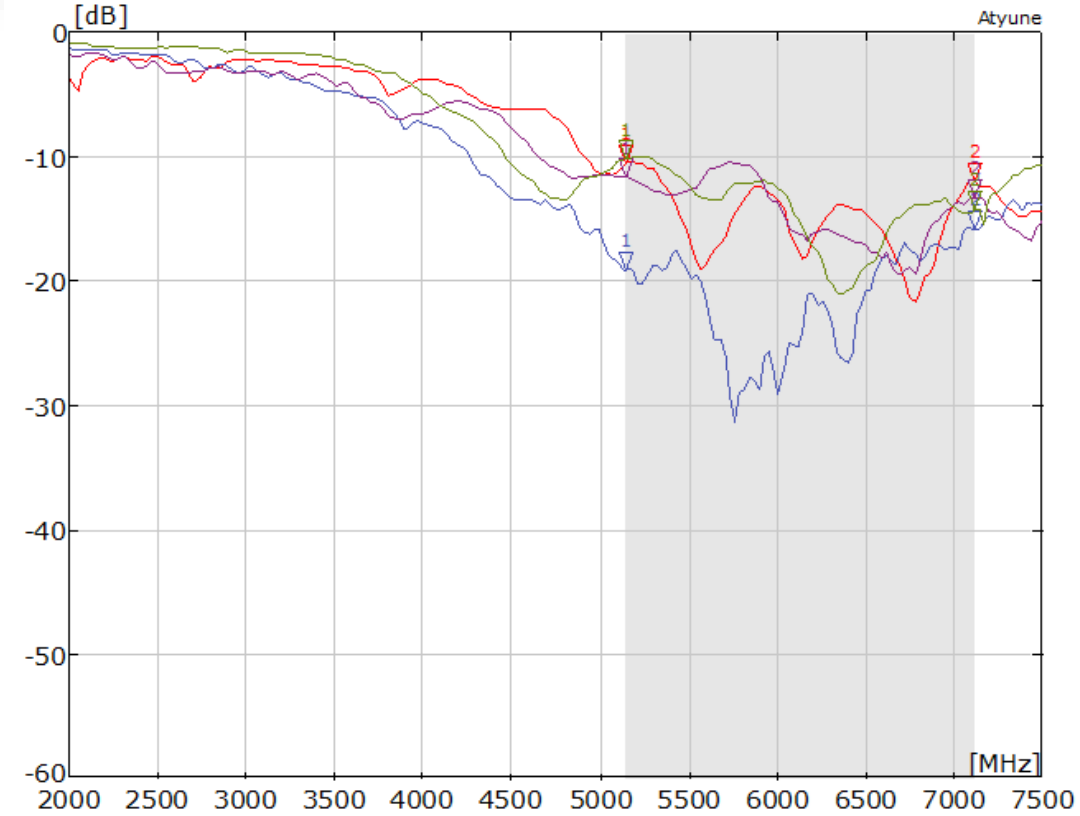
MARKERS:	MHz	dB
5G.Scan		
	1: 5150	-15.86
	2: 5925	-13.67

S-Parameter – Return Loss for 6G Antennas



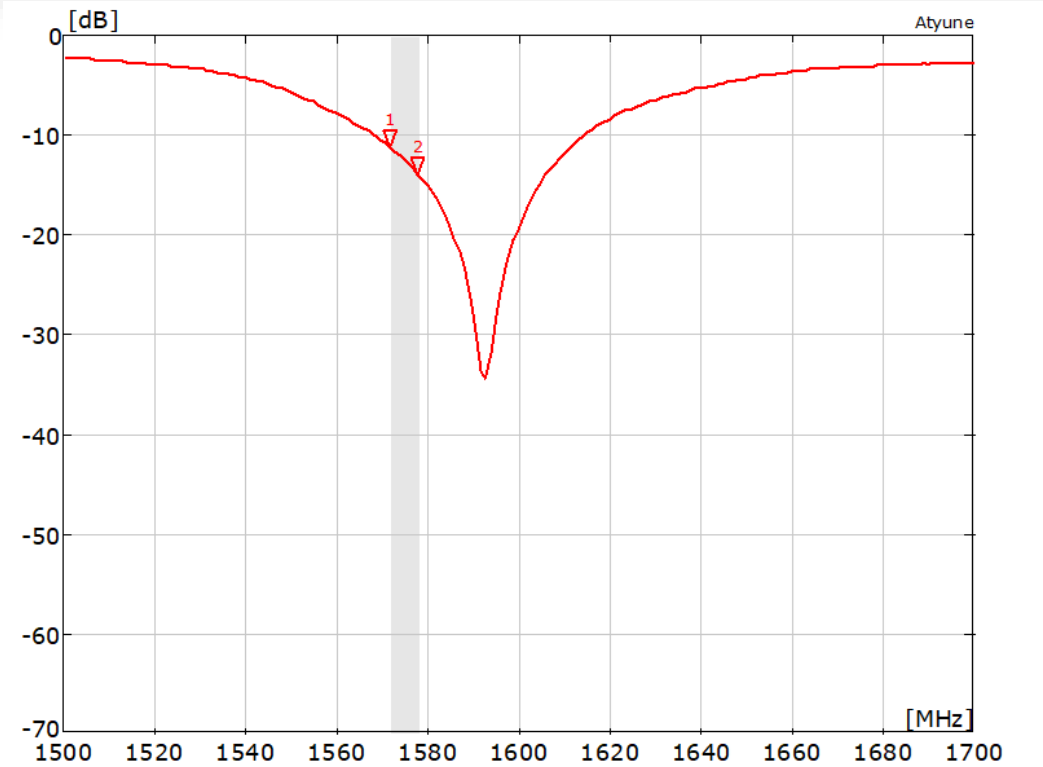
MARKERS:	MHz	dB
6G_A0-1		
	1: 5925	-14.86
	2: 7125	-12.35
6G_A0-2		
	1: 5925	-12.92
	2: 7125	-14.72
6G_A1-1		
	1: 5925	-13.15
	2: 7125	-13.51
6G_A1-2		
	1: 5925	-13.99
	2: 7125	-16.46

S-Parameter – Return Loss for 5G&6G Antennas



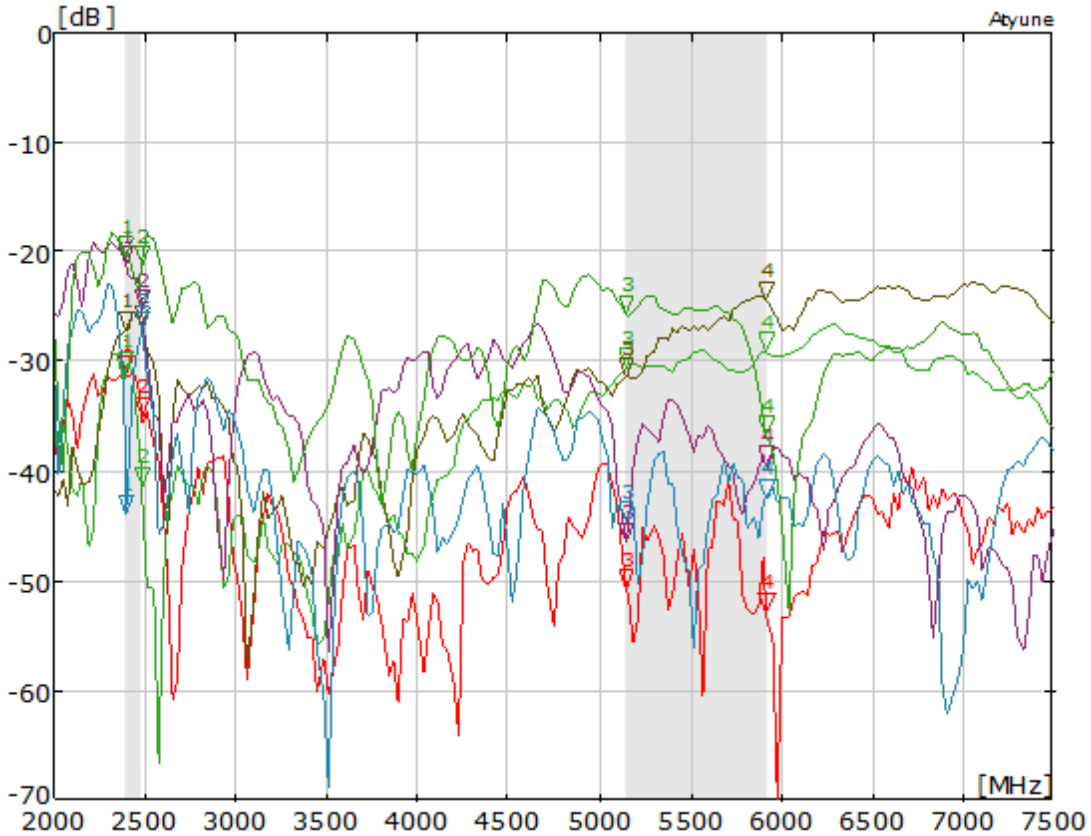
MARKERS:	MHz	dB
5.6G_A2-1		
	1: 5150	-10.45
	2: 7125	-11.97
5.6G_A2-2		
	1: 5150	-18.92
	2: 7125	-15.80
5.6G_A3-1		
	1: 5150	-11.57
	2: 7125	-13.12
5.6G_A3-2		
	1: 5150	-10.08
	2: 7125	-14.18

S-Parameter – Return Loss for GPS Antenna



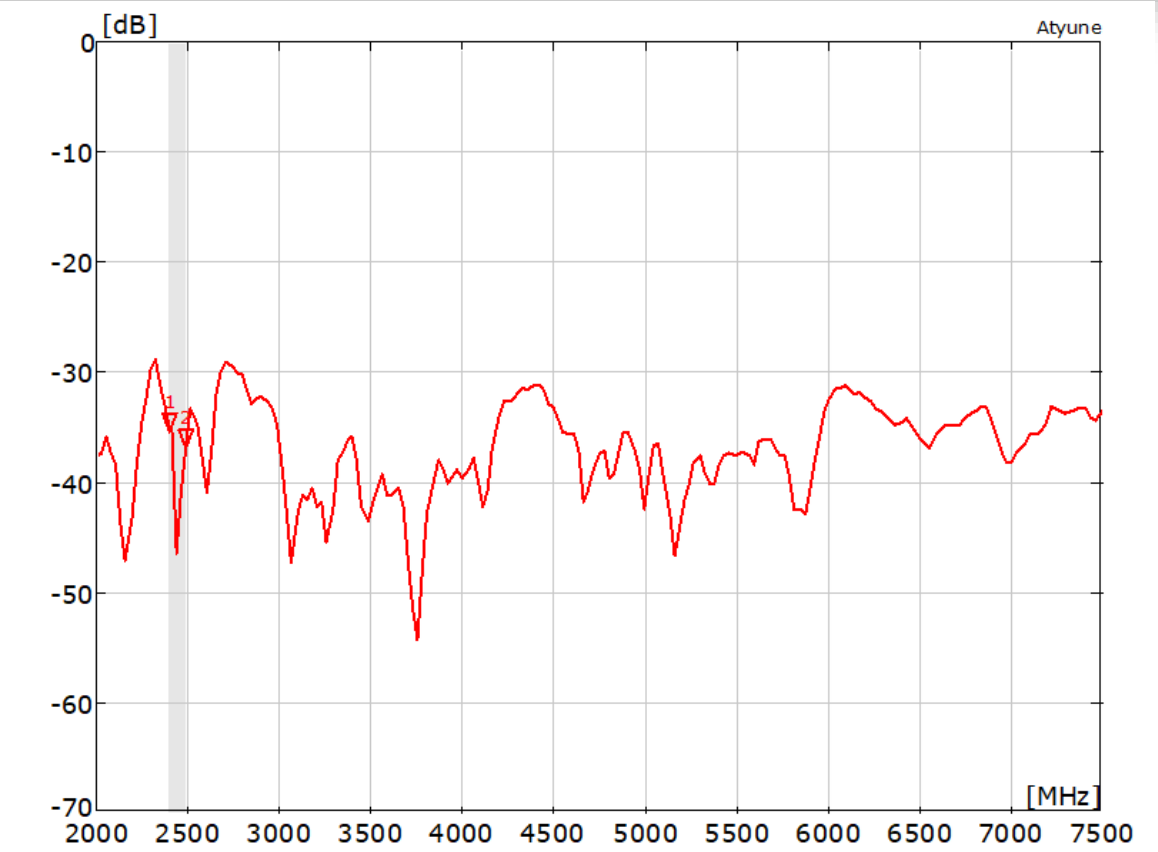
MARKERS:	MHz	dB
GPS		
	1: 1572	-11.19
	2: 1578	-13.81

S-Parameter – Isolation for 2G&5G Antennas



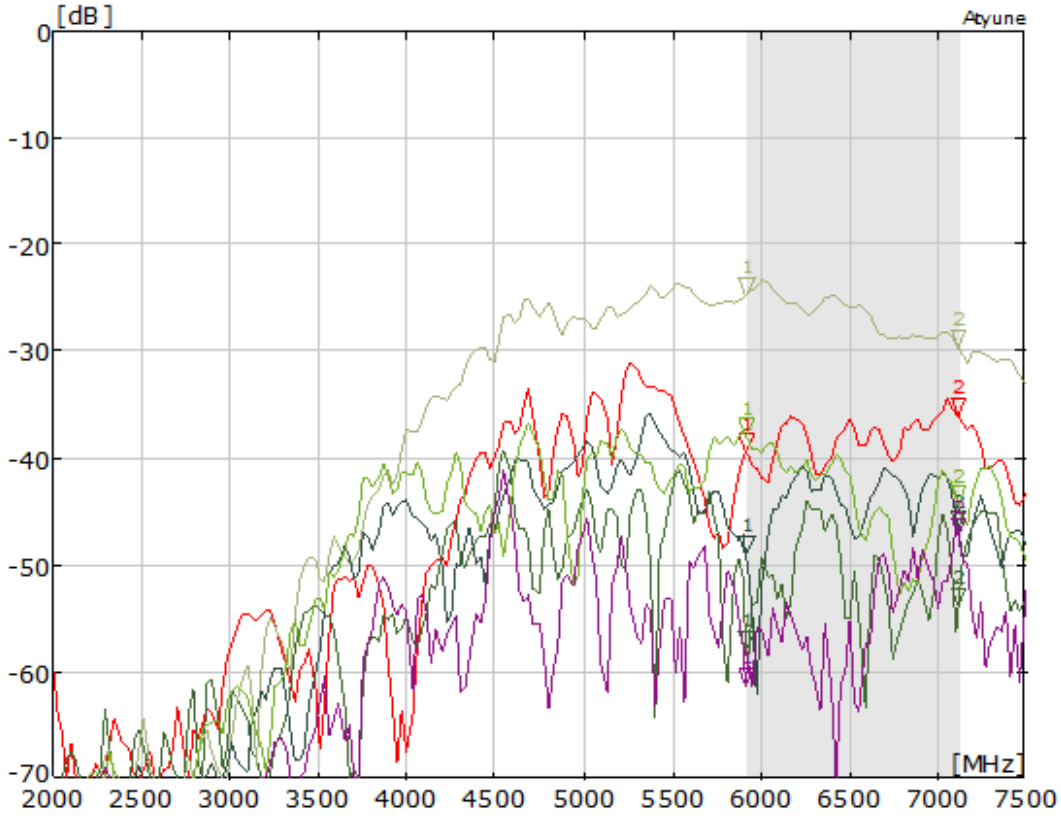
MARKERS:	MHz	dB	MHz	dB
2.5G_A0-2.5G_A1				
	1: 2400	-31.07	3: 5150	-50.53
	2: 2490	-35.00	4: 5925	-52.71
2.5G_A0-2.5G_A2				
	1: 2400	-30.56	3: 5150	-30.50
	2: 2490	-41.24	4: 5925	-29.02
2.5G_A0-2.5G_A3				
	1: 2400	-27.10	3: 5150	-31.31
	2: 2490	-26.55	4: 5925	-24.29
2.5G_A1-2.5G_A2				
	1: 2400	-21.04	3: 5150	-46.34
	2: 2490	-25.21	4: 5925	-39.31
2.5G_A1-2.5G_A3				
	1: 2400	-43.75	3: 5150	-44.53
	2: 2490	-27.12	4: 5925	-42.26
2.5G_A3-2.5G_A2				
	1: 2400	-20.16	3: 5150	-25.64
	2: 2490	-21.10	4: 5925	-36.60

S-Parameter – Isolation for BT/Thread Antennas



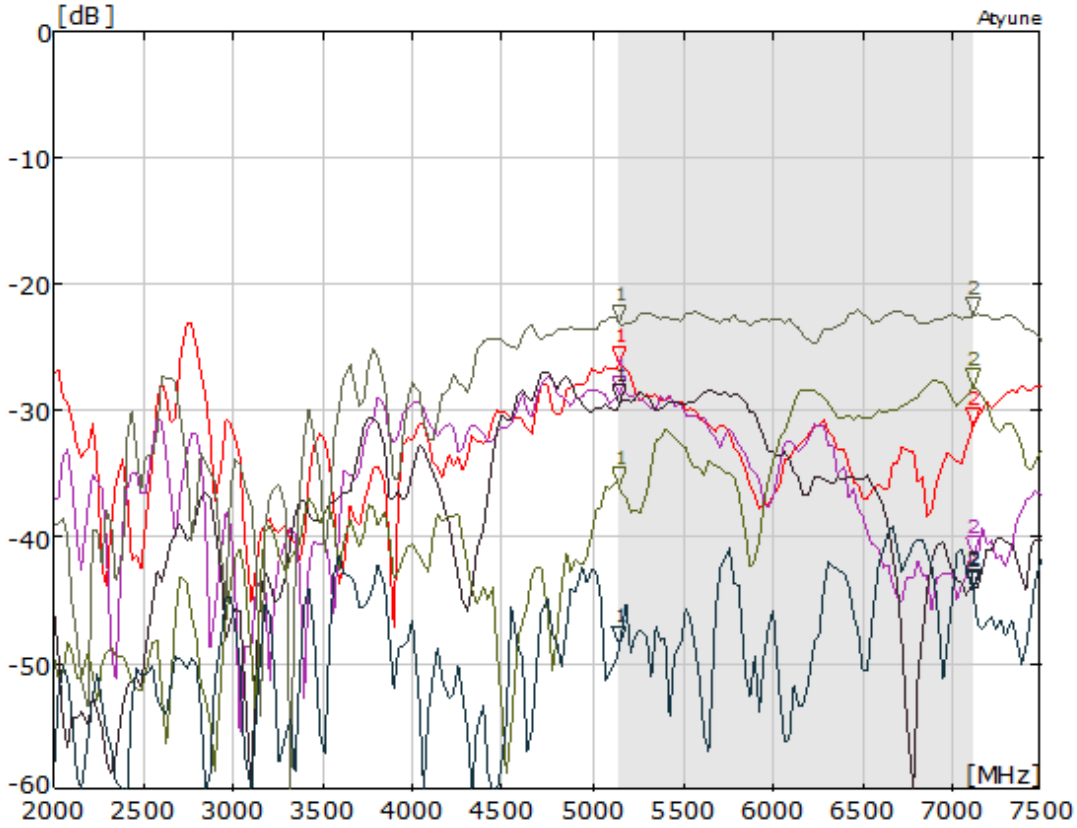
MARKERS:	MHz	dB
BLE_A1-BLE_A2		
	1: 2400	-35.39
	2: 2490	-36.79

S-Parameter – Isolation for 6G Antennas



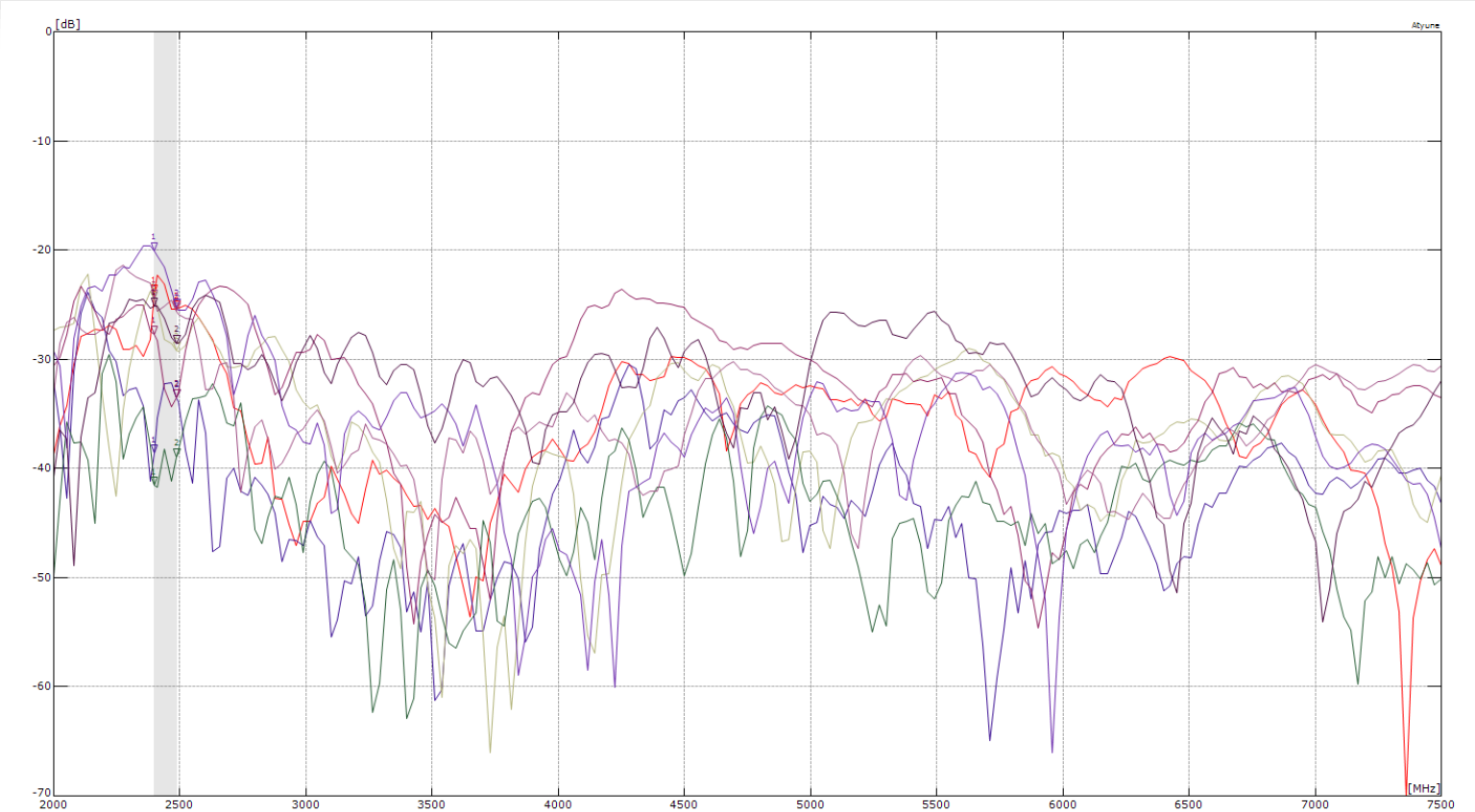
MARKERS:	MHz	dB
6G_A0-1-6G_A0-2		
	1: 5925	-39.38
	2: 7125	-36.03
6G_A0-1-6G_A1-1		
	1: 5925	-57.73
	2: 7125	-53.80
6G_A0-1-6G_A1-2		
	1: 5925	-24.62
	2: 7125	-29.57
6G_A0-2-6G_A1-1		
	1: 5925	-48.95
	2: 7125	-46.47
6G_A0-2-6G_A1-2		
	1: 5925	-37.92
	2: 7125	-44.21
6G_A1-1-6G_A1-2		
	1: 5925	-61.23
	2: 7125	-47.10

S-Parameter – Isolation for 5G6G Antennas

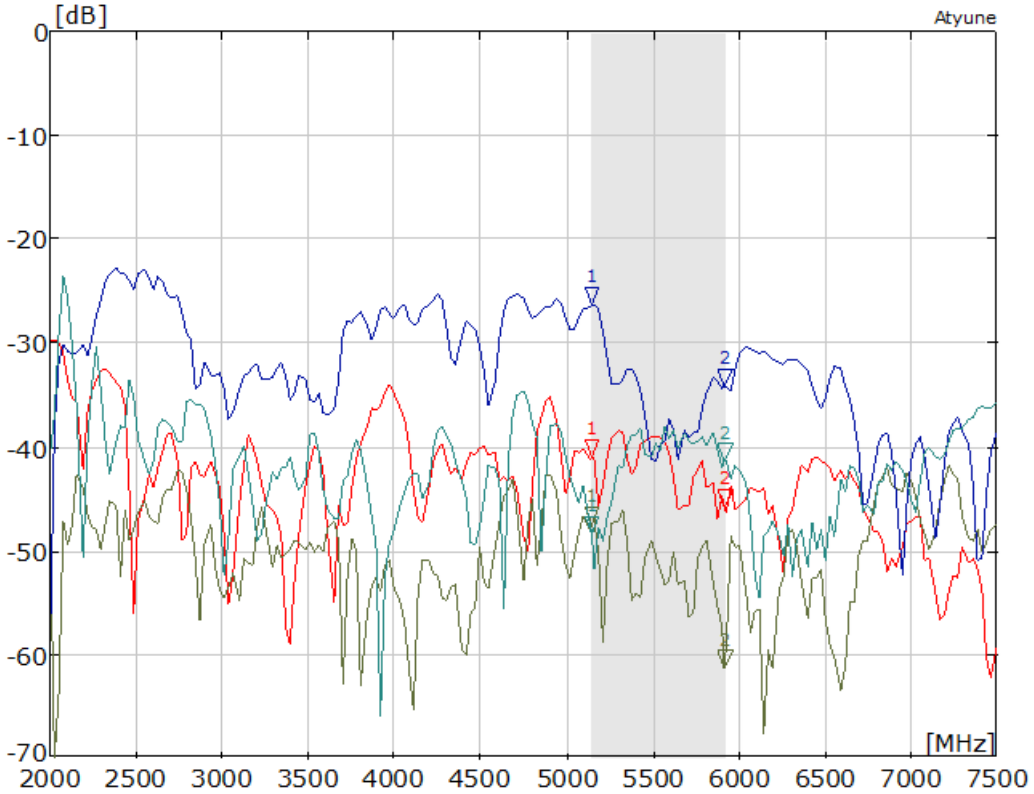


MARKERS:	MHz	dB
5.6G_A2-1-5.6G_A2-2		
	1: 5150	-26.35
	2: 7125	-31.24
5.6G_A2-1-5.6G_A3-1		
	1: 5150	-28.72
	2: 7125	-41.39
5.6G_A2-1-5.6G_A3-2		
	1: 5150	-29.45
	2: 7125	-43.90
5.6G_A2-2-5.6G_A3-1		
	1: 5150	-22.99
	2: 7125	-22.47
5.6G_A2-2-5.6G_A3-2		
	1: 5150	-35.95
	2: 7125	-28.12
5.6G_A3-1-5.6G_A3-2		
	1: 5150	-48.42
	2: 7125	-44.05

S-Parameter – Isolation for Dual band Antennas& BT/Thread Antennas

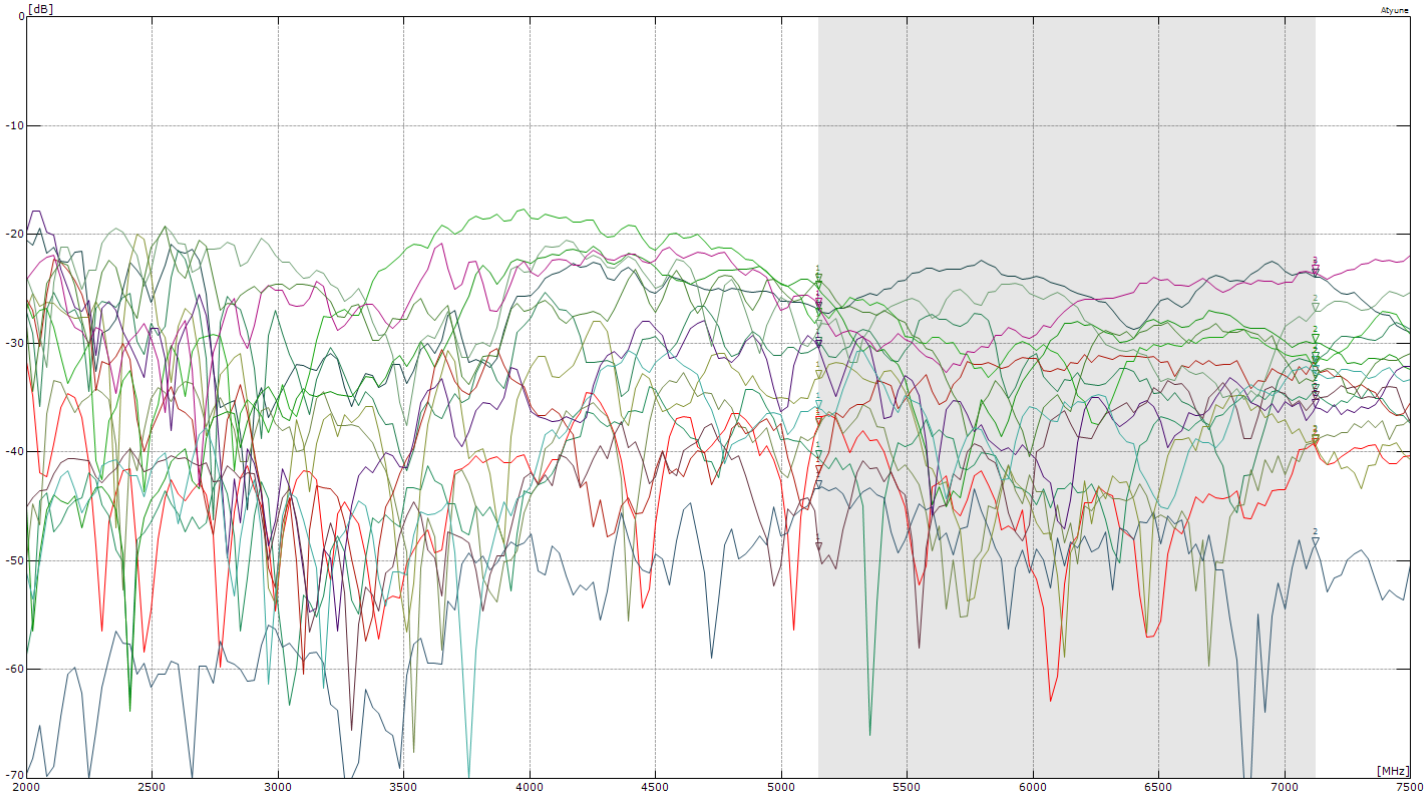


S-Parameter – Isolation for Dual band Antennas &5G Antennas

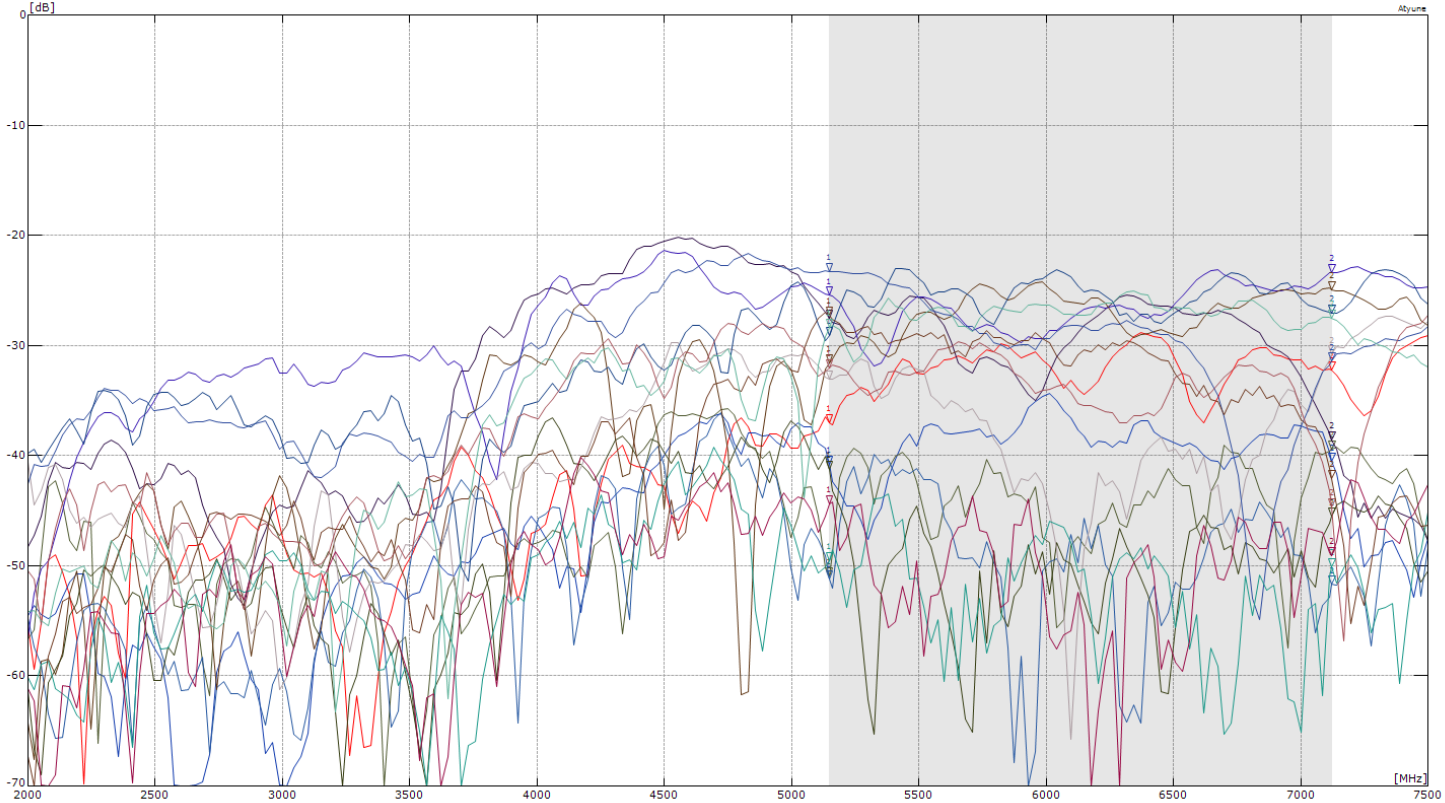


MARKERS:	MHz	dB
2.5G_A2-5G.Scan		
	1: 5150	-40.80
	2: 5925	-45.78
2.5G_A0-5G.Scan		
	1: 5150	-47.44
	2: 5925	-61.12
2.5G_A1-5G.Scan		
	1: 5150	-26.25
	2: 5925	-34.06
2.5G_A3-5G.Scan		
	1: 5150	-48.32
	2: 5925	-41.28

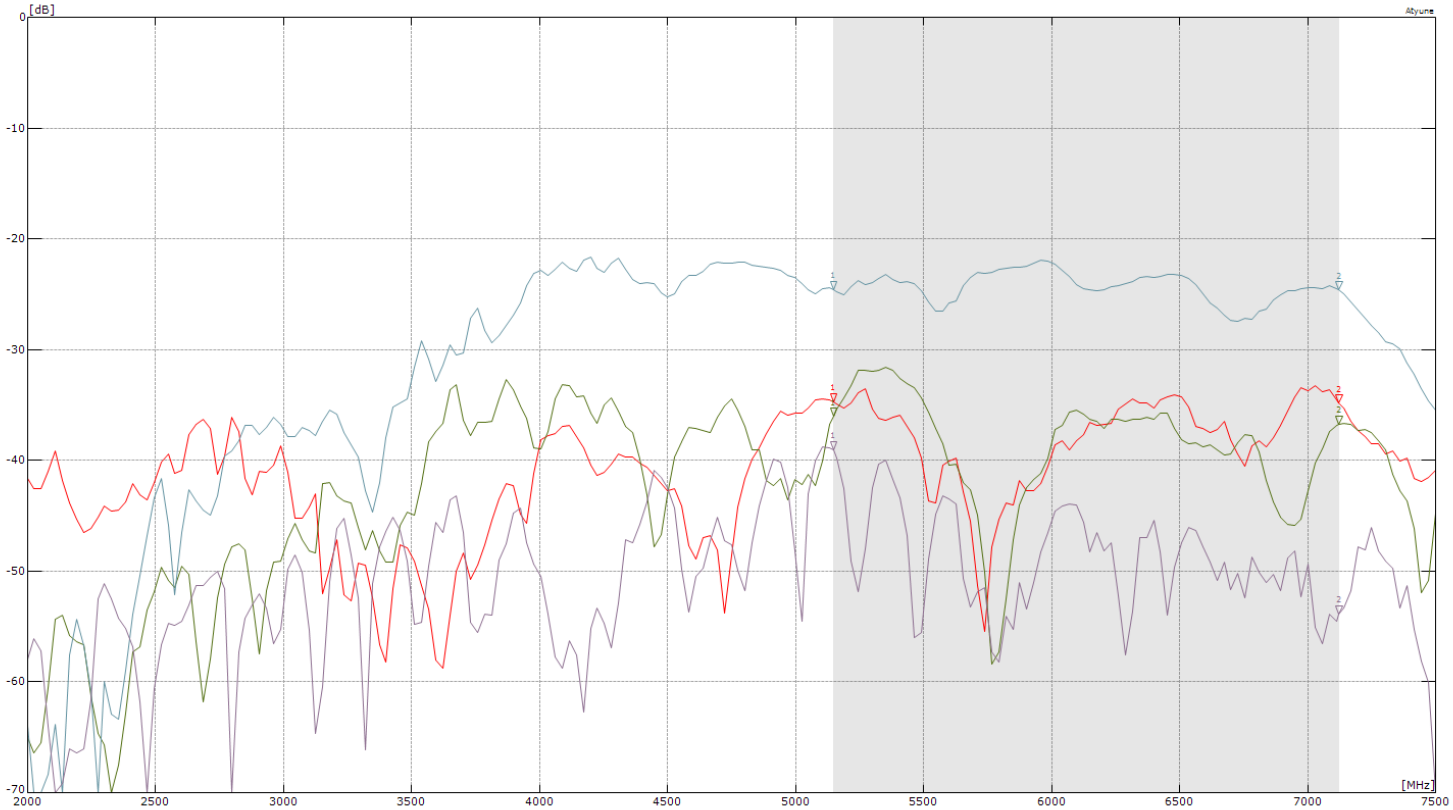
S-Parameter – Isolation for Dual band Antennas & 5G6G Antennas



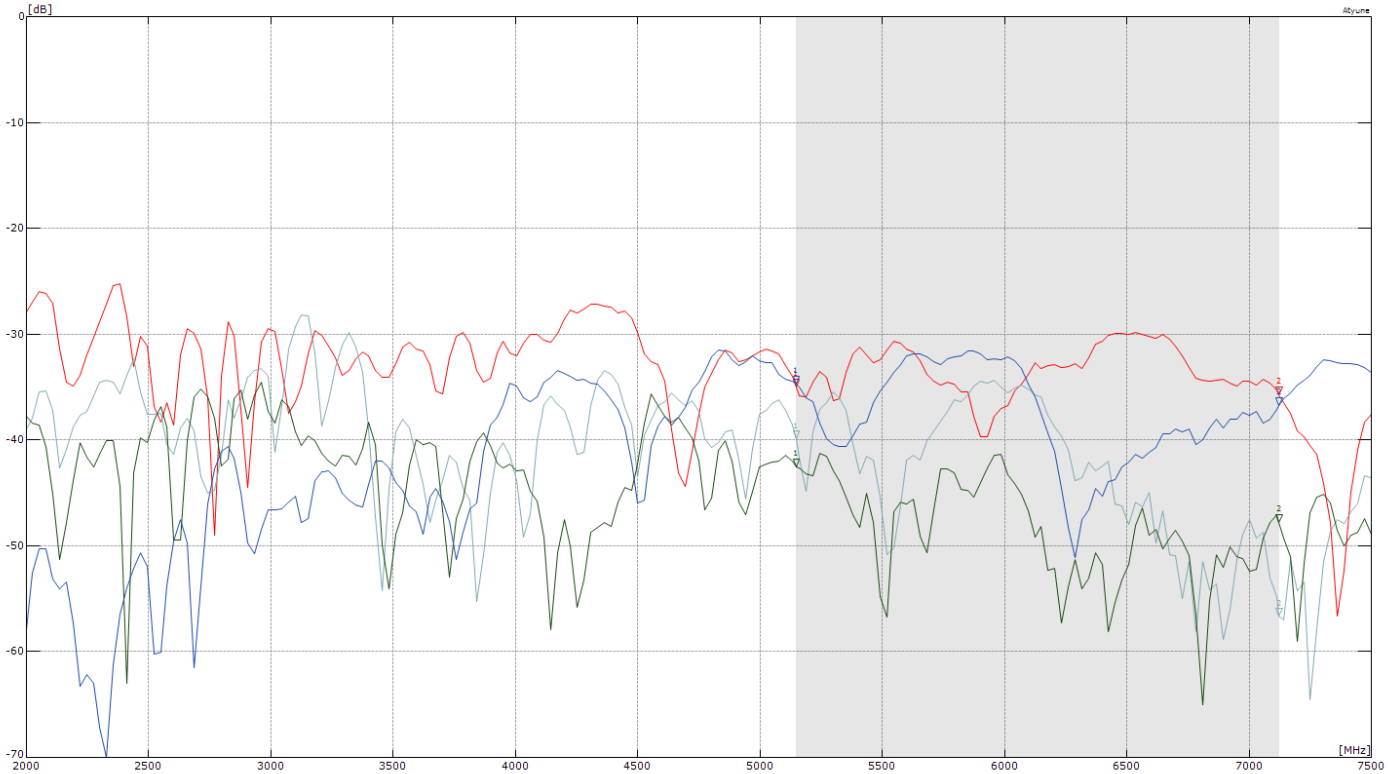
S-Parameter – Isolation for Dual band Antennas &6G Antennas



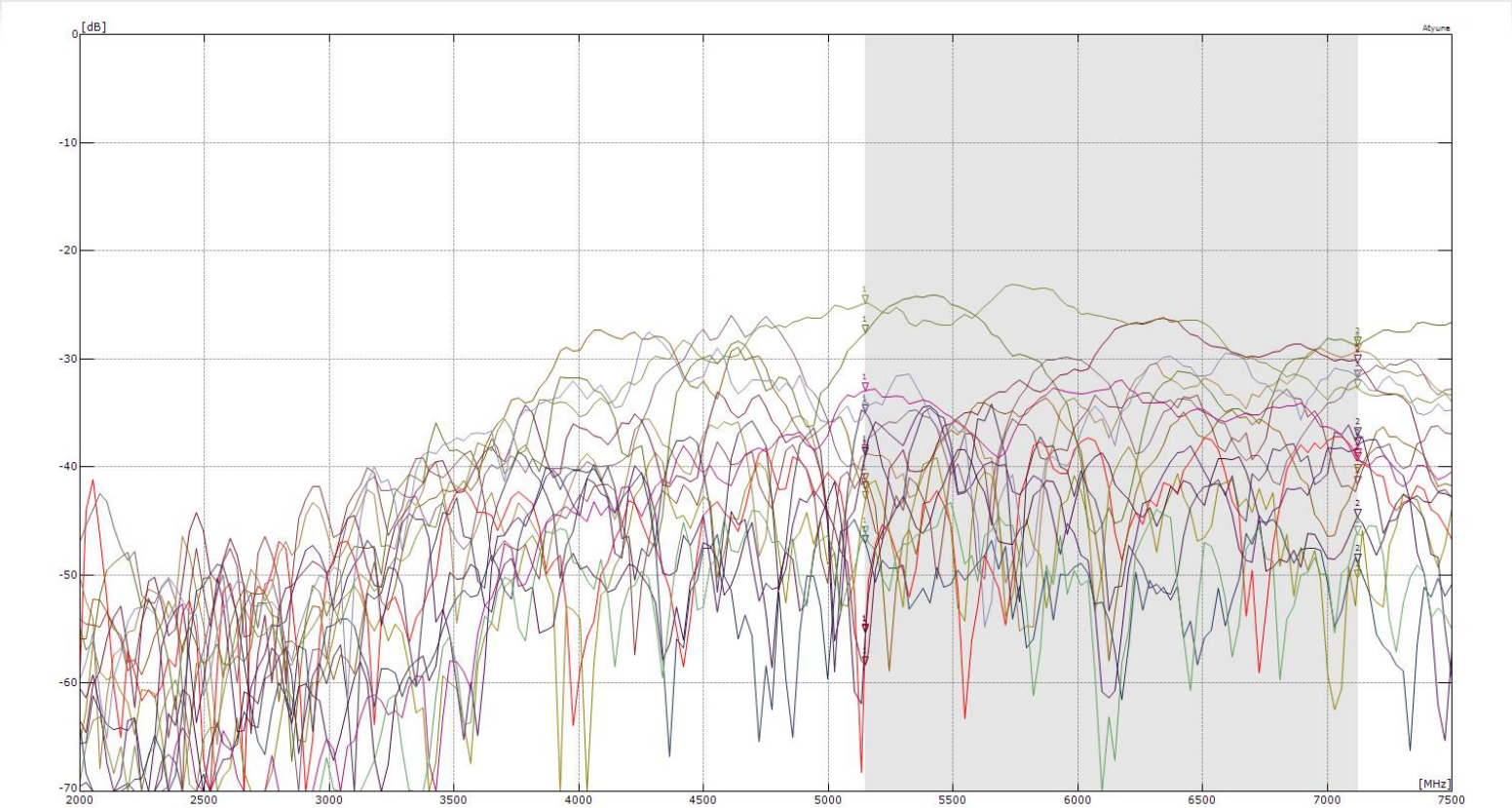
Isolation for 5G Antennas & 6G Antennas



Isolation for 5G&6G Antennas & 5G Antennas



Isolation for 5G&6G Antennas & 6G Antennas

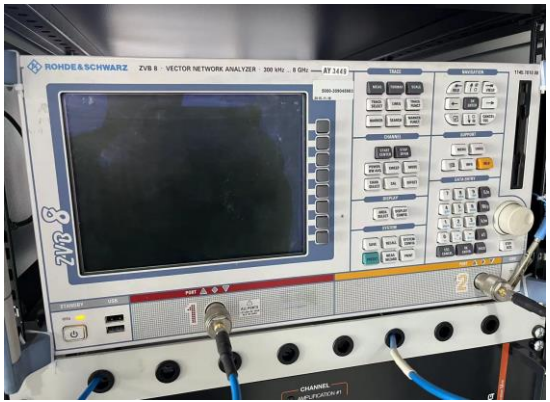


Radiated Measurements

Actual Equipment List and Calibration Information

Vendor	Model	Calibrated Date	Calibrated Until
MVG industries	SLv2	2021/12/13	2022/12/12
ROHDE&SCHWARZ	ZVB.8	2022/8/26	2023/8/25

Test personnel	Test date
Randy	2022/10/08



- Test software:
  Satimo Passive Measurement Version: 1.8.0
  SatEnv Version: 3.0.3.0 build23

- location of the testing:
  Airgain China office in Suzhou

Step 2: Connect DUT with Chamber

- Connect cable coming from DUT, designated as “2.5G_ANT0” to the chamber’s cable.
- Run sequence of radiated tests .
- Disconnect the chamber’s cable from 2.5G_ANT0 .
- Repeat this process for all 16 RF ports of DUT.

Antenna Realized Efficiency (%) – 2.4 GHz Wi-Fi Antennas

Frequency (MHz)	Ant0_2G4 (%)	Ant1_2G4 (%)	Ant2_2G4 (%)	Ant3_2G4 (%)
2400	64.4	64.9	67.8	60.6
2410	66.5	64.3	68.4	64.2
2420	66.8	63.4	69.2	67.9
2430	66.9	63.6	69.1	69.8
2440	67.9	64.1	69.6	72.2
2450	67.9	64.5	70.3	72.3
2460	68.2	65.6	70.2	74.5
2470	68.7	66.8	70.4	75.3
2480	68.0	67.5	70.6	76.3
2490	67.2	68.2	70.0	76.0
Average	67.2	65.3	69.6	70.9

Antenna Realized Efficiency (%) – 5 GHz Wi-Fi Antennas

Frequency (MHz)	Ant0_5G (%)	Ant1_5G (%)	Ant2_5G (%)	Ant3_5G (%)
5150	63.0	69.5	71.4	75.3
5200	64.3	73.1	75.0	78.3
5300	63.0	72.2	71.7	77.3
5400	62.3	71.0	69.5	75.5
5500	63.4	72.1	71.2	76.8
5600	61.0	70.8	68.5	74.9
5700	60.6	69.5	69.9	74.1
5800	57.8	71.1	70.5	74.7
5850	56.3	70.8	69.6	73.9
5925	57.7	73.9	70.2	76.5
Average	60.9	71.4	70.8	75.7

Antenna Efficiency (%) – 6 GHz Wi-Fi Antennas

Frequency (MHz)	Ant0-1_6G (%)	Ant0-2_6G (%)	Ant1-1_6G (%)	Ant1-2_6G (%)
5925	66.6	58.6	65.2	56.9
6000	64.2	59.7	64.8	53.5
6100	63.5	60.5	64.9	52.9
6200	64.5	60.3	67.0	54.9
6300	64.5	59.6	65.9	53.2
6400	63.9	60.1	65.9	53.0
6500	59.4	61.9	65.1	52.2
6600	57.0	61.3	64.2	51.2
6700	58.0	57.9	64.0	52.8
6800	58.6	60.6	64.3	51.1
6900	58.2	61.1	63.2	49.2
7125	50.9	55.5	58.9	48.0
Average	60.8	59.8	64.4	52.4

Antenna Realized Efficiency (%) – 5 GHz Wi-Fi Antennas

Frequency (MHz)	Ant2-1_5G (%)	Ant2-2_5G (%)	Ant3-1_5G (%)	Ant3-2_5G (%)
5150	63.1	75.4	63.7	60.5
5200	67.9	77.4	63.5	63.6
5300	68.8	77.5	64.4	61.2
5400	67.5	75.1	60.9	60.1
5500	72.9	76.7	66.7	61.8
5600	70.7	74.5	64.5	60.3
5700	71.8	74.2	66.4	63.0
5800	70.2	74.1	66.0	61.9
5850	68.2	72.3	65.1	61.9
Average	69.0	75.3	64.6	61.6

Antenna Efficiency (%) – 6 GHz Wi-Fi Antennas

Frequency (MHz)	Ant2-1_6G (%)	Ant2-2_6G (%)	Ant3-1_6G (%)	Ant3-2_6G (%)
5925	68.7	71.8	64.8	62.3
6000	70.5	69.9	65.9	62.2
6100	70.3	66.6	65.6	61.2
6200	69.3	62.2	68.2	63.8
6300	67.5	65.2	66.7	63.9
6400	65.3	70.2	65.2	65.1
6500	68.3	70.4	63.8	64.4
6600	67.8	69.9	62.2	64.2
6700	69.1	67.8	64.6	61.9
6800	68.6	69.0	63.8	61.8
6900	65.6	68.1	62.8	59.4
7125	67.0	67.6	61.1	58.6
Average	67.4	69.0	63.4	62.2

Antenna Peak Realized Gain – 2.4 GHz Wi-Fi Antennas

Frequency (MHz)	Ant0_2G4 (dBi)	Ant1_2G4 (dBi)	Ant2_2G4 (dBi)	Ant3_2G4 (dBi)
2400	5.8	3.7	4.4	4.2
2410	5.5	3.6	4.5	4.1
2420	5.6	3.4	4.6	4.5
2430	5.6	3.2	4.6	4.5
2440	5.6	3.0	4.6	4.5
2450	5.6	2.8	4.7	4.8
2460	5.6	2.8	4.7	4.9
2470	5.6	2.7	4.6	4.9
2480	5.5	3.1	4.8	5.0
2490	5.4	3.4	4.8	5.2

Antenna Peak Realized Gain – 5 GHz Wi-Fi Antennas

Frequency (MHz)	Ant0_5G (dBi)	Ant1_5G (dBi)	Ant2_5G (dBi)	Ant3_5G (dBi)
5150	6.7	5.1	4.5	4.9
5200	6.6	5.7	4.7	5.3
5300	6.4	6.0	5.0	5.1
5400	6.7	5.6	4.9	4.7
5500	6.5	5.4	5.4	4.7
5600	6.6	5.2	4.9	4.5
5700	6.7	5.0	5.0	4.4
5800	6.4	4.6	5.3	4.9
5850	6.0	4.2	5.1	5.3
5925	6.0	4.6	5.1	5.9

Antenna Peak Gain – 6 GHz Wi-Fi Antennas

Frequency (MHz)	Ant0-1_6G (dBi)	Ant0-2_6G (dBi)	Ant1-1_6G (dBi)	Ant1-2_6G (dBi)
5925	6.3	3.6	5.9	6.1
6000	5.7	3.9	5.9	4.8
6100	5.7	3.6	5.6	5.2
6200	5.5	3.4	5.9	6.4
6300	5.9	3.9	5.7	6.3
6400	5.9	4.4	5.2	4.8
6500	5.3	4.7	5.3	3.9
6600	5.3	4.4	5.6	4.4
6700	4.6	3.6	5.9	4.7
6800	4.2	3.3	5.9	4.9
6900	5.0	3.7	5.7	4.3
7125	4.5	3.3	5.3	4.5

Antenna Peak Realized Gain – 5 GHz Wi-Fi Antennas

Frequency (MHz)	Ant2-1_5G (dBi)	Ant2-2_5G (dBi)	Ant3-1_5G (dBi)	Ant3-2_5G (dBi)
5150	4.2	4.4	4.5	3.0
5200	4.7	4.5	4.6	3.4
5300	4.7	4.3	5.1	2.7
5400	4.9	4.1	5.0	3.2
5500	5.1	4.1	4.9	3.2
5600	4.7	4.9	5.2	3.0
5700	4.7	4.5	5.4	3.7
5800	5.1	4.2	5.5	4.3
5850	5.0	4.0	5.2	4.2

Antenna Peak Gain – 6 GHz Wi-Fi Antennas

Frequency (MHz)	Ant2-1_6G (dBi)	Ant2-2_6G (dBi)	Ant3-1_6G (dBi)	Ant3-2_6G (dBi)
5925	4.7	3.7	5.0	4.0
6000	4.6	3.5	5.0	3.7
6100	4.2	4.6	4.7	3.6
6200	4.5	4.9	4.4	4.0
6300	4.5	4.8	4.1	3.9
6400	4.1	4.7	4.3	3.6
6500	3.9	4.6	4.3	3.6
6600	3.8	4.7	4.4	3.5
6700	3.7	5.1	4.9	3.4
6800	4.0	5.3	5.3	3.3
6900	3.8	5.0	5.5	3.0
7125	4.0	5.2	4.2	2.7

Antenna Peak Gain & Efficiency– Additional BT Antennas

Frequency (MHz)	Thread 2 (%)	BLE1_BT/Thread 1 (%)
2400	57.0	68.0
2410	58.9	69.4
2420	60.9	70.2
2430	61.7	70.7
2440	63.1	71.5
2450	63.6	71.7
2460	63.9	72.1
2470	65.2	72.3
2480	65.6	72.1
2490	65.6	71.6
Average	62.6	71.0

Frequency (MHz)	Thread 2 (dBi)	BLE1_BT/Thread 1 (%)
2400	4.1	4.9
2410	3.8	5.1
2420	4.1	5.2
2430	4.2	5.4
2440	4.5	5.5
2450	4.7	5.6
2460	4.7	5.6
2470	4.7	5.7
2480	4.7	5.7
2490	4.8	5.6

Antenna Peak Gain & Efficiency– Additional GPS & Scan Antennas

Frequency (MHz)	Peak Gain (dBi)	Efficiency (%)
1572	2.6	44.3
1573	2.6	44.8
1574	2.7	45.2
1575.42	2.7	45.6
1576	2.7	45.7
1577	2.8	46.1
Average	-	45.3

Frequency (MHz)	Peak Gain (dBi)	Efficiency (%)
5150	5.5	64.8
5200	6.1	67.9
5300	5.3	68.1
5400	5.3	68.4
5500	5.2	68.3
5600	5.0	67.7
5700	5.1	69.2
5800	5.4	69.2
5850	5.4	68.5
5925	5.4	70.4
Average	-	68.2

Antennas Uncorrelated Gain & Correlated Gain

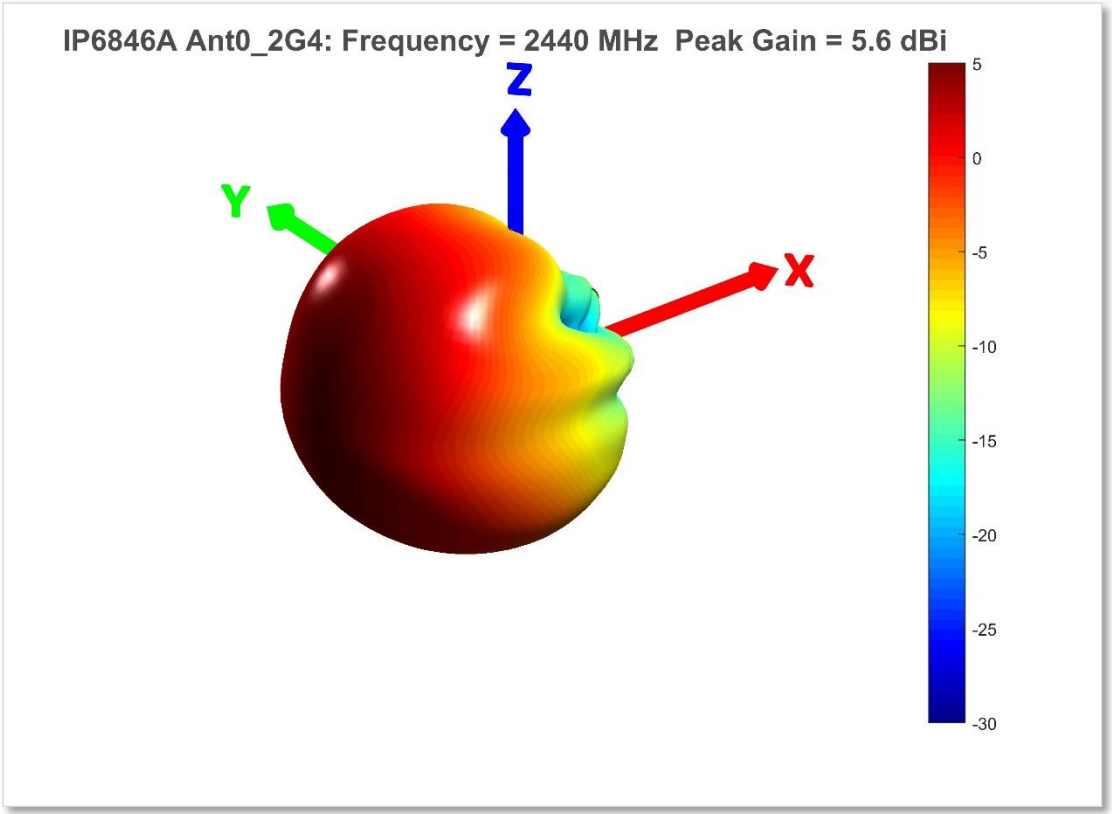
Frequency (MHz)	Uncorrelated (dBi)	Correlated (dBi)
2400	2.6	8.3
2410	2.7	8.5
2420	3.0	8.6
2430	3.1	8.6
2440	3.1	8.8
2450	3.0	8.8
2460	3.3	9.0
2470	3.4	9.2
2480	3.6	9.3
2490	3.7	9.5
5150	3.1	8.8
5200	3.5	9.2
5300	3.3	9.1
5400	3.1	8.7
5500	3.4	9.0
5600	3.0	8.5
5700	2.7	8.0
5800	1.9	7.3
5850	2.0	7.4
5925	2.3	7.6

Frequency (MHz)	Uncorrelated (dBi)	Correlated (dBi)
5925	2.1	5.9
6000	1.6	5.6
6100	1.2	5.5
6200	2.1	6.5
6300	1.7	6.5
6400	1.7	6.5
6500	1.3	6.4
6600	1.5	6.4
6700	0.5	5.6
6800	0.6	5.6
6900	1.0	5.9
7125	0.6	6.1

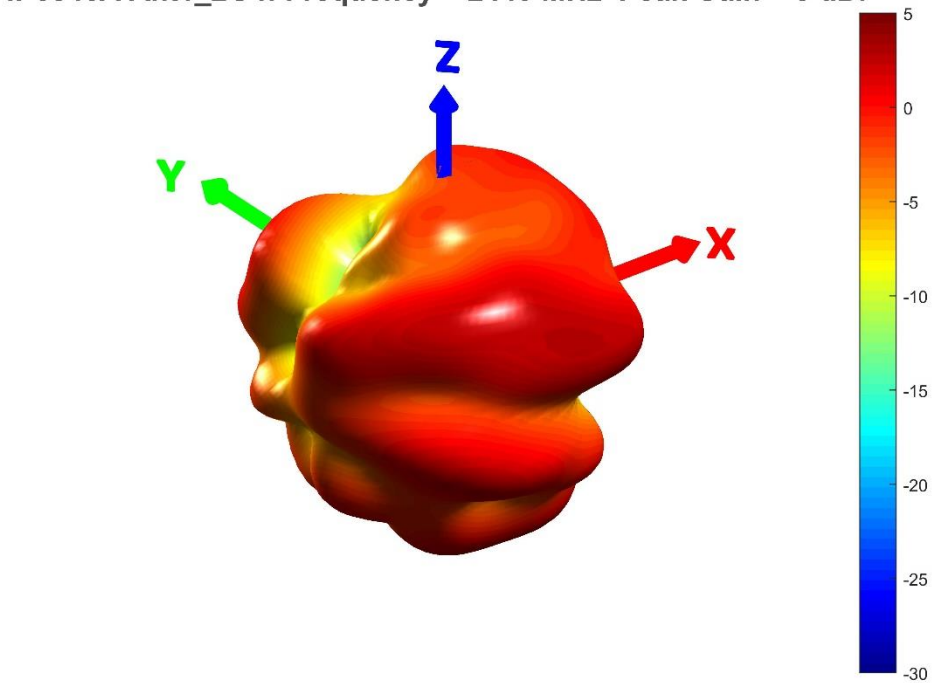
Frequency (MHz)	Uncorrelated (dBi)	Correlated (dBi)
5150	2.0	7.5
5200	2.0	7.5
5300	2.1	7.5
5400	2.0	7.5
5500	2.2	7.9
5600	2.6	8.4
5700	2.9	8.6
5800	2.3	8.0
5850	1.9	7.6
5925	1.8	7.5
6000	2.2	7.7
6100	2.2	7.8
6200	2.0	7.6
6300	2.0	7.8
6400	2.2	7.9
6500	2.1	7.8
6600	2.4	8.2
6700	2.4	8.1
6800	2.0	7.7
6900	2.2	7.8
7125	2.4	8.0

Radiation Patterns

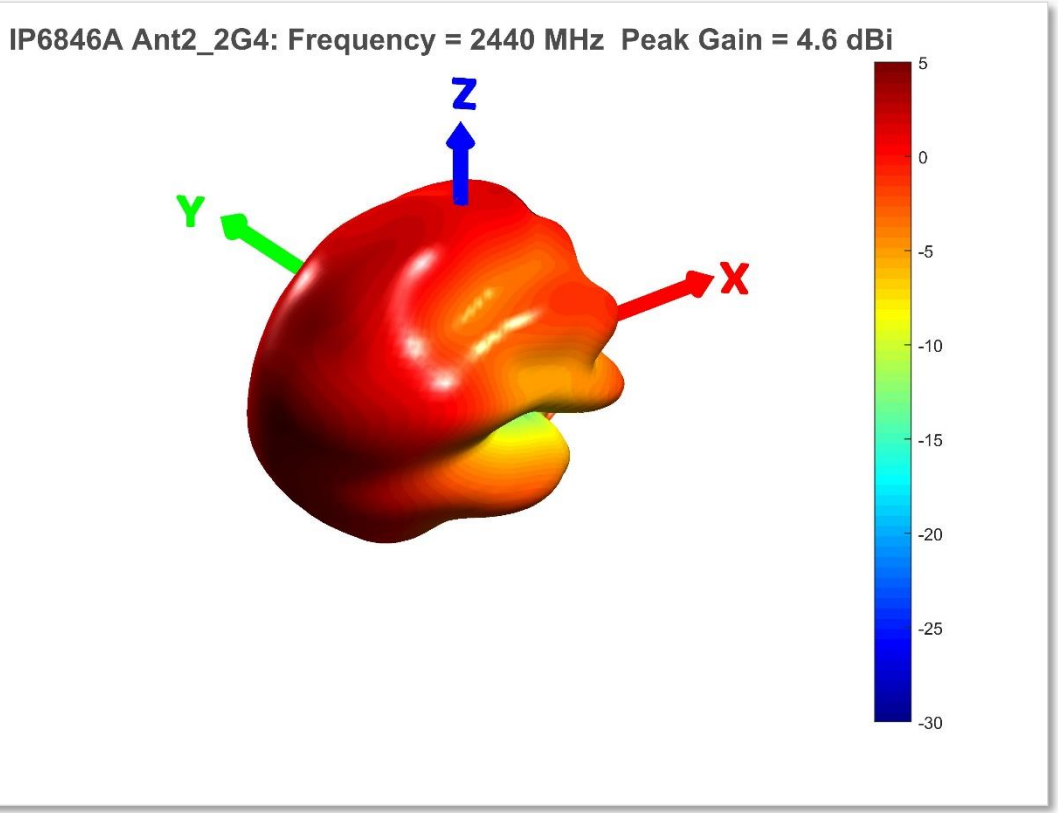
Total Gain 3D Pattern: Ant0_2G4 at 2440MHz



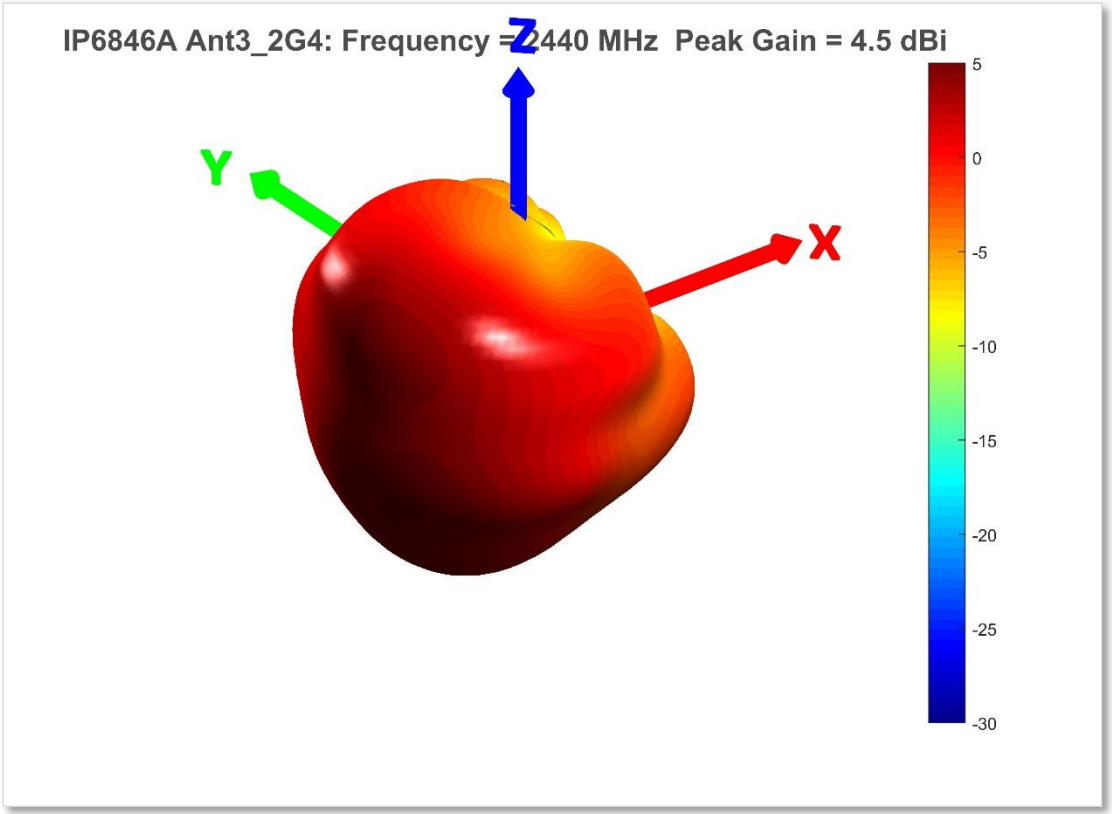
Total Gain 3D Pattern: Ant1_2G4 at 2440MHz



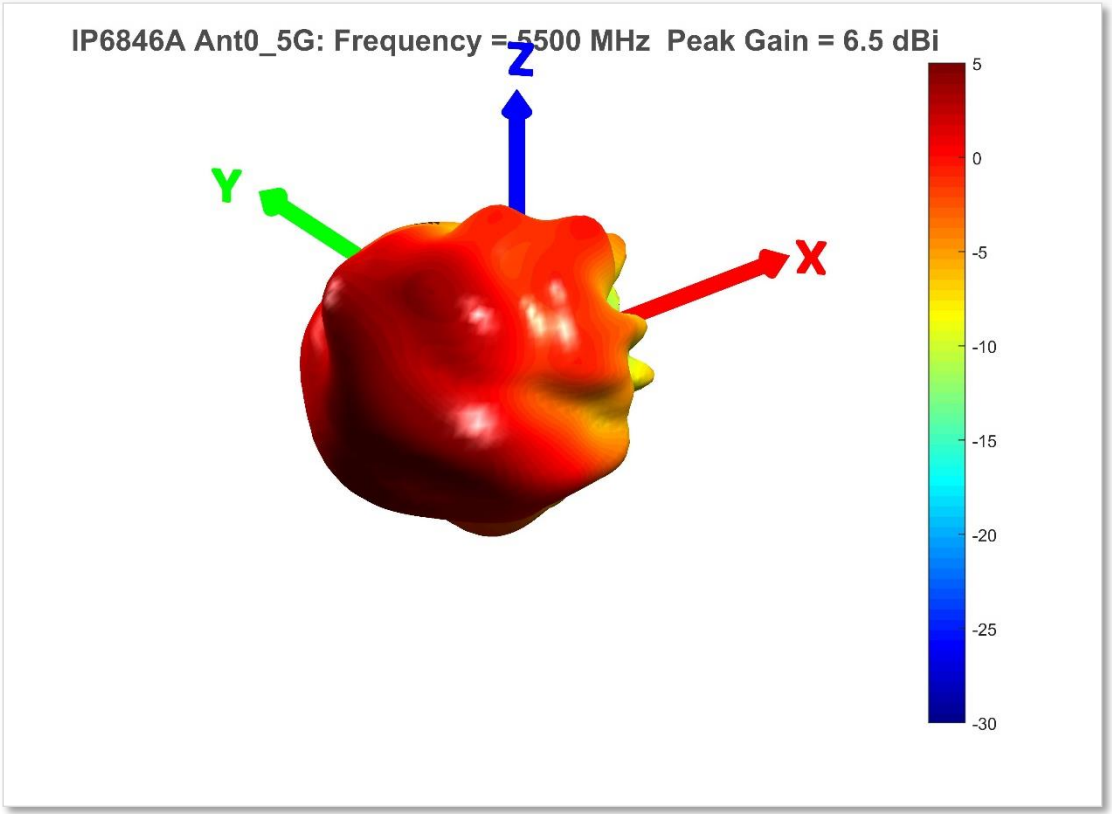
Total Gain 3D Pattern: Ant2_2G4 at 2440MHz



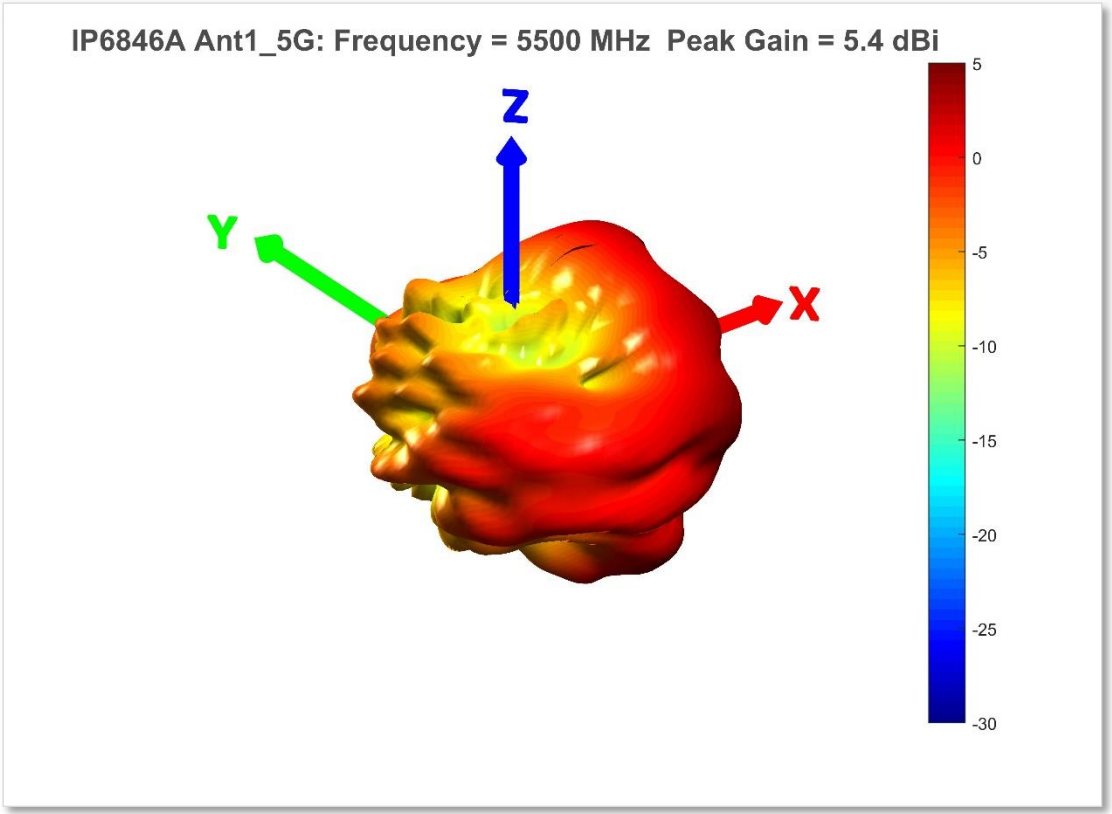
Total Gain 3D Pattern: Ant3_2G4 at 2440MHz



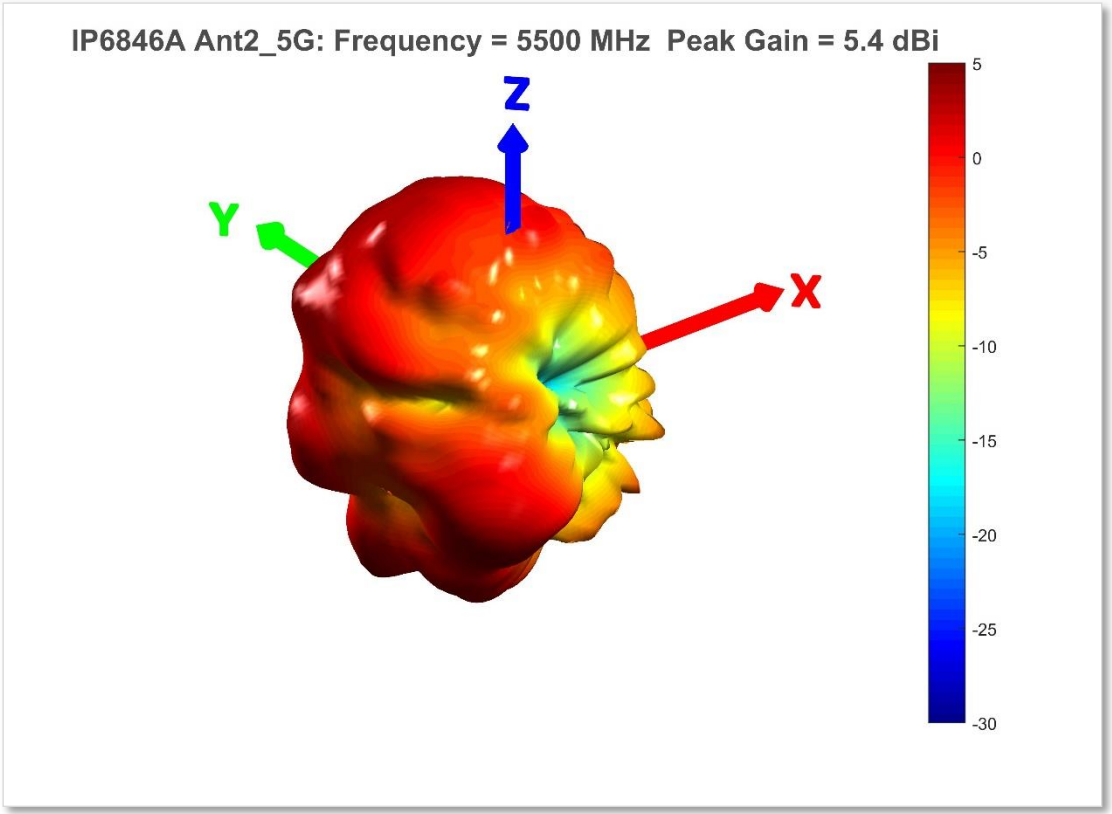
Total Gain 3D Pattern: Ant0_5G at 5500MHz



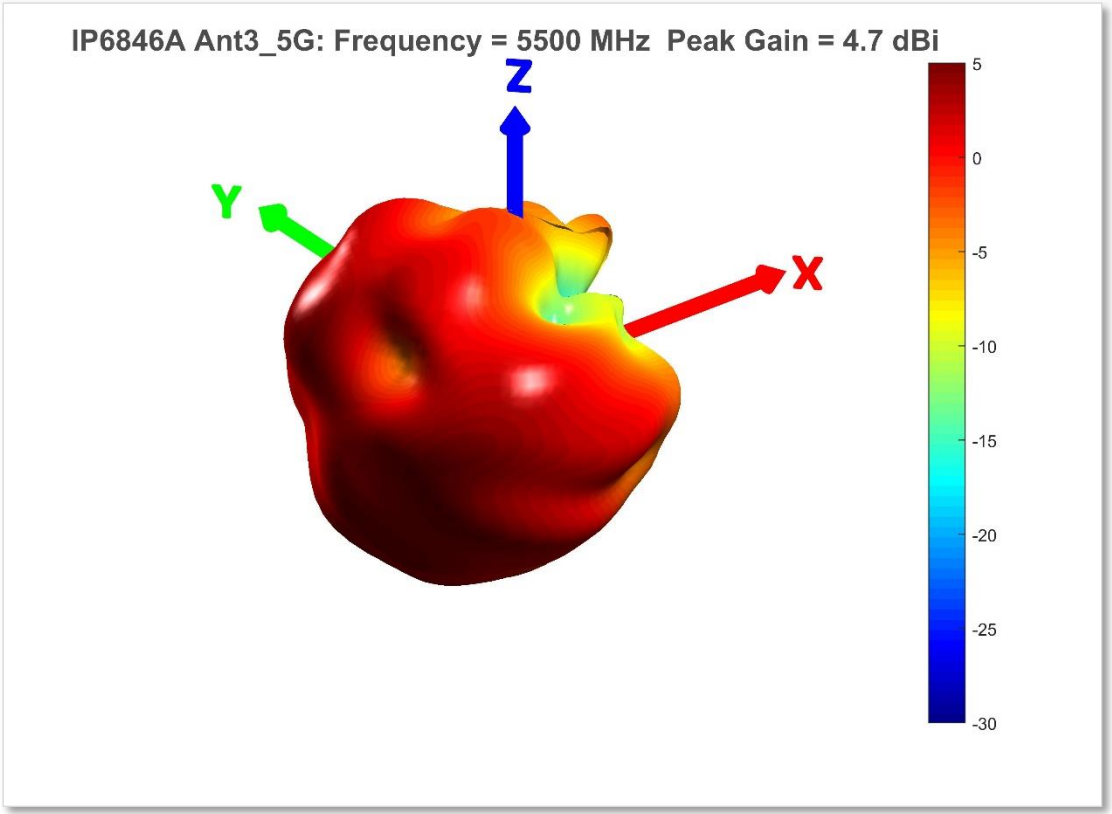
Total Gain 3D Pattern: Ant1_5G at 5500MHz



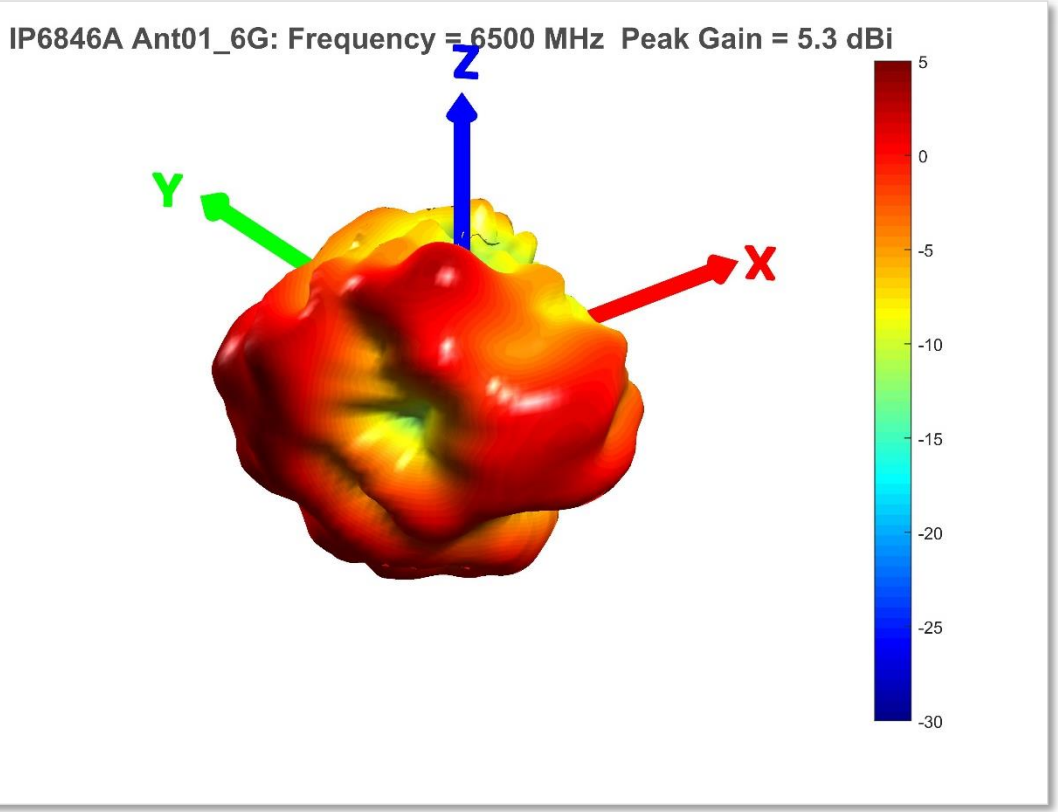
Total Gain 3D Pattern: Ant2_5G at 5500MHz



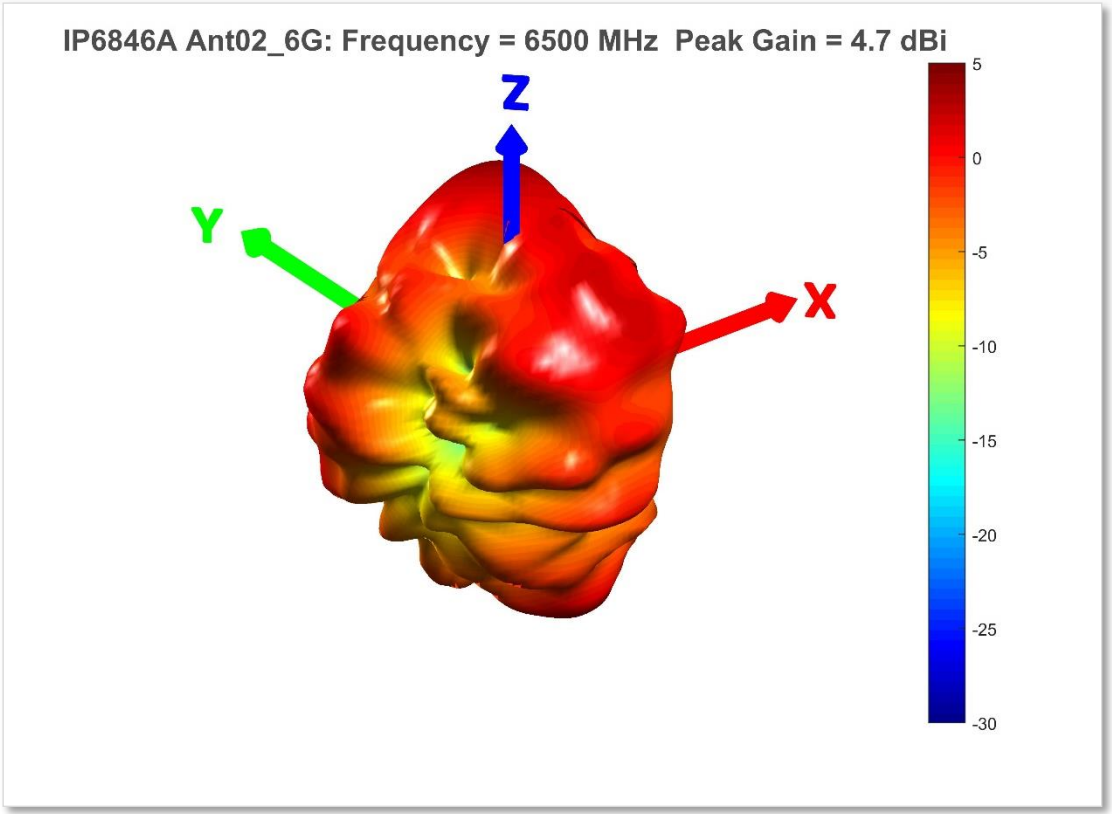
Total Gain 3D Pattern: Ant3_5G at 5500MHz



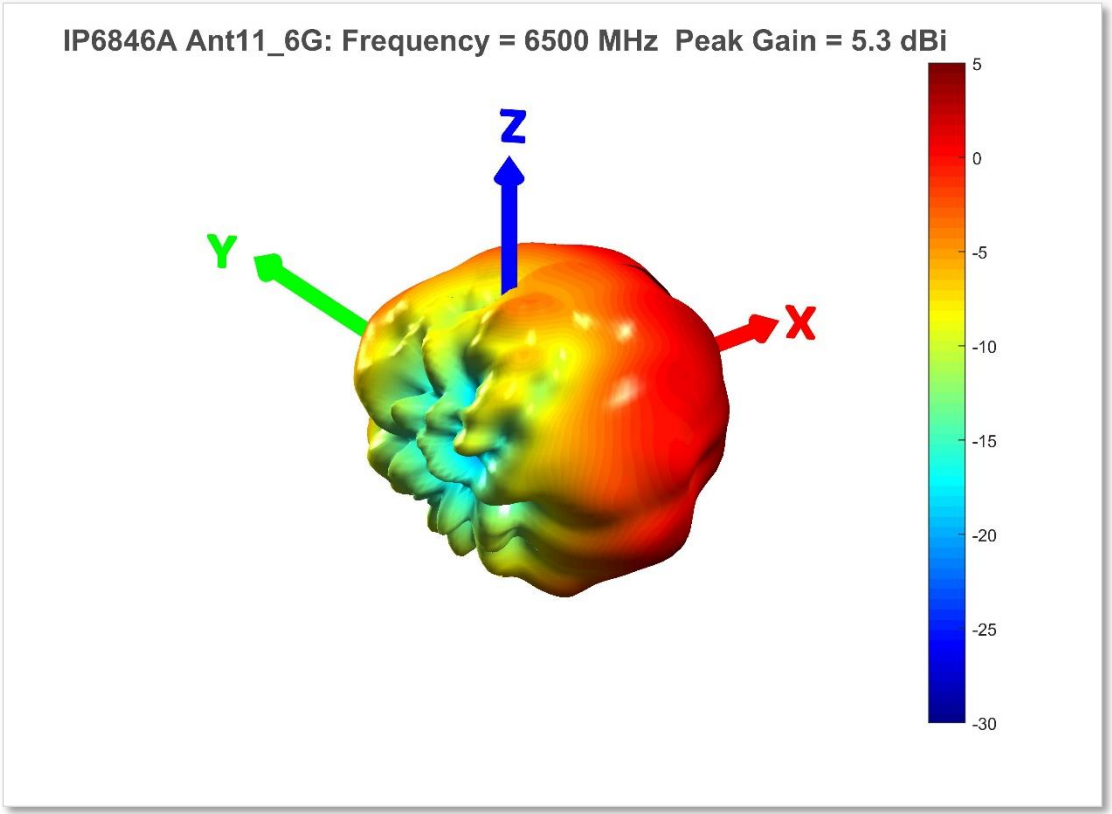
Total Gain 3D Pattern: Ant0-1_6G at 6500MHz



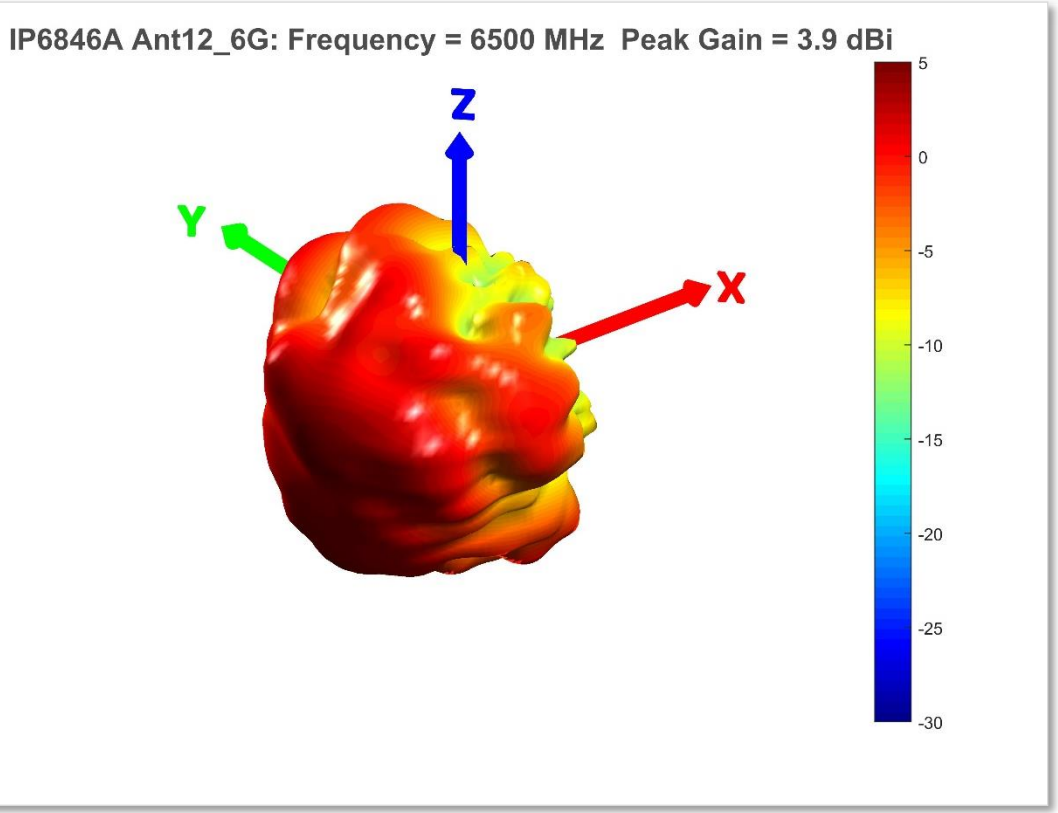
Total Gain 3D Pattern: Ant0-2_6G at 6500MHz



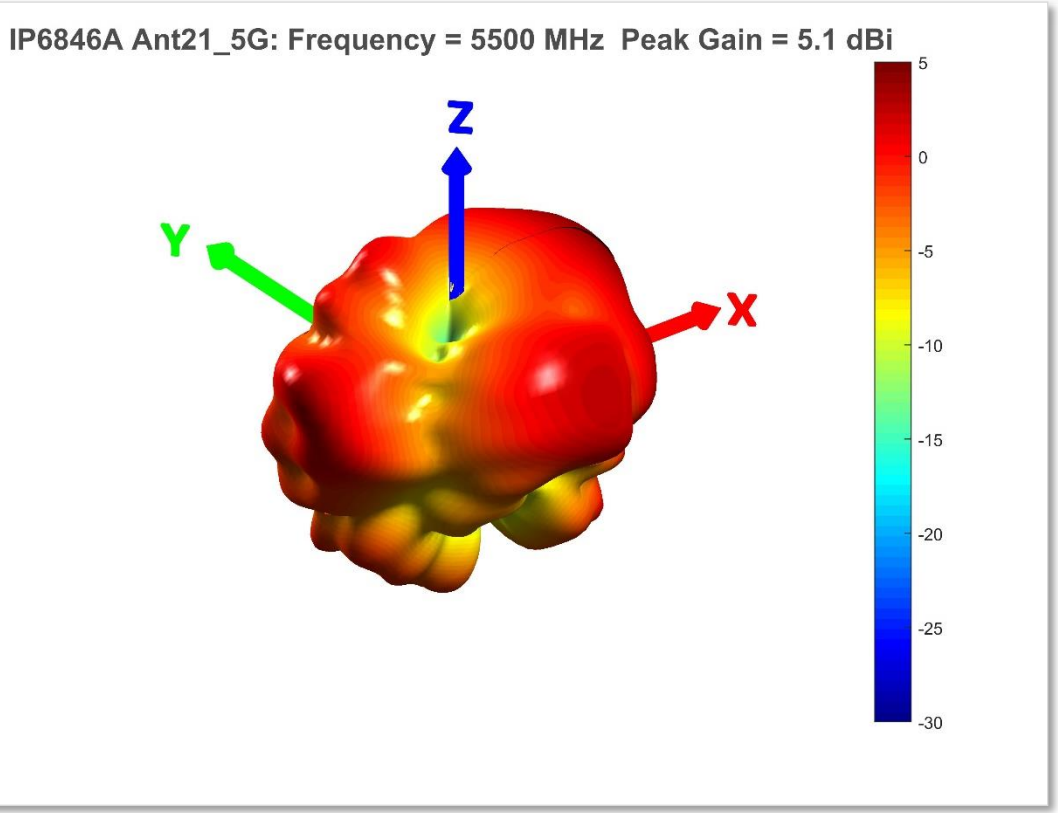
Total Gain 3D Pattern: Ant1-1_6G at 6500MHz



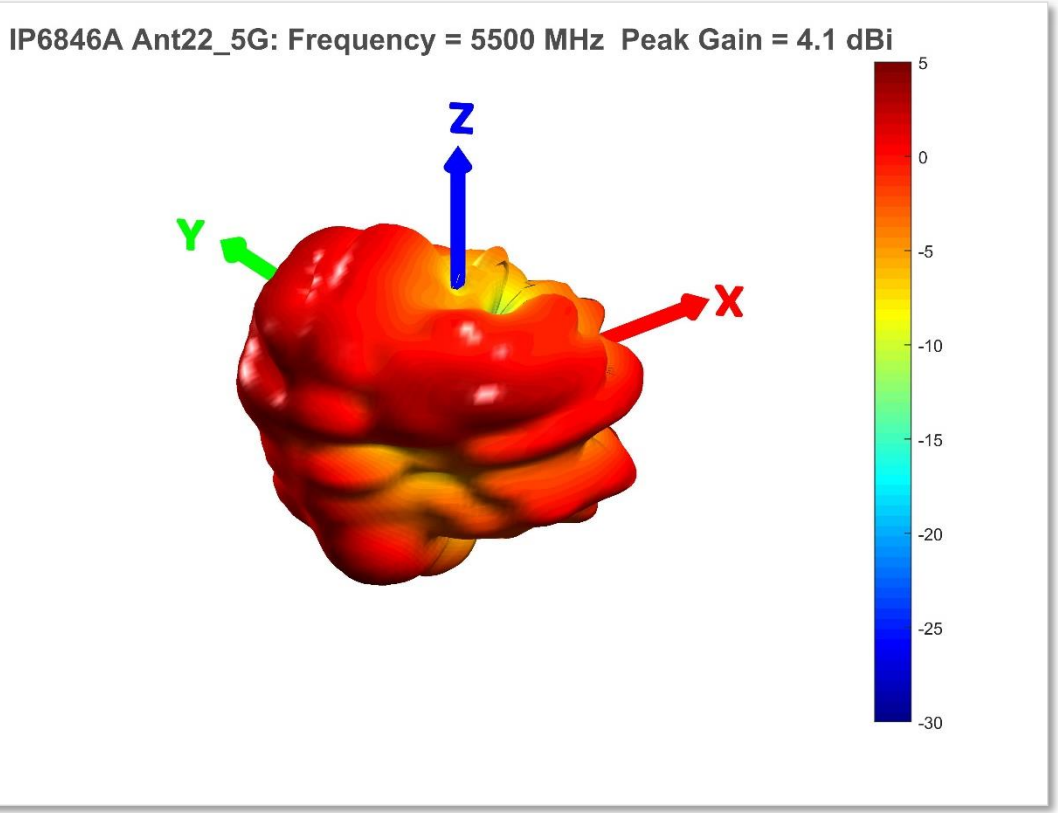
Total Gain 3D Pattern: Ant1-2_6G at 6500MHz



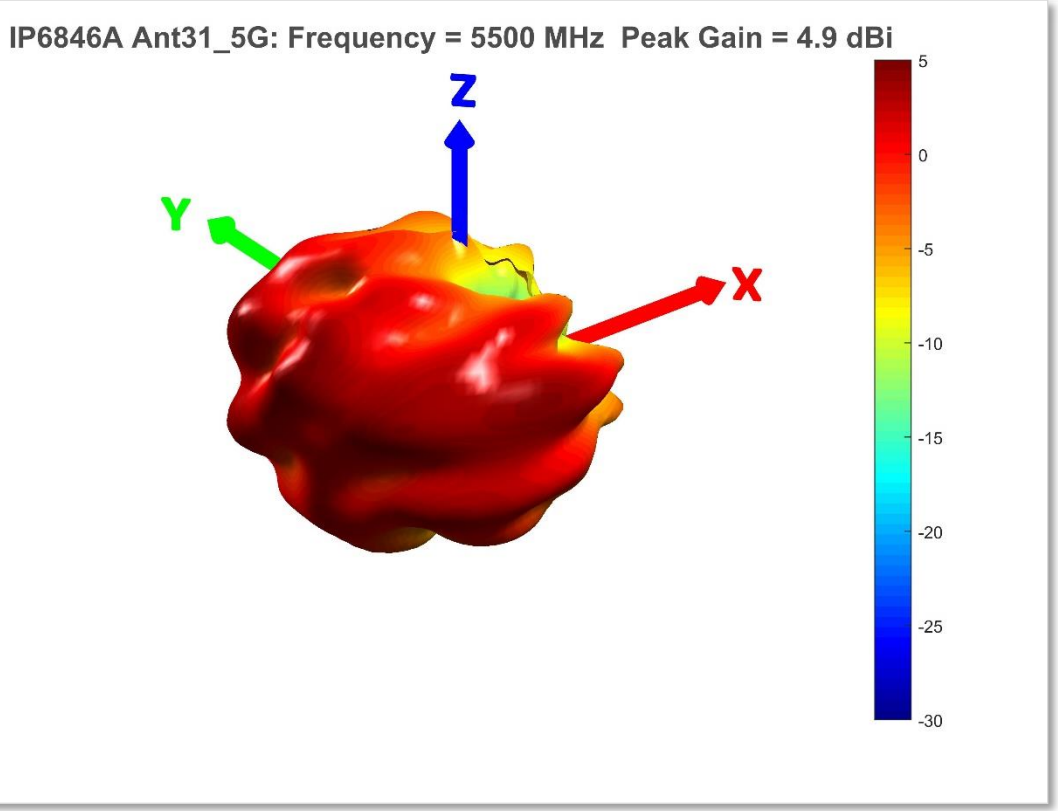
Total Gain 3D Pattern: Ant2-1_5G at 5500MHz



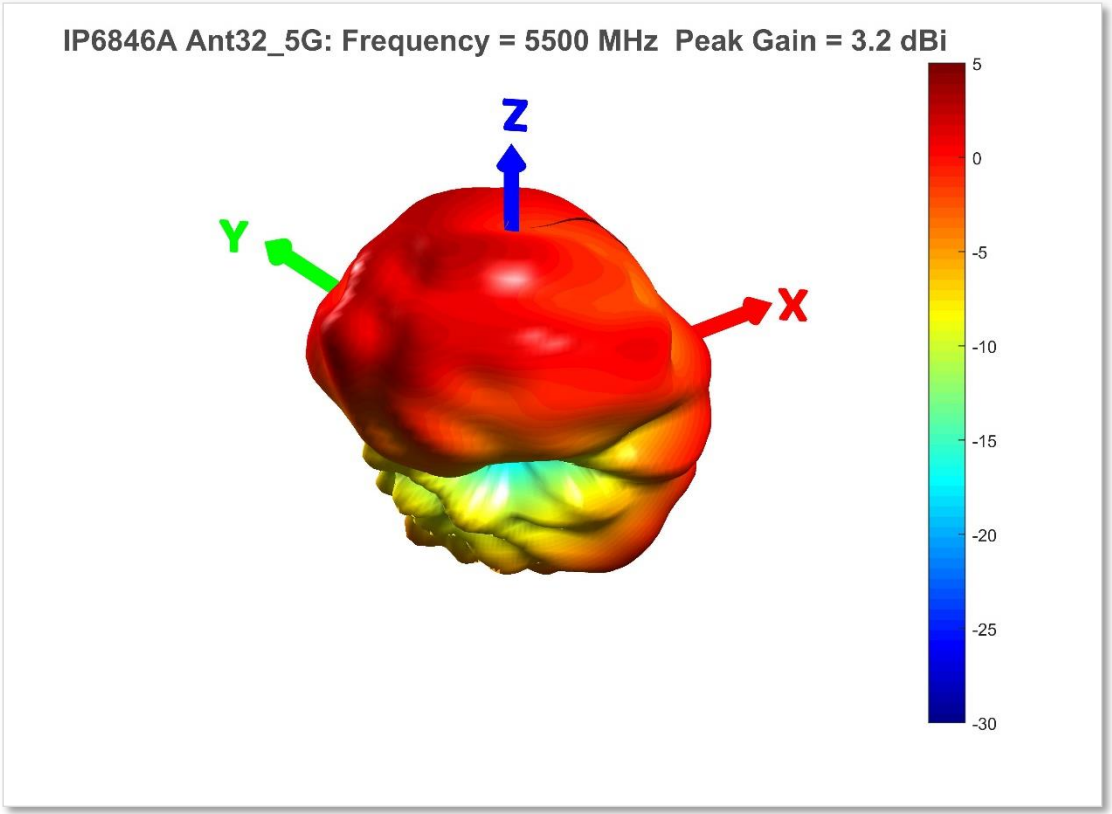
Total Gain 3D Pattern: Ant2-2_5G at 5500MHz



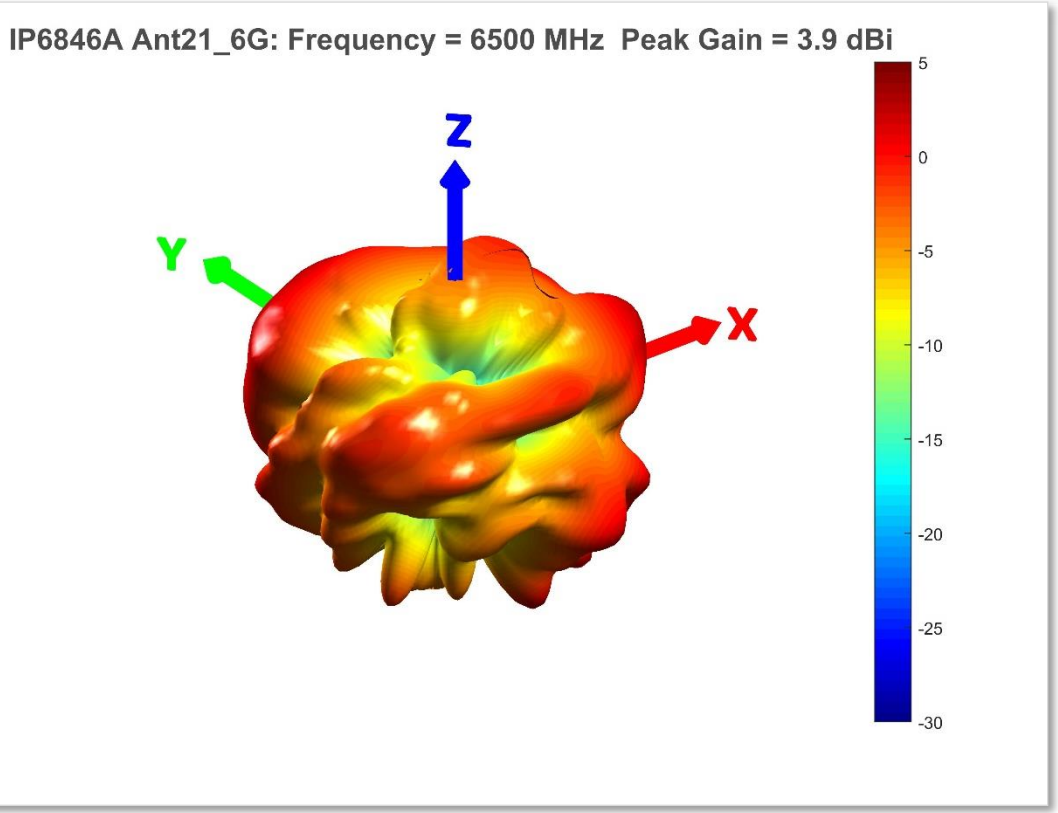
Total Gain 3D Pattern: Ant3-1_5G at 5500MHz



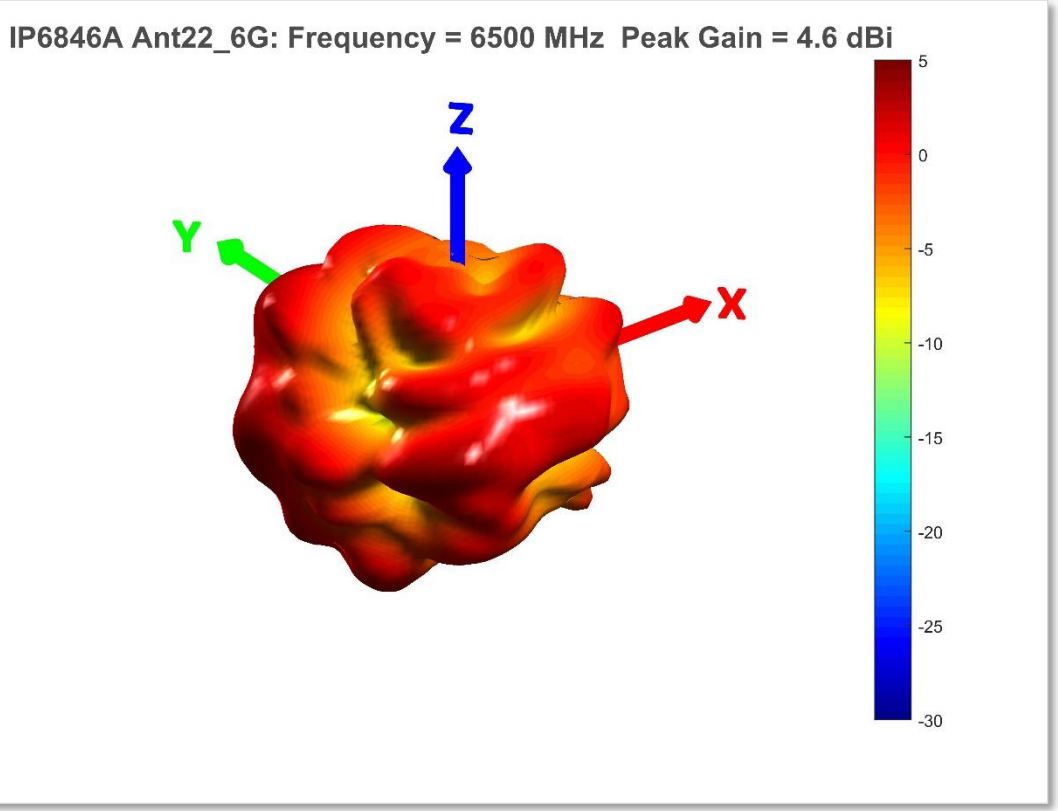
Total Gain 3D Pattern: Ant3-2_5G at 5500MHz



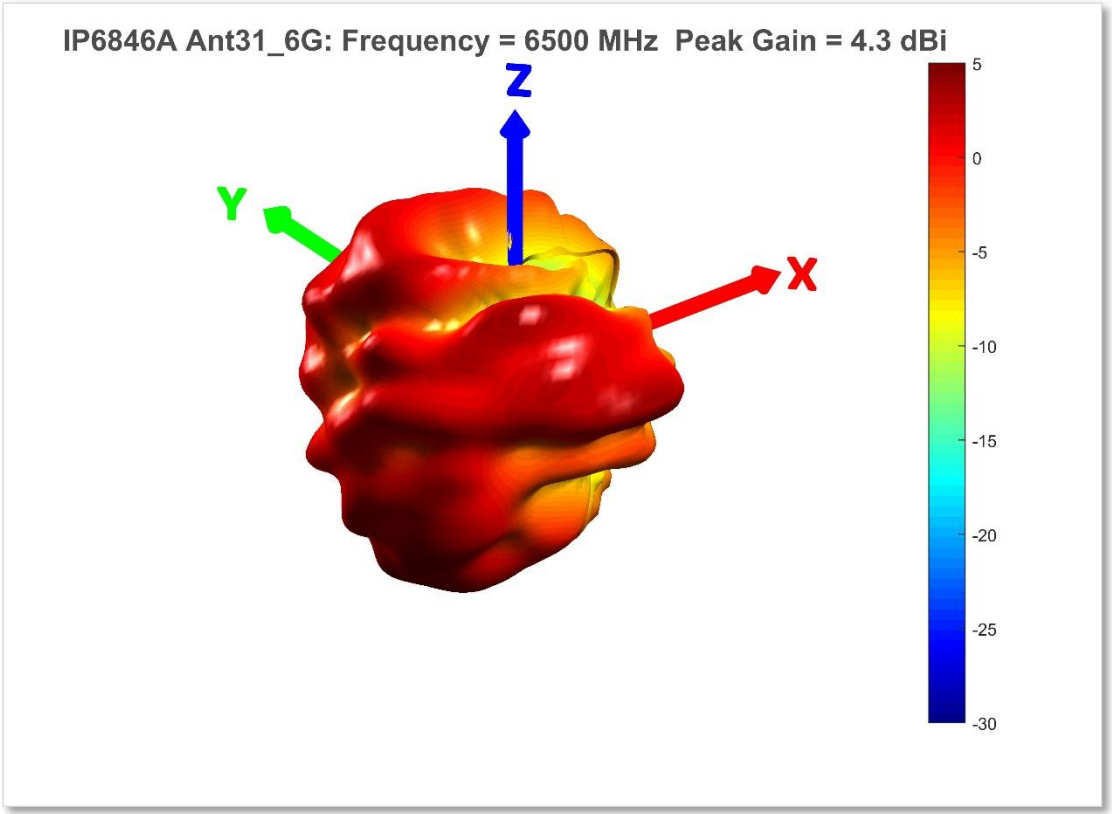
Total Gain 3D Pattern: Ant2-1_6G at 6500MHz



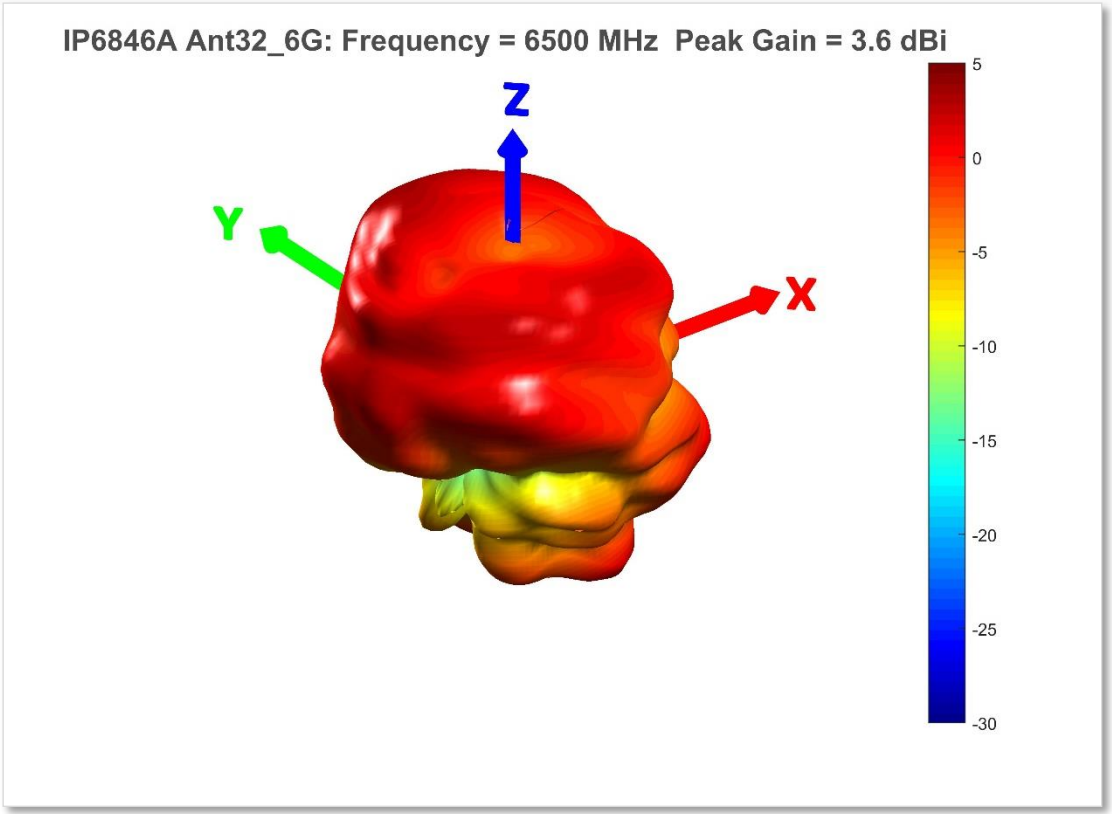
Total Gain 3D Pattern: Ant2-2_6G at 6500MHz



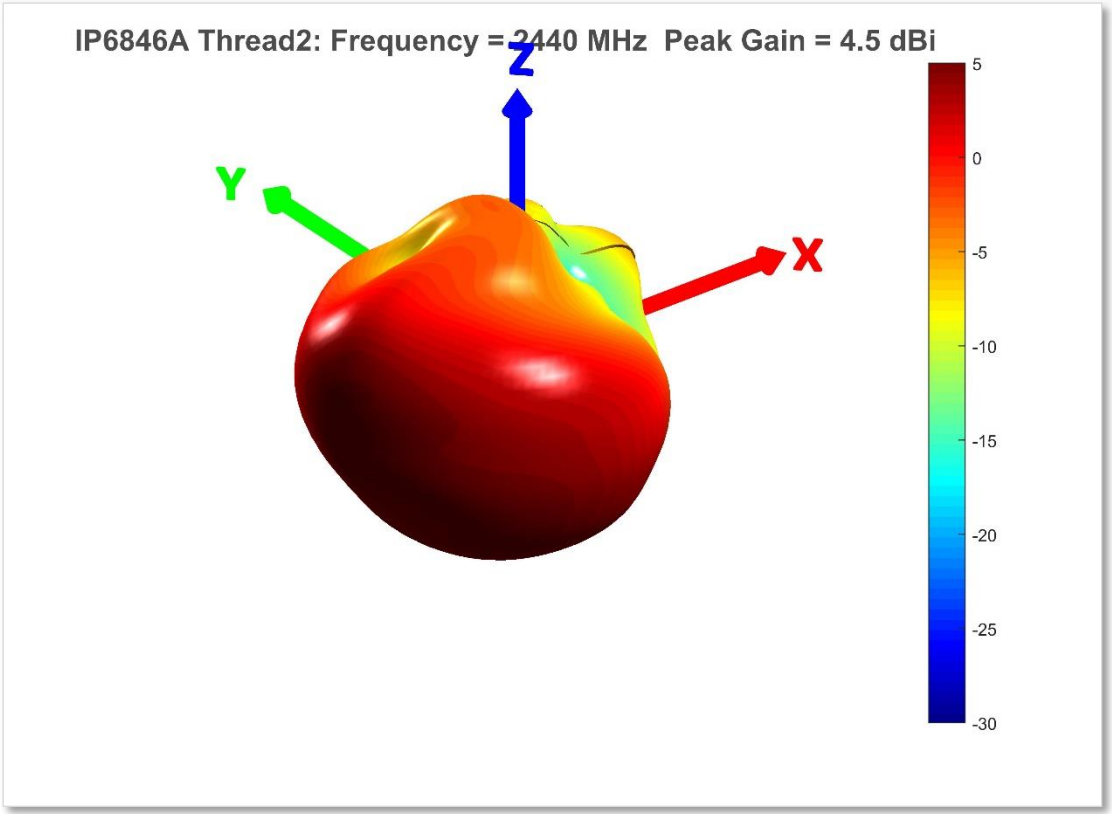
Total Gain 3D Pattern: Ant3-1_6G at 6500MHz



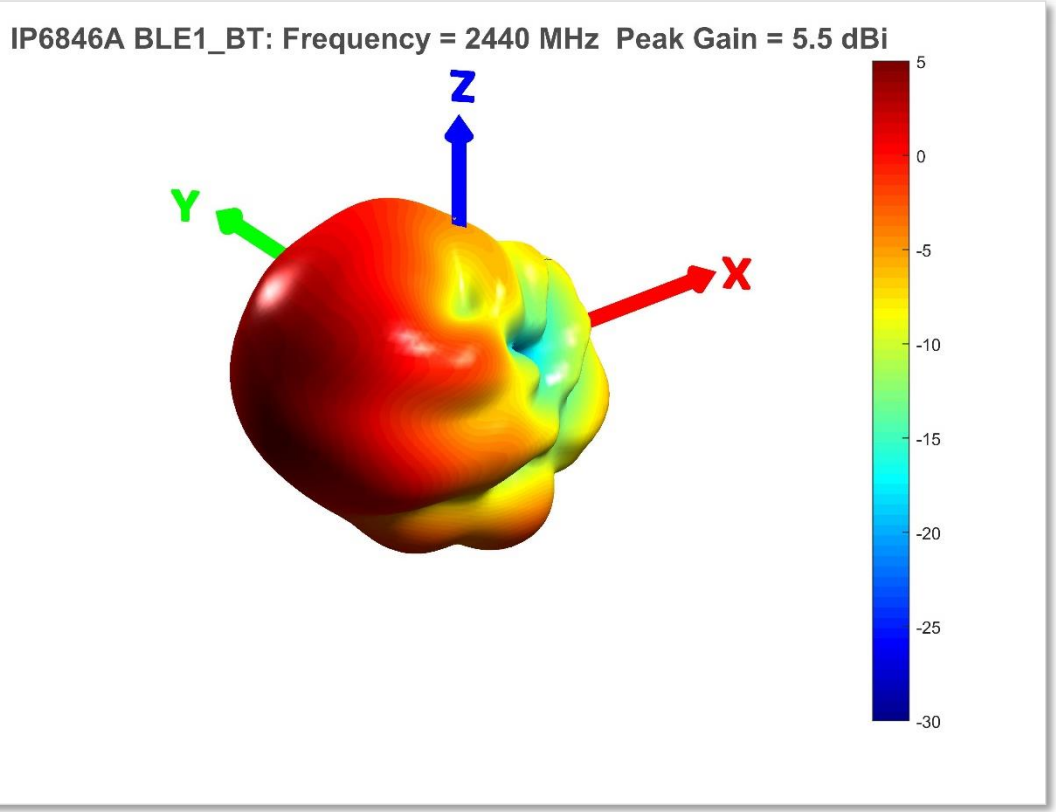
Total Gain 3D Pattern: Ant3-2_6G at 6500MHz



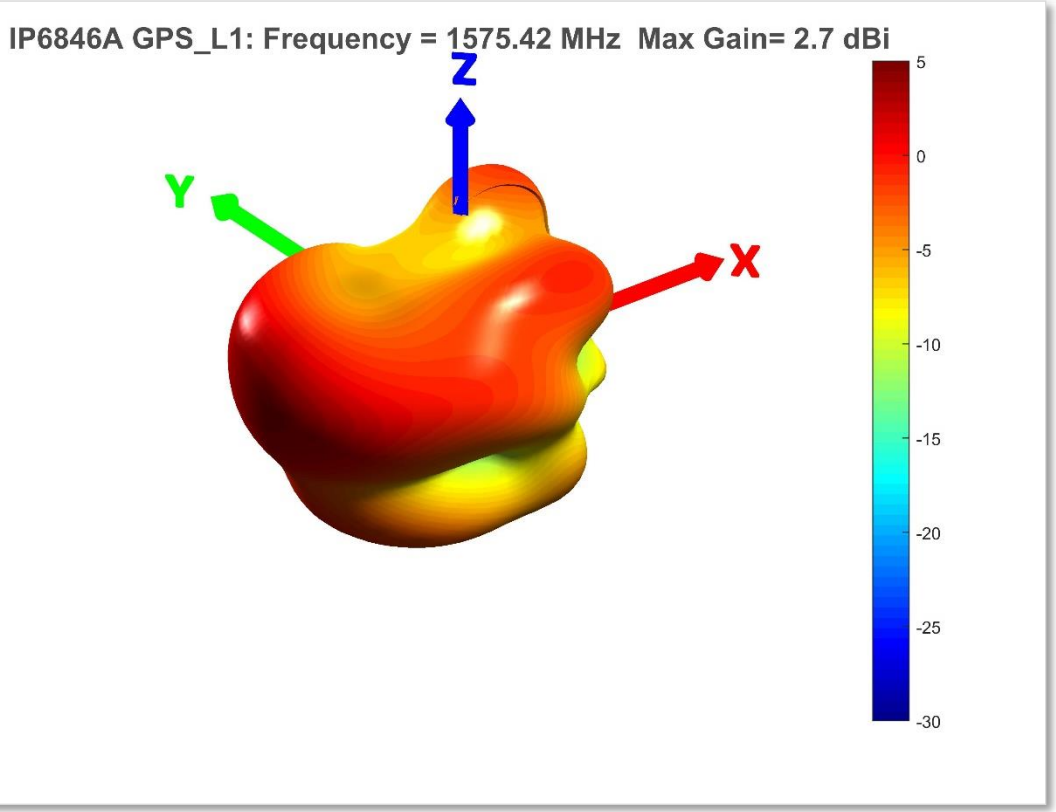
Total Gain 3D Pattern: Thread 2 at 2440MHz



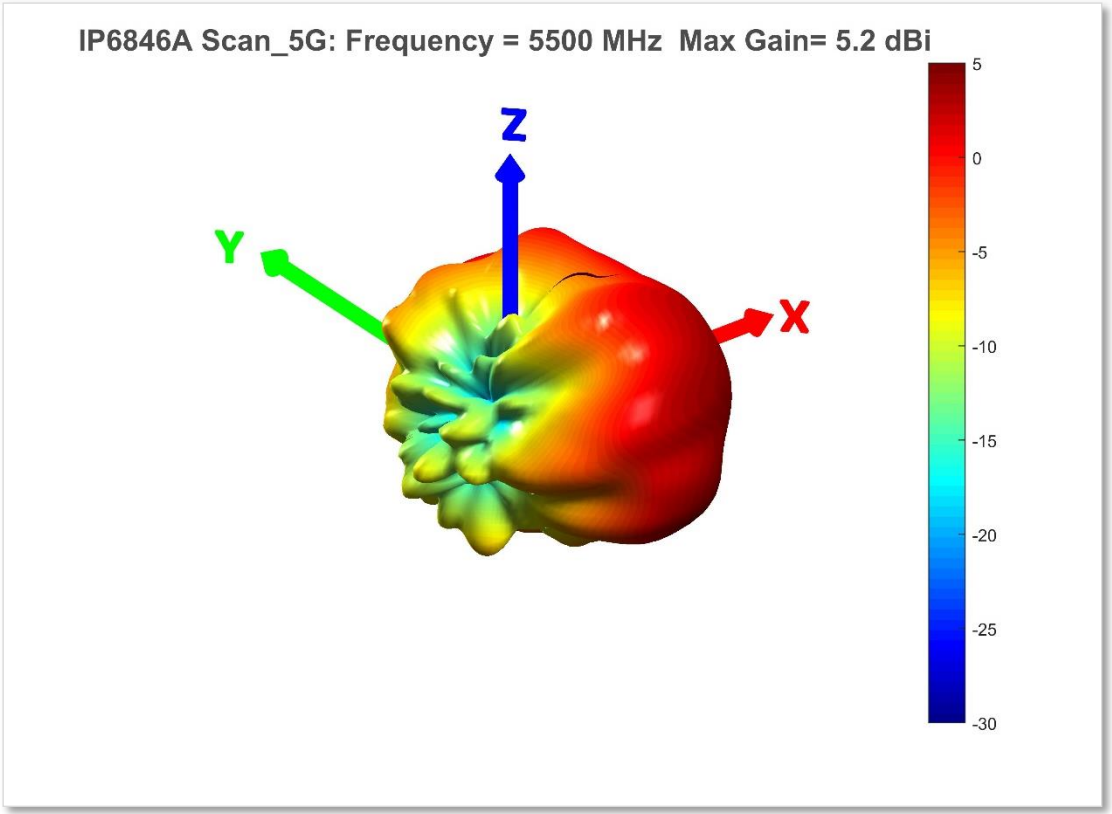
Total Gain 3D Pattern: BLE1_BT/ Thread 1 at 2440MHz



Total Gain 3D Pattern: GPS_L1 at 1575.42MHz



Total Gain 3D Pattern: Scan_5G at 5500MHz



Conclusions

- Return Loss:
  Below -10dB for wifi antennas and GPS
  Below -10dB for BT/Thread antennas
- Isolation:
  Below -20dB between All antennas
- Efficiency:
  WiFi antenna (4 pcs, 2G&5G band) → 2.4G>60%, 5G>55%
  WiFi antenna (4 pcs, 6G band) → 6G>45%
  WiFi antenna (4 pcs, 5G&6G band) → 5G>60% , 6G>55%
  WiFi antenna (1 pcs, 5G band) → 5G>60%
  BT/Thread antenna (2 pcs, 2G4 band) → 2.4G>55%
  GPS antenna (1 pcs, 1575.42MHZ band) → 1575.42MHZ >40%
- Peak Gain:
  Less than 7dBi for antennas in the mockup