Maui 802.11ax WiFi – 6E

P3B ST Sample1 Measurement Report

Foxconn Industrial Internet
富士康工业互联网

NPBG WNBU RD Team

C9136I Antenna Production Information

Project Name: Maui

Model Name: C9136I

Antenna Manufacturer: HON LIN Technology Co., Ltd.

Address: 11F, No.32, Jihu Rd., Neihu Dist., Taipei City 114699, Taiwan R.O.C

Antenna Test Report Agenda

- Summary

- Antenna Sub-system Overview

- Measurement Environment

- MIMO1 Performance

- MIMO2 Performance

- MIMO3 Performance

- Serving Antennas Cross-Pair Isolation

- Aux Performance

- Aux Antennas Cross-Pair Isolation

- IoT Performance

Summary

- The complete verification of P3B soft tool sample has executed with 1 unit, overall performance is close to CNC sample, but part of parameter has slightly difference. Tabular comparison list as below.
- Compliance team will adopt P3C ST sample (same as P3B ST) to do certification which is producing now, if Foxconn use P3B ST to do fine tune, the implement timing will be PP hard tool, but it will have exterior difference (antenna placement) and slight peak gain deviation. Need to confirm with Cisco if this report is OK, or we need to do some fine tune on P3B.

|	VSWR	Inner-pair Isolation	Cross-pair Isolation	Efficiency	Peak gain	Azimuth Ripple
P3A v2 CNC	< 2:1	DB2G: <-20dB DB5G: <-30dB SB5G: <-20dB SB6G: <-25dB	Dual5G: <-42.5dB 5GM-6G: <-29dB 5GS-6G: <-30dB 2GM-5GS: <-36dB 2GM-6G: <-41dB	DB2G: >55% DB5G: >53% SB5G: >50% SB6G: >55% Aux2G: >60% Aux5,6G: >60% IoT2G: >70%	DB2G: 2.9~4.2dBi DB5G: 3.0~4.6dBi SB5G: 3.4~5.7dBi SB6G: 4.5~6.3dBi Aux2G: 4.1~5.9dBi Aux5,6G: 4.3~6.1dBi IoT2G: 3.5~5.0dBi	DB2G: 7.8~10.5dB DB5G: 5.0~9.9dB SB5G: 4.6~8.0dB SB6G: 5.4~8.9dB Aux2G: 5.6~9.8dB Aux5,6G: 4.9~9.1dB IoT2G: 5.1~8.1dB
P3B ST	< 2:1	DB2G: <-20dB DB5G: <-30dB SB5G: <-20dB SB6G: <-25dB	Dual5G: <-40.5dB 5GM-6G: <-29dB 5GS-6G: <-30dB 2GM-5GS: <-36dB 2GM-6G: <-40.5dB	DB2G: >58% DB5G: >55% SB5G: >50% SB6G: >55% Aux2G: >60% Aux5,6G: >55% IoT2G: >68%	DB2G: 2.9~4.6dBi DB5G: 3.0~5.0dBi SB5G: 3.5~5.4dBi SB6G: 4.3~6.2dBi Aux2G: 4.5~5.6dBi Aux5,6G: 5.0~6.4dBi IoT2G: 3.0~5.2dBi	DB2G: 7.0~10.8dB DB5G: 5.5~11.0dB SB5G: 4.0~6.7dB SB6G: 5.1~8.5dB Aux2G: 6.7~10.8dB Aux5,6G: 5.0~11.2dB IoT2G: 4.9~7.2dB

Antenna Sub-system Overview
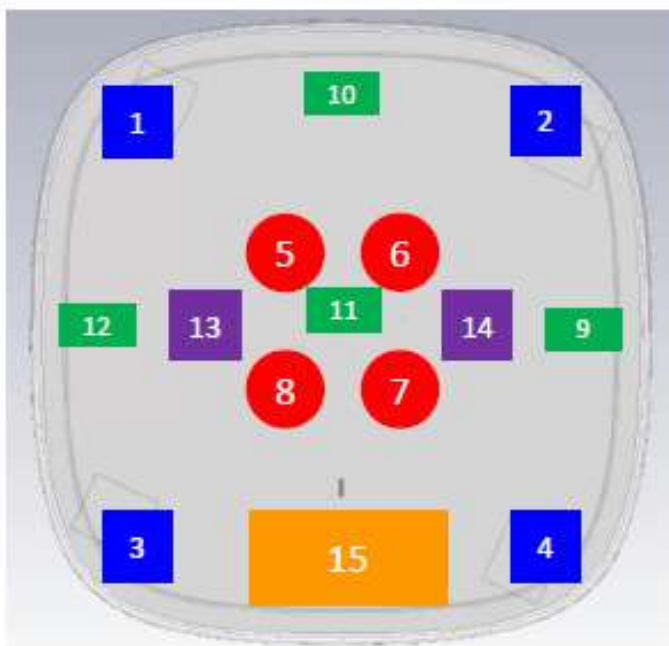
	MIMO1 (Ant1-4)	MIMO2 (Ant5-8)	MIMO3 (Ant9-12)	Aux (Ant13-14)	IoT (Ant15)
Working Frequency (MHz)	2400-2500 5150-5850	5150-5850	5935-7125	2400-2500 5150-7125	860-930 2400-2500
Type	PIFA	Dipole	PIFA	PIFA	PIFA
Polarization	V-pol	H-pol	V-pol	V-pol	V-pol

- Antenna mechanical design concept:
  - RF cable adopt OD 1.13 mm cables.
  - The antennas of MIMO1, MIMO3, AUX and IOT use metal stamping material which are been mounted on AL plate.
  - The antennas of MIMO2 will been heat-stick to top cover without any holder applied.
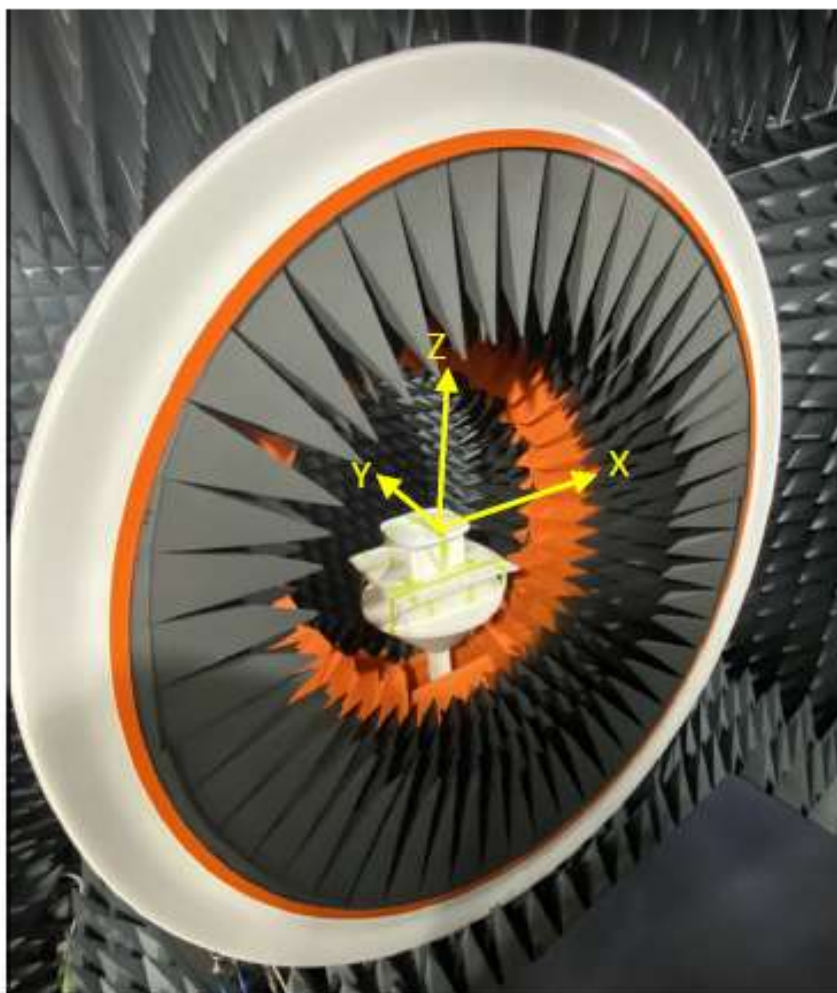
VNA Testing Information

- VNA model : Keysight E5071C calibrated to 8.5 GHz.
- Frequency sweep : 500~8000 MHz / 1201 points
- Data collection : VSWR / Isolation

On-The-Air Passive Testing Information

- Chamber model : SATIMO Starlab 2019 calibrated to 10 GHz.
- Frequency sweep : 868~928 MHz / 3 points
  2400~2500 MHz / 20 MHz
  5150~5850 MHz / 50 MHz
  5950~7150 MHz / 50 MHz
- Angle increment : 3D scanning 5 deg
  2D scanning 5 deg
- Data collection : Efficiency / Peak gain / Radiation pattern
- Orientation definition : Cisco's reference coordinate as below shown
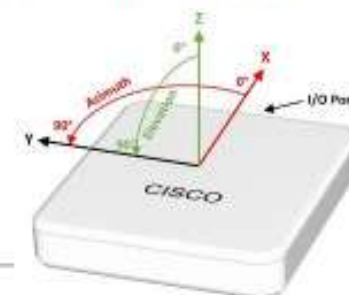
Measurement Environment (2/3)
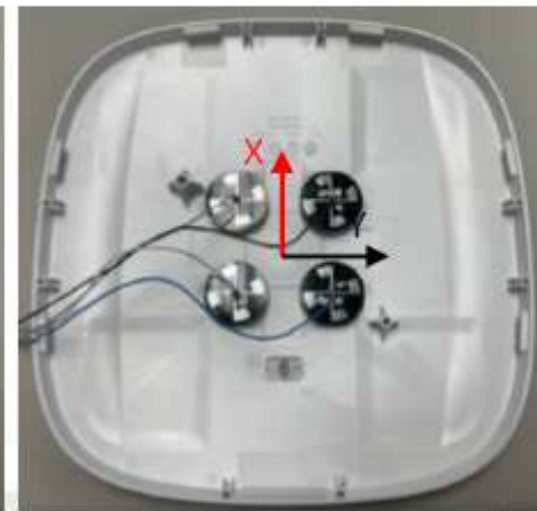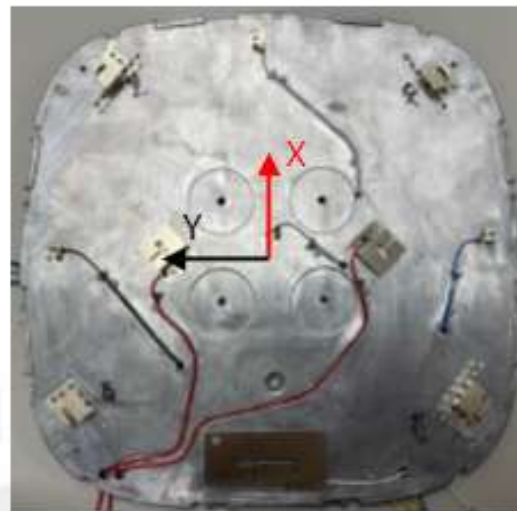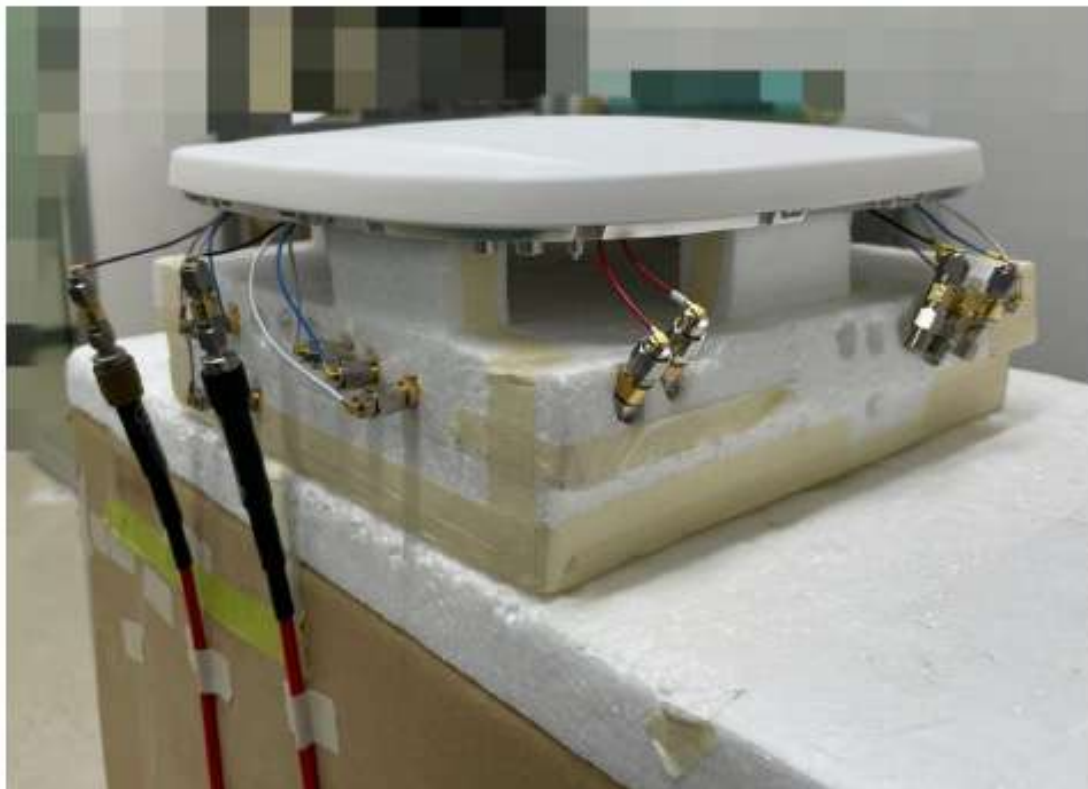
- Testing DUT is composed by soft tooling T1 sample which has been checked FAI by ME team.
- The testing fixture made by Styrofoam is specially used to place 50 Ohms load when data is collecting. Also, cables are been nicely routed inside the cable groove, therefore, the whole passive OTA and VNA measurement process has taken antenna system scenario into account.

Measurement Environment (3/3)
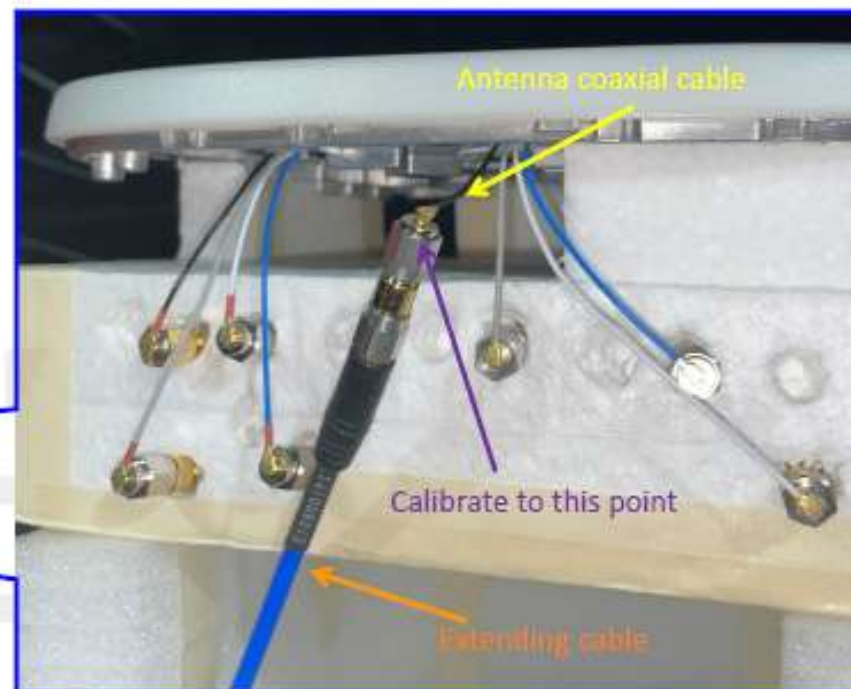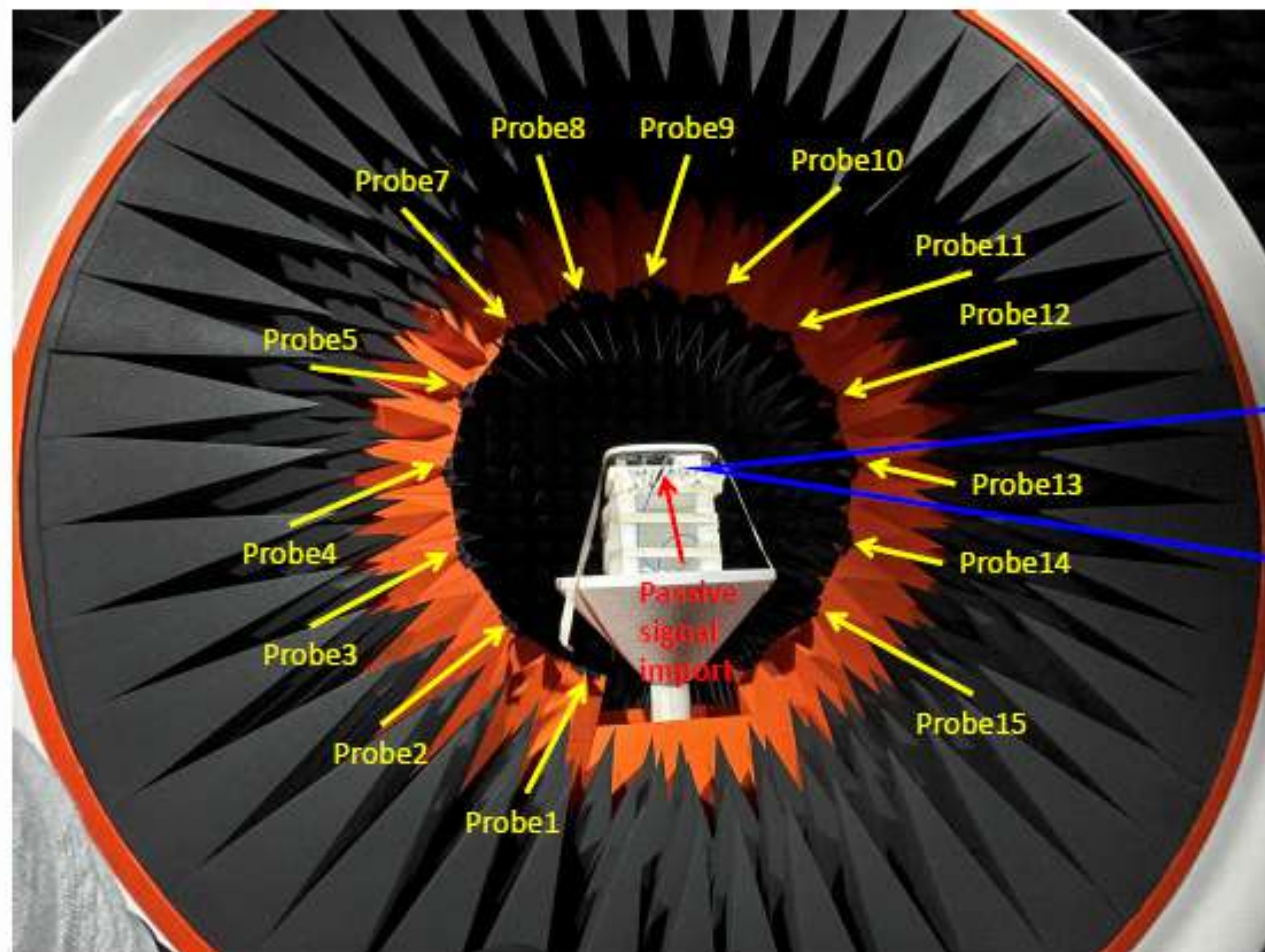
- Chamber calibration include Tx pass loss, extending cable (to IPEX connector), propagation loss, probe efficiency and Rx pass loss.
- The measurement value of antenna efficiency include antenna coaxial cable shown as above photo.

MIMO1 Performance – VSWR/Isolation
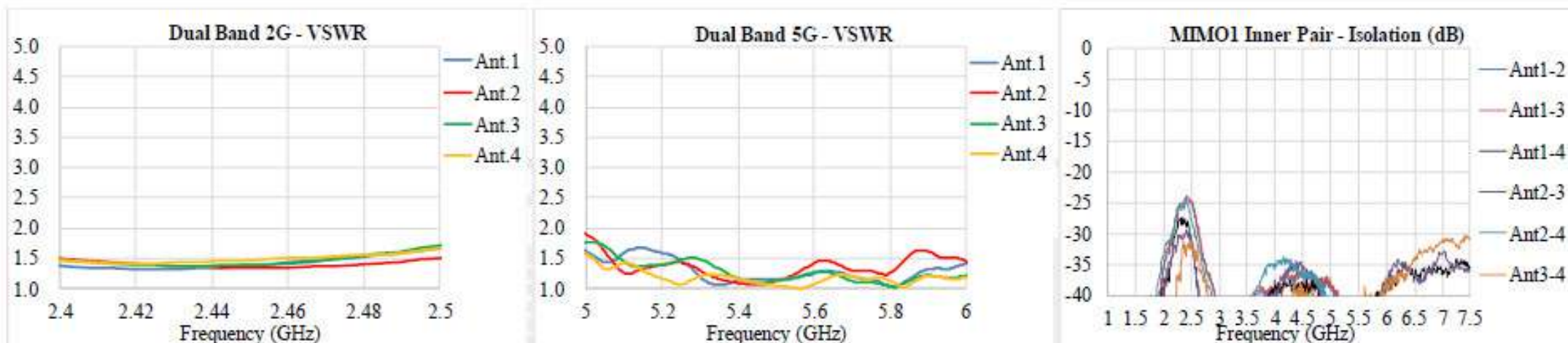
- The value of VSWR at 2400~2500 and 5150~5850 MHz under 2.

- Intra-pair isolation of MIMO1 is under -20 dB @2G and under -30 dB @5G.

Dual Band 2G - Efficiency (%)

Dual Band 2G - Peak Gain (dBi)

Dual Band 5G - Efficiency (%)

Dual Band 5G - Peak Gain (dBi)
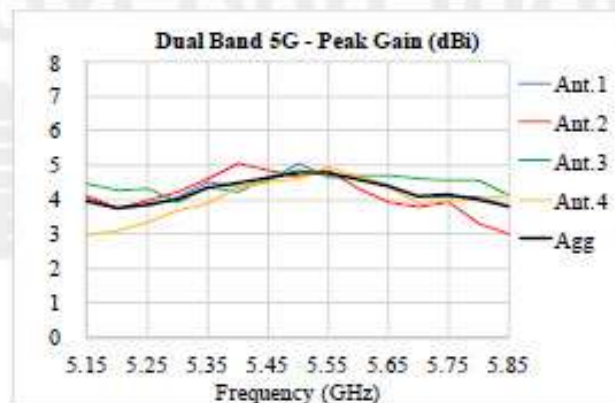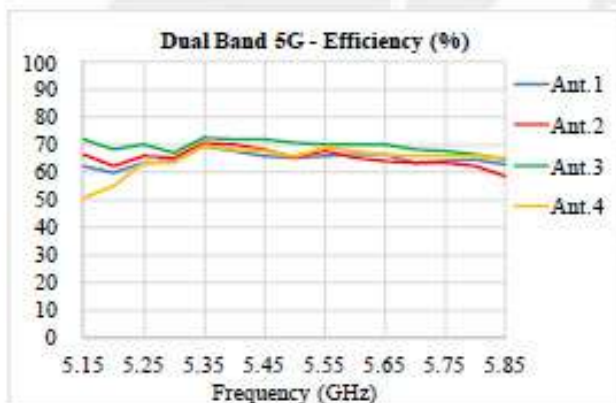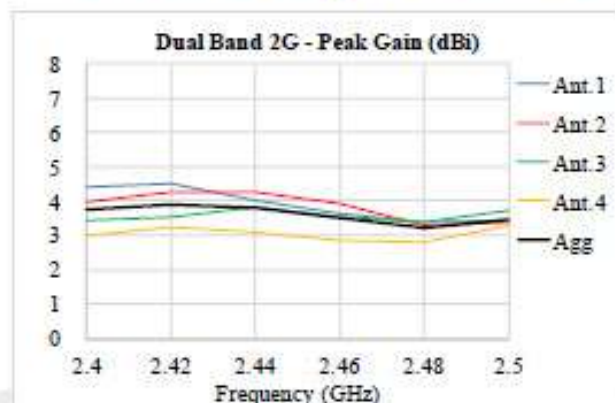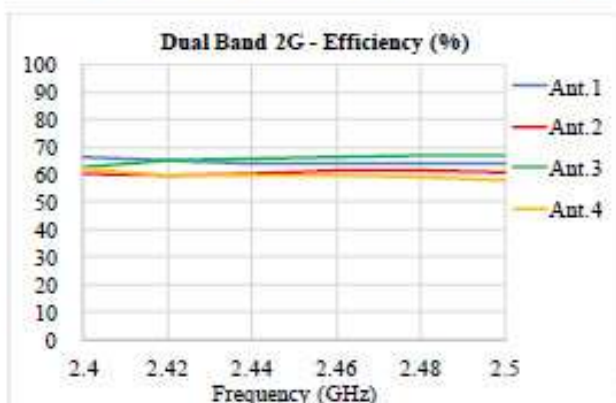
Freq.	Deviation between peak average gain			
	A1	A2	A3	A4
2.40E+09	0.69	0.24	-0.30	-0.76
2.42E+09	0.60	0.32	-0.36	-0.68
2.44E+09	0.18	0.43	0.00	-0.70
2.46E+09	0.11	0.44	0.02	-0.64
2.48E+09	0.18	0.06	0.18	-0.45
2.50E+09	-0.04	-0.09	0.28	-0.16
5.15E+09	0.11	0.18	0.55	-0.98
5.20E+09	-0.01	0.01	0.55	-0.63
5.25E+09	-0.03	0.09	0.43	-0.54
5.30E+09	0.08	0.25	-0.06	-0.28
5.35E+09	0.17	0.25	0.00	-0.46
5.40E+09	-0.15	0.52	-0.30	-0.12
5.45E+09	-0.10	0.22	0.01	-0.14
5.50E+09	0.25	-0.13	0.07	-0.19
5.55E+09	-0.13	0.05	-0.08	0.16
5.60E+09	0.05	-0.26	0.13	0.06
5.65E+09	0.04	-0.43	0.36	0.00
5.70E+09	-0.04	-0.33	0.52	-0.20
5.75E+09	-0.06	-0.22	0.42	-0.17
5.80E+09	0.05	-0.70	0.54	0.02
5.85E+09	0.00	-0.77	0.35	0.33

- Antenna efficiency at 2400~2500 and 5150~5850 MHz is over 50%.

- 2.4G individual peak gain around 2.9~4.6 dBi, typical value around 3.6 dBi. Peak average gain of 2G is 4 dBi.

- 5G individual peak gain around 3.0~5.0 dBi, typical value around 4.0 dBi. Peak average gain of 5G is 5 dBi.

MIMO1 Performance – Radiation Pattern (A1)
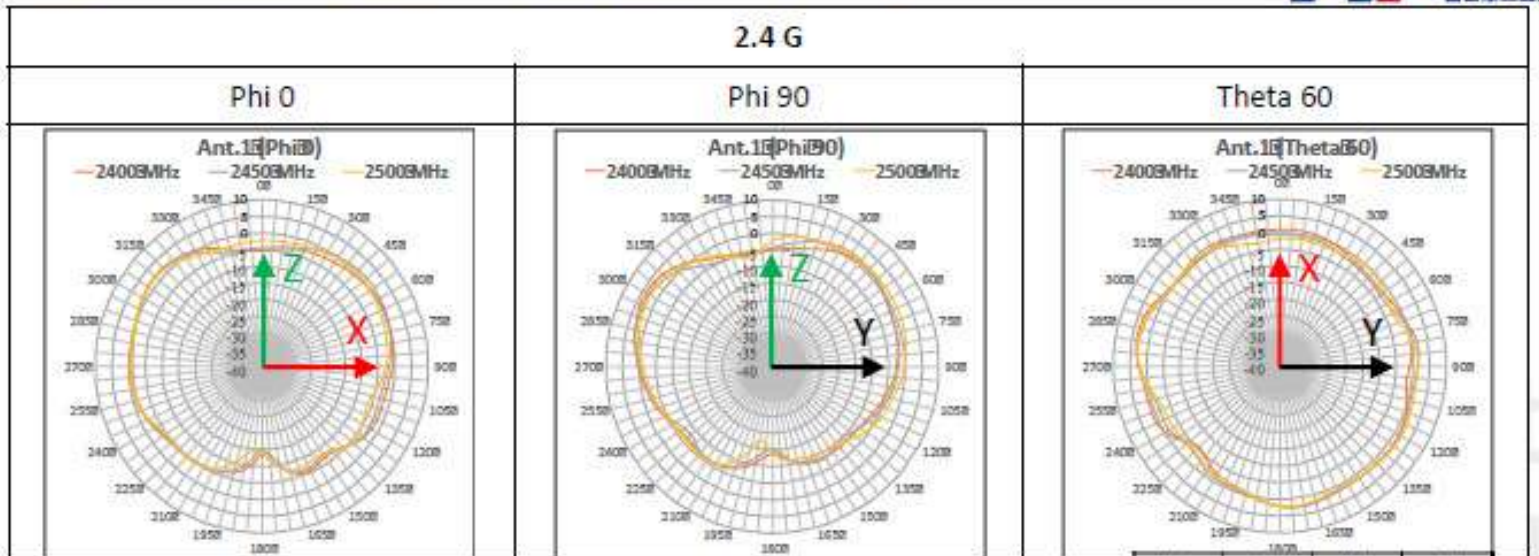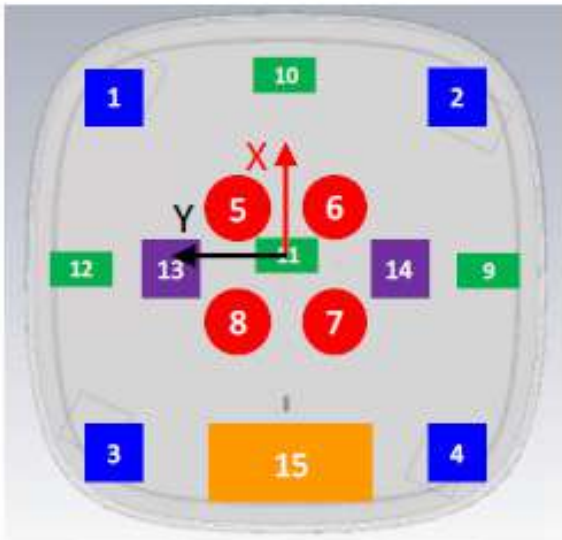
Fii Confidential
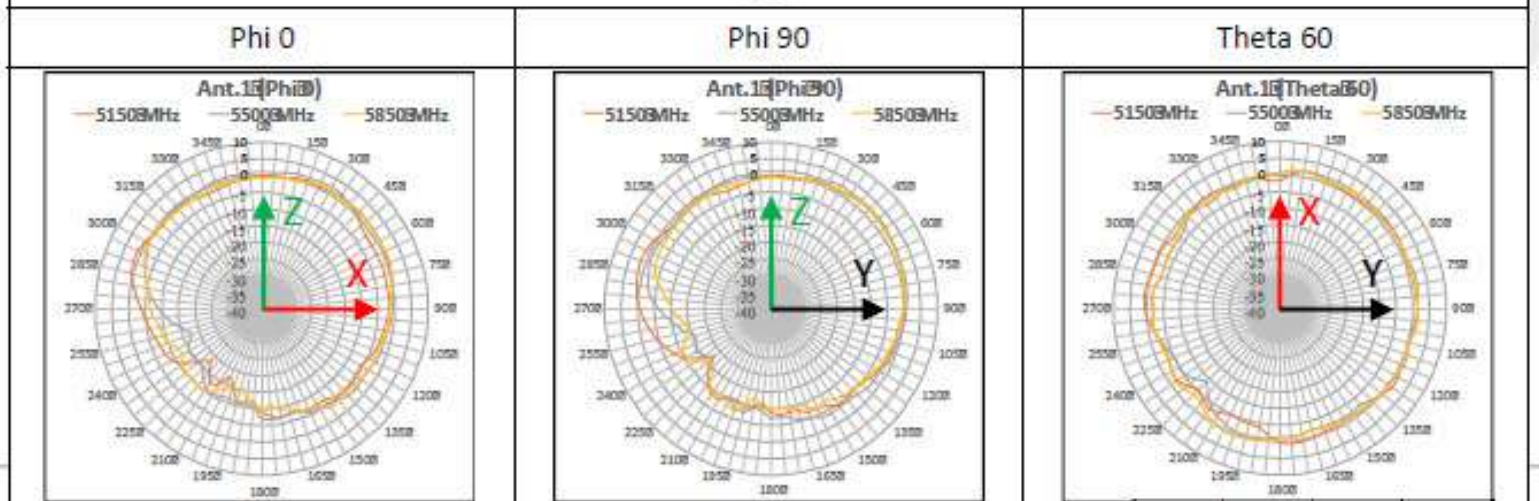
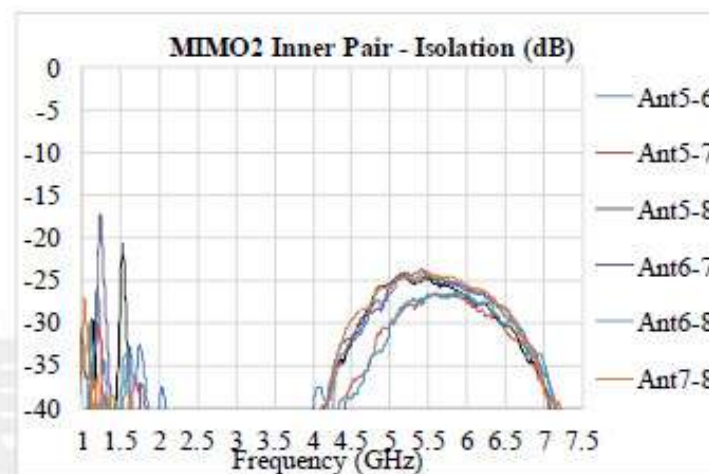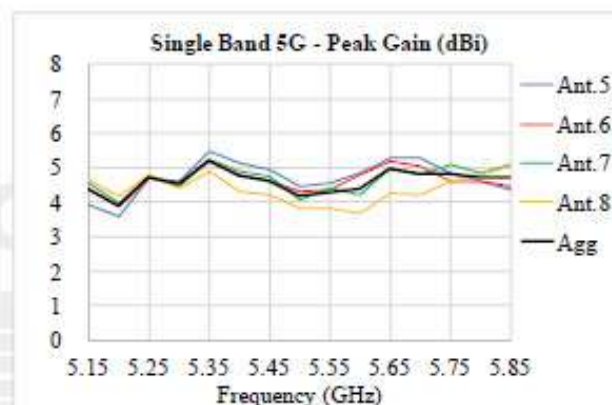# MIMO1 Performance – Radiation Pattern (A2)

Fii Confidential
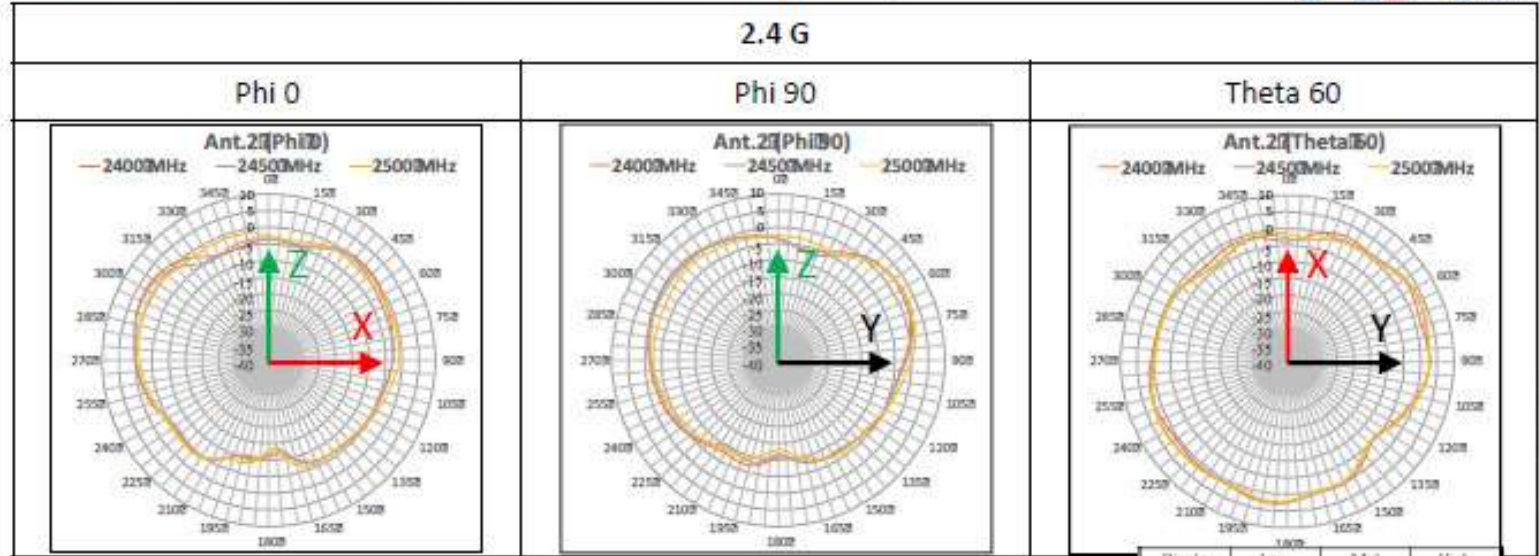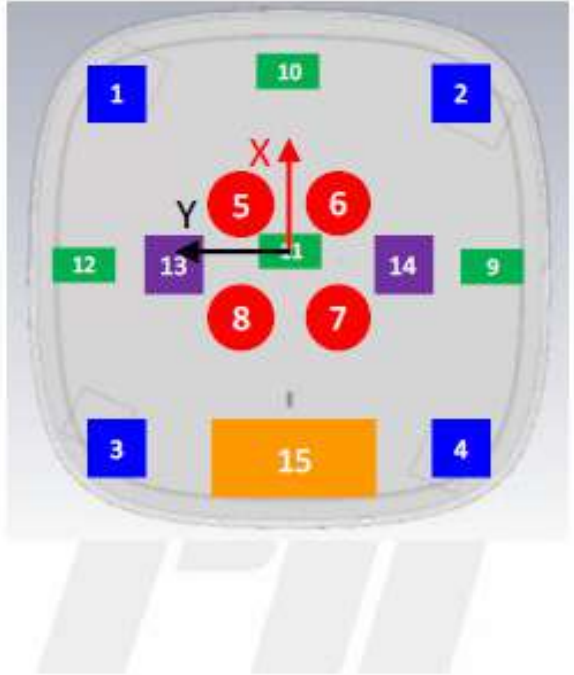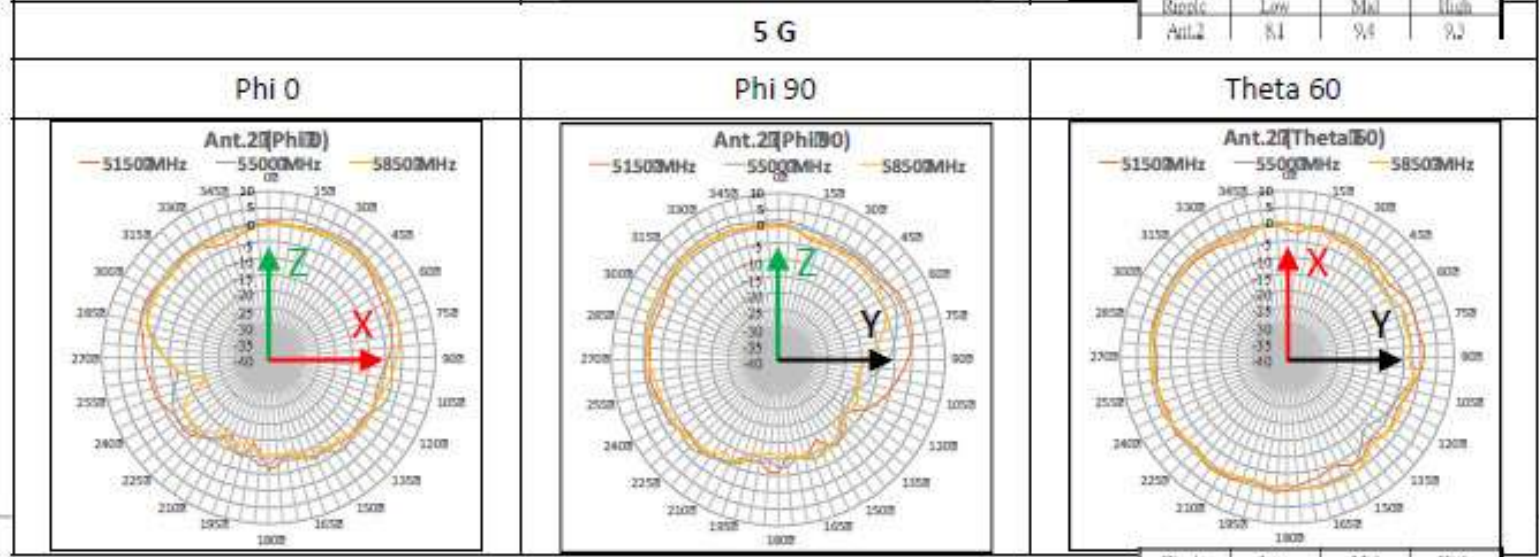
MIMO1 Performance – Radiation Pattern (A3)
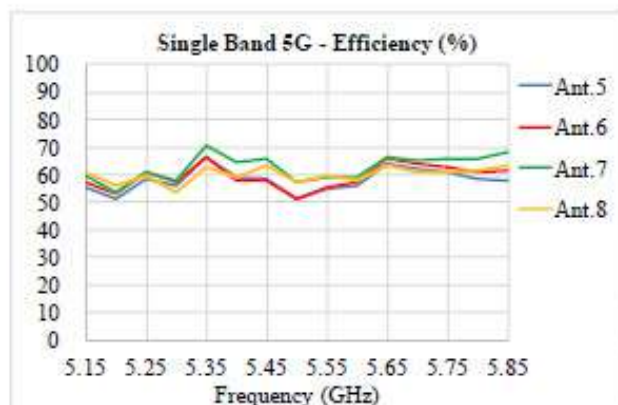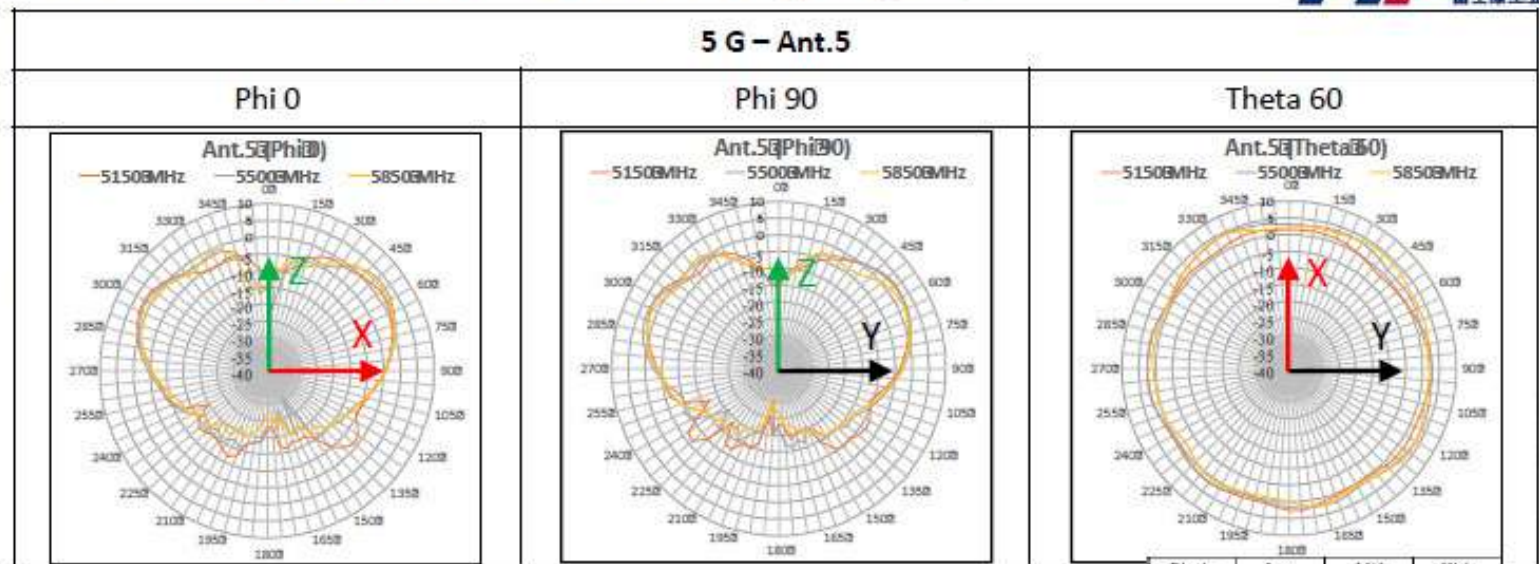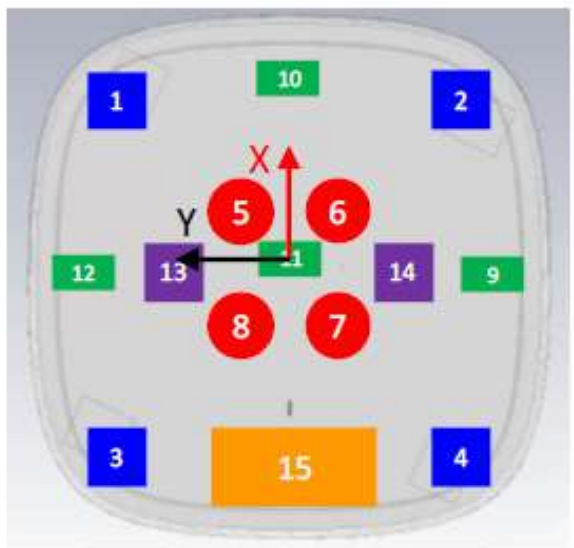
MIMO1 Performance – Radiation Pattern (A4)

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MIMO2 Performance – VSWR/Isolation

Single Band 5G - VSWR

MIMO2 Inner Pair - Isolation (dB)
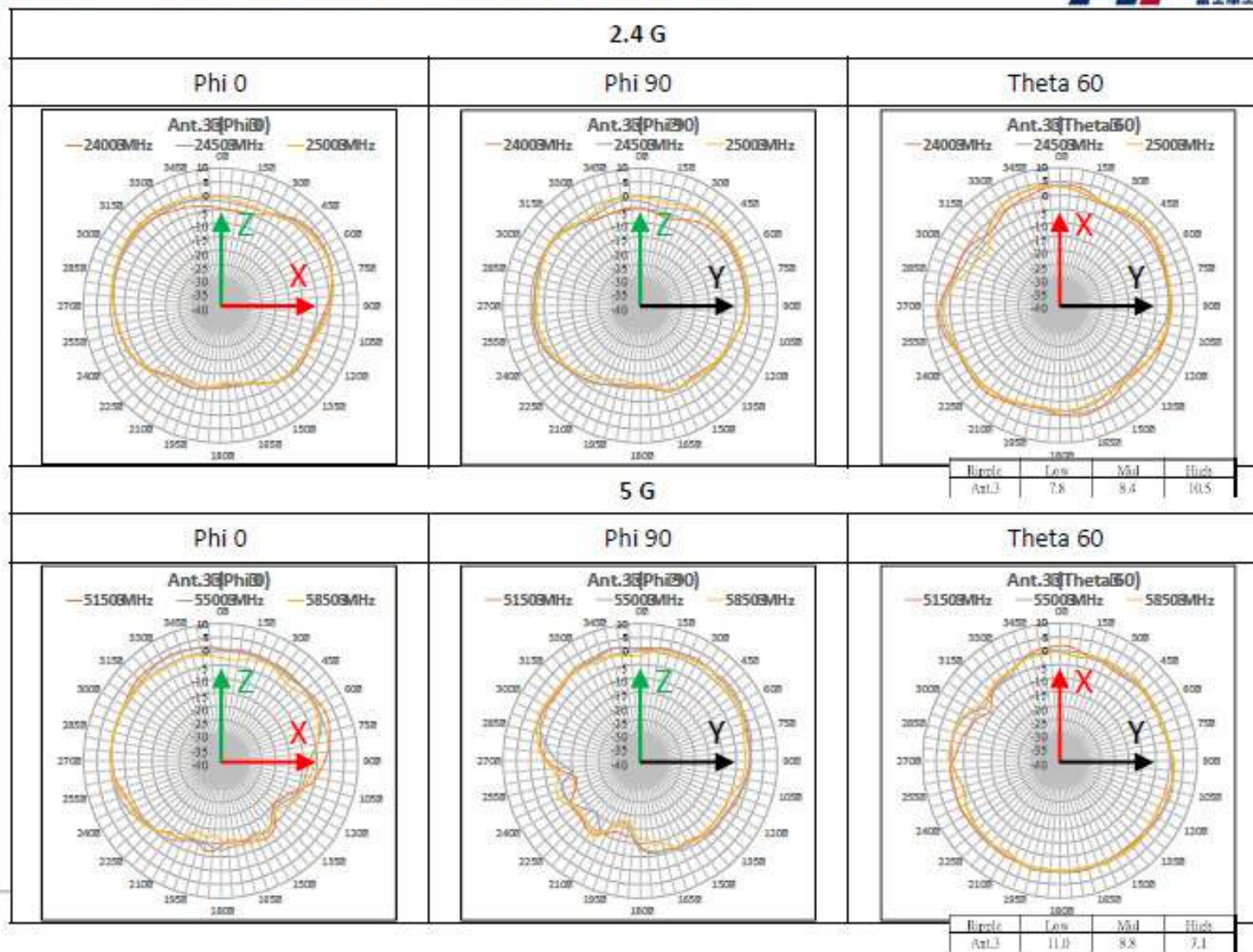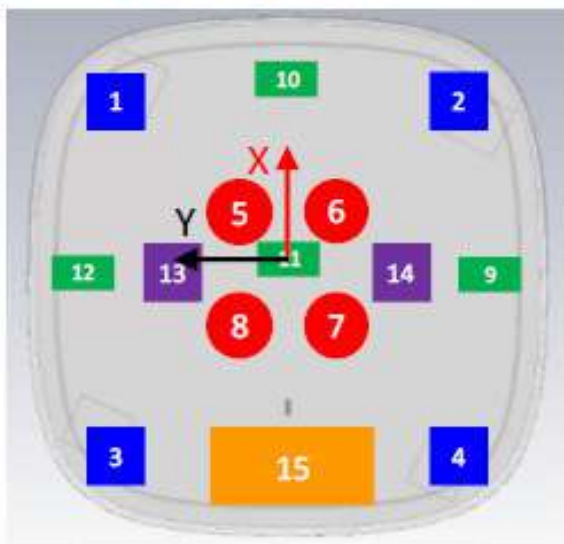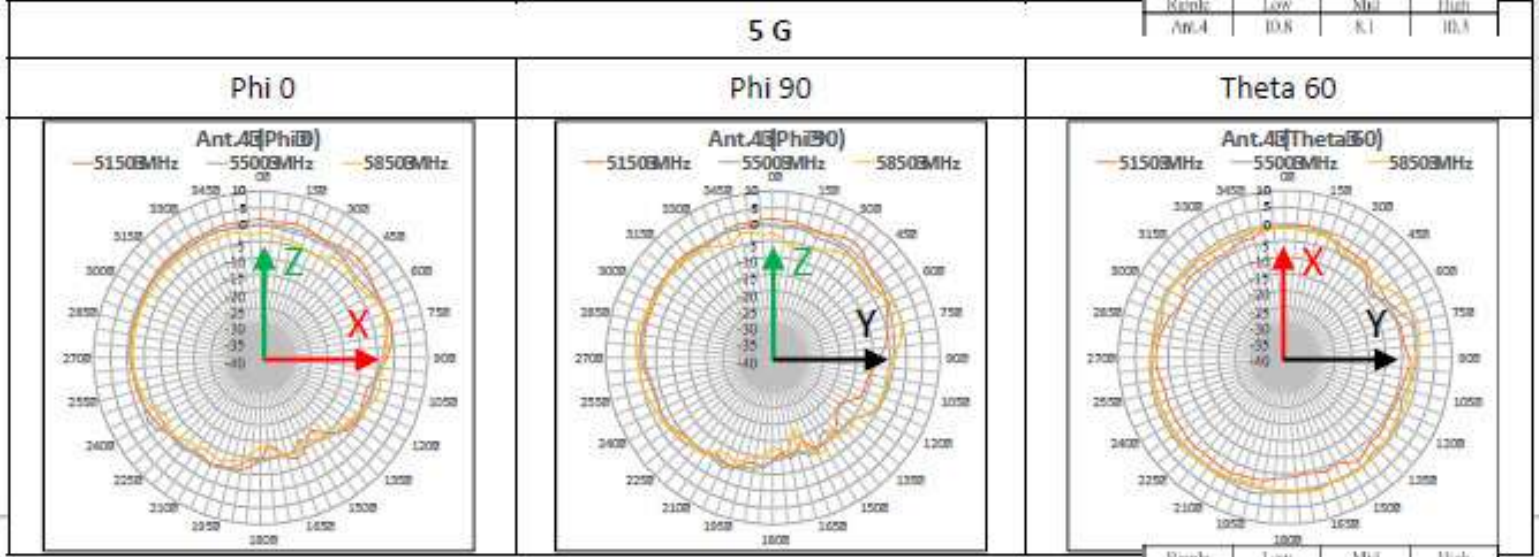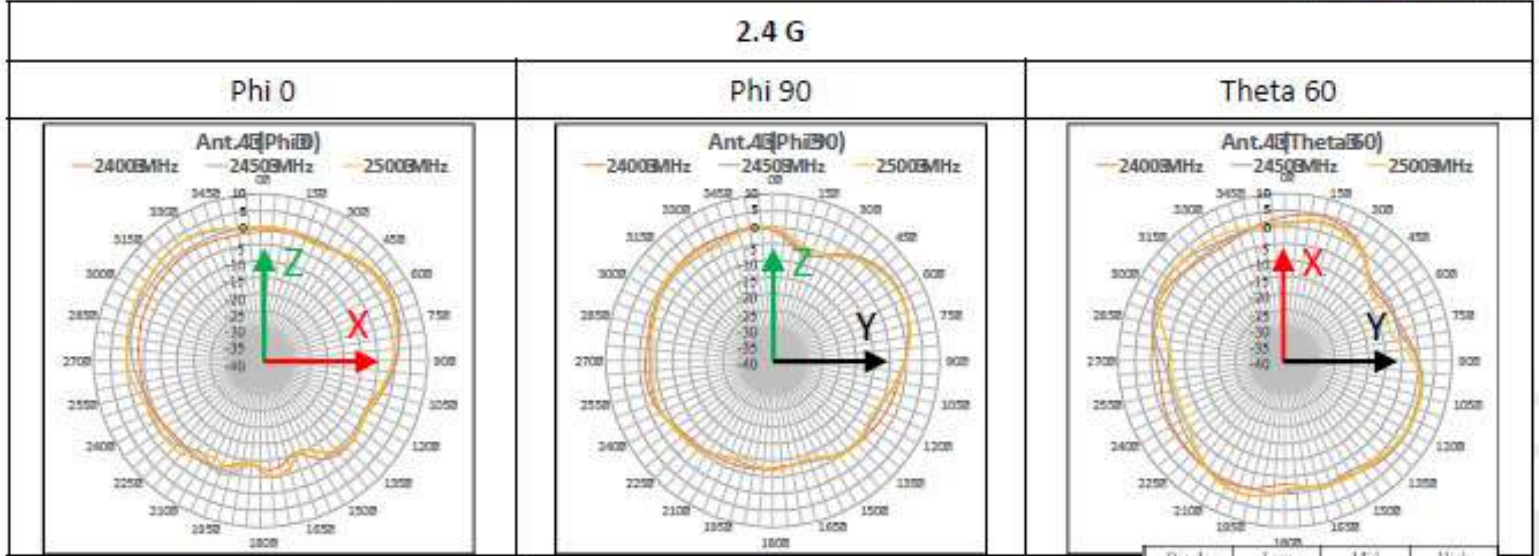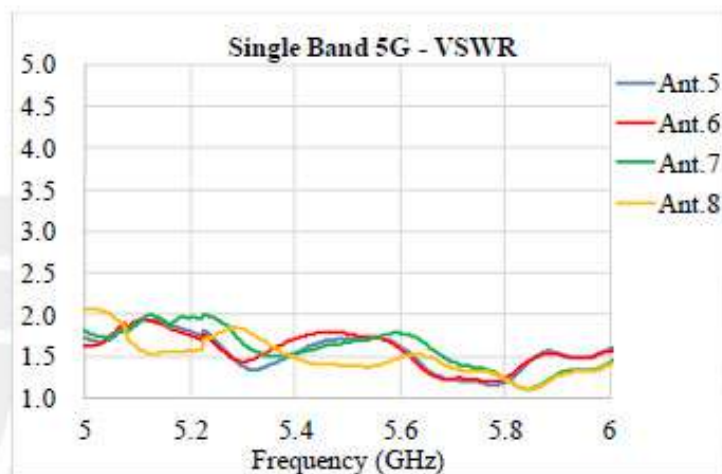
- The value of VSWR at 5150~5850 MHz under 2.

- Intra-pair isolation of MIMO2 is under -25 dB.
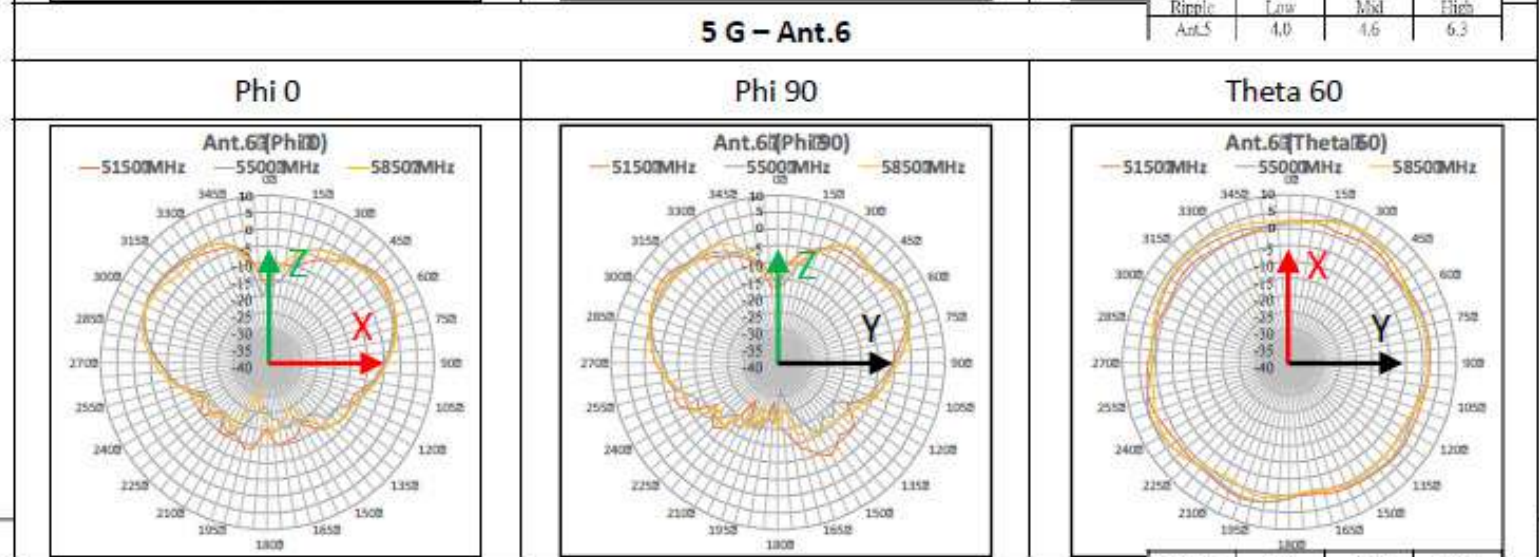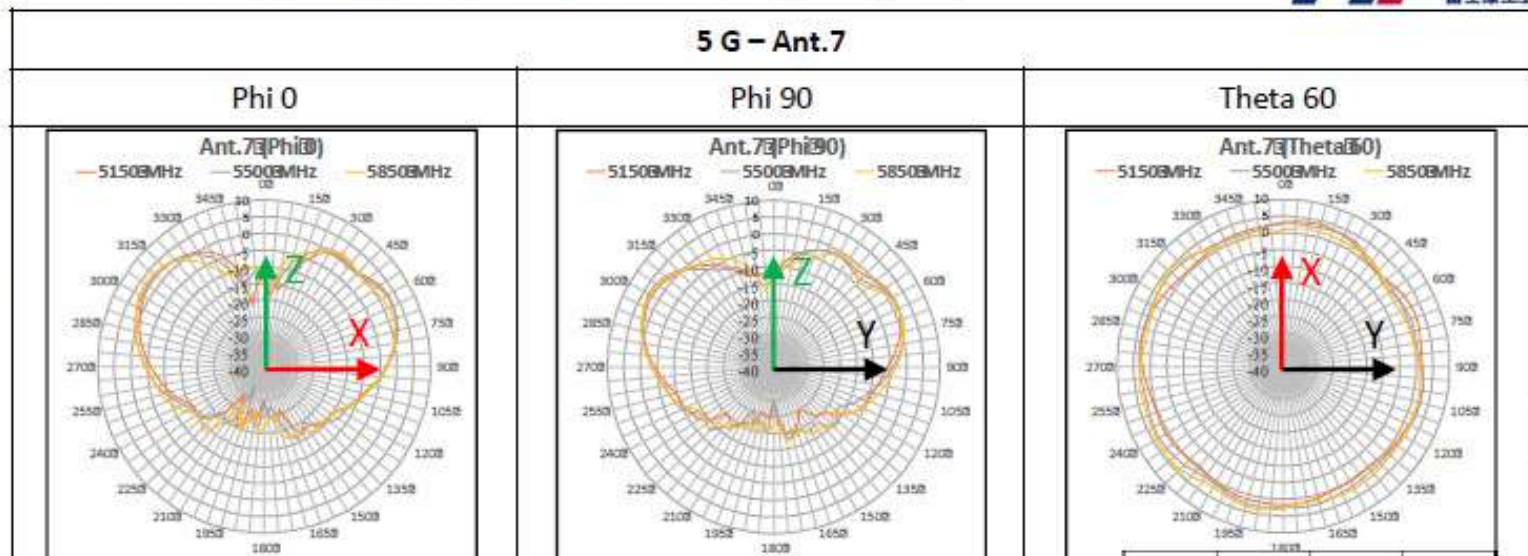
MIMO2 Performance – Efficiency/Peak Gain

Single Band 5G - Efficiency (%) — Ant.5, Ant.6, Ant.7, Ant.8

Single Band 5G - Peak Gain (dBi) — Ant.5, Ant.6, Ant.7, Ant.8, Agg

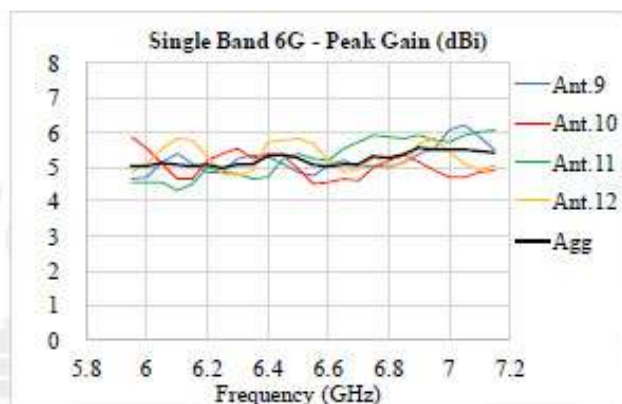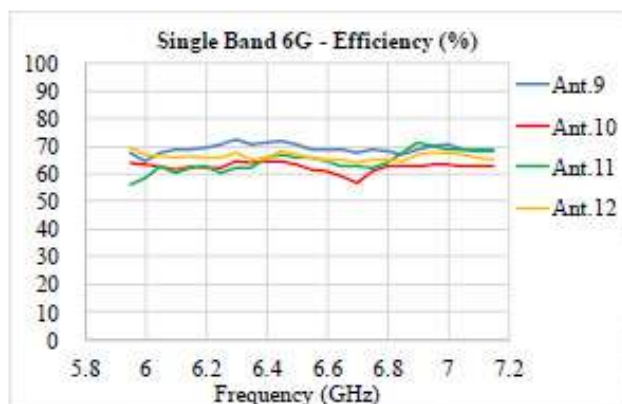| Deviation between peak avaerage gain				
Freq.	A5	A6	A7	A8
5.15E+09	-0.47	-0.01	0.17	0.27
5.20E+09	-0.33	-0.03	0.06	0.28
5.25E+09	-0.03	-0.04	0.01	0.06
5.30E+09	0.12	0.01	-0.05	-0.08
5.35E+09	0.28	-0.02	0.03	-0.31
5.40E+09	0.36	0.00	0.10	-0.50
5.45E+09	0.33	-0.02	0.10	-0.44
5.50E+09	0.30	0.15	-0.13	-0.35
5.55E+09	0.26	0.05	0.11	-0.45
5.60E+09	0.42	0.39	-0.20	-0.71
5.65E+09	0.34	0.24	0.04	-0.70
5.70E+09	0.44	0.19	-0.07	-0.64
5.75E+09	0.05	-0.20	0.31	-0.19
5.80E+09	-0.10	-0.10	0.13	0.07
5.85E+09	-0.40	-0.28	0.36	0.27

- Antenna efficiency at 5150~5850 MHz is over 50%.

- 5G individual peak gain around 3.5~5.4 dBi, typical value around 4.5 dBi. Peak average gain of 5G is 6 dBi.

MIMO2 Performance – Radiation Pattern (A5/6)

MIMO2 Performance – Radiation Pattern (A7/8)

5 G – Ant.7

	Phi 0	Phi 90	Theta 60

Ripole	Low	Mid	High
Ant.7	4.7	4.9	6.3

5 G – Ant.8

	Phi 0	Phi 90	Theta 60
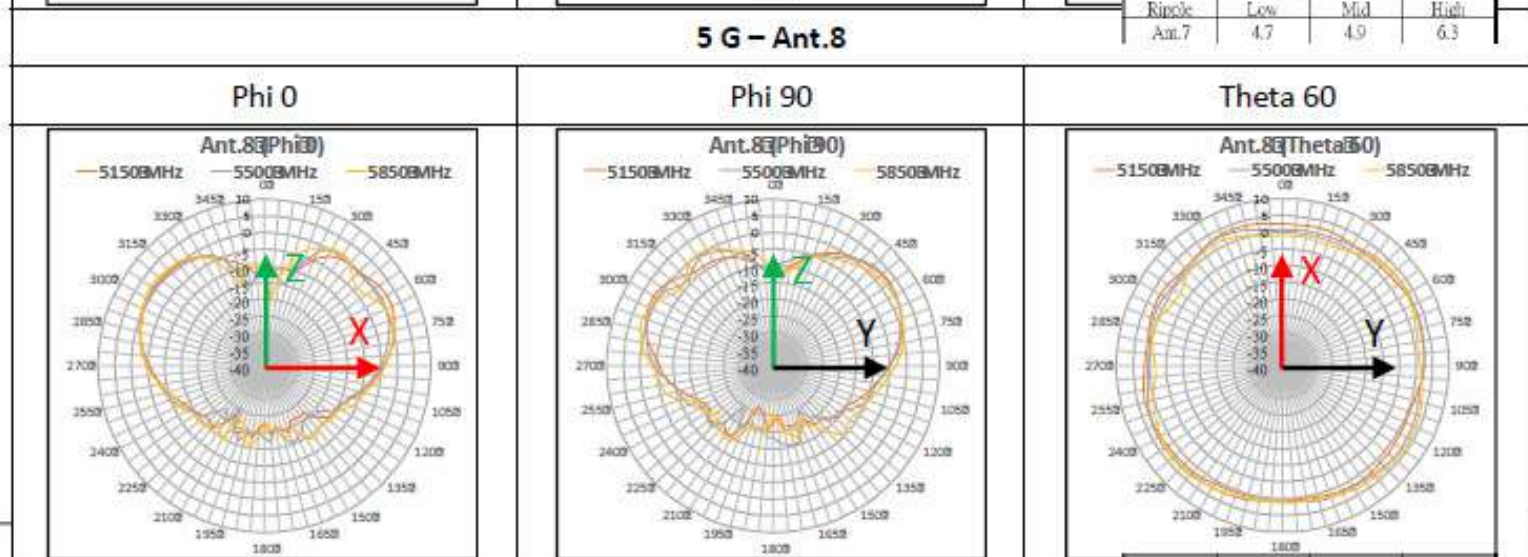
Ripole	Low	Mid	High
Ant.8	3.2	3.2	6.7

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Dual 5G (8x8) Peak Average Gain

Sample1

Dual Band 5G - Peak Gain (dBi)
Ant.1, Ant.2, Ant.3, Ant.4, Agg

Average peak = 4.8 dBi

Single Band 5G - Peak Gain (dBi)
Ant.5, Ant.6, Ant.7, Ant.8, Agg

Average peak = 5.2 dBi

5G 8*8 - Peak Gain (dBi)
Ant.1, Ant.2, Ant.3, Ant.4, Ant.5, Ant.6, Ant.7, Ant.8, Agg

Average peak = 4.8 dBi

Sample2

Dual Band 5G - Peak Gain (dBi)
Ant.1, Ant.2, Ant.3, Ant.4, Agg

Average peak = 4.1 dBi

Single Band 5G - Peak Gain (dBi)
Ant.5, Ant.6, Ant.7, Ant.8, Agg

Average peak = 4.9 dBi

5G 8*8 - Peak Gain (dBi)
Ant.1, Ant.2, Ant.3, Ant.4, Ant.5, Ant.6, Ant.7, Ant.8, Agg

Average peak = 4.5 dBi

Sample3

Dual Band 5G - Peak Gain (dBi)
Ant.1, Ant.2, Ant.3, Ant.4, Agg

Average peak = 4.1 dBi

Single Band 5G - Peak Gain (dBi)
Ant.5, Ant.6, Ant.7, Ant.8, Agg

Average peak = 5.3 dBi

5G 8*8 - Peak Gain (dBi)
Ant.1, Ant.2, Ant.3, Ant.4, Ant.5, Ant.6, Ant.7, Ant.8, Agg

Average peak = 4.8 dBi

MIMO3 Performance – VSWR/Isolation

- The value of VSWR at 5950~7150 MHz under 2.
- Intra-pair isolation of MIMO3 is under -25 dB.

MIMO3 Performance – Efficiency/Peak Gain

Single Band 6G - Efficiency (%)

Single Band 6G - Peak Gain (dBi)

	Deviation between peak avacrage gain			
Freq.	A9	A10	A11	A12
5.95E+09	-0.38	0.86	-0.45	-0.16
6.00E+09	-0.29	0.55	-0.45	0.12
6.05E+09	0.04	0.01	-0.55	0.44
6.10E+09	0.29	-0.41	-0.78	0.74
6.15E+09	0.04	-0.36	-0.55	0.75
6.20E+09	-0.25	0.10	-0.08	0.21
6.25E+09	-0.13	0.40	-0.14	-0.16
6.30E+09	0.15	0.42	-0.28	-0.34
6.35E+09	0.31	0.20	-0.41	-0.14
6.40E+09	-0.01	0.08	-0.57	0.44
6.45E+09	-0.28	-0.02	-0.14	0.42
6.50E+09	-0.40	-0.33	0.10	0.56
6.55E+09	-0.31	-0.55	0.15	0.62
6.60E+09	0.02	-0.45	0.20	0.19
6.65E+09	0.11	-0.40	0.46	-0.21
6.70E+09	-0.10	-0.47	0.64	-0.15
6.75E+09	-0.26	-0.34	0.59	-0.05
6.80E+09	-0.28	-0.11	0.57	-0.24
6.85E+09	-0.20	-0.05	0.48	-0.27
6.90E+09	-0.18	-0.40	0.39	0.14
6.95E+09	0.02	-0.63	0.24	0.31
7.00E+09	0.55	-0.82	0.23	-0.08
7.05E+09	0.68	-0.82	0.38	-0.41
7.10E+09	0.45	-0.60	0.56	-0.54
7.15E+09	0.09	-0.51	0.67	-0.35

- Antenna efficiency at 5950~7150 MHz is over 50%.

- 6G individual peak gain around 4.3~6.2 dBi, typical value around 5.3 dBi. Peak average gain of 6G is 6 dBi.

MIMO3 Performance – Radiation Pattern (A9/10)

6 G – Ant.9

Phi 0	Phi 90	Theta 60
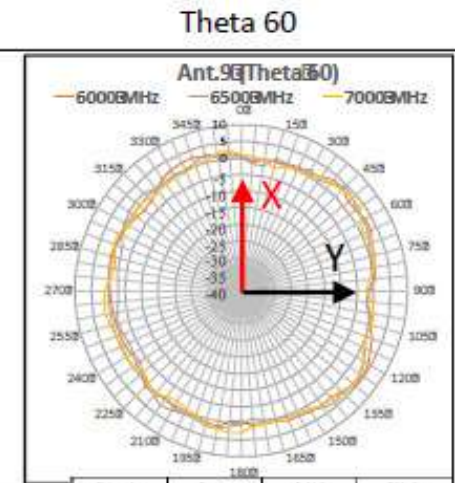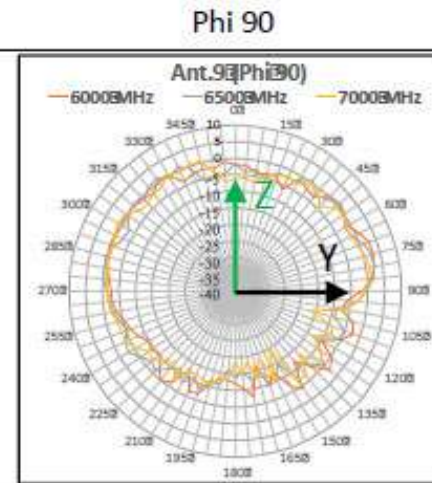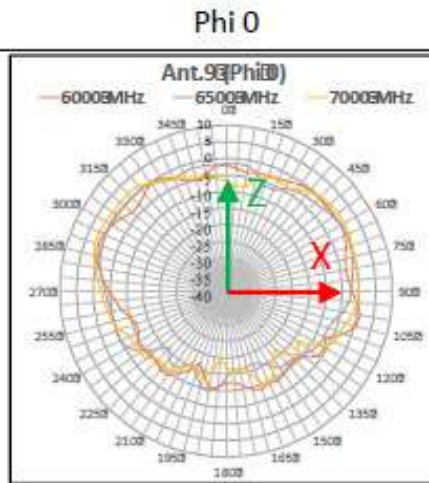
Ripple	Low	Mid	High
Ant.9	7.8	7.2	6.3

6 G – Ant.10

Phi 0	Phi 90	Theta 60
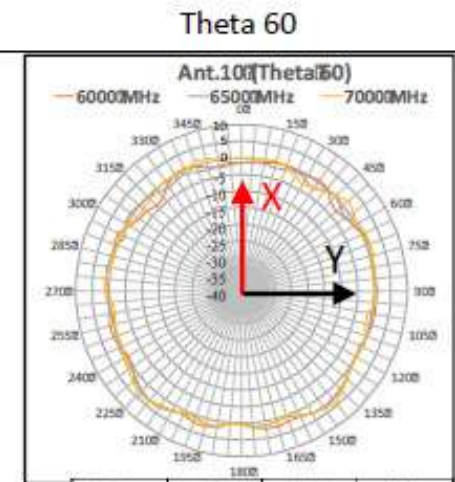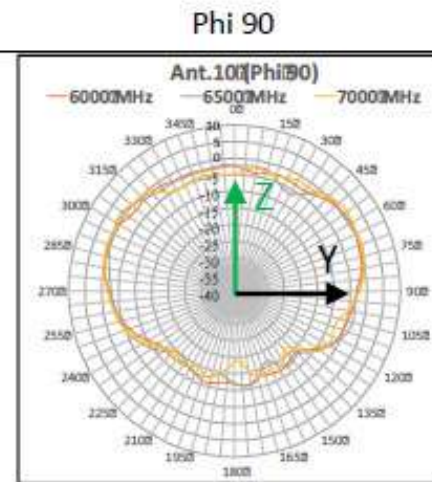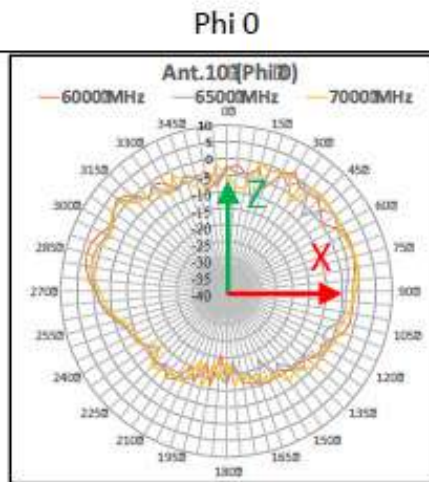
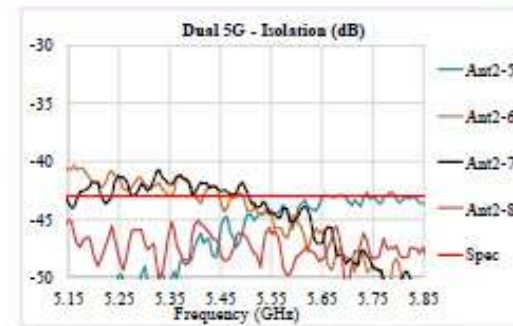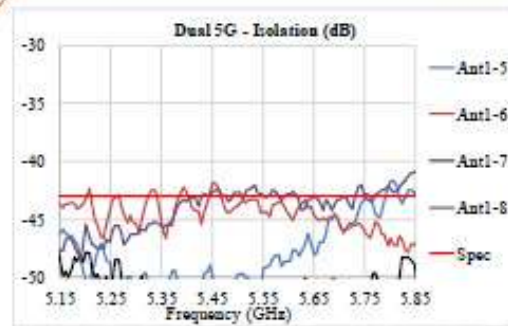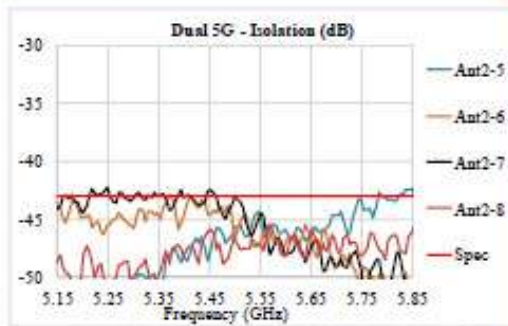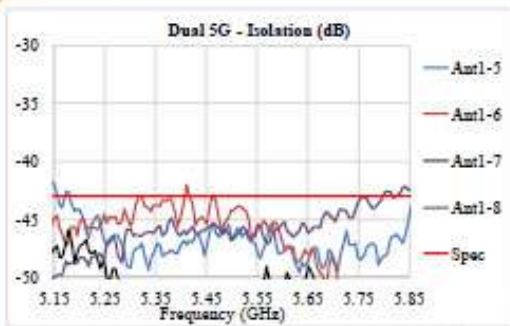| Ripple	Low	Mid	High
Ant.10	7.5	5.6	7.5

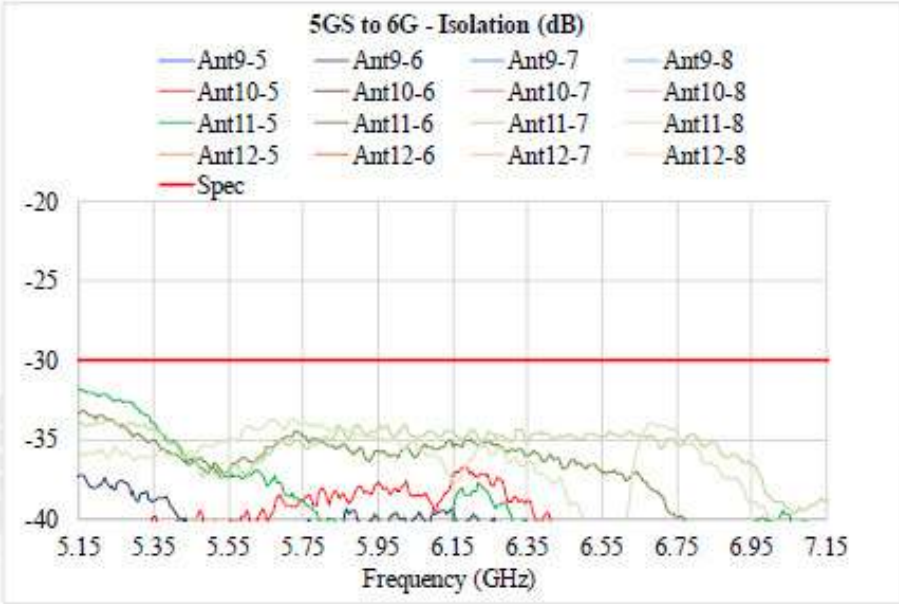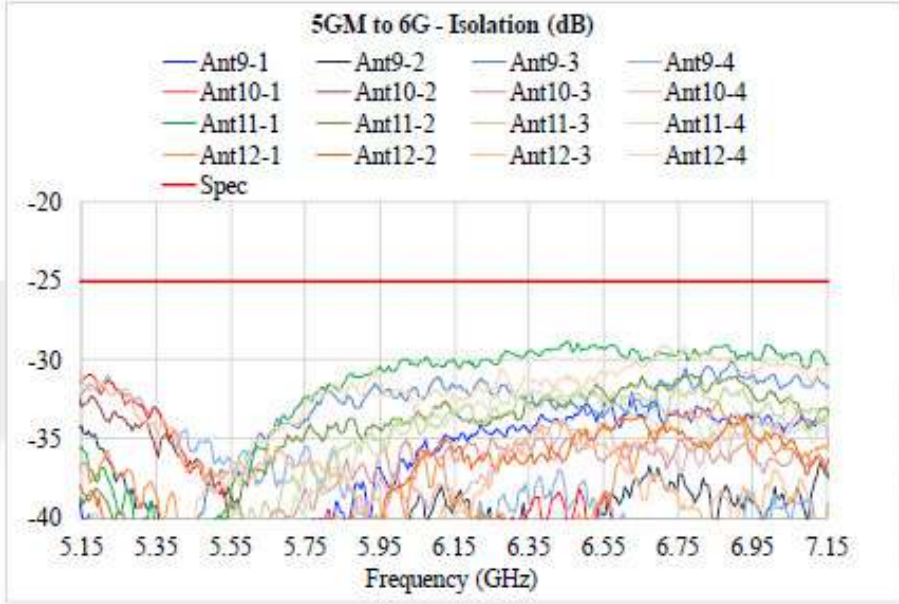# MIMO3 Performance – Radiation Pattern (A11/12)
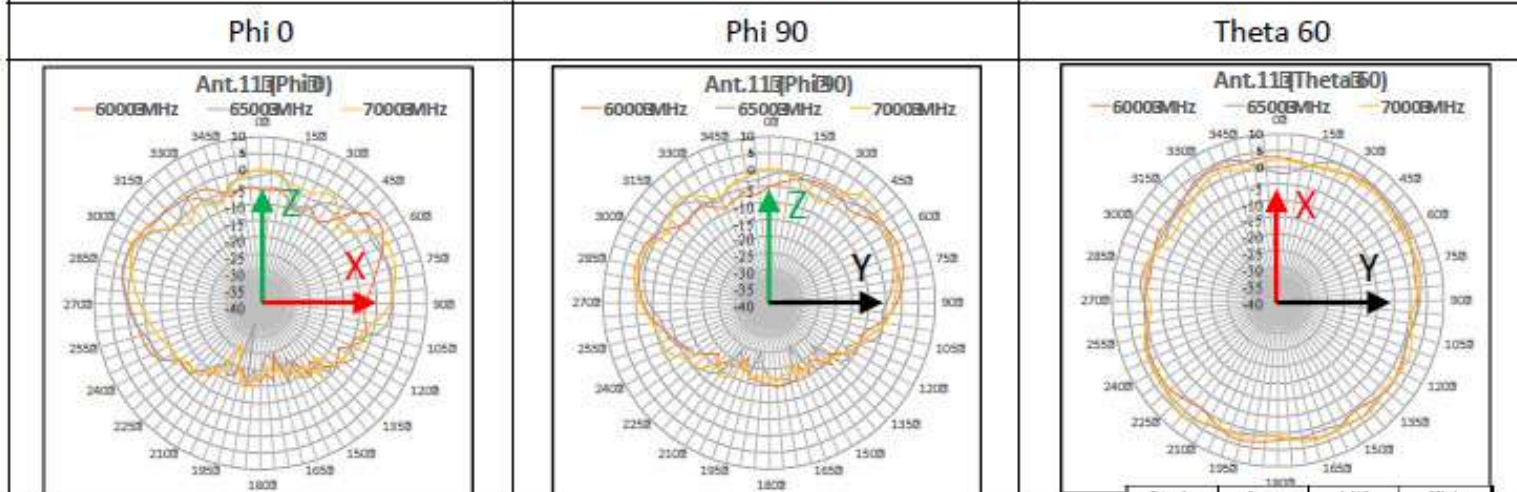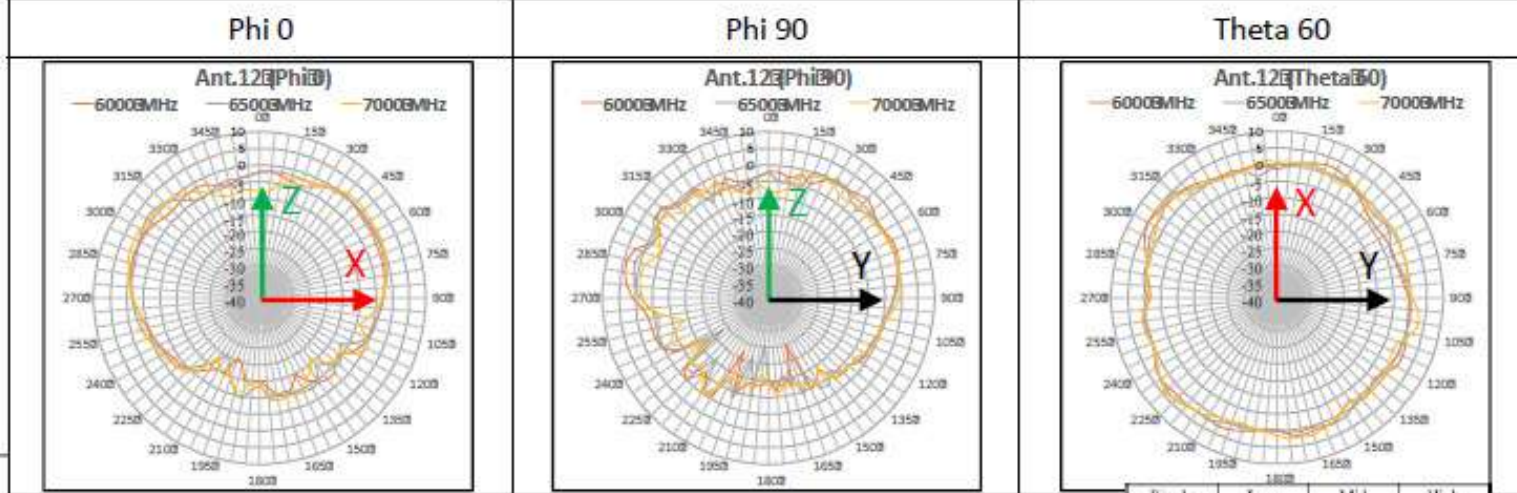
# Serving Antennas Dual 5GHz Cross-Pair Isolation

P3A v2 CNC

P3B ST
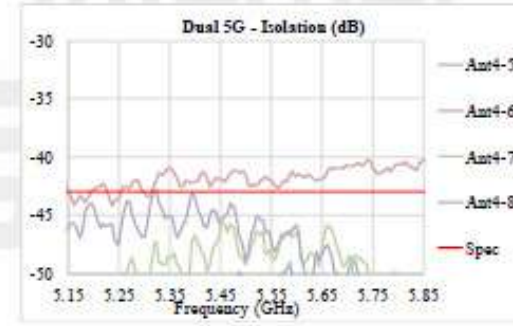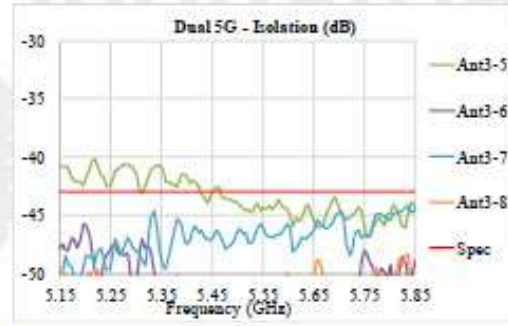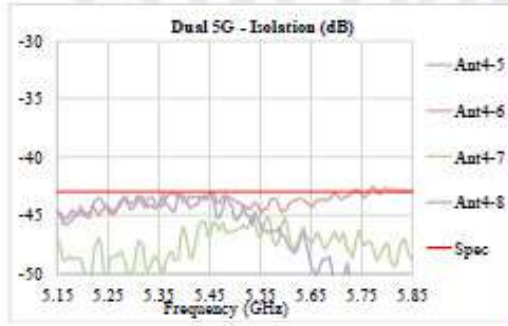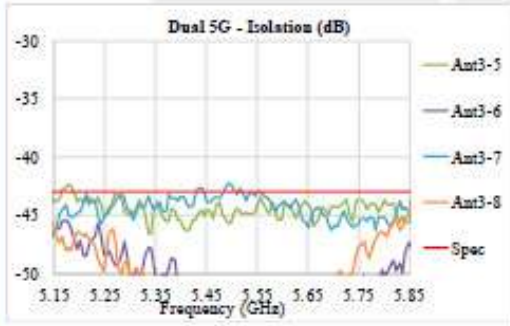
- The dual 5G isolation of soft tool sample has 2.5 dB deviation with CNC sample (CNC: -42.5 dB / ST: -40 dB), pair 1-8 / 2-6 / 2-7 / 3-5 / 4-6 over -43 dB, but all pairs are under -40 dB.

Serving Antennas 6G to 5G Cross-Pair Isolation

- 6G to 5GM under -29 dB over frequency (5150~7125 MHz).
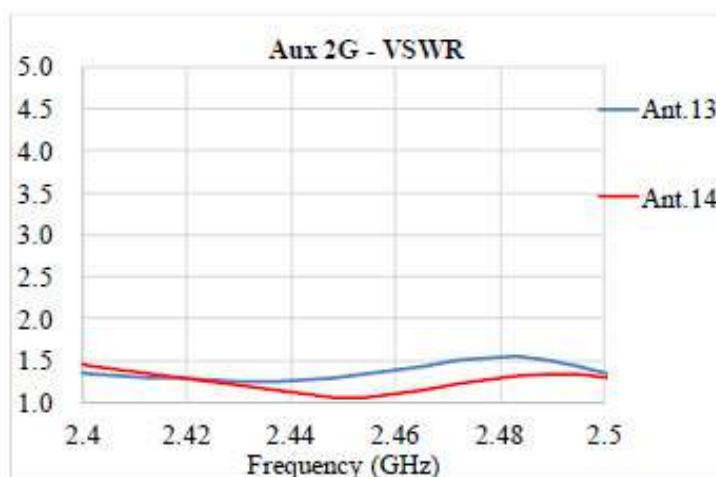
- 6G to 5GS under -30 dB over frequency (5150~7125 MHz).

Serving Antennas 2G to 5/6G Cross-Pair Isolation
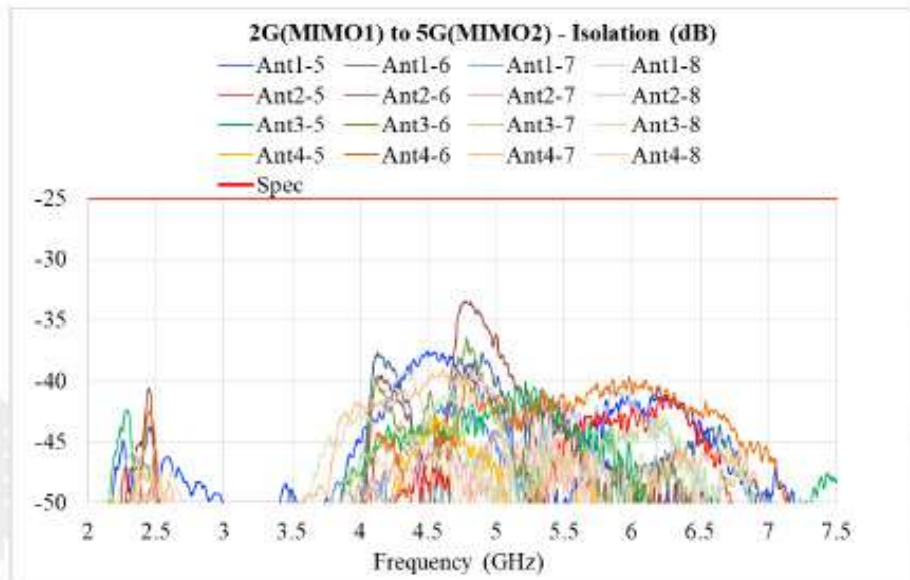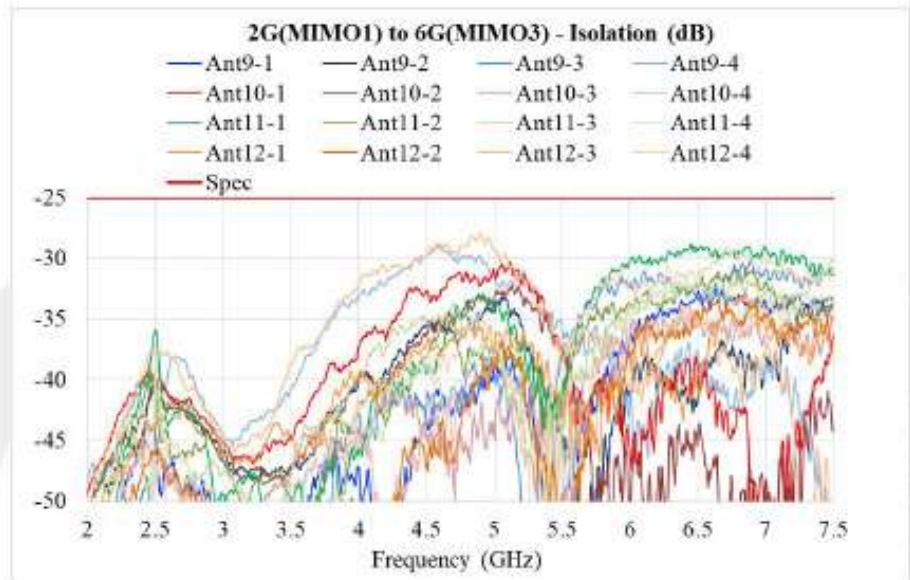
- 2GM to 6G isolation is under -36 dB over frequency (2400~2500 MHz).

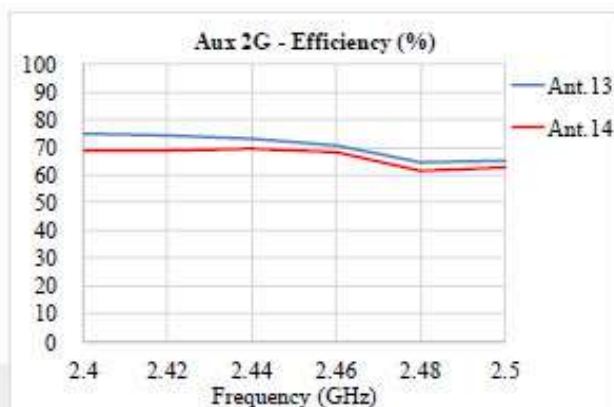- 2GM to 5GS isolation is under -40.5 dB over frequency (2400~2500 MHz).

Aux Performance – VSWR/Isolation
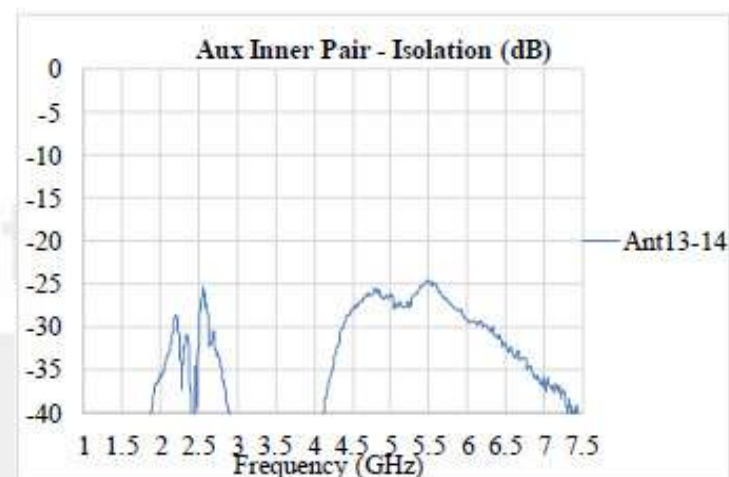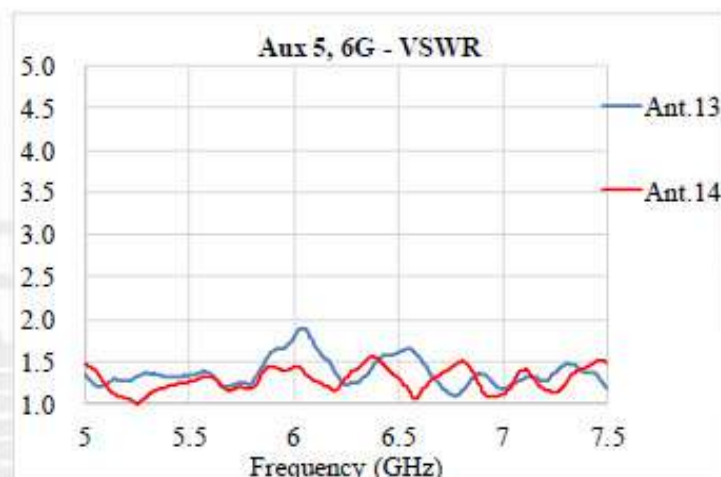
- The value of VSWR at 2400~2500, 5150~7150 MHz under 2.
- Intra-pair isolation of Aux is under -20 dB.

Aux Performance – Efficiency/Peak Gain

Aux 2G - Efficiency (%)

Aux 2G - Peak Gain (dBi)

Aux 5, 6G - Efficiency (%)

Aux 5, 6G - Peak Gain (dBi)
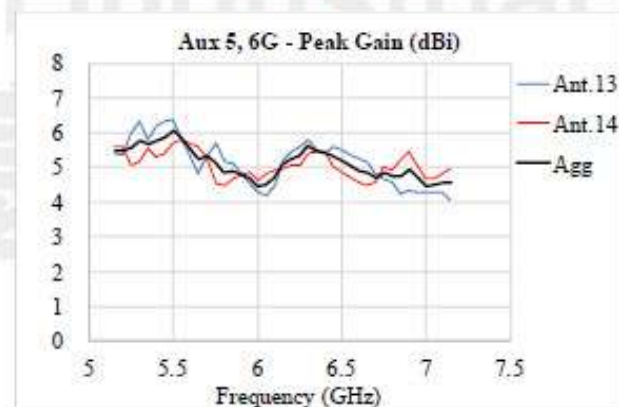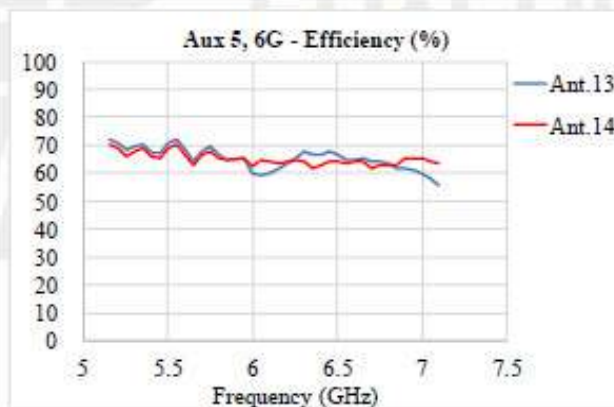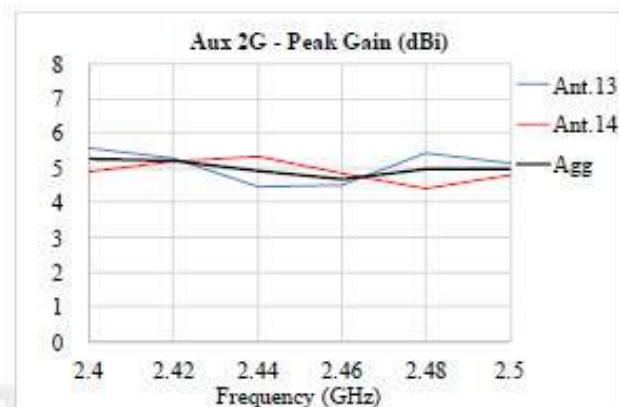
- Antenna efficiency at 2400~2500 and 5150~7150 MHz is over 50%.

- 2G individual peak gain around 4.5~5.6 dBi, typical value around 4.8 dBi. Peak average gain of 2G is 6 dBi.

- 5/6G individual peak gain around 5.0~6.4 dBi, typical value around 5.3 dBi. Peak average gain of 5/6G is 6 dBi.
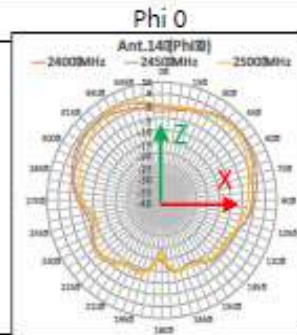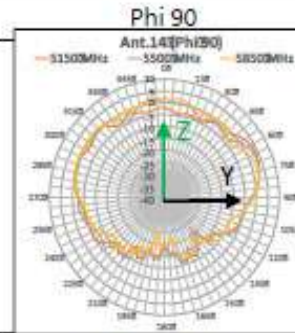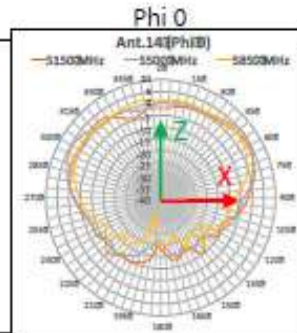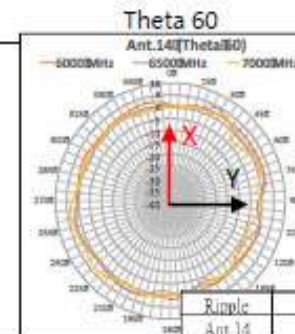
Aux Performance – Radiation Pattern (A13)

	2 G – Ant.13	
Phi 0	Phi 90	Theta 60

Ripple	Low	Mid	High
Ant.13	6.7	6.8	6.6

	5 G – Ant.13	
Phi 0	Phi 90	Theta 60

Ripple	Low	Mid	High
Ant.13	8.9	8.8	6.9

	6 G – Ant.13	
Phi 0	Phi 90	Theta 60

Ripple	Low	Mid	High
Ant.13	6.8	8.5	11.2
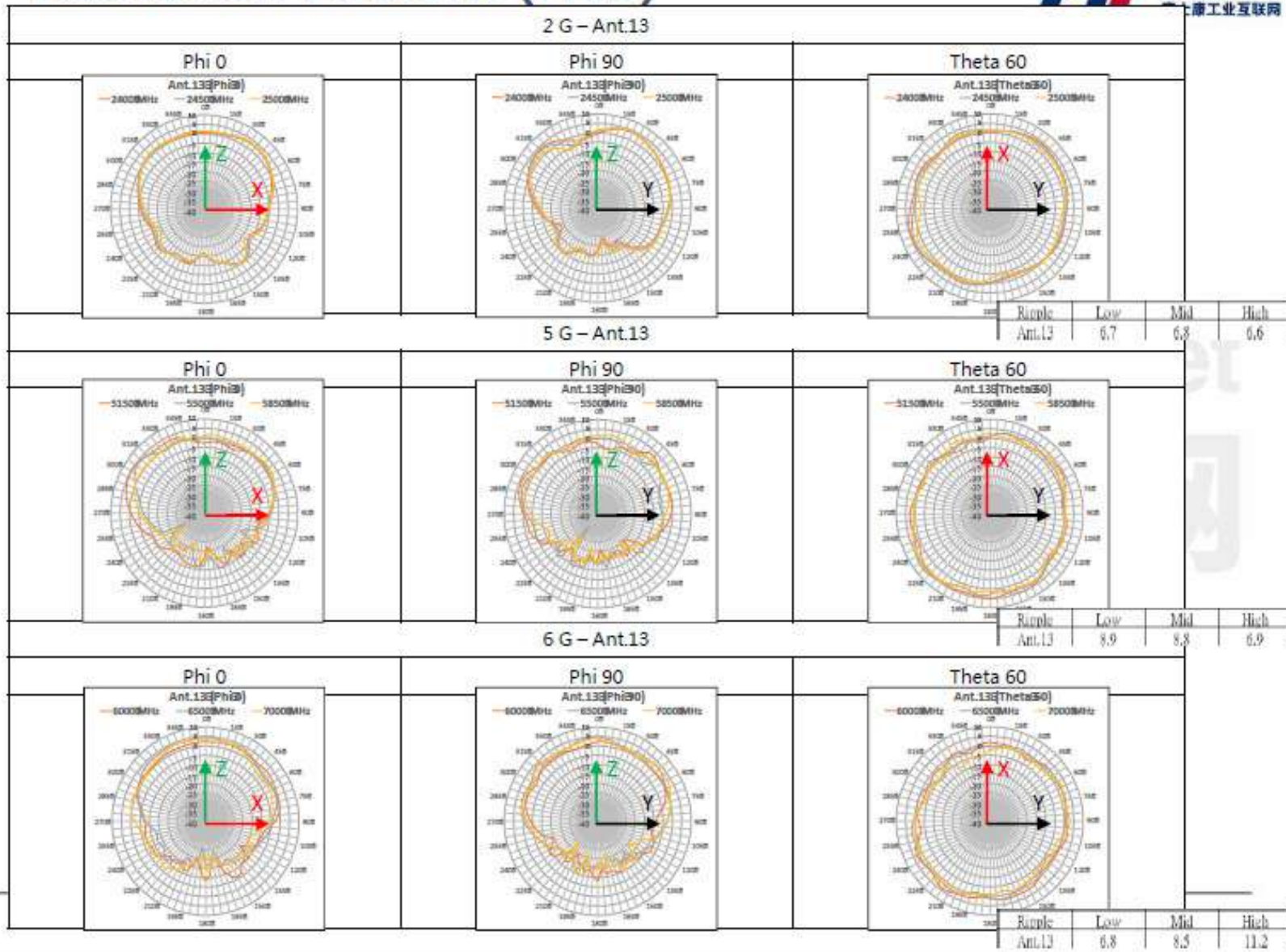
Aux Performance – Radiation Pattern (A14)

2 G – Ant.13
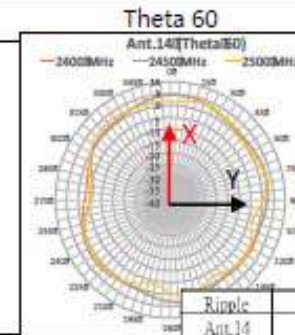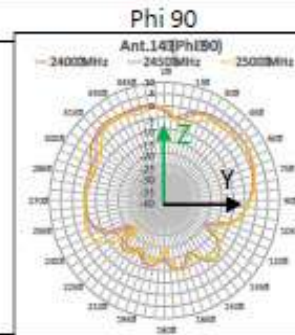
Ripple	Low	Mid	High
Ant.14	7.6	10.8	8.8

5 G – Ant.13
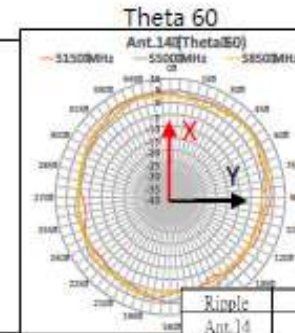
Ripple	Low	Mid	High
Ant.14	7.6	6.6	5.1

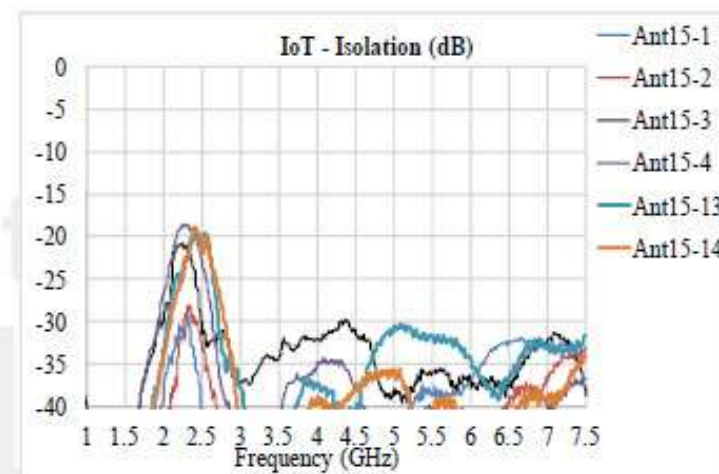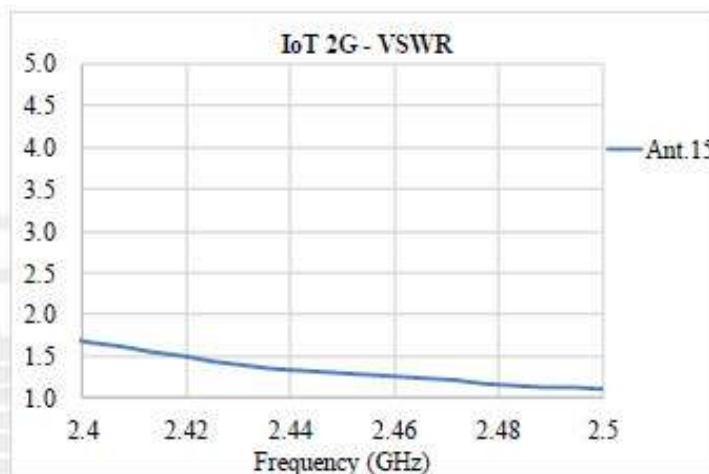6 G – Ant.13
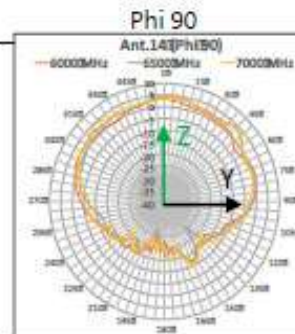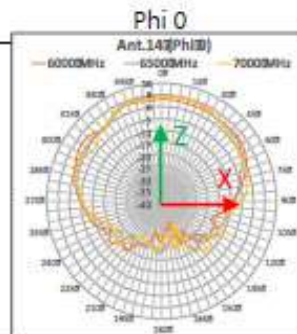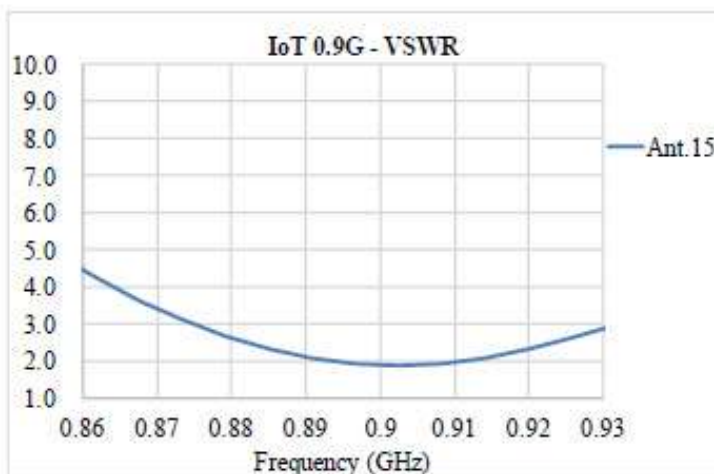
Ripple	Low	Mid	High
Ant.14	5.0	8.2	8.2

Serving Antennas AUX to MIMO Cross-Pair Isolation
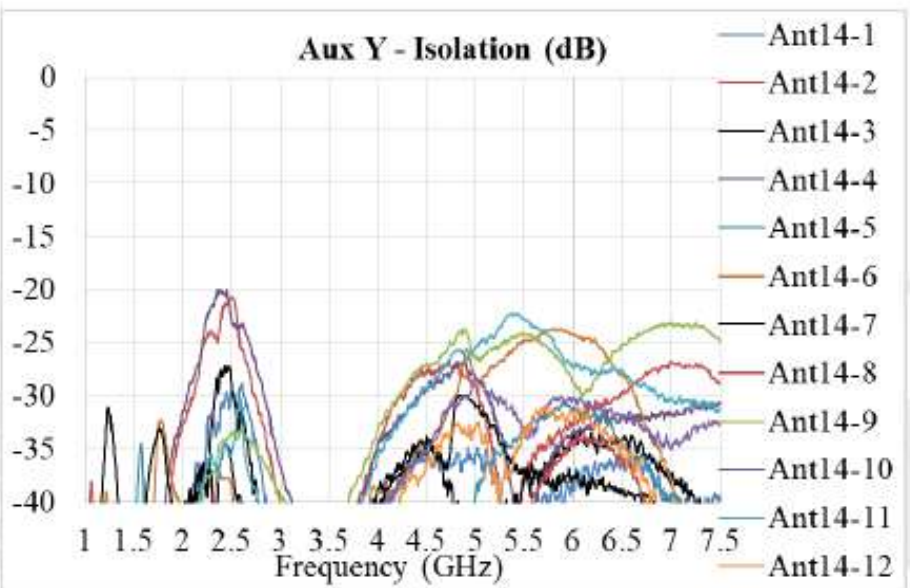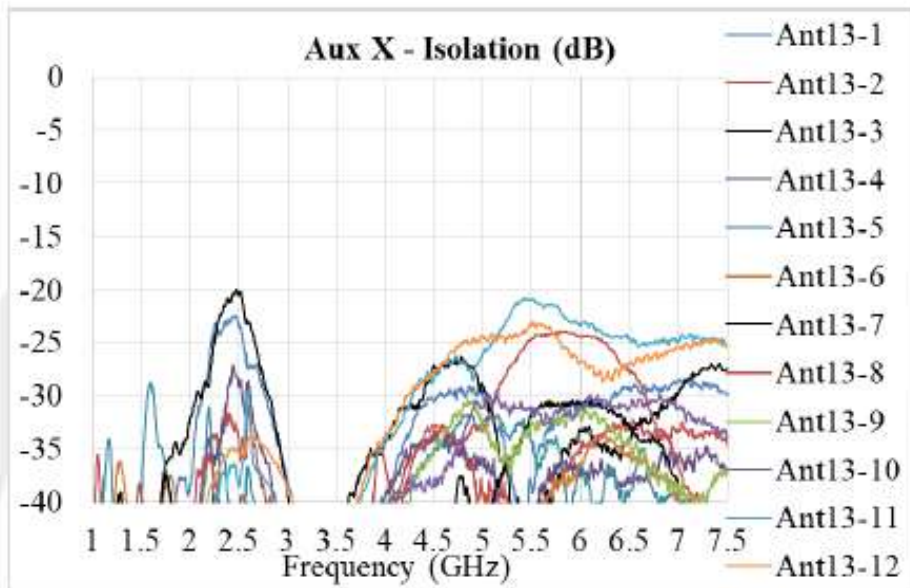
- AUX to MIMO1 isolation is under -20 dB over frequency (2400~2500 MHz).
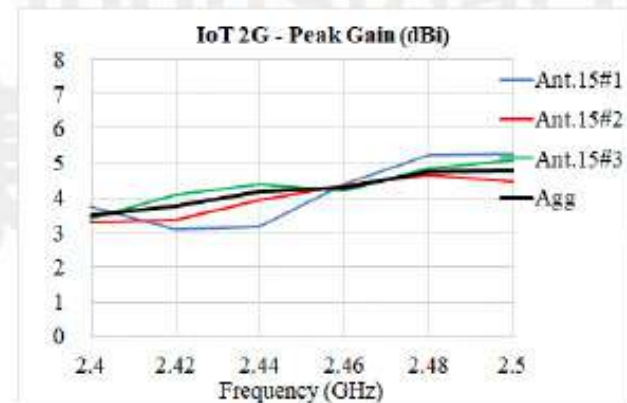- AUX to MIMO2/3 isolation is under -20 dB over frequency (5150~7125 MHz).
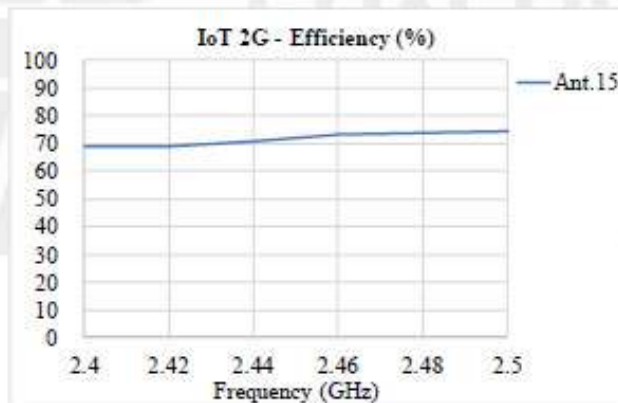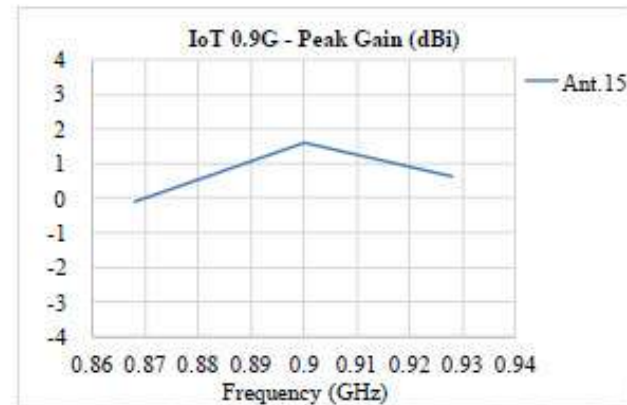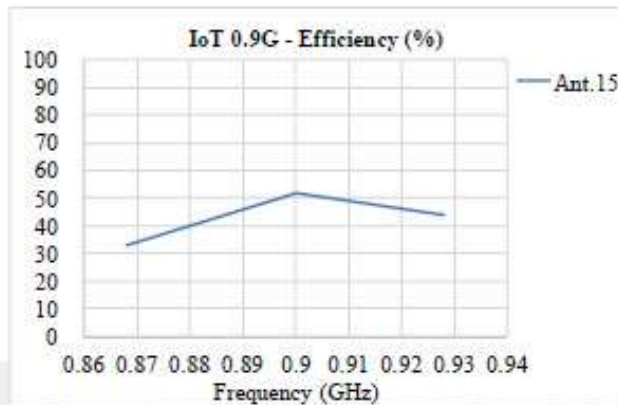
IoT Performance – VSWR/Isolation

- The value of VSWR at 2400~2500 MHz under 2, 0.9G VSWR is for reference since we'll review it by efficiency value.
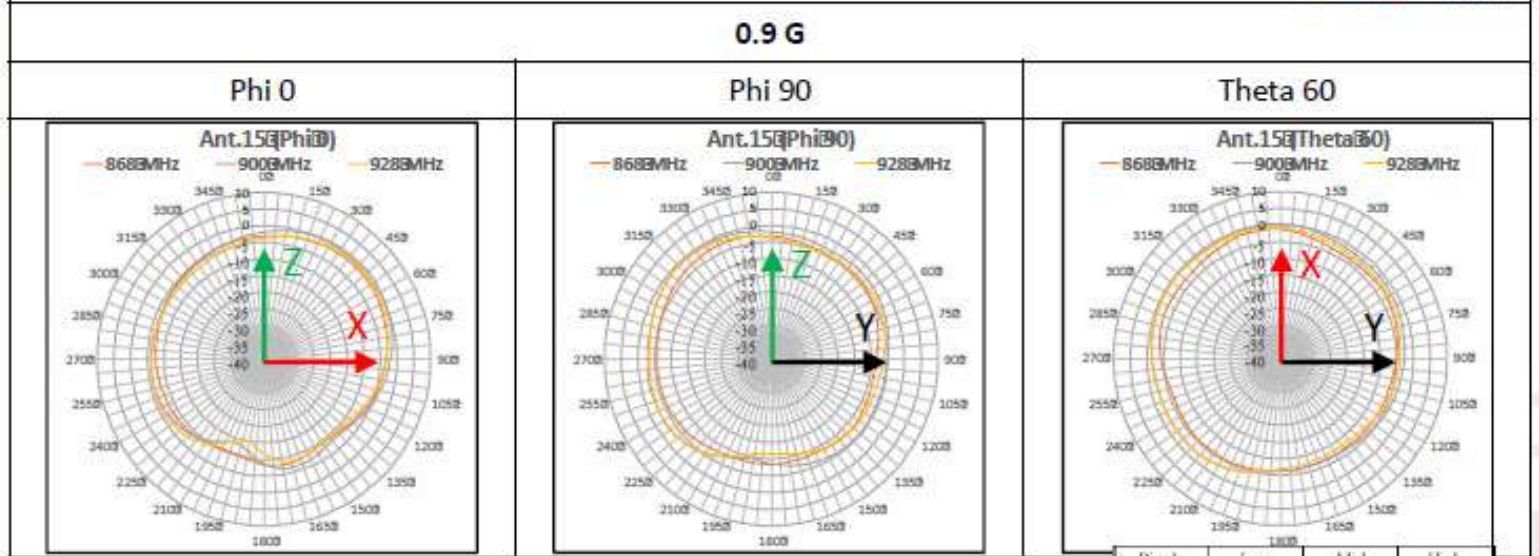- Isolation of IoT is under -15dB.

IoT Performance – Efficiency/Peak Gain

IoT 0.9G - Efficiency (%)

IoT 0.9G - Peak Gain (dBi)

IoT 2G - Efficiency (%)
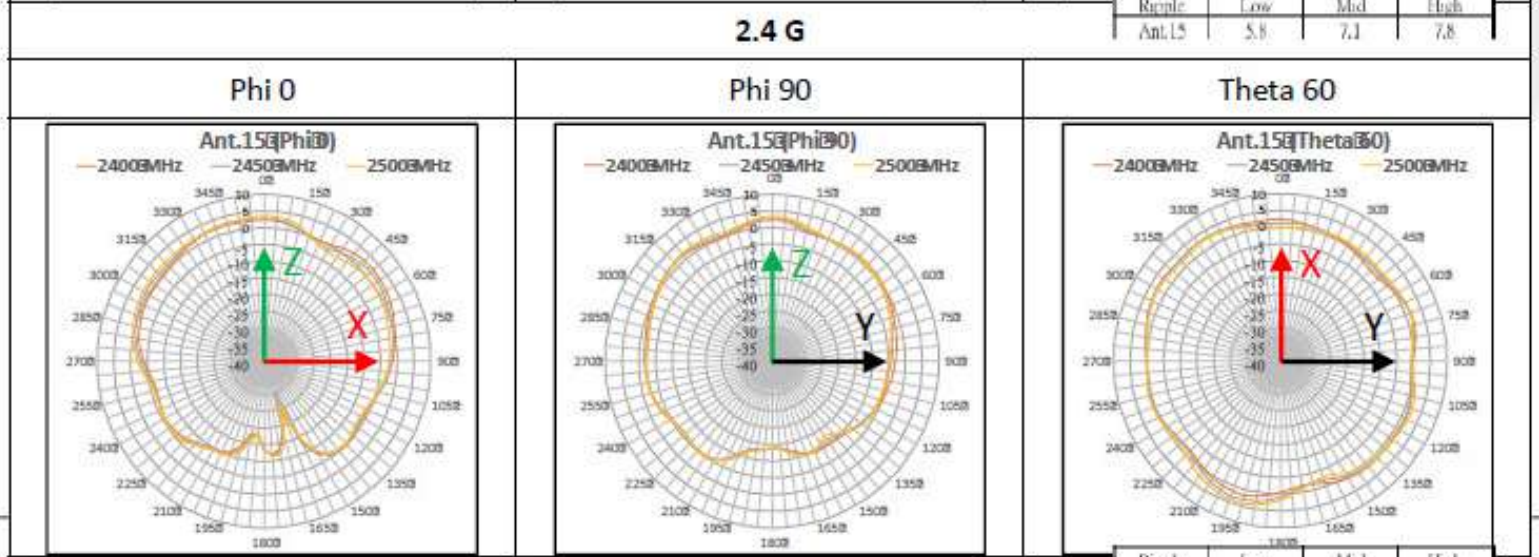
IoT 2G - Peak Gain (dBi)

- Antenna efficiency at 2400~2500 is over 50%, 868~928 MHz also over 35%.

- Peak gain at 2G around 4.1~5.5 dBi, typical value around 4.8 dBi.

IoT Performance – Radiation Pattern (A15)

Fii Confidential

Thank You!