Antenna Test Report for 4x4 Wi-Fi 6 AP (M/N:MR46-HW)

WNC Wistron NeWeb Corp.

☐ Normal ☐ Internal Use ■ Confidential ☐ Restricted Confidential

Contents

General Information

- **Antenna Information:**

  - Brand: WNC

    20 Park Ave. II, Hsinchu Science Park, Hsinchu 308, Taiwan

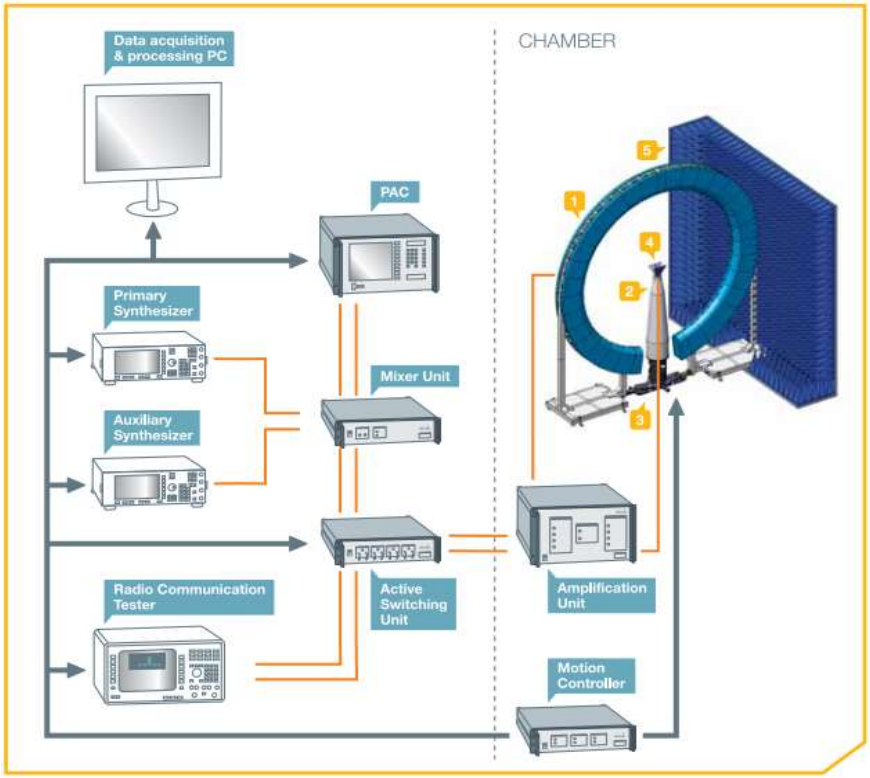
- **Antenna Type:**
  - **Wi-Fi 2.4G: PIFA (M/N:95XKAA15.GKJ)**
  - **Wi-Fi 5G: PIFA (M/N:95XKAA15.GKJ)**
  - **BLE: PIFA (M/N:95XKAA15.GKL)**
  - **Scanning: PIFA (M/N:95XKAA15.GKK)**

- **Test Date and Member**

  Date: 2020/04/27

  Member: Gary

Test Setup and Diagram



SG 64 uses analog RF signal generators to emit EM waves from the probe array to the antenna under test (AUT) or vice versa.

It uses the NPAC as an RF receiver for antenna measurements. The NPAC also drives the electronic scanning of the probe array.

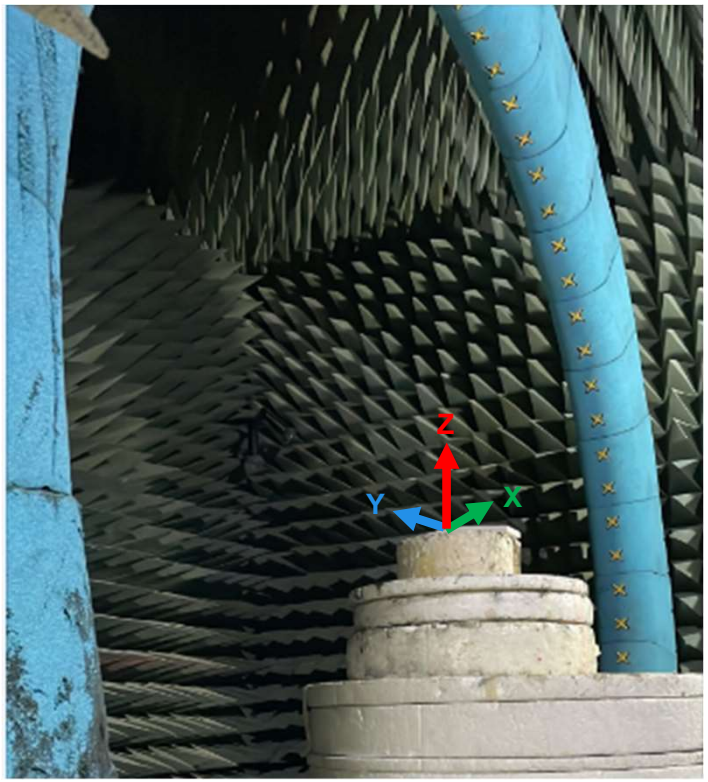
The NPAC includes the fastest and most accurate sources and receivers on the market.

Equipment

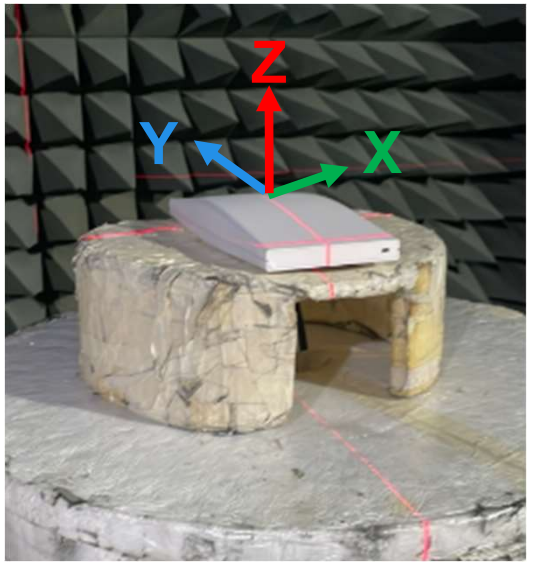
Device	Type/Model	Serial#	Manufacturer	Calibrated Date	Calibrated Until
SG64 Chamber	Standard	SG64	MVG	2020/03/30	2024/03/30
Turn Table	Customization	-	Machinery Dept.	2020/03/30	2024/03/30
New Probe Array Controller	N/A	1102341-4535	MVG	2020/03/30	2024/03/30
Power Supply Unit	N/A	1103211-13204	MVG	2020/03/30	2024/03/30
Activve Switching Unit	N/A	1102347-7214	MVG	2020/03/30	2024/03/30
TX Amplification Unit	N/A	1102527-5909	MVG	2020/03/30	2024/03/30
RX Amplification Unit	N/A	1102536-3823	MVG	2020/03/30	2024/03/30
Transfer Swittching Unit	N/A	1102183-3351	MVG	2020/03/30	2024/03/30
Mixer Unit	N/A	1102545-7208	MVG	2020/03/30	2024/03/30
Power And Control Unit	N/A	1102706-7209	MVG	2020/03/30	2024/03/30
Antenna Probe	DP 400-6000	-	MVG	2020/03/30	2024/03/30
Cable 13.7m - 400MHz to 18GHz	SS402	00100A1F5A1XXS	Woken	2020/03/30	2024/03/30
Temperature & Humidity Meter	HTC-01	-	Metravi	2020/03/30	2024/03/30

Note:
1. There are 63 set ANT probes in WNC's SG64 Chamber.

Test Setup and Procedure



- Place the device at the center of the chamber.
- Connect the antenna cable to RF cable of the chamber
- Run Satimo test SW (**NPAC Spherical Measurement, v1.5.4 (GIT-E6965664)**)
- Get 3D data in 2.8125 degree step from phi 0°~360°and theta -90°~ +90°, including efficiency, peak gain, 2D & 3D radiation pattern.
- This is far field test for **MR46-HW** antenna verification.
- This is passive measurement, which means the device is off and not in any operating mode.

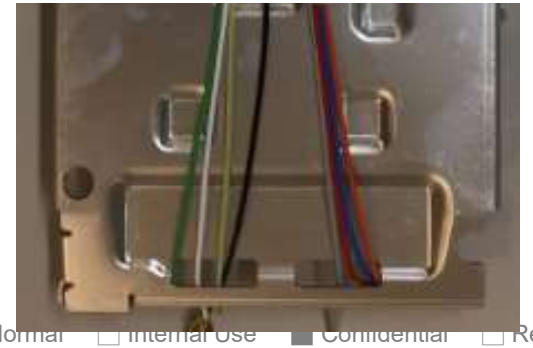


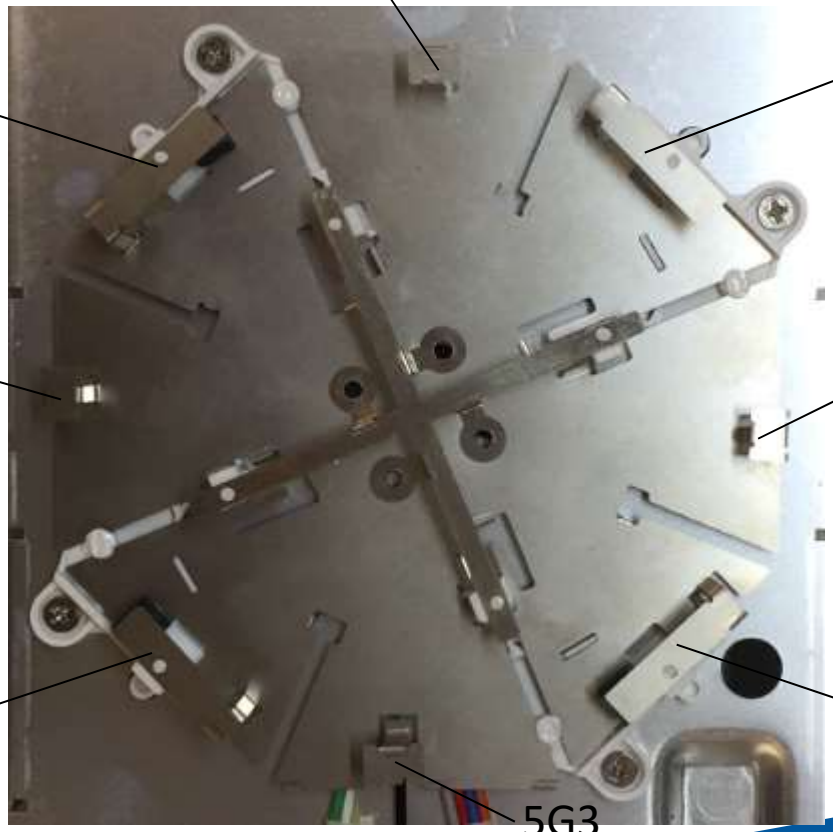
Summary

- ***VSWR***
  - *Under 2 for 2.4GHz and 5GHz application*
- ***Isolation***
  - *Above 20dB for all antennas*
- ***Average Radiation efficiency (excluding cable length loss)***
  - *72% for 2.4GHz antenna ; 80% for 5GHz antenna*
  - *74% for Scanning 2.4GHz ; 84% for Scanning 5GHz*
  - *72% for BT antenna*
- ***Peak gain***
  - *3.7dBi for 2.4GHz antenna ; 5.4dBi for 5G antenna*
  - *3.8dBi for Scanning 2.4GHz ; 5dBi for Scanning 5G*
  - *4.2dBi for BT antenna*

Antenna Placement

4x4 Modularized WiFi Antenna





Test Product Specification

Top cover

Main-Board

Chassis-Bottom

Bottom cover

Antenna Efficiency and Peak Gain

	Frequency (MHz)	2400	2450	2500	Avg.
2G1	Eff. (%)	64%	68%	63%	65%
	Avg. Gain (dB)	-1.96	-1.64	-2.03	
	w/o cable loss Eff. (%)	72%	78%	71%	74%
	Peak Gain (dBi)	3.58	3.70	3.36	
2G2	Eff. (%)	64%	68%	64%	65%
	Avg. Gain (dB)	-1.96	-1.66	-1.92	
	w/o cable loss Eff. (%)	72%	77%	73%	74%
	Peak Gain (dBi)	3.37	3.26	3.07	
2G3	Eff. (%)	62%	65%	62%	63%
	Avg. Gain (dB)	-2.09	-1.85	-2.07	
	w/o cable loss Eff. (%)	69%	73%	70%	71%
	Peak Gain (dBi)	3.32	3.26	3.08	
2G4	Eff. (%)	61%	67%	62%	63%
	Avg. Gain (dB)	-2.11	-1.74	-2.11	
	w/o cable loss Eff. (%)	68%	74%	68%	70%
	Peak Gain (dBi)	3.02	3.03	2.88	

Antenna Efficiency and Peak Gain

	Frequency (MHz)	5150	5350	5550	5750	5850	Avg.
5G1	Eff. (%)	68%	71%	65%	67%	64%	67%
	Avg. Gain (dB)	-1.64	-1.51	-1.84	-1.72	-1.93	
	w/o cable loss Eff. (%)	85%	88%	81%	84%	80%	83%
	Peak Gain (dBi)	4.03	5.23	4.53	4.14	4.37	
5G2	Eff. (%)	66%	72%	62%	65%	64%	66%
	Avg. Gain (dB)	-1.83	-1.43	-2.04	-1.86	-1.95	
	w/o cable loss Eff. (%)	79%	87%	76%	79%	77%	79%
	Peak Gain (dBi)	3.33	4.04	4.44	3.75	3.24	
5G3	Eff. (%)	70%	73%	67%	70%	69%	70%
	Avg. Gain (dB)	-1.58	-1.36	-1.73	-1.52	-1.60	
	w/o cable loss Eff. (%)	79%	83%	76%	80%	78%	79%
	Peak Gain (dBi)	4.06	4.82	5.44	4.27	4.51	
5G4	Eff. (%)	63%	70%	67%	66%	62%	66%
	Avg. Gain (dB)	-2.03	-1.58	-1.74	-1.83	-2.1	
	w/o cable loss Eff. (%)	76%	84%	81%	79%	74%	79%
	Peak Gain (dBi)	3.11	3.72	4.43	4.35	4.26	

Antenna Efficiency and Peak Gain

	Frequency (MHz)	2400	2450	2500	Avg.	5150	5350	5550	5750	5850	Avg.
Scanning	Eff. (%)	64%	65%	66%	65%	67%	68%	64%	68%	65%	66%
	Avg. Gain (dB)	-1.96	-1.89	-1.83		-1.77	-1.67	-1.94	-1.68	-1.85	
	w/o cable loss Eff. (%)	73%	74%	75%	74%	84%	86%	81%	86%	82%	84%
	Peak Gain (dBi)	3.84	3.37	3.31		4.78	5.08	4.79	4.72	4.58	

	Frequency (MHz)	2400	2450	2500	Avg.
BT	Eff. (%)	65%	72%	67%	68%
	Avg. Gain (dB)	-1.89	-1.45	-1.73	
	w/o cable loss Eff. (%)	68%	76%	71%	72%
	Peak Gain (dBi)	3.77	4.24	3.63	

Antenna Composite gain- calculated Method

Directional Gain Calculations (co-pol)

In-Band Measurement, Unequal Antenna Gains

- If Any Transmit Signals Are Correlated:
- Directional Gain= $10\log[(10^{\frac{G_1}{20}}+10^{\frac{G_2}{20}}+\ldots+10^{\frac{G_n}{20}})^2/N_{ant}]\ dBi$
- If All Transmit Signals Are Completely Uncorrelated:
- Directional Gain= $10\log[(10^{\frac{G_1}{10}}+10^{\frac{G_2}{10}}+\ldots+10^{\frac{G_n}{10}})/N_{ant}]\ dBi$

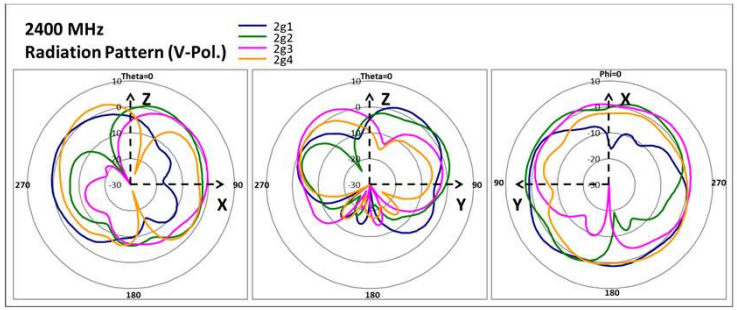
N_{ant}: Number of Transmit Antennas

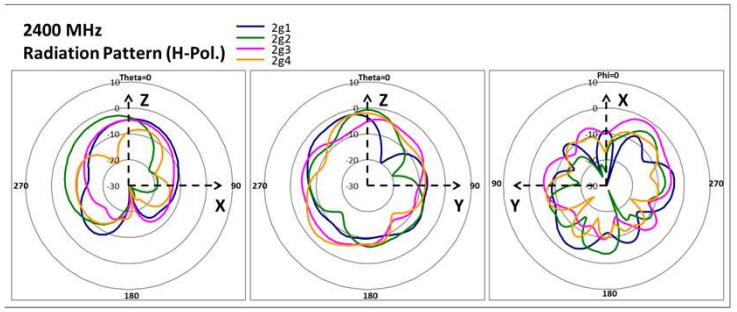
$G_1, G_2, \ldots, G_n$: Gain of Individual Antennas

April 13, 2016 TCB Workshop 7

Antenna Composite gain- data calculated explain

1. Measure 4 antennas and output V-pol.(Gain theta) and H-pol.(Gain phi) radiation pattern.

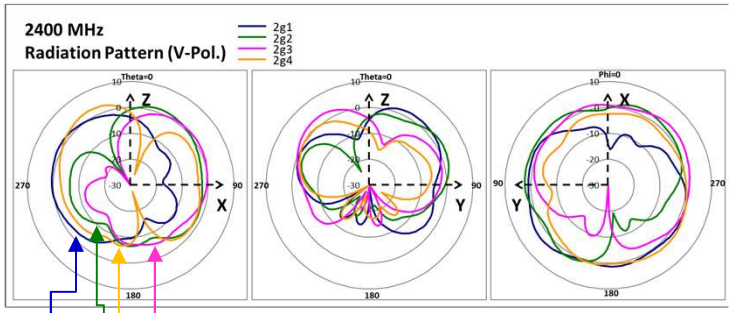




Antenna Composite gain- data calculated explain

2. Calculate with four antennas pattern by page13 formula.

- Below table(circled in red) is four antennas XZ cut plane in V-pol.(gain theta) data, these data by using formula to calculation and output directional gain.
- Use same method to get YZ / XY plane directional gain data.



Example:

- If Any Transmit Signals Are Correlated:
- Directional Gain= $10\log[(10^{\frac{G_1}{20}}+10^{\frac{G_2}{20}}+\ldots+10^{\frac{G_n}{20}})^2/N_{ant}]\ dBi$

v-pol	XZ cut								
Ant1		-3.76814	-4.19292	-4.66602	-5.19607	-5.78957	-6.44544	-7.16206	-7.93125
Ant2		-0.75284	-0.25145	0.18119	0.547973	0.859547	1.103471	1.295622	1.418946
Ant3		-5.25615	-4.41829	-3.67379	-3.01051	-2.41228	-1.87137	-1.38116	-0.93979
Ant4		-2.01204	-3.31614	-4.92656	-6.97685	-9.72533	-13.788	-21.2627	-25.473
correlated calculated directional gain		3.88	3.24	3.14	3.01	2.83	2.61	2.35	2.07	2.04
uncorrelated calculated directional gain		-1.38	-2.62	-2.69	-2.73	-2.72	-2.67	-2.58	-2.45	-2.30

.....

Max. directional gain in XZ cut

- If All Transmit Signals Are Completely Uncorrelated:
- Directional Gain= $10\log[(10^{\frac{G_1}{10}}+10^{\frac{G_2}{10}}+\ldots+10^{\frac{G_n}{10}})/N_{ant}]\ dBi$

Using same calculation method output XZ, YZ and XY cut in v-pol. and h-pol. directional gain

Antenna Composite gain- data calculated explain

3. Calculate three cut planes(XZ/YZ/XY) and find maximum value of three planes. This maximum value will be this frequency directional gain.
Example for 2.4GHz :

	XZ-plane	Frequency	2400	2450	2500
Corr. Composite	H-Pol.	Peak Gain	0.81	0.71	-1.27
	V-Pol.	Peak Gain	3.88	4.81	4.62
UnCorr. Composite	H-Pol.	Peak Gain	-4.98	-4.62	-6.78
	V-Pol.	Peak Gain	-1.38	-0.89	-1.25

	YZ-plane	Frequency	2400	2450	2500
Corr. Composite	H-Pol.	Peak Gain	3.30	1.35	-0.18
	V-Pol.	Peak Gain	5.62	7.65	7.07
UnCorr. Composite	H-Pol.	Peak Gain	-2.55	-3.82	-5.48
	V-Pol.	Peak Gain	-0.19	1.64	1.06

	XY-plane	Frequency	2400	2450	2500
Corr. Composite	H-Pol.	Peak Gain	1.21	0.66	-0.22
	V-Pol.	Peak Gain	6.20	7.74	7.03
UnCorr. Composite	H-Pol.	Peak Gain	-4.37	-5.02	-5.56
	V-Pol.	Peak Gain	0.43	1.78	1.06

Corr. Composite	H-Pol.		3.30	1.35	-0.18
	V-Pol.		6.20	7.74	7.07
UnCorr. Composite	H-Pol.		-2.55	-3.82	-5.48
	V-Pol.		0.43	1.78	1.06

Antenna Composite gain- data calculated explain

Calculate three cut planes(XZ/YZ/XY) and find maximum value of three planes. This maximum value will be this frequency directional gain.
Example for 5GHz :

	XZ-plane	Frequency	5150	5350	5550	5750	5850
Corr. Composite	Total	Peak Gain	7.72	8.55	8.51	7.37	8.50
UnCorr. Composite	Total	Peak Gain	1.74	2.66	2.77	1.59	2.66

	YZ-plane	Frequency	5150	5350	5550	5750	5850
Corr. Composite	Total	Peak Gain	7.58	8.04	7.31	7.95	7.83
UnCorr. Composite	Total	Peak Gain	1.66	2.26	1.64	2.06	1.89

	XY-plane	Frequency	5150	5350	5550	5750	5850
Corr. Composite	Total	Peak Gain	8.40	8.93	8.51	8.11	8.54
UnCorr. Composite	Total	Peak Gain	2.40	2.98	2.79	2.22	2.73

Corr. Composite	Total		8.40	8.93	8.51	8.11	8.54
UnCorr. Composite	Total		2.40	2.98	2.79	2.22	2.73

Antenna Composite gain

	Composite Gain	2.4 ~ 2.4835
Single - 2G 4x4	Correlated	7.74
	Un-Correlated	1.78

	Composite Gain	5.15 ~ 5.25	5.25 ~ 5.35	5.47 ~ 5.725	5.725 ~ 5.85
Single - 5G 4x4	Correlated	8.40	8.93	8.51	8.11
	Un-Correlated	2.40	2.98	2.79	2.22

			Antenna gain (dBi)				Calculated Directional Gain (dBi) **Correlated**
Frequency	Position (θ, ϕ)of **directional gain**	Polarization	ANT 0	ANT 1	ANT 2	ANT 3	
2.4 ~ 2.4835	(θ=60, ϕ=93)	V-pol.	2.63	0.06	1.75	2.22	7.74
5.15 ~ 5.25	(θ=60, ϕ=186)	V-pol.	2.24	1.81	3.19	2.23	8.40
5.25 ~ 5.35	(θ=60, ϕ=200)	V-pol.	4.57	2.32	1.99	2.52	8.93
5.47 ~ 5.725	(θ=60, ϕ=0)	V-pol.	0.11	0.94	4.25	3.90	8.51
5.725 ~ 5.85	(θ=60, ϕ=332)	V-pol.	0.32	1.26	2.05	4.22	8.11

Antenna Composite gain

Single – 2G 2x2	Composite Gain	2400	2450	2500
1-2	Correlated	4.88	4.82	3.91
	Un-Correlated	1.91	1.82	1.02

Single – 2G 2x2	Composite Gain	2400	2450	2500
1-3	Correlated	4.05	5.61	5.12
	Un-Correlated	1.04	2.65	2.13

Single – 2G 2x2	Composite Gain	2400	2450	2500
1-4	Correlated	4.66	6.12	5.29
	Un-Correlated	1.66	3.12	2.29

Antenna Composite gain

Single – 2G 2x2	Composite Gain	2400	2450	2500
2-3	Correlated	5.27	4.66	4.91
	Un-Correlated	2.31	1.66	1.91

Single – 2G 2x2	Composite Gain	2400	2450	2500
2-4	Correlated	3.88	5.09	4.89
	Un-Correlated	1.02	2.10	1.92

Single – 2G 2x2	Composite Gain	2400	2450	2500
3-4	Correlated	4.68	5.08	4.60
	Un-Correlated	1.76	2.07	1.59

Antenna Composite gain

Single – 5G 2x2	Composite Gain	5150	5350	5550	5750	5850
1-2	Correlated	5.85	7.50	7.32	5.60	5.39
	Un-Correlated	2.84	4.56	4.31	2.64	2.38

Single – 5G 2x2	Composite Gain	5150	5350	5550	5750	5850
1-3	Correlated	6.62	7.02	6.90	6.61	6.78
	Un-Correlated	3.61	4.16	4.04	3.60	3.78

Single – 5G 2x2	Composite Gain	5150	5350	5550	5750	5850
1-4	Correlated	5.47	6.74	5.34	5.85	5.53
	Un-Correlated	2.56	3.78	2.58	2.89	2.66

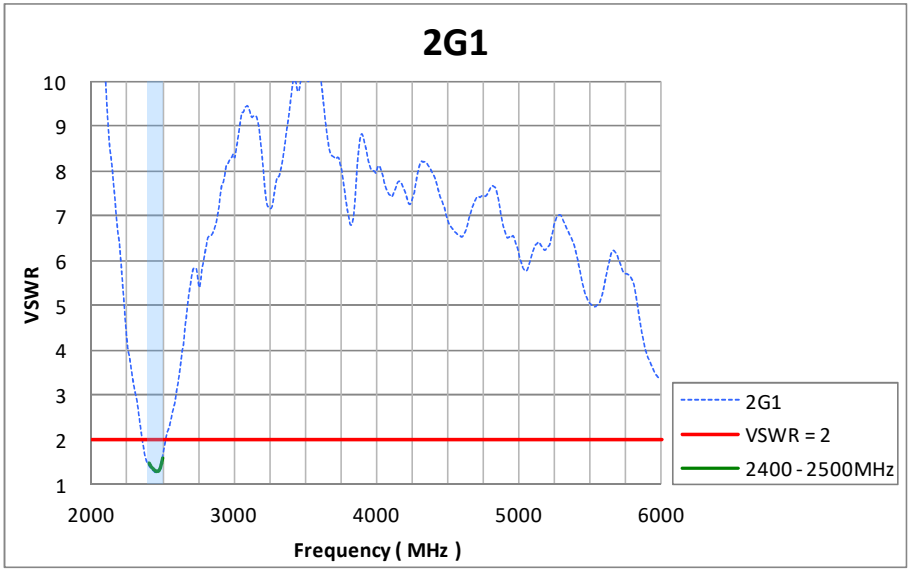
Antenna Composite gain

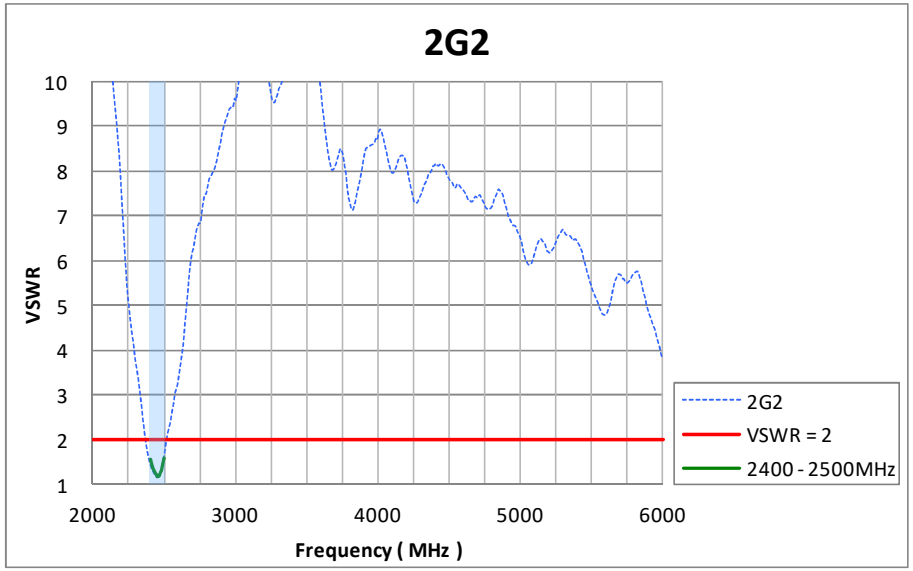
Single – 5G 2x2	Composite Gain	5150	5350	5550	5750	5850
2-3	Correlated	5.54	6.35	6.56	5.33	5.66
	Un-Correlated	2.56	3.37	3.58	2.37	2.81

Single – 5G 2x2	Composite Gain	5150	5350	5550	5750	5850
2-4	Correlated	5.73	6.26	6.36	5.88	5.48
	Un-Correlated	2.73	3.28	3.36	2.99	2.63

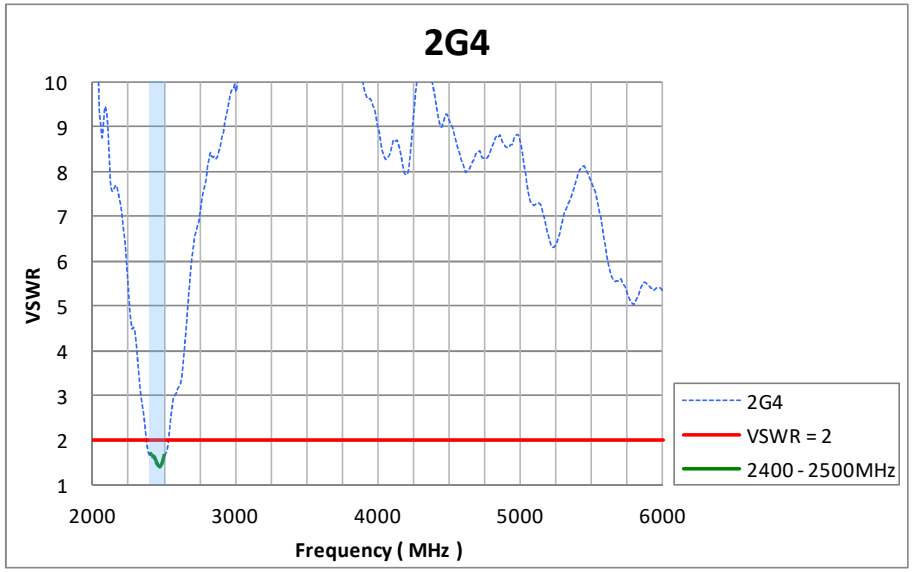
Single – 5G 2x2	Composite Gain	5150	5350	5550	5750	5850
3-4	Correlated	5.84	6.82	7.71	6.21	7.27
	Un-Correlated	2.86	3.87	4.70	3.27	4.26

VSWR for 2G

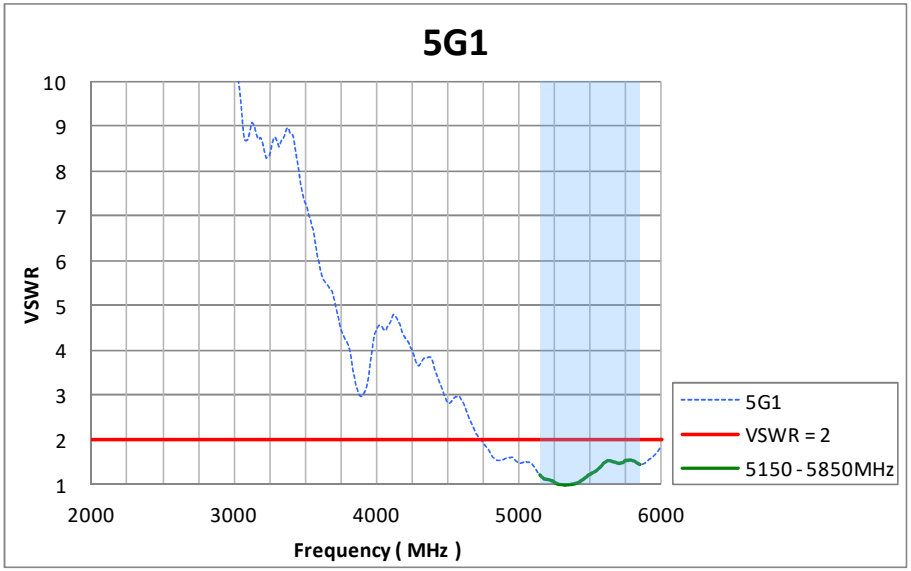

2G1
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
2G1
VSWR = 2
2400 - 2500MHz

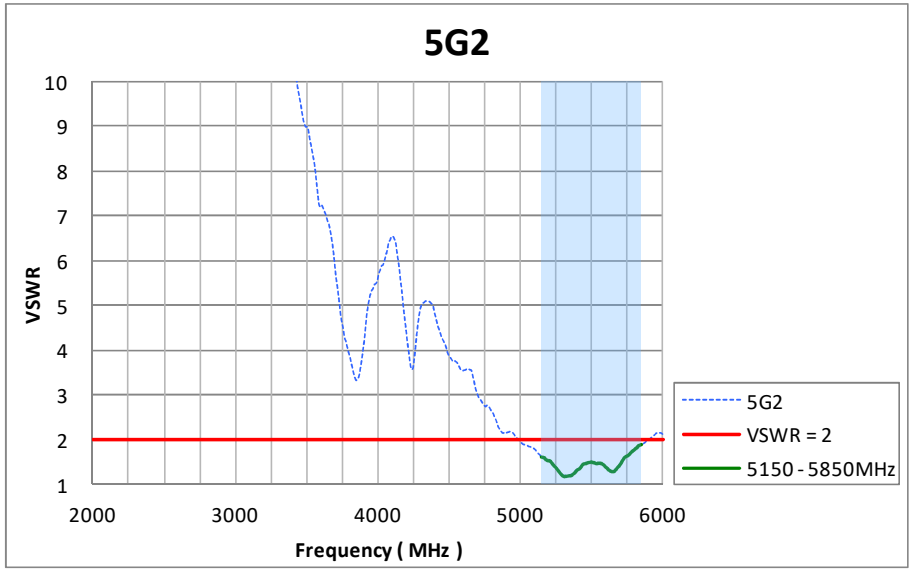

2G2
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
2G2
VSWR = 2
2400 - 2500MHz

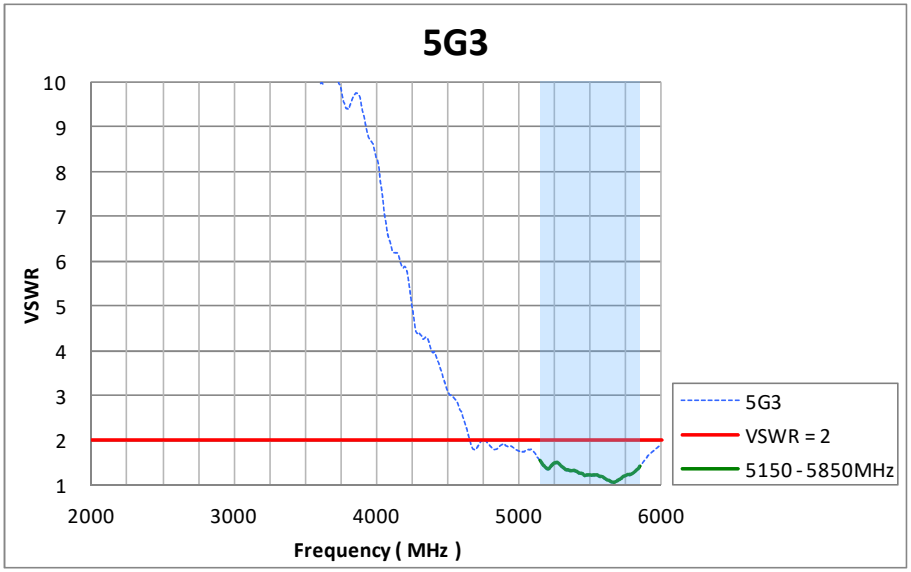

2G3
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
2G3
VSWR = 2
2400 - 2500MHz

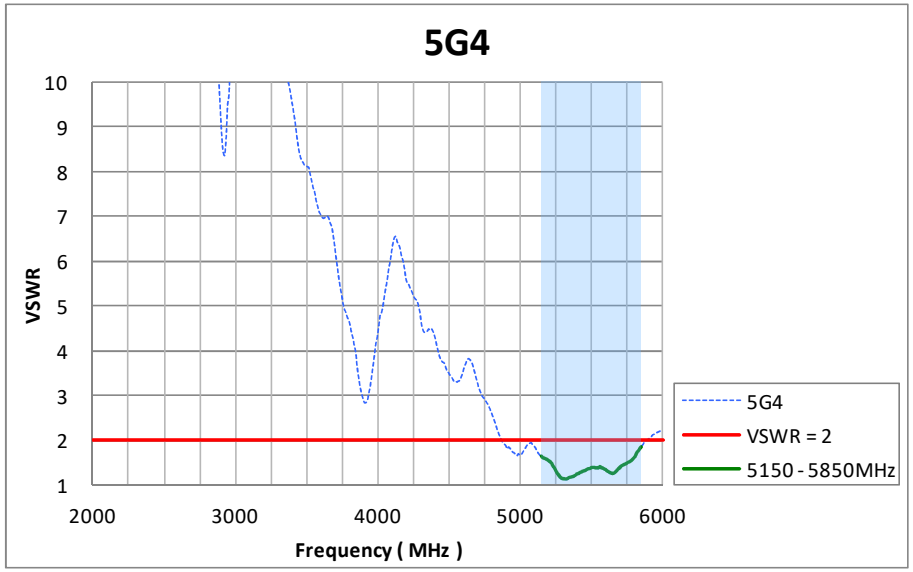

2G4
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
2G4
VSWR = 2
2400 - 2500MHz

VSWR for 5G

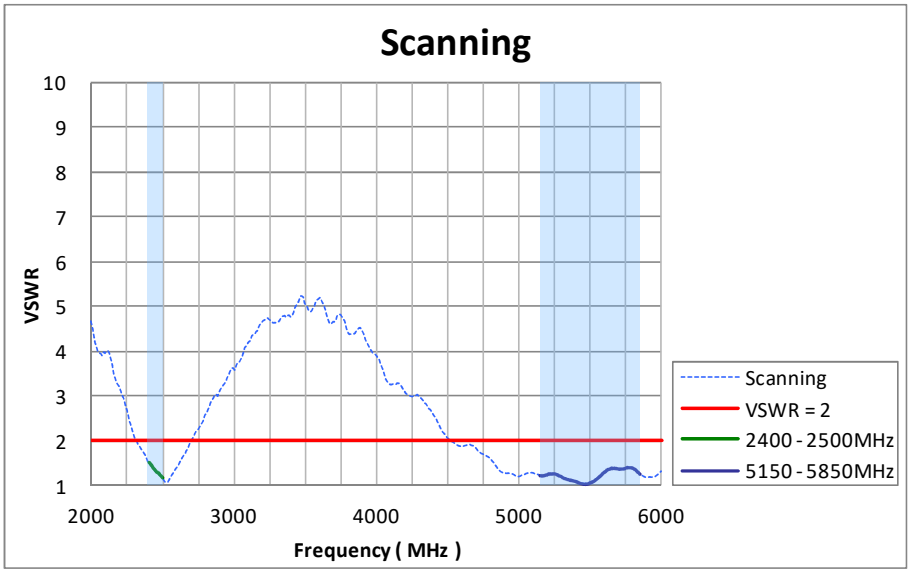

5G1
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
5G1
VSWR = 2
5150 - 5850MHz

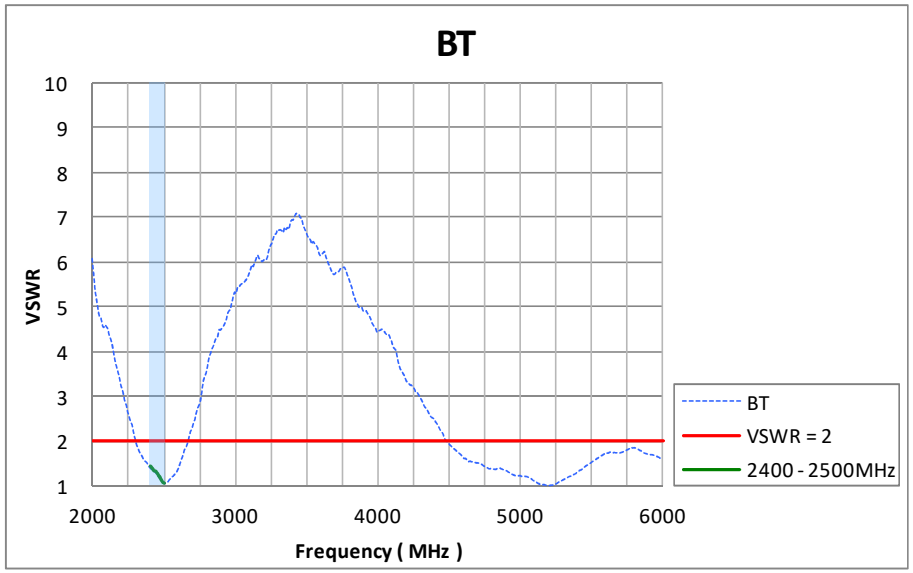

5G2
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
5G2
VSWR = 2
5150 - 5850MHz


5G3
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
5G3
VSWR = 2
5150 - 5850MHz

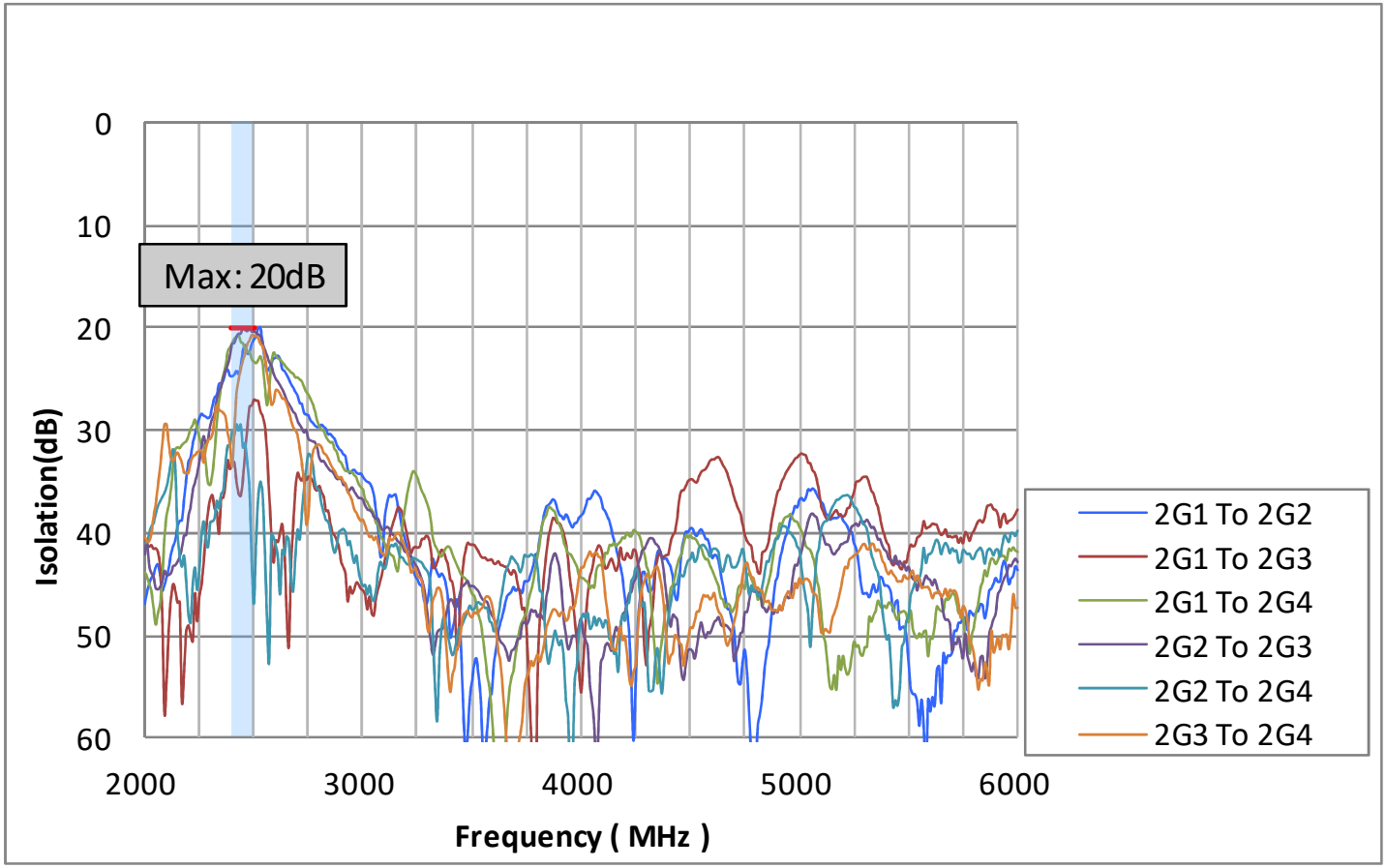

5G4
VSWR
10
9
8
7
6
5
4
3
2
1
2000
3000
4000
5000
6000
Frequency (MHz)
5G4
VSWR = 2
5150 - 5850MHz

VSWR for Scanning / BT

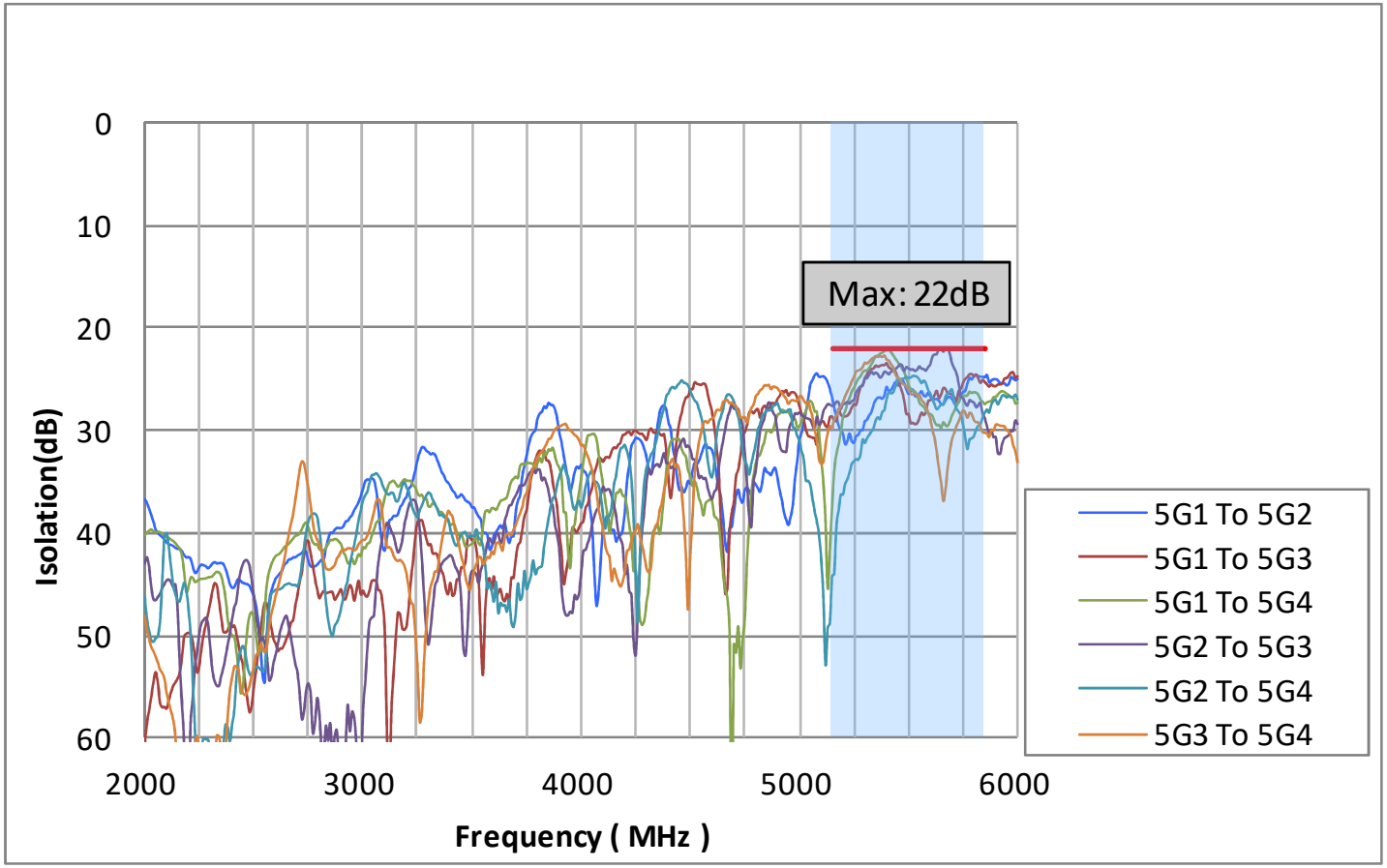




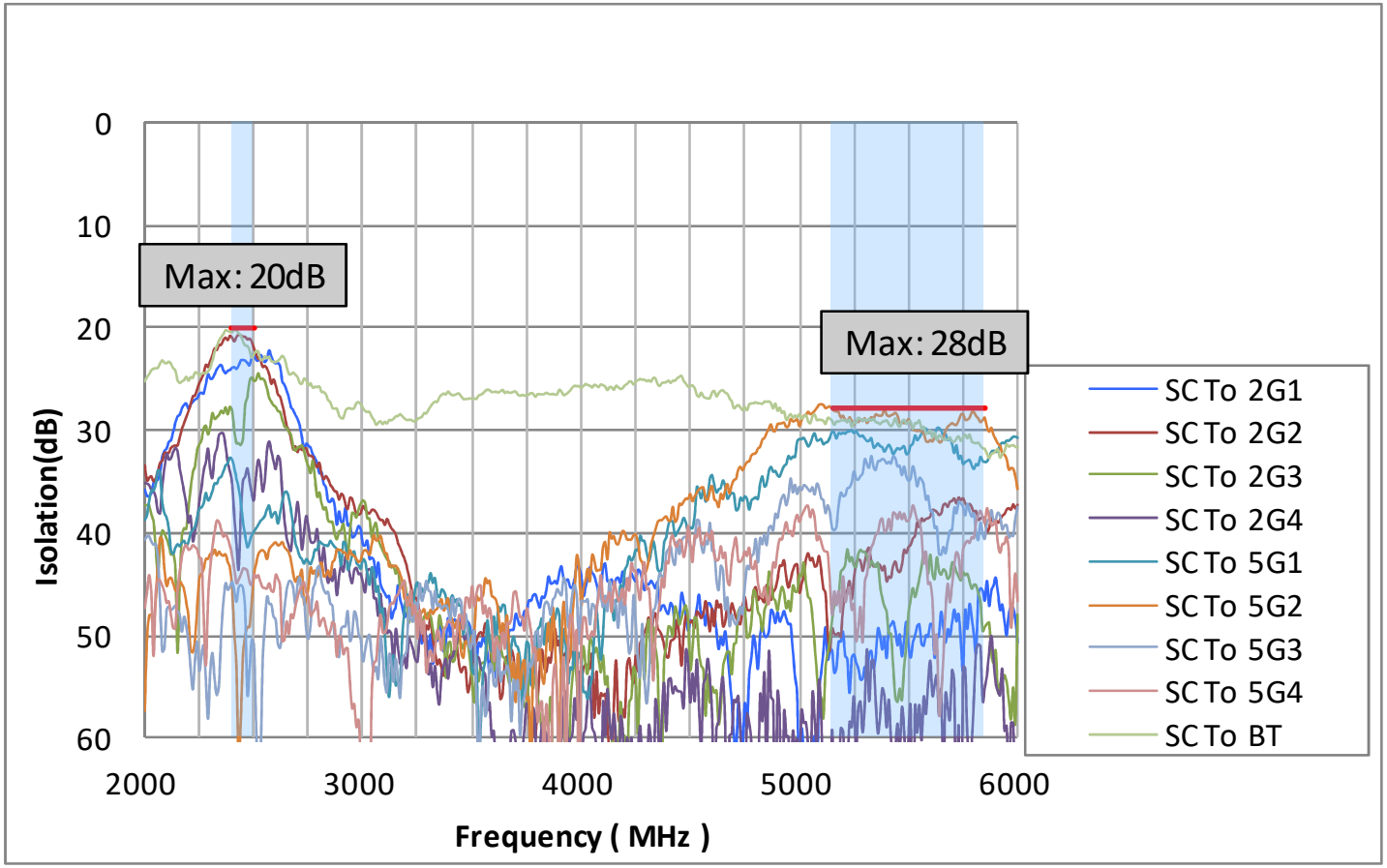
Isolation for 2G ANTs



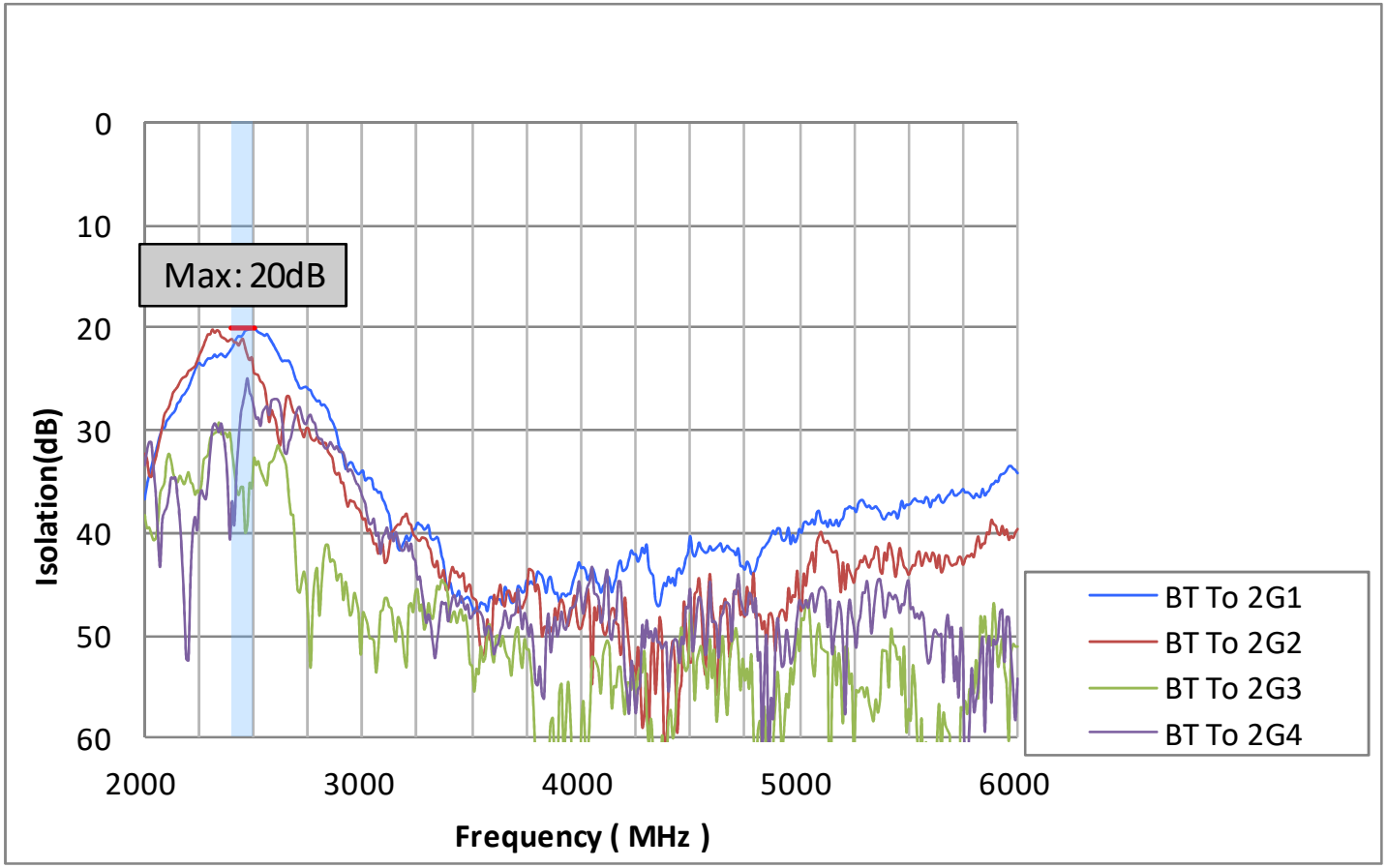
Isolation for 5G ANTs



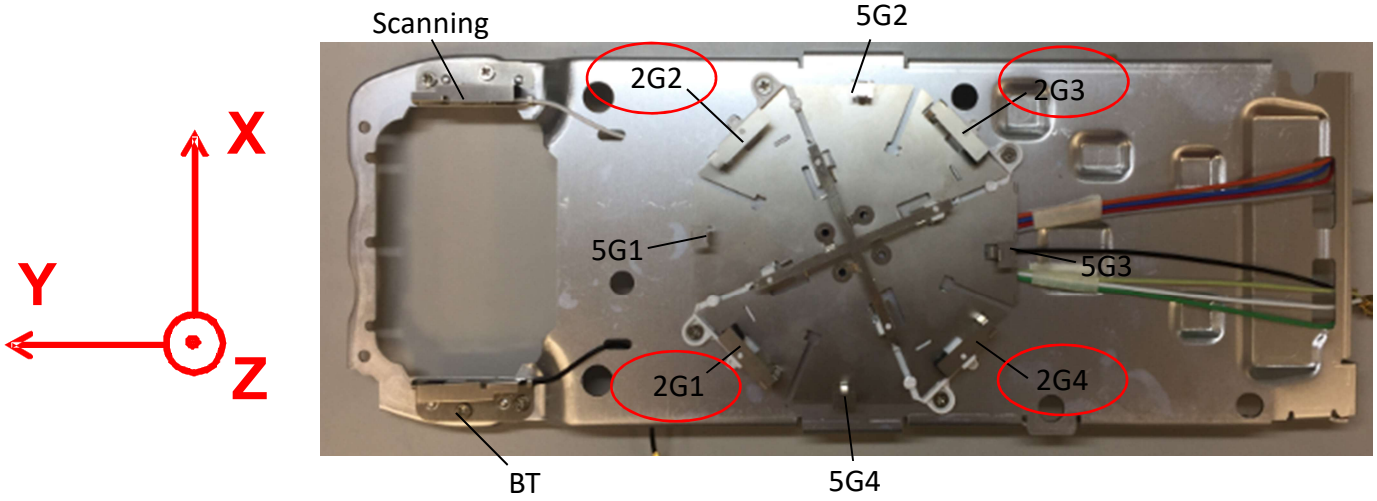
Isolation for Scanning to others



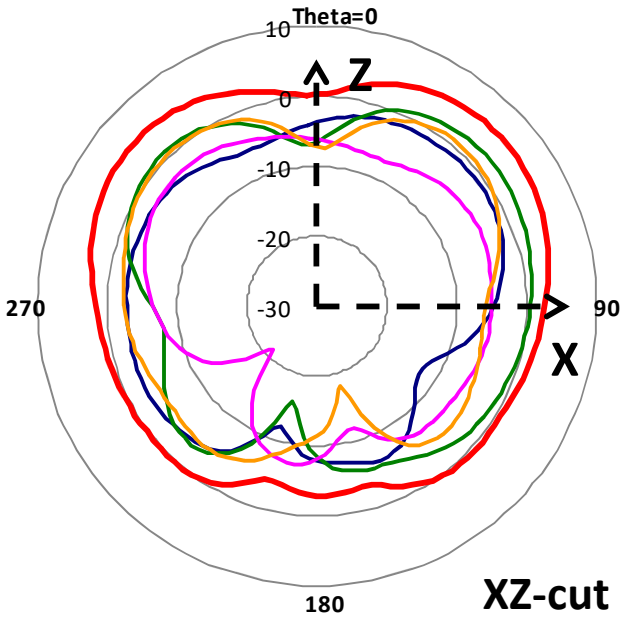
Isolation for BT to others



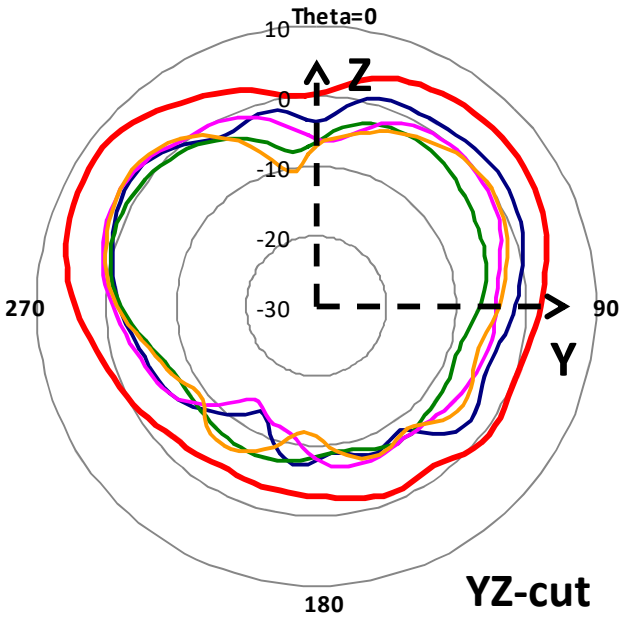
Radiation Pattern for 2.4G



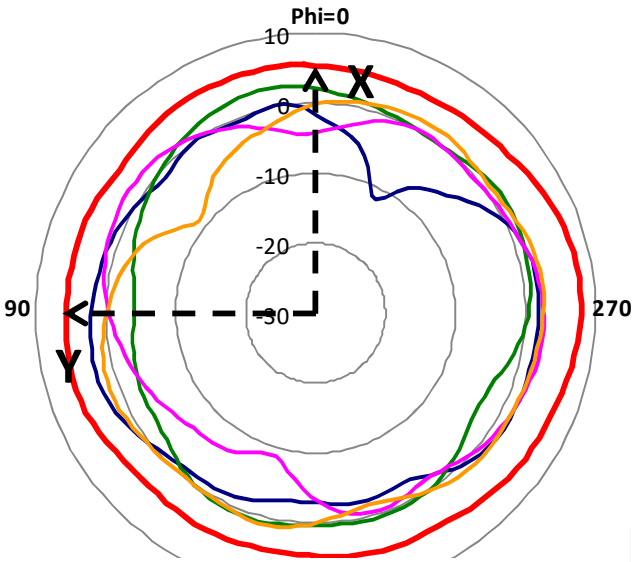
Directional Gain
2G1
2G2
2G3
2G4



XZ-cut

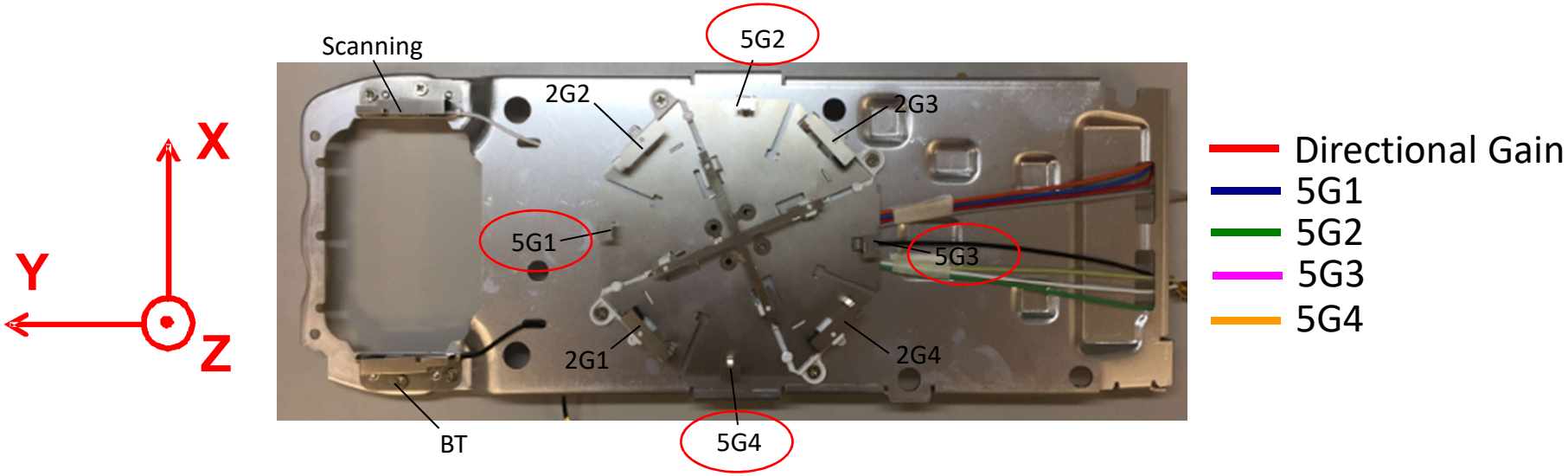


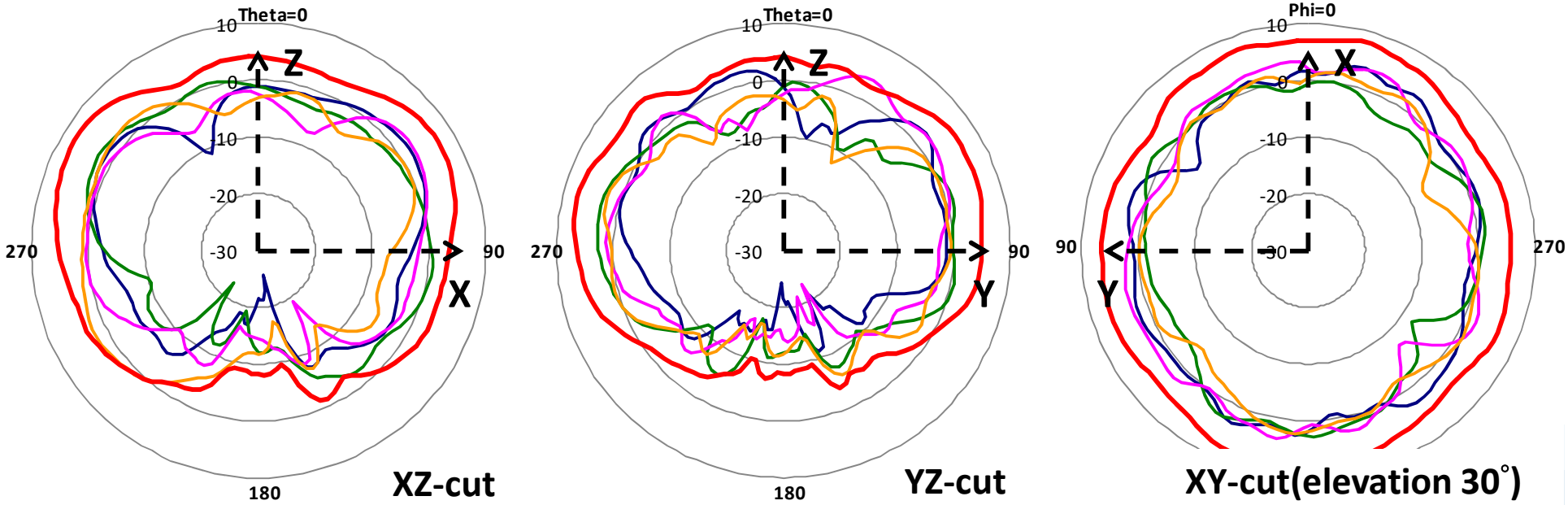
YZ-cut



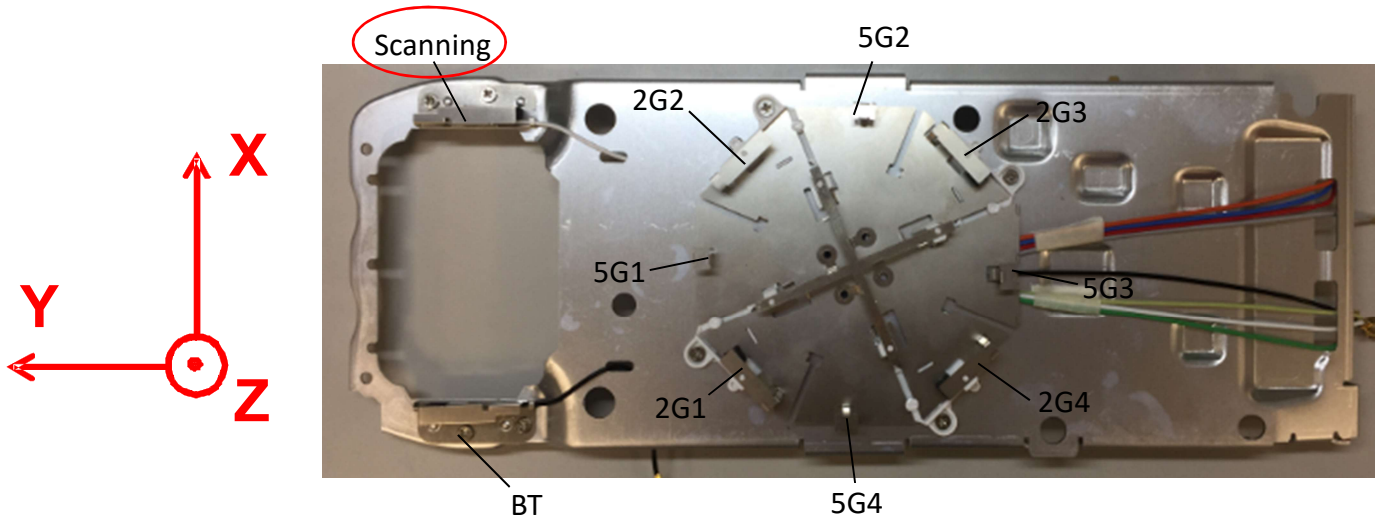
XY-cut(elevation 30°)

Radiation Pattern for 5G

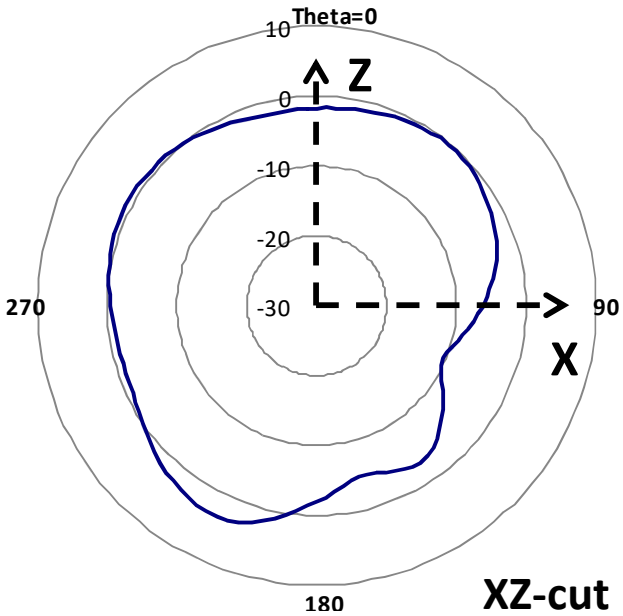




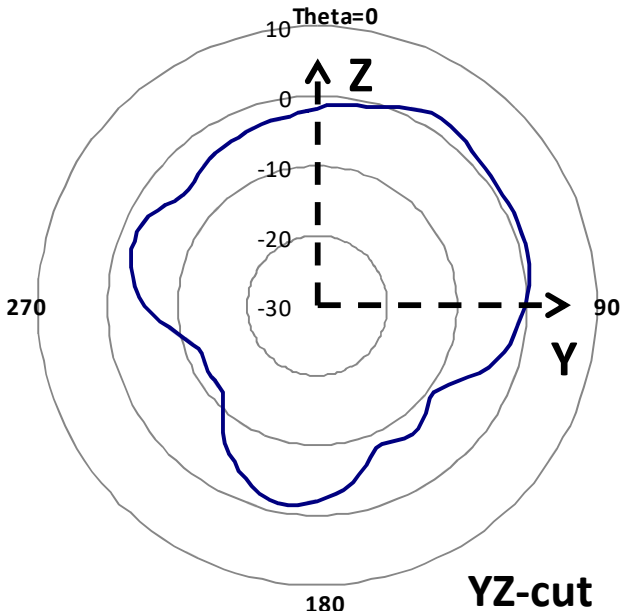
Radiation Pattern for Scanning @ 2.4G



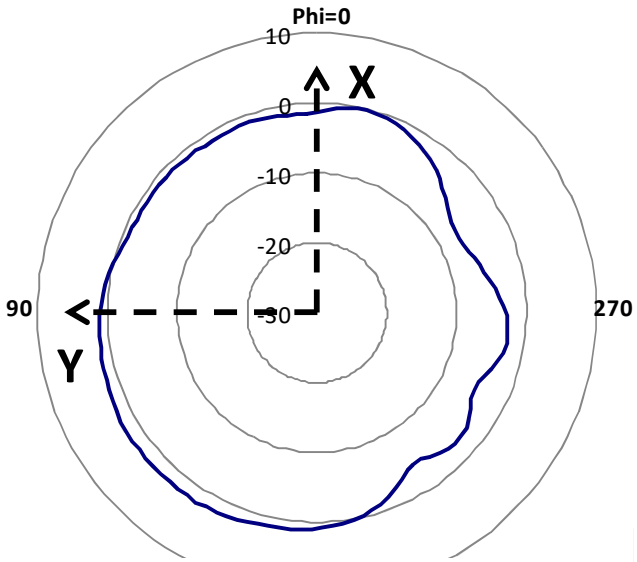
Scanning



XZ-cut

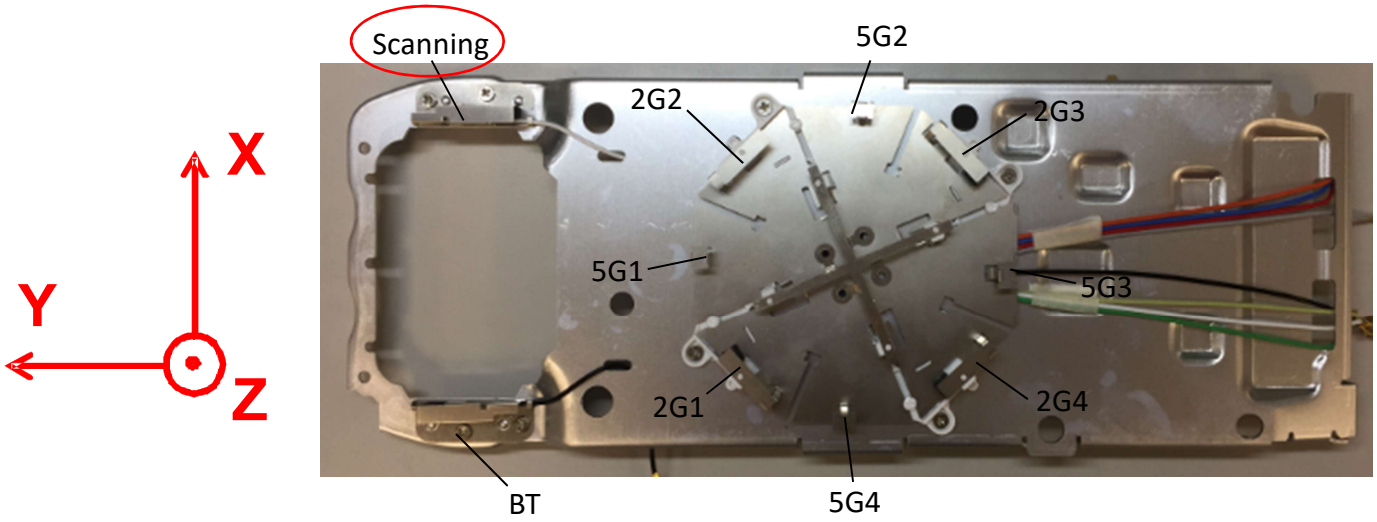


YZ-cut

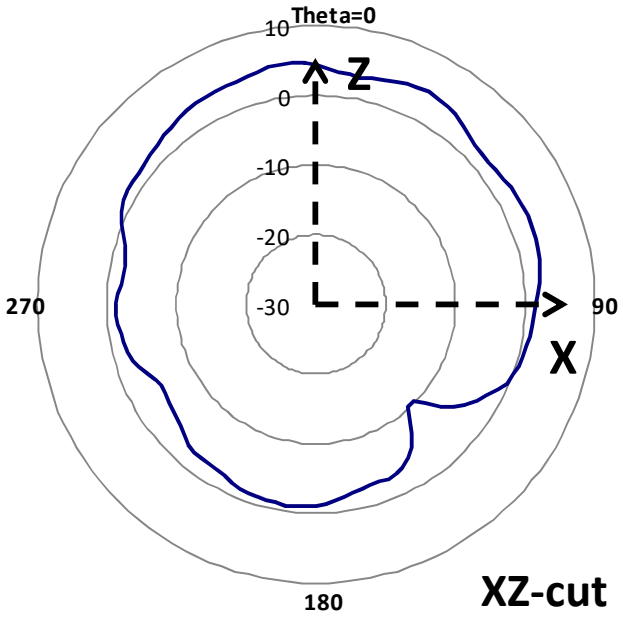


XY-cut(elevation 30°)

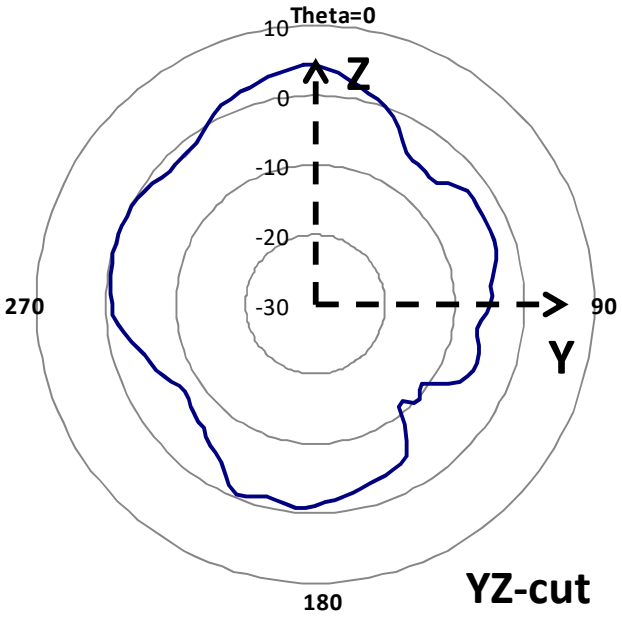
Radiation Pattern for Scanning @ 5G



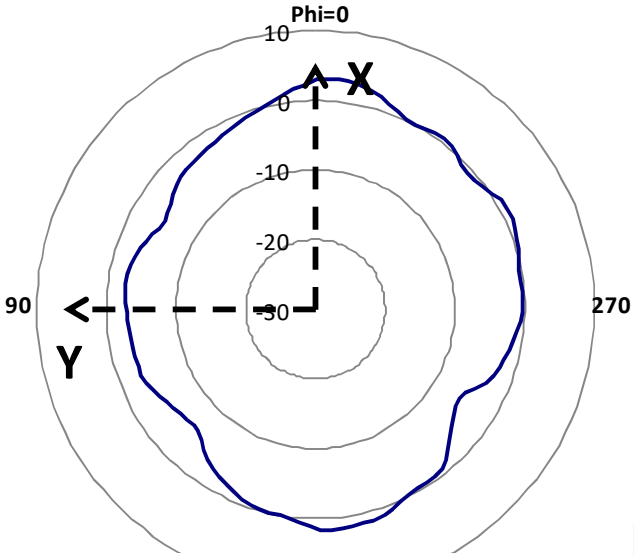
Scanning



XZ-cut

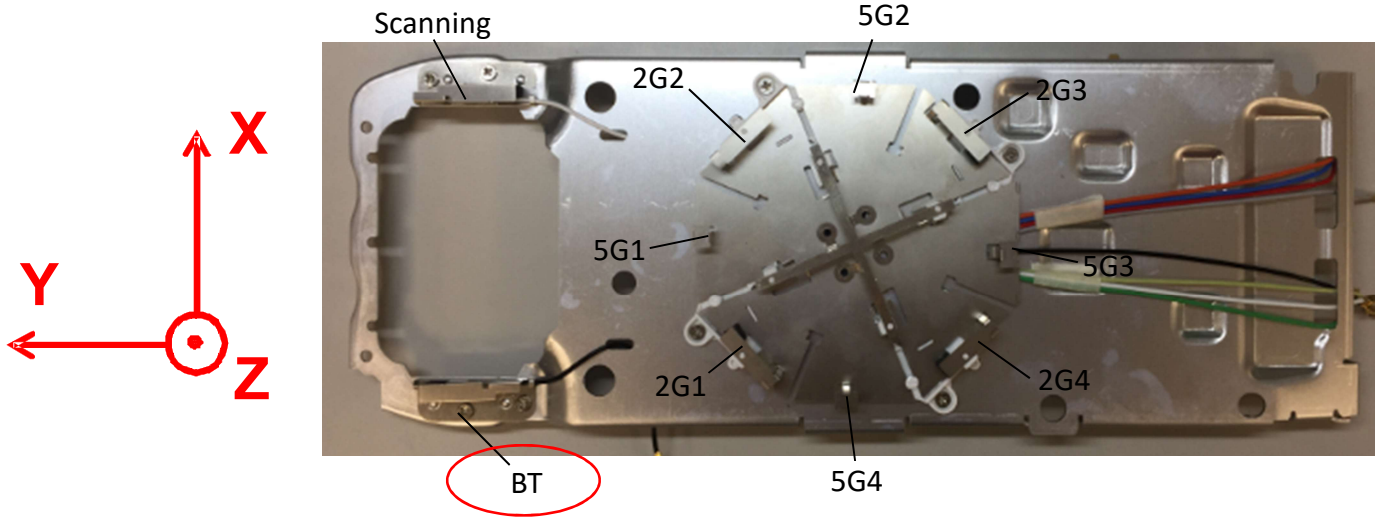


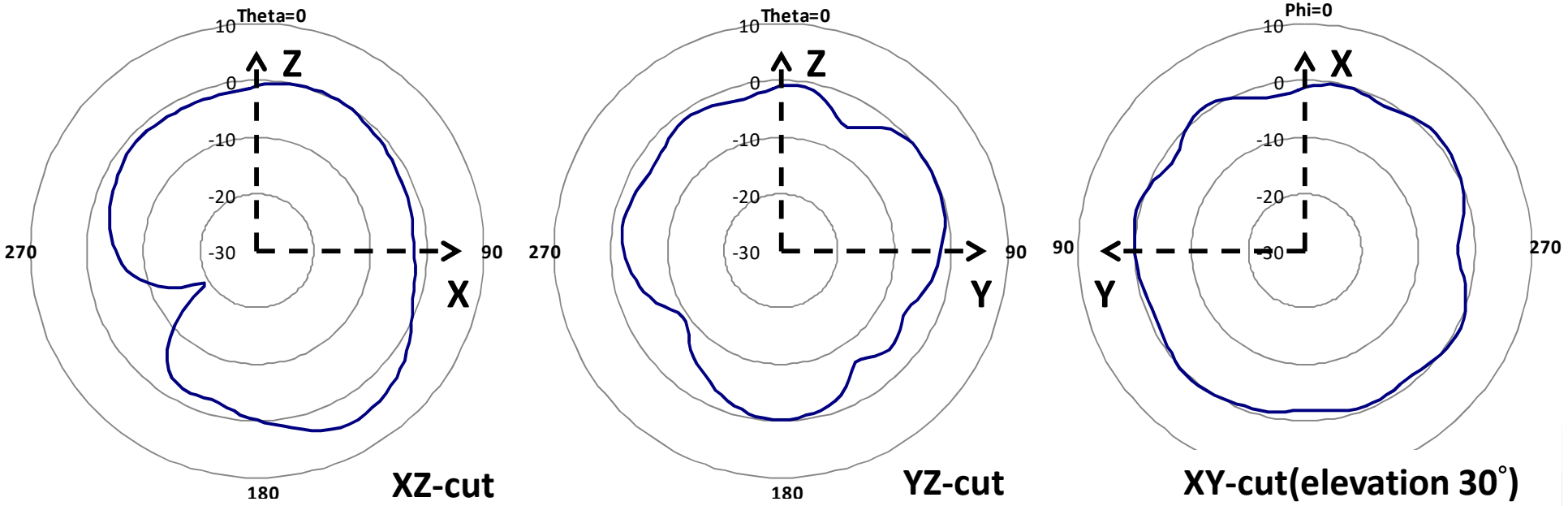
YZ-cut



XY-cut(elevation 30°)

Radiation Pattern for BT





WNC

Wistron NeWeb Corp.