



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



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General Information

■ Antenna Information:

- Brand: WNC

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

■ Antenna Type:

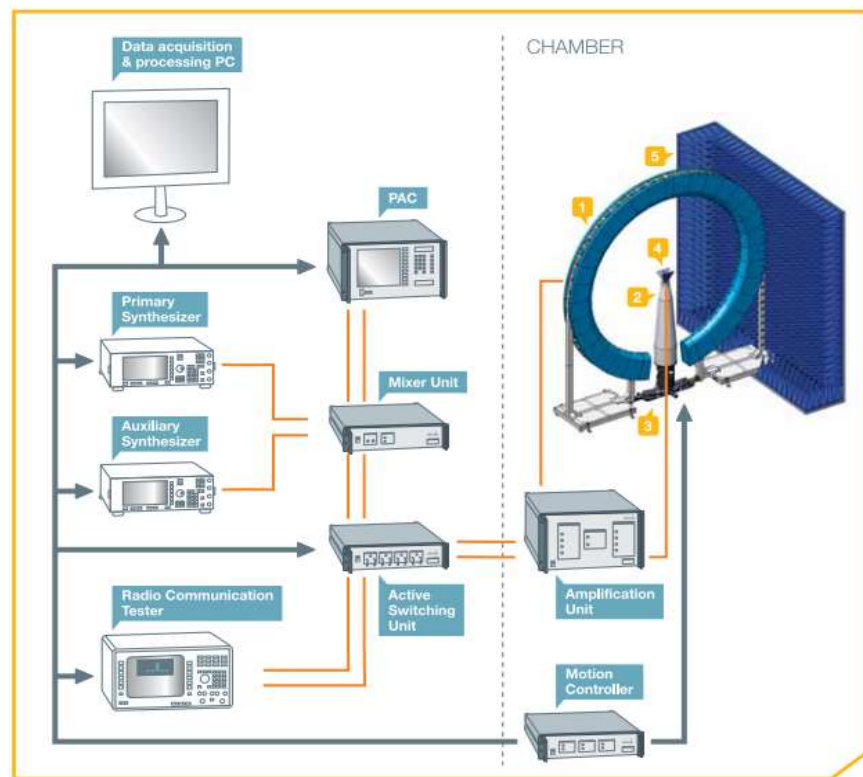
- Wi-Fi 2.4G: PIFA (M/N:95XKAA15.GKJ)
- Wi-Fi 5G: PIFA (M/N:95XKAA15.GKJ)
- BLE: PIFA (M/N:95XKAA15.GKL)
- Scanning: PIFA (M/N:95XKAA15.GKK)

■ 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
Active 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 Swtting 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

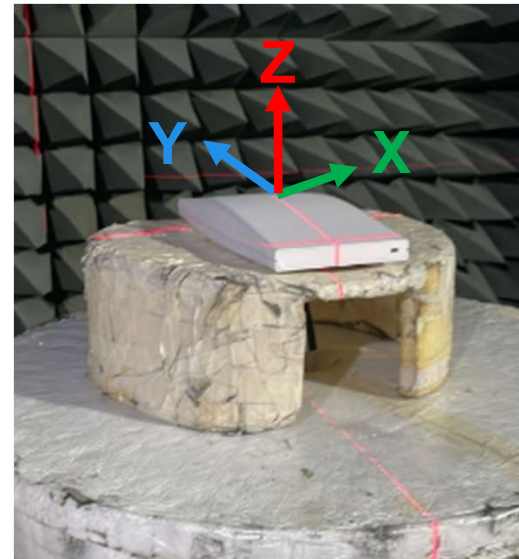
Note:

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*

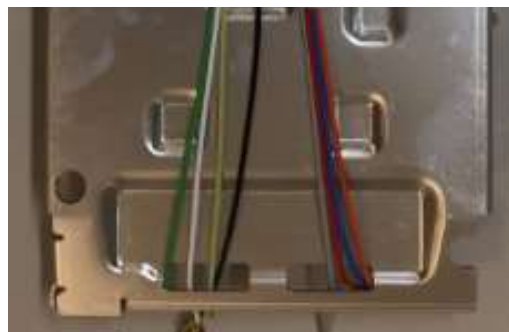
- **Peak gain**

- *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



2G1

Scanning

5G1

2G2

5G4

5G2

2G4

2G3

5G3

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= $10\log[(10^{\frac{G_1}{20}} + 10^{\frac{G_2}{20}} + \dots + 10^{\frac{G_n}{20}})^2 / N_{ant}] \text{ dBi}$

- If All Transmit Signals Are Completely Uncorrelated:

- Directional Gain= $10\log[(10^{\frac{G_1}{10}} + 10^{\frac{G_2}{10}} + \dots + 10^{\frac{G_n}{10}}) / N_{ant}] \text{ dBi}$

N_{ant} : Number of Transmit Antennas

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

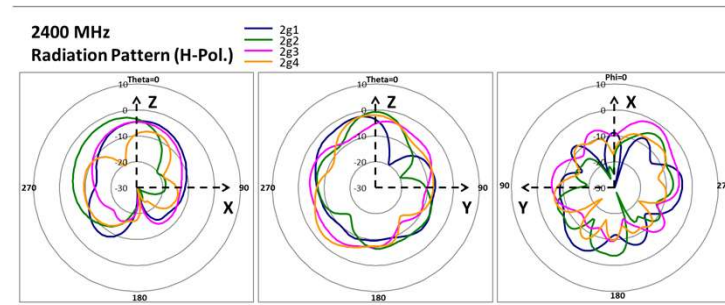
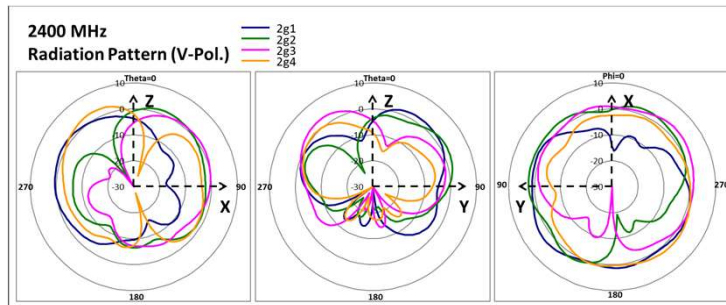
April 13, 2016

TCB Workshop

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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:

$$\text{Directional Gain} = 10\log\left[\frac{G_1^2 + G_2^2 + \dots + G_n^2}{N_{ant}}\right] \text{ dBi}$$

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	

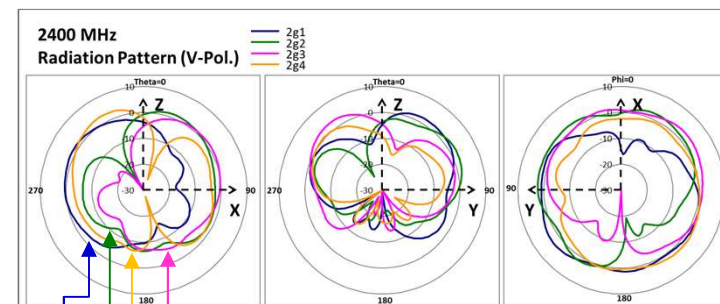
Max. directional gain in XZ cut

● If All Transmit Signals Are Completely Uncorrelated:

$$\text{Directional Gain} = 10\log\left[\frac{G_1 + G_2 + \dots + G_n}{N_{ant}}\right] \text{ dBi}$$



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

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

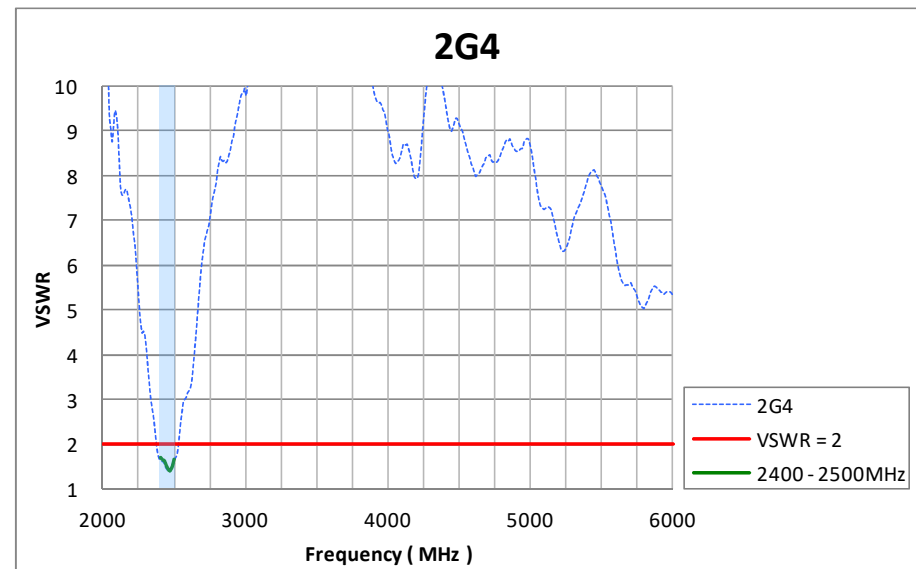
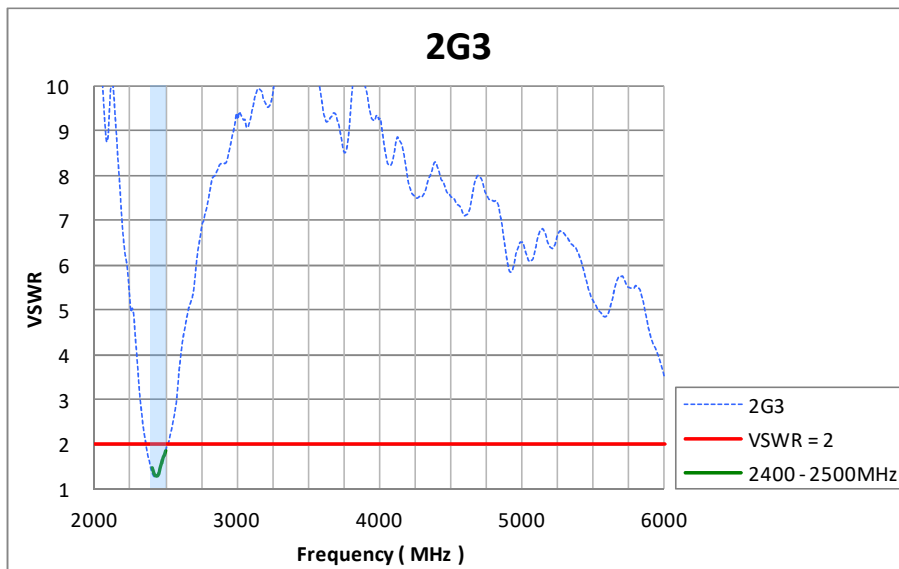
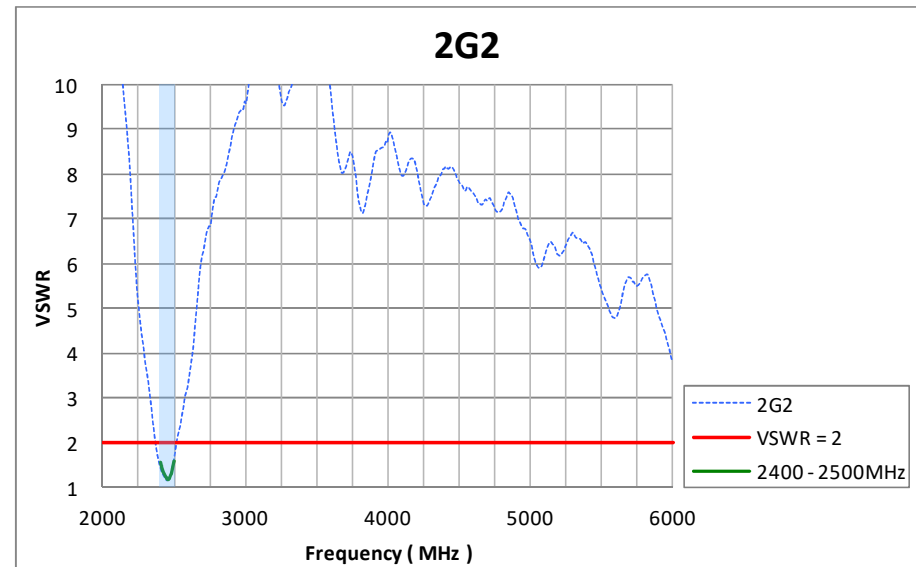
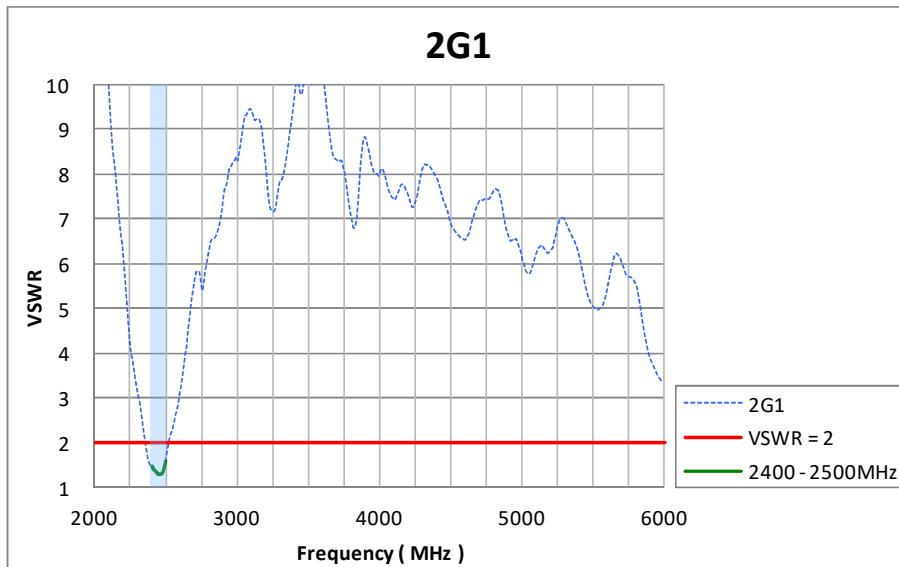
Antenna Composite gain

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

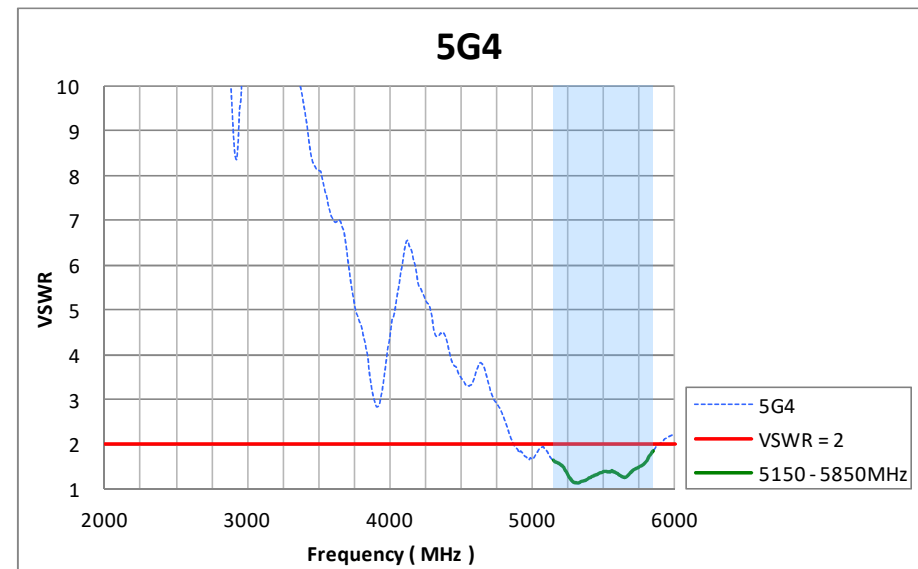
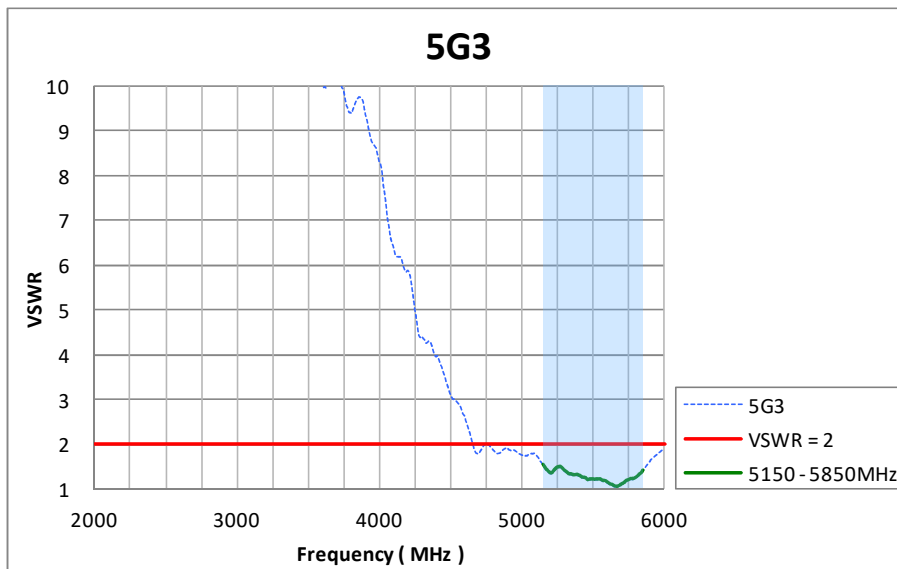
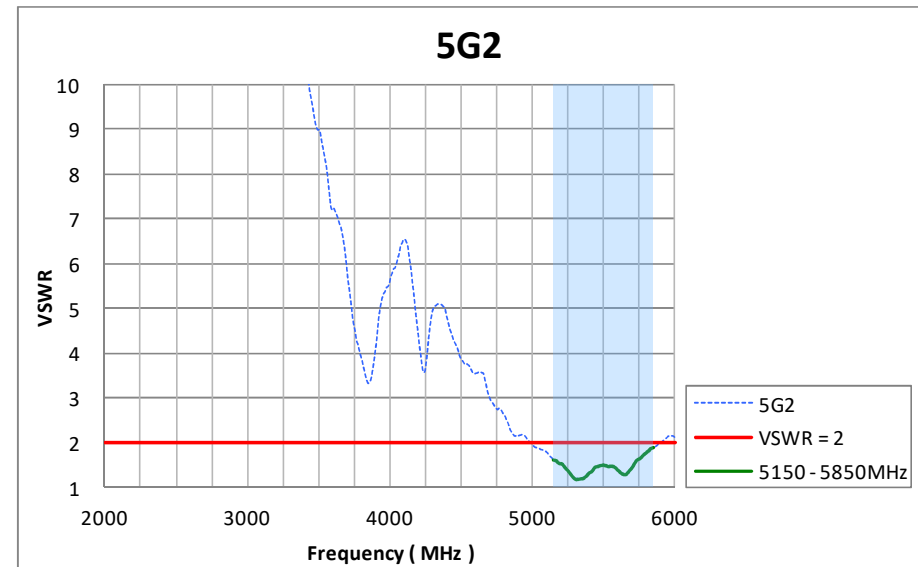
Single – 5G 2x2	Composite Gain	5150	5350	5550	5750	5850
2-4	Correlated	5.73	6.26	6.36	5.88	5.48
	Un-Correlated	2.73	3.28	3.36	2.99	2.63

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

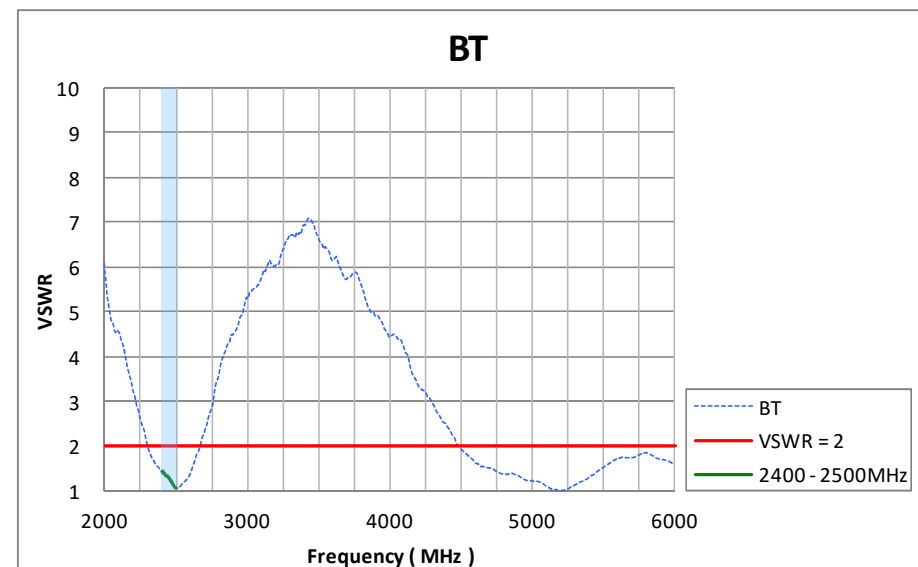
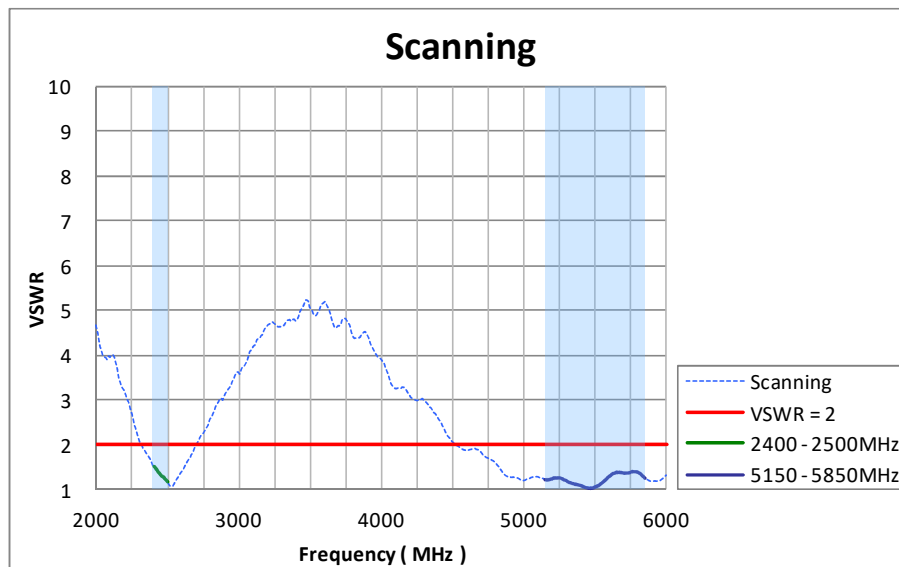
VSWR for 2G



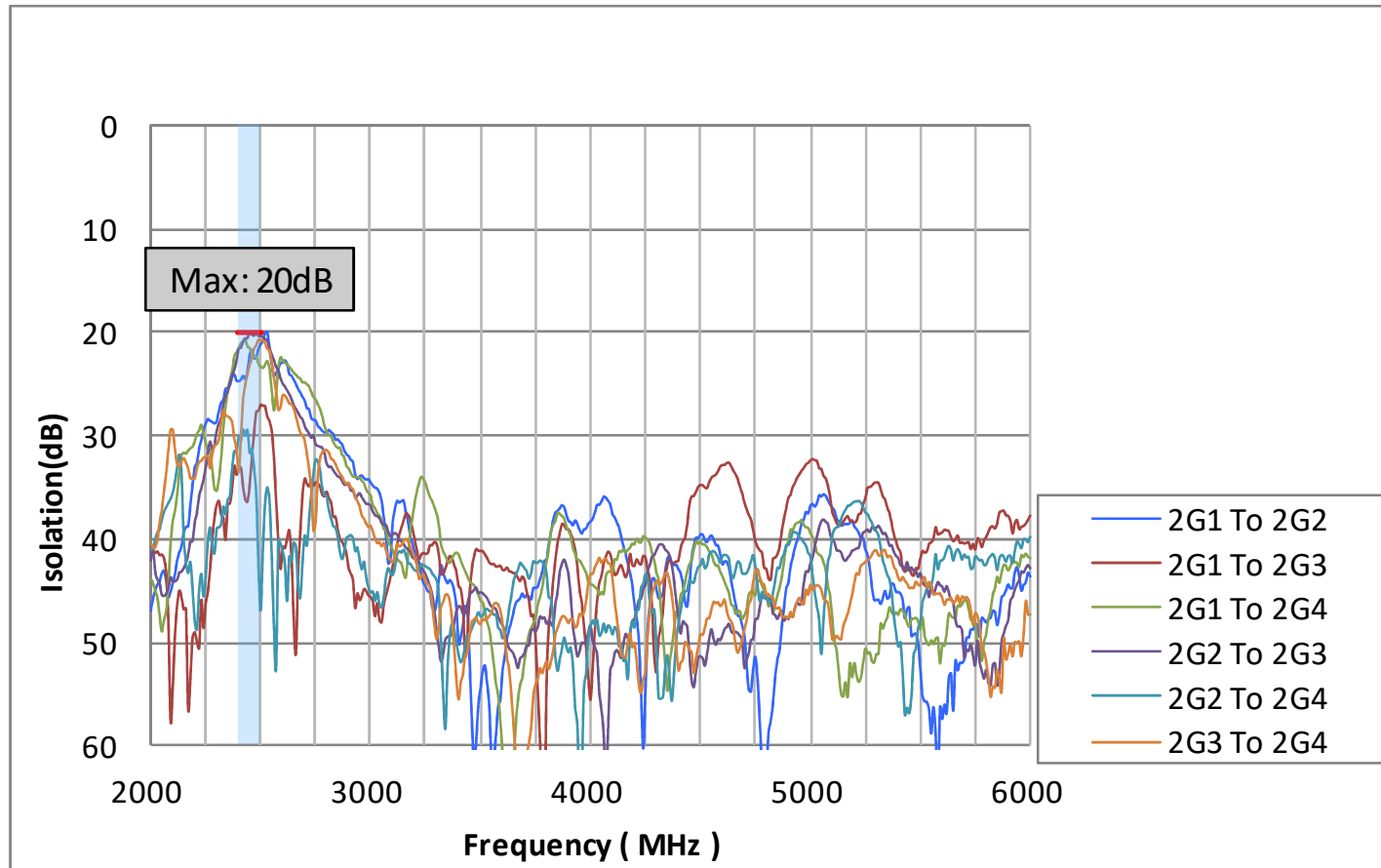
VSWR for 5G



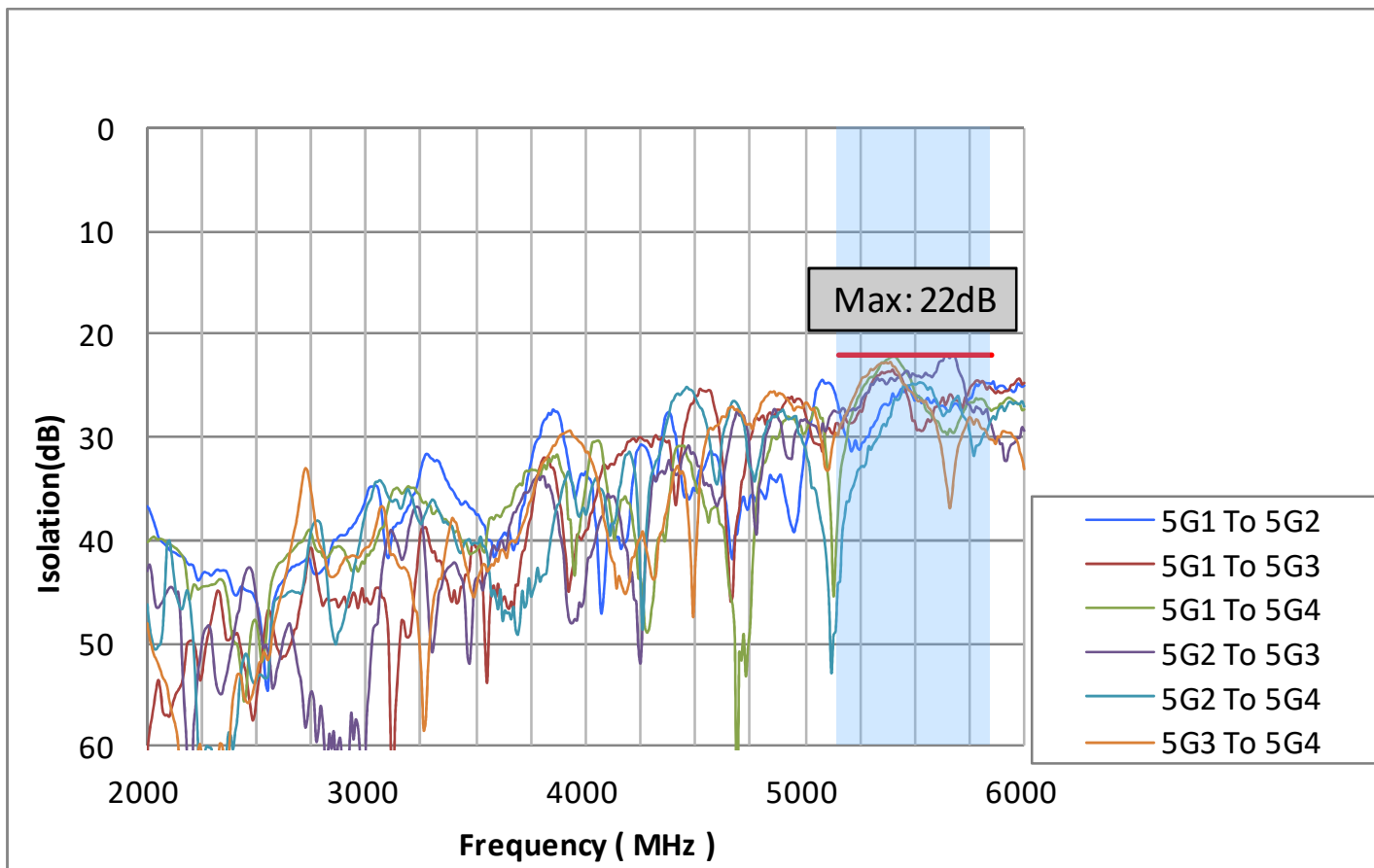
VSWR for Scanning / BT



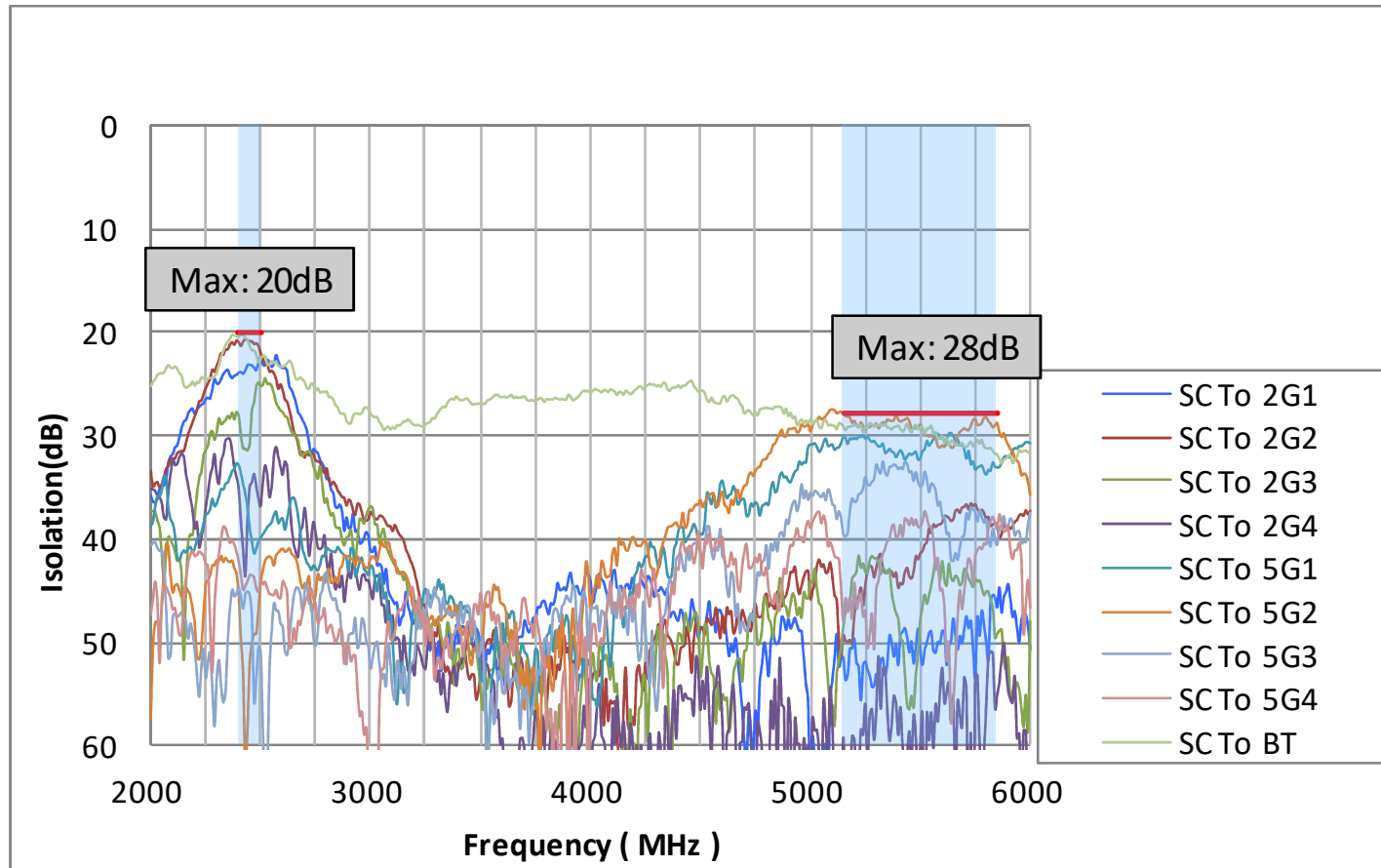
Isolation for 2G ANTs



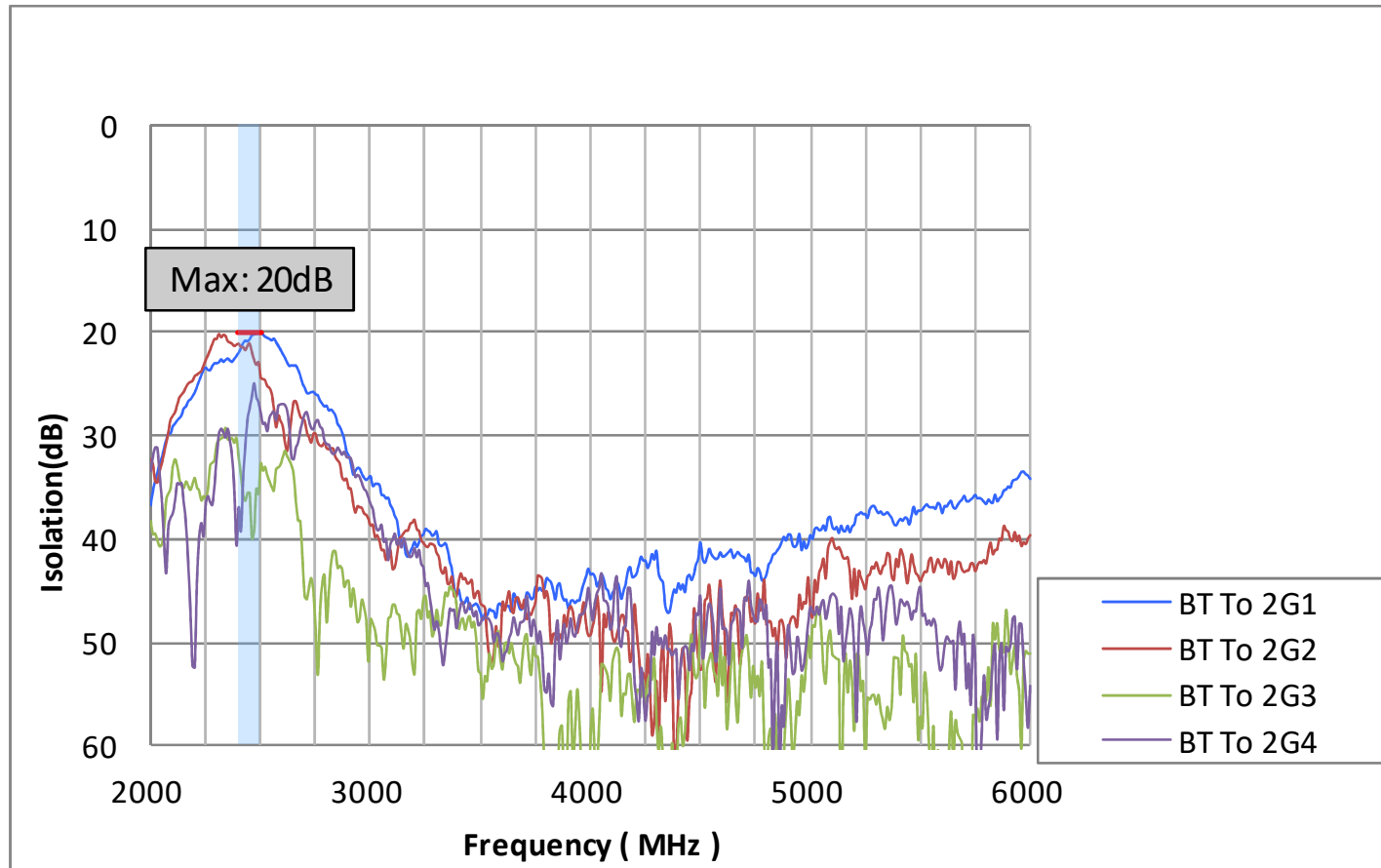
Isolation for 5G ANTs



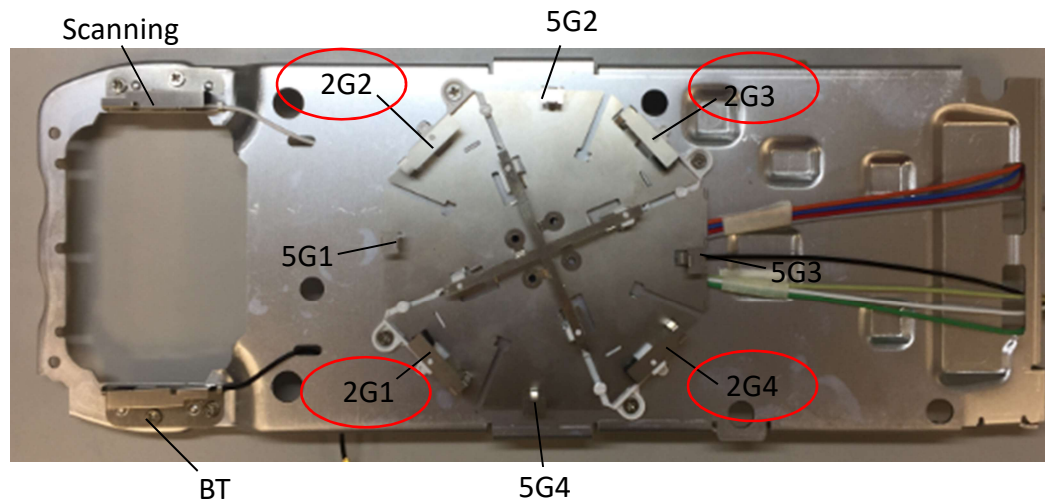
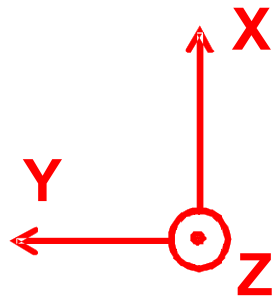
Isolation for Scanning to others



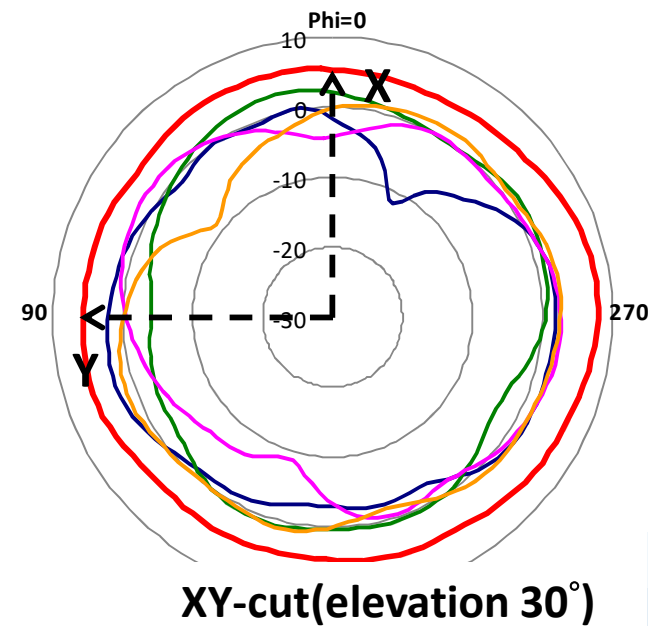
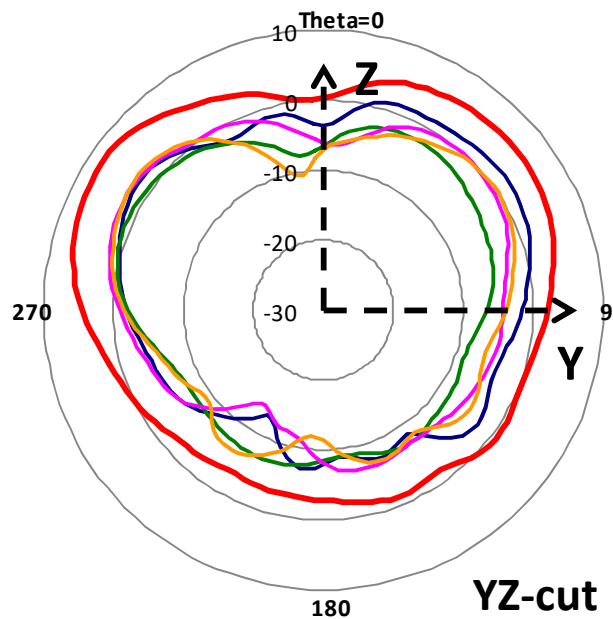
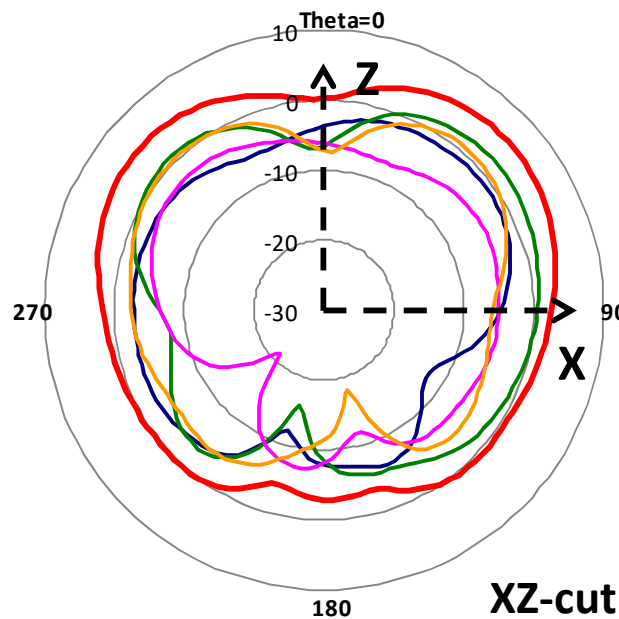
Isolation for BT to others



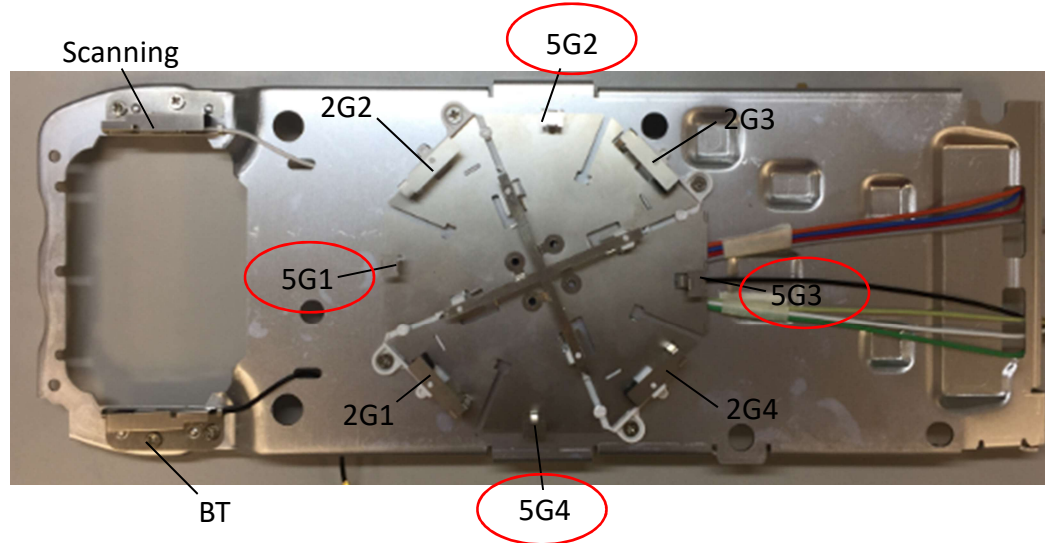
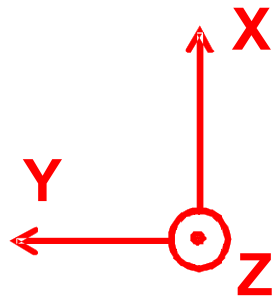
Radiation Pattern for 2.4G



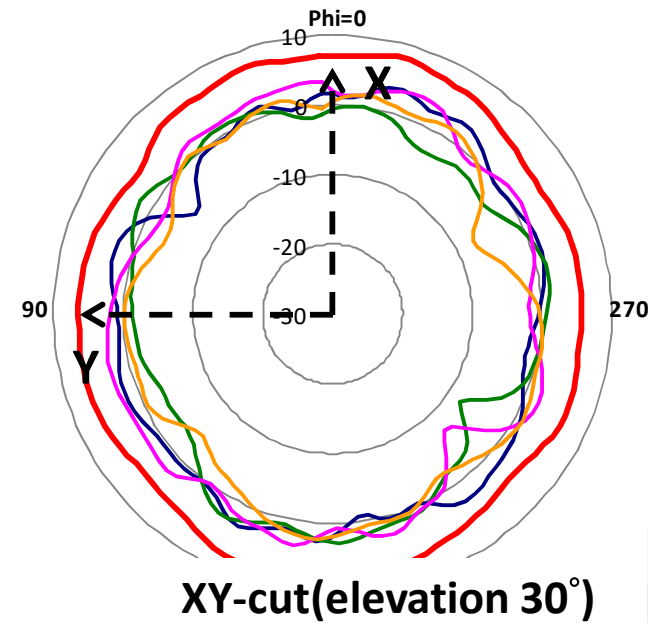
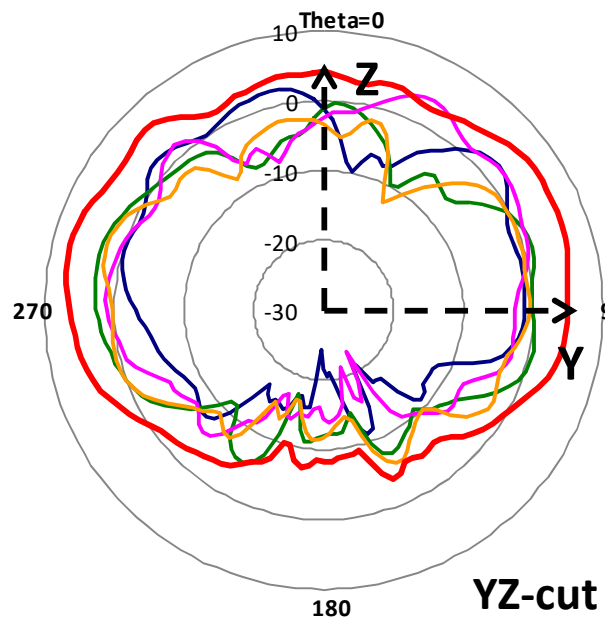
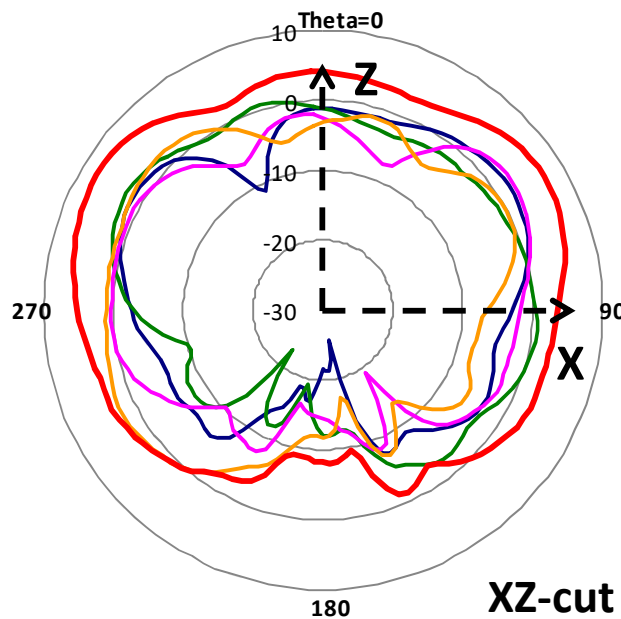
- Directional Gain
- 2G1
- 2G2
- 2G3
- 2G4



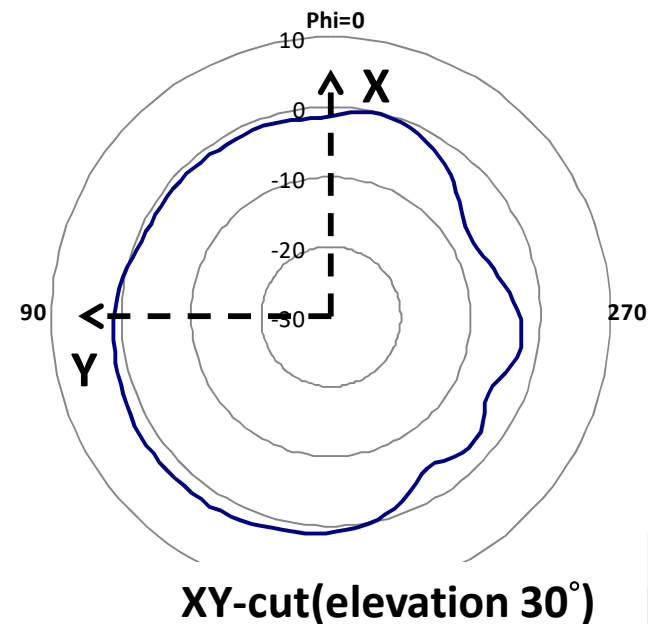
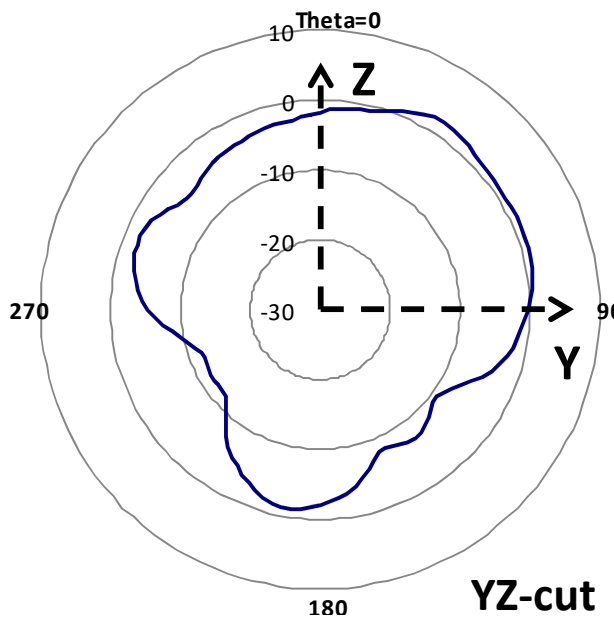
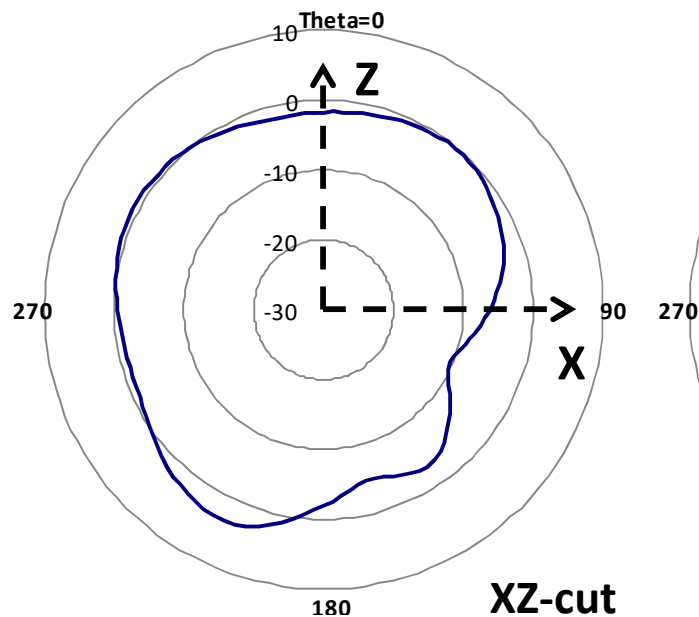
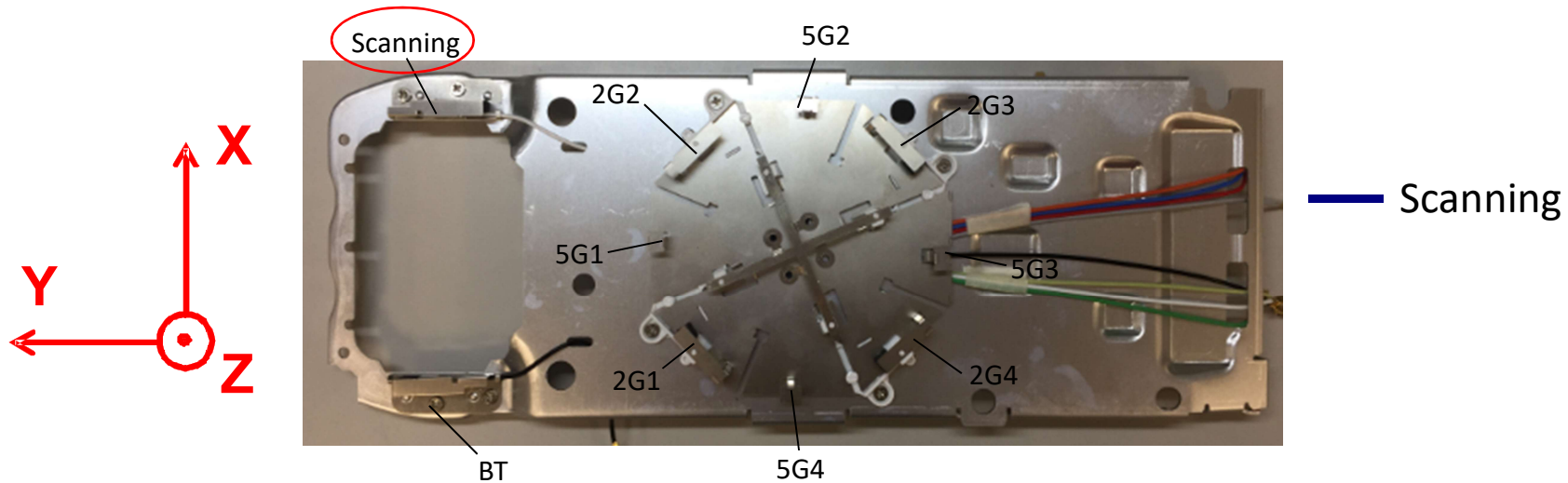
Radiation Pattern for 5G



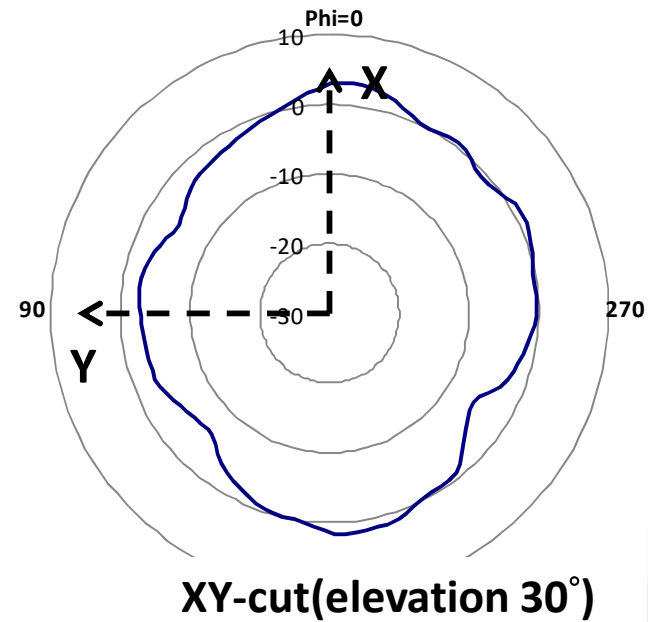
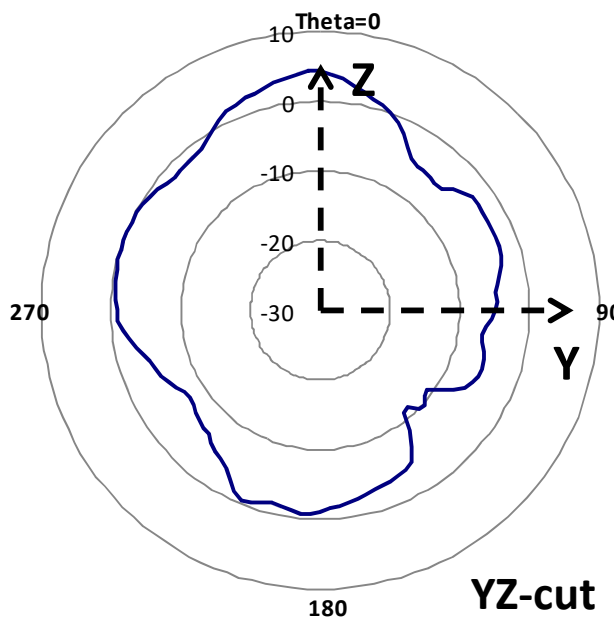
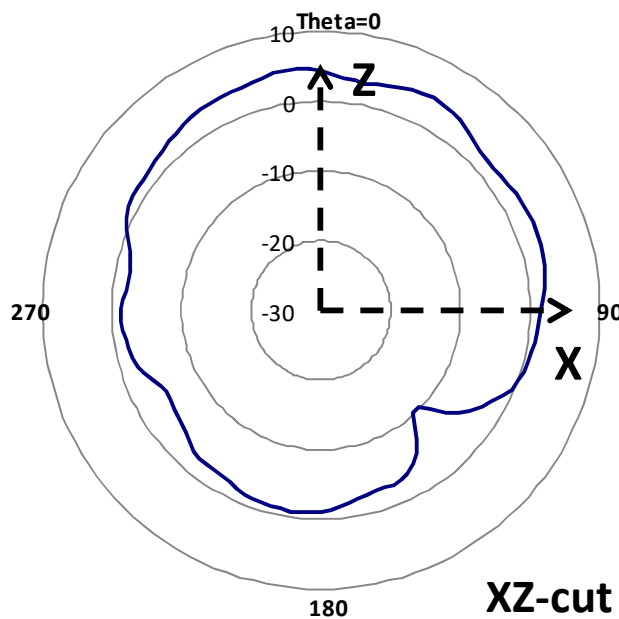
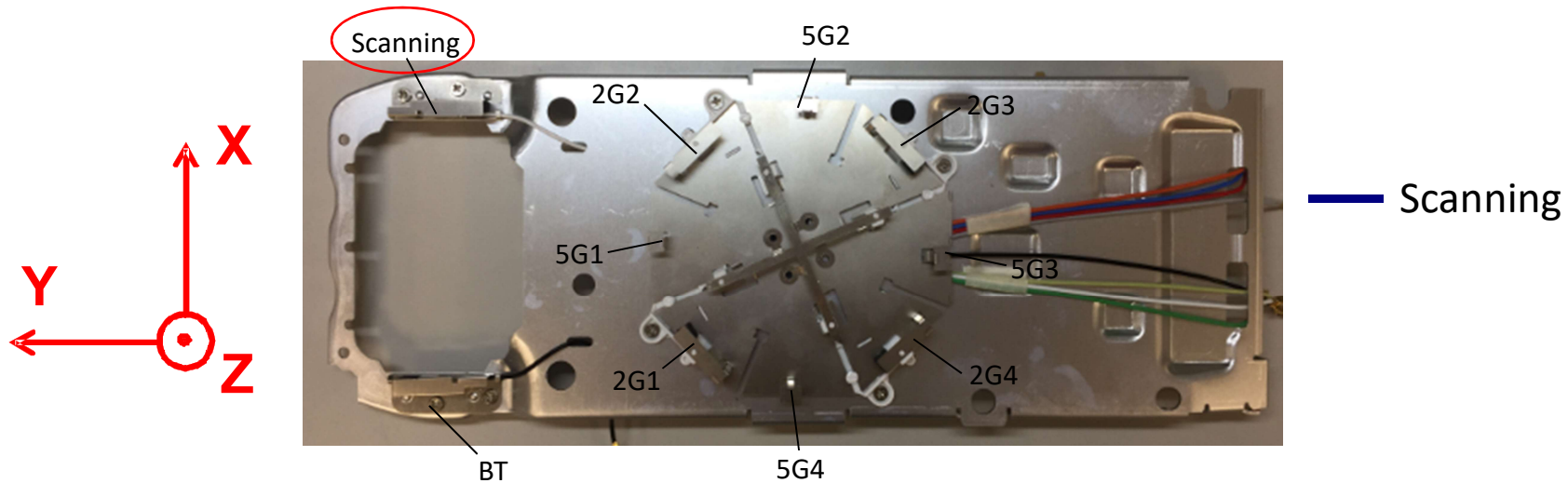
- Directional Gain
- 5G1
- 5G2
- 5G3
- 5G4



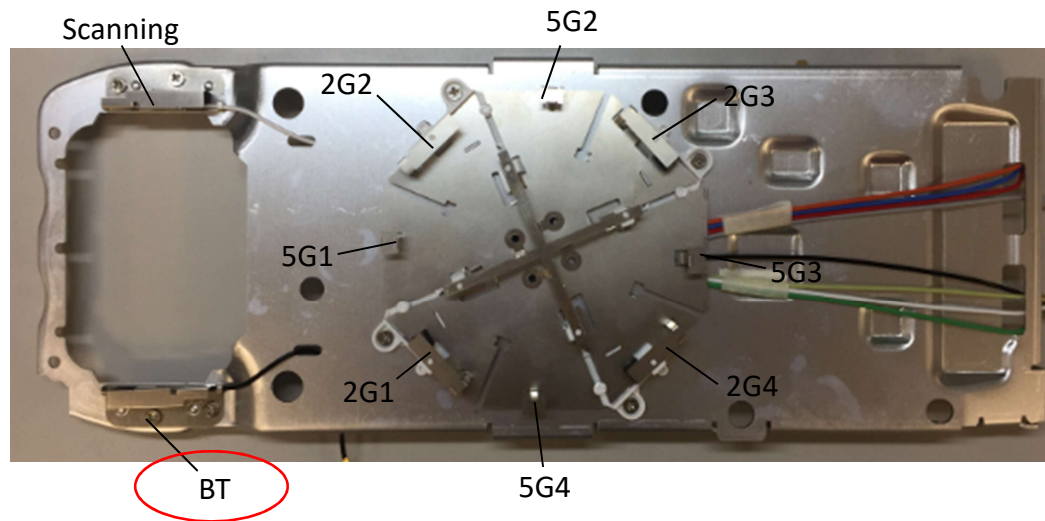
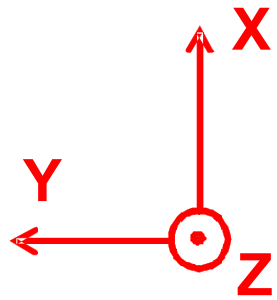
Radiation Pattern for Scanning @ 2.4G



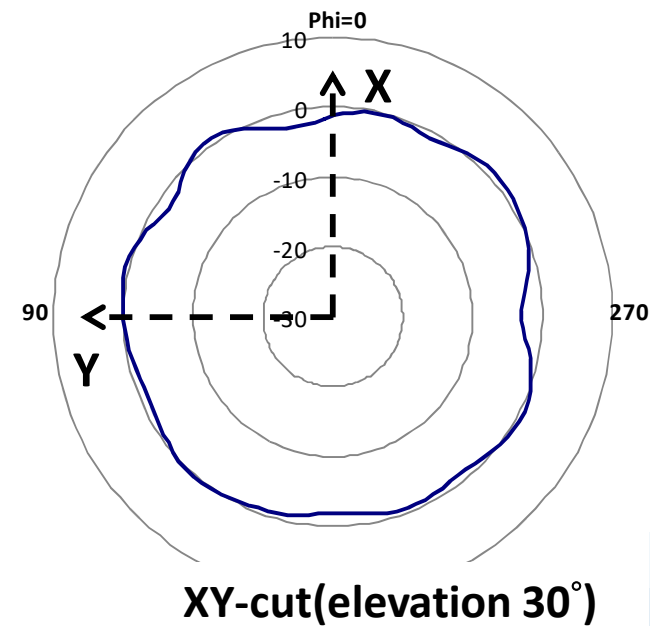
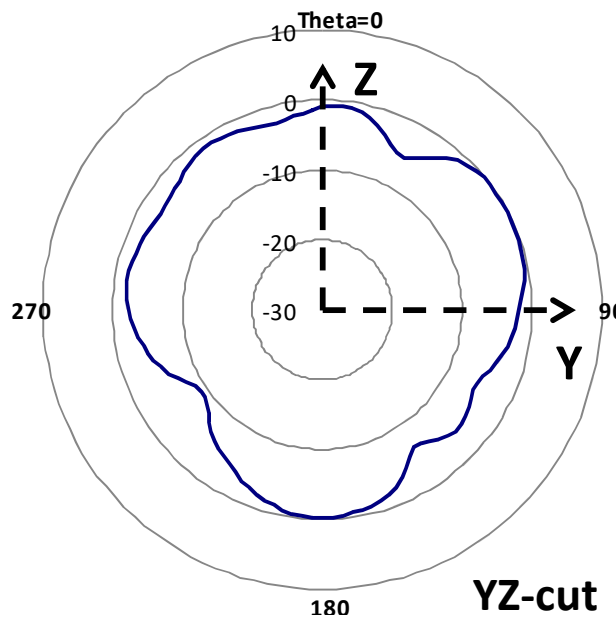
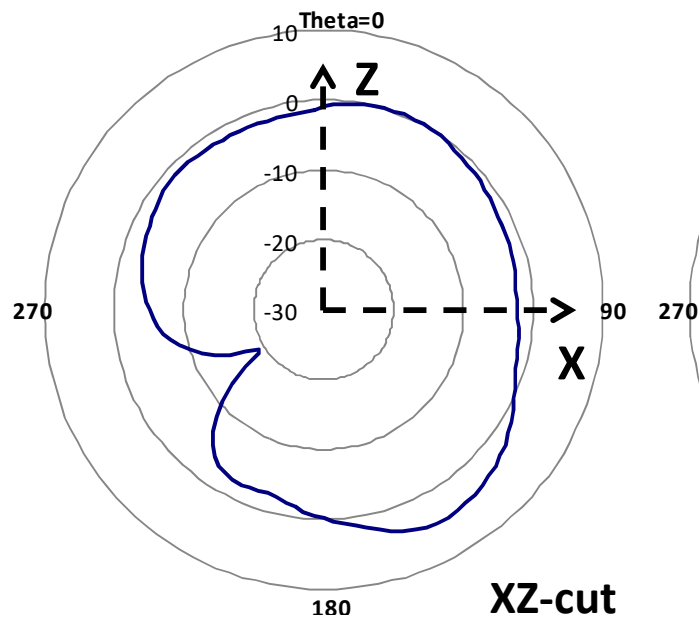
Radiation Pattern for Scanning @ 5G



Radiation Pattern for BT



— BT



WNC

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