FAP-441K
DVT Antenna Test Report

Customer	Fortinet
Project	FAP-441K
Project Description	Wi-Fi _ 2/5G*4 Wi-Fi _ 6G*4 Scanning_2/5/6G*2 BLE/Zigbee*1 GPS*1
Date	2023/09/19
Prepared by	Daniel
Report Version	V2

Senao Networks, Inc.

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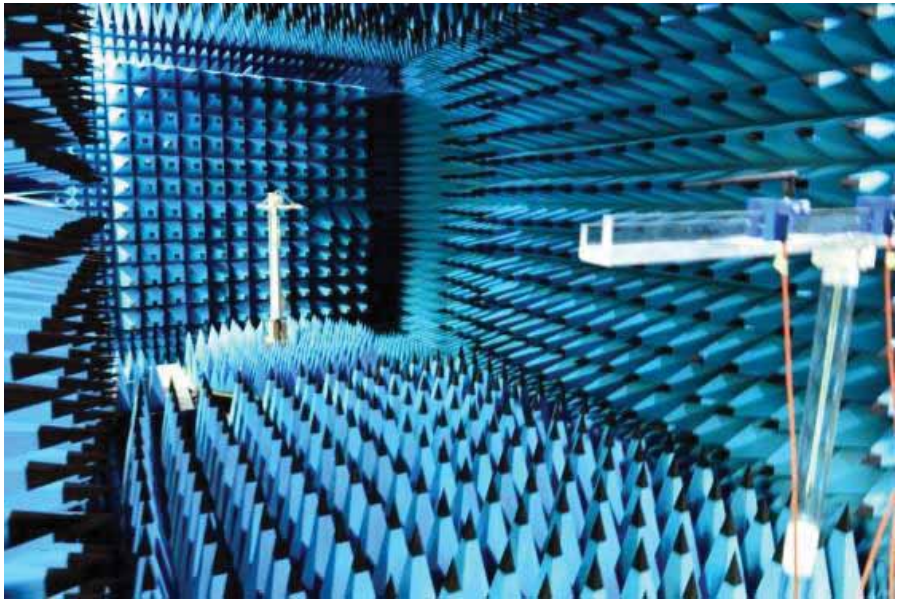
Executive Summary

- **Agenda**
  - Antenna Development Resource
  - Antenna Testing Set Up
  - Placement and Specification
  - S11 & Isolation
  - Radiation Pattern
  - Efficiency and Gain

Antenna Development Resource

3D Anechoic Chamber - BWANT

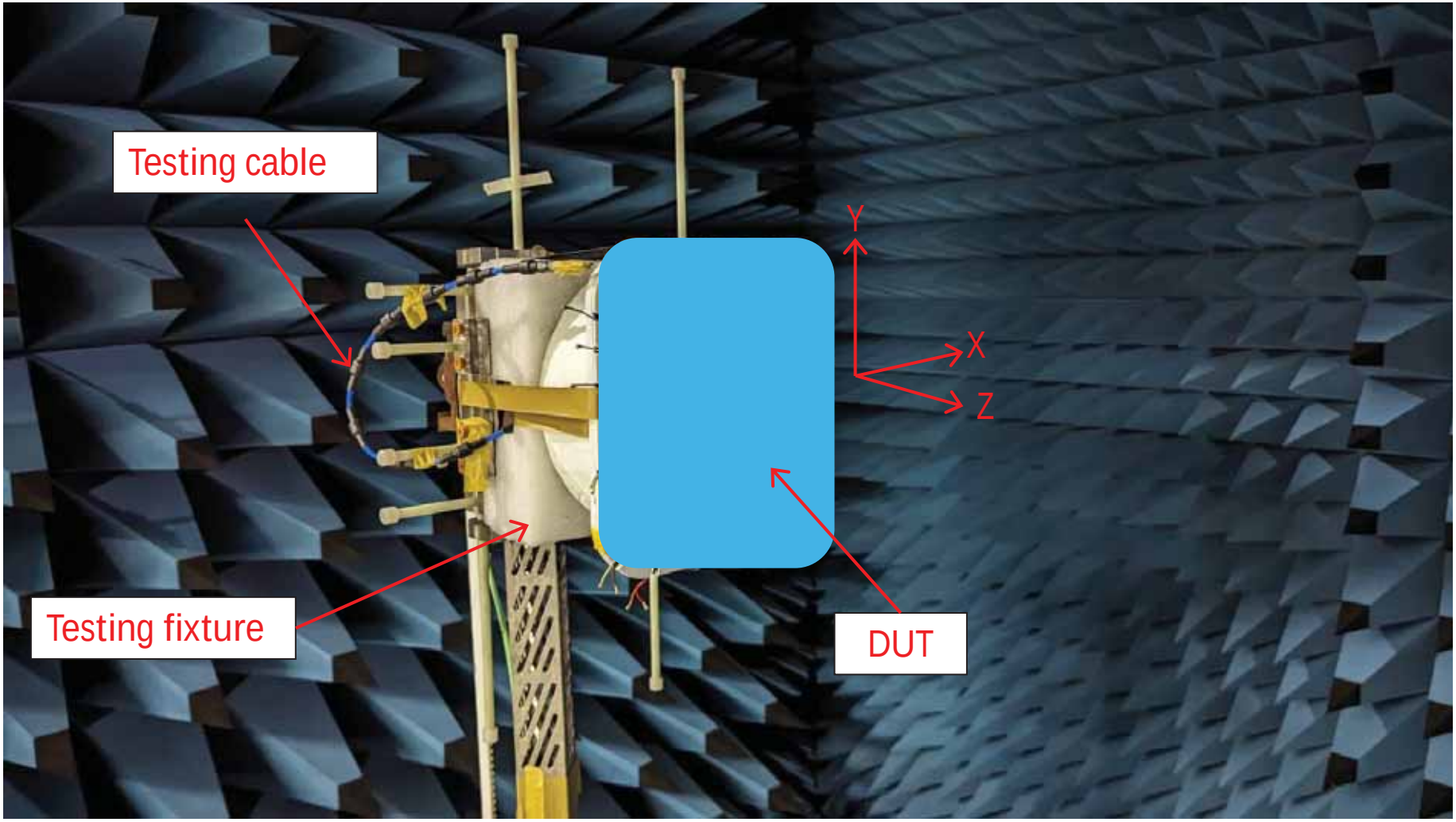
- Size: 7.32M(L)x3.66M(W)X3.66M(H)
- Testing range from 400MHz to 7GHz
- Chamber Isolation : 10KHz to 10GHz >100dB (NSA 94-106)
- Calibration antenna : BWANT SD650 /SD740 /SD900 /SD1150 /SD1575 /SD1800 /SD2140 /SD2450 /SD3200 /SD3600 /SD4550 /SD5400 /HA-0508
- Calibration date: 2022/10/27
- Test software : BWANT 3D Passive



3D Anechoic Chamber

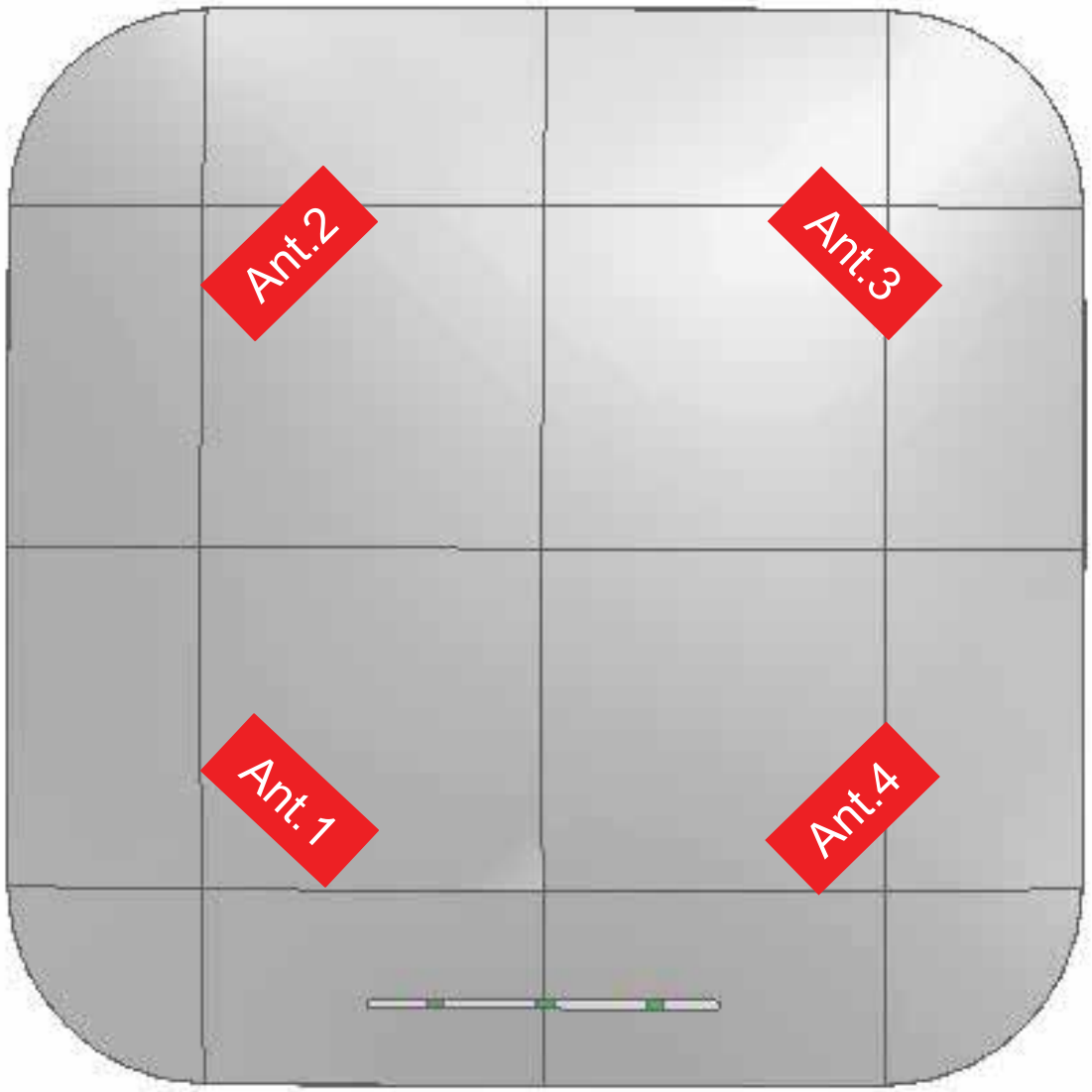
Antenna Testing Set Up

- The DUT is set up on the test fixture and the antenna is connected to the test cable to measure the antenna performance.



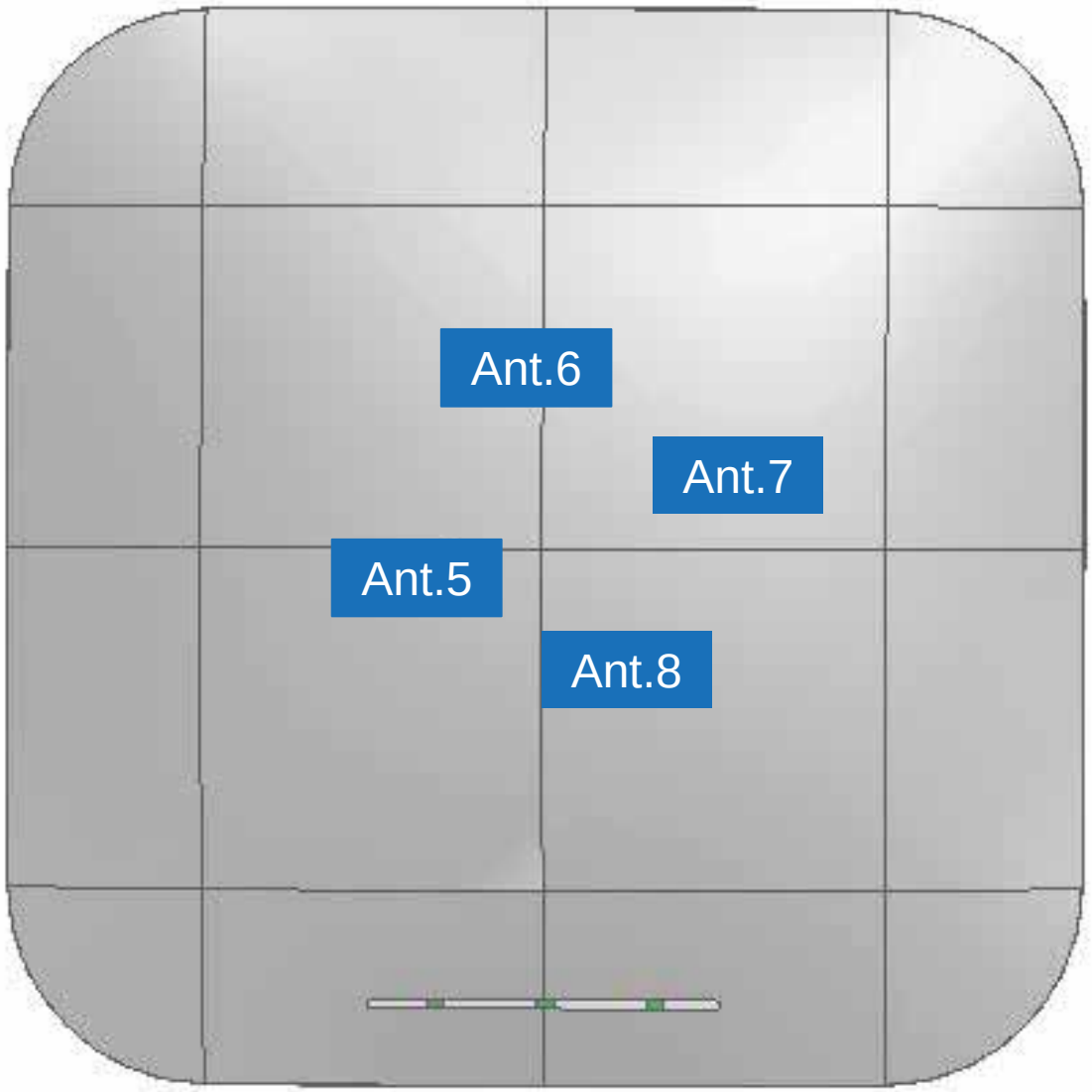
Placement and specification

Radio_1 Ant.1~4	
Wi-Fi Frequency	2400~2500MHz
Return Loss	-10dB
Antenna Type	Pifa
Material	Metal
Feeding	Cable
Radio_2 Ant.1~4	
Wi-Fi Frequency	5150~5895MHz
Return Loss	-10dB
Antenna Type	Pifa
Material	Metal
Feeding	Cable
Ant.1	
Brand Name :	Senao
P/N	5718A0730300
Ant.2	
Brand Name :	Senao
P/N	5718A0731300
Ant.3	
Brand Name :	Senao
P/N	5718A0732300
Ant.4	
Brand Name :	Senao
P/N	5718A0733300



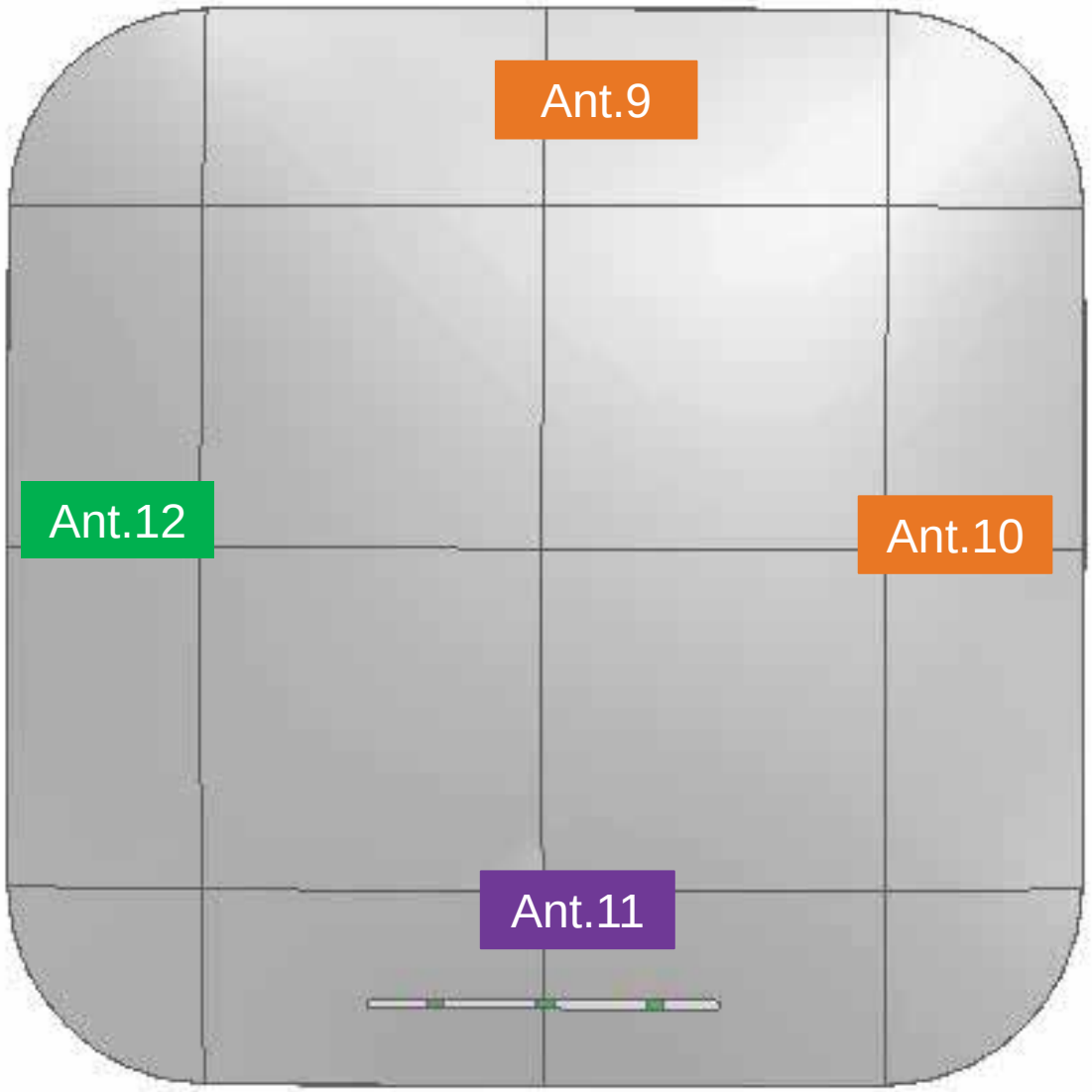
Placement and specification

Radio_3 Ant.5~8	
Wi-Fi Frequency	5925~7125MHz
Return Loss	-10dB
Antenna Type	Alford Loop
Material	FR4
Feeding	Cable
Ant.5	
Brand Name :	AWAN
P/N	7102A0657000
Ant.6	
Brand Name :	AWAN
P/N	7102A0659000
Ant.7	
Brand Name :	AWAN
P/N	7102A0660000
Ant.8	
Brand Name :	AWAN
P/N	7102A0658000

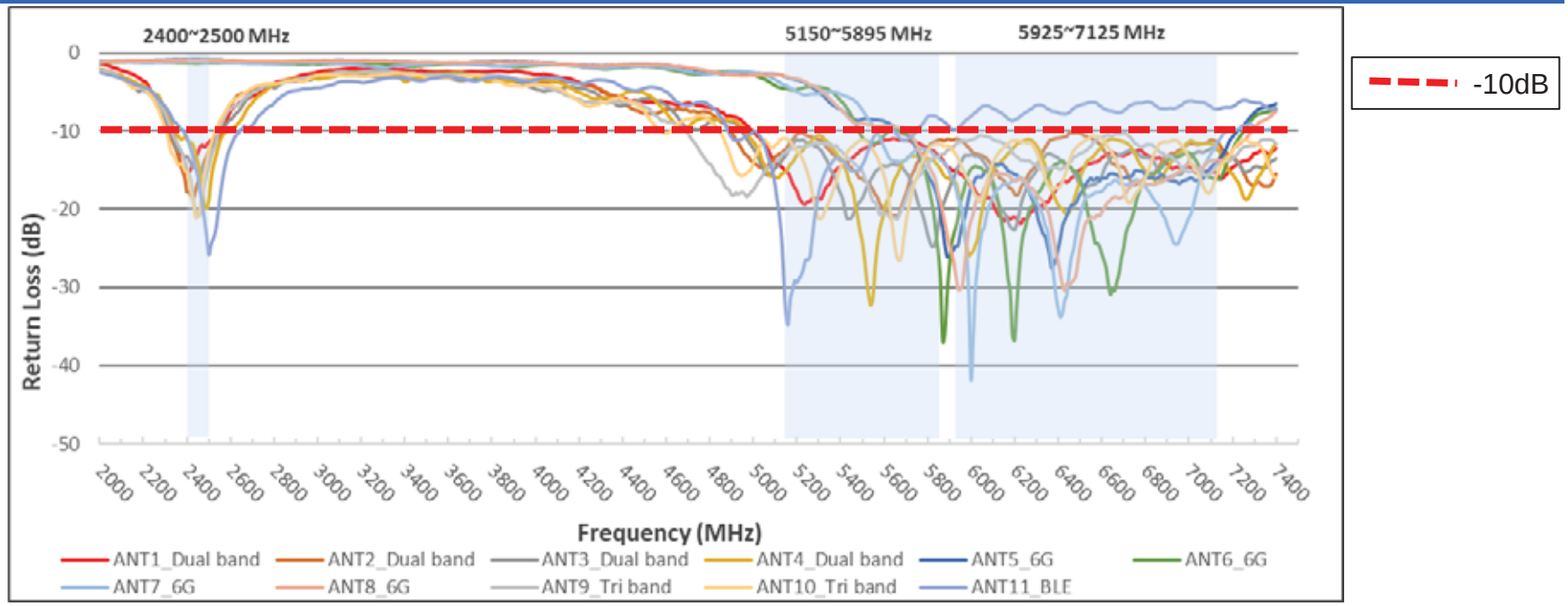


Placement and specification

Radio_4 Ant.9~10	
Wi-Fi Frequency	2400~2500MHz
Wi-Fi Frequency	5150~5895MHz
Wi-Fi Frequency	5925~7125MHz
Return Loss	-10dB
Antenna Type	Pifa
Material	Metal
Feeding	Cable
Ant.9	
Brand Name :	Senao
P/N	5718A0734300
Ant.10	
Brand Name :	Senao
P/N	5718A0735300
BLE/Zigbee Ant.11	
Wi-Fi Frequency	2400~2500MHz
Return Loss	-10dB
Antenna Type	Pifa
Material	Metal
Feeding	Cable
Brand Name :	Senao
P/N	5718A0736300
GPS Ant.12	
Wi-Fi Frequency	1565~1585MHz
Return Loss	-10dB
Antenna Type	Patch
Material	Ceramic
Feeding	Cable
Brand Name :	Quectel
P/N	7102A0656000

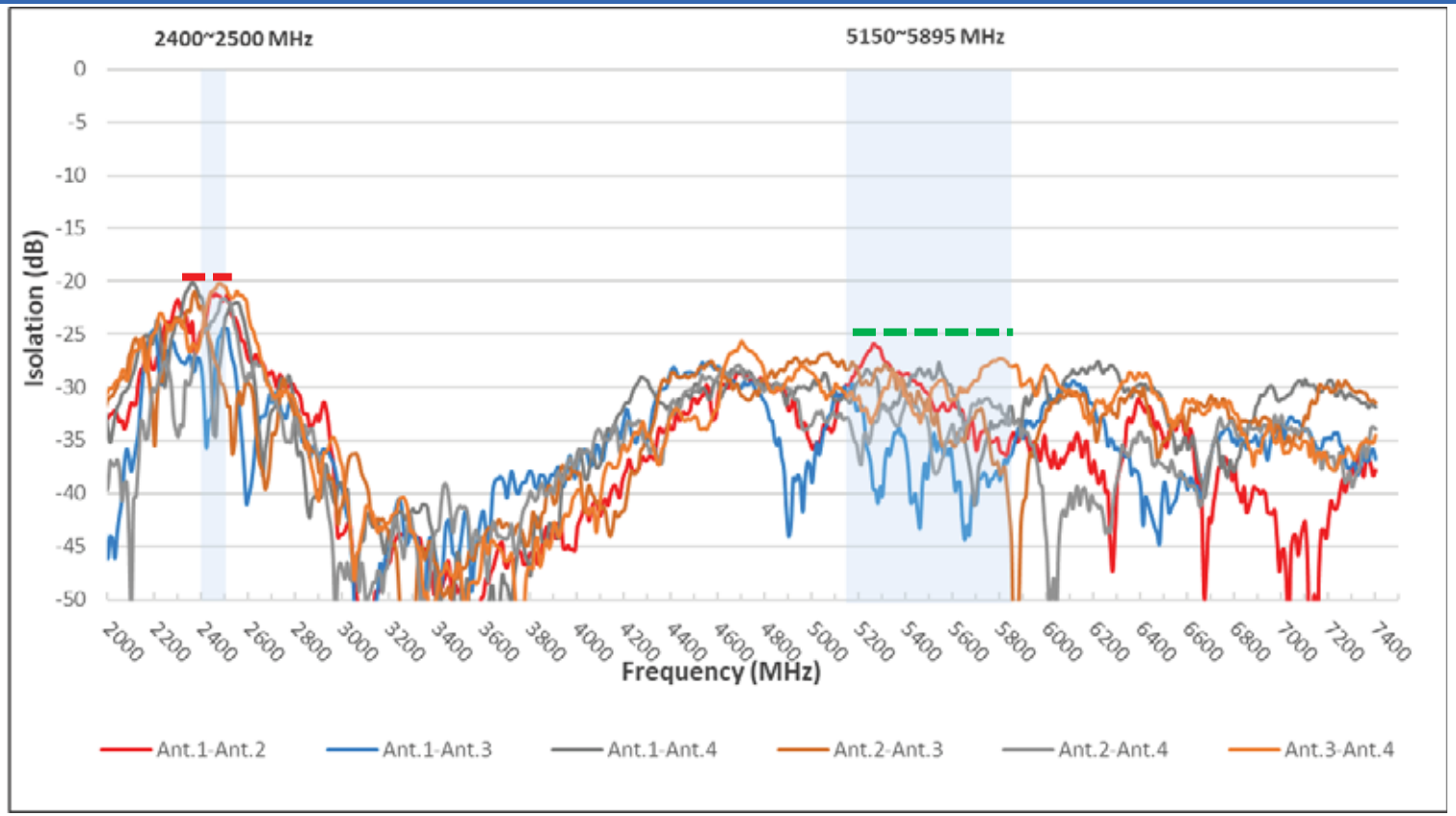


Return Loss



Return Loss											
Freq. (MHz)	Ant.1	Ant.2	Ant.3	Ant.4	Ant.5	Ant.6	Ant.7	Ant.8	Ant.9	Ant.10	Ant.11
2400	13.2	11.9	12.9	10.6	0.9	1.2	0.9	1.1	17.1	21.5	11.7
2450	12.7	16.2	24.6	19.6	0.9	1.3	1.0	1.1	16.1	16.0	13.4
2500	12.9	19.7	18.5	17.2	1.0	1.4	1.0	1.2	10.4	11.4	16.4
5150	10.3	11.8	11.3	10.6	4.8	5.4	5.4	5.9	14.0	10.2	19.3
5500	10.9	18.0	16.3	10.7	8.6	14.2	10.0	9.6	12.8	13.0	10.4
5850	42.0	14.6	19.8	16.5	16.0	21.4	18.6	12.8	32.9	16.9	9.3
5895	14.69	11.06	17.43	16.23	26.15	27.41	15.25	24.45	12.35	11.99	9.42
5925	21.3	19.1	25.2	13.9	13.1	14.3	15.8	19.9	20.9	16.6	7.8
6500	28.2	21.9	16.4	19.4	14.4	18.5	17.2	26.0	26.3	28.0	5.5
7125	26.7	16.9	20.7	18.7	10.8	11.4	10.5	11.6	19.7	25.6	6.2

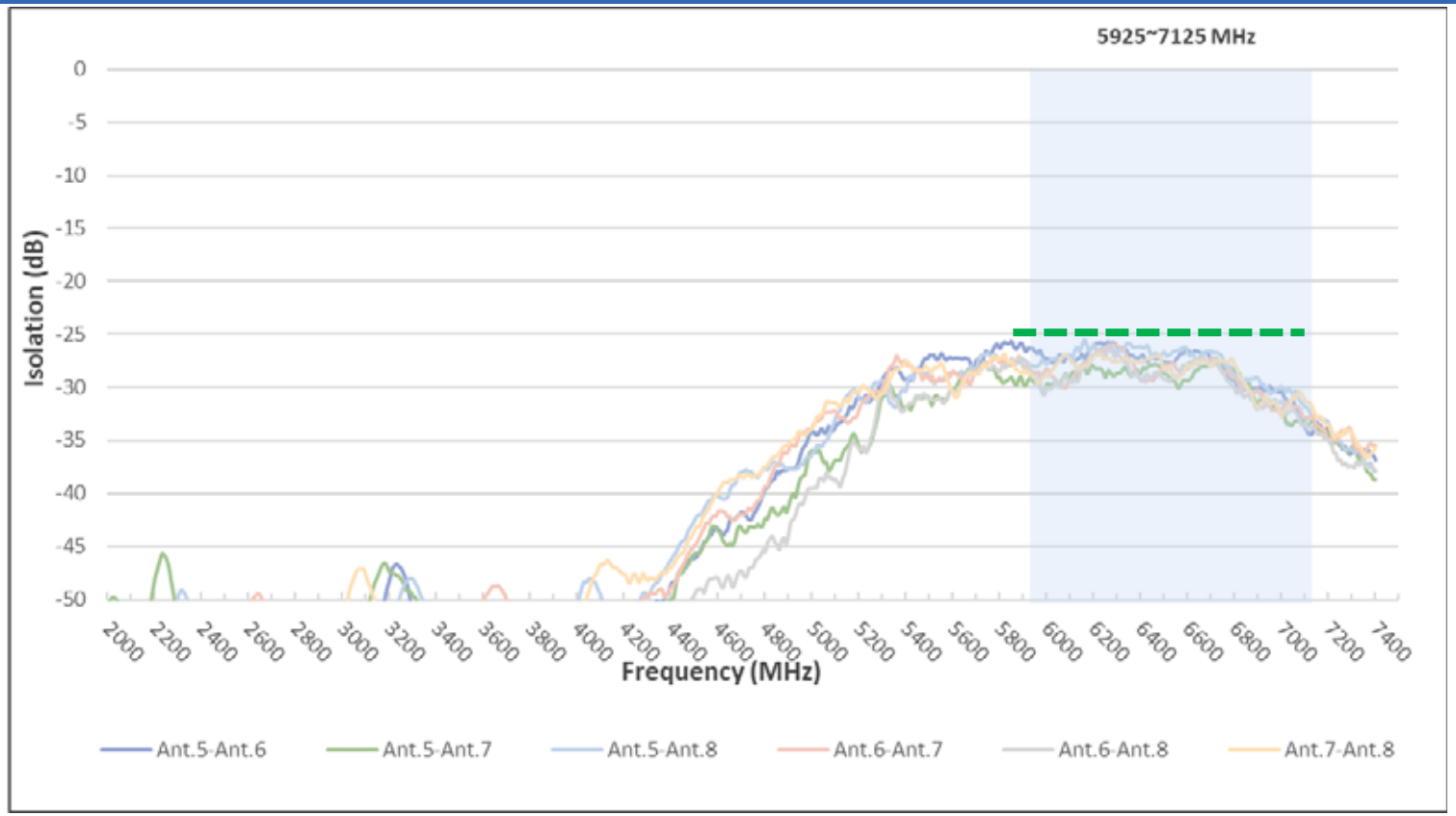
Wi-Fi 2/5G_ Isolation



-20dB
-25dB

Radio 1&2 to Radio 1&2	
Radio 1 Frequency	2400~2500MHz
Radio 2 Frequency	5150~5895MHz
Isolation 2G	Range -30dB ~ -20dB
Isolation 5G	Range -45dB ~ -25dB

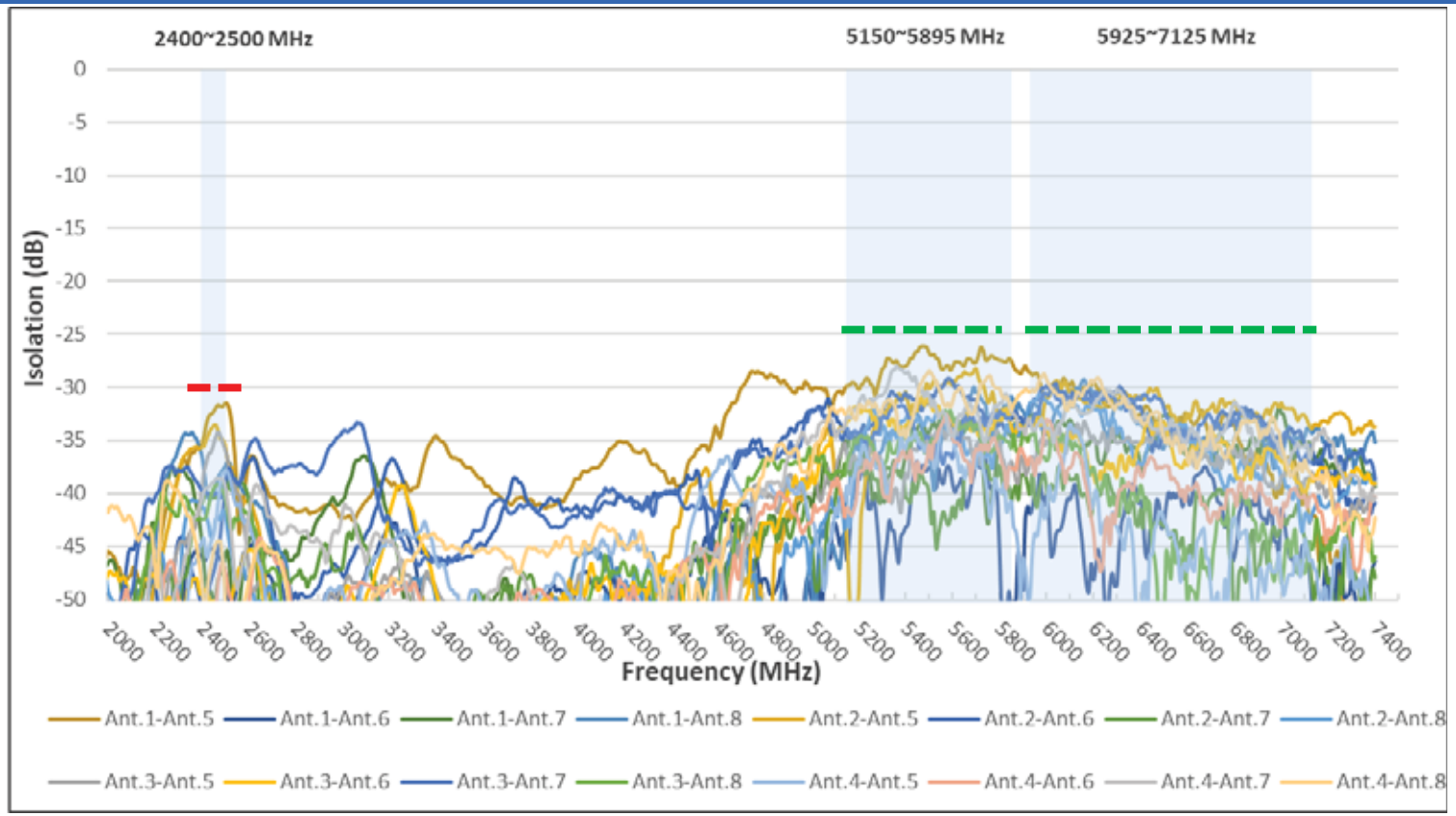
Wi-Fi 6G_ Isolation



-25dB

Radio 3 to Radio 3	
Radio 3 Frequency	5925~7125MHz
Isolation 6G	Range -35dB ~ -25dB

Wi-Fi Cross Isolation



-30dB

-25dB

Radio 1&2 to Radio 3

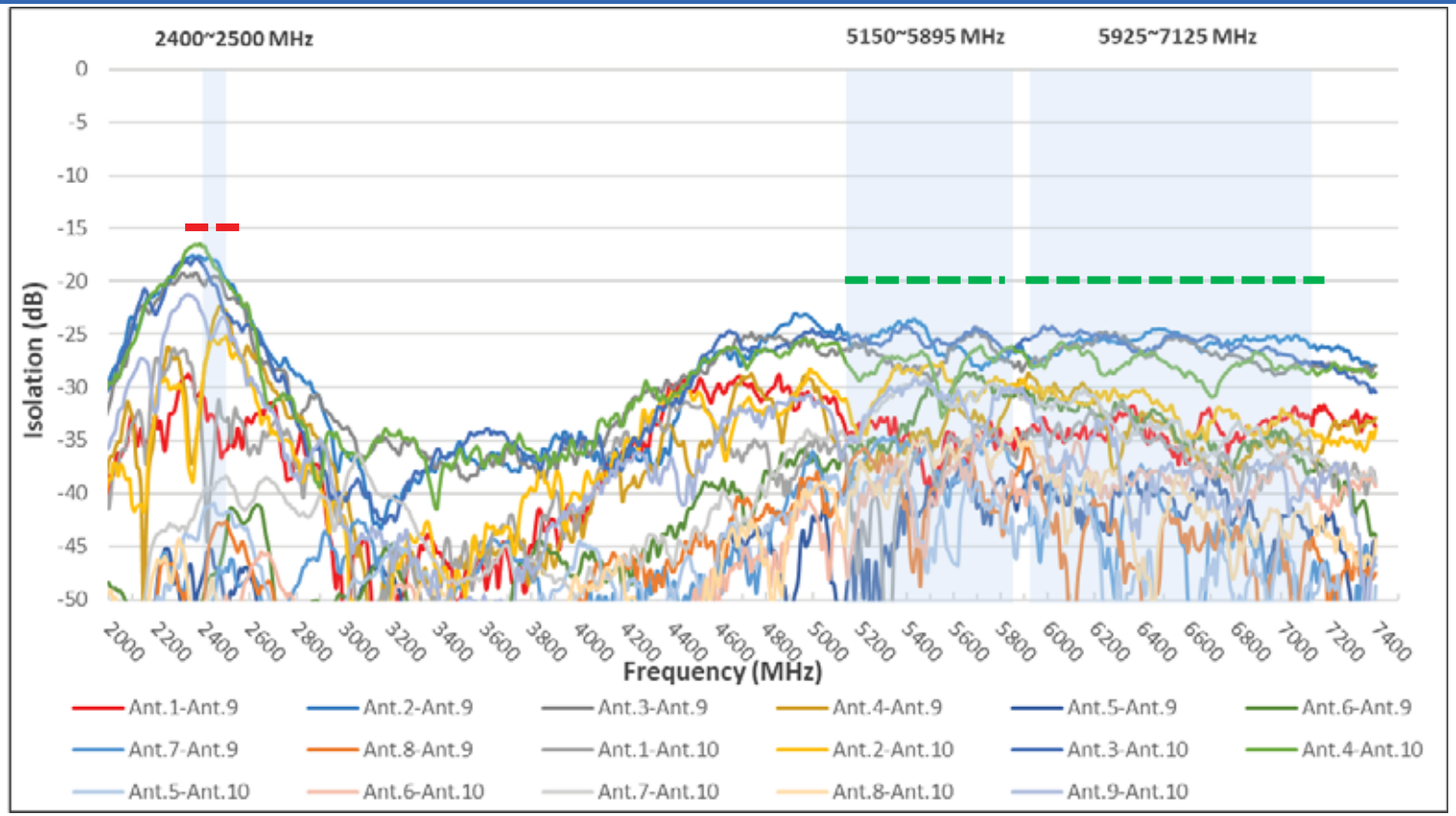
Radio 1 Frequency 2400~2500MHz Radio 2 Frequency 5150~5895MHz

Radio 3 Frequency 5925~7125MHz

Isolation 2G Range -60dB ~ -30dB Isolation 5G Range -50dB ~ -25dB

Isolation 6G Range -50dB ~ -25dB

Scanning Isolation



-15dB
-20dB

Radio 4 to Radio 1~3

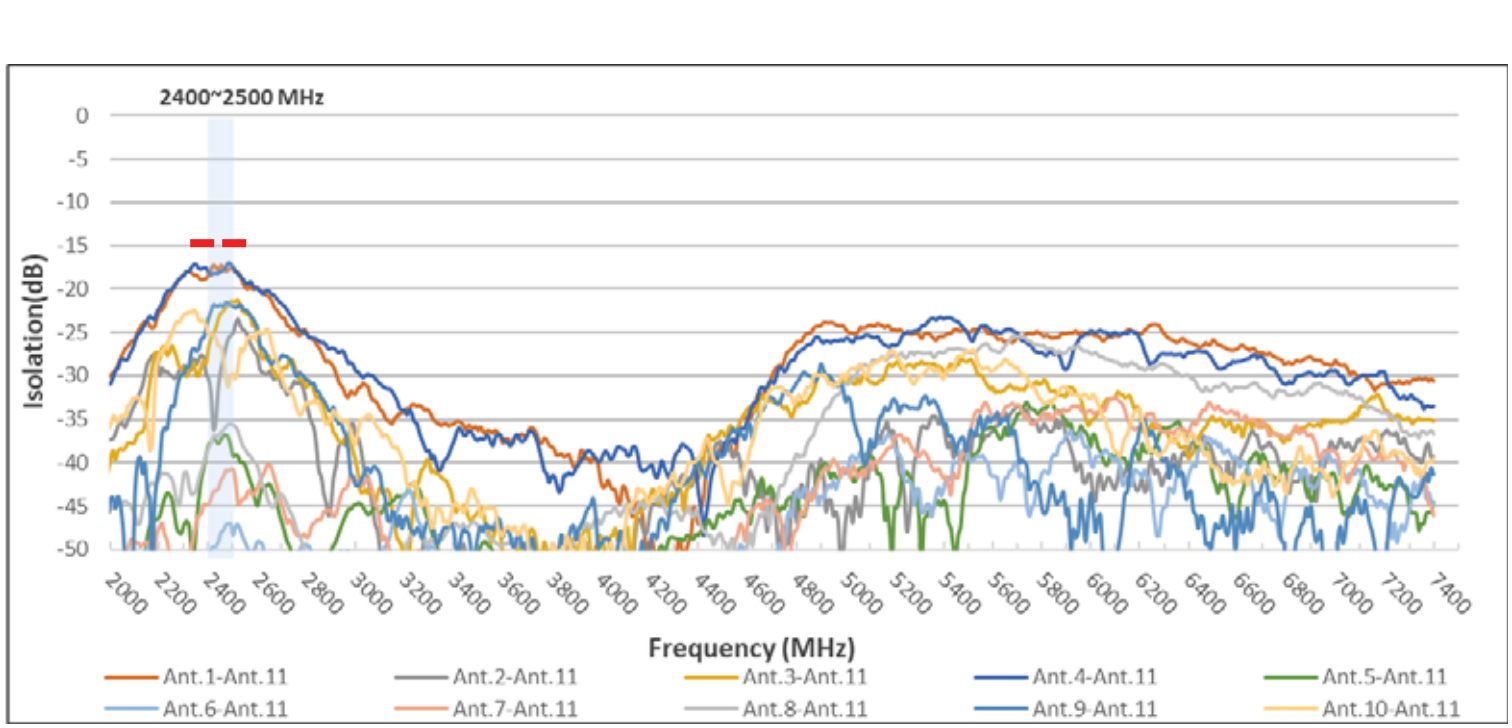
Radio 1 Frequency 2400~2500MHz Radio 2 Frequency 5150~5895MHz

Radio 3 Frequency 5925~7125MHz Radio 4 Tri band All

Isolation 2G Range -60dB ~ -17dB Isolation 5G Range -50dB ~ -23dB

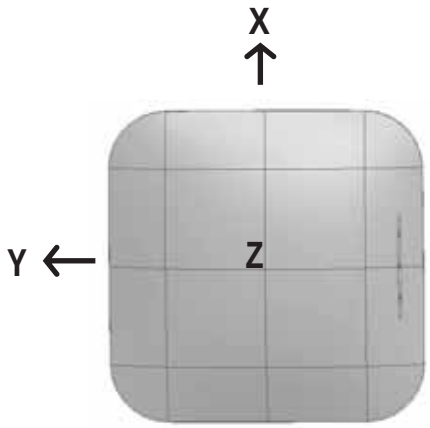
Isolation 6G Range -60dB ~ -24dB

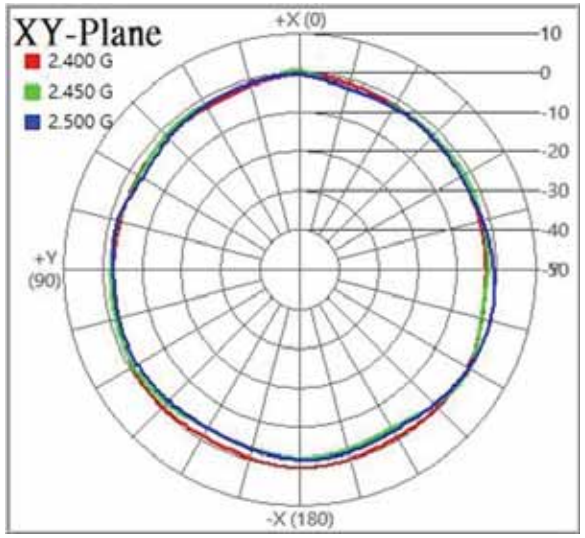
BLE/Zigbee Isolation

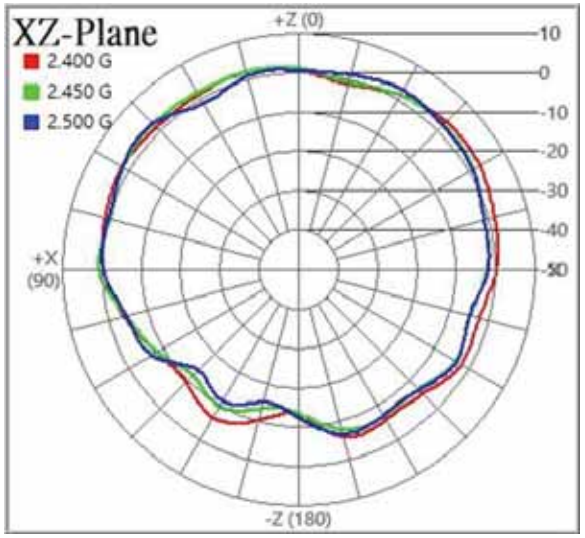


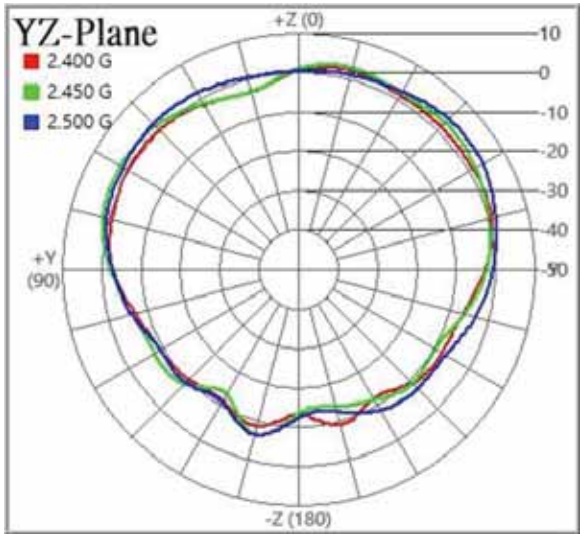
BLE to Radio 1~4			
Radio 1 Frequency	2400~2500MHz	Radio 2	Frequency5150~5850MHz
Radio 3 Frequency	5925~7125MHz	Radio 4	Tri band All
Isolation 2G	Range -50dB ~ -17dB		

2D Pattern – Ant.1_2.45GHz

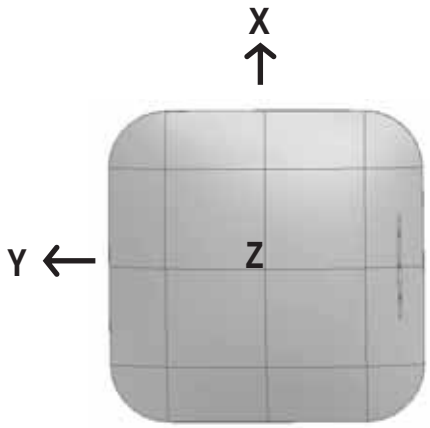


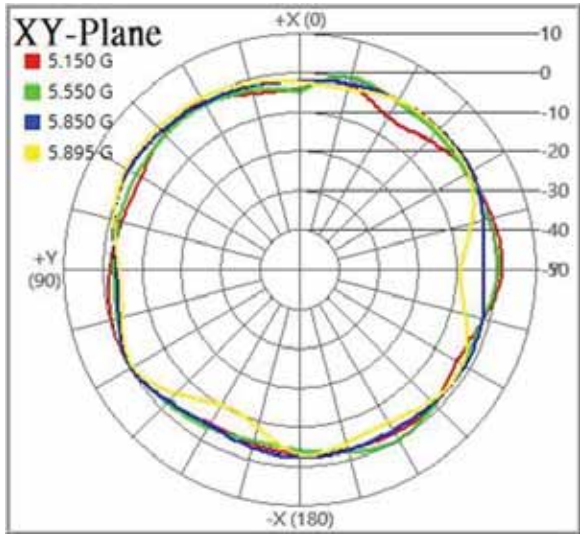


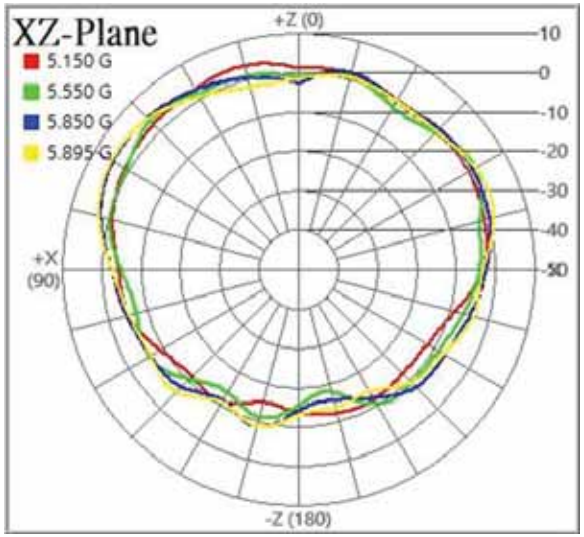


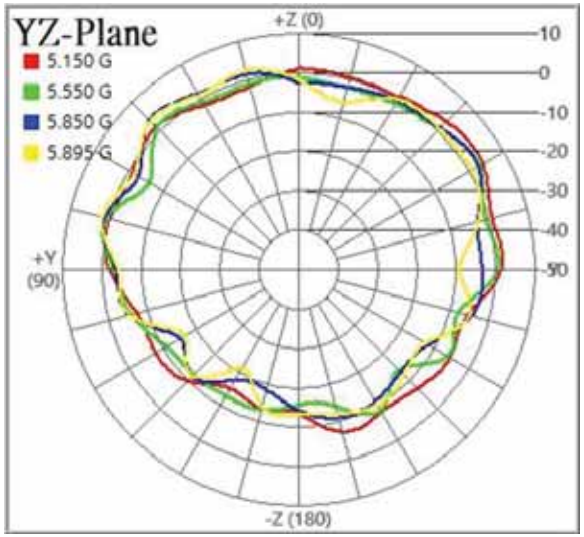


2D Pattern – Ant.1_5.5GHz

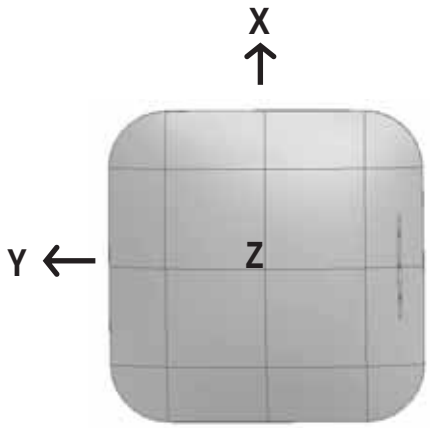


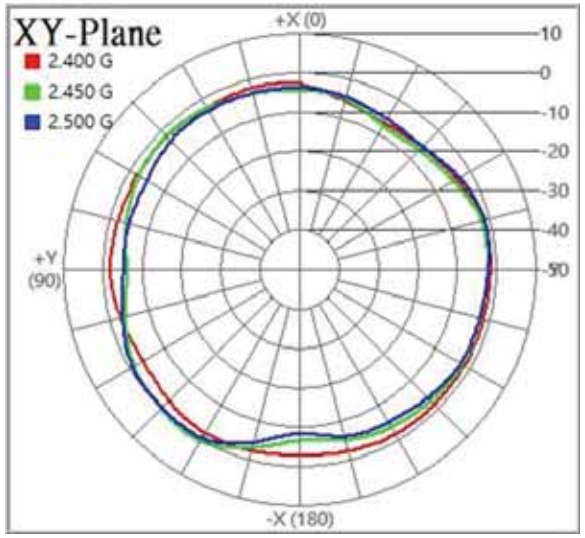


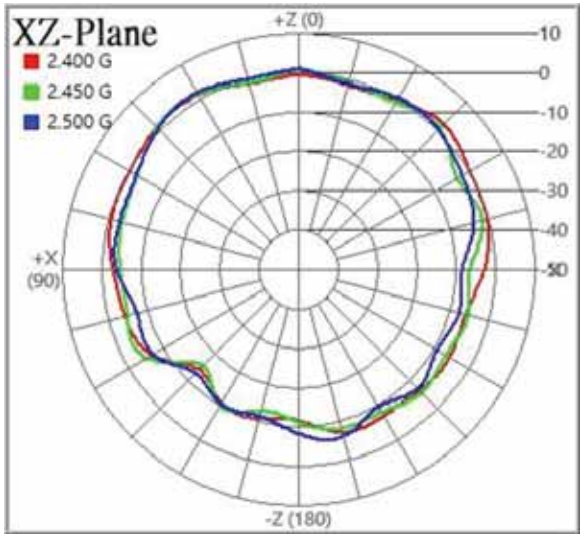


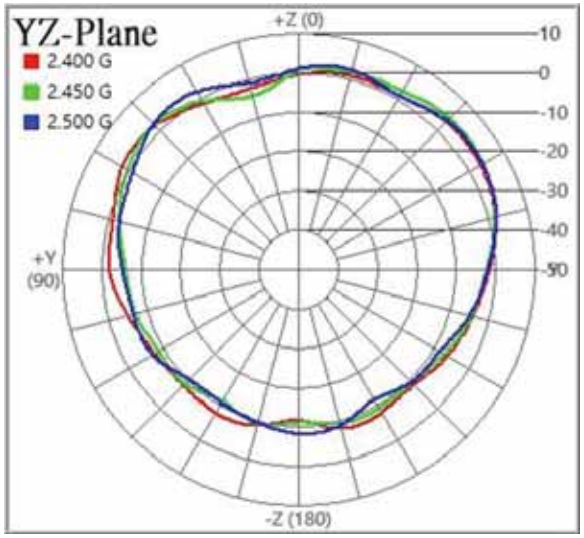


2D Pattern – Ant.2_2.45GHz

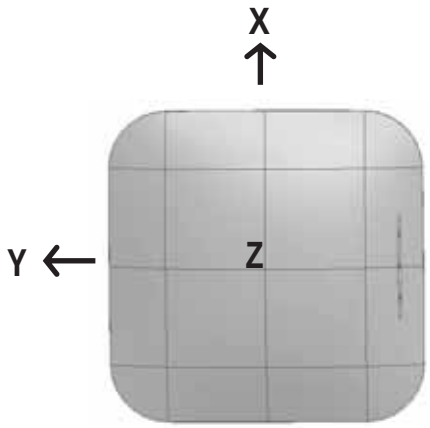


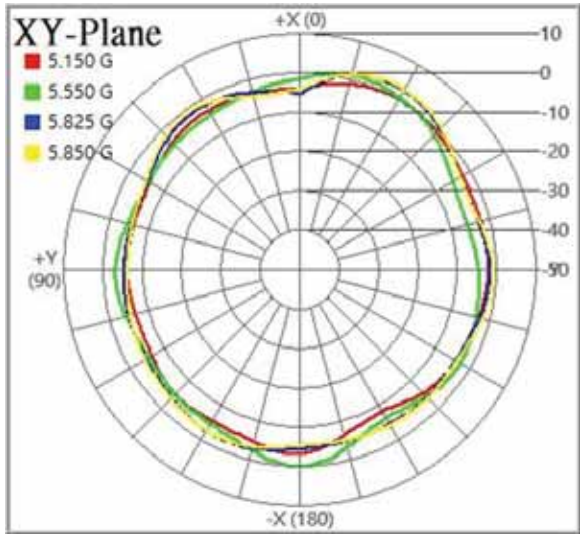


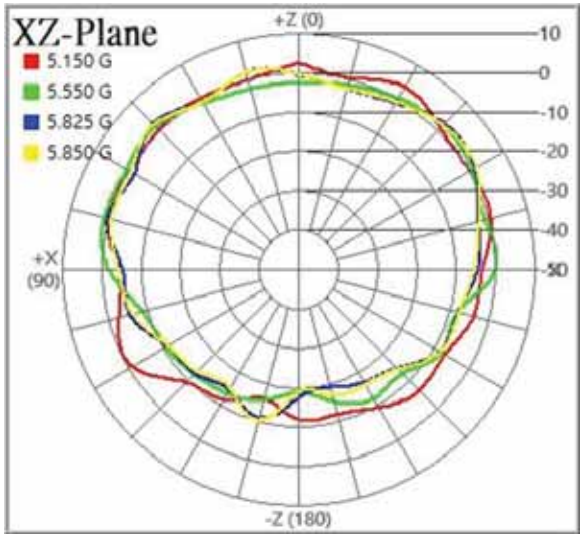


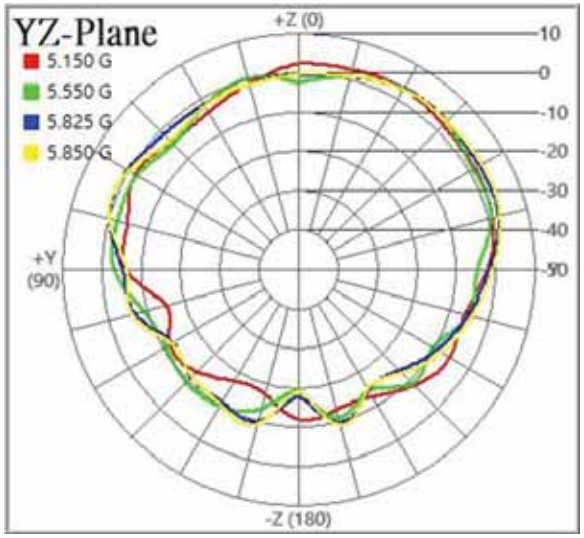


2D Pattern – Ant.2_5.5GHz

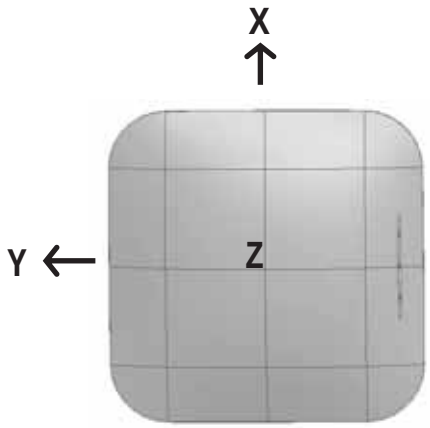


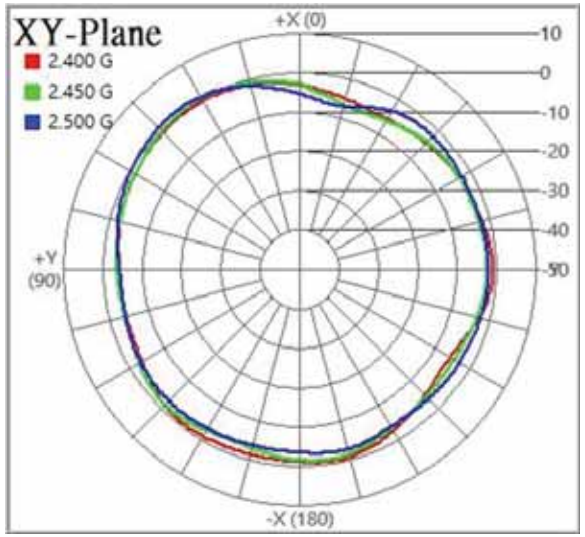


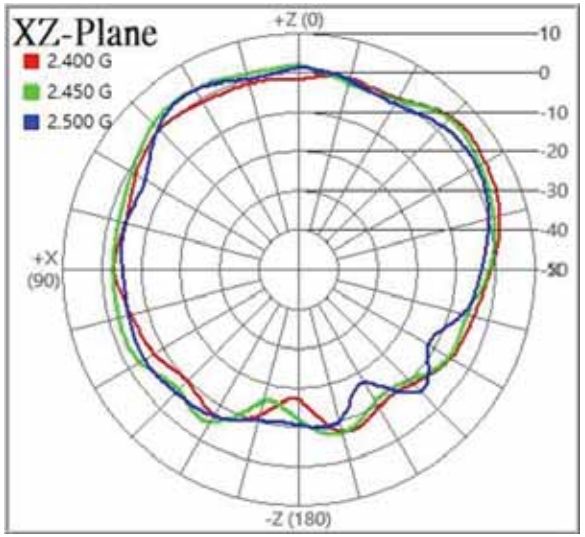


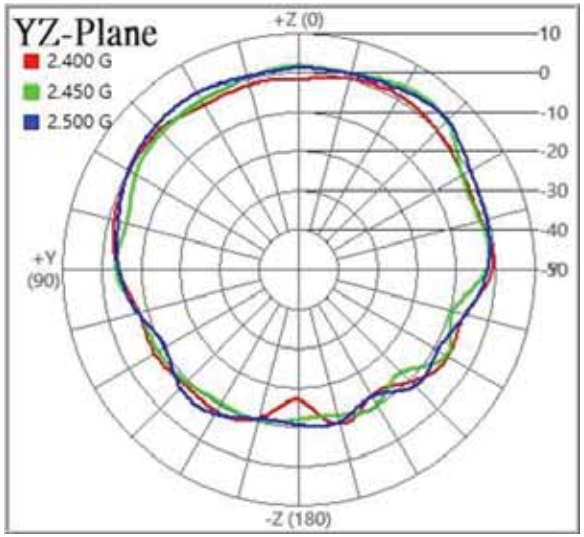


2D Pattern – Ant.3_2.45GHz

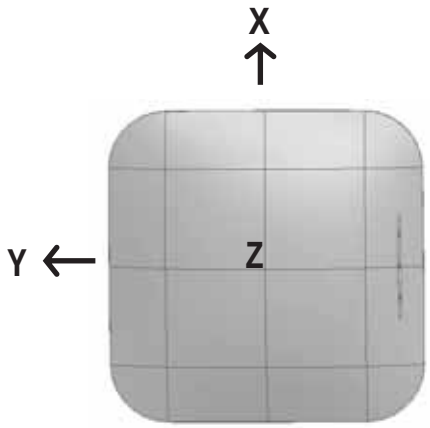


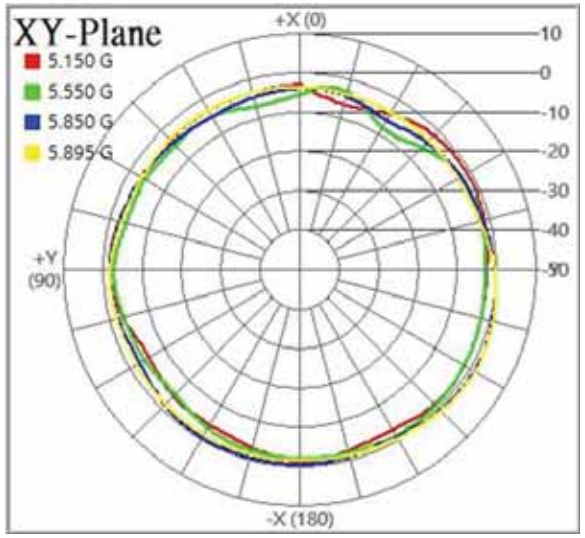


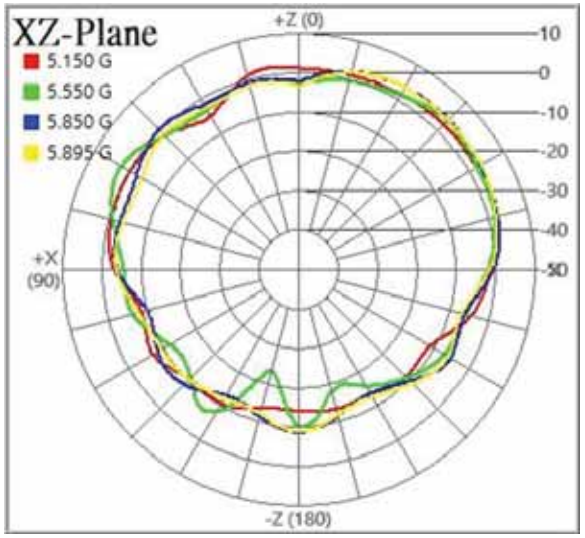


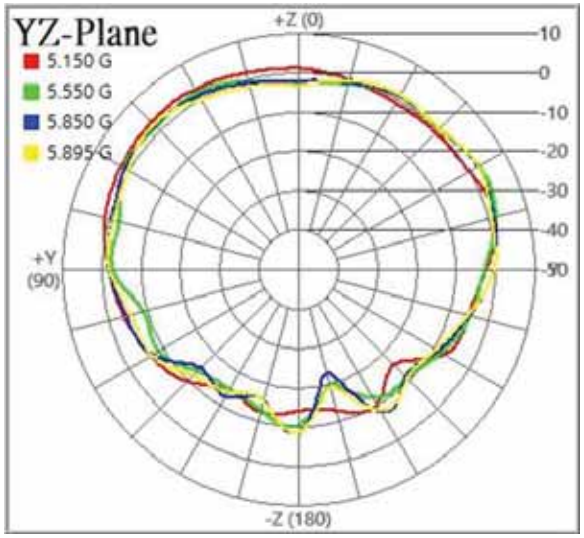


2D Pattern – Ant.3_5.5GHz

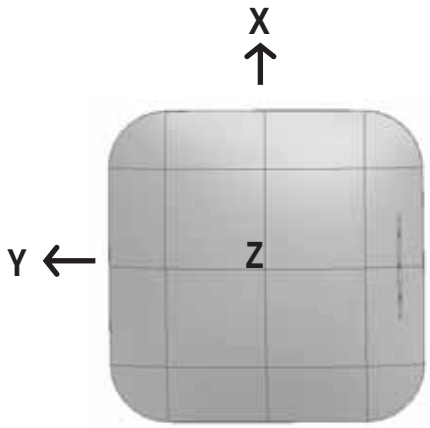


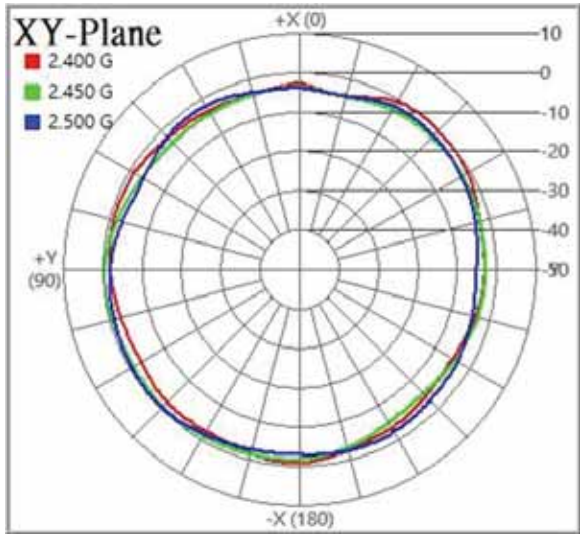


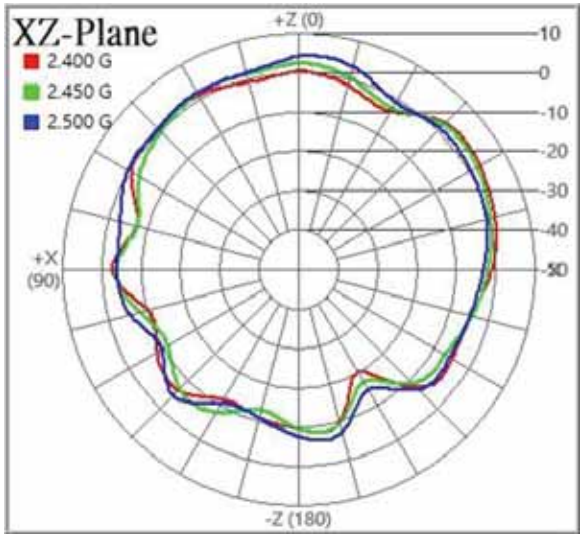


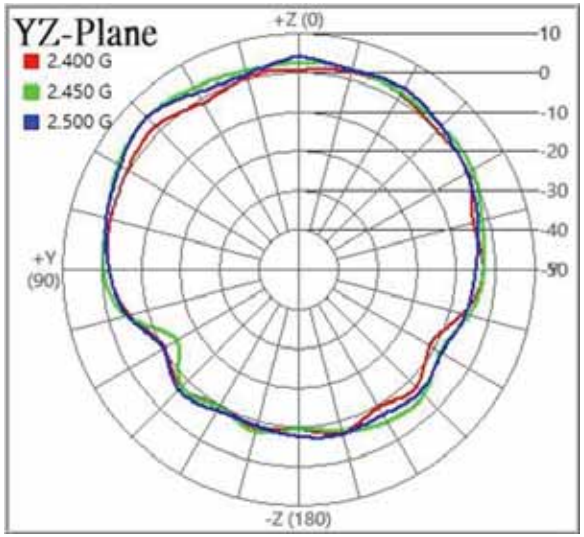


2D Pattern – Ant.4_2.45GHz

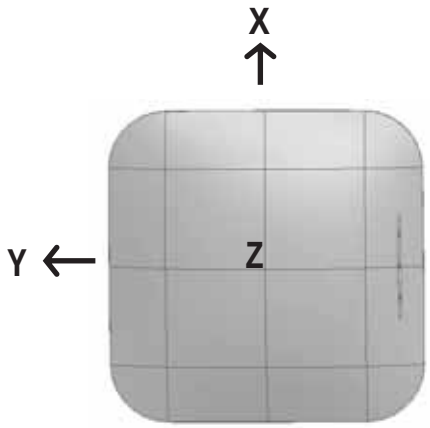


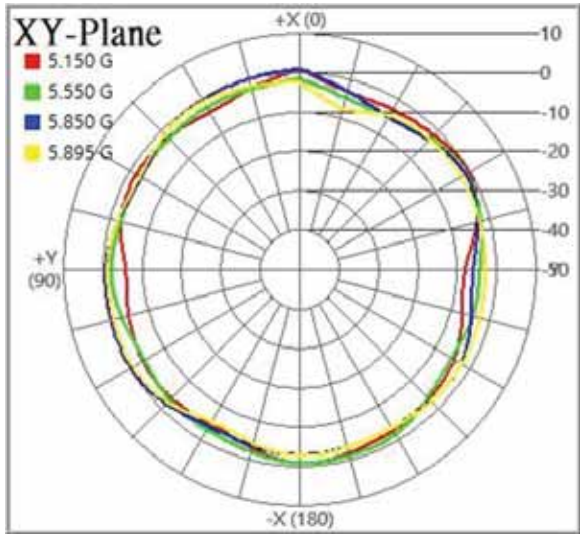


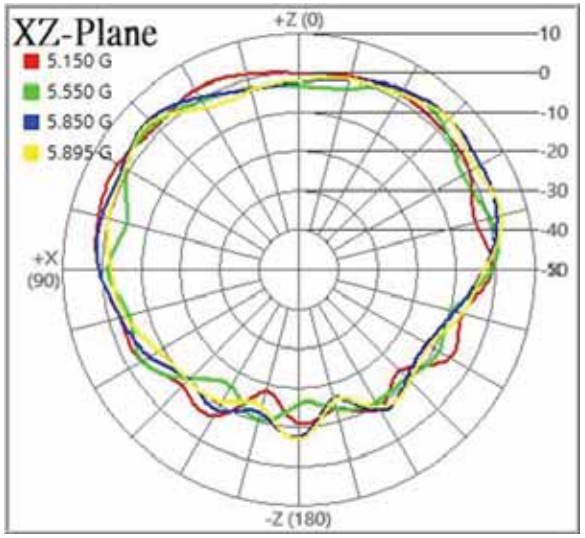


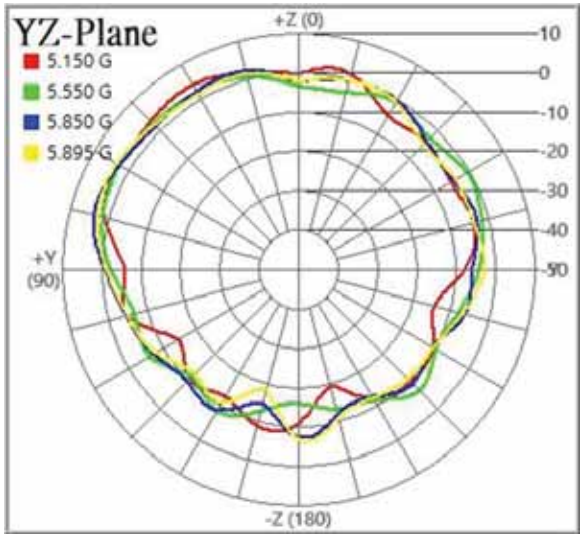


2D Pattern – Ant.4_5.5GHz

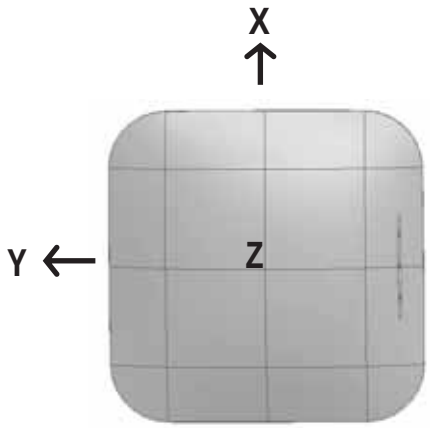


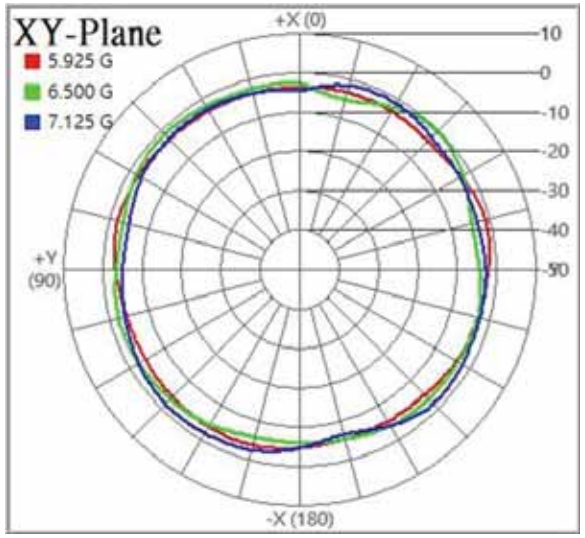


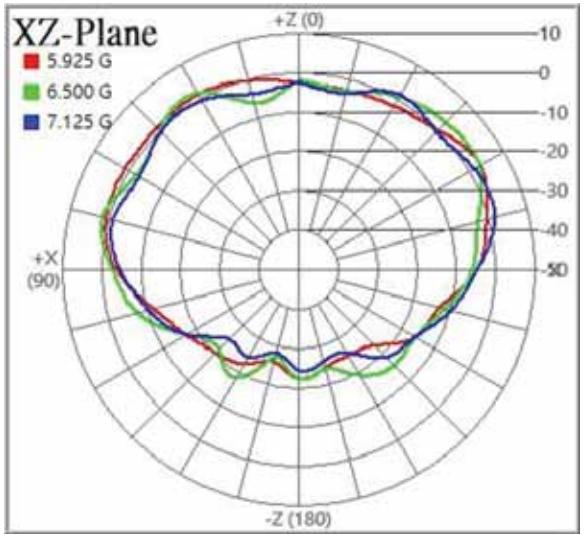


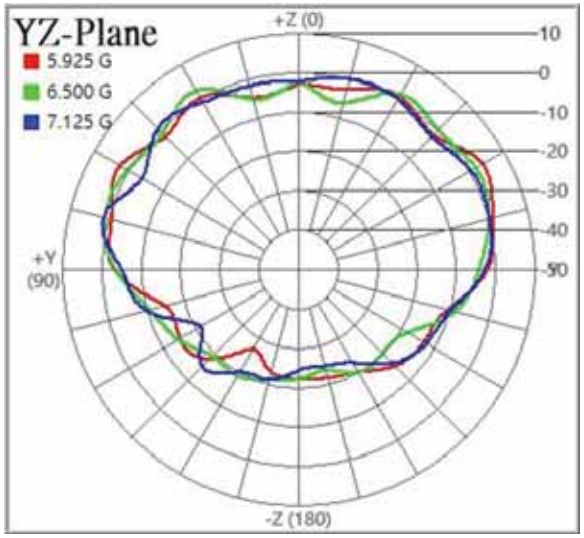


2D Pattern – Ant.5_6.5GHz

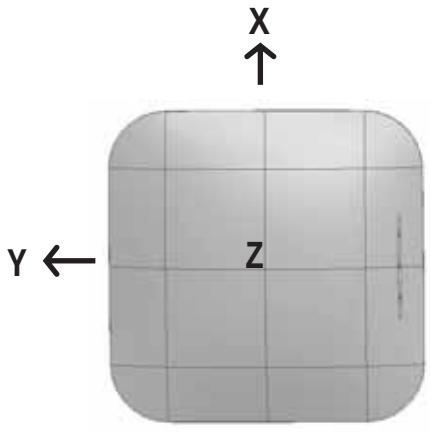


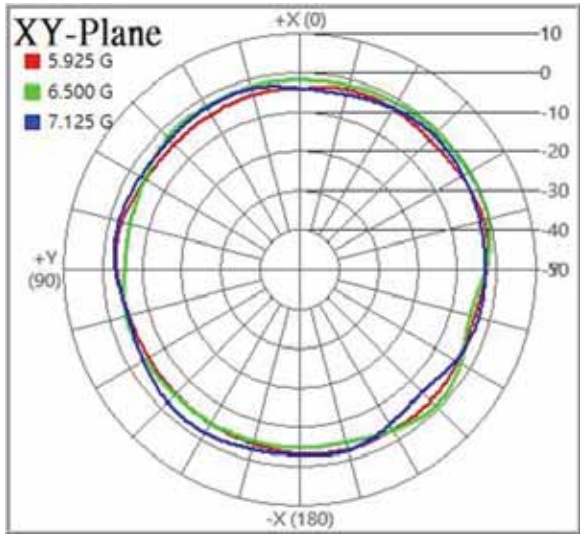


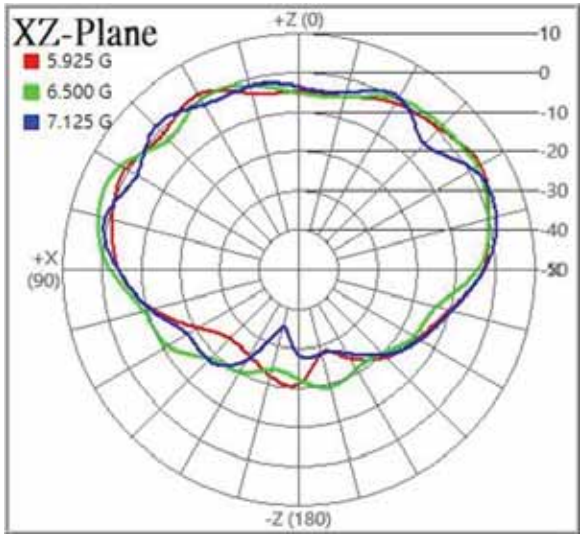


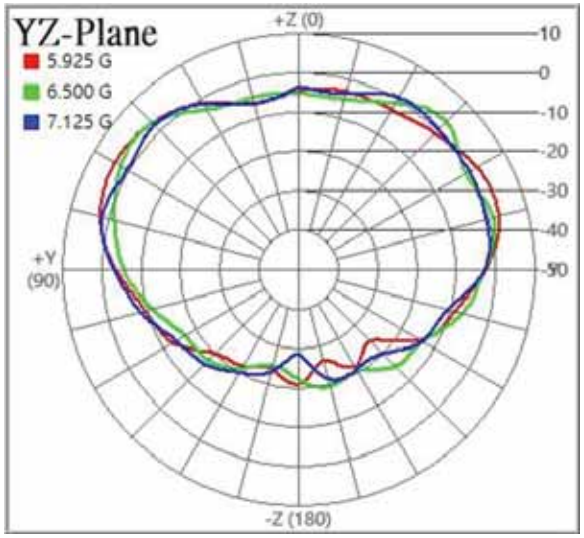


2D Pattern – Ant.6_6.5GHz

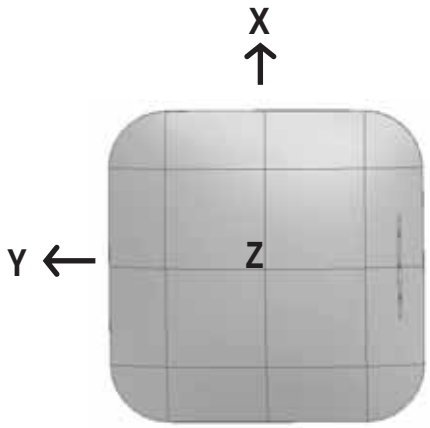


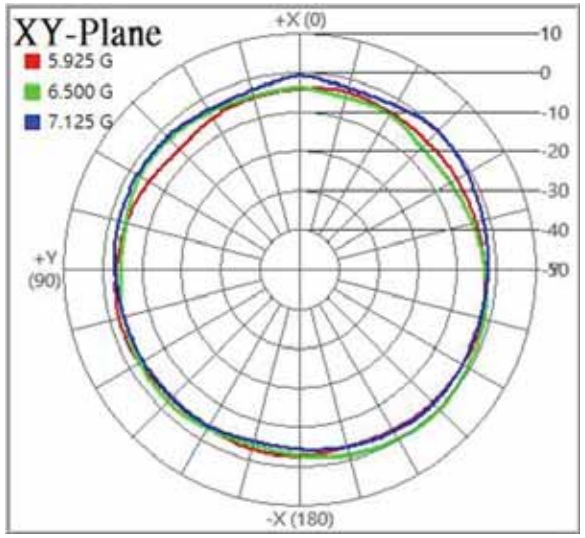


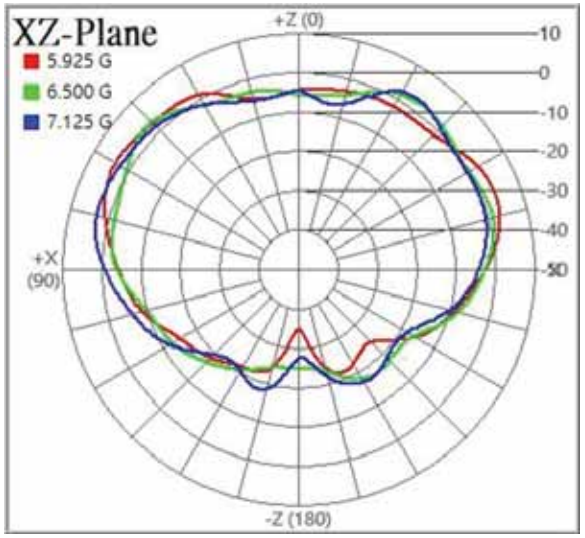


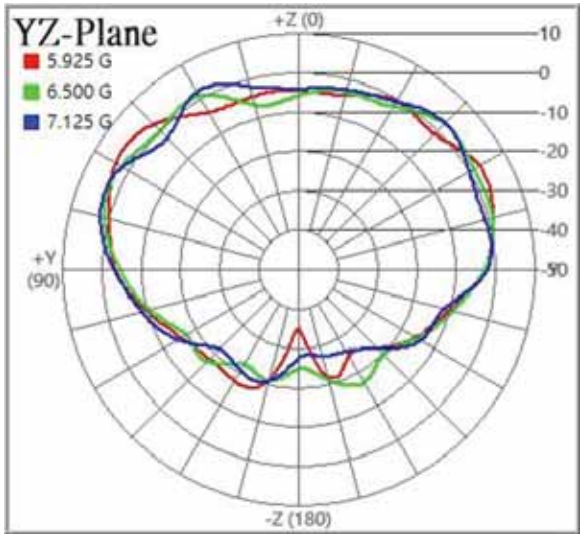


2D Pattern – Ant.7_6.5GHz

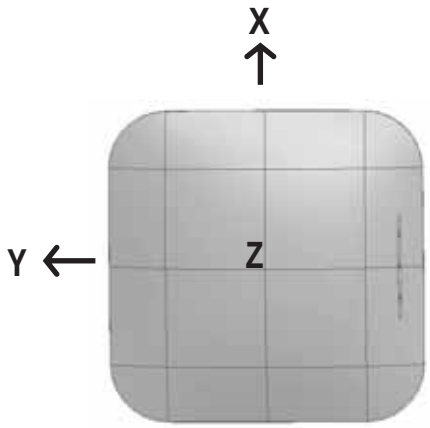


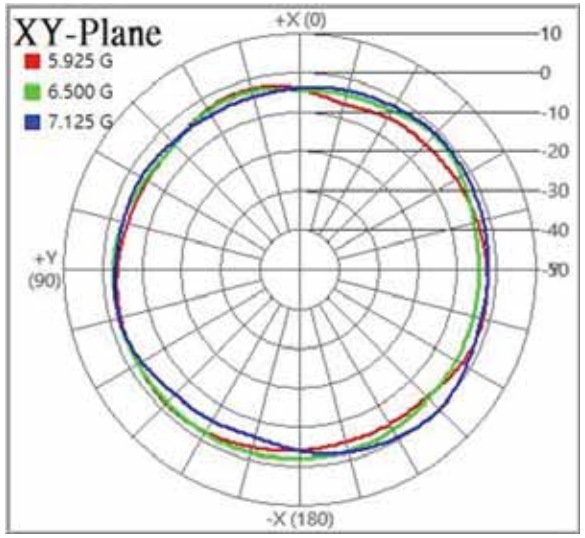


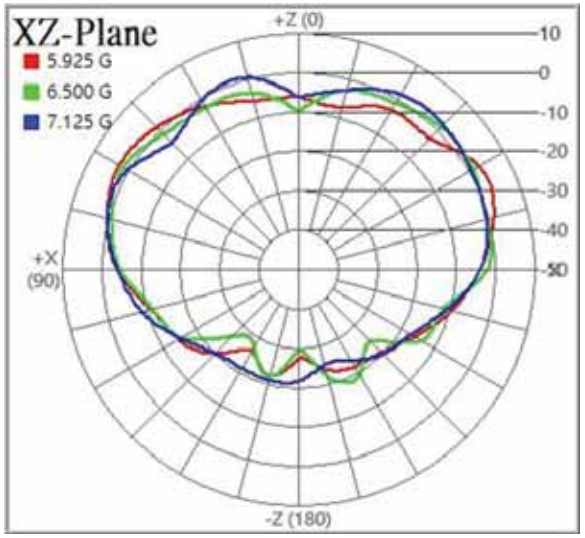


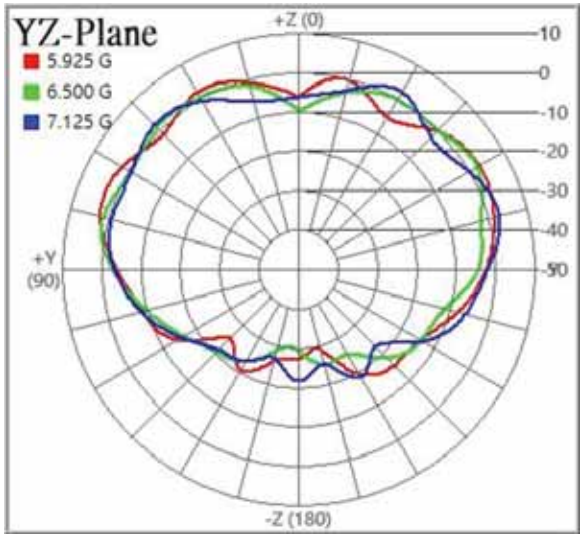


2D Pattern – Ant.8_6.5GHz

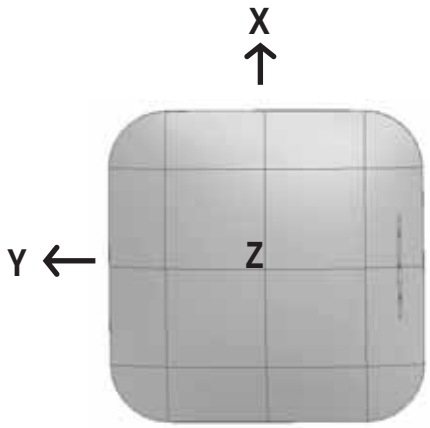


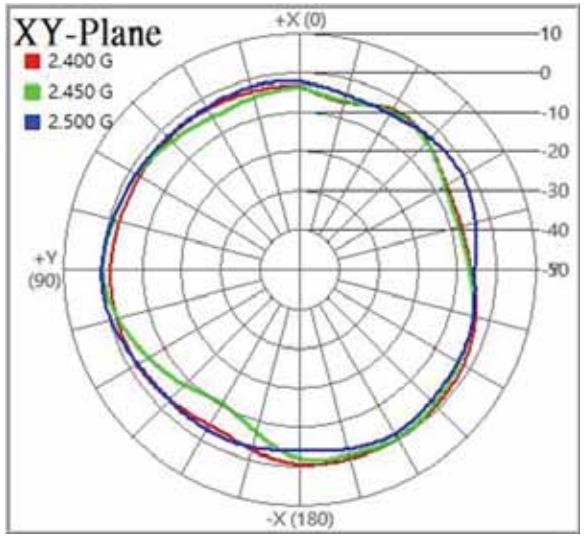


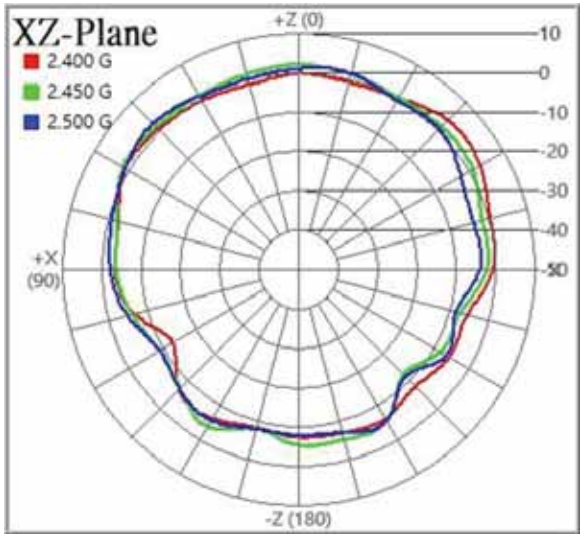


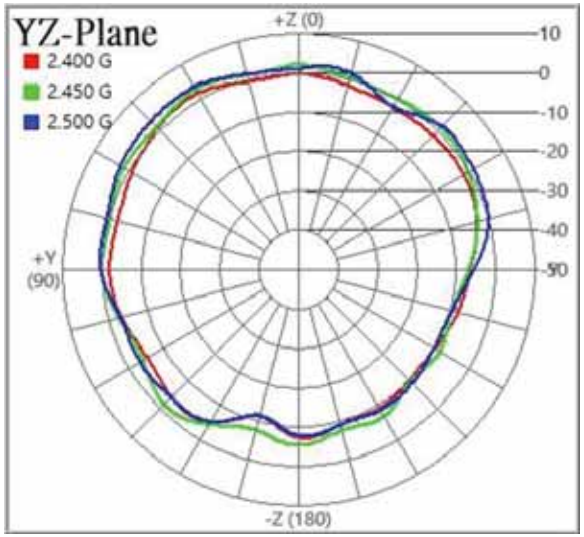


2D Pattern – Ant.9_2.45GHz

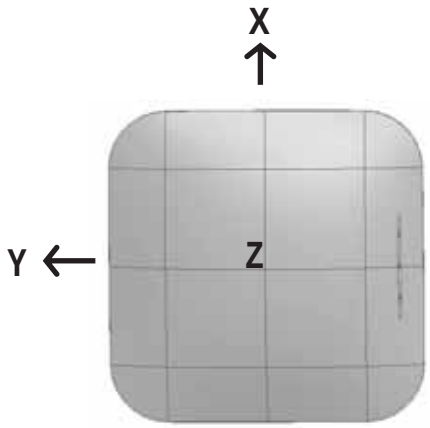


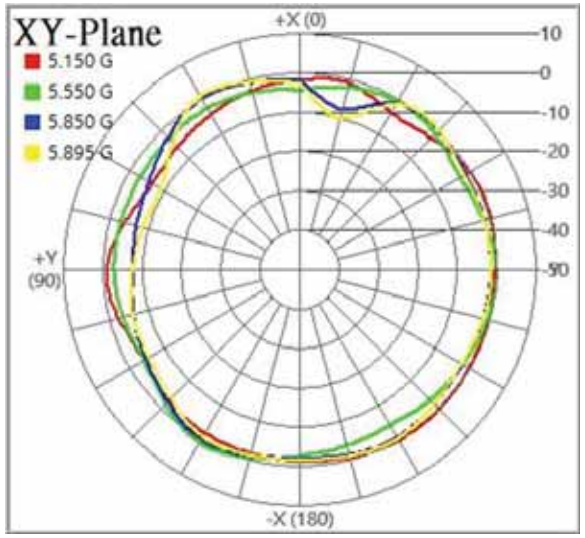


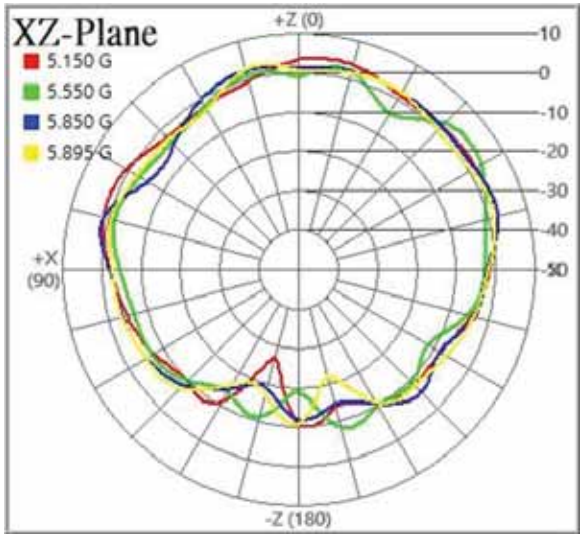


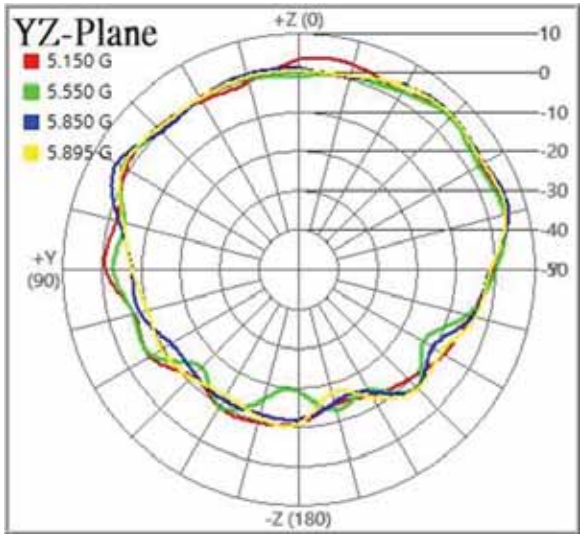


2D Pattern – Ant.9_5.5GHz

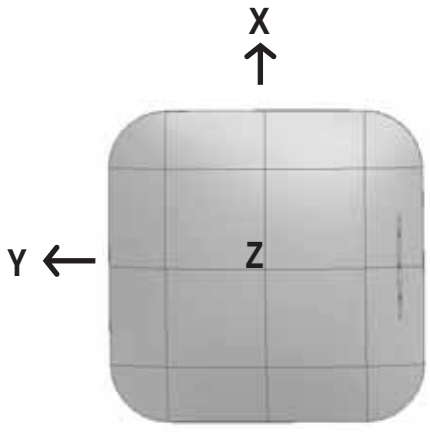


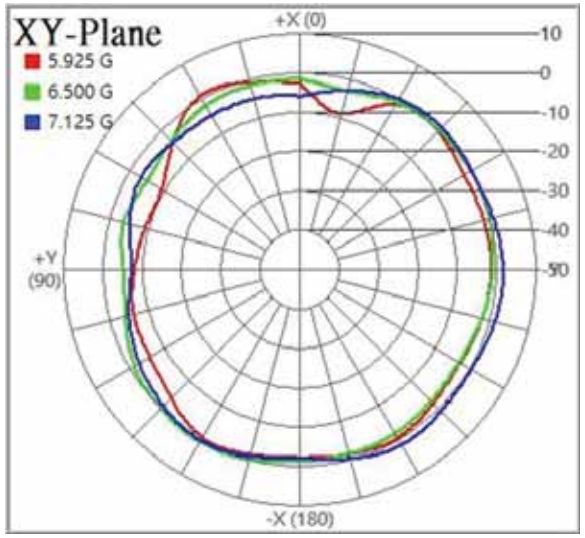


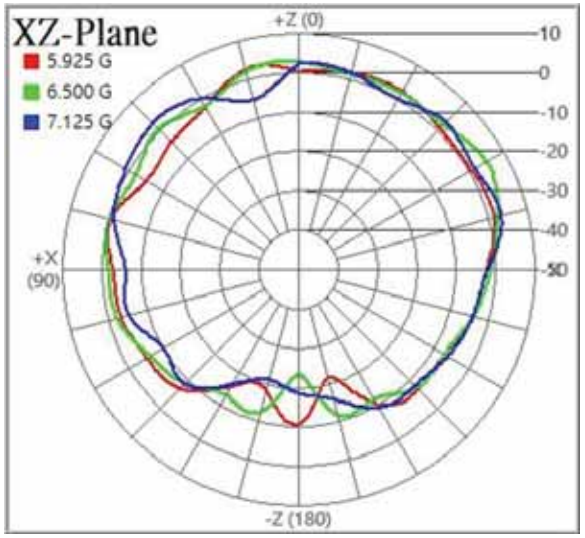


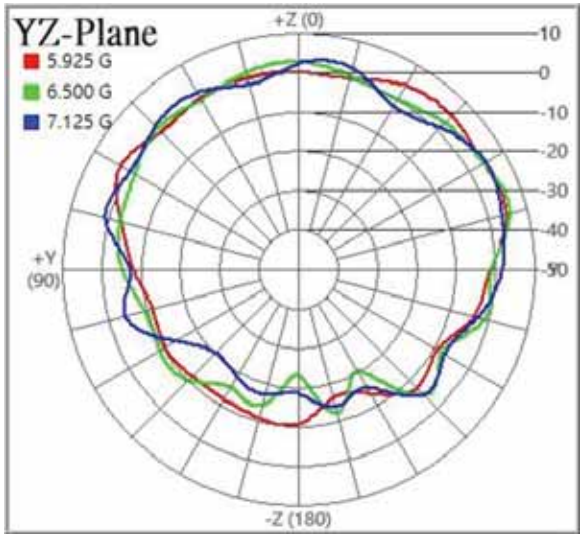


2D Pattern – Ant.9_6.5GHz

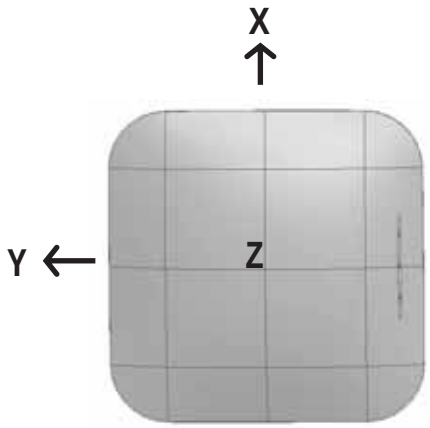


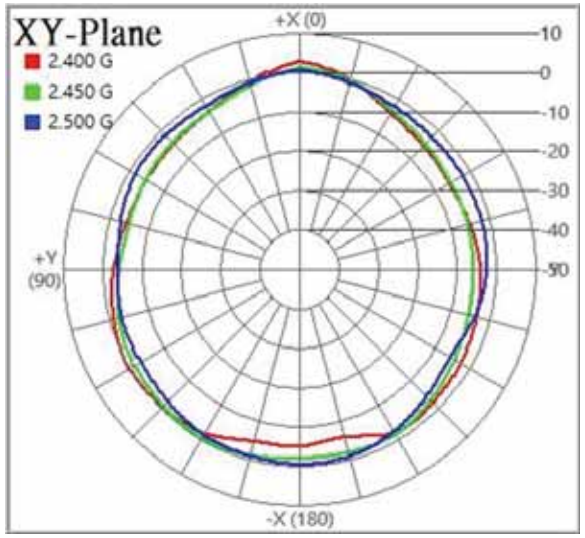


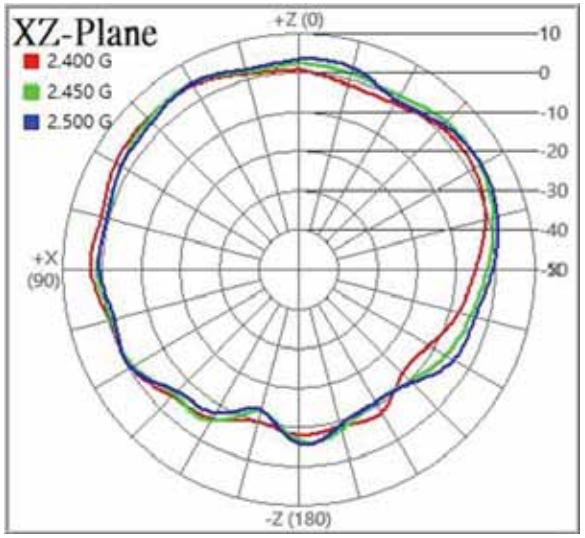


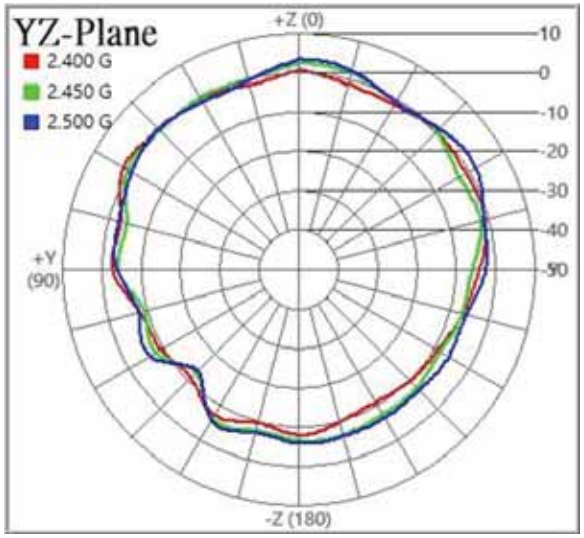


2D Pattern – Ant.10_2.45GHz

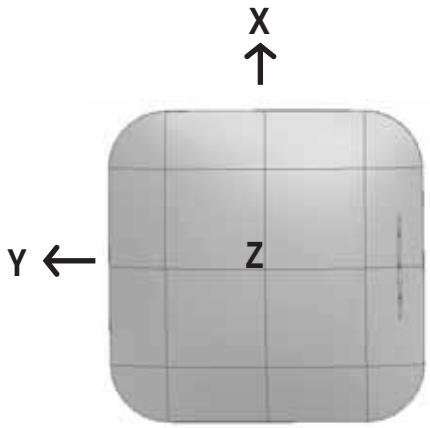


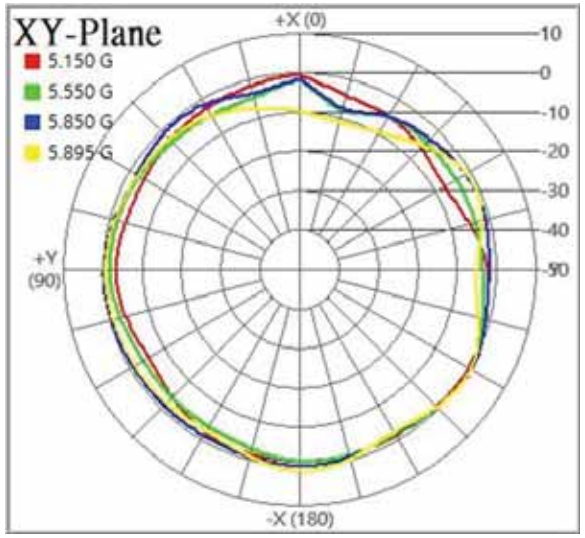


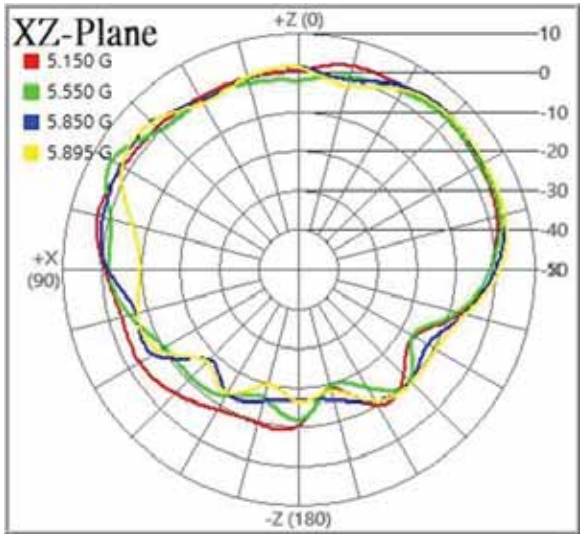


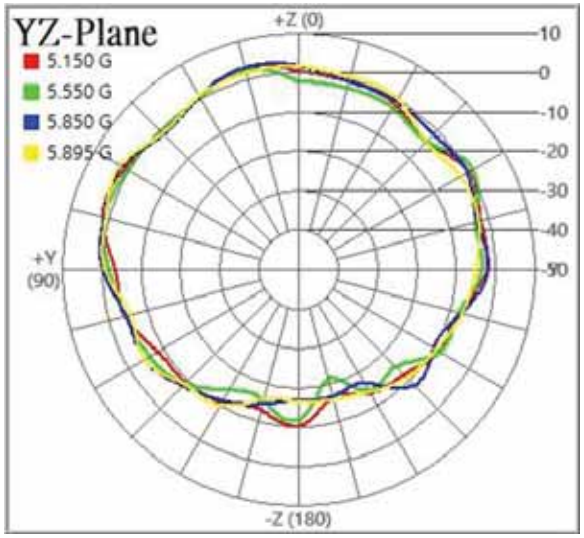


2D Pattern – Ant.10_5.5GHz

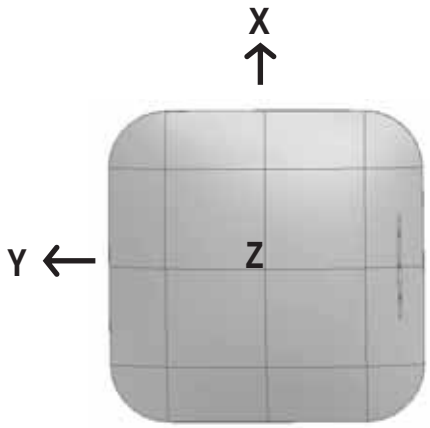


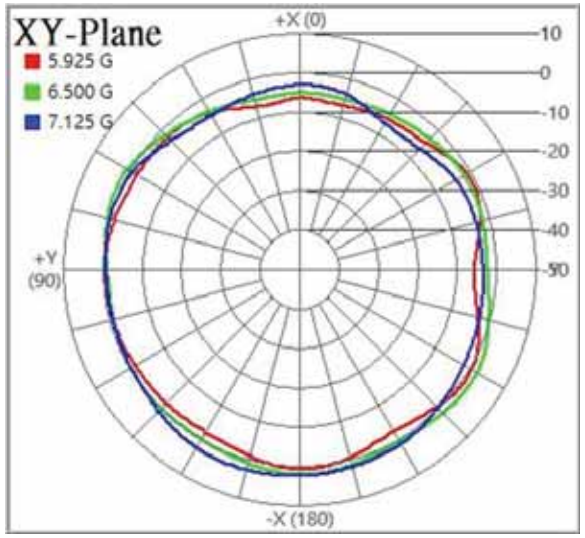


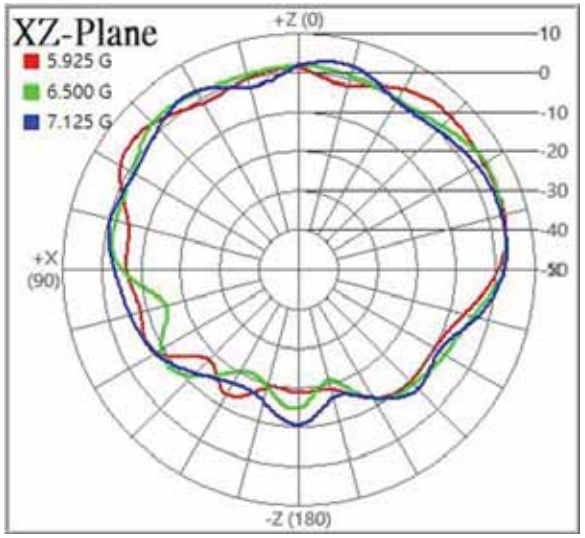


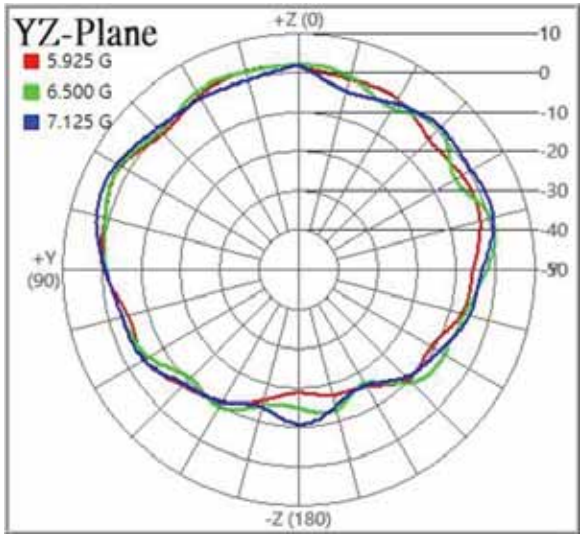


2D Pattern – Ant.10_6.5GHz

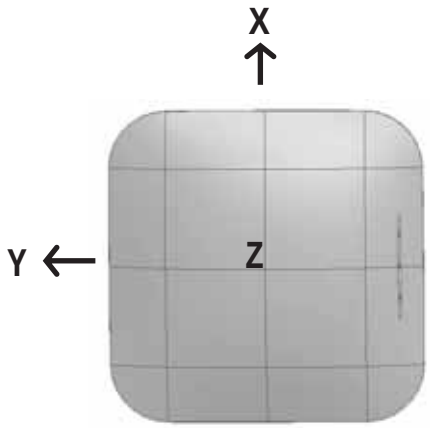


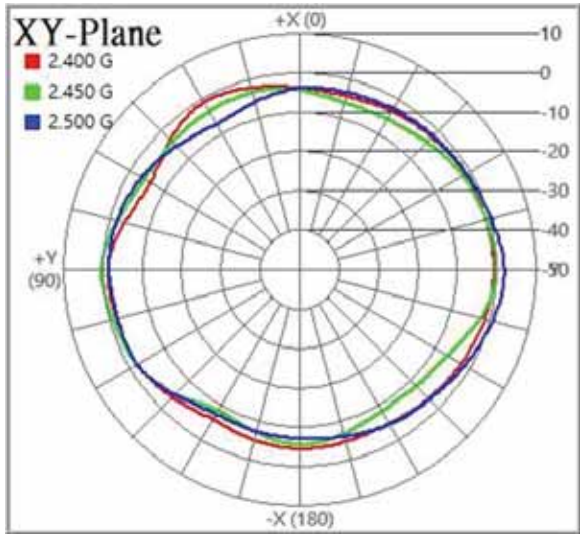


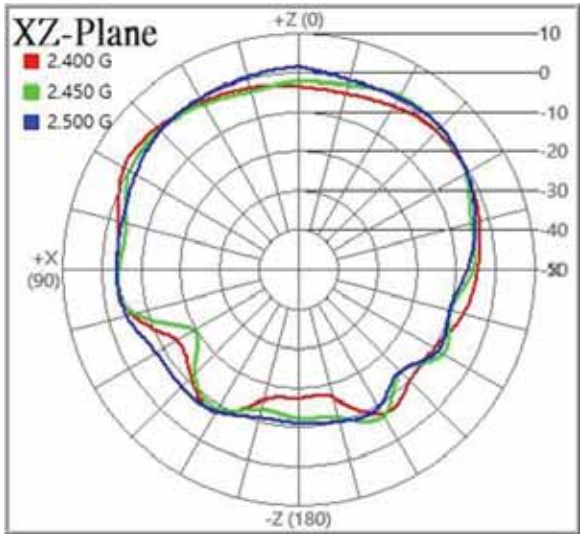


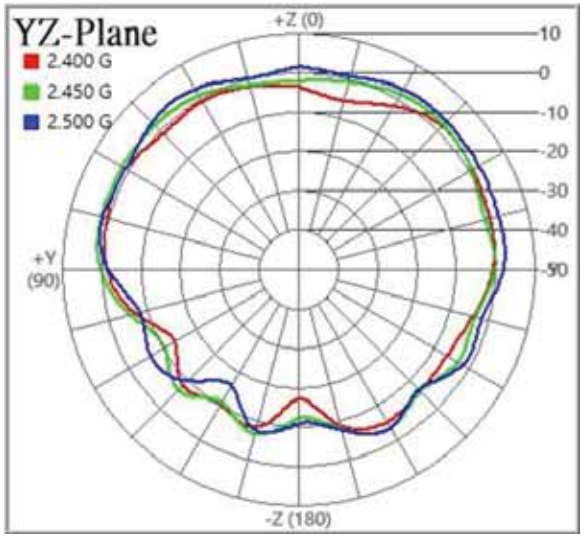


2D Pattern – Ant.11_2.45GHz

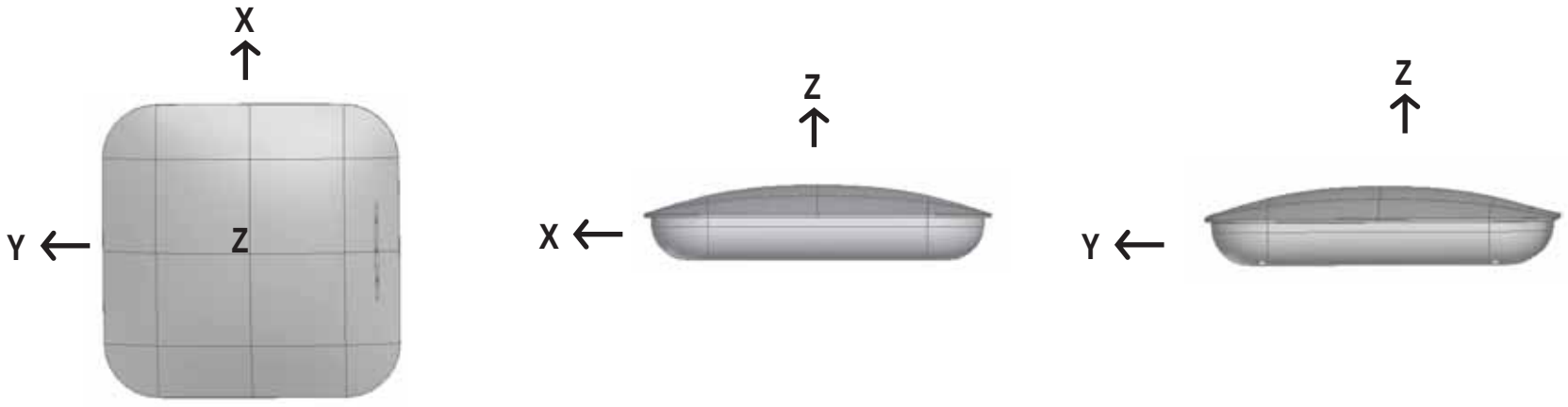


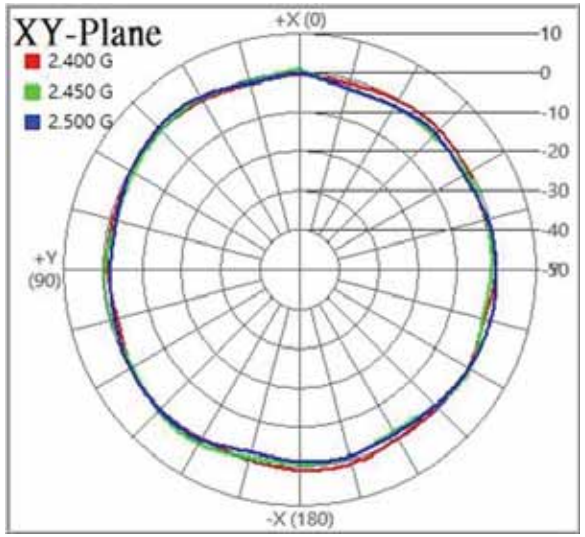


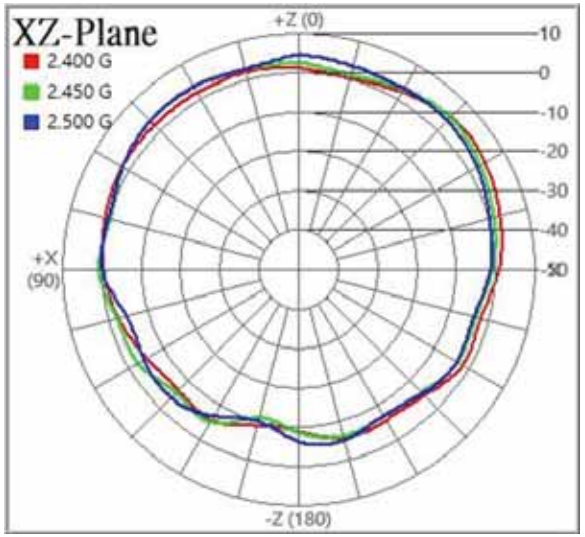


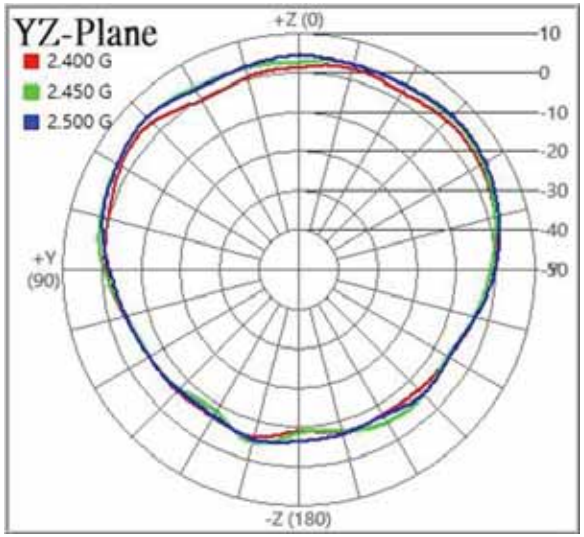


2D Combine Pattern – Radio1_2.45GHz (Ant.1~4)

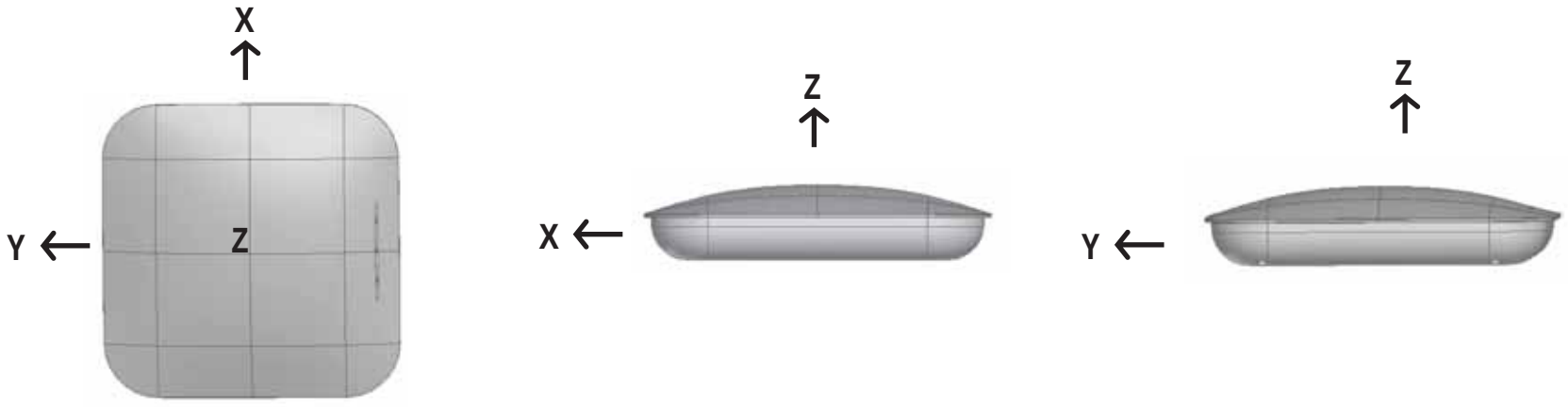


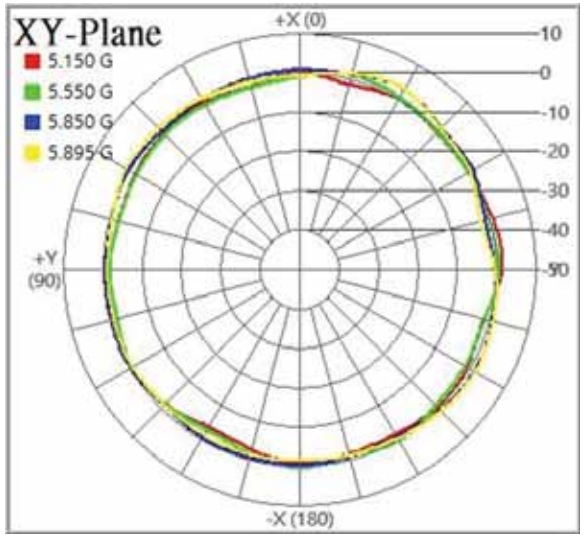


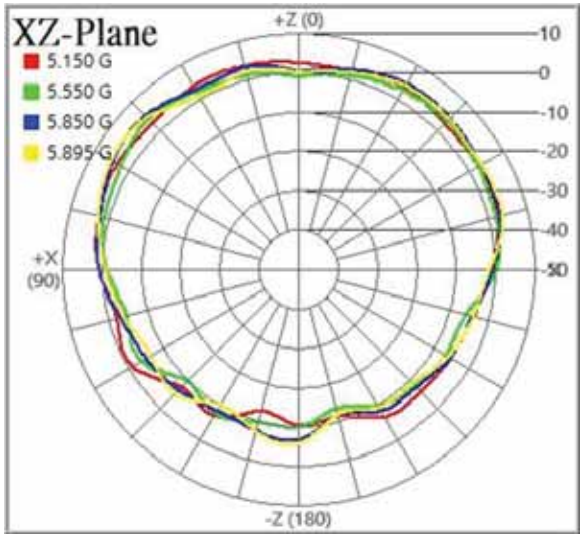


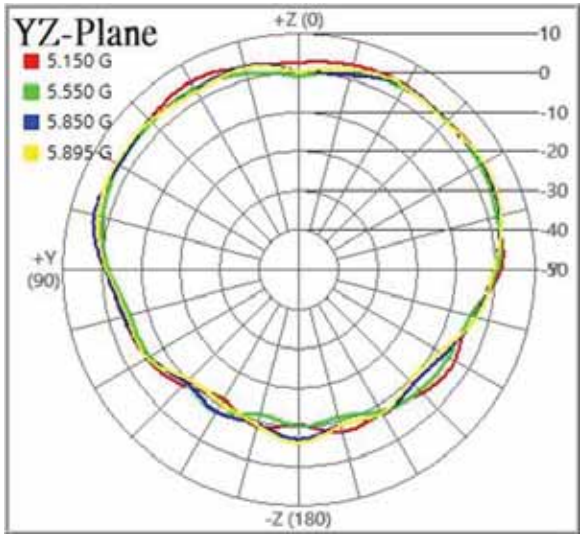


2D Combine Pattern – Radio2_5.5GHz(Ant.1~4)

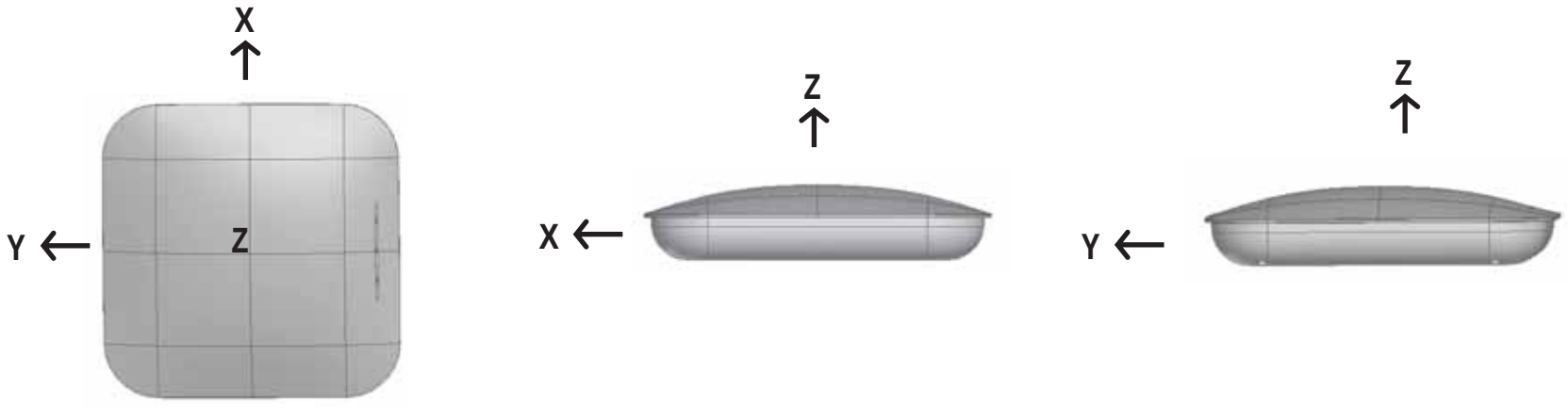


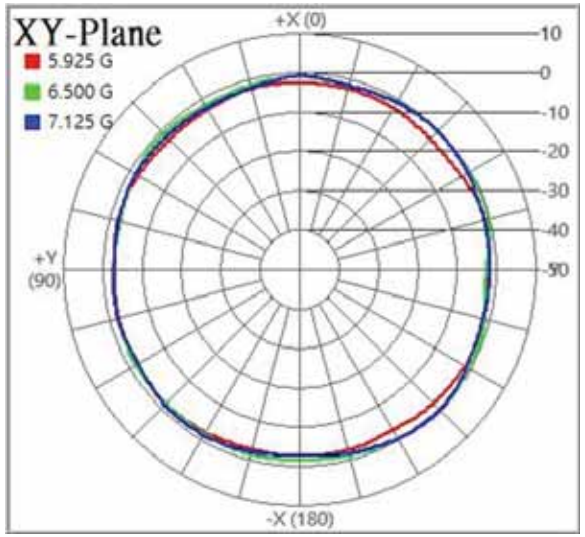


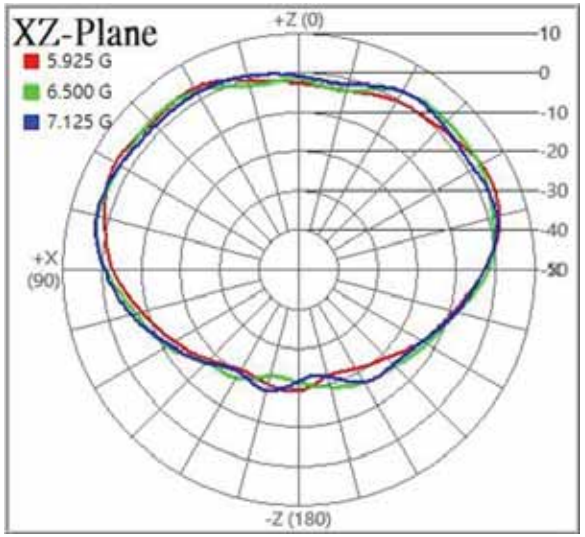


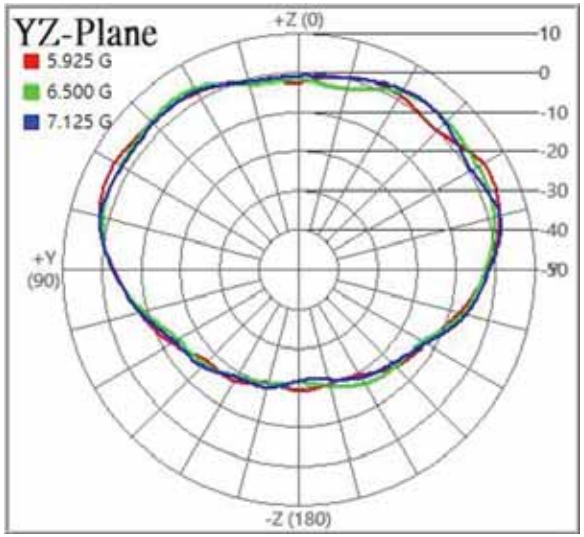


2D Combine Pattern – Radio3_6.5GHz (Ant.5~8)

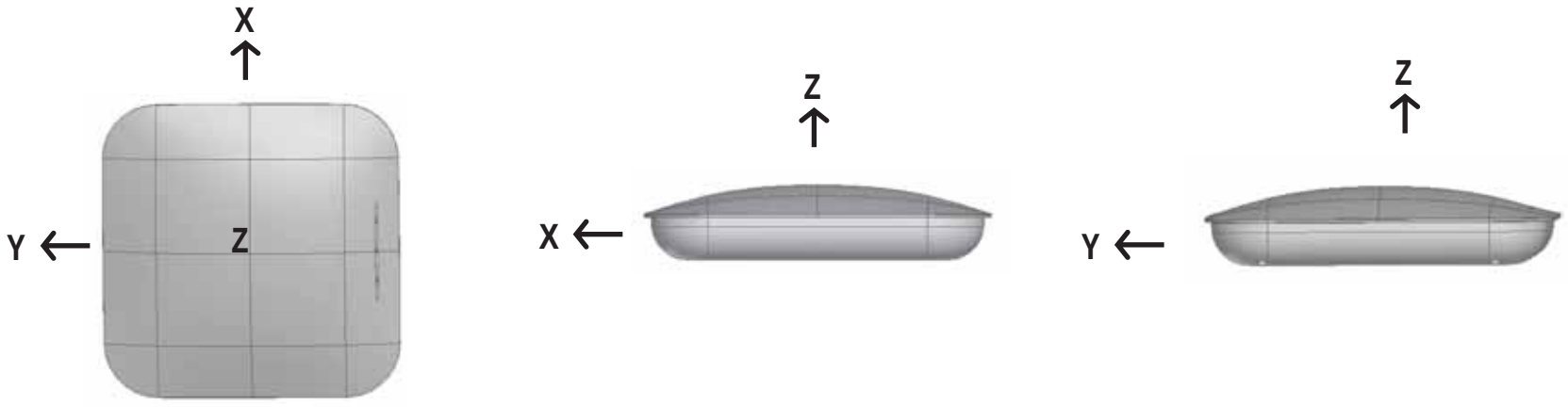


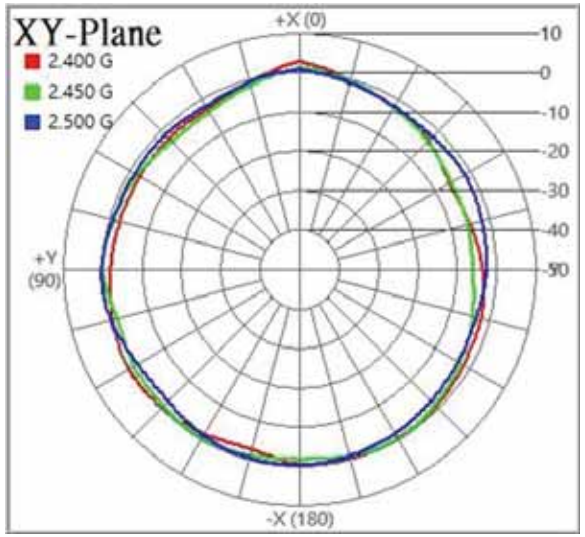


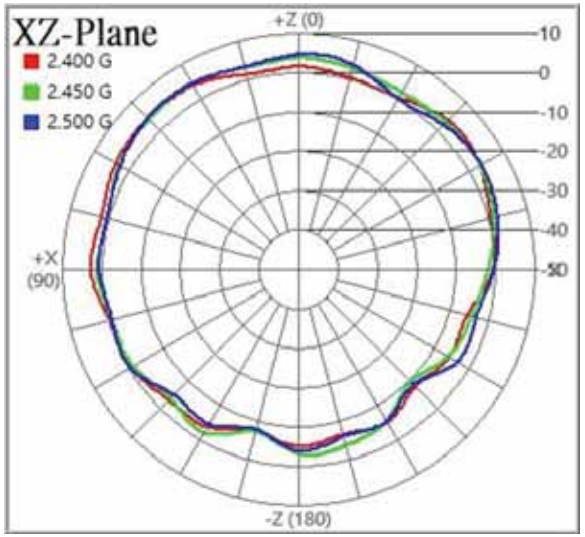


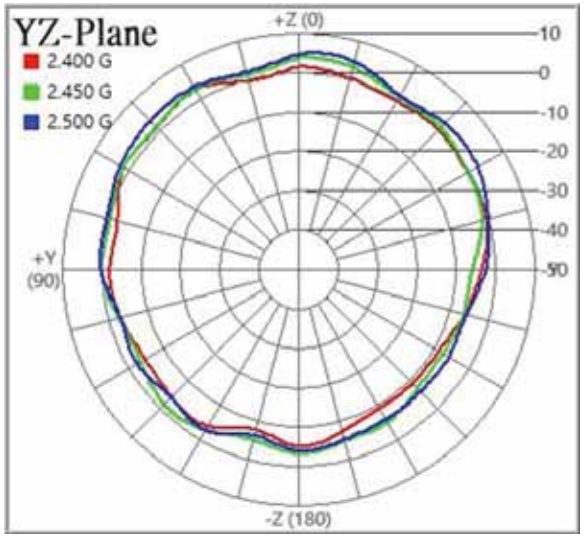


2D Combine Pattern – Radio4_2.45GHz(Ant.9&10)

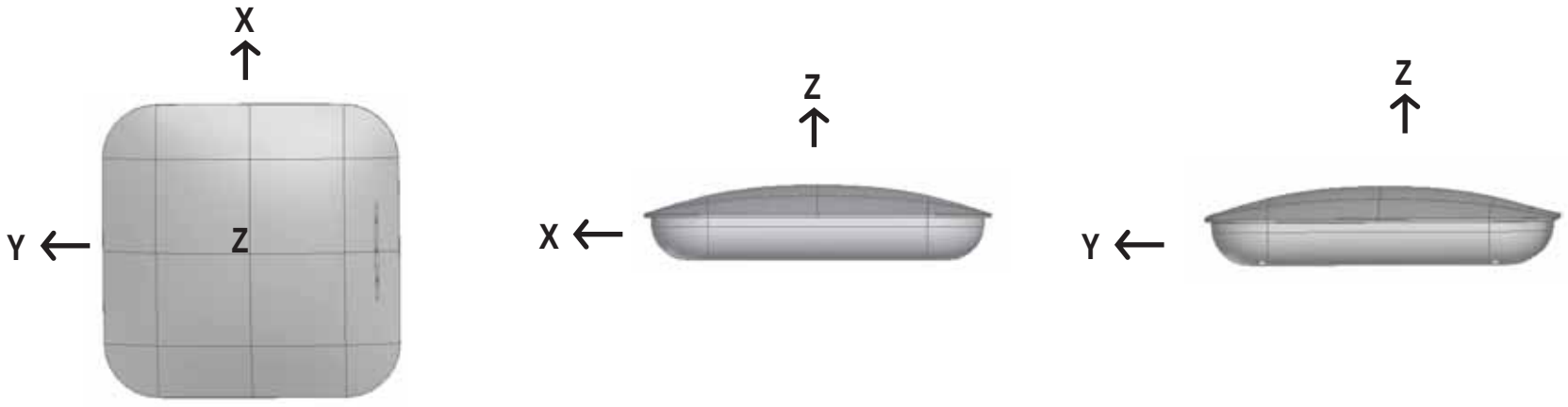


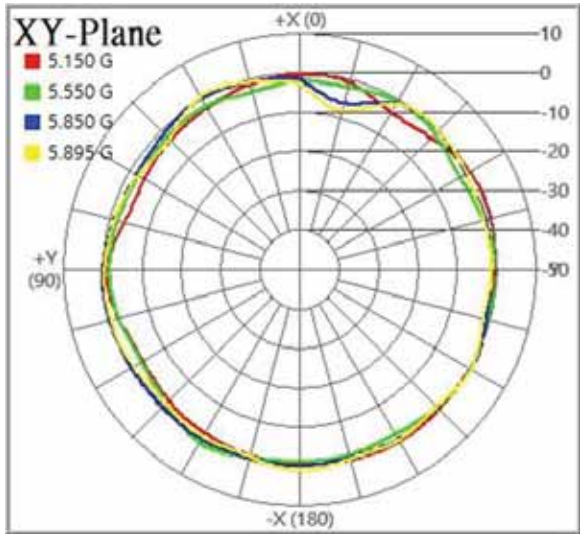


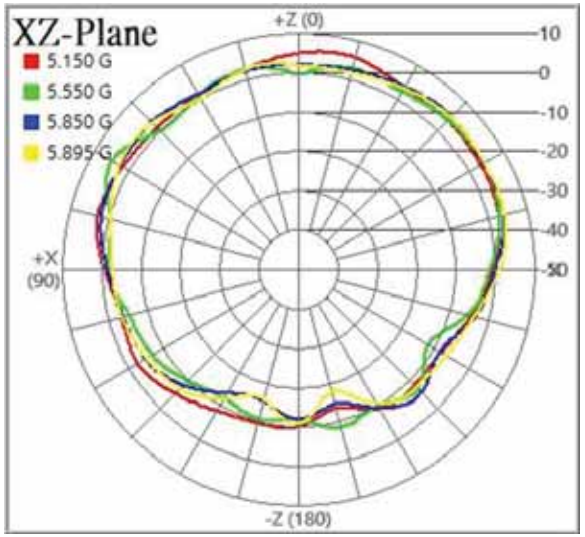


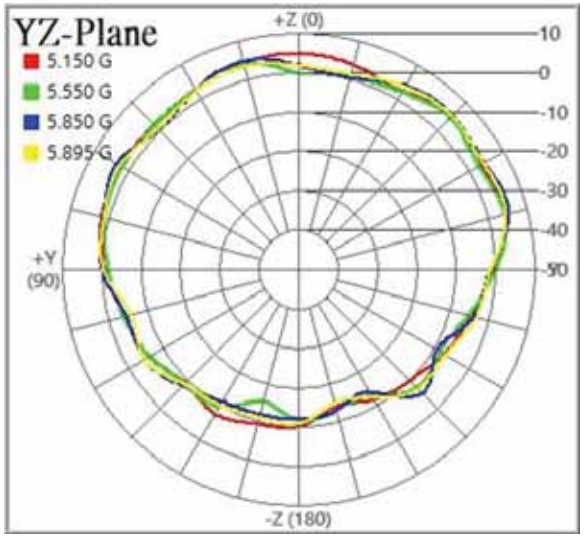


2D Combine Pattern – Radio4_5.5GHz(Ant.9&10)

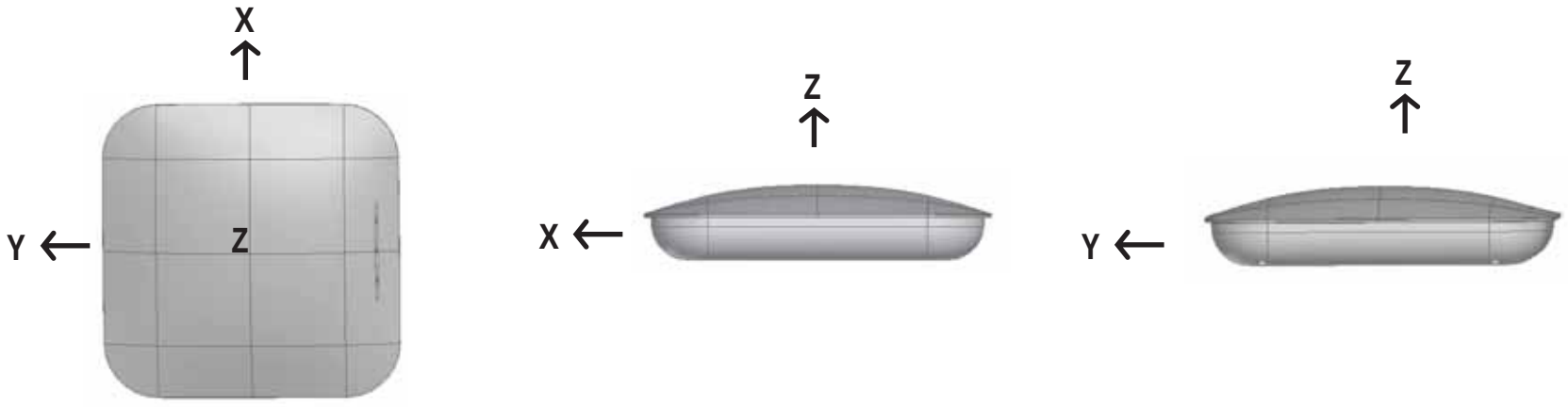


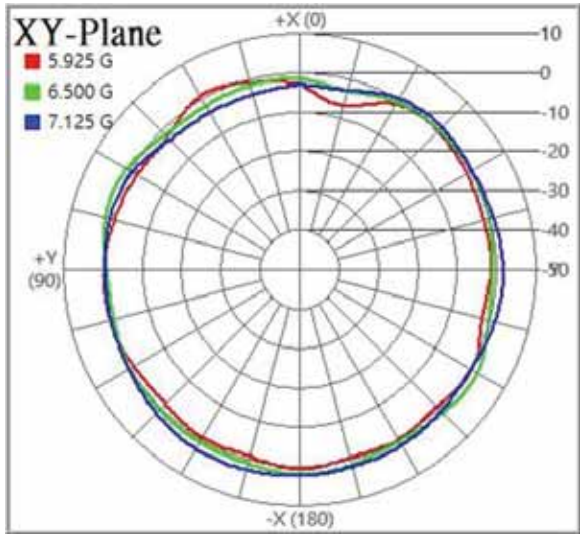


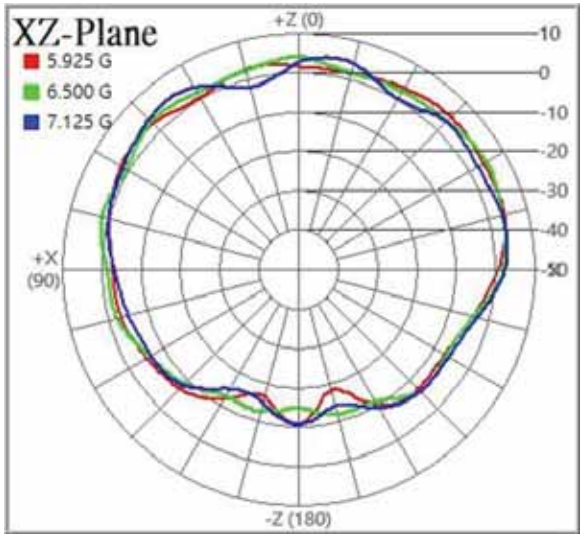


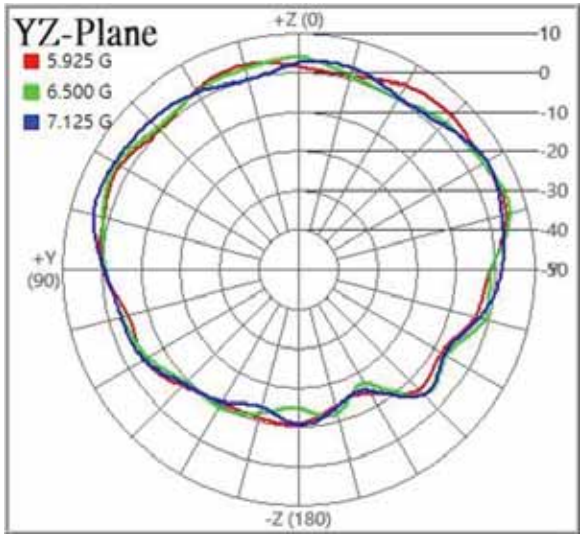


2D Combine Pattern – Radio4_6.5GHz(Ant.9&10)









Gain Table

Freq.(MHz)	Ant.1_Dual band		Ant.2_Dual band		Ant.3_Dual band		Ant.4_Dual band	
	Efficiency(%)	Peak Gain(dBi)	Efficiency(%)	Peak Gain(dBi)	Efficiency(%)	Peak Gain(dBi)	Efficiency(%)	Peak Gain(dBi)
2400	68.4	4.1	63.6	4.6	60.5	4.7	68.7	3.6
2450	69.3	4.0	65.7	4.8	62.4	4.7	68.9	3.5
2500	66.4	4.5	66.3	4.7	64.4	4.0	66.4	4.5
5150	75.0	5.9	74.1	5.7	74.5	5.7	70.9	5.7
5500	77.7	6.3	74.1	6.0	71.3	5.7	71.1	5.6
5850	76.5	6.1	70.8	5.9	76.7	6.1	72.4	5.8
5895	75.0	6.4	71.2	6.6	74.8	6.4	75.9	6.2

Freq.(MHz)	Ant.5_6G		Ant.6_6G		Ant.7_6G		Ant.8_6G	
	Efficiency(%)	Peak Gain(dBi)	Efficiency(%)	Peak Gain(dBi)	Efficiency(%)	Peak Gain(dBi)	Efficiency(%)	Peak Gain(dBi)
5925	67.4	4.7	61.2	4.6	63.8	4.7	61.8	4.7
6500	69.6	5.1	67.1	4.6	63.1	4.9	67.2	5.2
7125	61.0	4.8	66.3	4.5	67.9	4.9	62.7	4.8

Gain Table

Freq.(MHz)	Ant.9_Tri band		Ant.10_Tri band	
	Efficiency(%)	Peak Gain(dBi)	Efficiency(%)	Peak Gain(dBi)
2400	65.7	4.3	60.0	4.1
2450	65.5	4.7	63.8	4.3
2500	64.3	4.4	67.7	4.3
5150	69.7	5.3	69.5	4.6
5500	74.9	5.5	66.3	5.0
5850	71.1	5.9	66.5	5.0
5895	69.4	5.4	67.8	4.8
5925	69.4	5.4	67.9	4.9
6500	76.5	5.6	71.8	4.9
7125	70.0	5.5	74.2	4.9

Freq.(MHz)	Ant.11_BLE/Zigbee	
	Efficiency(%)	Peak Gain(dBi)
2400	61.2	3.3
2450	64.0	4.0
2500	63.1	4.5