



FAP-222KL

Antenna Test Report

A faint, light blue world map is visible in the background of the lower-left section of the slide.

Senao Networks Inc.

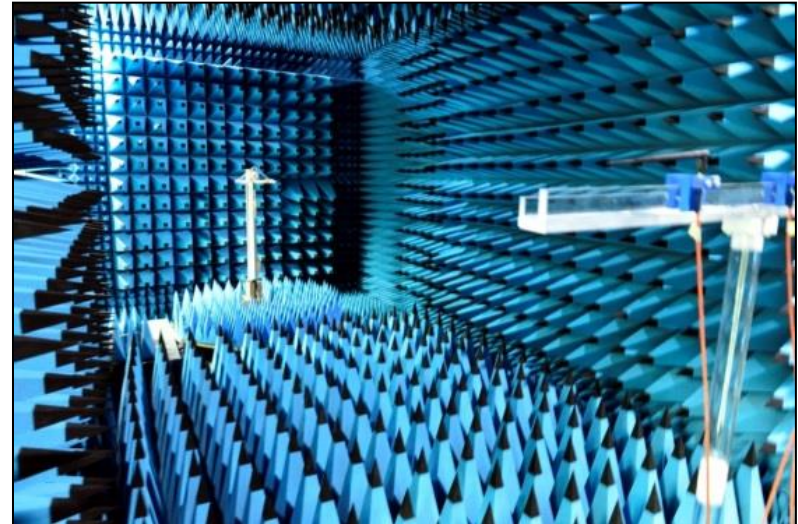
Customer	Fortinet
Project	FAP-222KL
Project Description	LTE*1
	GPS*1
	Lora*1
	Wi-Fi*2
Date	2025/12/23
Prepared by	Daniel
Report Version	V03

Version	Date	Description
V01	2025/05/15	EVT sample testing
V02	2025/05/28	Antenna optimization
V03	2025/12/23	Delete Lora-1

- Antenna Test Information
- Antenna Test Setup
- Placement and Specification
- VSWR & Isolation
- Radiation Pattern
- Combine Pattern
- Efficiency and Gain

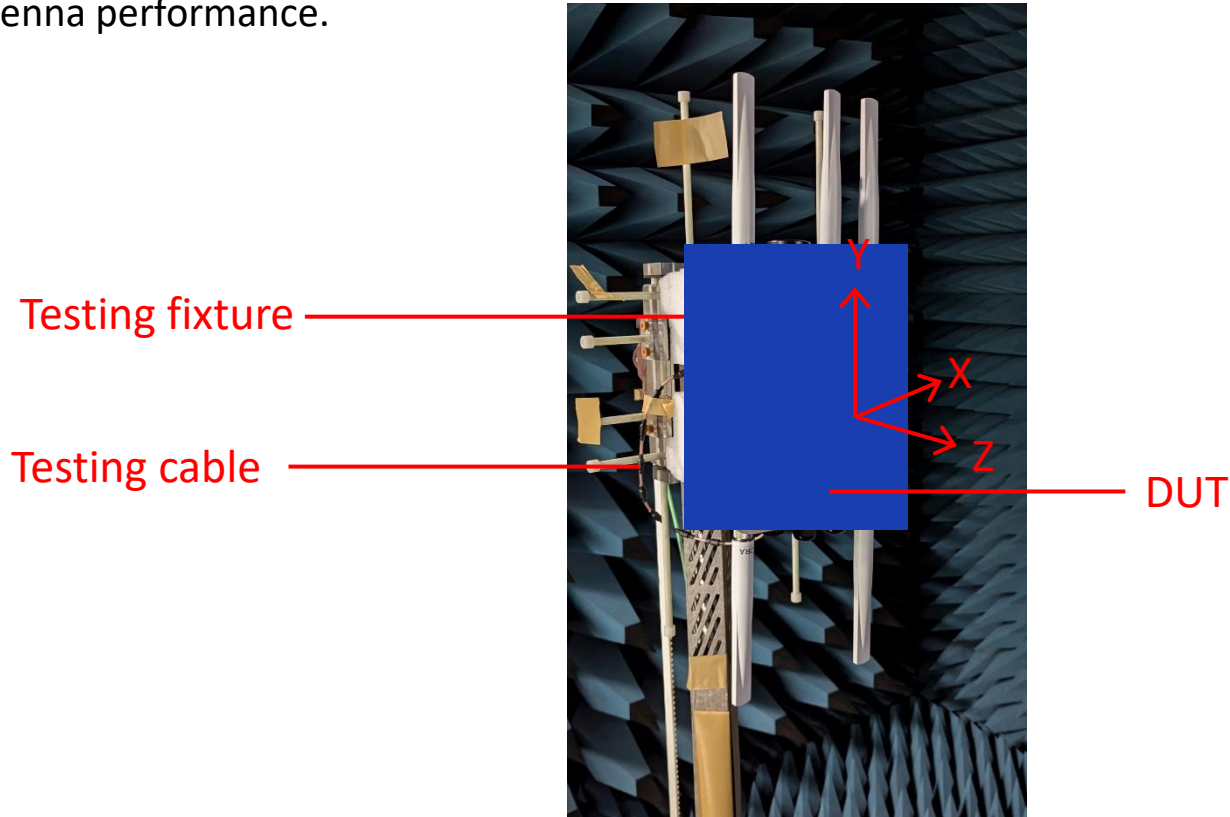
3D Anechoic Chamber - BWANT

- Size: 7.32M(L)x3.66M(W)x3.66M(H)
- Testing range from 600MHz to 8.5GHz
- 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
- Test software : BWANT 3D Passive

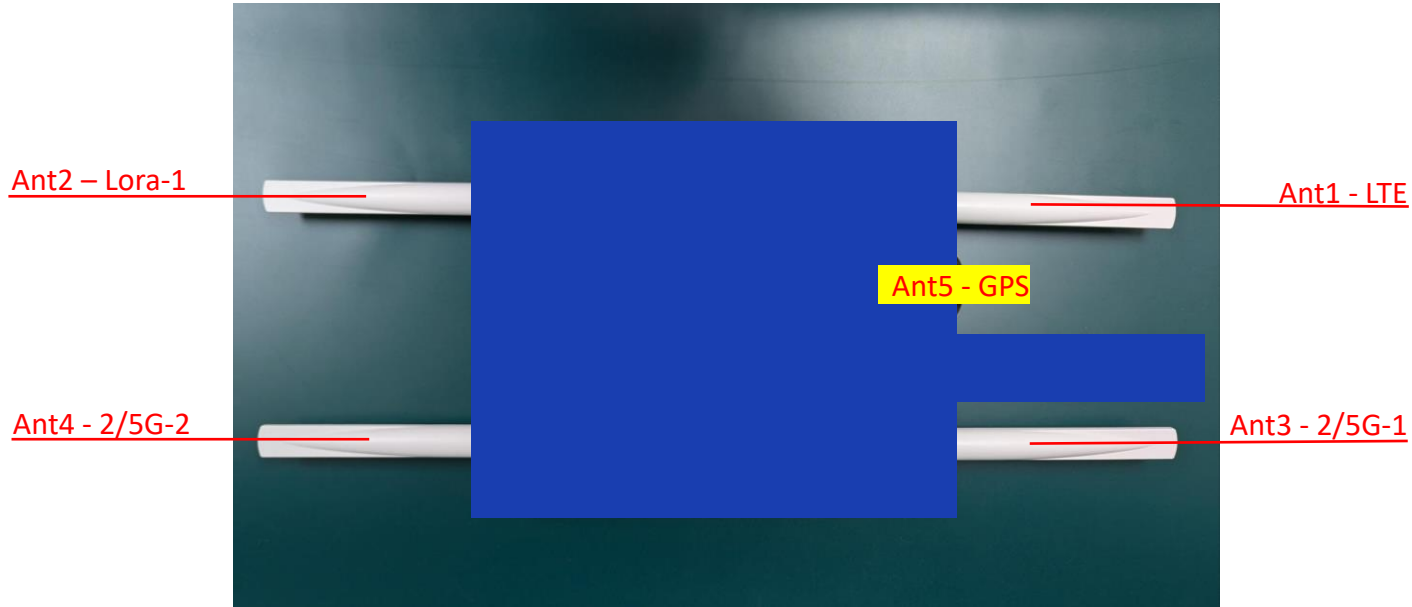


Antenna Test Setup

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



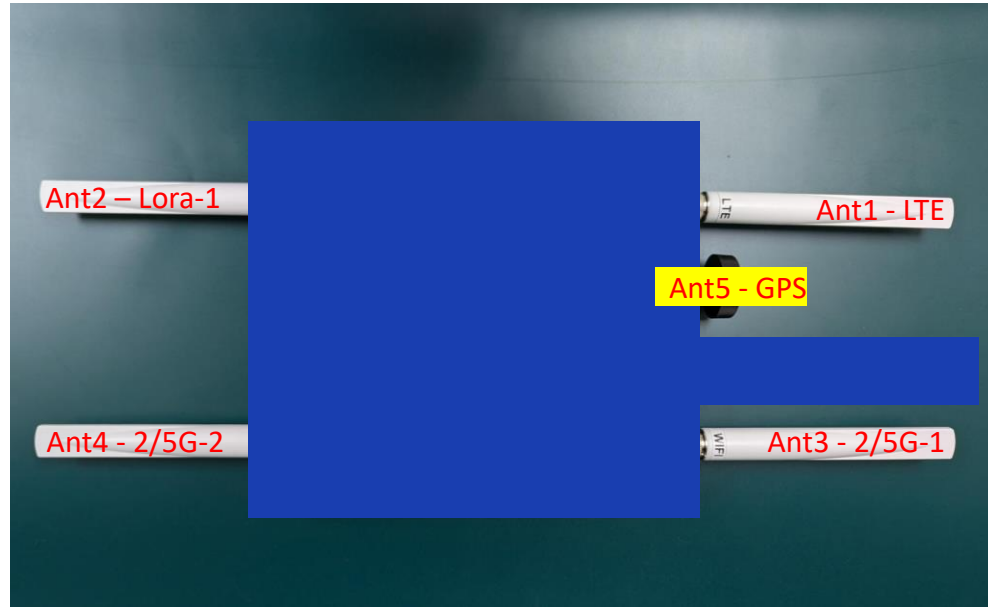
Placement and Specification

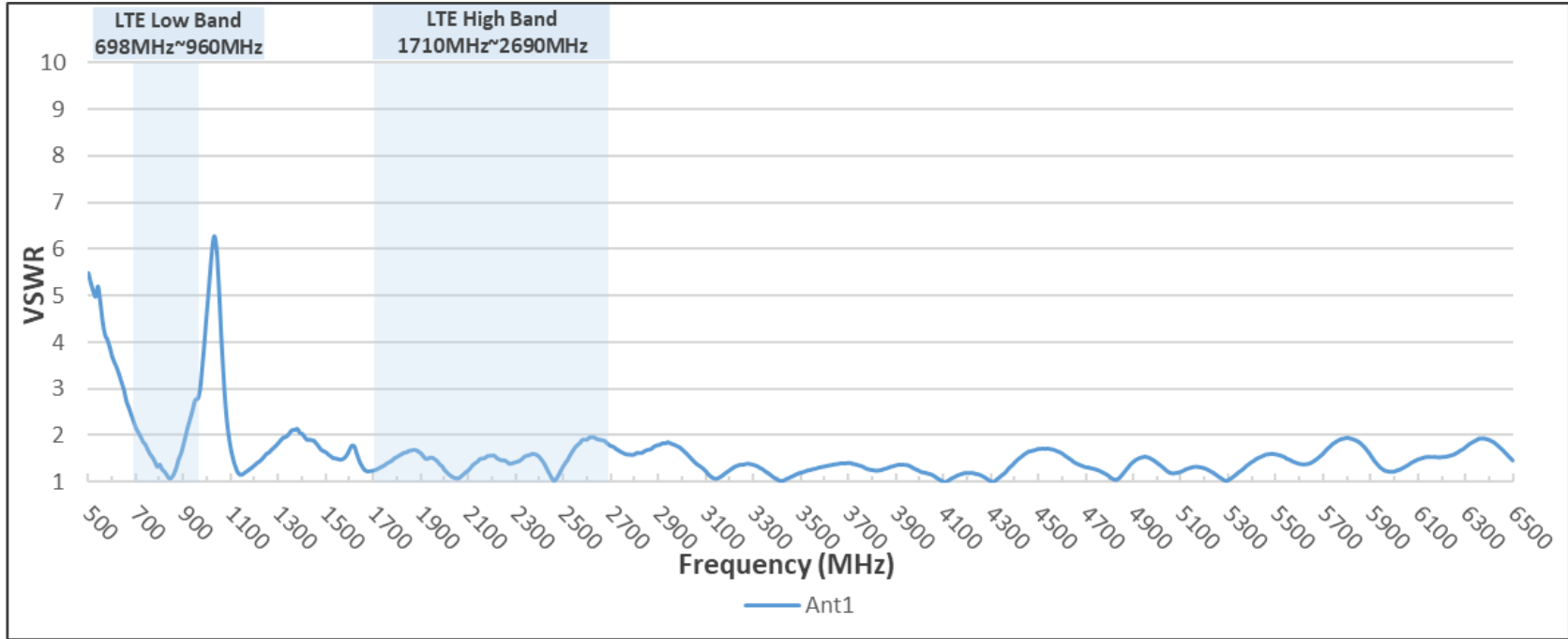


Ant No.	Operating Band	Peak Gain (dBi)	Efficiency (%)	Ant Type	Feeding
A 1	698~960 MHz 1710~2690MHz	3.6@Low band 4.2@High band	50%@Low band 50%@High band	DIPOLE	N-Type to IPEX
A 2	863~928MH MHz	3.7	55%	DIPOLE	N-Type to IPEX
A 3~4	2400 ~ 2500 MHz 5150 ~ 5895 MHz	4.9@2G 6.6@5G	60%@2G 60%@5G	DIPOLE	N-Type to IPEX
A 5	1565~1600 MHz	2.01@GPS	50%@GPS	PATCH	N-Type to IPEX

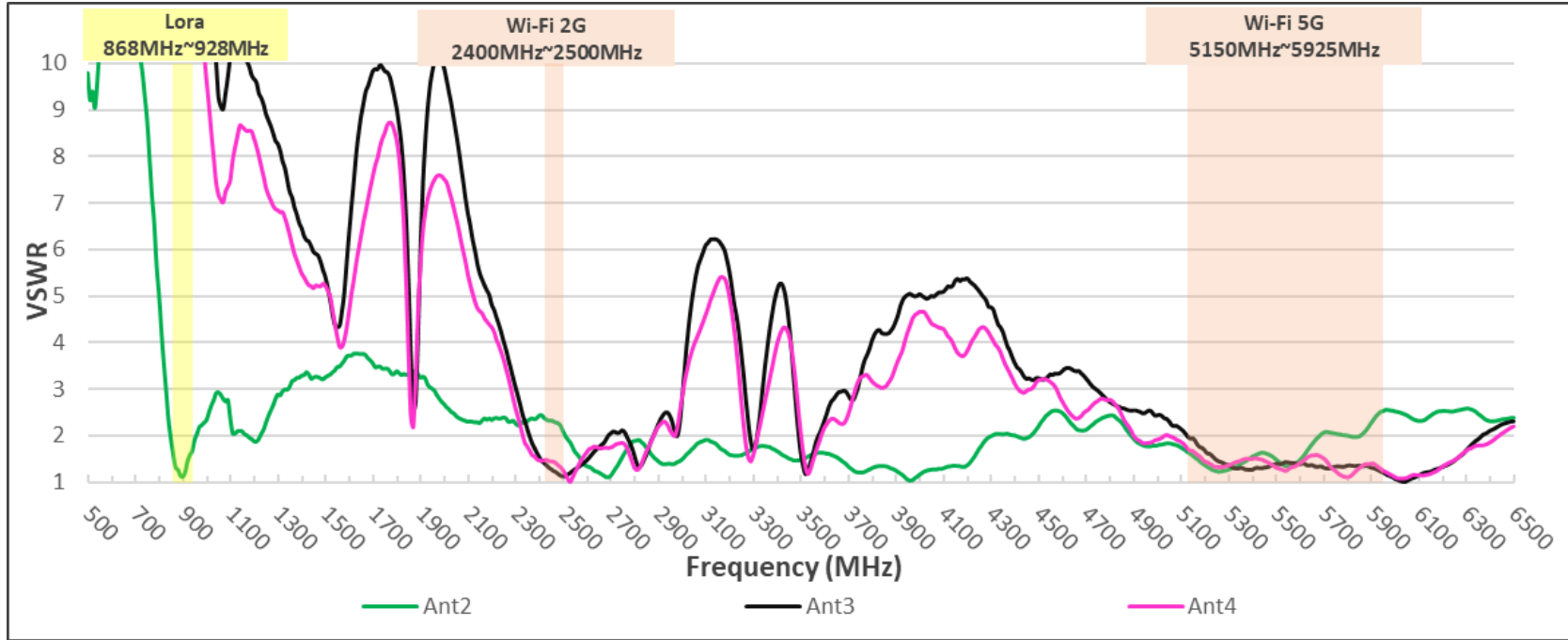
Placement and Specification

Ant.1	
Brand Name :	AWAN
P/N	7102A1358000
Ant.2	
Brand Name :	AWAN
P/N	7102A1361000
Ant.3	
Brand Name :	AWAN
P/N	7102A1357000
Ant.4	
Brand Name :	AWAN
P/N	7102A1357000
Ant.5	
Brand Name :	AWAN
P/N	7102A1359000





Ant1:LTE, Ant2:Lora , Ant3:Wi-Fi , Ant4:Wi-Fi



Ant1:LTE, Ant2:Lora , Ant3:Wi-Fi , Ant4:Wi-Fi

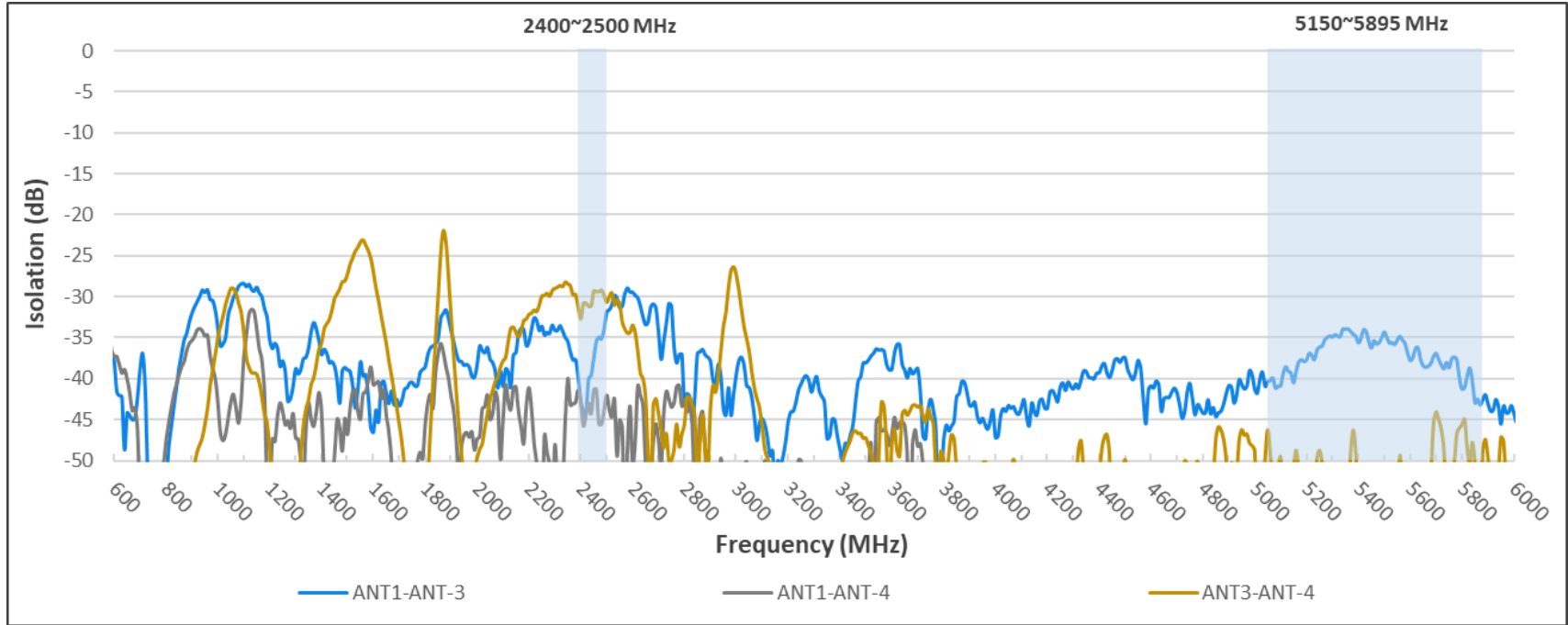
Antenna VSWR Table

LTE	
Freq. (MHz)	Ant1
700	2.16
830	1.15
960	2.79
1710	1.26
1760	1.40
1810	1.57
1860	1.67
1910	1.55
1960	1.48
2010	1.20
2060	1.08
2110	1.31
2160	1.50
2200	1.57
2300	1.42
2350	1.57
2400	1.53
2450	1.09
2500	1.33
2550	1.74
2600	1.91
2650	1.91
2690	1.81

Lora	
Freq. (MHz)	Ant2
868	1.33
883	1.28
898	1.13
913	1.23
928	1.60

Wi-Fi		
Freq. (MHz)	Ant3	Ant4
2400	1.55	1.48
2450	1.29	1.45
2500	1.14	1.26
5150	1.95	1.68
5500	1.40	1.32
5850	1.37	1.31

Antenna Isolation



Ant1:LTE, Ant2:Lora , Ant3:Wi-Fi , Ant4:Wi-Fi

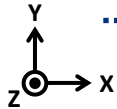
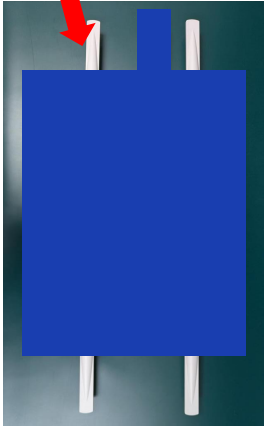
Antenna Isolation Table

S21			
Freq. (MHz)	ANT1-ANT-3	ANT1-ANT-4	ANT3-ANT-4
868			
900			
928			
2400	-42.63	-42.81	-32.65
2450	-37.56	-41.33	-29.28
2500	-31.87	-41.99	-30.62
5150			-50.51
5500			-53.66
5895			-50.64

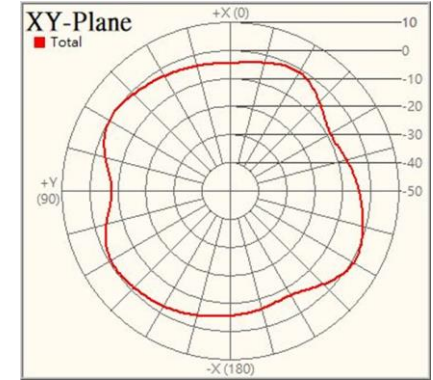
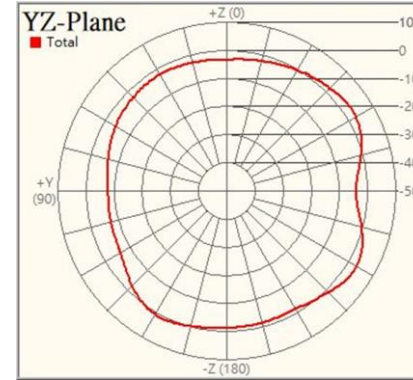
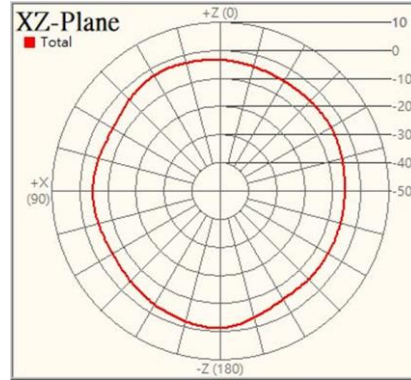
Ant1:LTE, Ant2:Lora , Ant3:Wi-Fi , Ant4:Wi-Fi

2D Radiation Pattern – LTE

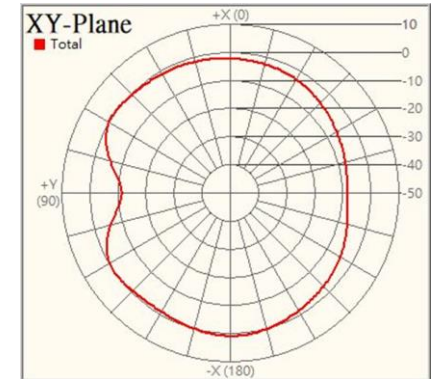
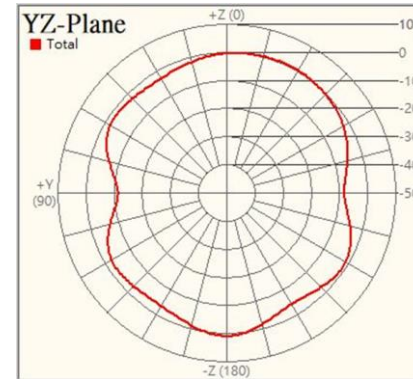
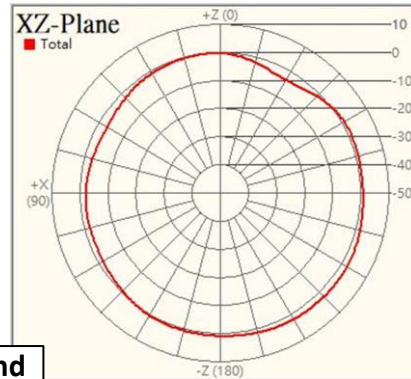
Ant1 - LTE



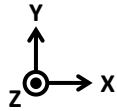
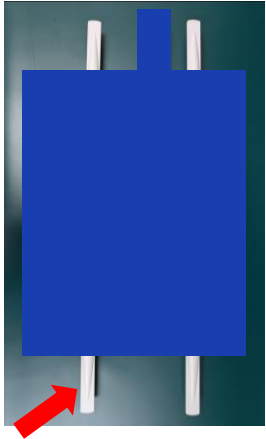
Low Band



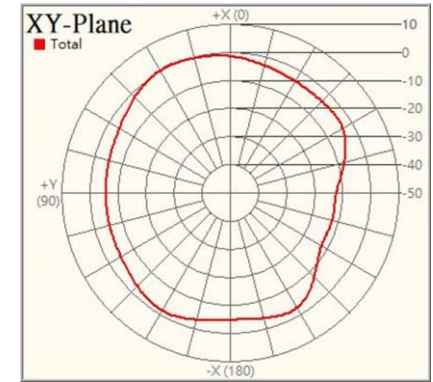
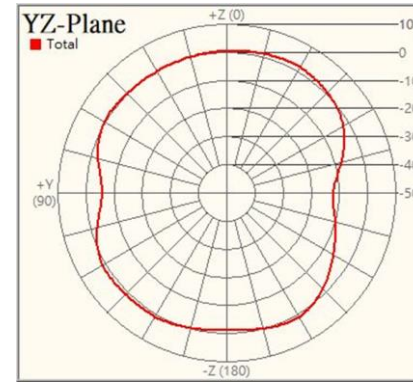
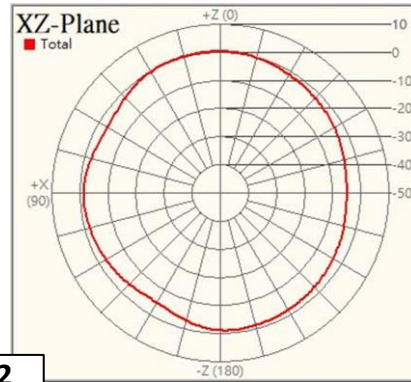
High Band



2D Radiation Pattern – LORA

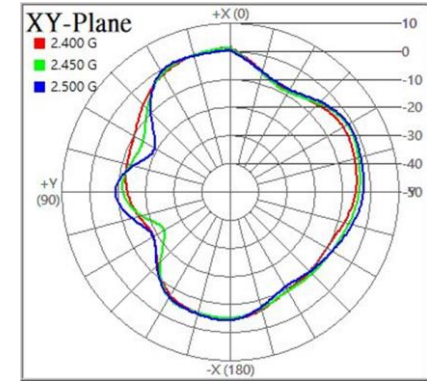
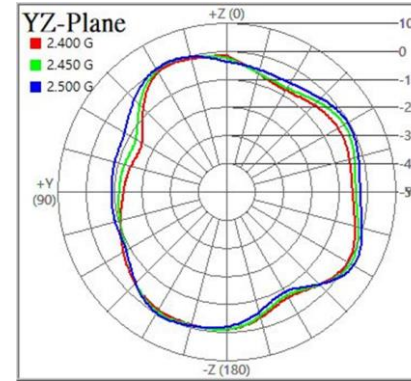
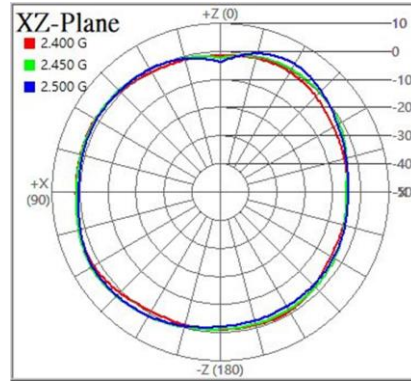
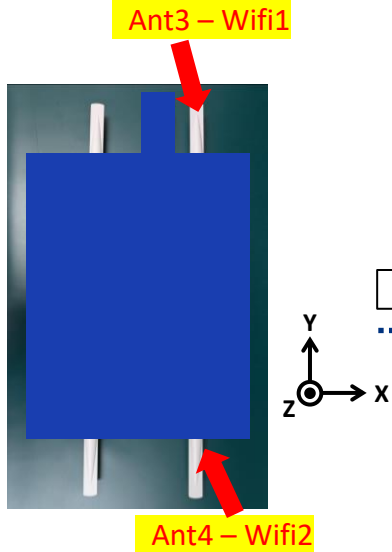


Ant2

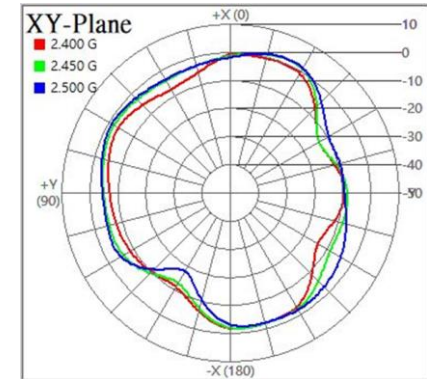
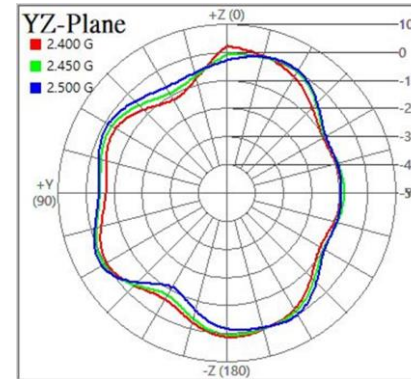
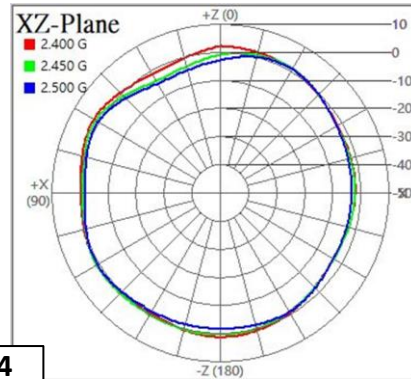


Ant2 – Lora1

2D Radiation Pattern – Wi-Fi Radio 1

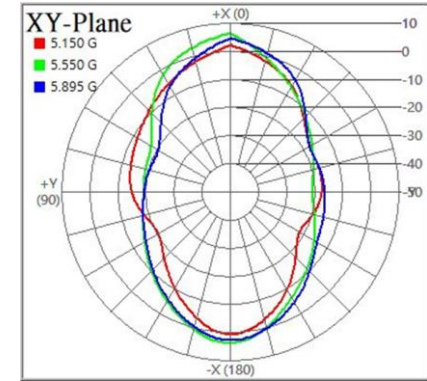
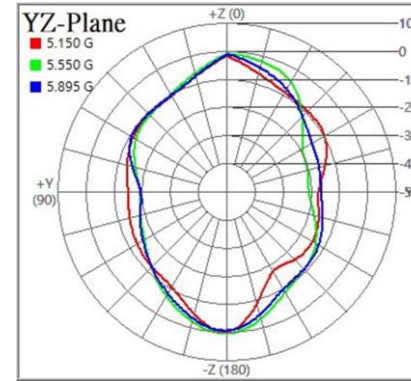
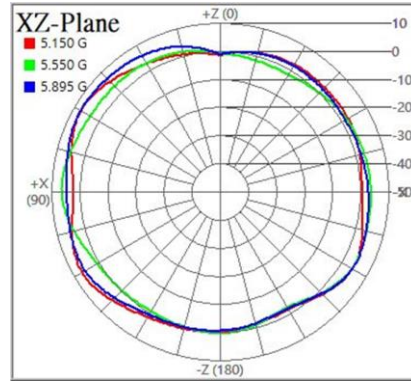
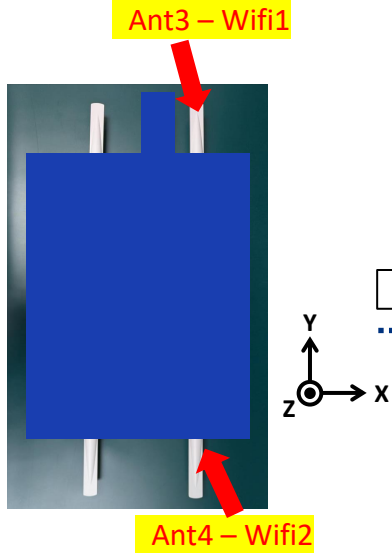


Ant3

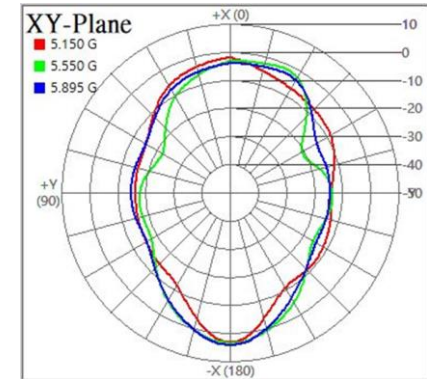
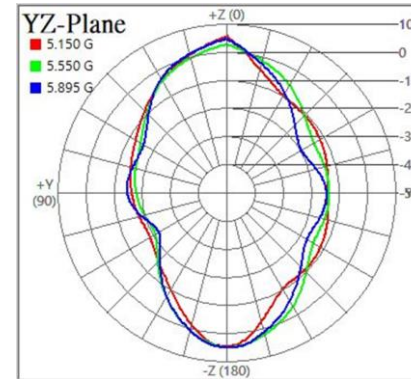
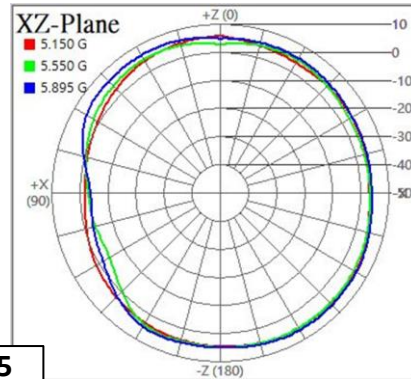


Ant4

2D Radiation Pattern – Wi-Fi Radio 2

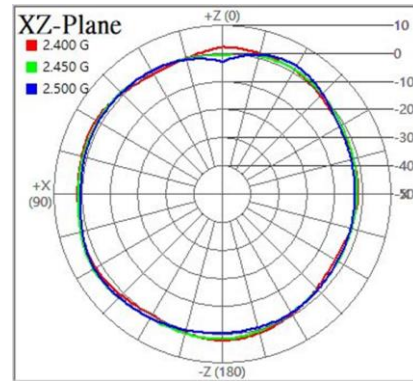
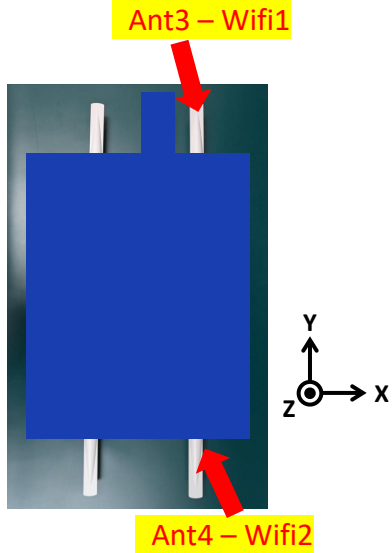


Ant4

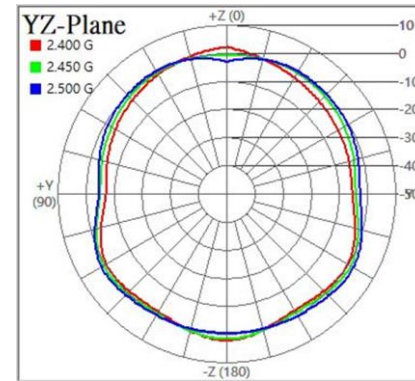


Ant5

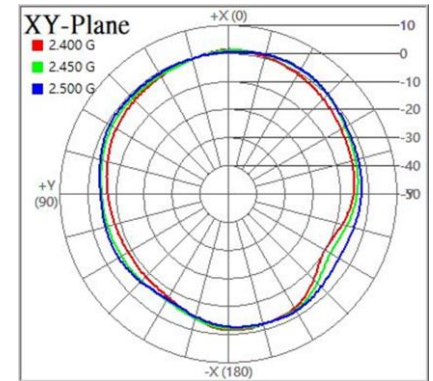
Combine Pattern – Wi-Fi Radio 1



XZ-Plane

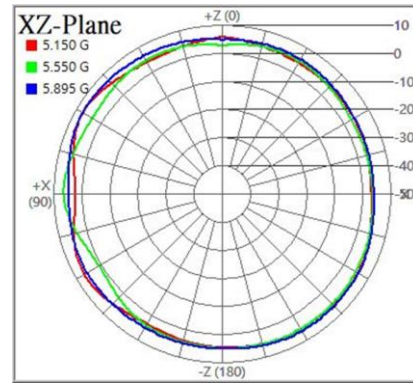
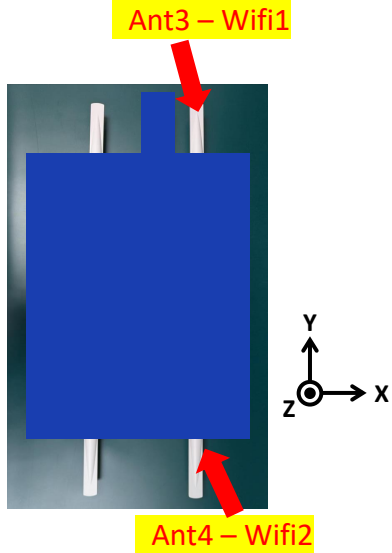


YZ-Plane

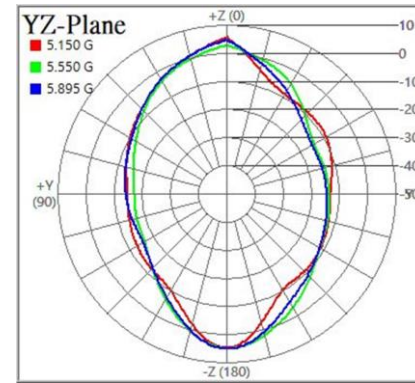


XY-Plane

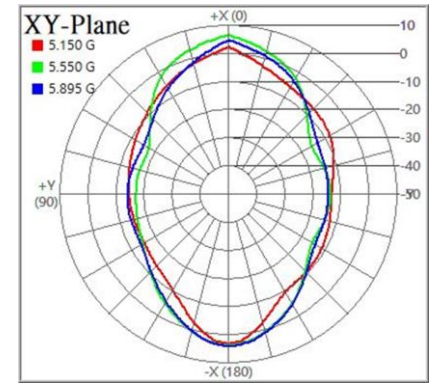
Combine Pattern – Wi-Fi Radio 2



XZ-Plane



YZ-Plane



XY-Plane

Antenna Efficiency and Gain

LTE Antenna Performance		
Freq. (MHz)	Efficiency (%)	Peak Gain (dBi)
700	55	2.5
720	58	3.0
740	54	3.2
760	53	2.9
780	51	3.5
800	54	2.4
820	53	2.6
840	53	3.3
860	61	3.2
880	62	3.2
900	67	3.1
920	68	3.6
940	58	2.8
960	51	2.7

LTE Antenna Performance		
Freq. (MHz)	Efficiency (%)	Peak Gain (dBi)
1710	73	4.0
1750	70	4.1
1800	68	4.0
1850	67	4.2
1900	63	3.6
1950	67	3.8
2000	67	3.5
2050	71	3.2
2100	61	3.0
2170	54	1.9
2200	55	1.7
2300	61	2.0
2350	60	2.4
2400	63	2.8
2450	64	2.6
2500	72	2.5
2550	67	2.6
2600	60	2.5
2650	57	2.8
2690	60	3.0

Cable length :100mm
 Cable Loss
 Lowband:0.25dB
 High band:0.45dB

Antenna Efficiency and Gain

The test values already include cable loss. The longer the cable, the greater the loss, which inevitably degrades the overall antenna performance, including antenna gain. If we consider only the antenna itself, the WiFi 2G gain can exceed 5 dBi.

Antenna Cable Loss		
Item	Cable length	Cable loss
Ant 2	250mm	900MHz=0.43dB
Ant 3	100mm	2450MHz=0.52dB, 5500MHz=0.81dB
Ant 4	250mm	2450MHz=0.76dB, 5500MHz=1.28dB

Lora Antenna Performance		
Freq. (MHz)	Ant.2	
	Efficiency (%)	Peak Gain (dBi)
863	60	3.3
873	57	3.0
883	57	3.7
893	63	2.9
903	61	3.1
913	67	3.6
923	65	3.7
928	60	3.7

Wi-Fi Antenna Performance				
Freq. (MHz)	Ant.3		Ant.4	
	Efficiency (%)	Peak Gain (dBi)	Efficiency (%)	Peak Gain (dBi)
2400	66	4.4	68	4.1
2450	68	4.9	71	4.5
2500	69	4.8	67	4.2
5150	64	5.9	62	5.7
5500	68	6.6	60	6.4
5895	66	6.2	62	6.1

- The LTE antenna efficiency is higher than 50%, with peak gains of around 3.6dBi at low band, 4.2 dBi at high band.
- The Lora antenna efficiency is higher than 55%, with peak gains of around 3.7dBi.
- The Wi-Fi antenna efficiency is higher than 60%, with peak gains of around 4.9 dBi at Radio1, 6.6 dBi at Radio2.
- Due to the longer antenna cable, the increased cable loss inevitably affects the antenna performance.
- The antennas are fixed on the bottom cover, and it also has an omnidirectional radiation pattern in the horizontal direction.