



Customer Name & Project: EAO2522P-2 Ver4.3

Prepared By: Jeffrey

Date: 22nd October 2021

Airgain Project Code:

Airgain, Inc.

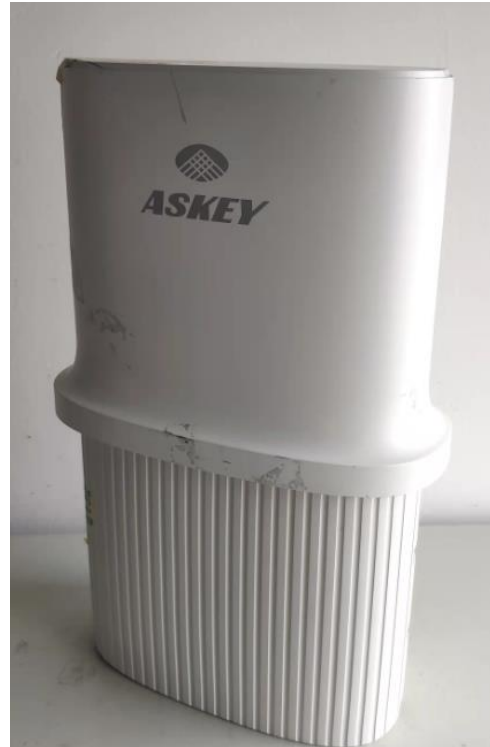
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- This presentation summarizes the antennas system that Airgain plans to develop for EAO2522P-2 project
- The antenna solution is updated based upon the actual devices provided by October 18, 2021

- 2*2G4, 2*5G single band antenna



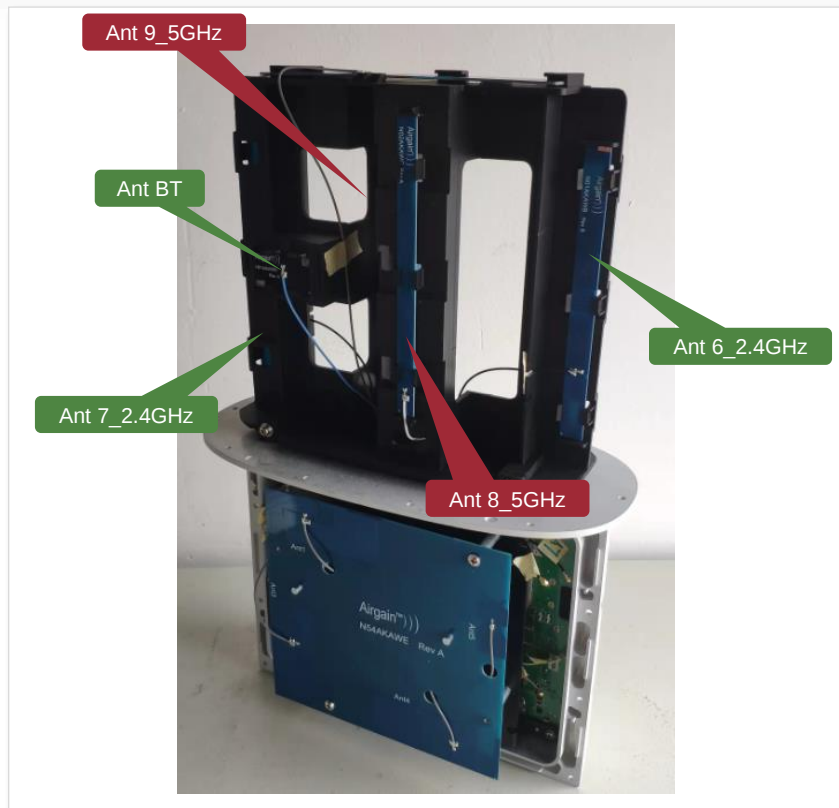
Summary of Requirements



- ANT6&ANT7 : 2400-2485MHz 3.5dBi gain Omni antenna
- ANT8&ANT9 : 5100-5925MHz 6dBi gain Omni antenna
- BT : 2400-2490MHz
- Return loss : <-10 for WiFi
- Isolation : <-20 (Negotiable)
- Efficiency : $>60\%$ (Negotiable)

Airgain Antenna System Proposal

Antenna System Proposal



Antenna #	Part Number	Type	Estimated Cable Length
Ant 6_2.4GHz	N01AKAWB	Dipole, cable fed	200mm
Ant 7_2.4GHz	N01AKAWG	Dipole, cable fed	240mm
Ant 8_5GHz	N02AKAWC	Dipole, cable fed	240mm
Ant 9_5GHz	N02AKAWH	Dipole, cable fed	240mm
Ant BT	N01AKAWD	Dipole, cable fed	210mm

S-Parameters

Actual Equipment List and Calibration Information

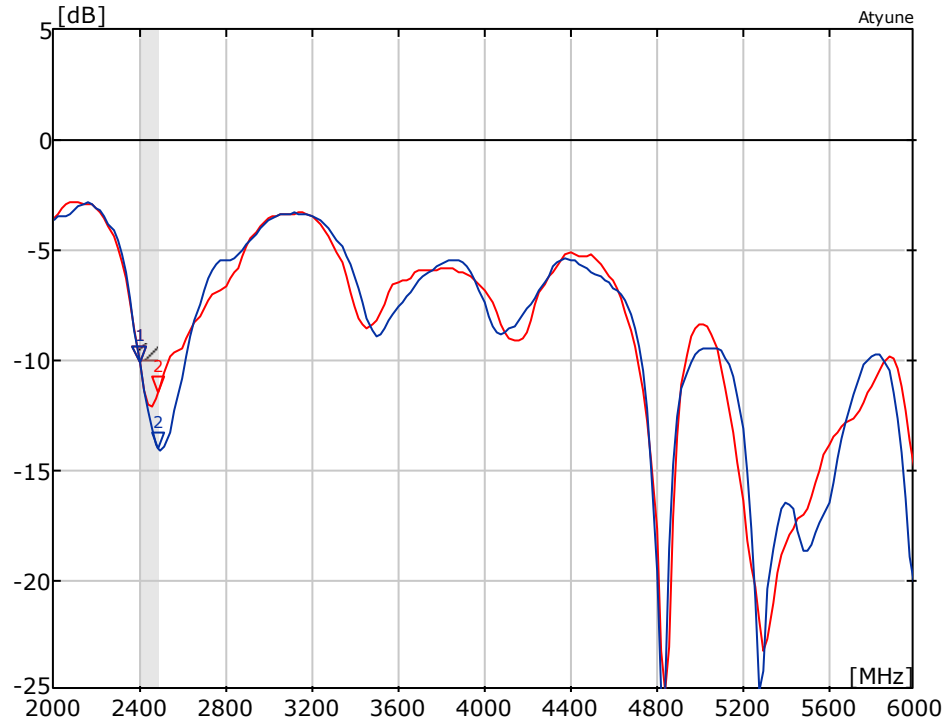


Vendor	Model	Calibrated Date	Calibrated Until
Agilent Technologies	E5071B	2021/8/18	2022/8/18



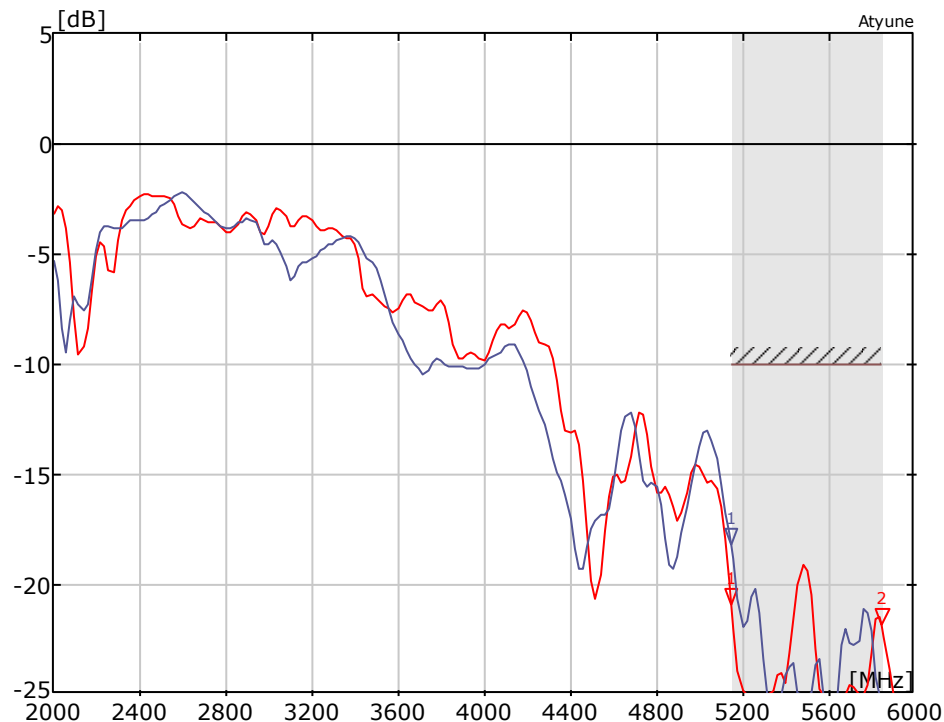
- Test personnel: Jeffrey
- Test date: 21st October 2021

S-Parameter – Return Loss for 2.4GHz Wi-Fi Antennas



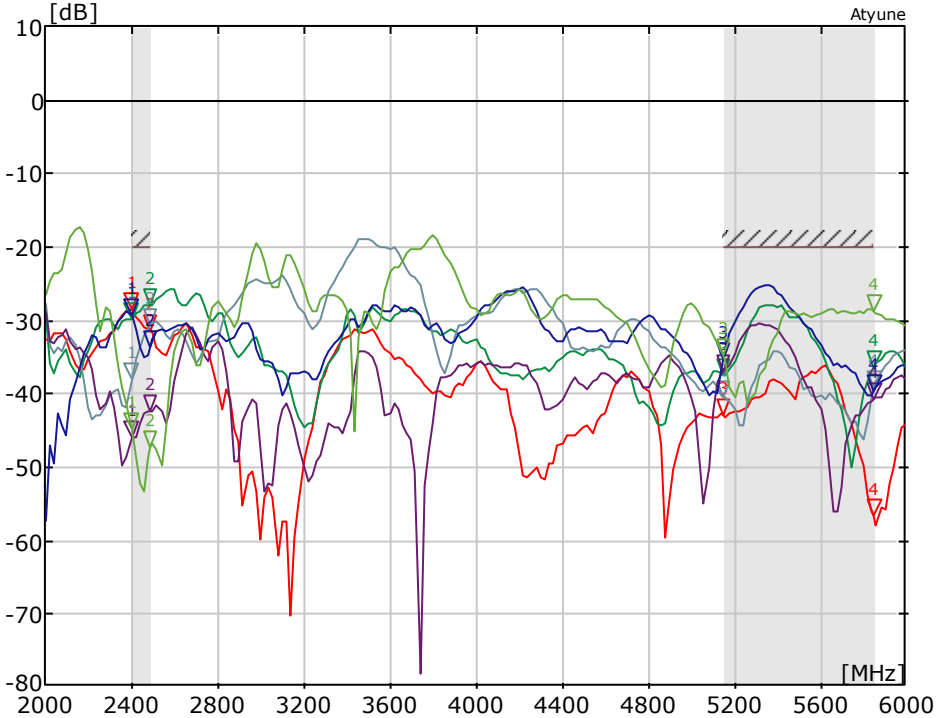
MARKERS:	MHz	dB
Ant 6		
—	1: 2400	-10.07
—	2: 2490	-11.40
Ant 7		
—	1: 2400	-10.05
—	2: 2490	-13.99

S-Parameter – Return Loss for 5GHz Wi-Fi Antennas



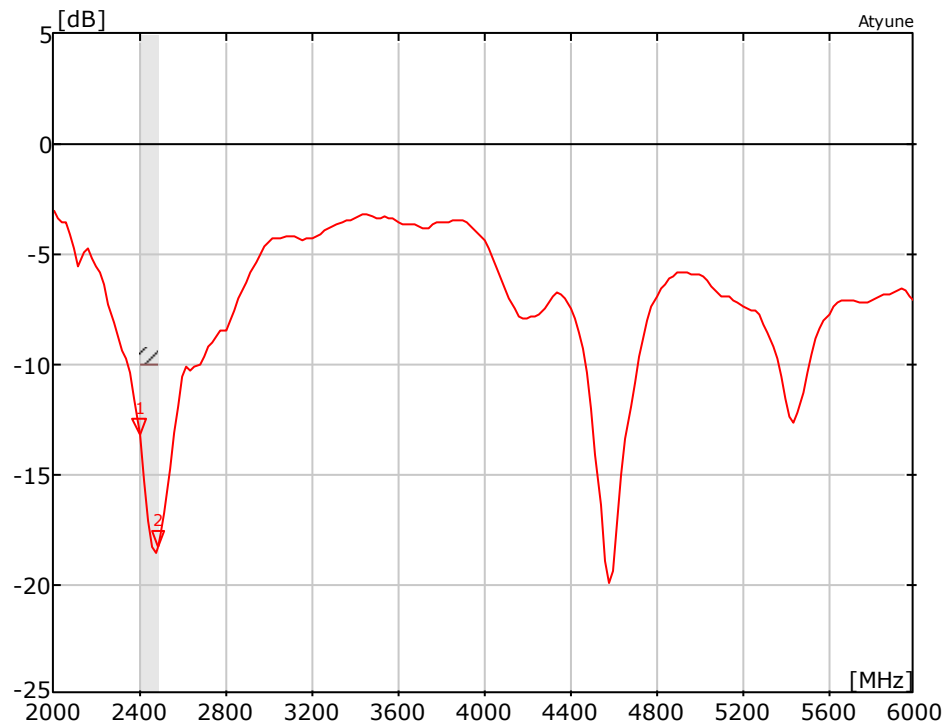
MARKERS:	MHz	dB
Ant 8		
	1: 5150	-20.87
	2: 5850	-21.79
Ant 9		
	1: 5150	-18.12
	2: 5850	-32.00

S-Parameter – Isolation Between 2.4GHz to 5GHz Wi-Fi Antennas



MARKERS:	MHz	dB	MHz	dB
Ant 6 - Ant 7				
	1: 2400	-28.41	3: 5150	-42.79
	2: 2490	-31.32	4: 5850	-56.34
Ant 6 - Ant 8				
	1: 2400	-29.72	3: 5150	-37.27
	2: 2490	-27.86	4: 5850	-36.29
Ant 6 - Ant 9				
	1: 2400	-37.83	3: 5150	-40.21
	2: 2490	-30.59	4: 5850	-39.02
Ant 7 - Ant 8				
	1: 2400	-45.86	3: 5150	-36.82
	2: 2490	-42.27	4: 5850	-40.54
Ant 7 - Ant 9				
	1: 2400	-29.20	3: 5150	-35.18
	2: 2490	-33.53	4: 5850	-39.43
Ant 8 - Ant 9				
	1: 2400	-44.67	3: 5150	-34.64
	2: 2490	-47.12	4: 5850	-28.53

S-Parameter – Return Loss for BT Antennas



MARKERS:	MHz	dB
BT		
1:	2400	-13.15
2:	2490	-18.19

Radiated Measurements

Actual Equipment List and Calibration Information



Vendor	Model	Calibrated Date	Calibrated Until
MVG industries	SLv2	2020/12/13	2021/12/12
ROHDE&SCHWARZ	ZVB.8	2021/8/18	2022/8/18



- 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
- Test personnel: Randy
- Test date: 21st October 2021

1. Fix the DUT on the dielectric support structure and connect the feeding cable to the antenna used for test
2. Set measurement parameters such as frequency range and sampling angle
3. Perform 2D test and then get far-field data (radiation pattern, gain, efficiency)

Step 2: Connect DUT with Chamber



- Connect cable coming from DUT, designated as “Ant 6 ” to the chamber’s cable.
- Run sequence of radiated tests .
- Disconnect the chamber’s cable from Ant 6 .
- Repeat this process for all 5 RF ports of DUT.

Antenna Realized Efficiency (%) – 2.4 & 5 GHz Wi-Fi Antennas



Frequency (MHz)	Ant6_2G4 (%)	Ant7_2G4 (%)
2400	53.3	53.3
2410	54.9	54.5
2420	55.8	55.7
2430	56.0	56.2
2440	57.3	57.6
2450	58.6	59.0
2460	59.0	59.8
2470	59.9	61.0
2480	60.3	61.7
2490	60.2	61.9
Average	57.5	58.1

Frequency (MHz)	Ant8_5G (%)	Ant9_5G (%)
5150	53.0	46.8
5200	56.5	47.4
5300	53.4	51.6
5400	52.6	51.9
5500	55.6	52.7
5600	52.1	51.1
5700	54.2	48.1
5800	50.4	49.9
5850	49.0	49.9
5925	51.6	50.6
Average	52.9	50.0

Antenna Peak Realized Gain – 2.4 & 5 GHz Wi-Fi Antennas



Frequency (MHz)	Ant6_2G4 (dBi)	Ant7_2G4 (dBi)
2400	3.4	3.6
2410	3.5	3.7
2420	3.5	3.7
2430	3.5	3.7
2440	3.6	3.8
2450	3.7	3.9
2460	3.8	4.0
2470	3.8	4.1
2480	3.9	4.2
2490	3.9	4.2

Frequency (MHz)	Ant8_5G (dBi)	Ant9_5G (dBi)
5150	5.0	4.1
5200	5.3	4.1
5300	6.3	5.4
5400	6.5	5.8
5500	7.2	6.4
5600	7.2	6.9
5700	7.5	6.6
5800	7.4	6.8
5850	7.5	6.9
5925	7.9	6.9

Ant10 Peak Gain & Efficiency– Additional BT Antenna



Frequency (MHz)	Peak Gain (dBi)	Efficiency (%)
2400	3.9	59.1
2410	4.1	61.4
2420	4.3	62.5
2430	4.4	63.1
2440	4.6	64.5
2450	4.7	65.1
2460	4.8	65.0
2470	5.0	65.7
2480	5.1	65.8
2490	5.3	65.4
Average	-	63.8

Antenna Horizontal Elevation 30° Gain – 5 GHz Wi-Fi Antennas



5.0GHz Band Ant8

Phi=0(deg) X-Z				
Angle	5150MHz	5200MHz	5300MHz	
300	0.13	0.55	0.68	
303	-0.84	-0.35	-1.04	
306	-1.24	-0.57	-1.42	
309	-1.08	-0.16	-0.32	
312	-0.82	0.35	0.96	
315	-0.85	0.56	1.53	
318	-1.48	0.06	0.88	
321	-3.01	-1.59	-1.39	
324	-5.28	-4.73	-5.51	
327	-7.12	-8.84	-10.31	
330	-7.74	-10.35	-10.62	
333	-7.54	-8.81	-8.93	
336	-6.29	-6.85	-8.14	
339	-4.74	-5.28	-8.35	
342	-3.98	-4.53	-8.48	
345	-4.19	-4.40	-6.91	
348	-5.10	-4.49	-4.74	
351	-6.40	-4.93	-3.59	
354	-8.25	-6.39	-4.12	
357	-11.05	-9.57	-6.89	
0	-13.34	-13.83	-12.49	
3	-11.70	-13.33	-13.22	
6	-9.00	-10.38	-9.17	
9	-6.95	-8.05	-7.53	
12	-5.70	-6.39	-7.37	
15	-5.43	-5.74	-7.89	
18	-6.29	-6.34	-8.83	
21	-8.07	-8.30	-10.30	
24	-9.16	-10.68	-10.94	
27	-8.11	-10.12	-8.80	
30	-7.09	-8.16	-6.78	
33	-7.31	-7.44	-6.32	
36	-8.03	-7.31	-6.68	
39	-7.47	-6.31	-6.03	
42	-6.13	-5.08	-4.38	
45	-5.58	-4.84	-3.20	
48	-6.06	-5.66	-2.89	
51	-6.80	-6.37	-3.18	
54	-6.61	-5.74	-3.53	
57	-5.20	-4.26	-3.37	
60	-2.96	-2.33	-2.50	

From to Black (XZ)	5150MHz	5200MHz	5300MHz
Max Value -60<θ<60	0.13	0.56	1.53

5.0GHz Band Ant8

Phi=90.00000000000002(deg) Y-Z				
Angle	5150MHz	5200MHz	5300MHz	
300	-4.59	-3.93	-2.74	
303	-4.67	-4.08	-3.44	
306	-4.74	-4.66	-5.50	
309	-4.48	-4.53	-6.17	
312	-3.96	-3.65	-4.30	
315	-4.30	-3.75	-3.84	
318	-6.59	-6.11	-6.33	
321	-10.62	-10.80	-11.38	
324	-8.22	-8.55	-7.61	
327	-4.22	-4.41	-3.82	
330	-2.45	-2.72	-2.82	
333	-2.30	-2.66	-3.58	
336	-3.19	-3.58	-5.01	
339	-4.66	-4.98	-5.94	
342	-6.34	-6.58	-6.53	
345	-8.14	-8.41	-7.86	
348	-10.20	-10.84	-10.41	
351	-12.59	-14.44	-13.73	
354	-14.74	-19.09	-15.09	
357	-14.97	-17.82	-13.75	
0	-13.34	-13.83	-12.49	
3	-11.60	-11.42	-11.92	
6	-10.17	-9.87	-11.52	
9	-8.84	-8.43	-10.48	
12	-7.62	-7.01	-8.82	
15	-6.75	-6.05	-7.41	
18	-6.34	-5.99	-6.92	
21	-6.23	-6.92	-7.74	
24	-6.16	-8.10	-10.15	
27	-6.04	-7.66	-12.47	
30	-5.93	-5.89	-9.32	
33	-5.88	-4.60	-5.59	
36	-5.59	-4.20	-3.47	
39	-4.42	-4.06	-2.58	
42	-2.41	-3.14	-2.33	
45	-0.54	-1.71	-2.24	
48	0.44	-0.85	-2.37	
51	0.16	-1.16	-3.31	
54	-1.69	-2.90	-5.66	
57	-5.53	-6.45	-9.30	
60	-9.84	-10.07	-8.73	

Side to Side (YZ)	5150MHz	5200MHz	5300MHz
Max Value -60<θ<60	0.44	-0.85	-2.24

5.0GHz Band Ant9

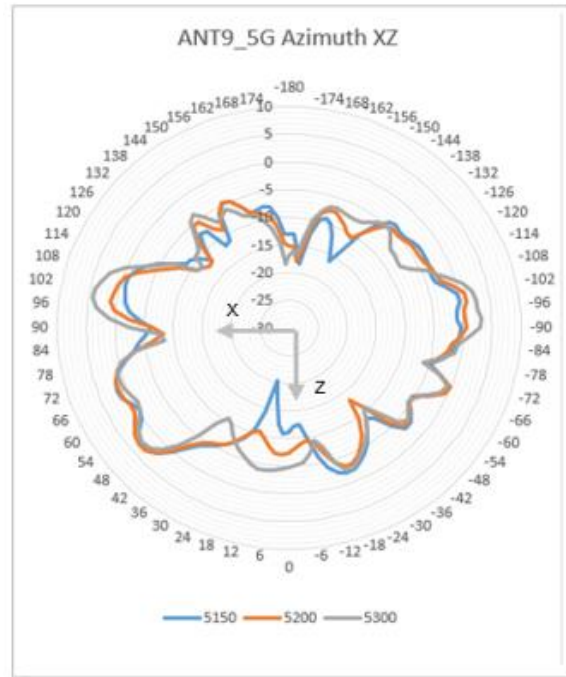
Phi=0(deg) X-Z				
Angle	5150MHz	5200MHz	5300MHz	
300	-5.43	-5.08	-4.60	
303	-5.28	-5.35	-5.46	
306	-4.04	-4.39	-4.55	
309	-2.89	-3.26	-3.47	
312	-2.94	-3.48	-4.60	
315	-4.84	-5.85	-8.31	
318	-8.13	-10.64	-10.74	
321	-8.94	-13.23	-8.87	
324	-6.90	-9.61	-7.19	
327	-5.13	-6.93	-5.76	
330	-3.85	-5.23	-4.55	
333	-2.89	-3.92	-3.38	
336	-2.21	-3.08	-2.38	
339	-1.98	-3.12	-2.37	
342	-2.43	-4.32	-4.11	
345	-3.78	-6.58	-7.76	
348	-6.19	-8.84	-9.32	
351	-9.57	-9.50	-6.93	
354	-12.47	-9.05	-5.59	
357	-12.29	-8.25	-5.20	
0	-11.01	-7.39	-4.84	
3	-10.74	-6.97	-4.39	
6	-12.27	-7.30	-4.04	
9	-16.60	-8.32	-3.88	
12	-20.20	-9.69	-4.03	
15	-14.26	-10.65	-4.57	
18	-10.60	-10.33	-5.38	
21	-8.65	-8.98	-6.31	
24	-7.41	-7.49	-7.33	
27	-6.42	-6.33	-8.59	
30	-5.53	-5.59	-9.97	
33	-4.73	-5.14	-10.62	
36	-3.78	-4.41	-8.59	
39	-2.12	-2.64	-4.69	
42	0.12	-0.19	-1.26	
45	2.07	1.93	1.09	
48	3.13	3.18	2.38	
51	3.10	3.46	2.68	
54	2.03	2.83	2.11	
57	0.40	1.64	0.90	
60	-0.30	0.73	-0.32	

From to Black (XZ)	5150MHz	5200MHz	5300MHz
Max Value -60<θ<60	3.13	3.46	2.68

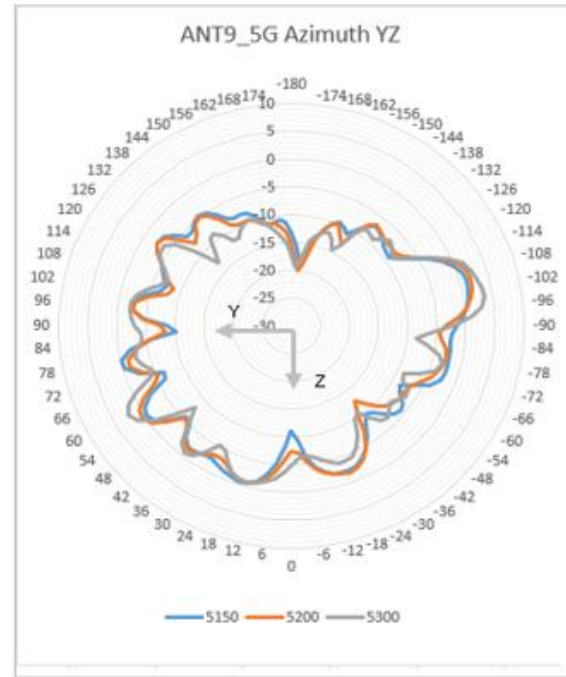
5.0GHz Band Ant9

Phi=90.00000000000002(deg) Y-Z				
Angle	5150MHz	5200MHz	5300MHz	
300	-8.45	-7.12	-6.93	
303	-7.74	-7.11	-6.64	
306	-6.32	-7.20	-7.41	
309	-5.79	-7.65	-7.98	
312	-6.24	-8.35	-7.39	
315	-7.48	-9.41	-6.71	
318	-9.09	-11.16	-7.07	
321	-9.69	-12.63	-8.72	
324	-8.28	-10.52	-10.63	
327	-6.20	-7.07	-9.82	
330	-4.44	-4.51	-7.26	
333	-3.18	-2.91	-5.27	
336	-2.43	-2.06	-4.19	
339	-2.13	-1.78	-3.85	
342	-2.19	-1.92	-4.03	
345	-2.50	-2.34	-4.55	
348	-3.12	-2.98	-5.29	
351	-4.27	-3.98	-6.05	
354	-6.32	-5.45	-6.43	
357	-9.38	-7.08	-6.02	
0	-11.01	-7.39	-4.84	
3	-8.14	-5.70	-3.44	
6	-4.95	-3.62	-2.27	
9	-2.74	-2.07	-1.47	
12	-1.36	-1.13	-1.01	
15	-0.65	-0.75	-0.83	
18	-0.51	-0.90	-0.98	
21	-0.81	-1.54	-1.63	
24	-1.39	-2.50	-2.99	
27	-2.04	-3.23	-4.84	
30	-2.51	-3.14	-5.19	
33	-2.42	-2.35	-3.08	
36	-1.88	-1.55	-1.12	
39	-1.77	-1.44	-0.58	
42	-2.95	-2.54	-1.78	
45	-5.33	-4.78	-4.93	
48	-5.46	-5.12	-7.86	
51	-2.76	-2.38	-4.61	
54	-0.90	-0.26	-0.82	
57	-0.30	0.57	1.47	
60	-0.79	0.26	2.27	

Side to Side (YZ)	5150MHz	5200MHz	5300MHz
Max Value -60<θ<60	-0.30	0.57	2.27

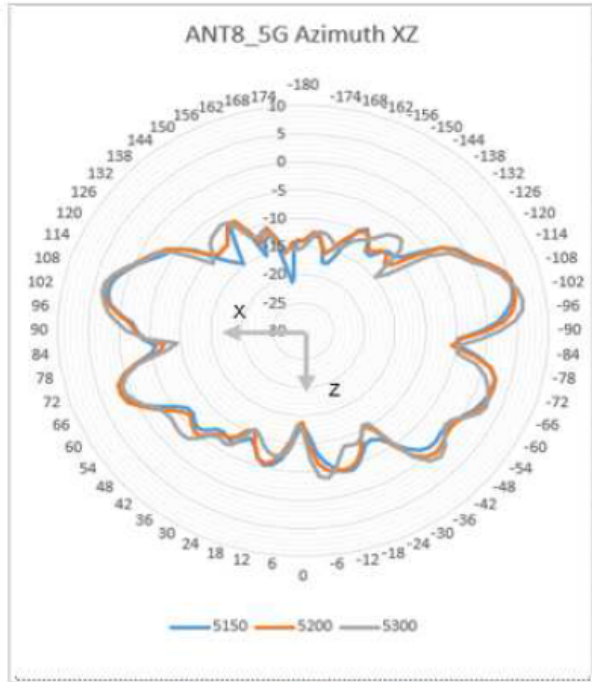


Front to Back (XZ)

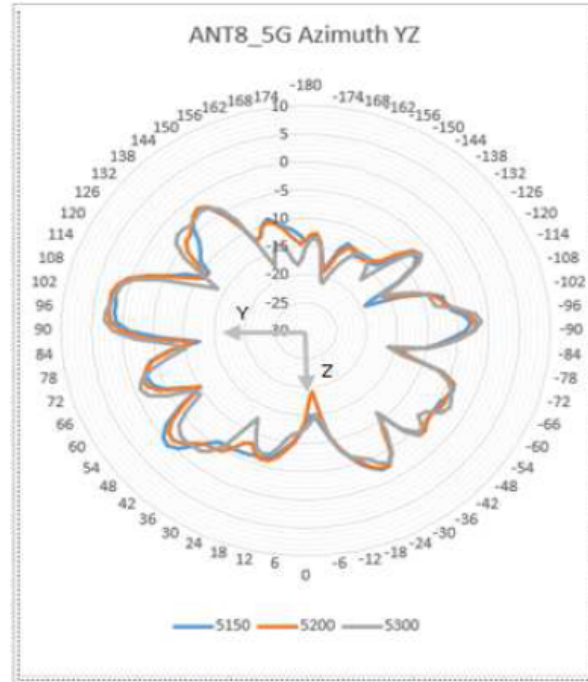


Side to Side (YZ)





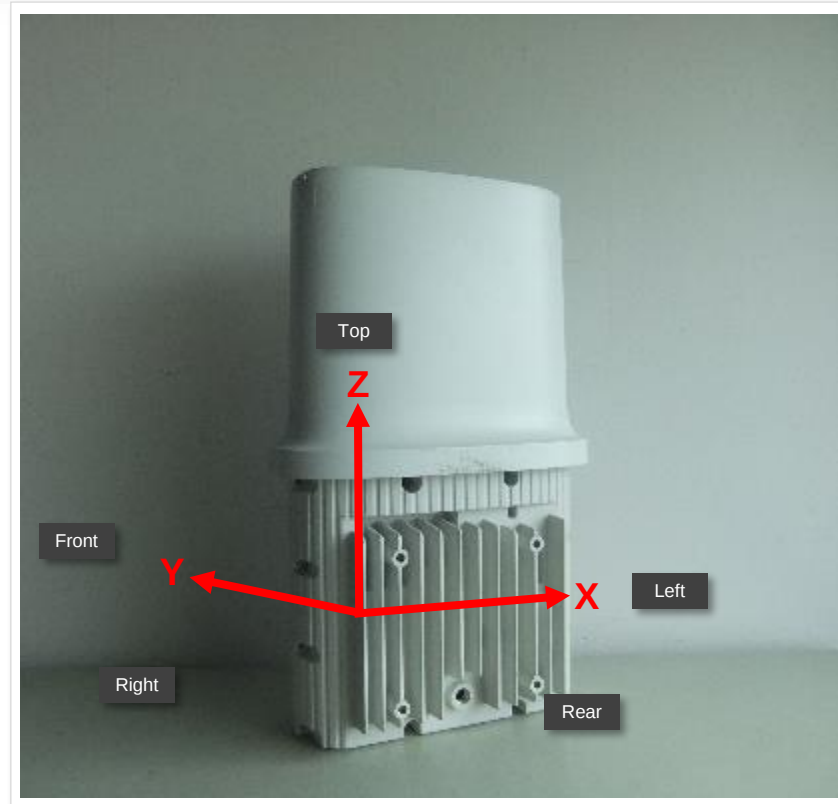
Front to Back (XZ)



Side to Side (YZ)



Radiation Patterns

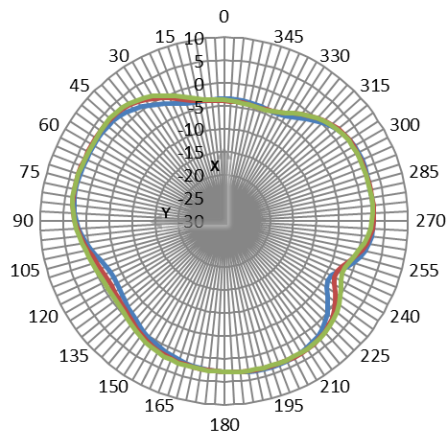


Orientation of EAO2522P

Total Gain Patterns: Ant6_2G4



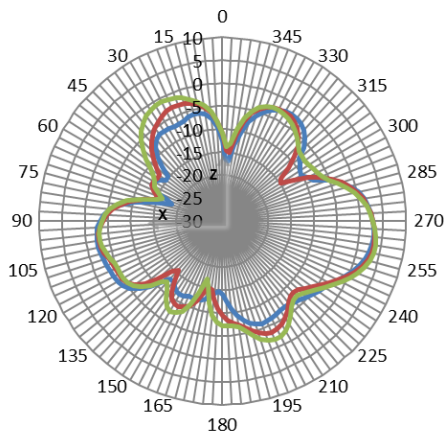
Ant6_2G4 Azimuth XY



— 2400MHz: Max=3.41 Avg=1.01
— 2440MHz: Max=3.39 Avg=1.35
— 2480MHz: Max=3.39 Avg=1.46

Azimuth (XY)

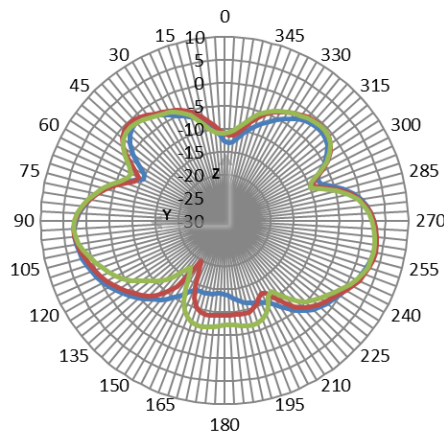
Ant6_2G4 Elevation XZ



— 2400MHz: Max=3.16 Avg=-4.17
— 2440MHz: Max=3.54 Avg=-3.88
— 2480MHz: Max=3.78 Avg=-3.31

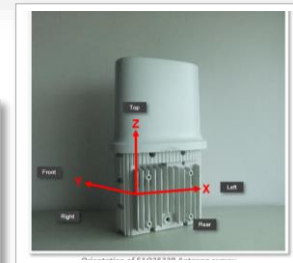
Front to Back (XZ)

Ant6_2G4 Elevation YZ



— 2400MHz: Max=3.25 Avg=-2.31
— 2440MHz: Max=3.53 Avg=-2.10
— 2480MHz: Max=3.12 Avg=-2.46

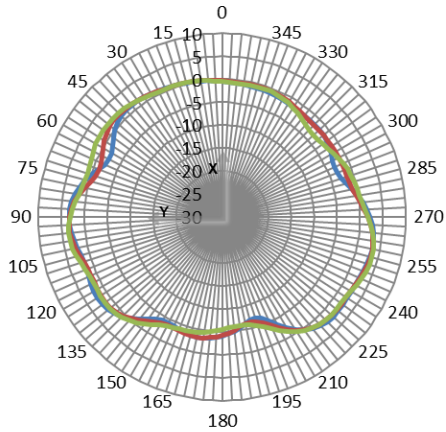
Side to Side (YZ)



Total Gain Patterns: Ant7_2G4



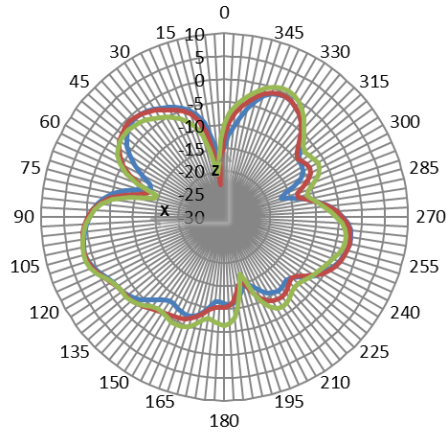
Ant7_2G4 Azimuth XY



— 2400MHz: Max=3.36 Avg=-0.27
— 2440MHz: Max=3.43 Avg=0.32
— 2480MHz: Max=3.77 Avg=0.52

Azimuth (XY)

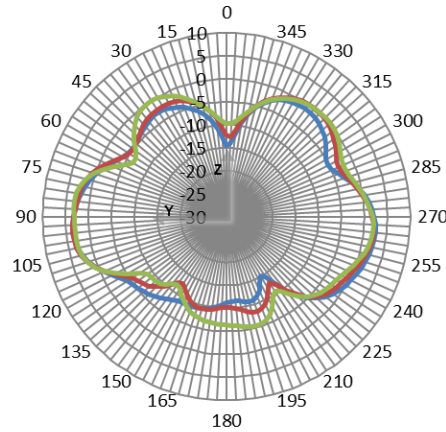
Ant7_2G4 Elevation XZ



— 2400MHz: Max=1.40 Avg=-4.42
— 2440MHz: Max=1.61 Avg=-4.06
— 2480MHz: Max=1.82 Avg=-3.91

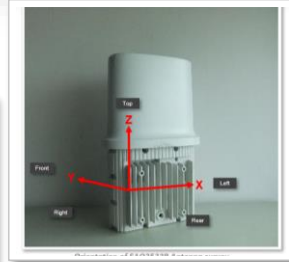
Front to Back (XZ)

Ant7_2G4 Elevation YZ

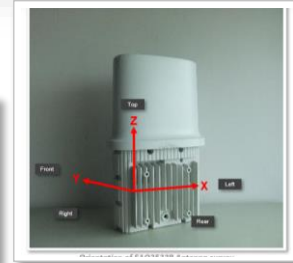


— 2400MHz: Max=3.60 Avg=-1.99
— 2440MHz: Max=3.61 Avg=-1.82
— 2480MHz: Max=3.26 Avg=-1.63

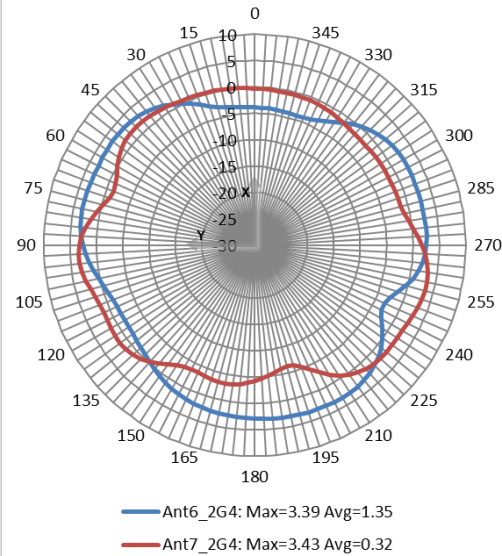
Side to Side (YZ)



Coverage Total Gain Patterns: Wi-Fi Antennas at 2440MHz

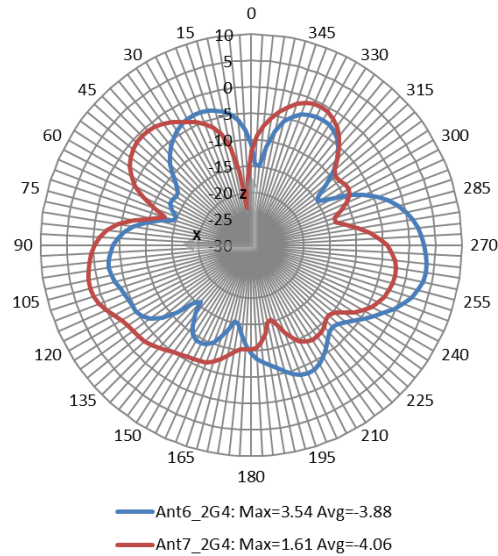


Azimuth XY 2440MHz



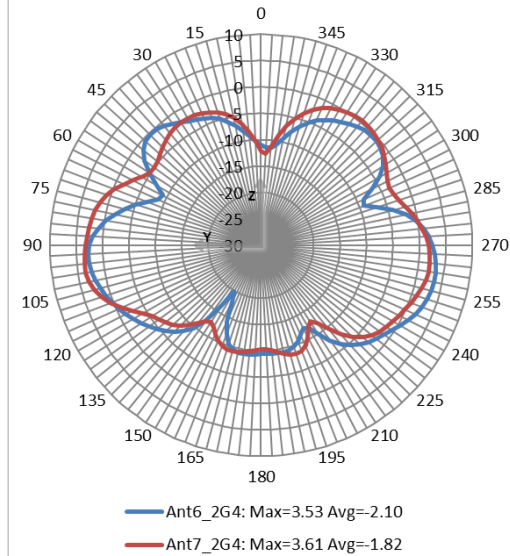
Azimuth (XY)

Elevation XZ 2440MHz



Front to Back (XZ)

Elevation YZ 2440MHz

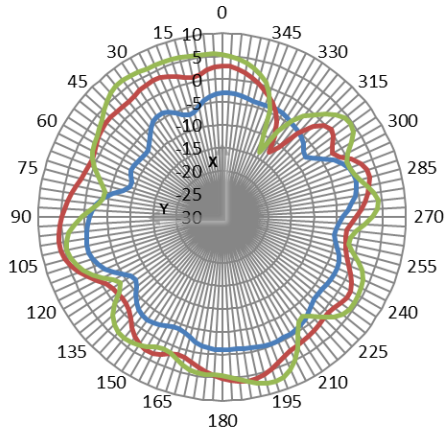


Side to Side (YZ)

Total Gain Patterns: Ant8_5G



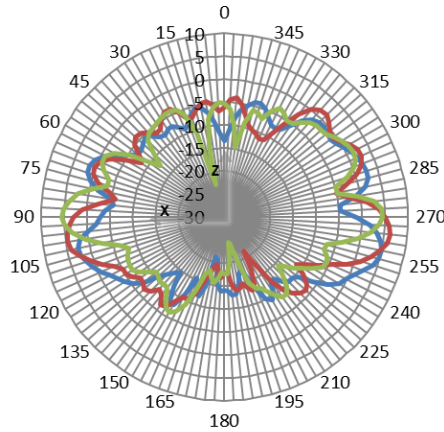
Ant8_5G Azimuth XY



— 5150MHz: Max=0.20 Avg=-2.96
— 5500MHz: Max=6.19 Avg=2.18
— 5925MHz: Max=7.69 Avg=3.34

Azimuth (XY)

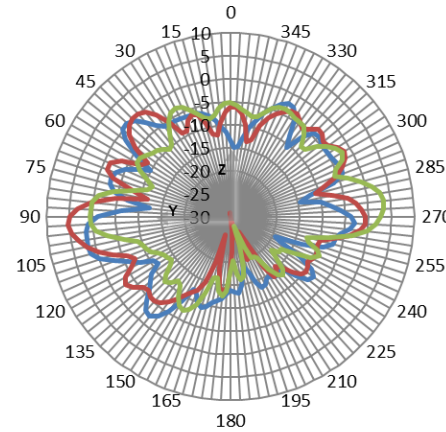
Ant8_5G Elevation XZ



— 5150MHz: Max=4.95 Avg=-2.46
— 5500MHz: Max=6.35 Avg=-1.71
— 5925MHz: Max=5.36 Avg=-2.98

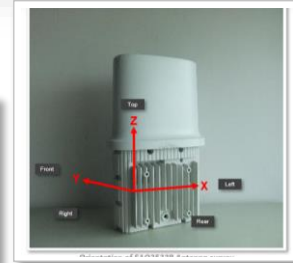
Front to Back (XZ)

Ant8_5G Elevation YZ



— 5150MHz: Max=1.74 Avg=-5.34
— 5500MHz: Max=5.39 Avg=-4.05
— 5925MHz: Max=3.41 Avg=-5.10

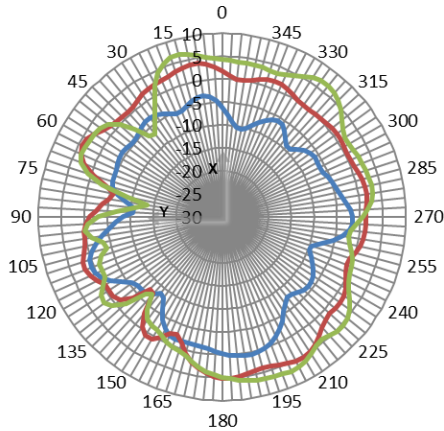
Side to Side (YZ)



Total Gain Patterns: Ant9_5G



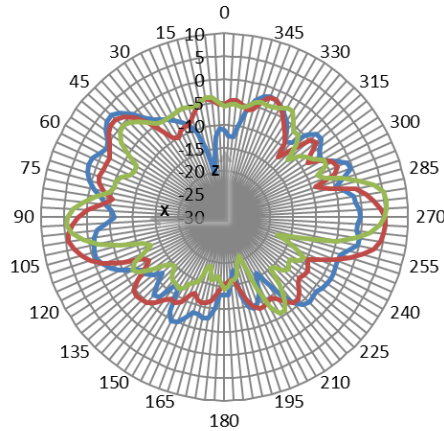
Ant9_5G Azimuth XY



— 5150MHz: Max=0.57 Avg=-3.90
— 5500MHz: Max=5.26 Avg=1.72
— 5925MHz: Max=6.83 Avg=3.02

Azimuth (XY)

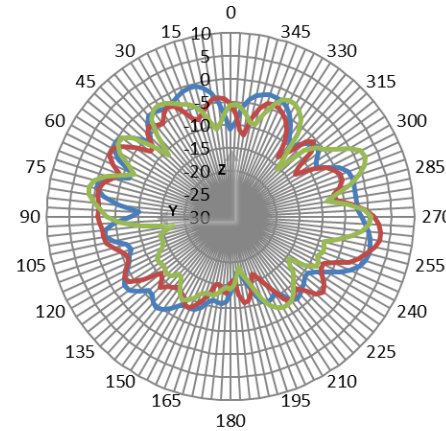
Ant9_5G Elevation XZ



— 5150MHz: Max=3.13 Avg=-3.44
— 5500MHz: Max=5.22 Avg=-2.34
— 5925MHz: Max=5.51 Avg=-3.24

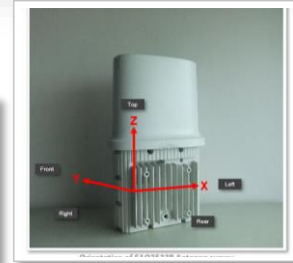
Front to Back (XZ)

Ant9_5G Elevation YZ

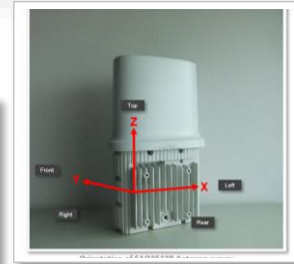


— 5150MHz: Max=1.22 Avg=-3.98
— 5500MHz: Max=2.97 Avg=-4.41
— 5925MHz: Max=2.11 Avg=-4.90

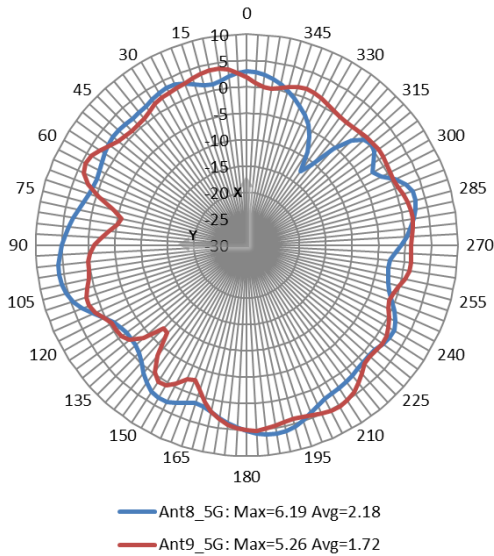
Side to Side (YZ)



Coverage Total Gain Patterns: Wi-Fi Antennas at 5500MHz

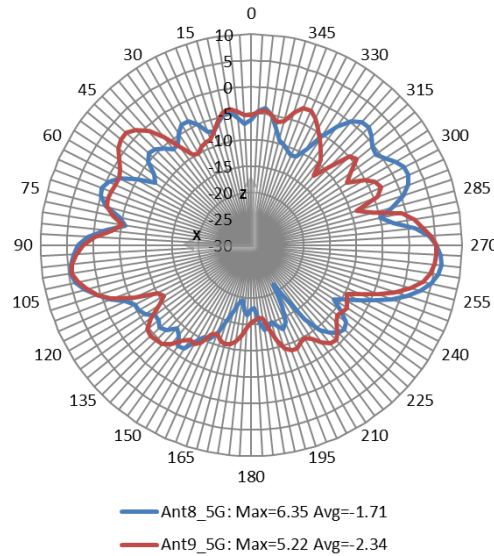


Azimuth XY 5500MHz



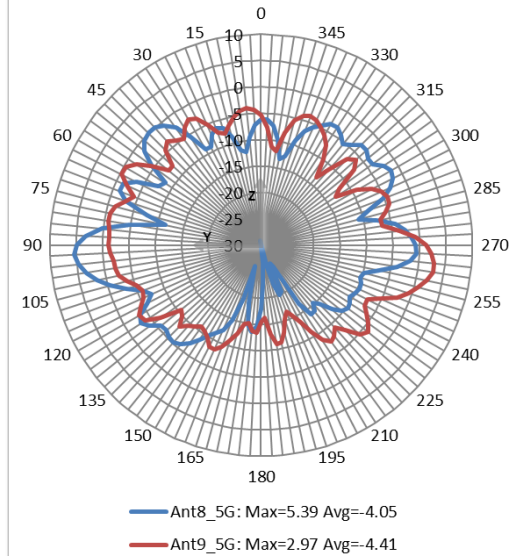
Azimuth (XY)

Elevation XZ 5500MHz



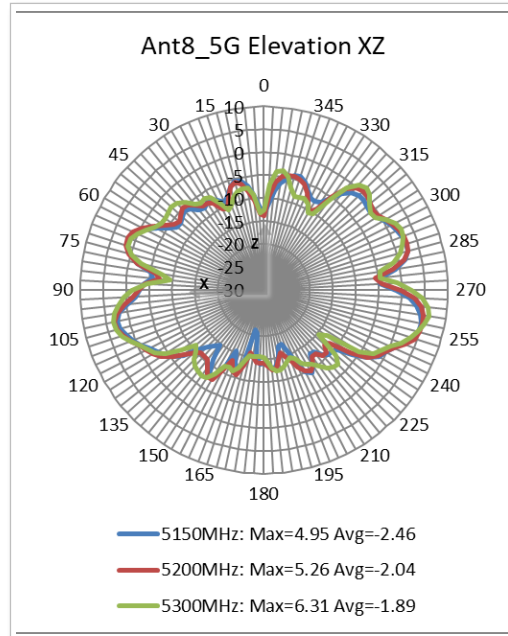
Front to Back (XZ)

Elevation YZ 5500MHz

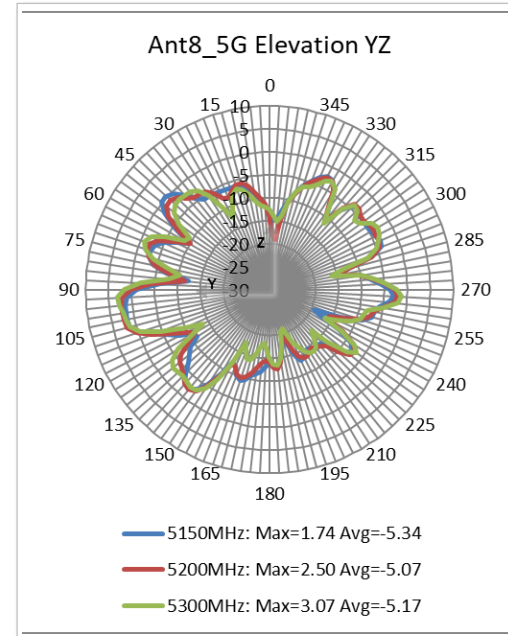


Side to Side (YZ)

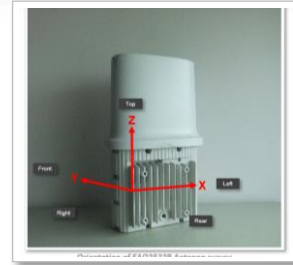
Total Gain Patterns: Ant8_5G



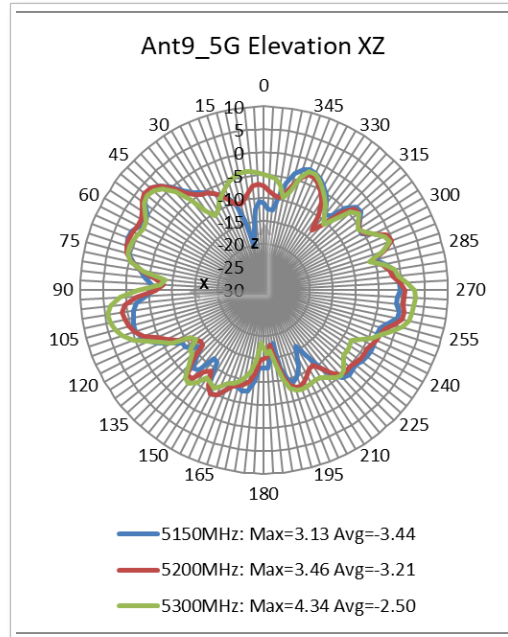
Side to Side (XZ)



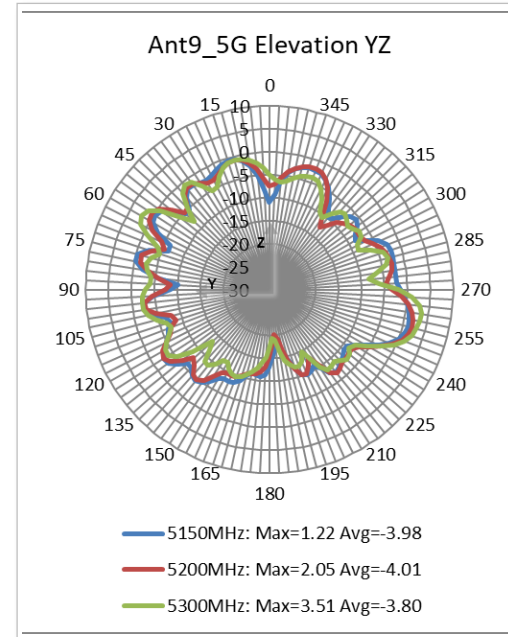
Front to Back (YZ)



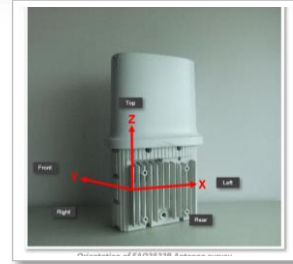
Total Gain Patterns: Ant9_5G



Side to Side (XZ)



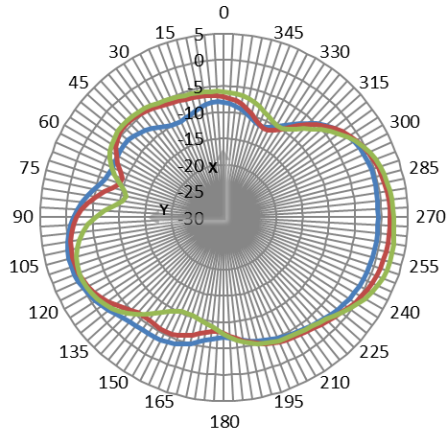
Front to Back (YZ)



Total Gain Patterns: Ant10_BT



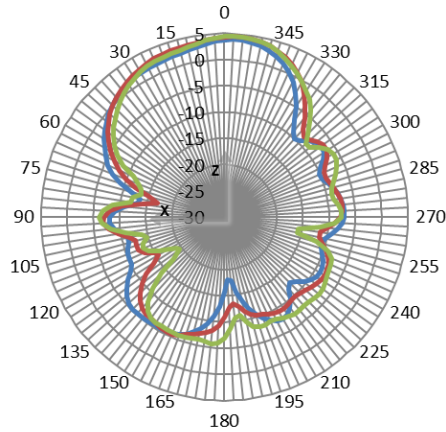
Ant10_BT Azimuth XY



— 2400MHz: Max=0.55 Avg=-3.34
— 2440MHz: Max=1.67 Avg=-2.78
— 2480MHz: Max=2.77 Avg=-2.59

Azimuth (XY)

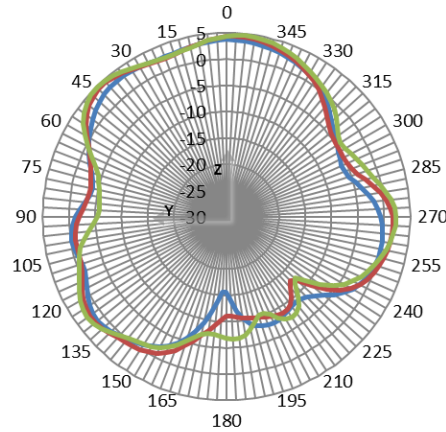
Ant10_BT Elevation XZ



— 2400MHz: Max=3.86 Avg=-3.07
— 2440MHz: Max=4.47 Avg=-2.51
— 2480MHz: Max=4.49 Avg=-2.62

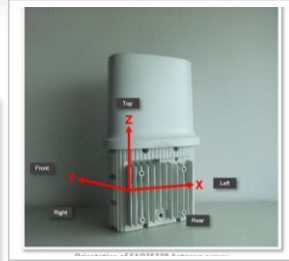
Front to Back (XZ)

Ant10_BT Elevation YZ



— 2400MHz: Max=3.76 Avg=-0.34
— 2440MHz: Max=4.43 Avg=0.19
— 2480MHz: Max=4.79 Avg=0.39

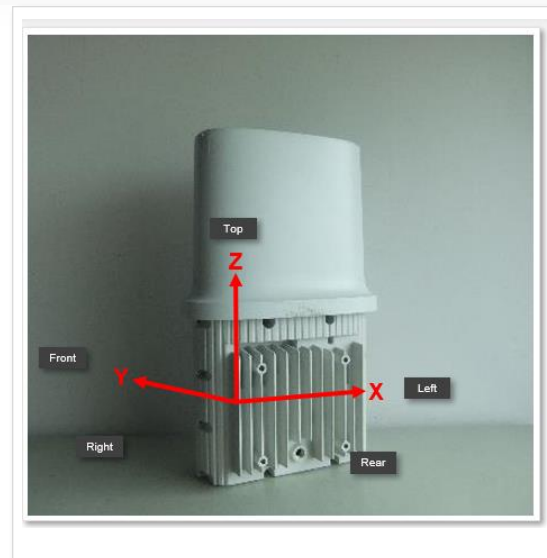
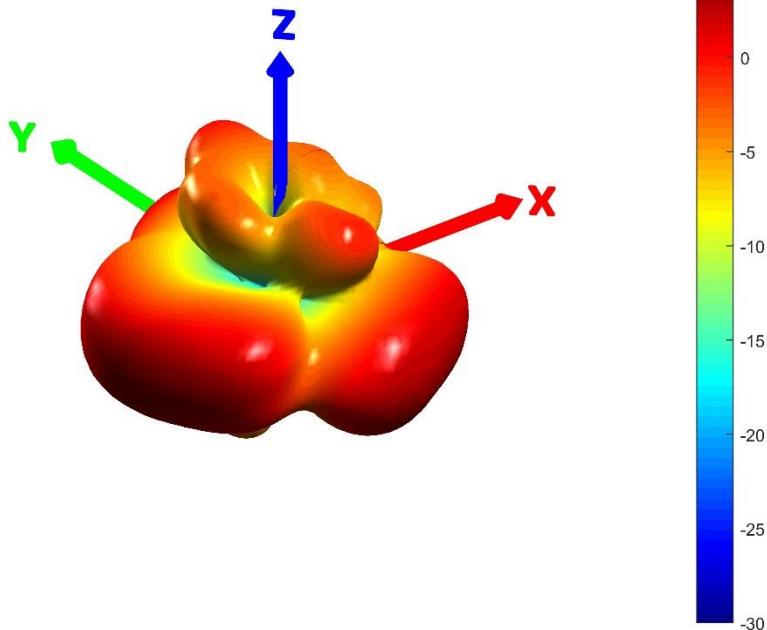
Side to Side (YZ)



Total Gain 3D Pattern: Ant6_2G4 at 2440MHz



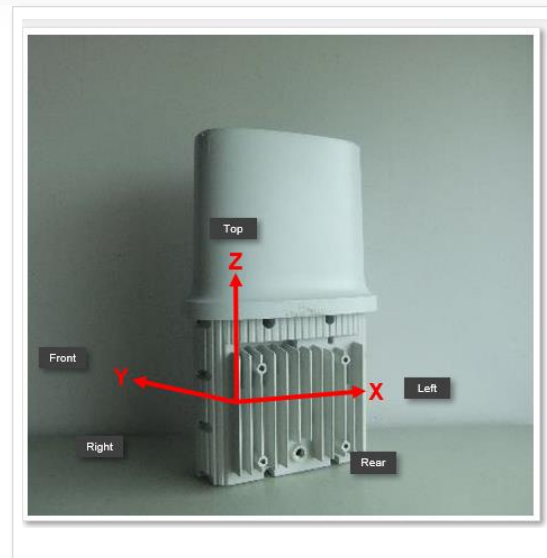
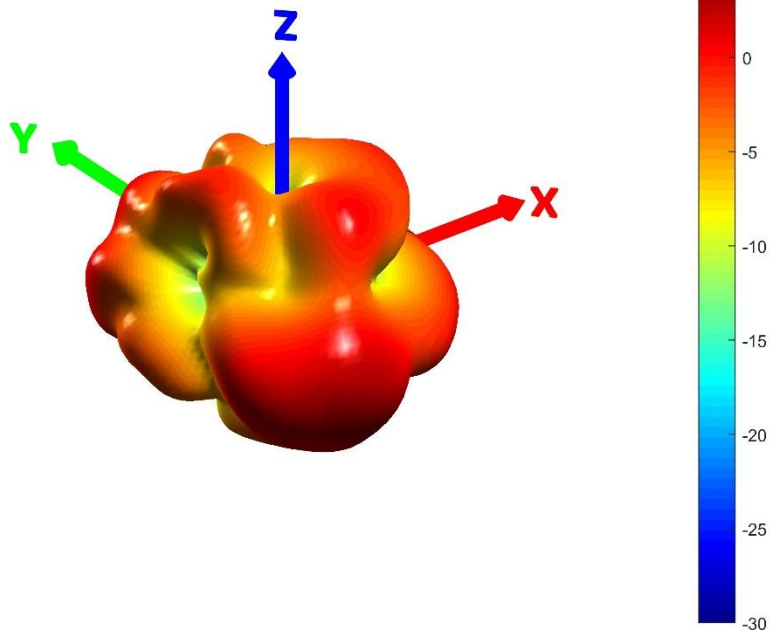
EAO2522P Ant6_2G4: Frequency = 2440 MHz Peak Gain = 3.6 dBi



Total Gain 3D Pattern: Ant7_2G4 at 2440MHz



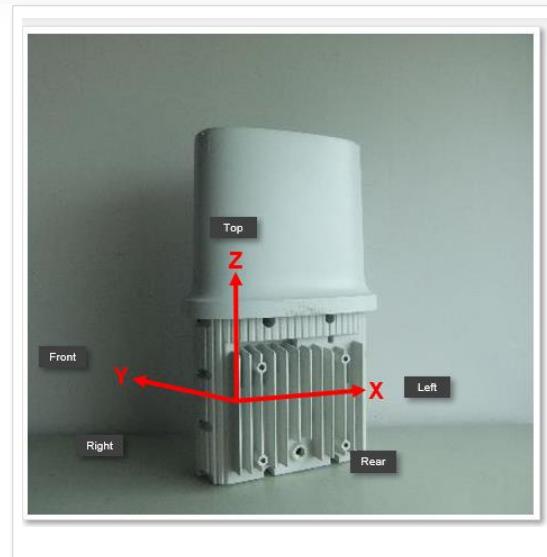
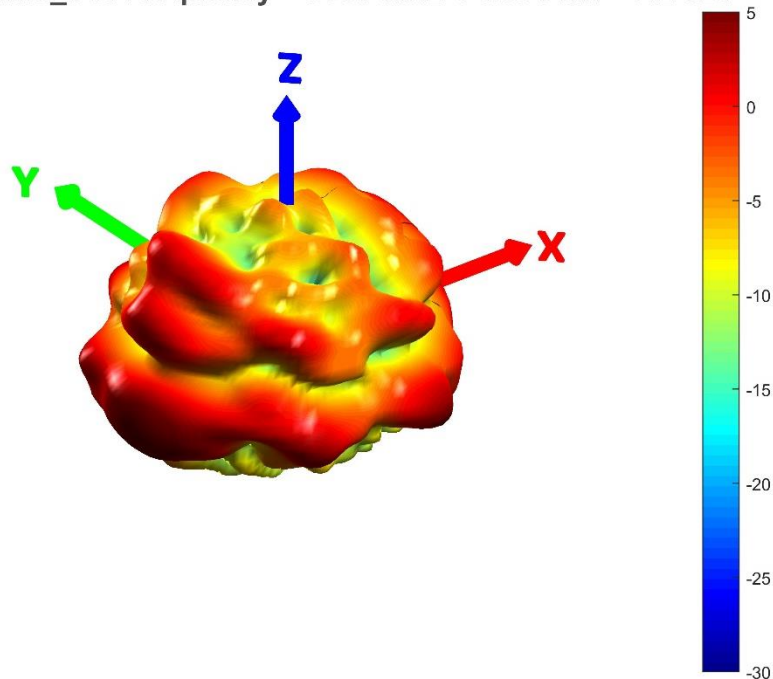
EA02522P Ant7_2G4: Frequency = 2440 MHz Peak Gain = 3.8 dBi



Total Gain 3D Pattern: Ant8_5G at 5500MHz



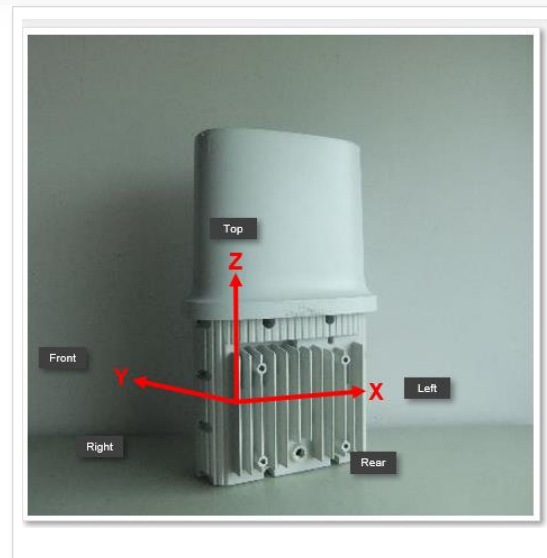
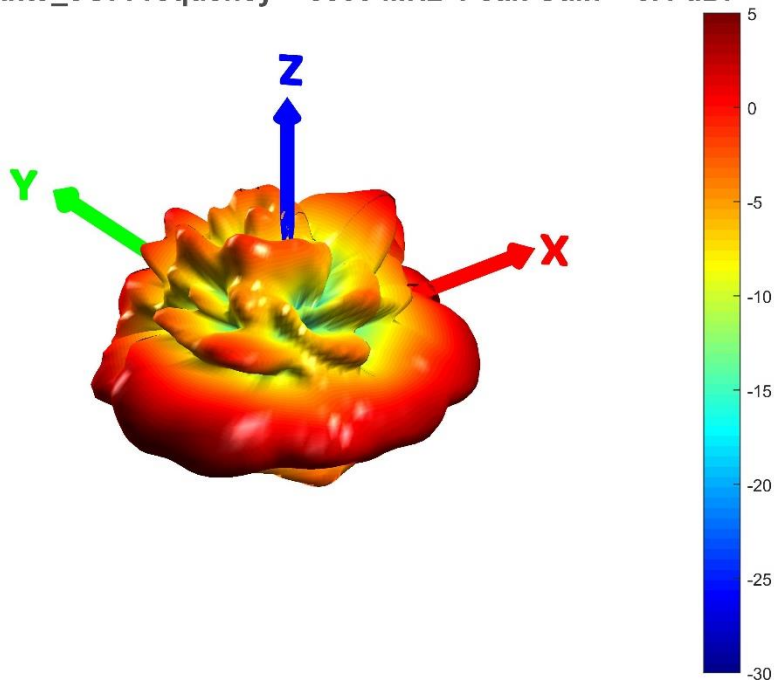
EAO2522P Ant8_5G: Frequency = 5500 MHz Peak Gain = 7.2 dBi



Total Gain 3D Pattern: Ant9_5G at 5500MHz



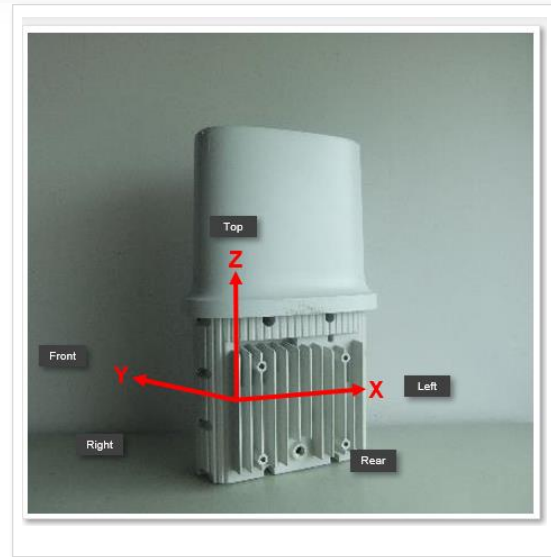
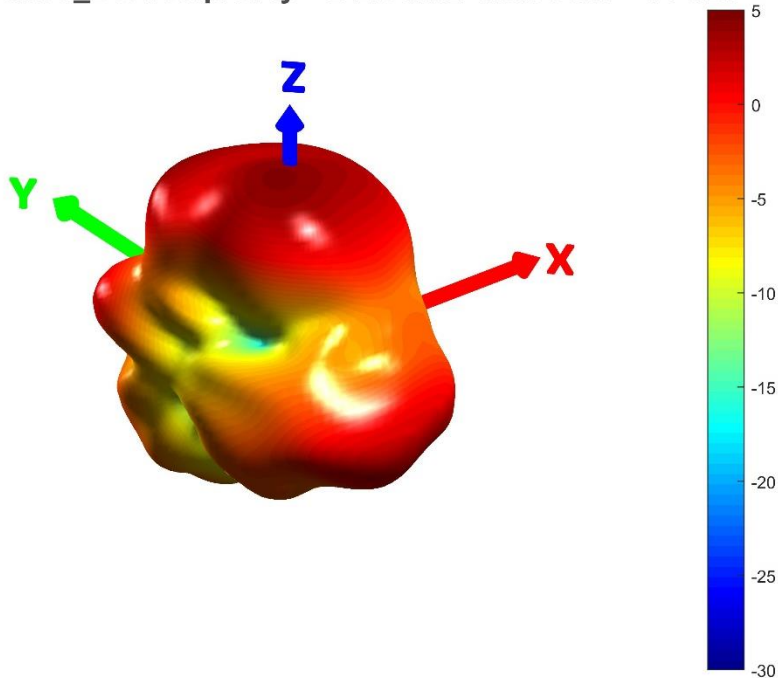
EAO2522P Ant9_5G: Frequency = 5500 MHz Peak Gain = 6.4 dBi



Total Gain 3D Pattern: Ant10_BT at 2440MHz



EAO2522P Ant10_BT: Frequency = 2440 MHz Max Gain= 4.6 dBi



- Return loss : < -10 for WiFi
- Isolation : < -20 for WiFi
- Efficiency : $> 48\%$ for all antennas
- Peak Gain : Ant6&Ant7: 2400-2485MHz 3.5dBi gain Omni antenna
Ant8&Ant9: 5150-5925MHz 6dBi gain Omni antenna