Antenna Test Report for 8x8 Wi-Fi 6 AP
(M/N:MR56-HW)

Wistron NeWeb Corp.

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Contents

General Information

- **Antenna Information:**

  \- Brand: WNC

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

- **Antenna Type:**
  - **Wi-Fi 2/5G: PIFA (95XKAA15.GJ1)**
  - **Wi-Fi 5G: PIFA (95XKAA15.GJ1)**
  - **BLE: PIFA (95XKAA15.GJ3)**
  - **Scanning: PIFA (95XKAA15.GJ2)**

- **Test Date and Member**

  Date: 2020/ 04/27

  Member: Gary

General Information

- **Radio information:**
  - **About 2.4G operation**
    - MR56 is 4 x 4 multiple input, multiple output (MIMO) with four spatial streams on 2.4 GHz.
    - And it offers MU-MIMO and OFDMA for more efficient transmission to multiple clients.
    - Supported modes are listed below:

2.4GHz Band		
MODULATION MODE	**TX & RX CONFIGURATION**	
802.11b	4TX	4RX
802.11g	4TX	4RX
802.11n (HT20)	4TX	4RX
802.11n (HT40)	4TX	4RX
VHT20	4TX	4RX
VHT40	4TX	4RX
802.11ax (HE20)	4TX	4RX
802.11ax (HE40)	4TX	4RX

Note:
1. All of modulation mode support beamforming function except 802.11b/g modulation mode.
2. The EUT support Beamforming and CDD mode, therefore both mode were investigated and the worst case scenario was identified. The worst case data were presented in test report.

- Note: The worst-case spatial stream configuration for 2.4G operation is N_{ss}=1.

General Information

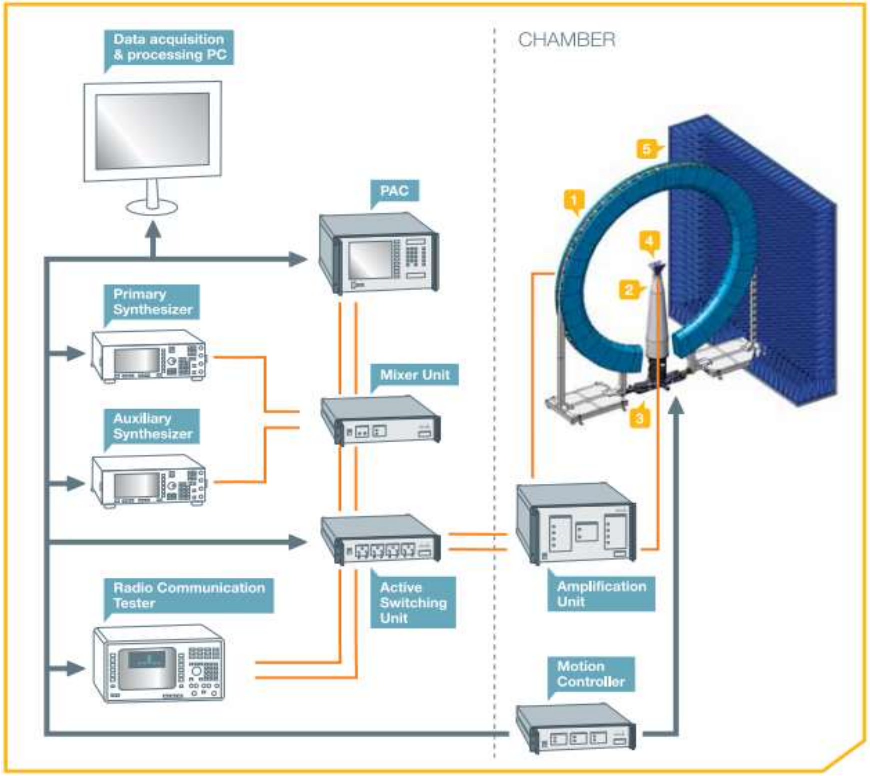
- **Radio information:**
  - **About 5G operation**
    - MR56 is 8 x 8 multiple input, multiple output (MIMO) with eight spatial streams on 5 GHz.
    - And it offers MU-MIMO and OFDMA for more efficient transmission to multiple clients.
    - Supported modes are listed below:

5GHz Band		
MODULATION MODE	**TX & RX CONFIGURATION**	
802.11a	8TX	8RX
802.11n (HT20)	8TX	8RX
802.11n (HT40)	8TX	8RX
802.11ac (VHT20)	8TX	8RX
802.11ac (VHT40)	8TX	8RX
802.11ac (VHT80)	8TX	8RX
802.11ac (VHT80+VHT80)	4TX+4TX	4RX +4RX
802.11ax (HE20)	8TX	8RX
802.11ax (HE40)	8TX	8RX
802.11ax (HE80)	8TX	8RX
802.11ax (HE80+HE80)	4TX+4TX	4RX +4RX

Note:
1. All of modulation mode support beamforming function except 802.11a modulation mode.
2. The EUT support Beamforming and Non-Beamforming mode, therefore both mode were investigated and the worst case scenario was identified. The worst case data were presented in test report.

- Note: The worst-case spatial stream configuration for 5G operation is N_{ss}=1.

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.

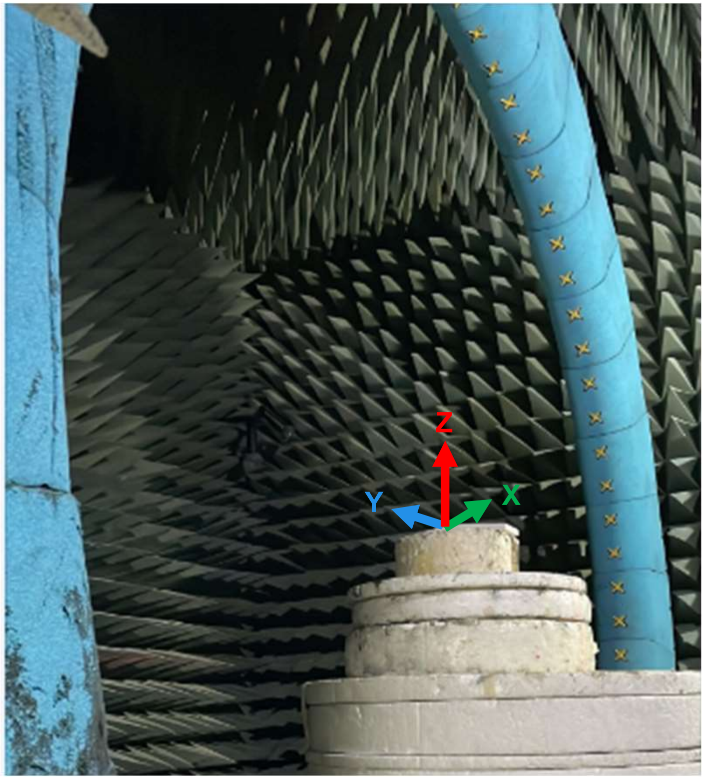
The NPAC includes the fastest and most accurate sources and receivers on the market.

Equipment

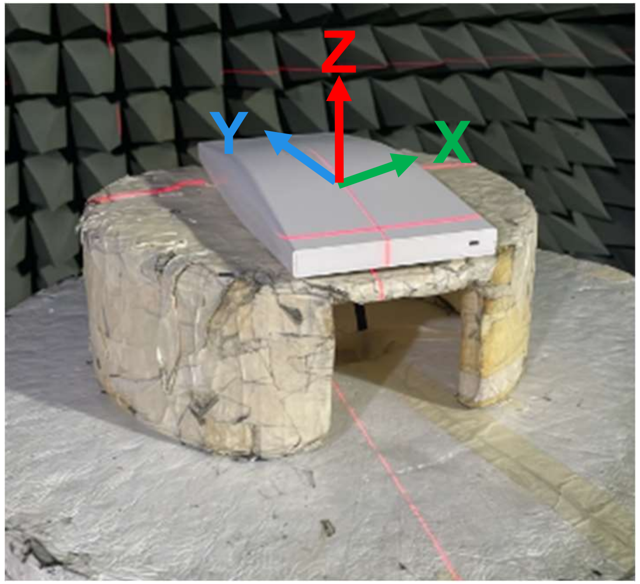
Device	Type/Model	Serial#	Manufacturer	Calibrated Date	Calibrated Until
SG64 Chamber	Standard	SG64	MVG	2020/03/30	2024/03/30
Turn Table	Customization	-	Machinery Dept.	2020/03/30	2024/03/30
New Probe Array Controller	N/A	1102341-4535	MVG	2020/03/30	2024/03/30
Power Supply Unit	N/A	1103211-13204	MVG	2020/03/30	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 **MR56-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*

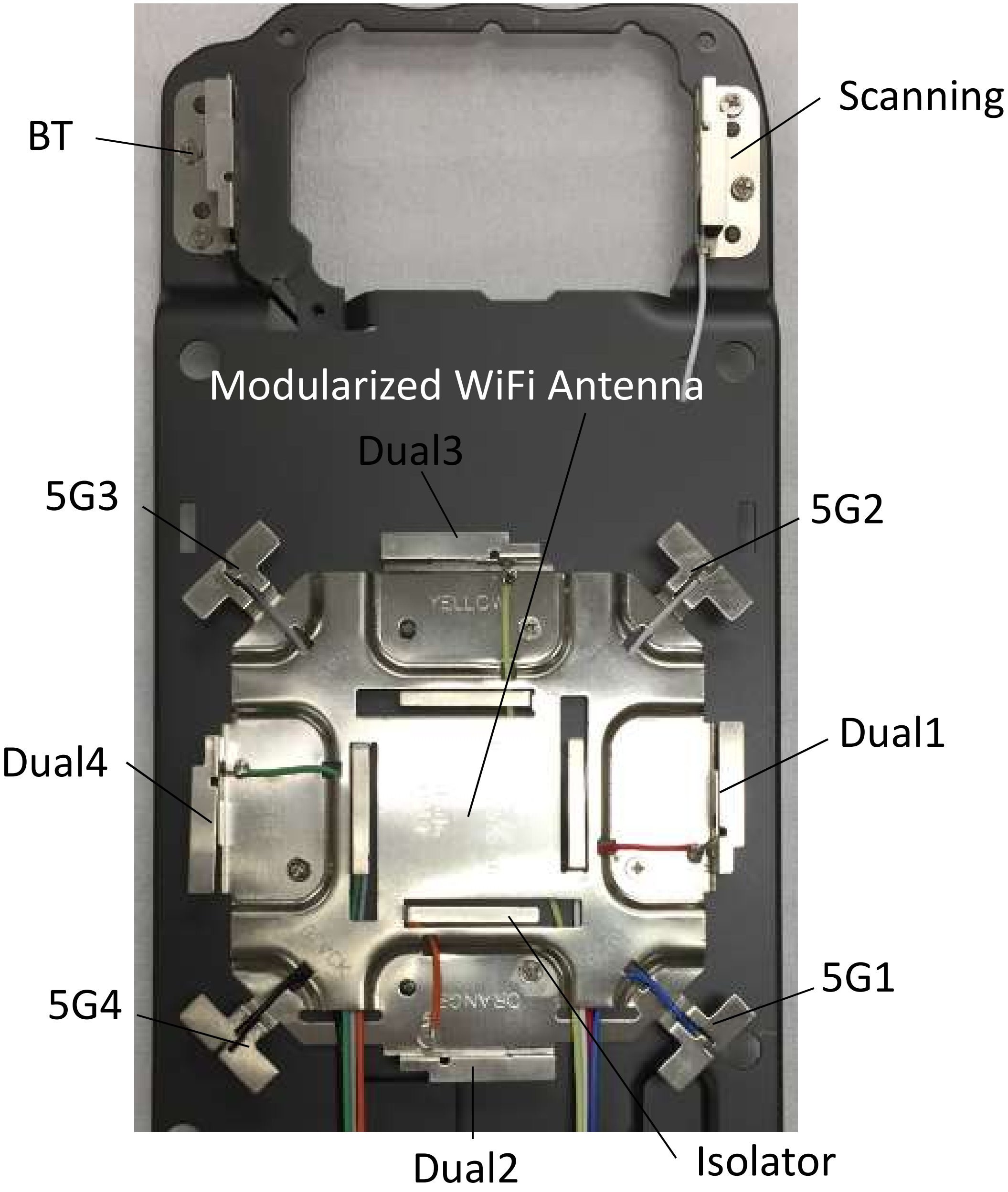
– ***Average Radiation efficiency (excluding cable length loss)***

- *70% for dual-band 2.4GHz antenna ; 81% for dual-band 5GHz antenna*
- *80% for 5GH antenna*
- *75% for Scanning 2.4GHz antenna ; 79% for Scanning 5GHz antenna*
- *68% for BT antenna*

– ***Peak gain***

- *5.5dBi for dual-band 2.4GHz antenna ; 6.4dBi for dual-band 5G antenna*
- *5.9dBi for 5GH antenna*
- *3.6dBi for Scanning 2.4GHz antenna ; 5.4dBi for Scanning 5G antenna*
- *3.6dBi for BT antenna*

Antenna Placement



WNC

Test Product Specification

Top cover

Main-Board


Chassis-Bottom


Bottom cover

Antenna Efficiency and Peak Gain

	Frequency (MHz)	2400	2450	2500	Avg.	5150	5350	5550	5750	5850	Avg.
Dual1	Eff. (%)	58%	64%	61%	61%	66%	69%	68%	68%	63%	67%
	Avg. Gain (dB)	-2.4	-1.95	-2.18		-1.79	-1.62	-1.67	-1.68	-2.01	
	w/o cable loss Eff. (%)	65%	72%	68%	69%	81%	84%	83%	83%	77%	81%
	Peak Gain (dBi)	4.64	5.44	5.28		4.88	5.45	5.54	5.87	5.50	
Dual2	Eff. (%)	59%	64%	62%	62%	62%	68%	63%	69%	66%	66%
	Avg. Gain (dB)	-2.28	-1.91	-2.07		-2.07	-1.68	-2	-1.59	-1.81	
	w/o cable loss Eff. (%)	67%	72%	70%	70%	75%	82%	77%	84%	80%	80%
	Peak Gain (dBi)	4.09	4.48	4.67		6.20	6.44	5.69	6.39	5.74	
Dual3	Eff. (%)	61%	65%	60%	62%	63%	69%	65%	68%	66%	66%
	Avg. Gain (dB)	-2.12	-1.84	-2.19		-2	-1.62	-1.88	-1.69	-1.78	
	w/o cable loss Eff. (%)	70%	75%	69%	71%	79%	86%	81%	85%	83%	83%
	Peak Gain (dBi)	4.90	4.63	4.82		5.18	5.94	5.34	5.58	5.38	
Dual4	Eff. (%)	58%	65%	59%	61%	72%	69%	63%	63%	61%	65%
	Avg. Gain (dB)	-2.36	-1.89	-2.29		-1.45	-1.62	-1.99	-2.01	-2.16	
	w/o cable loss Eff. (%)	66%	73%	67%	69%	88%	84%	77%	77%	74%	80%
	Peak Gain (dBi)	4.10	5.01	5.54		5.25	5.50	4.27	5.16	4.79	

Antenna Efficiency and Peak Gain

	Frequency (MHz)	5150	5350	5550	5750	5850	Avg.
5G1	Eff. (%)	69%	69%	64%	60%	64%	65%
	Avg. Gain (dB)	-1.6	-1.62	-1.93	-2.21	-1.92	
	w/o cable loss Eff. (%)	82%	82%	76%	71%	76%	78%
	Peak Gain (dBi)	5.35	5.28	4.96	5.40	5.66	
5G2	Eff. (%)	65%	69%	62%	68%	64%	66%
	Avg. Gain (dB)	-1.86	-1.58	-2.06	-1.68	-1.96	
	w/o cable loss Eff. (%)	82%	88%	79%	86%	81%	83%
	Peak Gain (dBi)	5.95	5.81	5.29	5.57	5.08	
5G3	Eff. (%)	58%	67%	67%	60%	61%	63%
	Avg. Gain (dB)	-2.35	-1.76	-1.73	-2.19	-2.18	
	w/o cable loss Eff. (%)	74%	85%	85%	77%	77%	79%
	Peak Gain (dBi)	4.65	5.40	4.92	4.27	4.24	
5G4	Eff. (%)	66%	65%	67%	72%	68%	68%
	Avg. Gain (dB)	-1.80	-1.89	-1.76	-1.41	-1.67	
	w/o cable loss Eff. (%)	78%	77%	79%	86%	81%	80%
	Peak Gain (dBi)	5.67	5.19	5.80	5.70	5.50	

Antenna Efficiency and Peak Gain

	Frequency (MHz)	2400	2450	2500	Avg.	5150	5350	5550	5750	5850	Avg.
Scanning	Eff. (%)	63%	71%	69%	68%	69%	67%	64%	69%	66%	67%
	Avg. Gain (dB)	-2.03	-1.51	-1.63		-1.62	-1.73	-1.93	-1.63	-1.81	
	w/o cable loss Eff. (%)	69%	78%	76%	75%	81%	79%	76%	81%	78%	79%
	Peak Gain (dBi)	3.18	3.69	3.10		5.43	4.97	4.71	5.01	4.72	

	Frequency (MHz)	2400	2450	2500	Avg.
BT	Eff. (%)	64%	67%	67%	66%
	Avg. Gain (dB)	-1.95	-1.77	-1.76	
	w/o cable loss Eff. (%)	66%	69%	69%	68%
	Peak Gain (dBi)	3.51	3.58	3.61	

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

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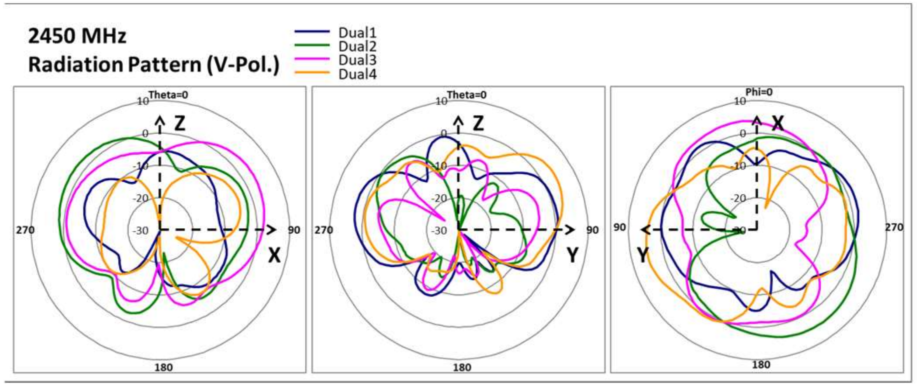
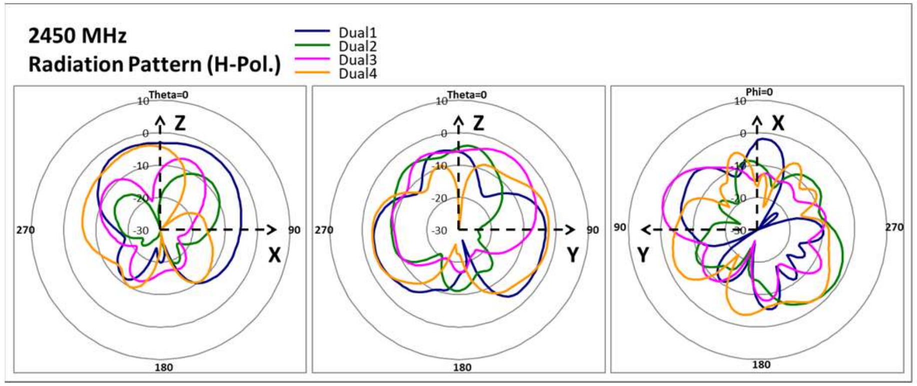
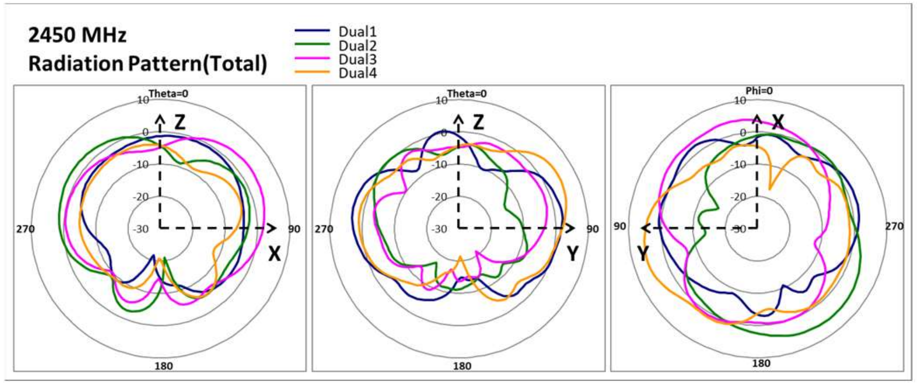
Antenna Composite gain- data calculated explain

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



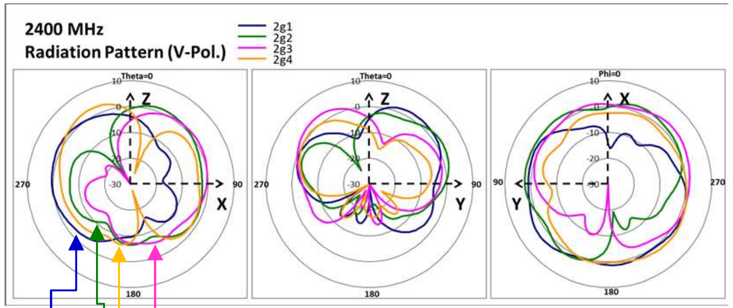




Antenna Composite gain- data calculated explain

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

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

Using same calculation method output XZ, YZ and XY cut in v-pol. , h-pol. and total 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
Dual1	Total	PeakGain	-2.67	-0.78	-1.02
Dual2	Total	PeakGain	0.44	2.61	4.12
Dual3	Total	PeakGain	2.04	3.53	2.74
Dual4	Total	PeakGain	-0.64	-3.42	-2.48
Corr. Composite	Total	Peak Gain	5.37	5.46	5.40
UnCorr. Composite	Total	Peak Gain	-0.44	-0.03	0.13

	YZ-plane	Frequency	2400	2450	2500
Dual1	Total	PeakGain	4.48	3.42	5.22
Dual2	Total	PeakGain	0.09	0.46	-0.93
Dual3	Total	PeakGain	-0.07	-1.76	-0.78
Dual4	Total	PeakGain	3.77	4.89	4.99
Corr. Composite	Total	Peak Gain	6.57	6.01	5.15
UnCorr. Composite	Total	Peak Gain	0.97	1.03	0.59

	XY-plane	Frequency	2400	2450	2500
Dual1	Total	PeakGain	3.36	2.19	3.99
Dual2	Total	PeakGain	4.09	5.70	4.40
Dual3	Total	PeakGain	4.90	4.15	4.82
Dual4	Total	PeakGain	3.67	5.57	5.08
Corr. Composite	Total	Peak Gain	5.99	6.53	6.26
UnCorr. Composite	Total	Peak Gain	0.72	1.44	1.09

Corr. Composite	Total	Peak Gain	6.57	6.53	6.26
UnCorr. Composite	Total	Peak Gain	0.97	1.44	1.09

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
5G1	Total	PeakGain	4.42	4.60	4.07	3.88	4.53
5G2	Total	PeakGain	5.26	5.65	4.99	5.18	4.69
5G3	Total	PeakGain	4.71	5.31	4.70	4.87	4.73
5G4	Total	PeakGain	4.66	5.68	4.31	5.18	4.87
Corr. Composite	Total	Peak Gain	10.58	10.71	10.21	10.68	10.30
UnCorr. Composite	Total	Peak Gain	4.57	4.70	4.19	4.67	4.29

	YZ-plane	Frequency	5150	5350	5550	5750	5850
5G1	Total	PeakGain	5.23	4.91	4.25	4.14	4.34
5G2	Total	PeakGain	5.20	4.98	5.28	5.41	4.90
5G3	Total	PeakGain	5.19	5.33	4.76	5.13	4.86
5G4	Total	PeakGain	5.17	5.51	4.85	5.62	5.04
Corr. Composite	Total	Peak Gain	10.73	10.71	10.33	10.54	10.15
UnCorr. Composite	Total	Peak Gain	4.72	4.70	4.32	4.53	4.16

	XY-plane	Frequency	5150	5350	5550	5750	5850
5G1	Total	PeakGain	4.60	4.39	4.85	5.67	4.68
5G2	Total	PeakGain	2.98	3.62	4.06	4.77	4.70
5G3	Total	PeakGain	2.42	3.86	3.54	4.71	4.51
5G4	Total	PeakGain	4.15	3.78	4.58	4.84	4.47
Corr. Composite	Total	Peak Gain	7.30	7.18	7.60	7.82	7.52
UnCorr. Composite	Total	Peak Gain	1.72	1.60	1.97	2.11	1.60

Corr. Composite			10.73	10.71	10.33	10.68	10.30
UnCorr. Composite			4.72	4.70	4.32	4.67	4.29

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 8x8 5GHz

	XZ-plane	Frequency	5150	5350	5550	5750
Dual1	H-Pol.	PeakGain	3.64	3.16	2.89	1.70
	V-Pol.	PeakGain	1.27	2.85	2.67	1.96
Dual2	H-Pol.	PeakGain	-3.32	-8.21	-11.76	-5.16
	V-Pol.	PeakGain	1.86	1.46	1.51	2.17
Dual3	H-Pol.	PeakGain	-6.14	-7.34	-7.52	-5.78
	V-Pol.	PeakGain	2.34	1.77	1.80	2.13
Dual4	H-Pol.	PeakGain	3.94	3.52	2.94	3.49
	V-Pol.	PeakGain	2.67	3.15	1.65	3.73
5G1	H-Pol.	PeakGain	1.19	1.55	-0.31	-0.27
	V-Pol.	PeakGain	2.11	1.75	2.20	2.23
5G2	H-Pol.	PeakGain	2.24	3.26	1.35	2.34
	V-Pol.	PeakGain	3.08	2.05	3.37	3.07
5G3	H-Pol.	PeakGain	1.50	2.03	1.49	1.84
	V-Pol.	PeakGain	2.37	2.71	2.22	2.08
5G4	H-Pol.	PeakGain	1.95	2.16	2.48	2.47
	V-Pol.	PeakGain	2.35	3.12	2.32	3.61
Corr. Composite	**H-Pol.**	**Peak Gain**	**8.67**	**8.91**	**7.80**	**8.70**
	V-Pol.	**Peak Gain**	**8.77**	**8.69**	**8.75**	**9.09**
UnCorr. Composite	**H-Pol.**	**Peak Gain**	**0.43**	**0.60**	**-0.28**	**0.39**
	V-Pol.	**Peak Gain**	**0.54**	**0.43**	**0.48**	**0.53**

	YZ-plane	Frequency	5150	5350	5550	5750
Dual1	H-Pol.	PeakGain	-5.99	-7.45	-7.81	-4.53
	V-Pol.	PeakGain	3.30	2.60	3.02	1.69
Dual2	H-Pol.	PeakGain	5.29	5.58	5.05	5.05
	V-Pol.	PeakGain	1.55	1.85	0.70	1.51
Dual3	H-Pol.	PeakGain	3.95	3.89	4.14	4.21
	V-Pol.	PeakGain	1.62	2.62	2.49	3.46
Dual4	H-Pol.	PeakGain	-6.47	-7.83	-4.93	-6.85
	V-Pol.	PeakGain	3.29	2.51	1.28	2.91
5G1	H-Pol.	PeakGain	1.82	2.02	2.50	1.37
	V-Pol.	PeakGain	2.58	2.40	0.98	1.08
5G2	H-Pol.	PeakGain	2.57	2.48	2.38	2.14
	V-Pol.	PeakGain	2.34	2.44	2.64	3.02
5G3	H-Pol.	PeakGain	2.75	2.93	2.27	2.39
	V-Pol.	PeakGain	2.32	2.26	2.21	1.82
5G4	H-Pol.	PeakGain	3.00	2.97	2.24	3.90
	V-Pol.	PeakGain	1.97	2.23	2.07	2.77
Corr. Composite	**H-Pol.**	**Peak Gain**	**8.93**	**9.02**	**8.84**	**9.20**
	V-Pol.	**Peak Gain**	**9.29**	**9.34**	**8.88**	**9.20**
UnCorr. Composite	**H-Pol.**	**Peak Gain**	**0.83**	**1.05**	**0.75**	**0.56**
	V-Pol.	**Peak Gain**	**0.69**	**0.74**	**0.19**	**0.40**

	XY-plane	Frequency	5150	5350	5550	5750
Dual1	H-Pol.	PeakGain	3.32	3.21	3.69	2.56
	V-Pol.	PeakGain	2.14	3.29	3.48	3.50
Dual2	H-Pol.	PeakGain	3.18	4.22	4.19	3.85
	V-Pol.	PeakGain	2.48	2.83	3.52	4.70
Dual3	H-Pol.	PeakGain	3.71	3.52	2.76	2.63
	V-Pol.	PeakGain	2.12	3.07	2.88	3.18
Dual4	H-Pol.	PeakGain	3.05	2.53	1.91	2.31
	V-Pol.	PeakGain	3.19	3.80	1.95	3.61
5G1	H-Pol.	PeakGain	4.20	4.04	4.81	5.47
	V-Pol.	PeakGain	-2.17	-0.95	-1.64	0.21
5G2	H-Pol.	PeakGain	2.86	3.33	3.59	4.24
	V-Pol.	PeakGain	-3.88	-3.10	-3.08	-2.49
5G3	H-Pol.	PeakGain	2.37	3.77	3.46	4.56
	V-Pol.	PeakGain	-3.16	-3.92	-2.74	-3.59
5G4	H-Pol.	PeakGain	3.99	3.56	4.33	4.45
	V-Pol.	PeakGain	-3.25	-2.51	-1.86	-2.30
Corr. Composite	**H-Pol.**	**Peak Gain**	**8.84**	**8.60**	**8.59**	**8.76**
	V-Pol.	**Peak Gain**	**5.59**	**5.98**	**6.24**	**6.63**
UnCorr. Composite	**H-Pol.**	**Peak Gain**	**0.53**	**0.36**	**0.37**	**0.40**
	V-Pol.	**Peak Gain**	**-2.67**	**-1.92**	**-1.91**	**-1.24**

Antenna Composite gain

	Composite Gain	2.4 ~ 2.4835
2G 4x4	Correlated	6.57
	Un-Correlated	0.97

	Composite Gain	5.15 ~ 5.25	5.25 ~ 5.35	5.47 ~ 5.725	5.725 ~ 5.85
5G 4x4	Correlated	10.73	10.71	10.33	10.68
	Un-Correlated	4.72	4.70	4.32	4.67

			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=250, ϕ=90)	V-pol.	1.06	-4.37	-0.07	3.72	6.57
5.15 ~ 5.25	(θ=197, ϕ=90)	V-pol.	4.53	5.12	5.08	4.07	10.73
5.25 ~ 5.35	(θ=180, ϕ=90)	V-pol.	4.58	4.84	5.30	3.96	10.71
5.47 ~ 5.725	(θ=191, ϕ=90)	V-pol.	3.45	4.93	4.67	4.11	10.33
5.725 ~ 5.85	(θ=169, ϕ=0)	V-pol.	3.85	5.04	4.82	4.86	10.68

Antenna Composite gain

	Composite Gain	5.15 ~ 5.25	5.25 ~ 5.35	5.47 ~ 5.725	5.725 ~ 5.85
5G 8x8	Correlated	9.29	9.34	8.88	9.20
	Un-Correlated	0.83	1.05	0.75	0.56

		Frequency			
	Antenna	5.15 ~ 5.25	5.25 ~ 5.35	5.47 ~ 5.725	5.725 ~ 5.85
Antenna gain (dBi)	Dual1	0.68	1.27	0.00	0.22
	Dual2	-6.28	-7.65	-3.55	-3.94
	Dual3	-4.02	-5.70	-5.62	-3.81
	Dual4	2.49	1.93	0.58	-0.10
	5G1	1.21	2.12	-0.18	1.08
	5G2	2.13	2.17	2.40	2.60
	5G3	1.15	1.25	1.48	1.32
	5G4	1.16	1.86	0.95	1.69
Polarization		V-pol.	V-pol.	V-pol.	V-pol.
Position (θ, ϕ) of directional gain		(θ=191, ϕ=90)	(θ=191, ϕ=90)	(θ=194, ϕ=90)	(θ=197, ϕ=90)
Calculated Directional Gain (dBi) Correlated		9.29	9.34	8.88	9.20

Antenna Composite gain

	Composite Gain	2.4 ~ 2.4835
2G 2x2 Dual_1+Dual_3	Correlated	6.33
	Un-Correlated	3.47

2G , 2x2 , Dual_1+Dual_3			Antenna gain (dBi)		Calculated Directional Gain (dBi) **Correlated**
Frequency	Position (θ, ϕ) of **directional gain**	Polarization	ANT 1	ANT 3	
2.4 ~ 2.4835	(θ=60, ϕ=318)	V-pol.	1.52	4.81	6.33

	Composite Gain	5.15 ~ 5.25	5.25 ~ 5.35	5.47 ~ 5.725	5.725 ~ 5.85
5G 2x2 Dual_2+Dual_3	Correlated	8.47	8.92	8.16	8.59
	Un-Correlated	5.47	5.91	5.17	5.58

5G, 2x2 , Dual_2+Dual_3			Antenna gain (dBi)		Calculated Directional Gain (dBi) **Correlated**
Frequency	Position (θ, ϕ) of **directional gain**	Polarization	ANT 2	ANT 3	
5.15 ~ 5.25	(θ=129, ϕ=90)	V-pol.	5.79	5.13	8.47
5.25 ~ 5.35	(θ=129, ϕ=90)	V-pol.	6.10	5.72	8.92
5.47 ~ 5.725	(θ=129, ϕ=90)	V-pol.	5.68	4.60	8.16
5.725 ~ 5.85	(θ=60, ϕ=98)	V-pol.	5.66	5.51	8.59

Antenna Composite gain

Dual band	Composite Gain	2400	2450	2500	/	5150	5350	5550	5750	5850
1-2	Correlated	5.41	5.43	4.78		6.07	6.17	5.87	6.16	5.75
	Un-Correlated	2.70	3.21	2.62		3.64	3.81	3.34	3.50	3.13

Dual band	Composite Gain	2400	2450	2500	/	5150	5350	5550	5750	5850
1-3	Correlated	4.81	5.97	6.33		5.92	6.07	6.05	5.93	5.98
	Un-Correlated	2.44	3.05	3.47		3.10	3.57	3.36	3.53	3.12

Dual band	Composite Gain	2400	2450	2500	/	5150	5350	5550	5750	5850
1-4	Correlated	5.52	6.14	6.09		7.41	7.63	7.61	7.68	6.88
	Un-Correlated	2.62	3.60	3.33		4.41	4.65	4.62	4.76	4.01

Antenna Composite gain

Dual band	Composite Gain	2400	2450	2500	/	5150	5350	5550	5750	5850
2-3	Correlated	5.22	6.01	5.30		8.47	8.92	8.16	8.59	8.13
	Un-Correlated	2.71	3.49	2.58		5.47	5.91	5.17	5.58	5.12

Dual band	Composite Gain	2400	2450	2500	/	5150	5350	5550	5750	5850
2-4	Correlated	4.47	6.11	5.03		5.84	5.68	5.43	5.97	5.23
	Un-Correlated	1.97	3.60	2.41		3.44	3.37	3.13	3.09	2.68

Dual band	Composite Gain	2400	2450	2500	/	5150	5350	5550	5750	5850
3-4	Correlated	5.72	5.18	4.34		6.07	5.55	5.63	5.65	5.53
	Un-Correlated	2.87	2.82	2.31		3.06	3.16	2.98	2.75	2.75

Antenna Composite gain

Single – 5G	Composite Gain	5150	5350	5550	5750	5850
1-2	Correlated	7.85	8.03	7.35	7.52	7.57
	Un-Correlated	4.85	5.03	4.35	4.54	4.56

Single – 5G	Composite Gain	5150	5350	5550	5750	5850
1-3	Correlated	7.85	8.10	7.22	7.56	7.21
	Un-Correlated	4.84	5.09	4.21	4.63	4.21

Single – 5G	Composite Gain	5150	5350	5550	5750	5850
1-4	Correlated	7.98	7.99	7.45	7.38	7.50
	Un-Correlated	4.97	5.00	4.44	4.39	4.49

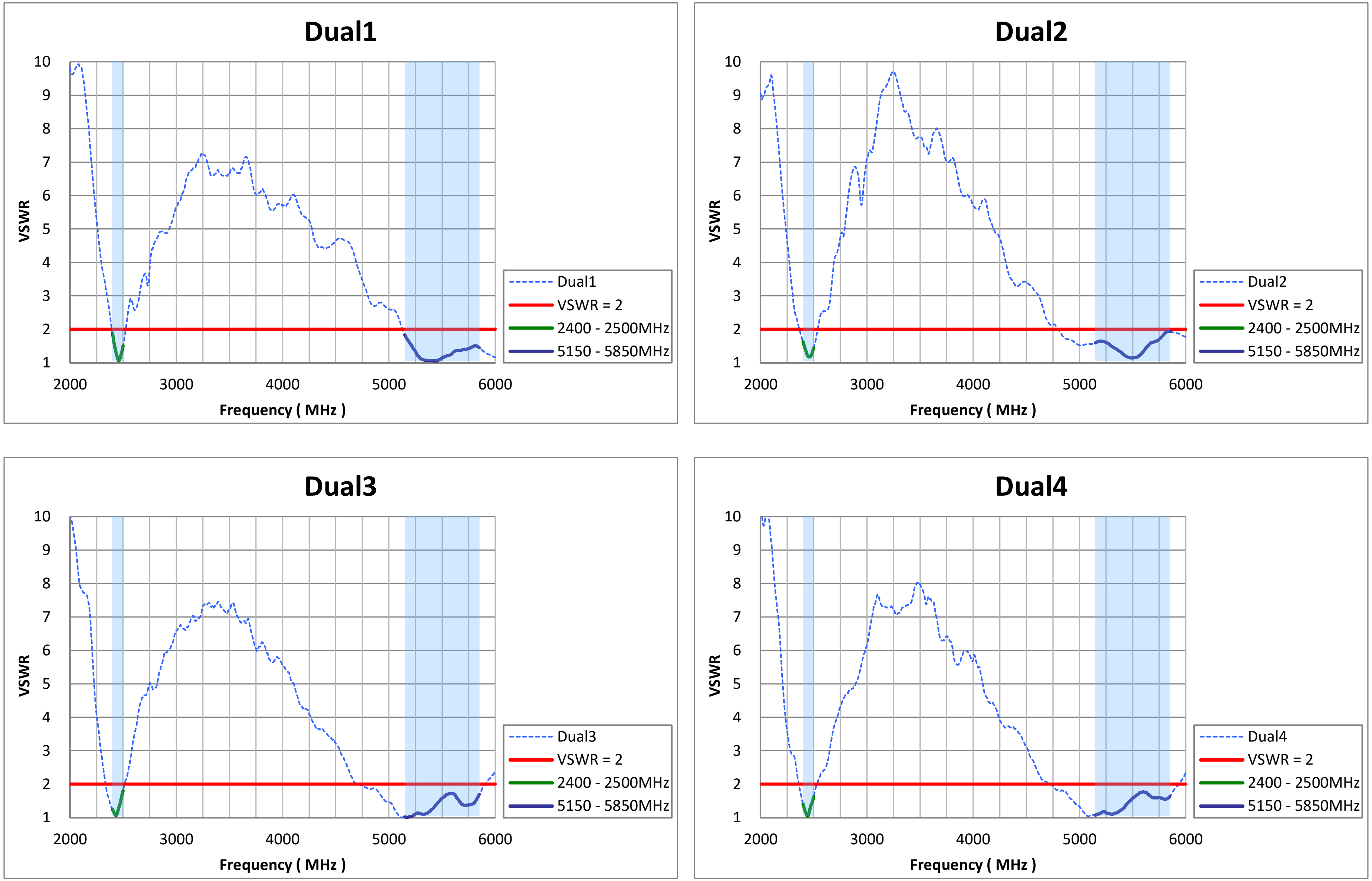
Antenna Composite gain

Single – 5G	Composite Gain	5150	5350	5550	5750	5850
2-3	Correlated	8.11	8.33	8.04	8.11	7.78
	Un-Correlated	5.10	5.32	5.03	5.10	4.77

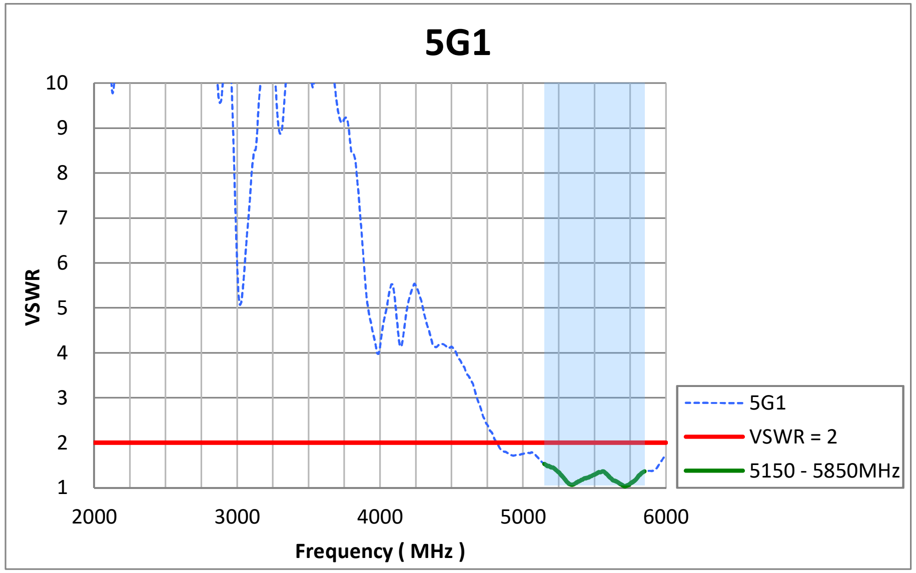
Single – 5G	Composite Gain	5150	5350	5550	5750	5850
2-4	Correlated	7.91	7.94	7.67	7.96	7.62
	Un-Correlated	4.90	4.95	4.67	4.95	4.62

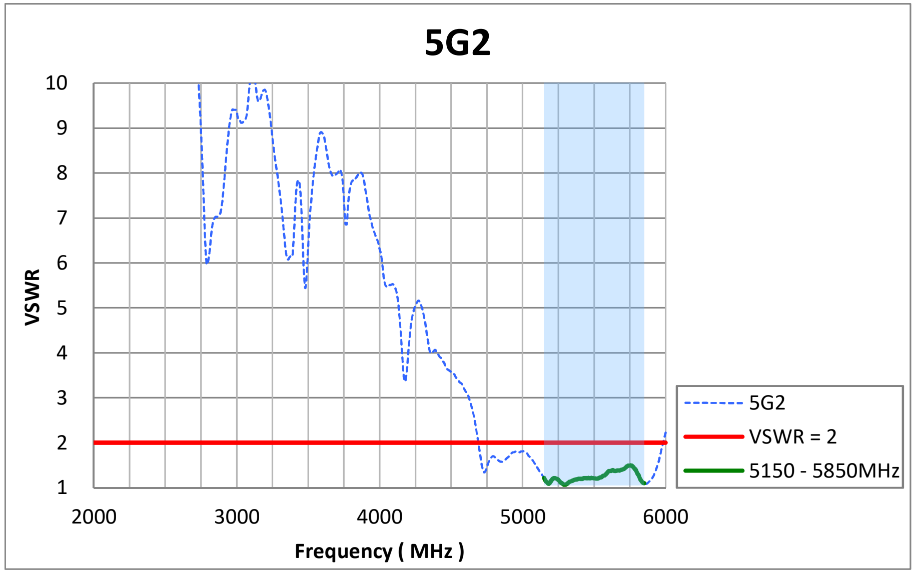
Single – 5G	Composite Gain	5150	5350	5550	5750	5850
3-4	Correlated	7.68	8.27	7.67	7.91	7.81
	Un-Correlated	4.68	5.26	4.67	4.93	4.80

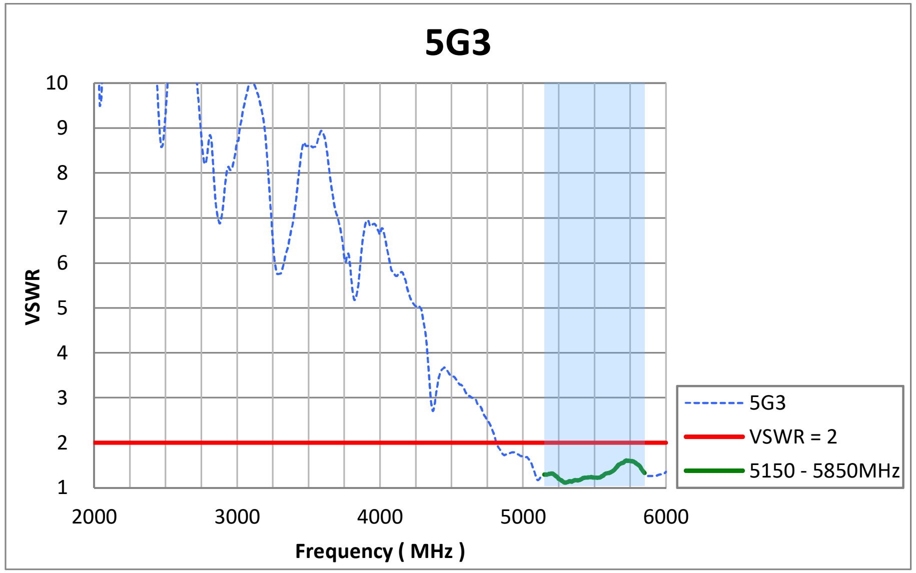
VSWR for Dual Band

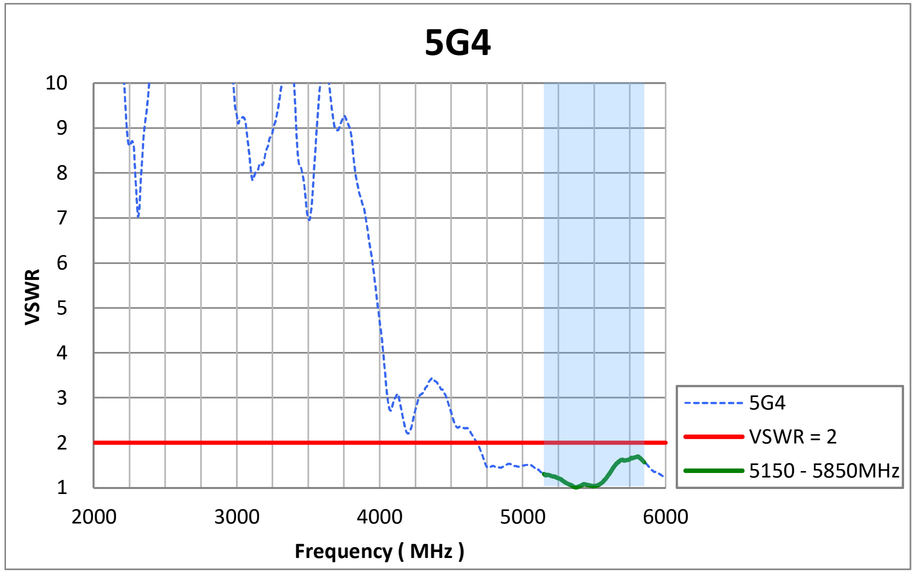


VSWR for 5G

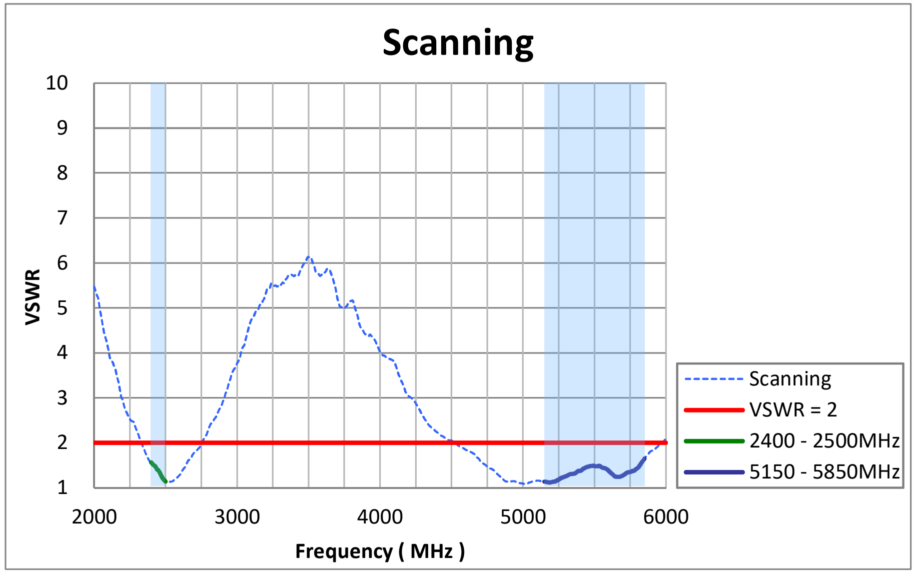

5G1
10
9
8
7
6
5
4
3
2
1
VSWR
2000
3000
4000
5000
6000
Frequency (MHz)
5G1
VSWR = 2
5150 - 5850MHz

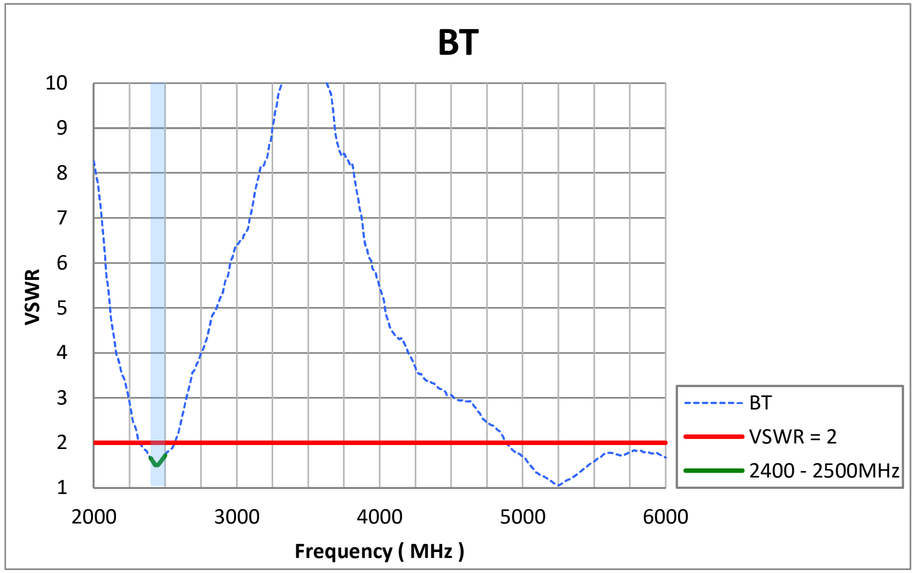

5G2
10
9
8
7
6
5
4
3
2
1
VSWR
2000
3000
4000
5000
6000
Frequency (MHz)
5G2
VSWR = 2
5150 - 5850MHz


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

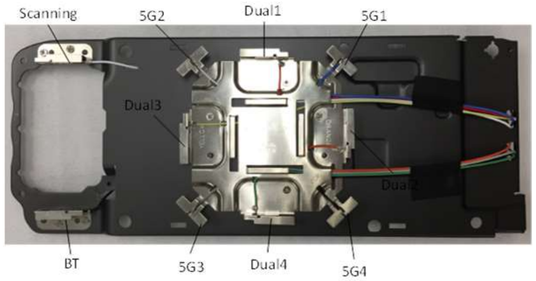

5G4
10
9
8
7
6
5
4
3
2
1
VSWR
2000
3000
4000
5000
6000
Frequency (MHz)
5G4
VSWR = 2
5150 - 5850MHz

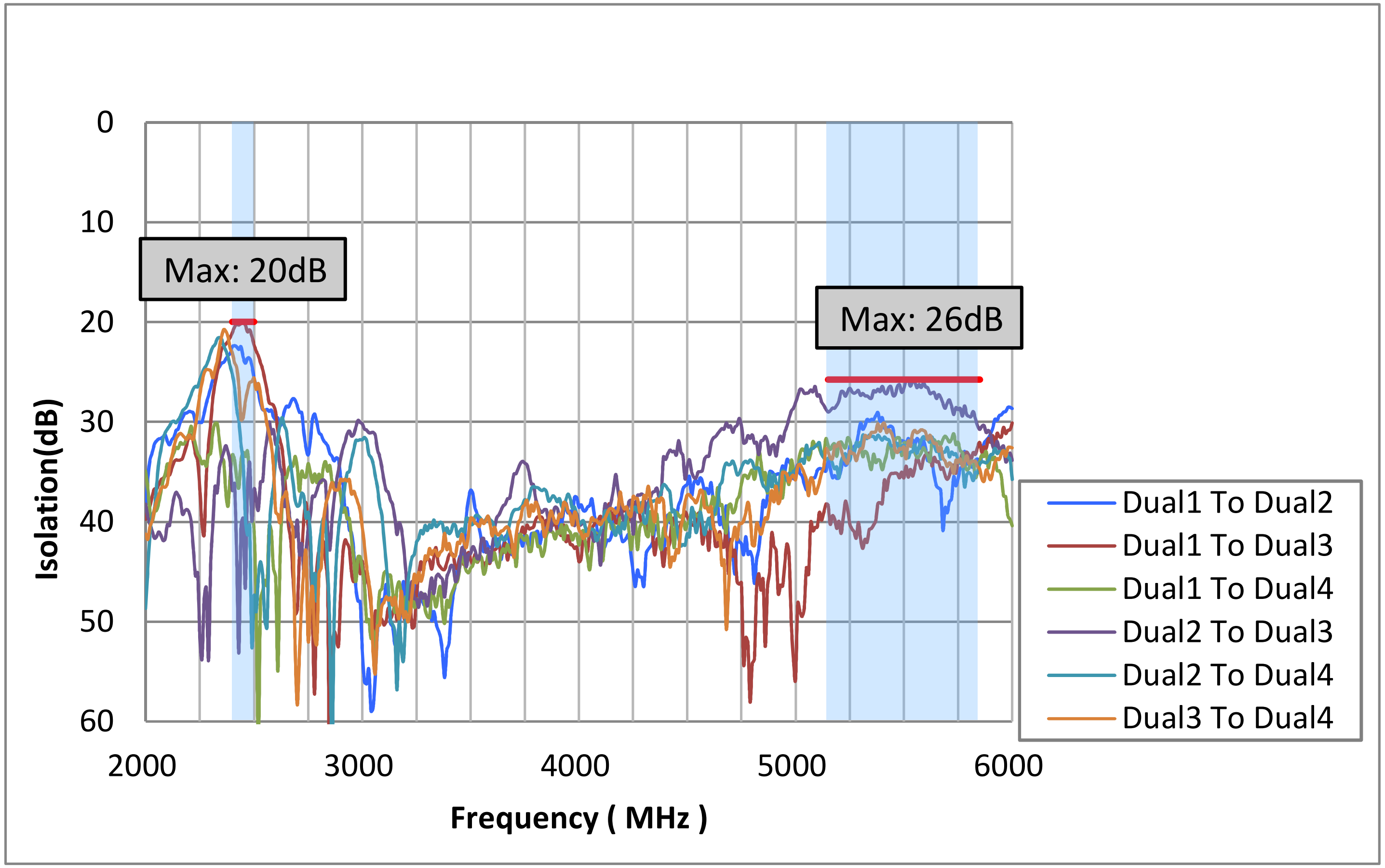
VSWR for Scanning / BT



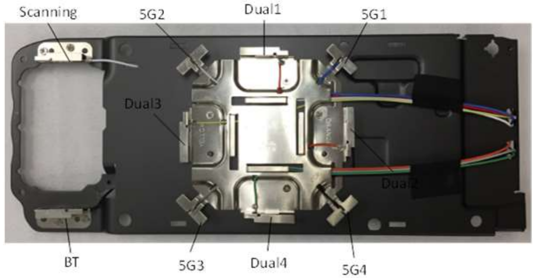


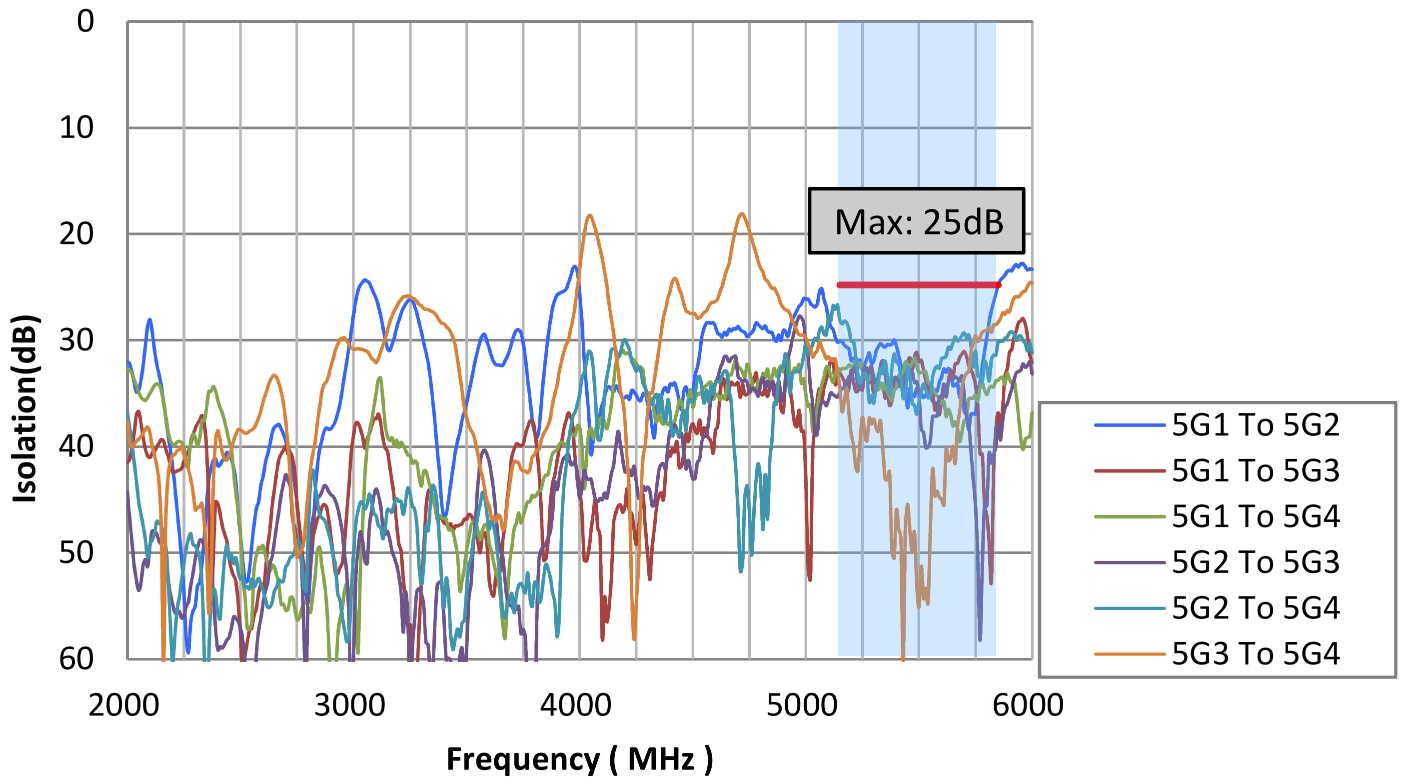
Isolation for Dual-Band ANTs



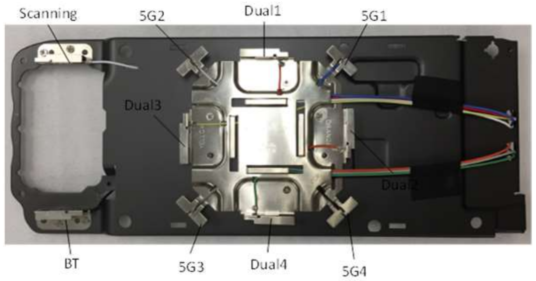


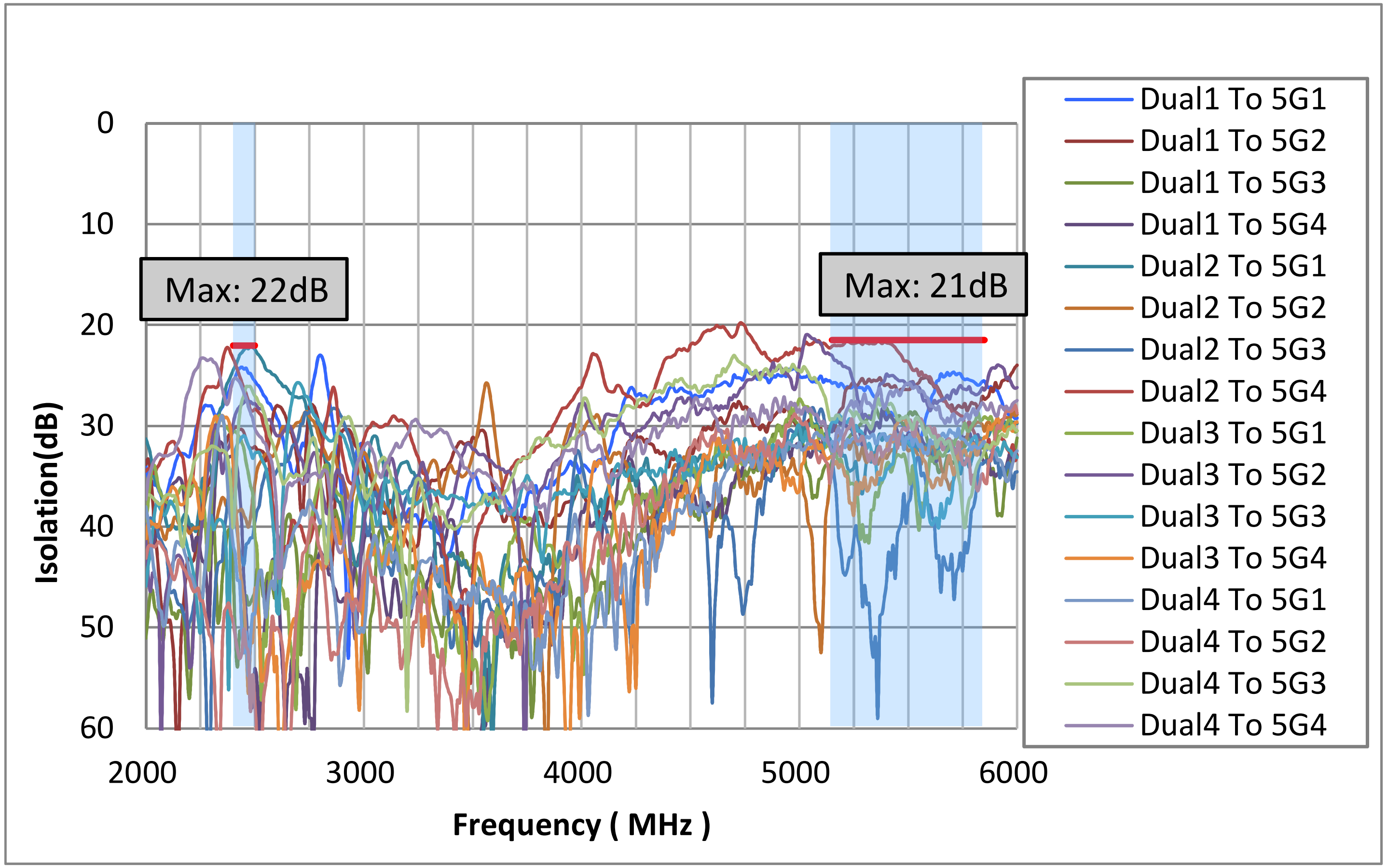
Isolation for 5G ANTs



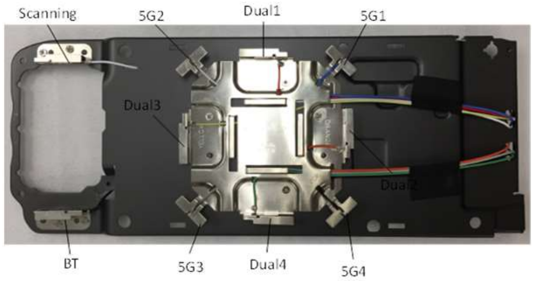


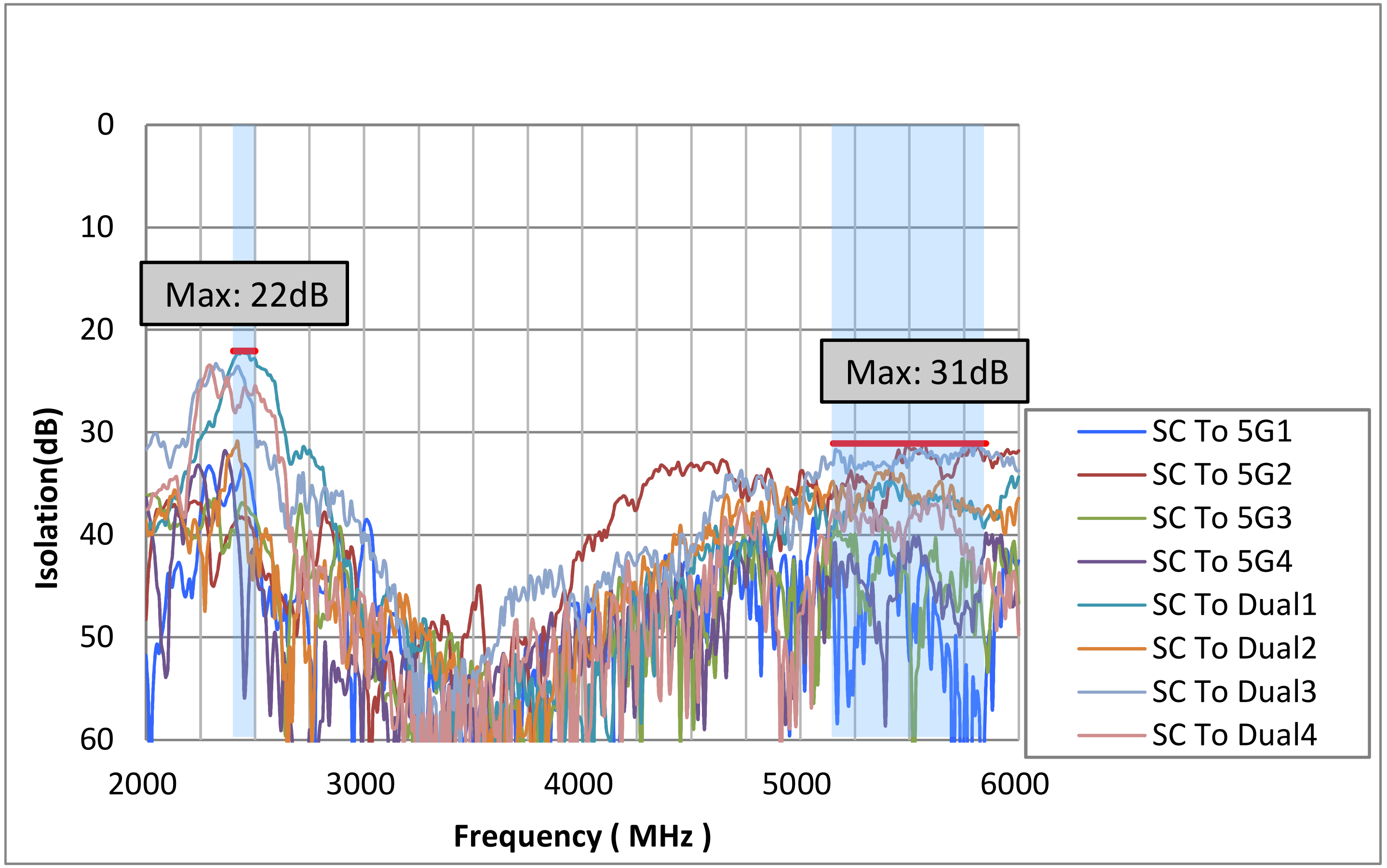
Isolation for Dual-Band to 5G ANTs



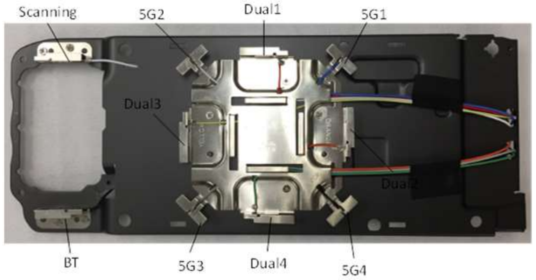


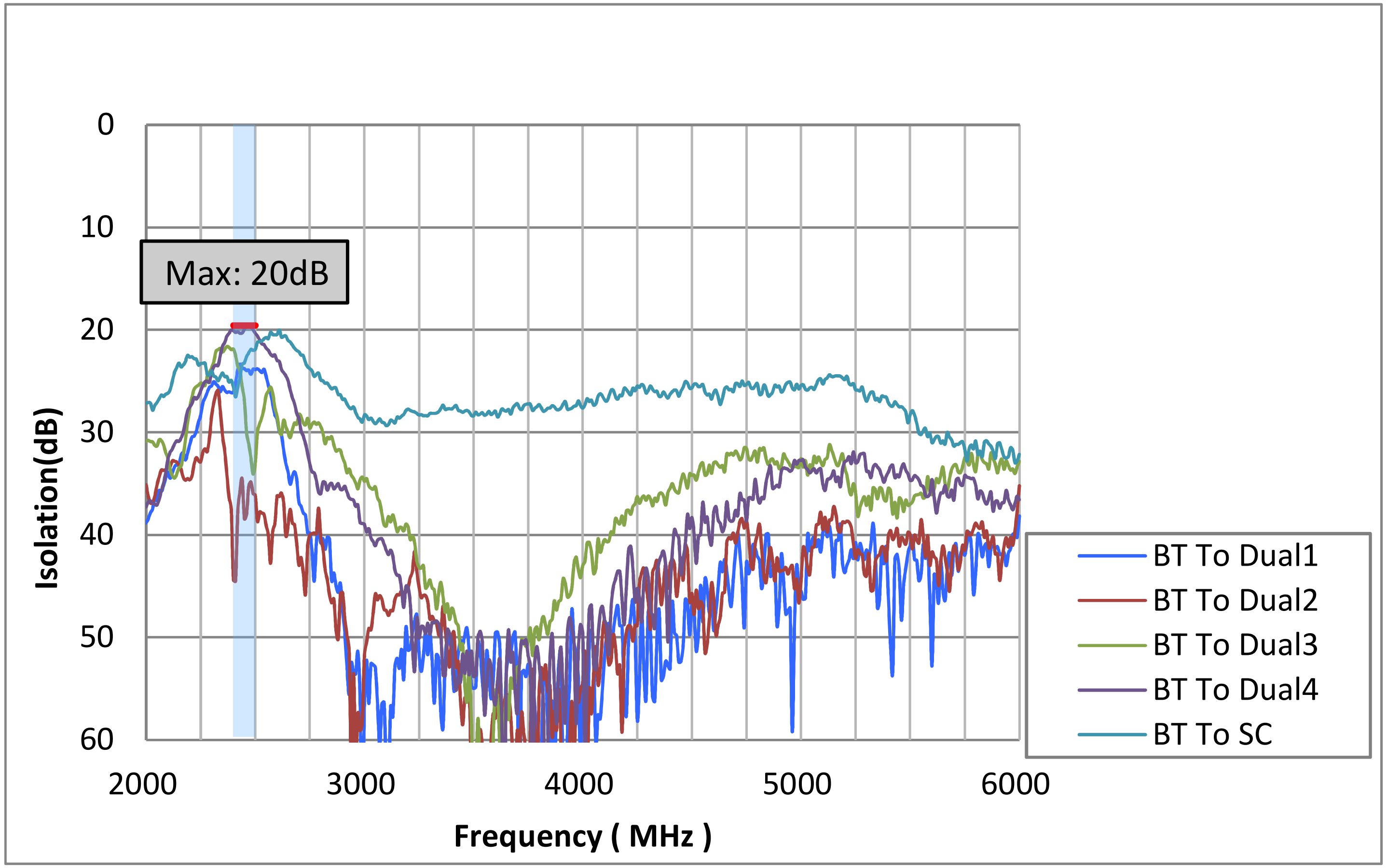
Isolation for Scanning to others



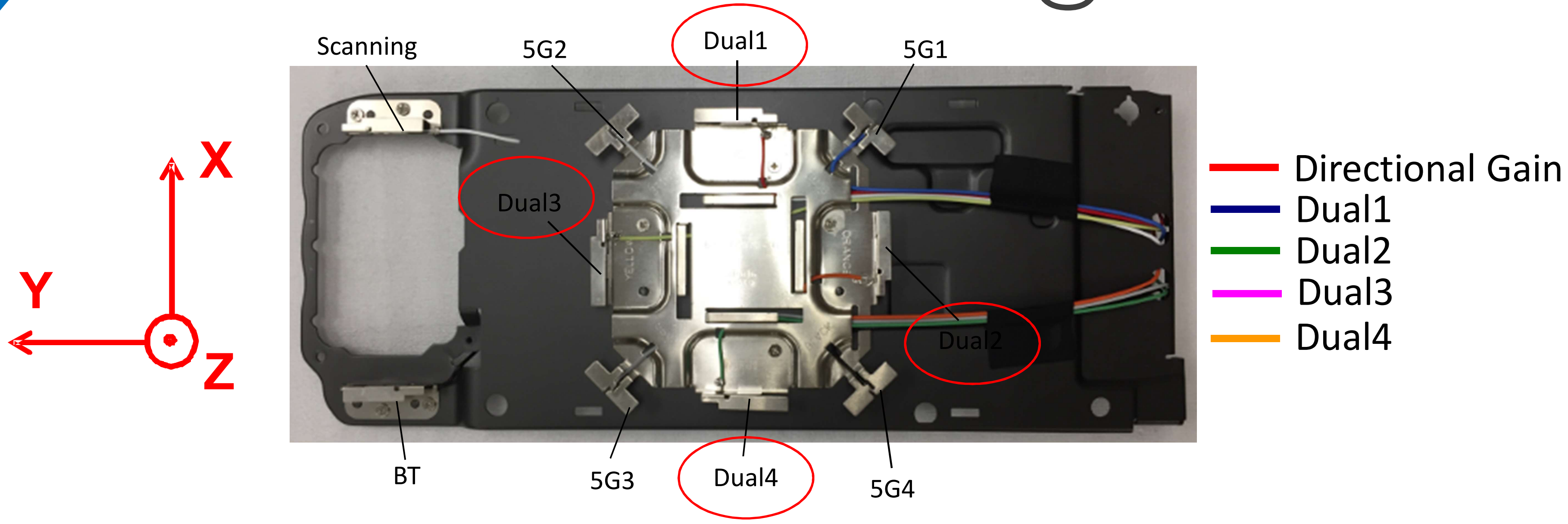


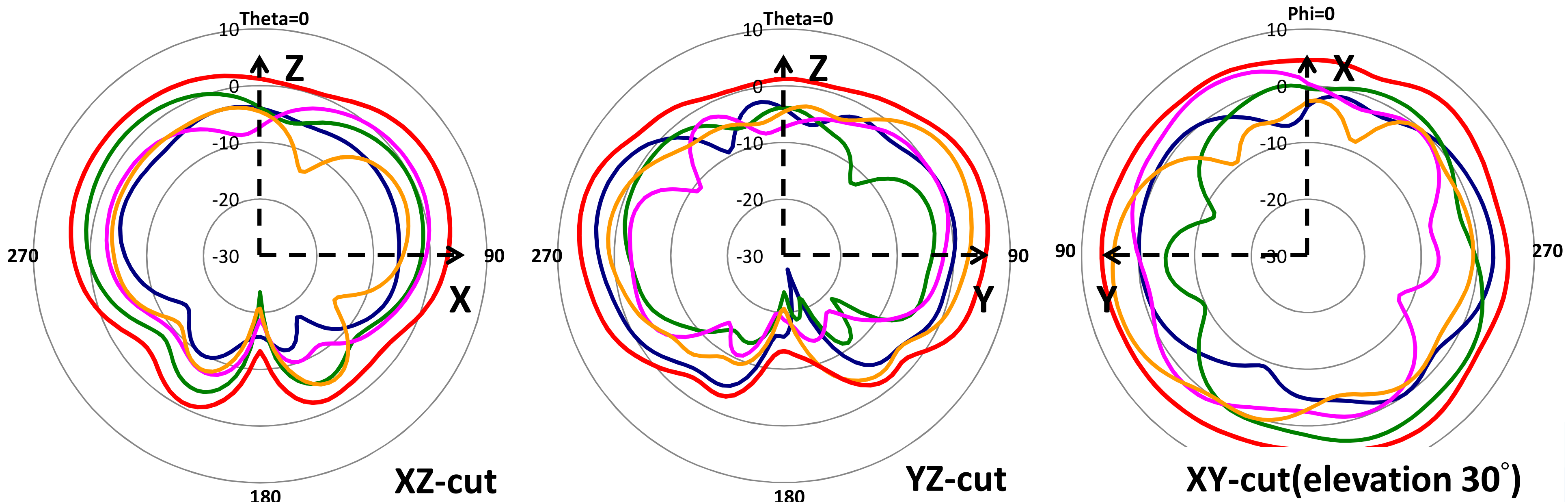
Isolation for BT to others



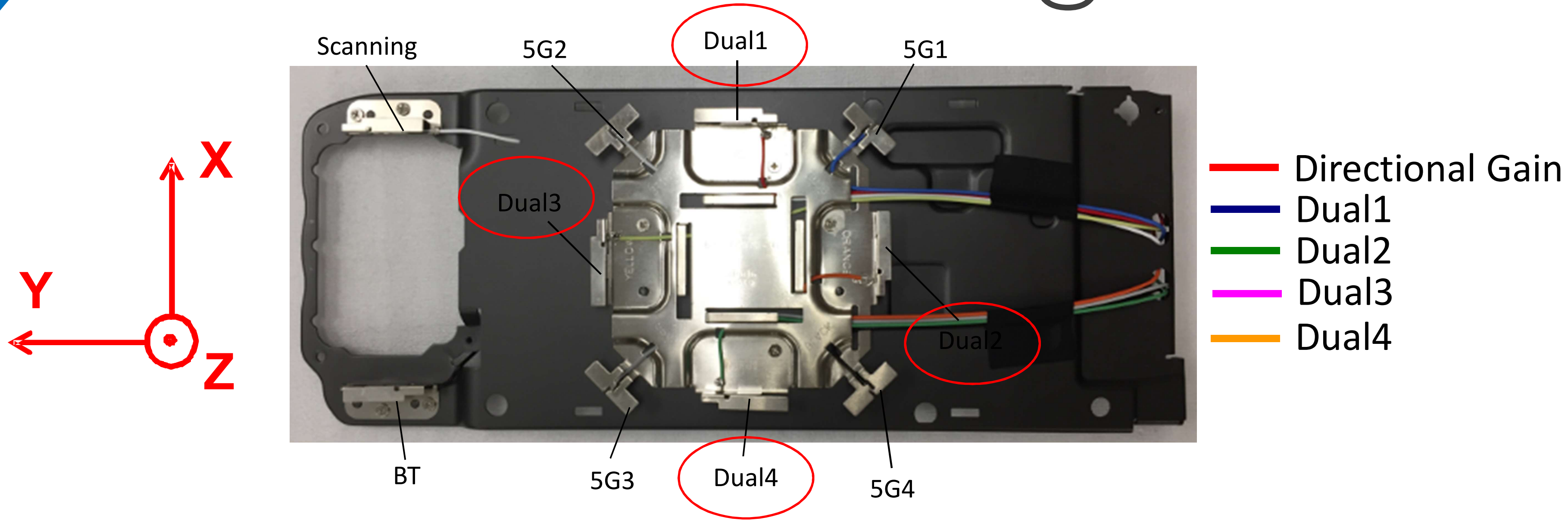


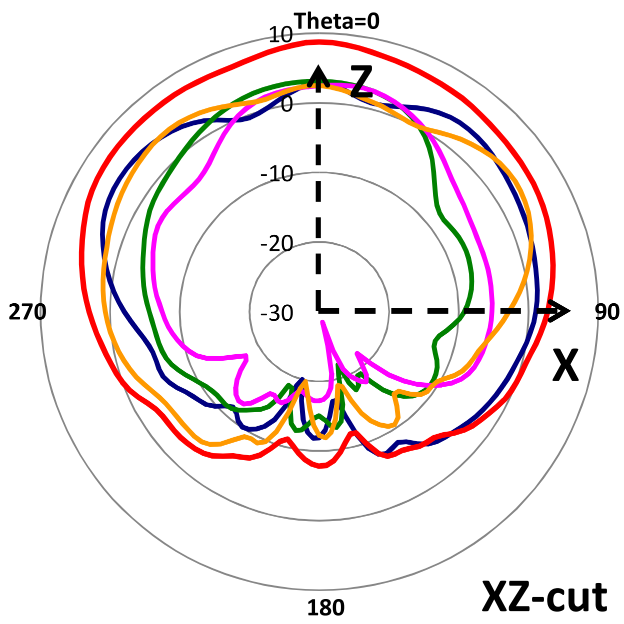
Radiation Pattern for Dual-Band @ 2.4GHz

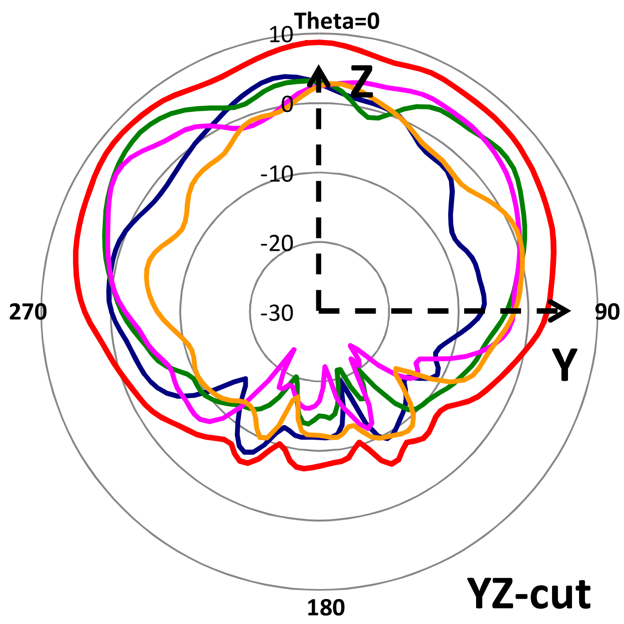


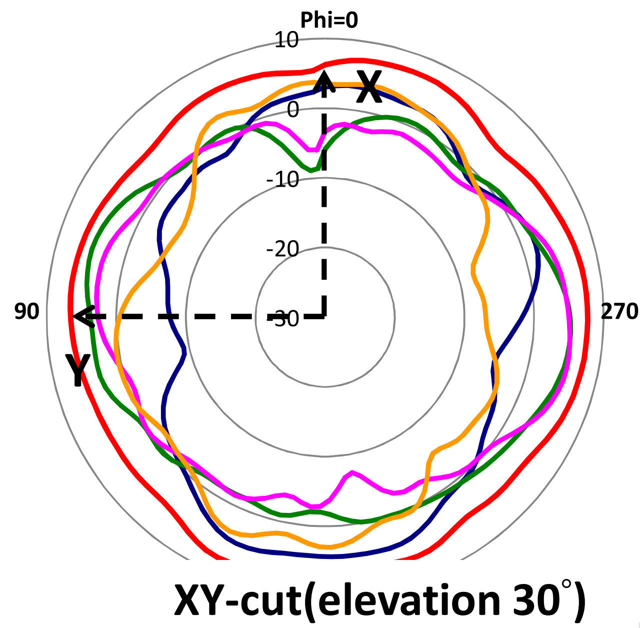


Radiation Pattern for Dual-Band @ 5GHz

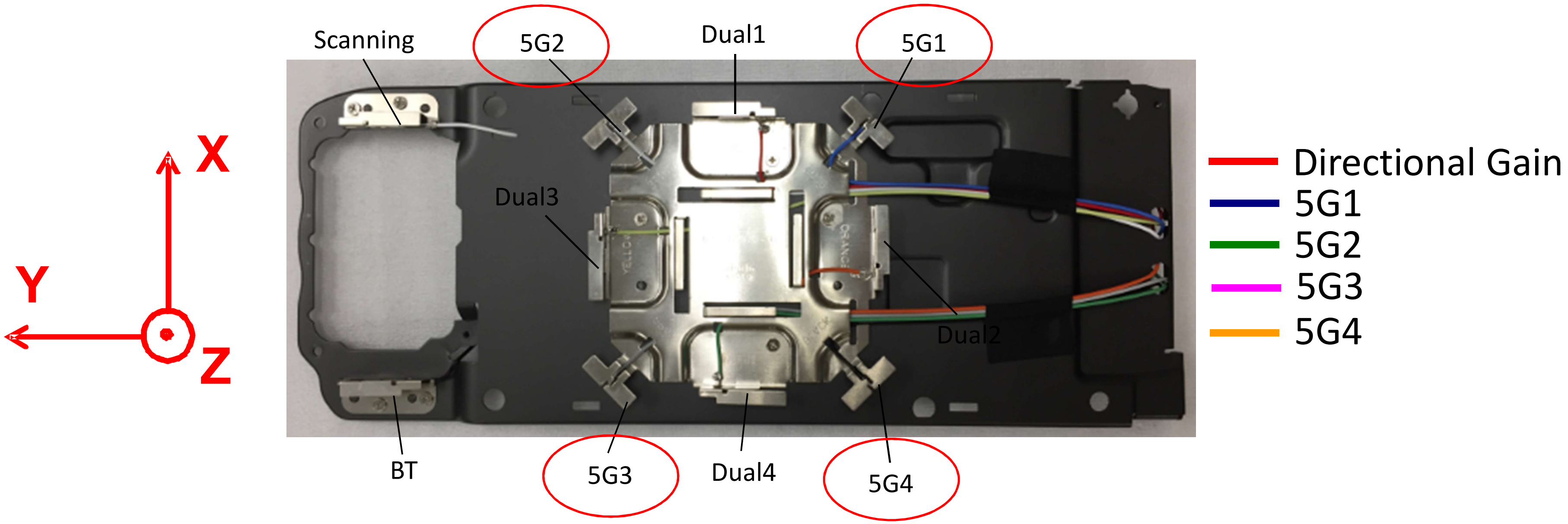


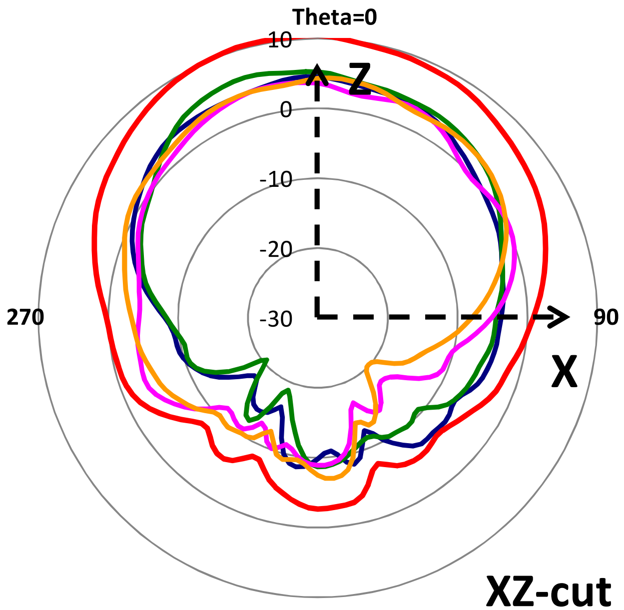


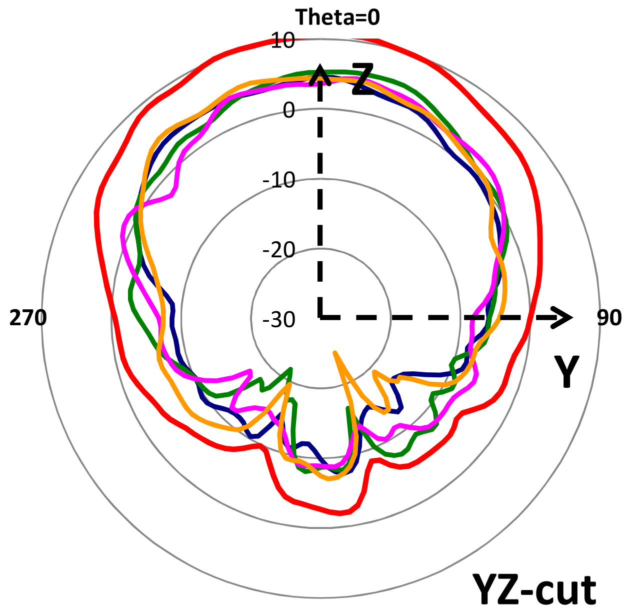


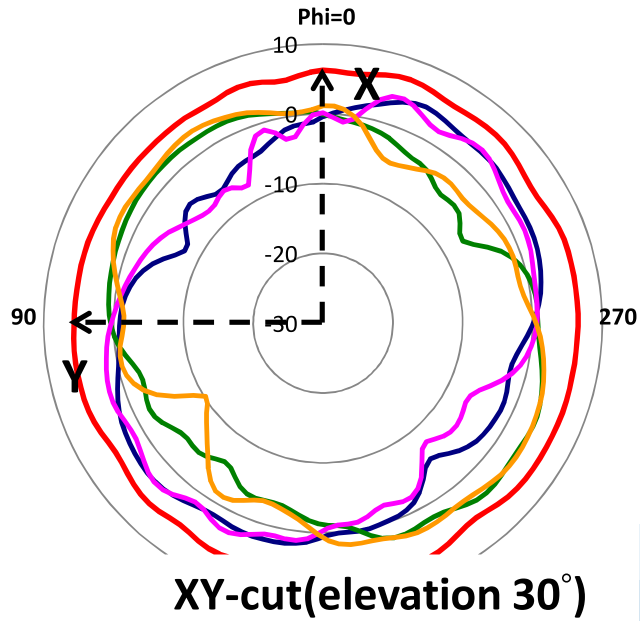


Radiation Pattern for 5G

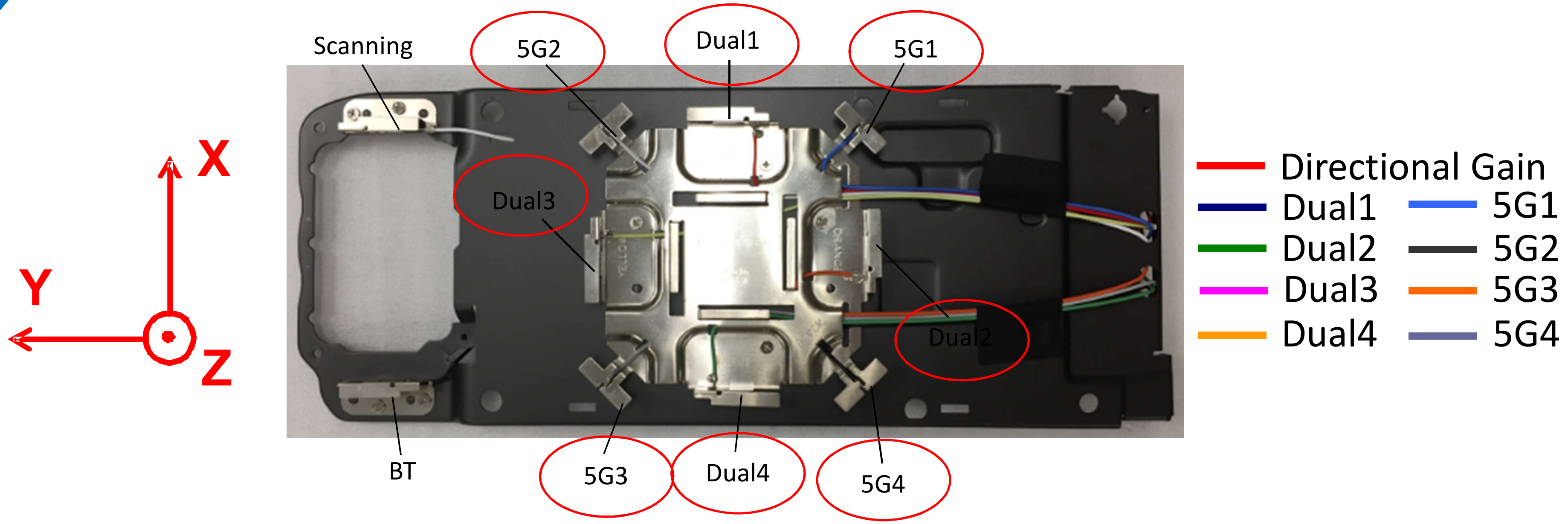


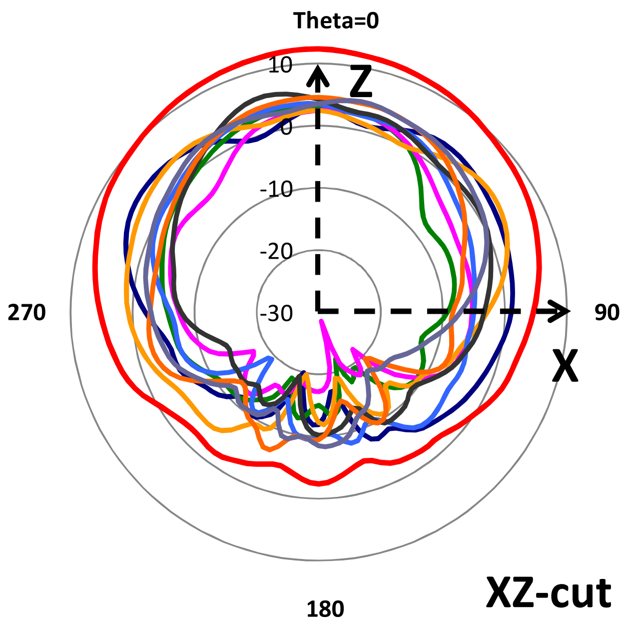




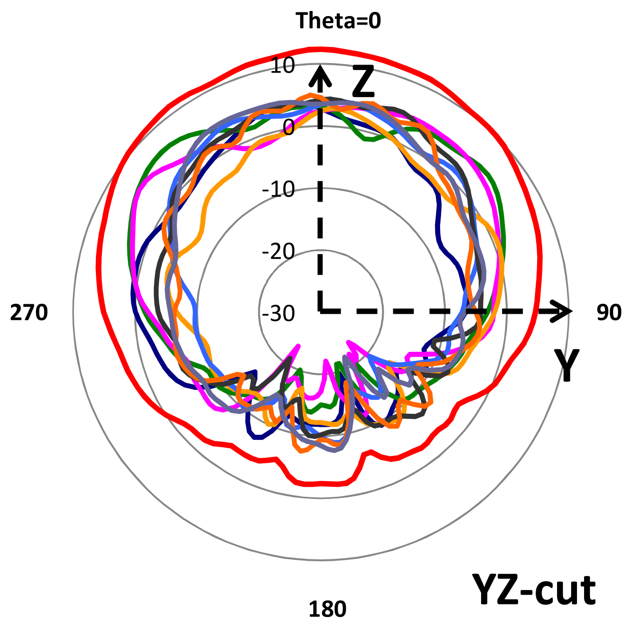


Radiation Pattern for 8x8 5G

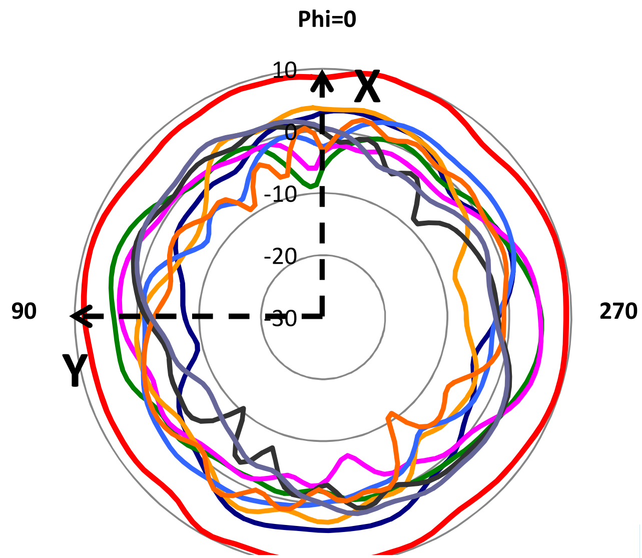




XZ-cut

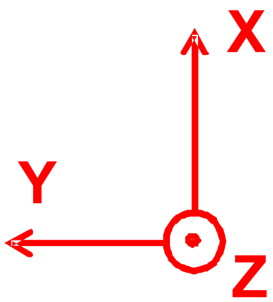


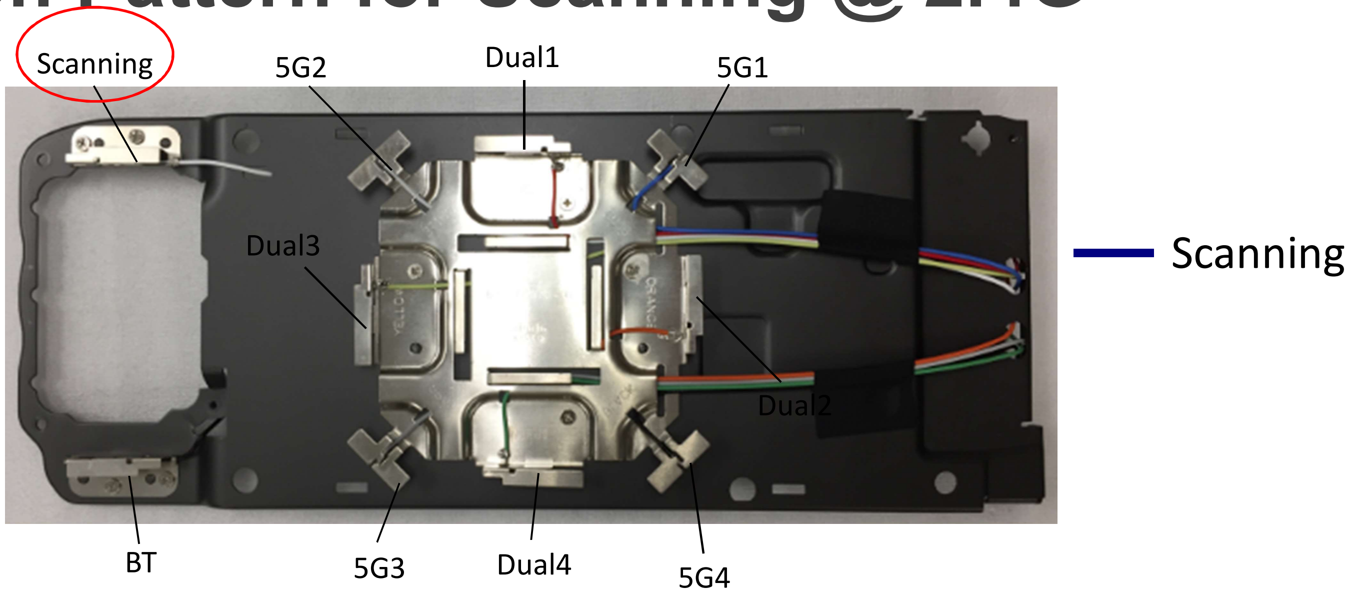
YZ-cut

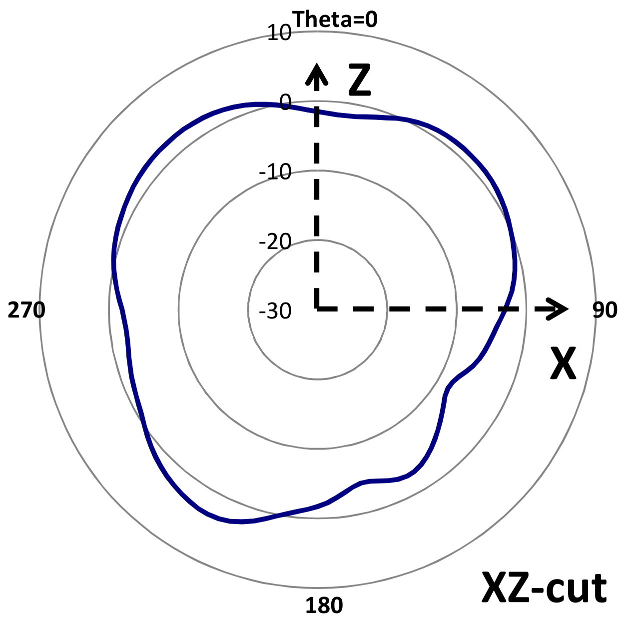


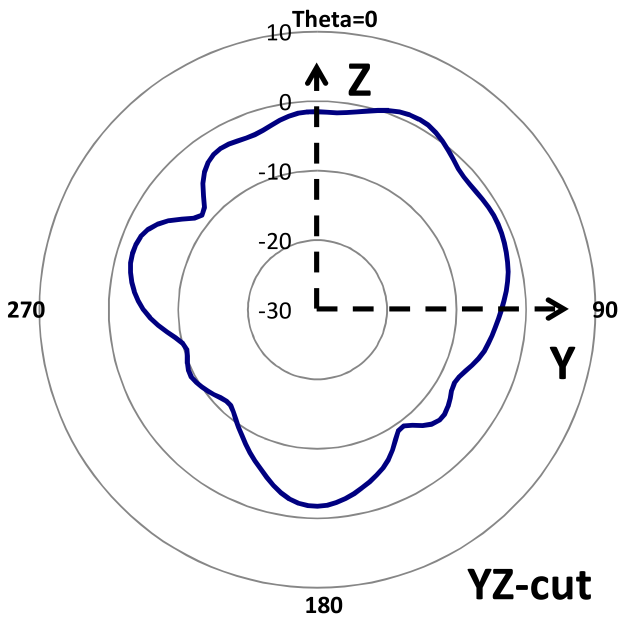
XY-cut(elevation 30°)

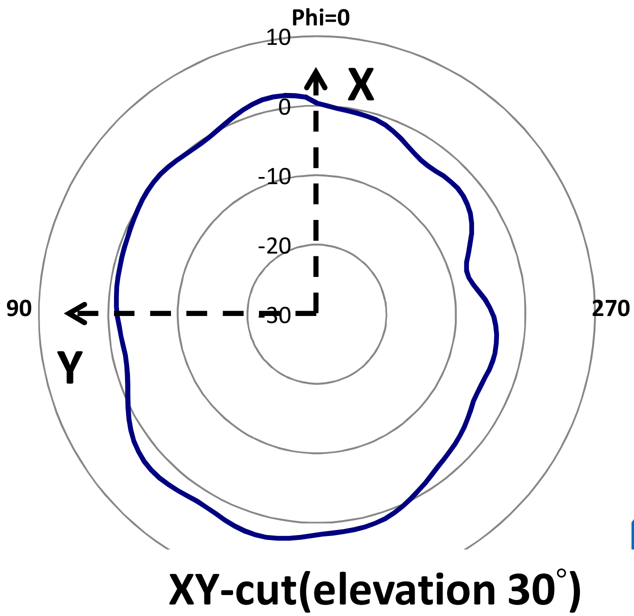
Radiation Pattern for Scanning @ 2.4G



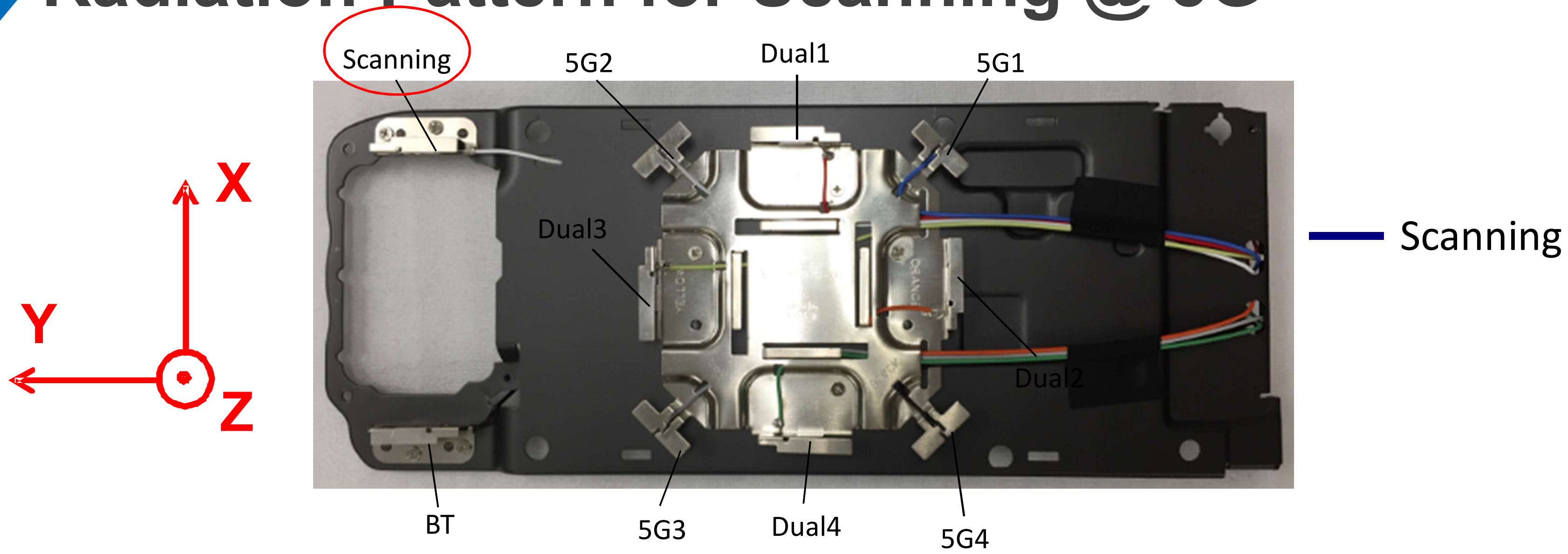


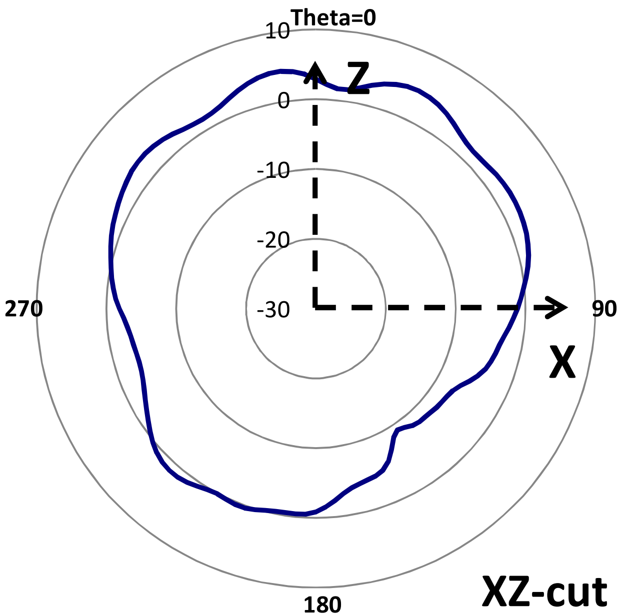


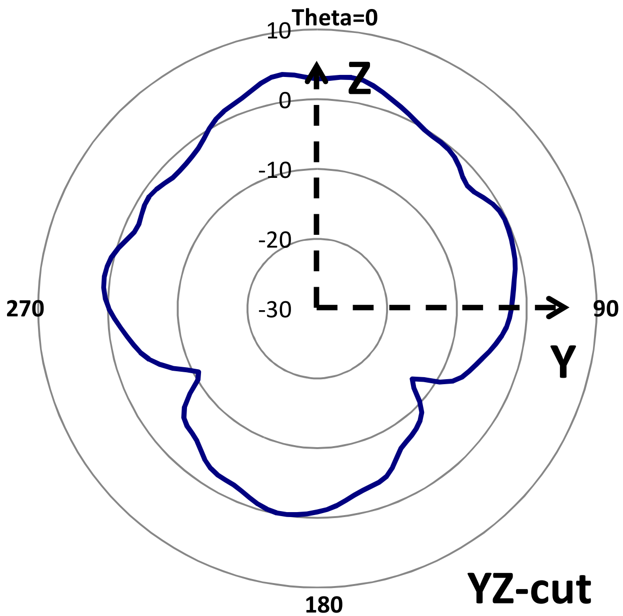


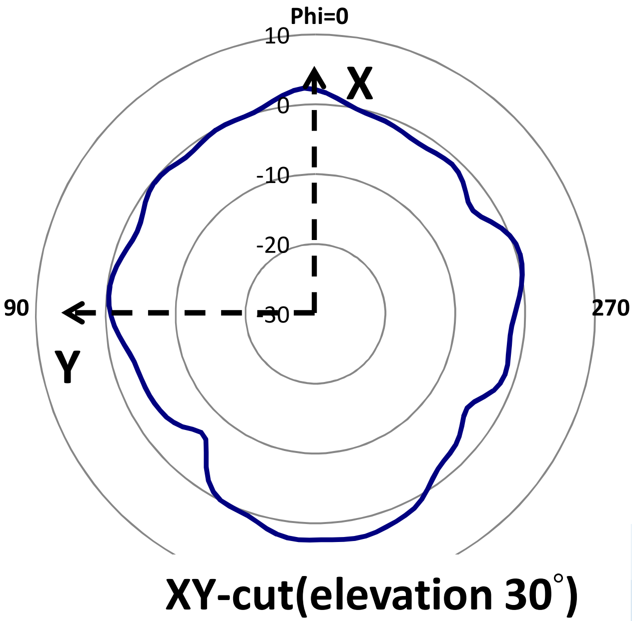


Radiation Pattern for Scanning @ 5G

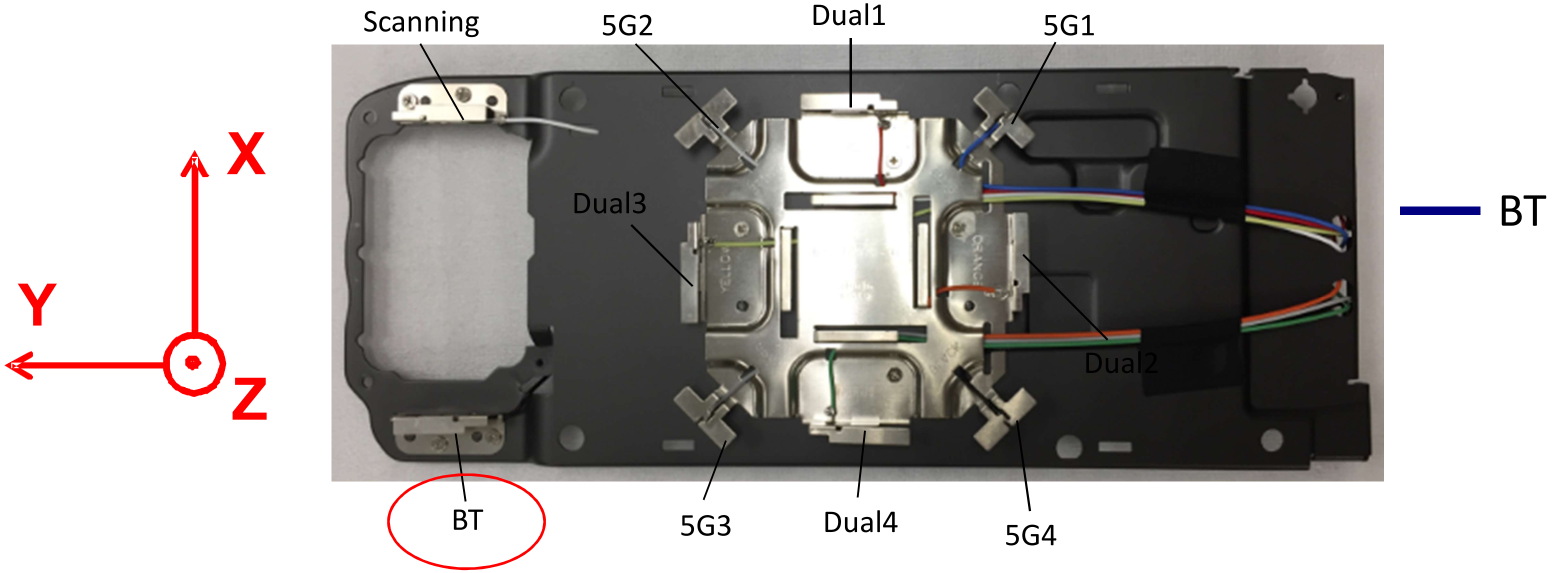


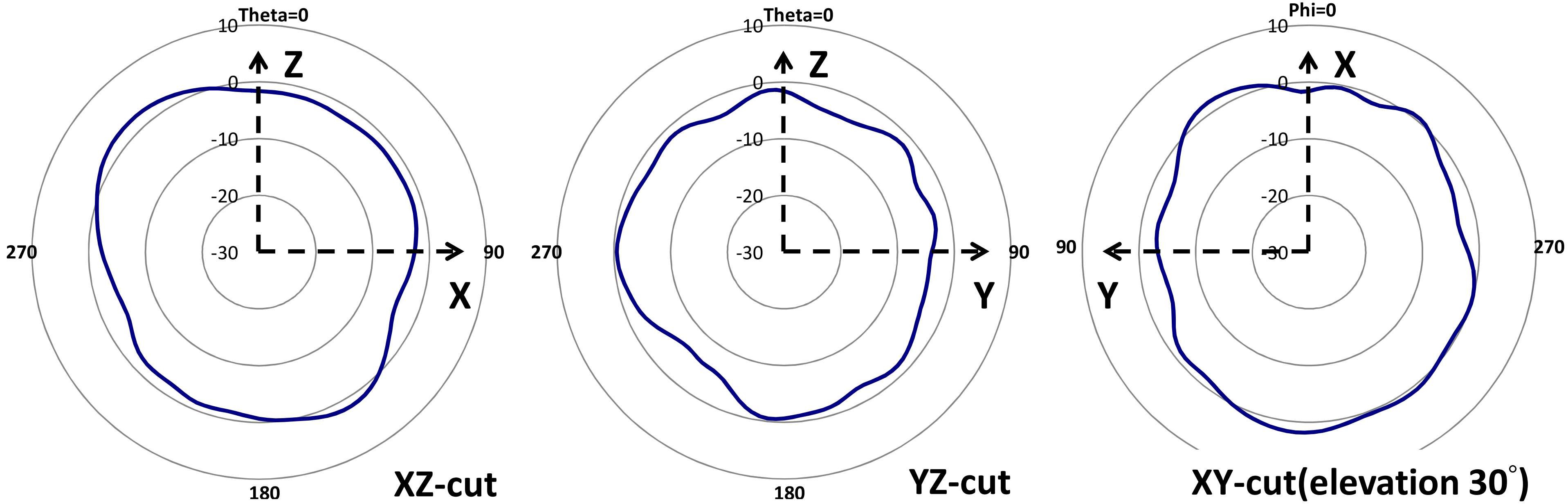






Radiation Pattern for BT



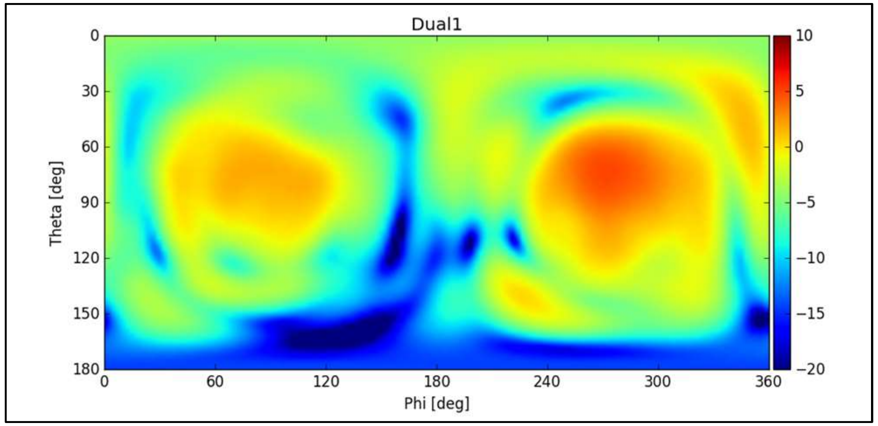


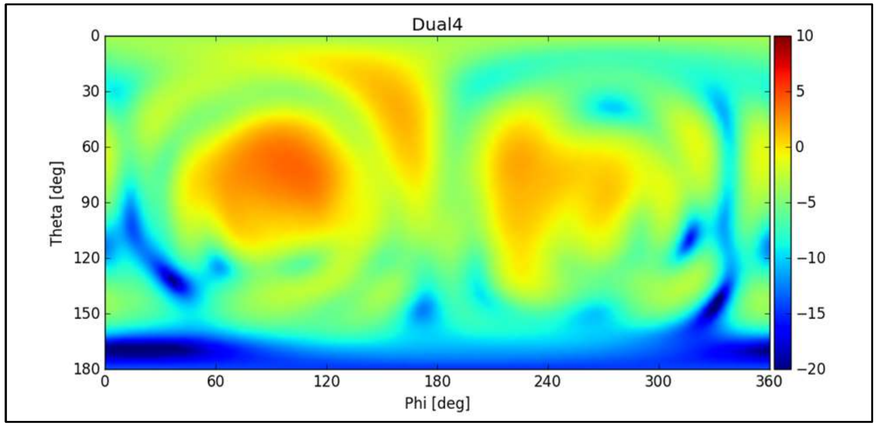
XZ-cut

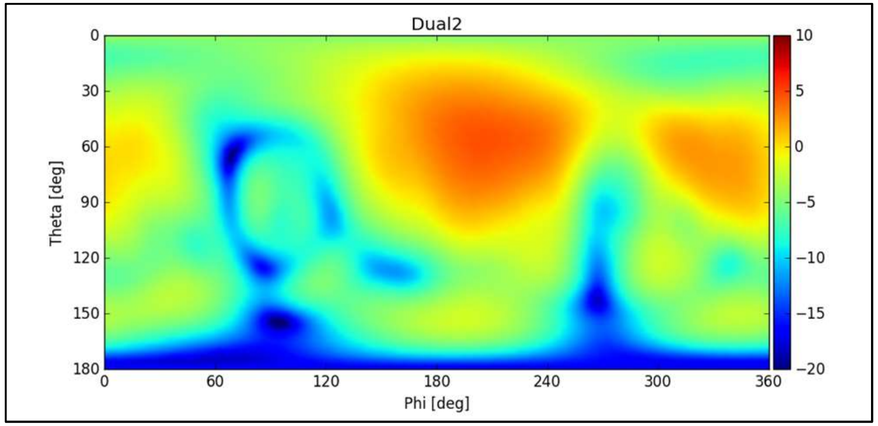
YZ-cut

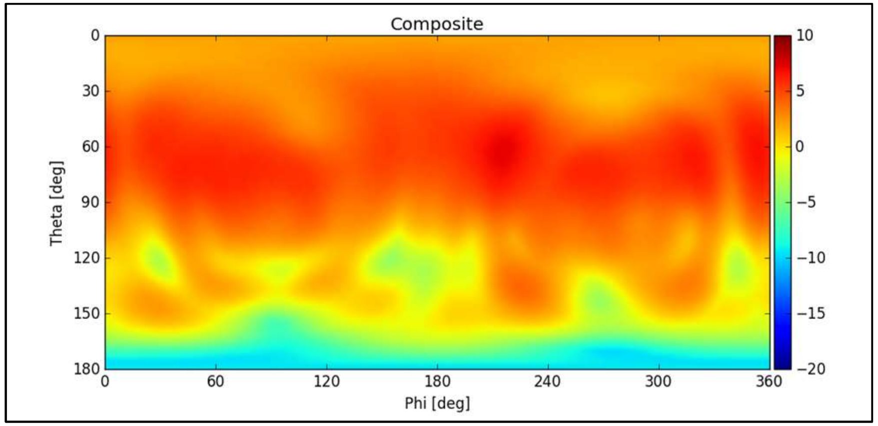
XY-cut(elevation 30°)

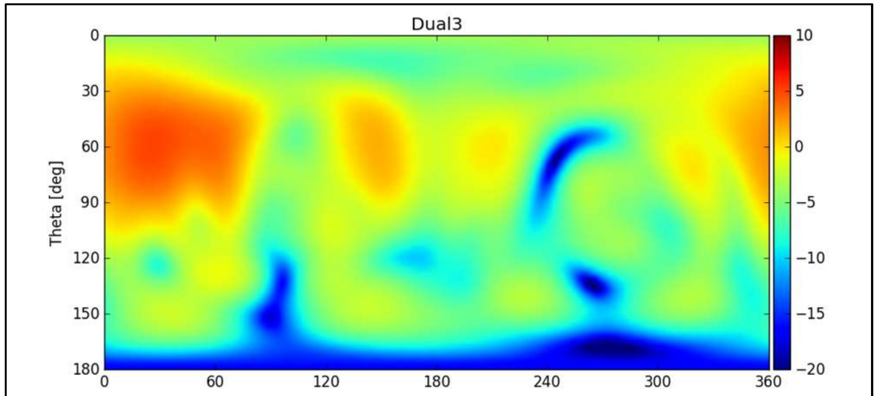
3D Radiation Pattern for Dual-Band @ 2.4GHz

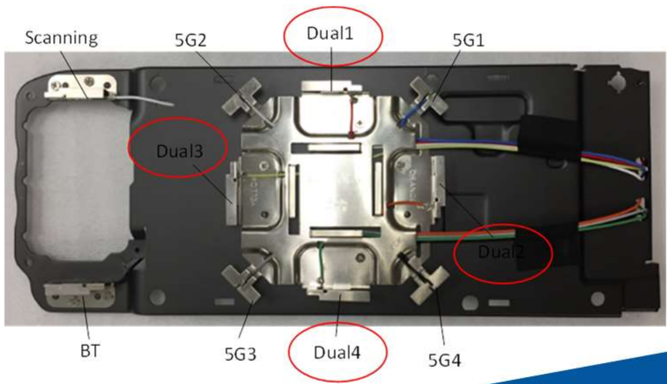




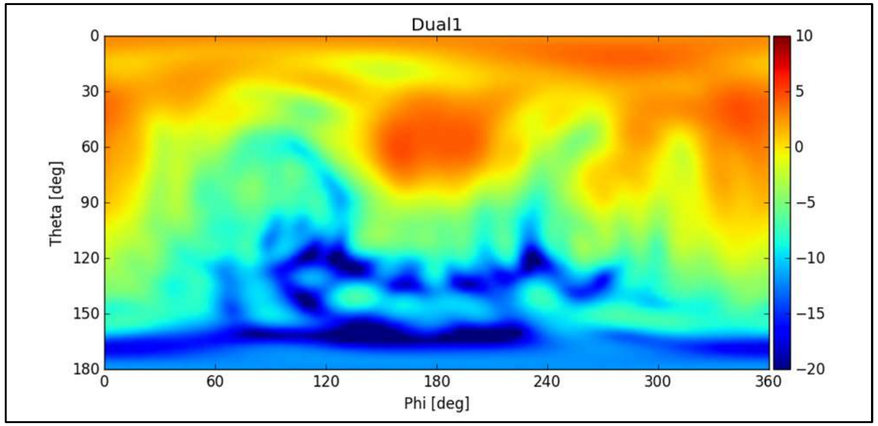


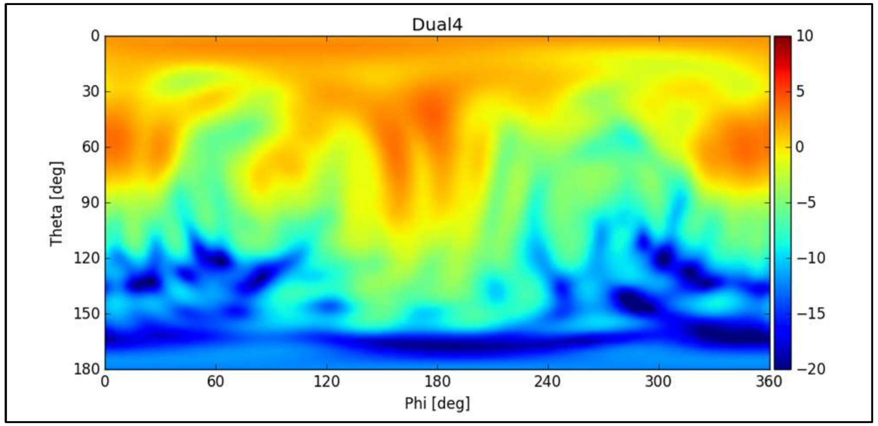


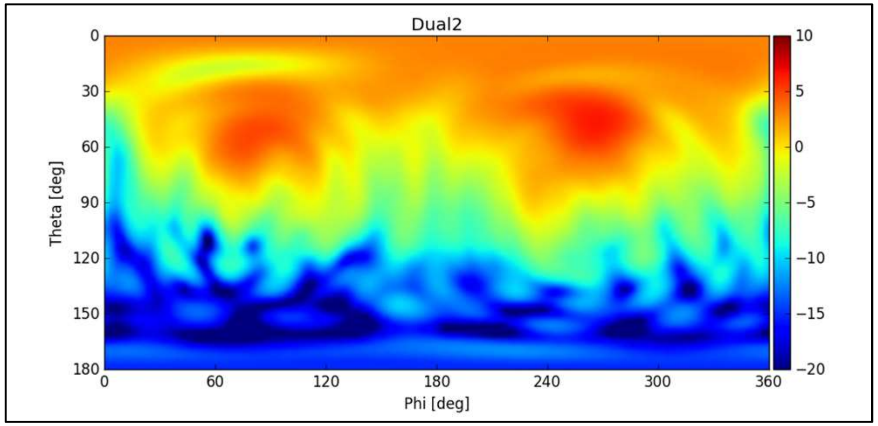


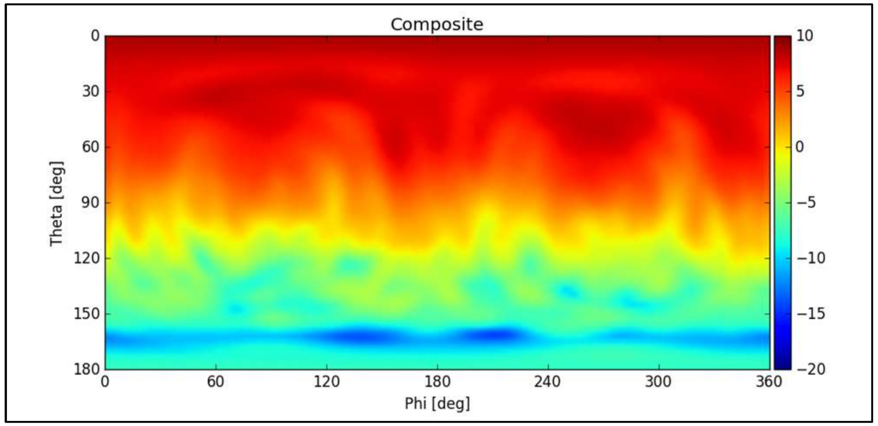


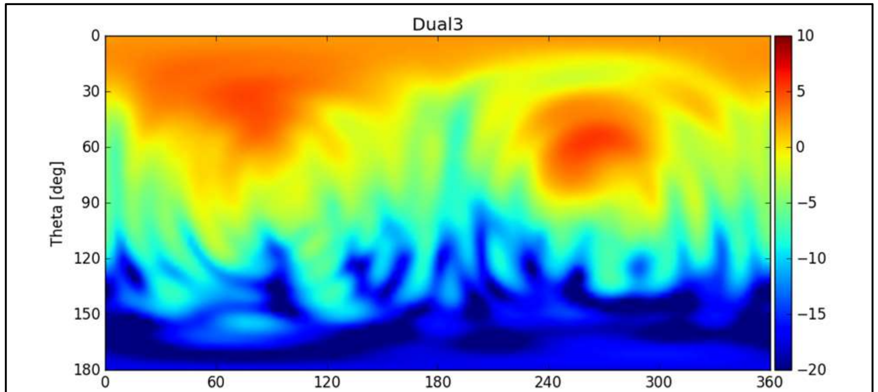
3D Radiation Pattern for Dual-Band @ 5GHz

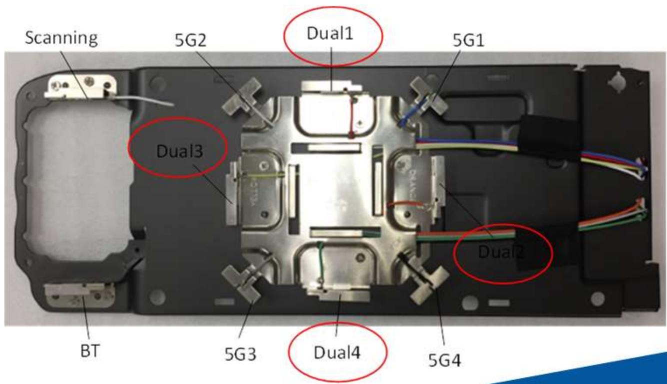




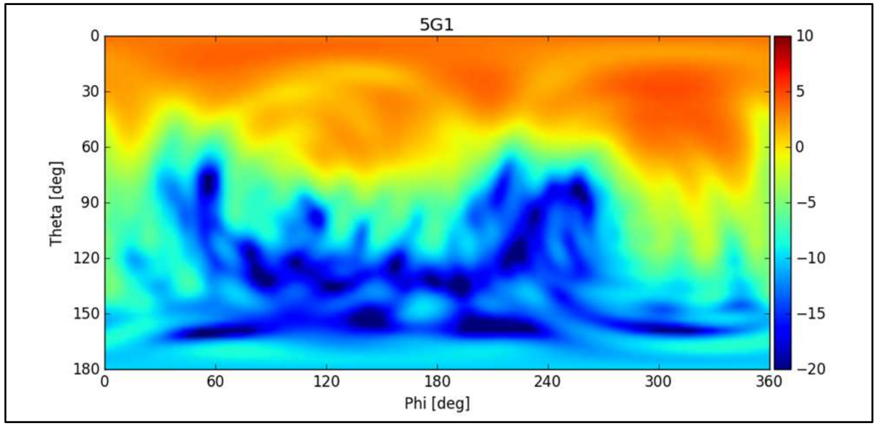


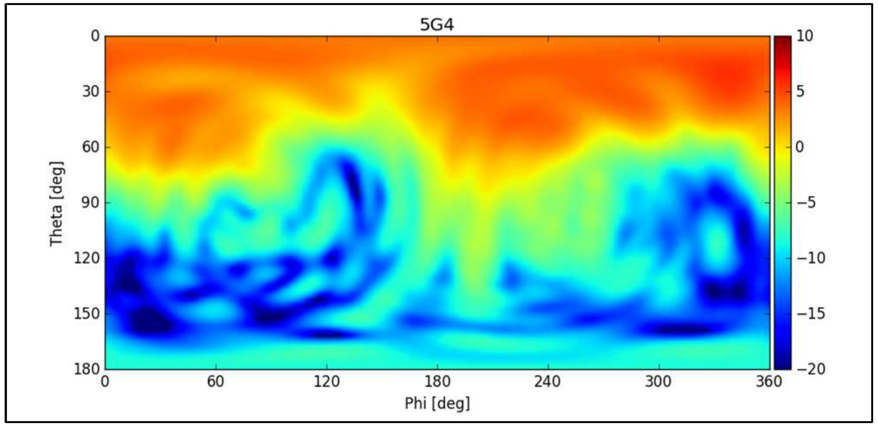


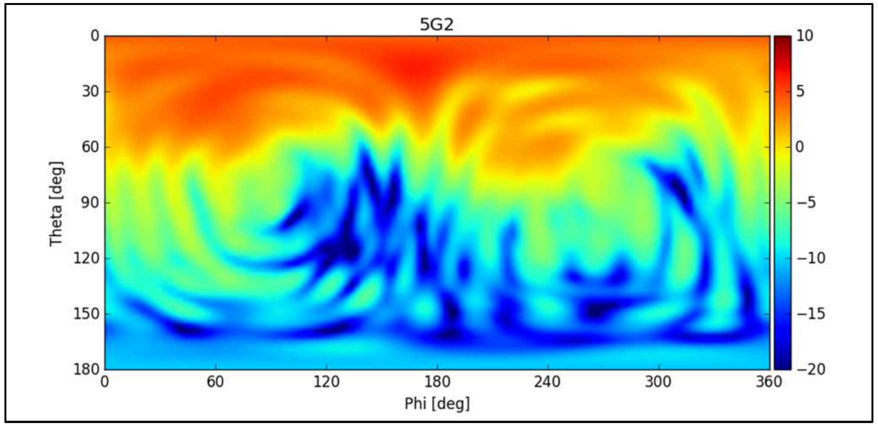


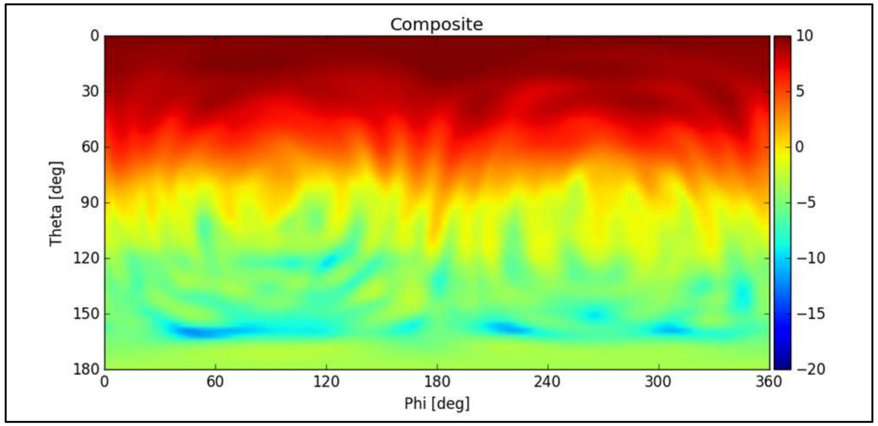


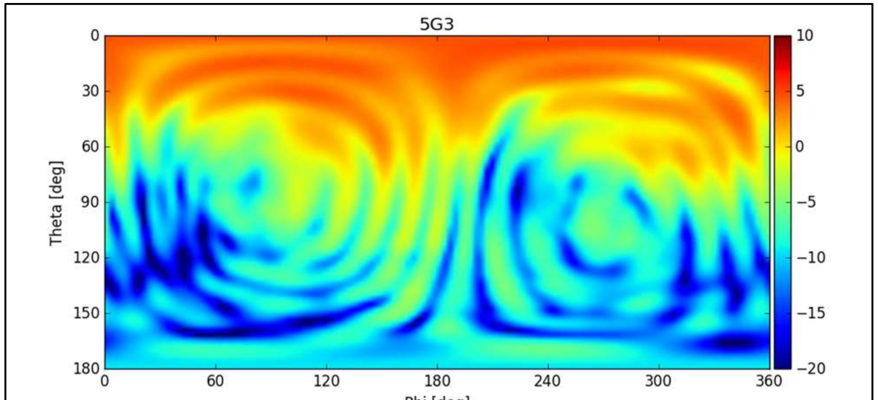
3D Radiation Pattern for 5G

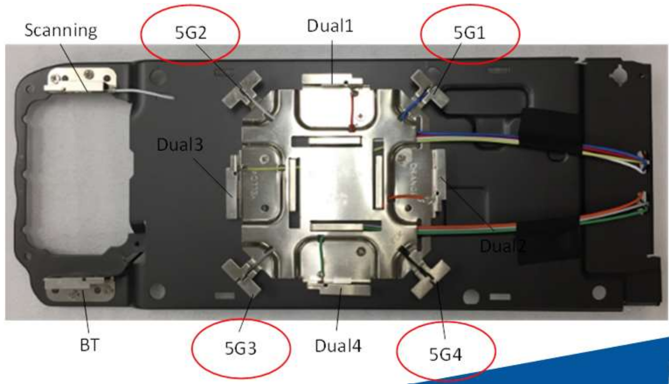




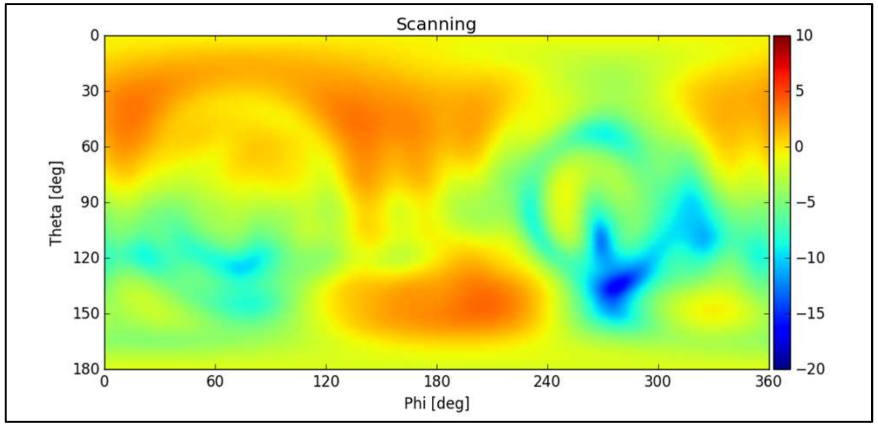


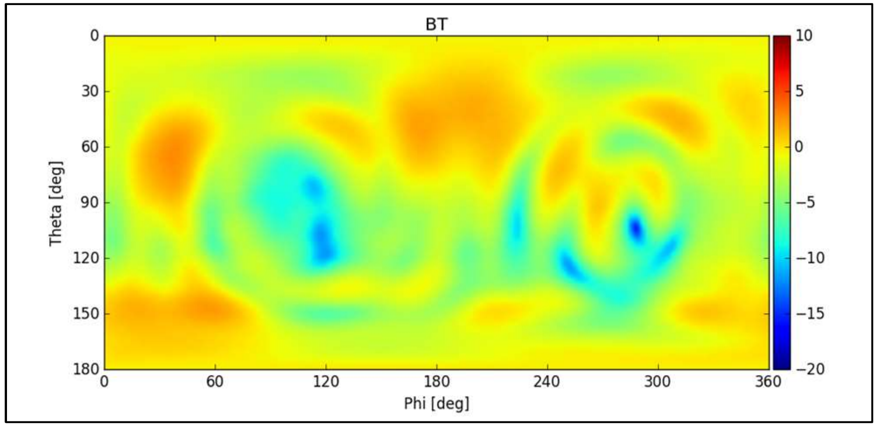




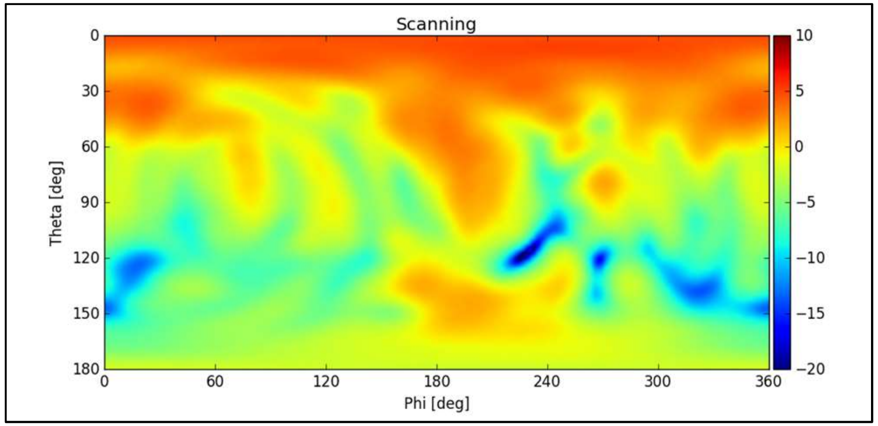


3D Radiation Pattern for Scanning / BT

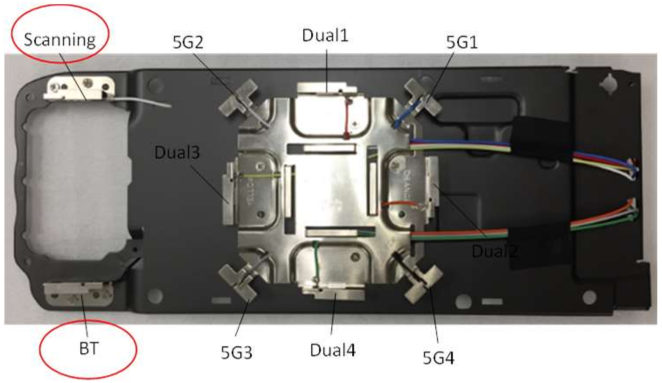




2.4G



5G



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