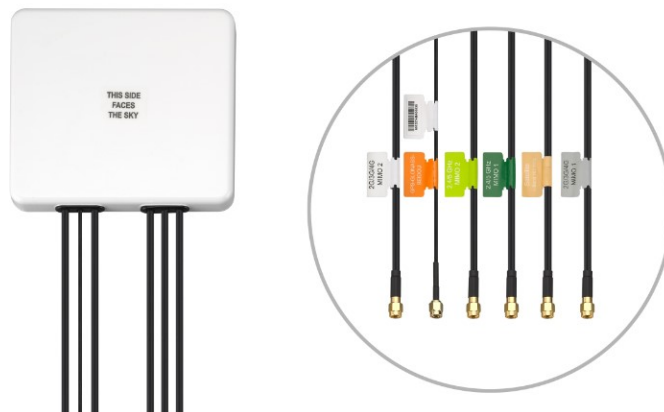


# DRAFT SPECIFICATION

PATENT PENDING

- Part No. : **MA931.A.LBICGH.001**
- Product Name : MA931 Guardian 6in1 Adhesive Mount Antenna  
LTE\*2+Wi-Fi\*3+GNSS
- Features : Low-profile Housing – Mounts flush to Wall  
2\* LTE MIMO 698-960MHz/1710-2170MHz/ 2490-2690MHz/ 3300-3600MHz  
3\* Wi-Fi MIMO 2.4GHz/5.8GHz  
1\* GPS-GLONASS-BeiDou Antenna  
Worldwide 4G Bands including 3G and 2G  
IP67 Waterproof Resistant Enclosure  
Dims: 146\*134\*20mm  
1M Low Loss KSR200-P and RG174 with SMA(M)/RP-SMA(M) connectors  
Cables and Connectors Customizable  
**RoHS Compliant**



## 1. Introduction

The MA931 Guardian is a next generation combination antenna. The first panel antenna worldwide designed for IoT Gateway and Router devices. It is a low profile 6in1 wall and adhesive mount antenna. It is a heavy-duty, fully IP67 waterproof resistant external M2M antenna for use by RF professionals in

- IoT Gateway and Routers
- HD Video Streaming
- Transportation
- Remote Monitoring Applications

This antenna delivers powerful MIMO antenna technology for worldwide 4G LTE bands at 698-960MHz /1710-2170MHz /2490-2690MHz /3300-3600MHz, dual-band 2.4/5.8GHz Wi-Fi, plus GPS-GLONASS-BeiDou for location accuracy. It enables designers to install only one antenna to cover all of these technologies.

4G wireless applications demand high speed data uplink and downlink. High efficiency and high gain MIMO antennas are necessary to achieve the required signal to noise ratio and throughput required to solve these challenges. Taoglas also takes care to have high isolation among these antennas to prevent self-interference. Low loss cables used to keep efficiency high over long cable lengths.

The GPS-GLONASS-BeiDou active antenna has been carefully designed for excellent performance across all GNSS bands, leading to higher location accuracy and stability of tracking in urban environments.

The housing dimension is 146\*134\*20mm. It is IP67 waterproof and comes with a 3M foam adhesive. The antenna can be mounted internally or externally on a vehicle. The MA931 comes with 1 meter, low loss KSR-200P coaxial cables for the LTE and Wi-Fi antennas, and RG174 coaxial cable for the GNSS antenna as standard. Customized cables and connector versions are also available.

## Specification

BeiDou-GPS-GLONASS				
Center Frequency	BeiDou:1561.098±2.046MHz GPS:1575.42±1.023MHz GLONASS:1602±5MHz			
Passive Antenna Efficiency(without cable loss)	BeiDou: 63% GPS: 48% GLONASS: 57%			
Passive Antenna Average Gain(without cable loss)	BeiDou: -1.97dBi GPS: -3.13dBi GLONASS: -2.39dBi			
Passive Antenna Peak Gain(without cable loss)	BeiDou: 3dBi GPS: 1.98dBi GLONASS: 3.01dBi			
VSWR	3:1 Max			
Impedance	50Ω			
Axial Ratio	BeiDou:<9.7 GPS:<14.02 GLONASS:<5.9			
Polarization	RHCP			
Cable	1 meter RG174 standard, fully customizable			
Connector	SMA(M) standard, fully customizable			
LNA and Filter Electrical Properties				
Center Frequency	BeiDou: 1561.098±2.046MHz GPS:1575.42±1.023MHz GLONASS:1602±5MHz			
Output Impedance	50Ω			
VSWR	< 2:1			
Return Loss	10dB Min.			
LNA Gain, Current Draw, and Noise Figure@GPS	Voltage	LNA Gain(Typ)	Current Draw(mA) Typ	Noise Figure(Typ)
	Min 1.8V	28dB	7.9mA	1.13dB
	Typ 3.0V	30dB	9.0mA	1.13dB
	Max 5.5V	33dB	9.9mA	1.14dB
Total Specification(Through Antenna, SAW Filter, and LNA)				
Frequency	1561.098±2.046MHz	1575.42±1.023MHz	1602±5MHz	
Gain@3V	1561MHz:28±3dBi	1575.42MHz:28±3dBi	1602MHz:28±3dBi	
Output Impedance	50Ω			

## 2G/3G/4G LTE Antenna

Frequency (MHz)		LTE700	GSM850	GSM900	DCS	PCS	UMTS1	LTE2600	LTE3500
		698~803	824~894	880~960	1710~1880	1850~1990	1920~2170	2490~2690	3300~3600
<b>Efficiency (%)</b>									
MIMO_1	Free space	50.82	55.85	41.29	66.47	70.19	71.51	49.20	50.92
	ABS	68.31	69.61	61.27	66.31	70.86	70.00	50.61	51.88
	Glass	67.99	67.37	62.94	66.89	71.80	69.58	51.00	52.83
	Metal	42.12	51.55	58.33	39.49	47.20	47.71	44.36	44.85
	Wall	67.97	70.42	66.80	63.91	64.94	63.35	50.37	51.49
MIMO_2	Free space	54.13	58.97	48.65	61.54	68.31	68.39	54.62	52.55
	ABS	71.74	66.05	58.58	63.18	69.29	69.23	53.95	54.95
	Glass	64.53	55.70	45.22	64.94	67.87	65.86	50.05	51.77
	Metal	55.62	63.13	56.59	32.14	40.89	43.97	54.22	52.90
	Wall	61.91	48.38	52.88	58.00	56.47	56.36	54.68	48.72
<b>Average Gain (dBi)</b>									
MIMO_1	Free space	-2.96	-2.62	-3.85	-1.78	-1.54	-1.46	-3.12	-2.96
	ABS	-1.68	-1.59	-2.13	-1.79	-1.50	-1.55	-3.00	-2.87
	Glass	-1.73	-1.73	-2.02	-1.75	-1.44	-1.58	-2.96	-2.79
	Metal	-3.94	-2.88	-2.37	-4.07	-3.27	-3.23	-3.57	-3.51
	Wall	-1.70	-1.53	-1.76	-1.95	-1.88	-1.99	-3.00	-2.89
MIMO_2	Free space	-2.72	-2.32	-3.17	-2.11	-1.66	-1.66	-2.65	-2.83
	ABS	-1.47	-1.81	-2.33	-2.00	-1.59	-1.60	-2.71	-2.63
	Glass	-1.93	-2.56	-3.46	-1.88	-1.68	-1.82	-3.04	-2.87
	Metal	-2.61	-2.00	-2.50	-4.95	-3.90	-3.59	-2.67	-2.77
	Wall	-2.09	-3.15	-2.79	-2.37	-2.48	-2.50	-2.63	-3.15
<b>Peak Gain (dBi)</b>									
MIMO_1	Free space	3.18	3.60	2.14	3.98	4.37	4.37	3.70	4.49
	ABS	4.65	4.00	3.45	5.24	6.05	6.05	4.69	3.18
	Glass	3.71	3.92	4.35	5.28	6.16	7.67	5.34	3.87
	Metal	5.09	3.10	4.73	4.50	4.96	5.69	6.02	4.96
	Wall	4.74	4.97	3.67	5.44	4.84	4.84	5.08	3.75
MIMO_2	Free space	5.83	3.66	2.57	3.78	4.01	4.01	3.87	3.97
	ABS	4.33	4.52	4.41	4.34	4.73	5.69	5.64	5.42
	Glass	3.02	3.14	1.36	4.99	5.89	6.02	6.18	4.42
	Metal	3.54	3.11	3.33	3.12	4.36	5.02	7.16	4.95
	Wall	3.21	1.77	2.15	5.49	5.49	7.20	6.10	4.74
Impedance				50Ω					
Polarization				Linear					
VSWR				< 3					
Cable				1 meter KSR200-P standard, fully customizable					
Connector				SMA(M) standard, fully customizable					

2.4GHz/5.8GHz Wi-Fi Antenna			
Frequency (MHz)		2400~2500	4900~5850
<b>Efficiency (%)</b>			
MIMO_1	Free space	57.73	48.06
	ABS	53.59	49.42
	Glass	53.98	47.16
	Metal	51.80	46.70
	Wall	61.02	46.29
MIMO_2	Free space	44.09	47.04
	ABS	46.34	46.79
	Glass	40.79	46.88
	Metal	45.58	45.59
	Wall	50.62	43.60
MIMO_3	Free space	TBC	TBC
	ABS	TBC	TBC
	Glass	TBC	TBC
	Metal	TBC	TBC
	Wall	TBC	TBC
<b>Average Gain (dBi)</b>			
MIMO_1	Free space	-2.39	-3.25
	ABS	-2.71	-3.13
	Glass	-2.68	-3.36
	Metal	-2.86	-3.44
	Wall	-2.15	-3.42
MIMO_2	Free space	-3.57	-3.33
	ABS	-3.37	-3.36
	Glass	-3.91	-3.35
	Metal	-3.45	-3.52
	Wall	-2.96	-3.67
MIMO_3	Free space	TBC	TBC
	ABS	TBC	TBC
	Glass	TBC	TBC
	Metal	TBC	TBC
	Wall	TBC	TBC
<b>Peak Gain (dBi)</b>			
MIMO_1	Free space	4.35	4.84
	ABS	5.34	5.18
	Glass	2.99	5.03
	Metal	5.22	5.98
	Wall	5.47	5.77
MIMO_2	Free space	2.94	5.70
	ABS	2.18	5.43
	Glass	3.75	7.07
	Metal	6.02	6.76
	Wall	3.23	5.97
MIMO_3	Free space	TBC	TBC
	ABS	TBC	TBC
	Glass	TBC	TBC
	Metal	TBC	TBC
	Wall	TBC	TBC

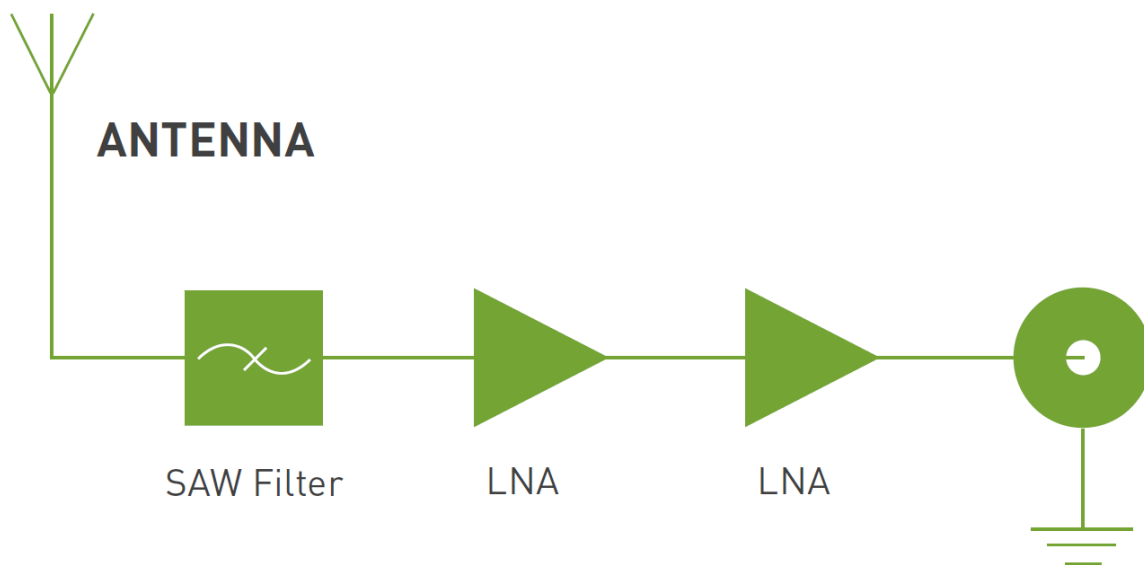
2.4GHz/5.8GHz Wi-Fi Antenna	
Impedance	50Ω
Polarization	Linear
VSWR	< 3
Cable	1 meter KSR200-P standard, fully customizable
Connector	RP-SMA(M) standard, fully customizable

MECHANICAL	
Antenna Dimensions	146*134*20mm
Casing	ASA
Weight (including cable)	438g
Ingress Protection Rating	IP67
ENVIRONMENTAL	
Operation Temperature	-40°C to 85°C
Storage Temperature	-40°C to 90°C
Humidity	Non-condensing 65°C 95% RH

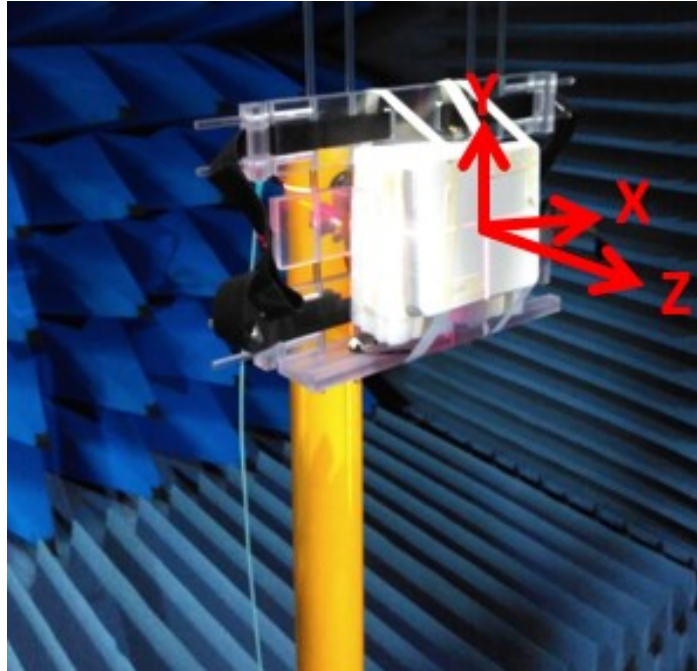
## 3. Antenna Characteristics

### 3.1 BeiDou-GPS-GLONASS

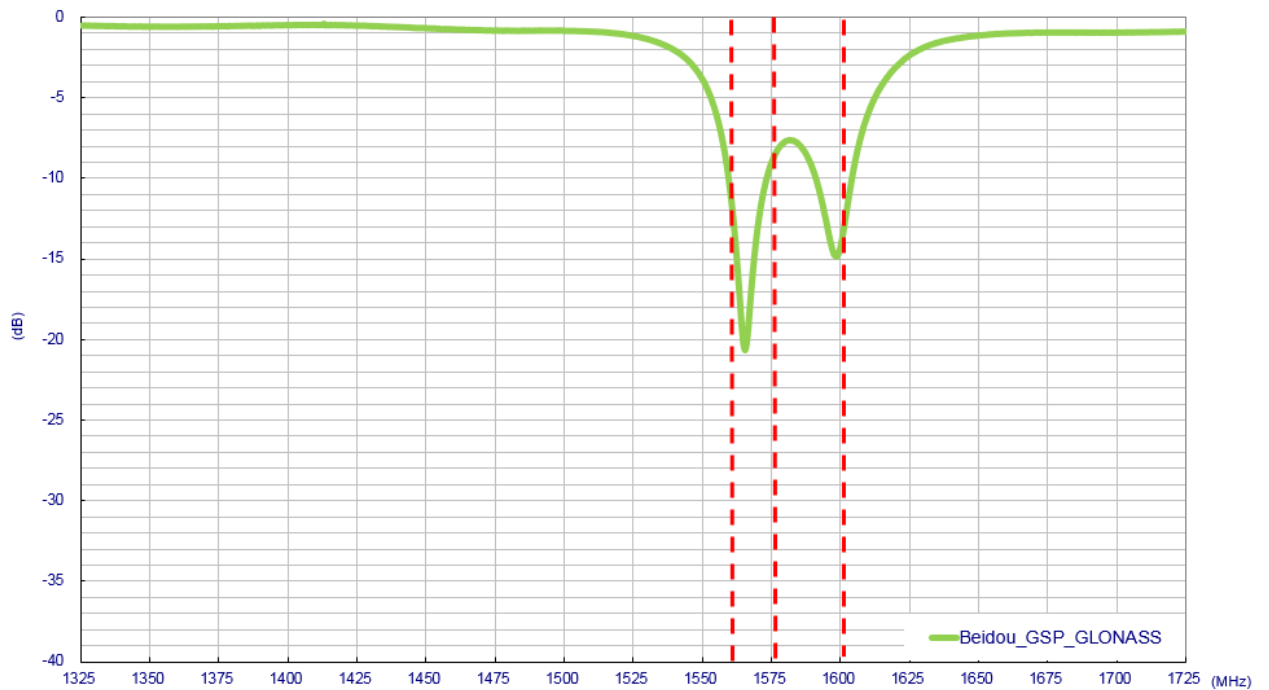
#### 3.1.1 Block Diagram (Active antenna)



### 3.1.2 Test Setup

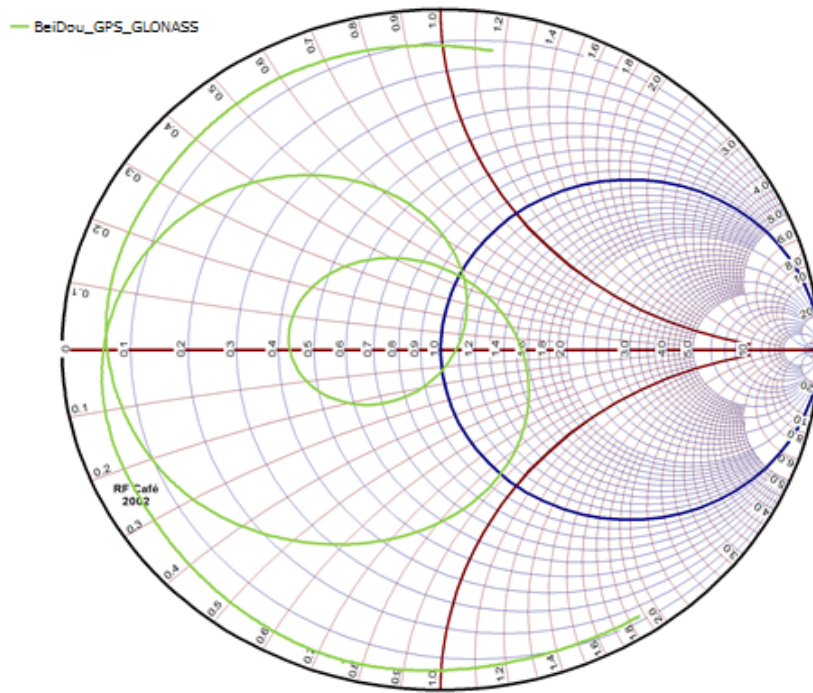


### 3.1.3 BeiDou-GPS-GLONASS Return Loss (Passive antenna)

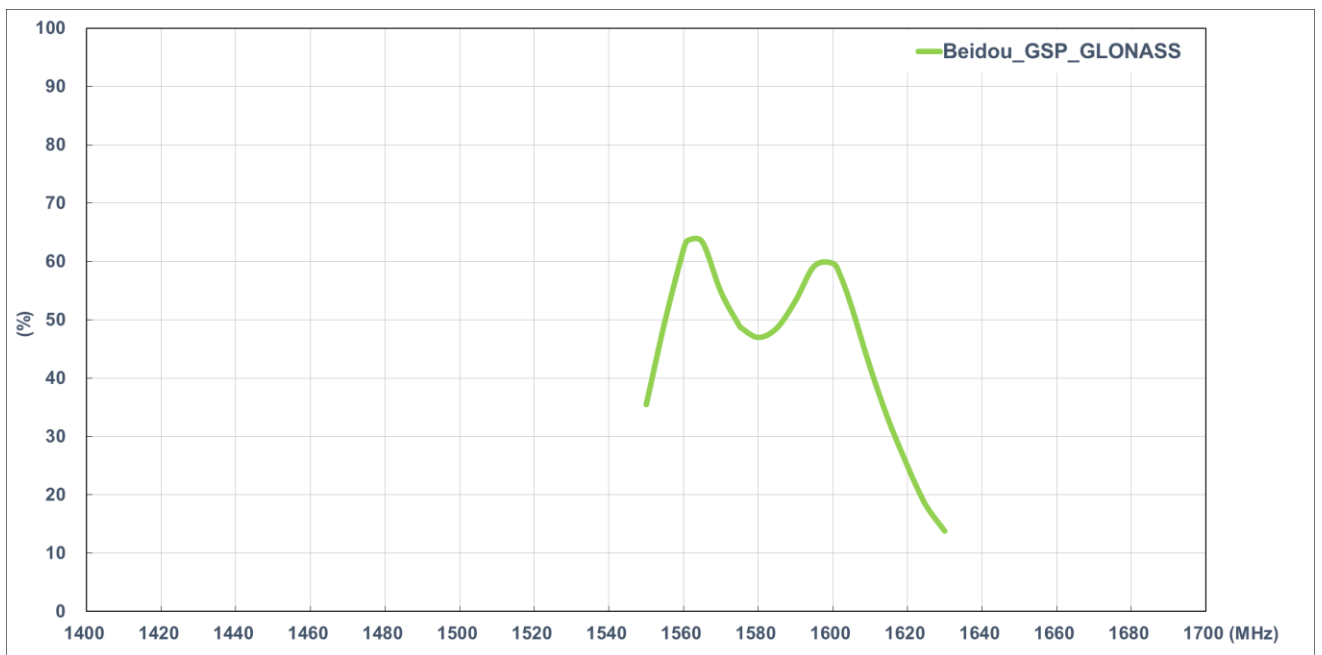




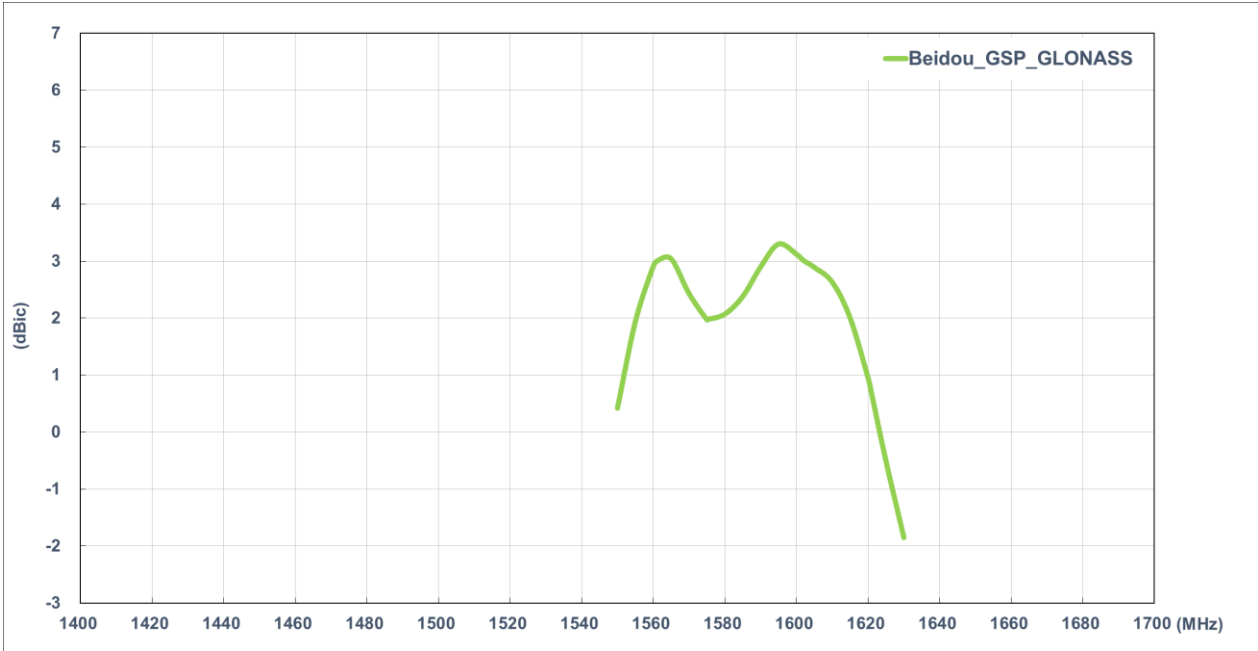
### 3.1.4 BeiDou-GPS-GLONASS Smith Chart (Passive antenna)



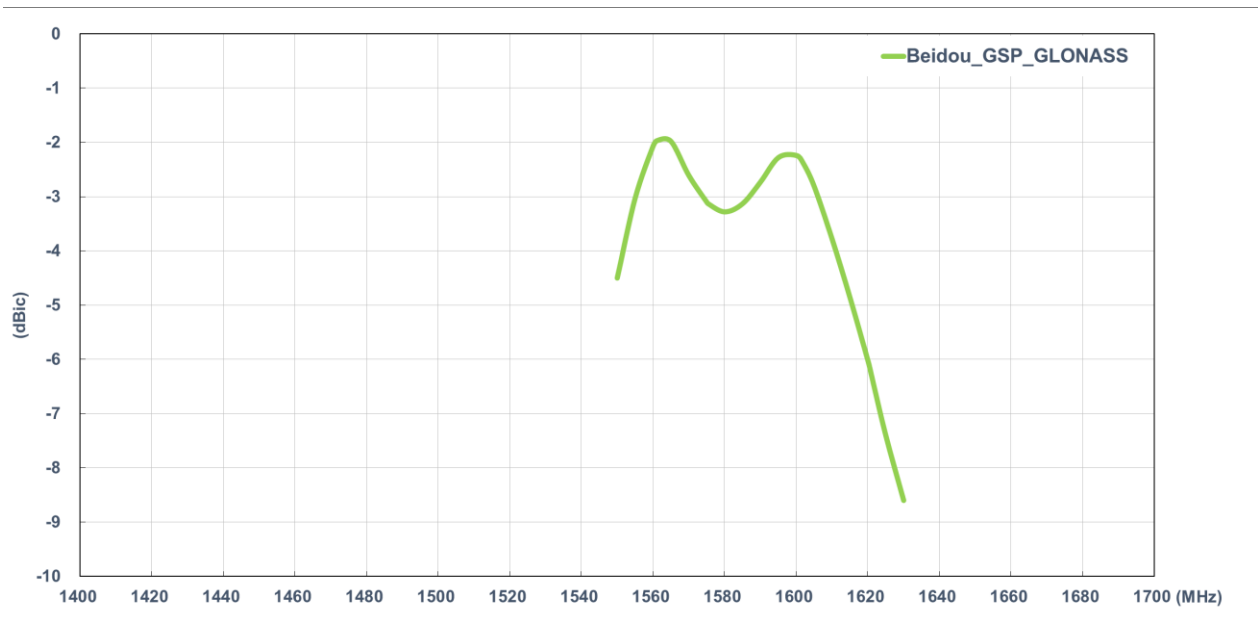
### 3.1.5 BeiDou-GPS-GLONASS Efficiency (Passive antenna)



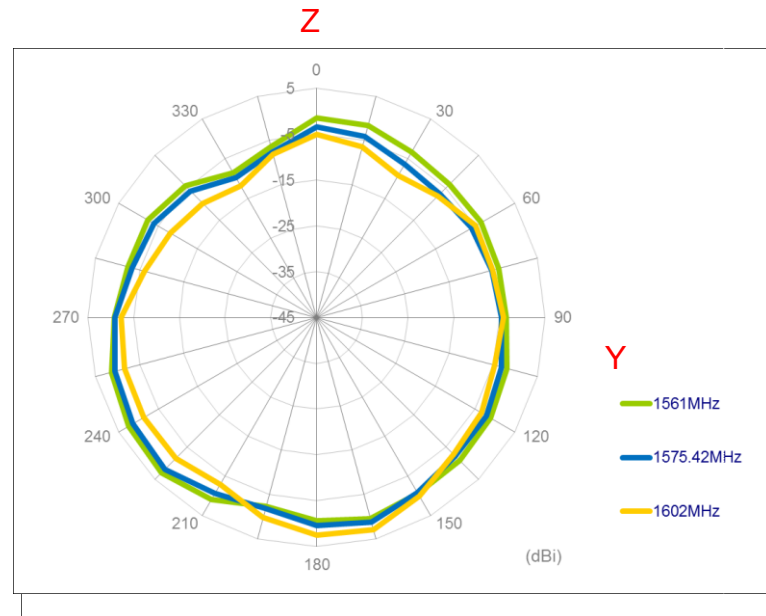
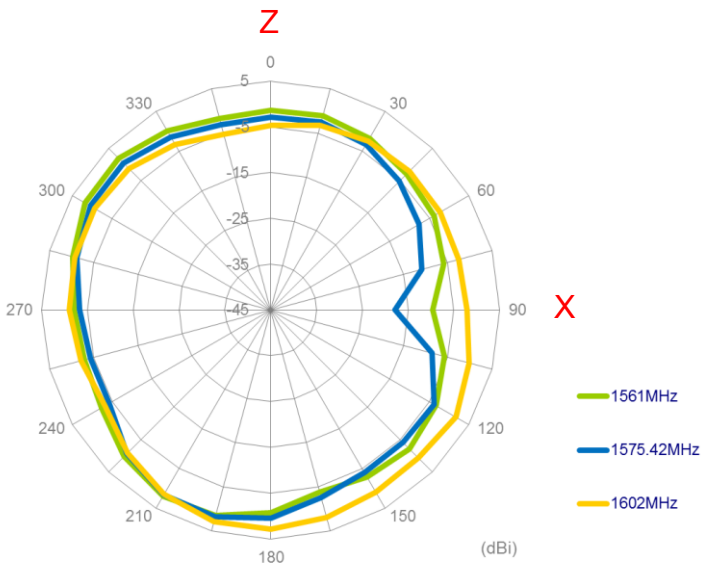
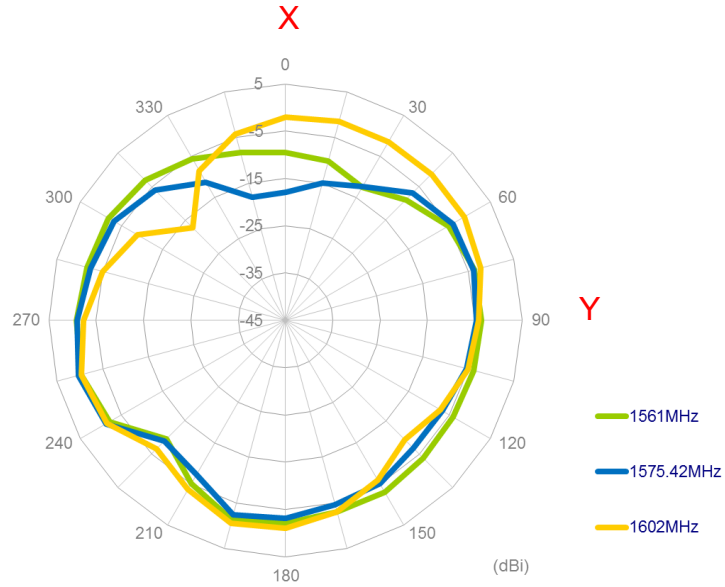
### 3.1.6 BeiDou-GPS-GLONASS Peak Gain (Passive antenna)



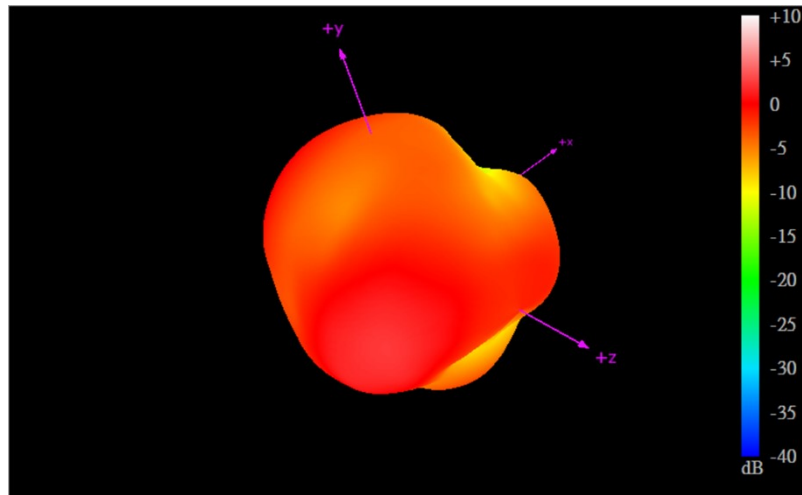
### 3.1.7 BeiDou-GPS-GLONASS Average Gain (Passive antenna)



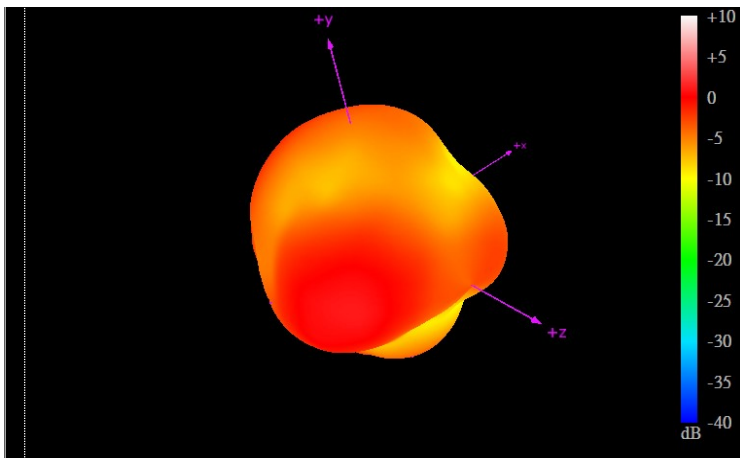
### 3.1.8 BeiDou-GPS-GLONASS Radiation Pattern (Passive antenna) 2D Radiation Pattern



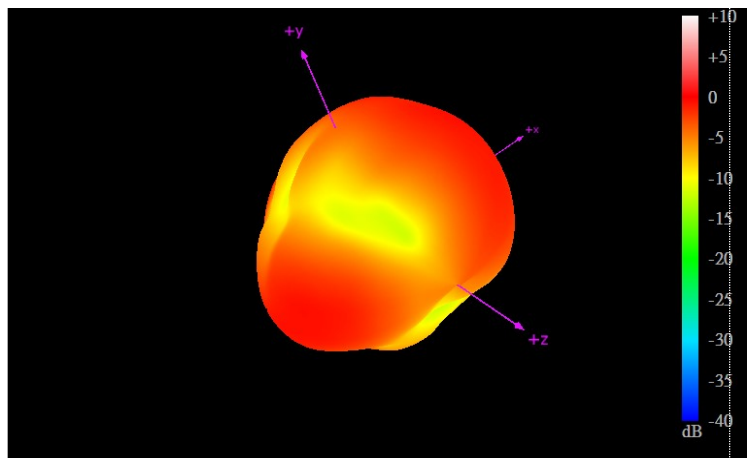
3D Radiation Pattern (Passive antenna)



1561MHz

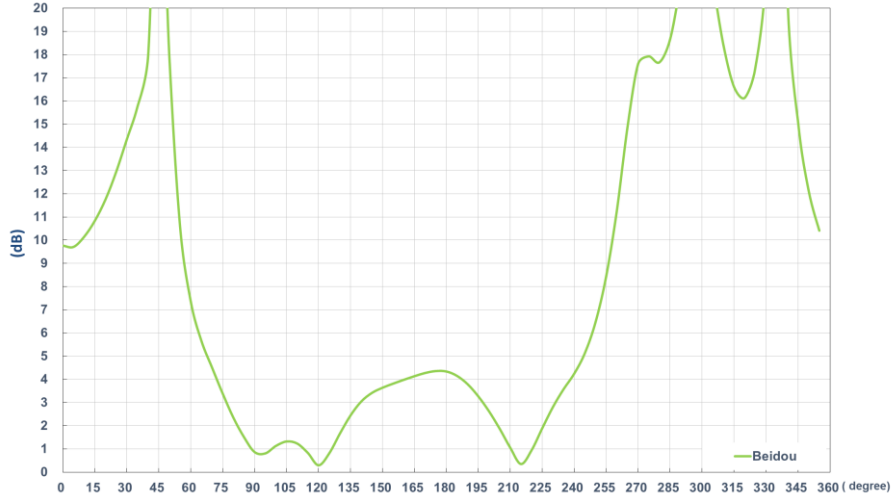


1575.42MHz

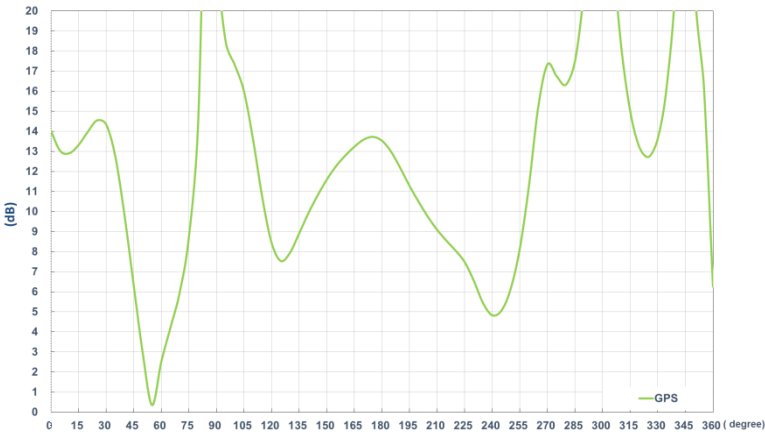


1602MHz

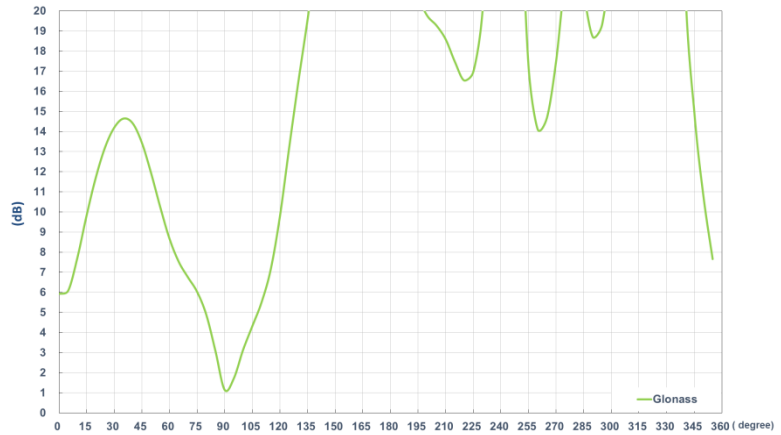
### 3.1.9 Axial Ratio (Passive antenna)



1561MHz

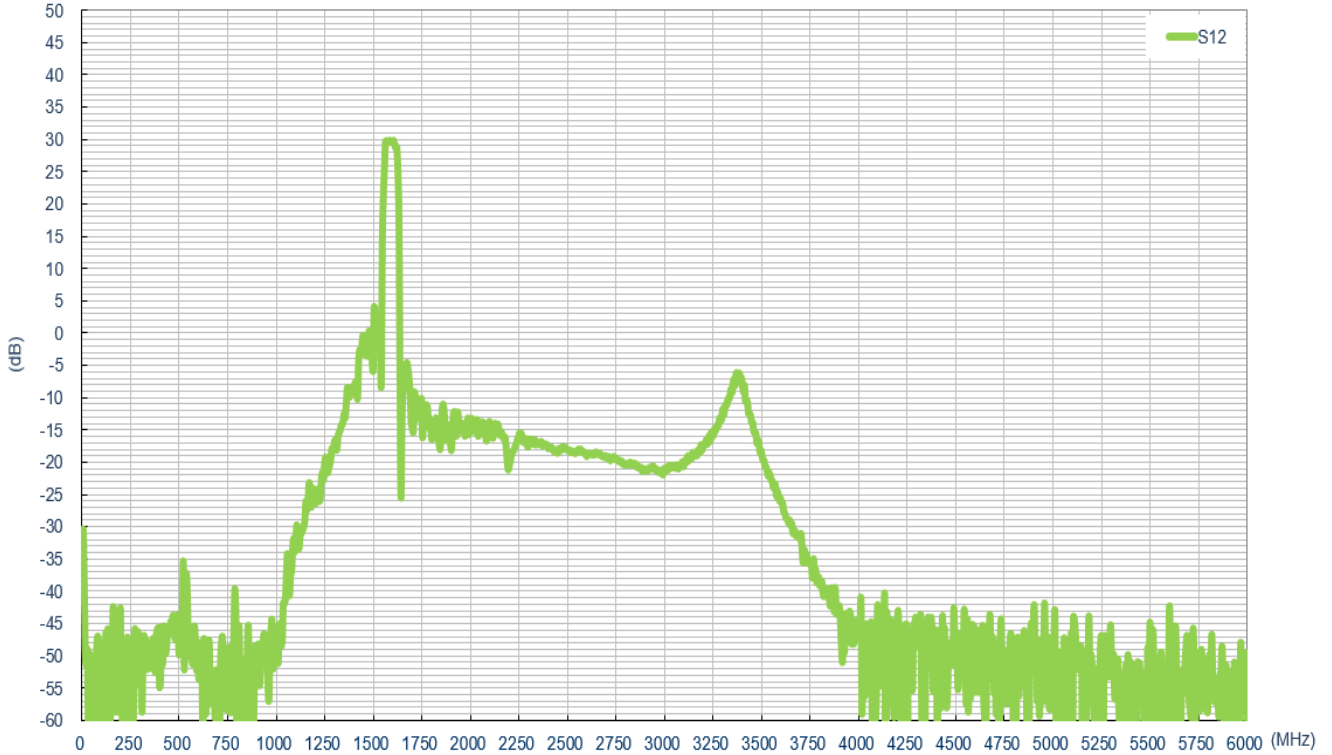


1575.42MHz

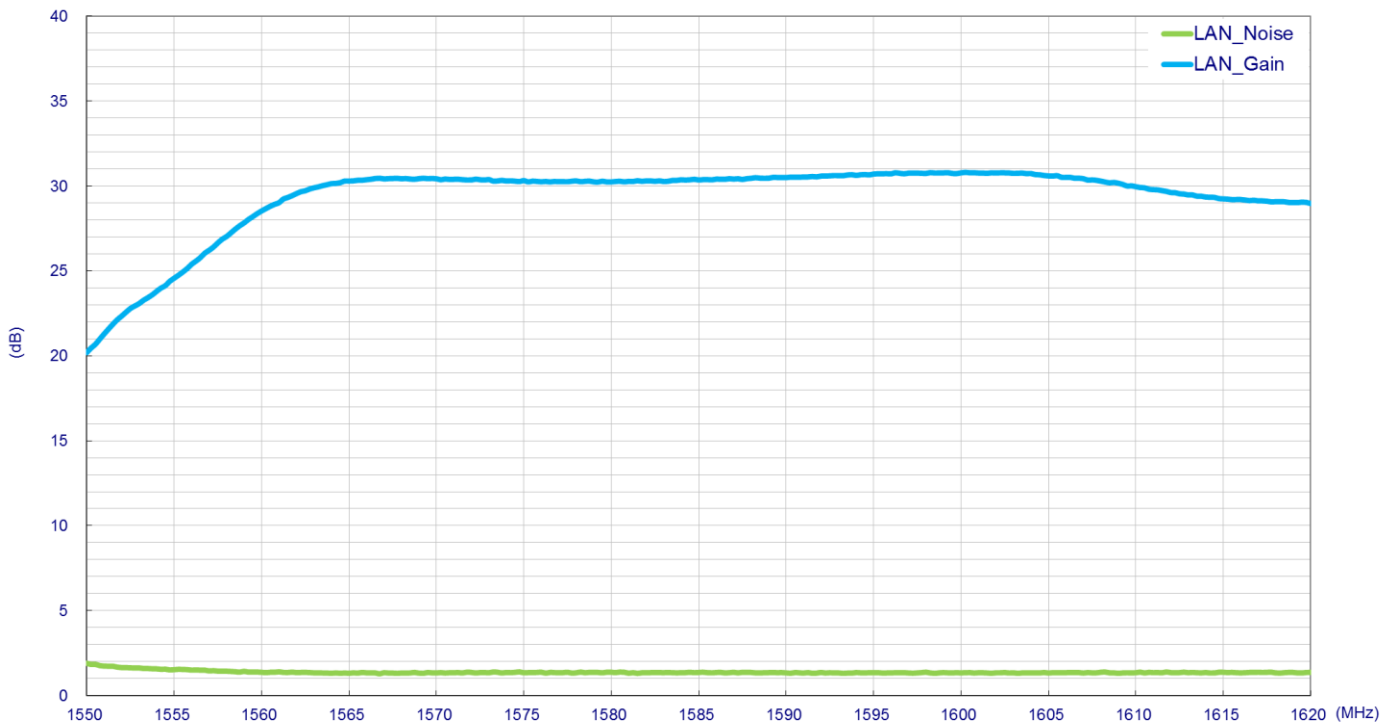


1602MHz

### 3.1.10 BeiDou-GPS-GLONASS LNA Gain and Noise Figure (Active antenna)



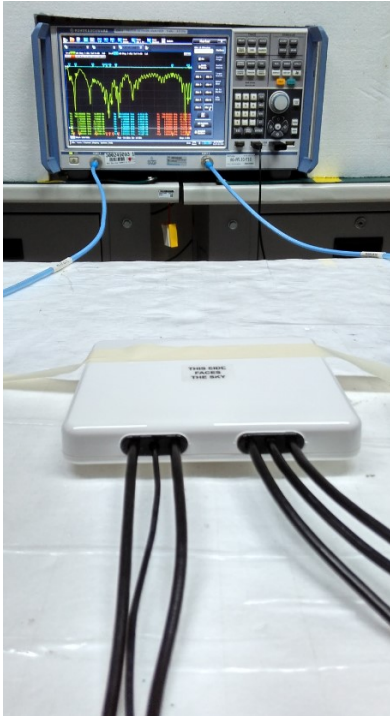
LNA Gain@3.0V



LNA Noise Figure @3.0V

### 3.2 LTE\_MIMO/Wi-Fi\_MIMO Antenna

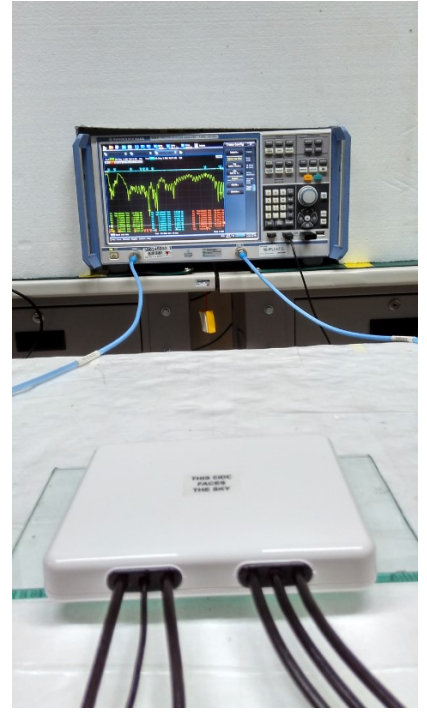
#### 3.2.1 Test Setup



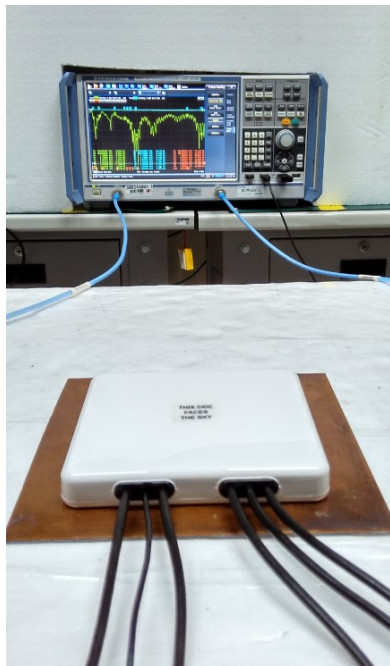
Free space



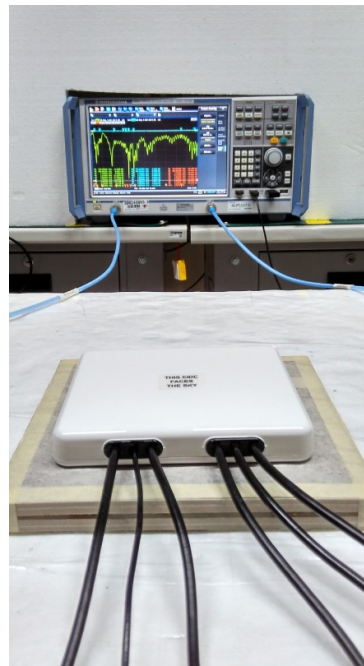
ABS



Glass



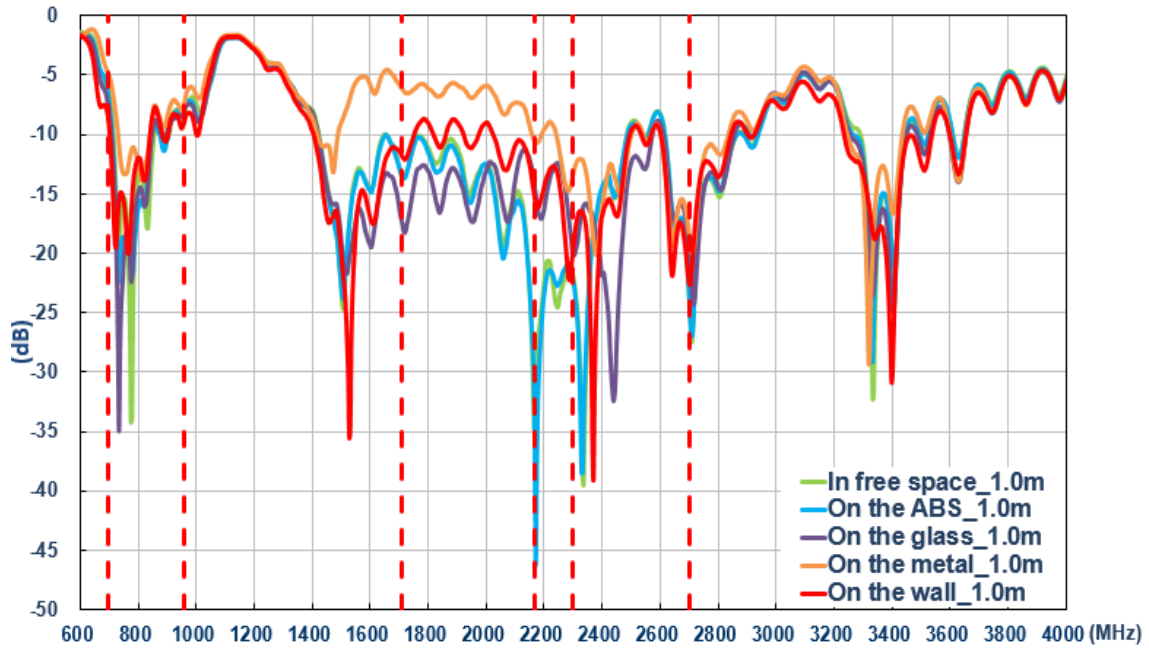
Metal



Wall

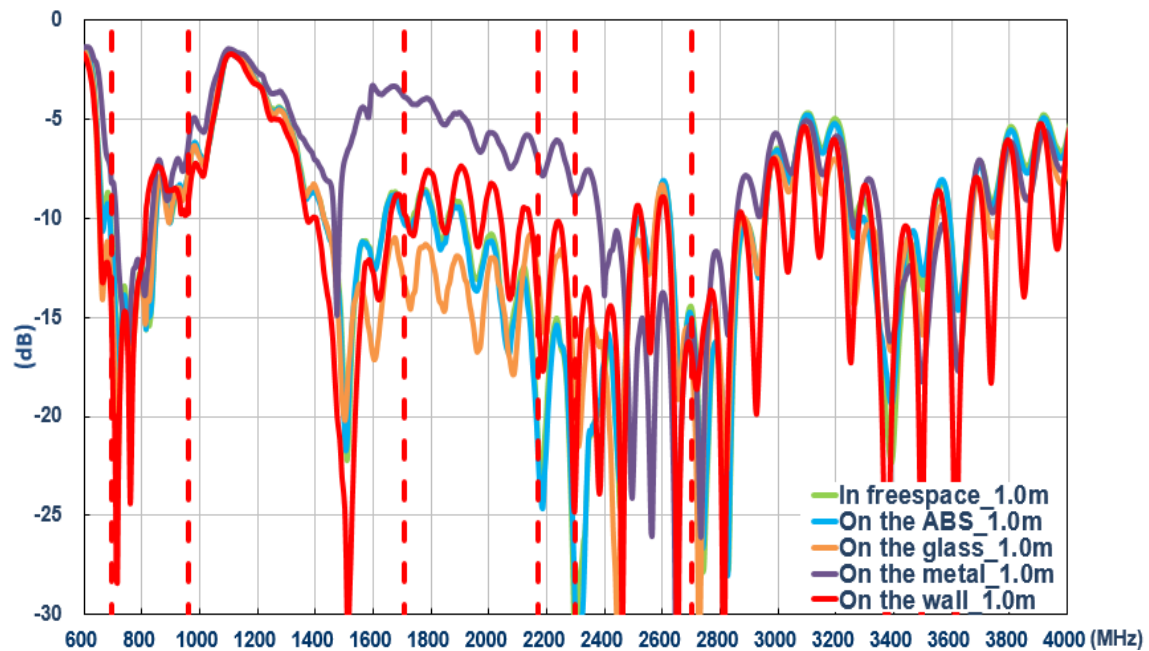
### 3.2.2 LTE\_1 Antenna Return Loss

Performance in different environments with 1 meter cable length



### 3.2.3 LTE\_2 Antenna Return Loss

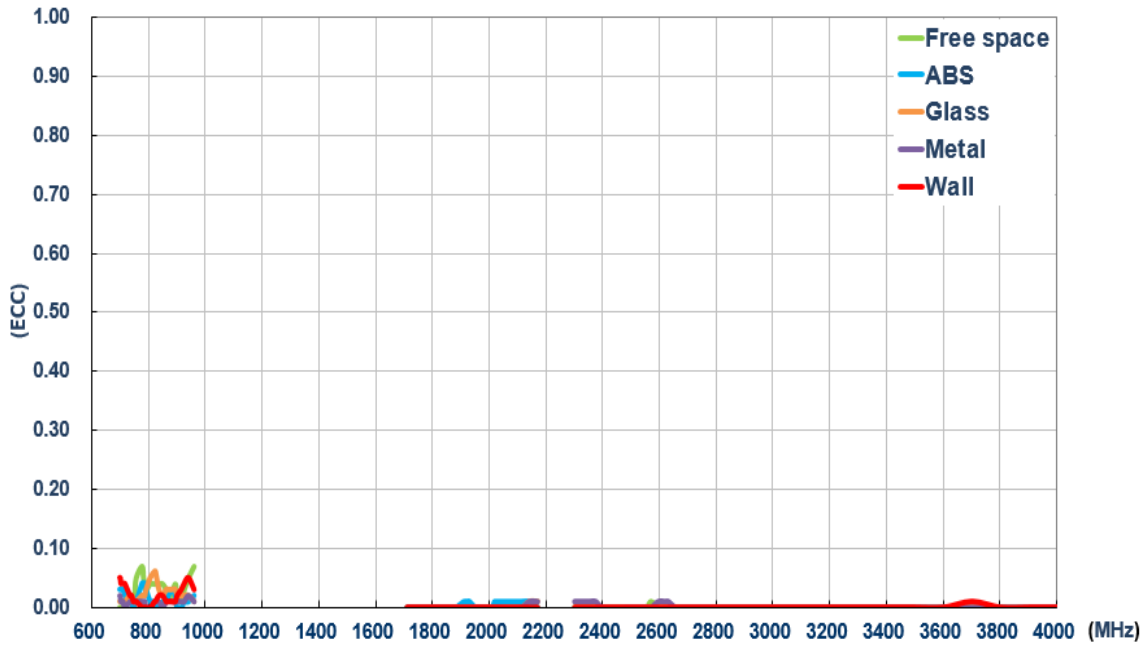
Performance in different environments with 1 meter cable length





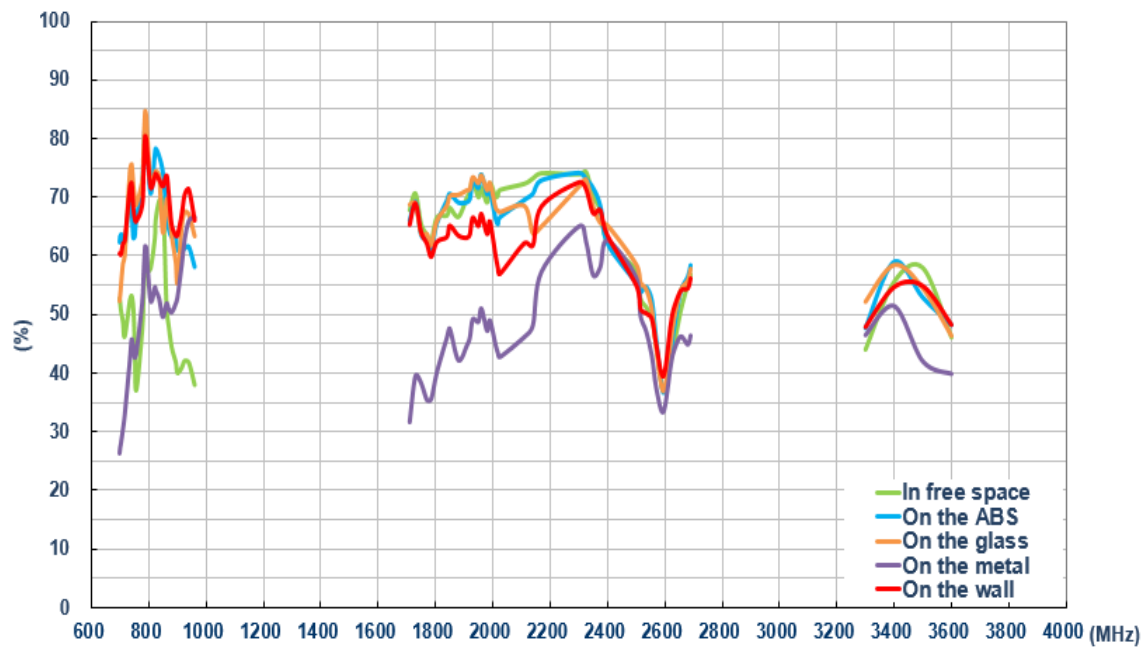
### 3.2.4 LTE Envelope Correlation Coefficient

Performance in different environments with 1 meter cable length



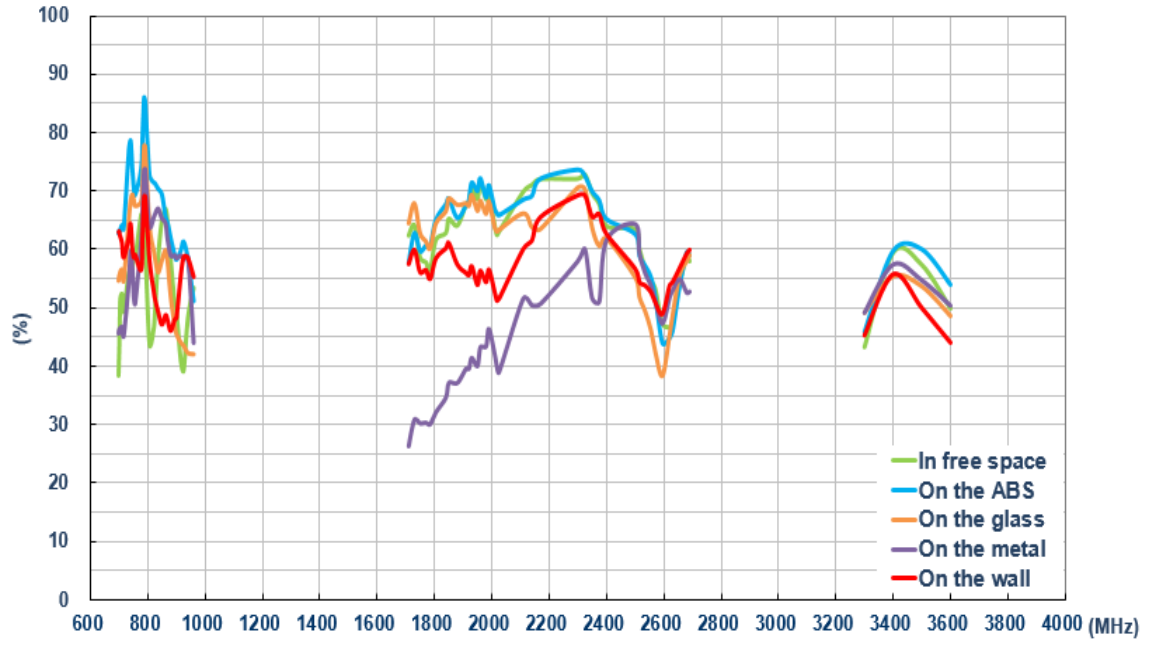
### 3.2.5 LTE\_1 Antenna Efficiency

Performance in different environments with 1 meter cable length



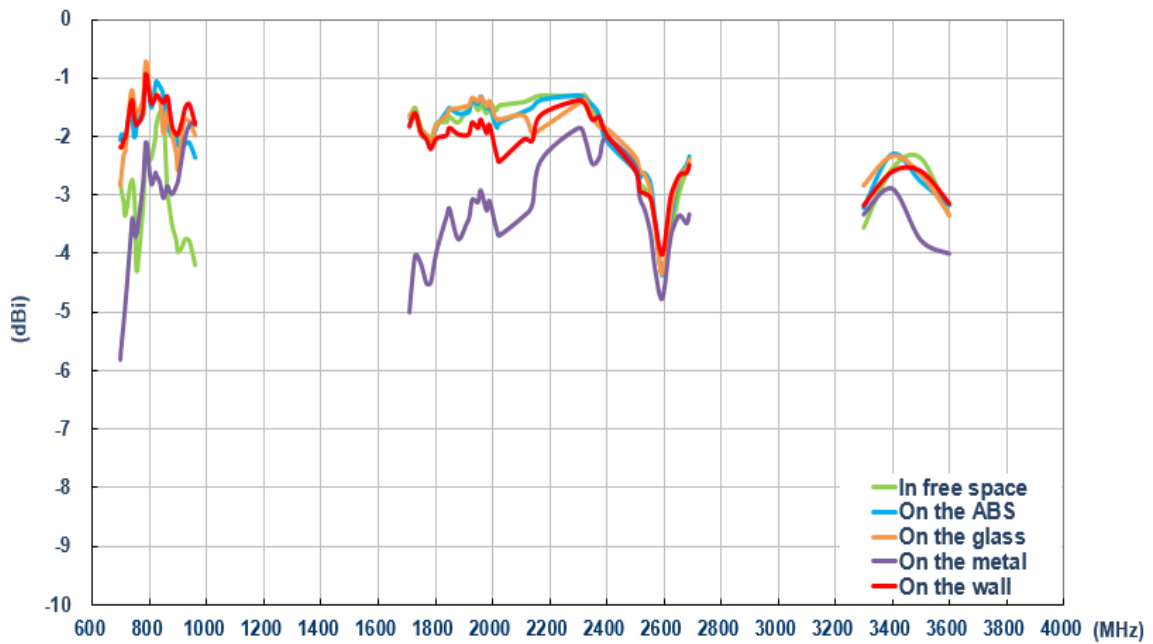
### 3.2.6 LTE\_2 Antenna Efficiency

Performance in different environments with 1 meter cable length



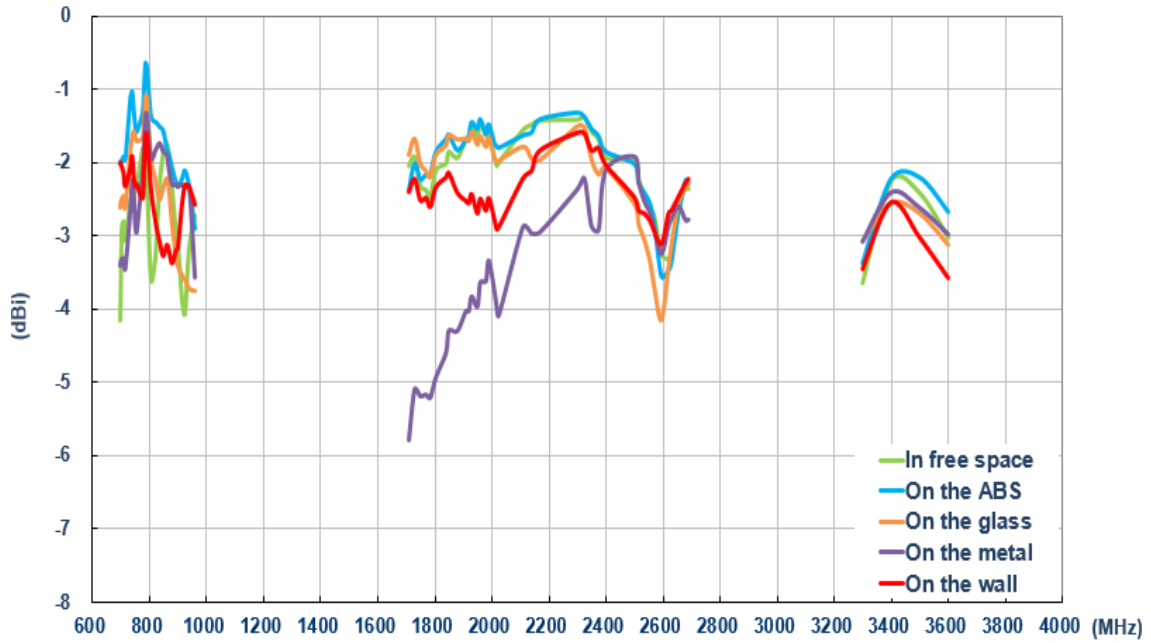
### 3.2.7 LTE\_1 Antenna Average Gain

Performance in different environments with 1 meter cable length



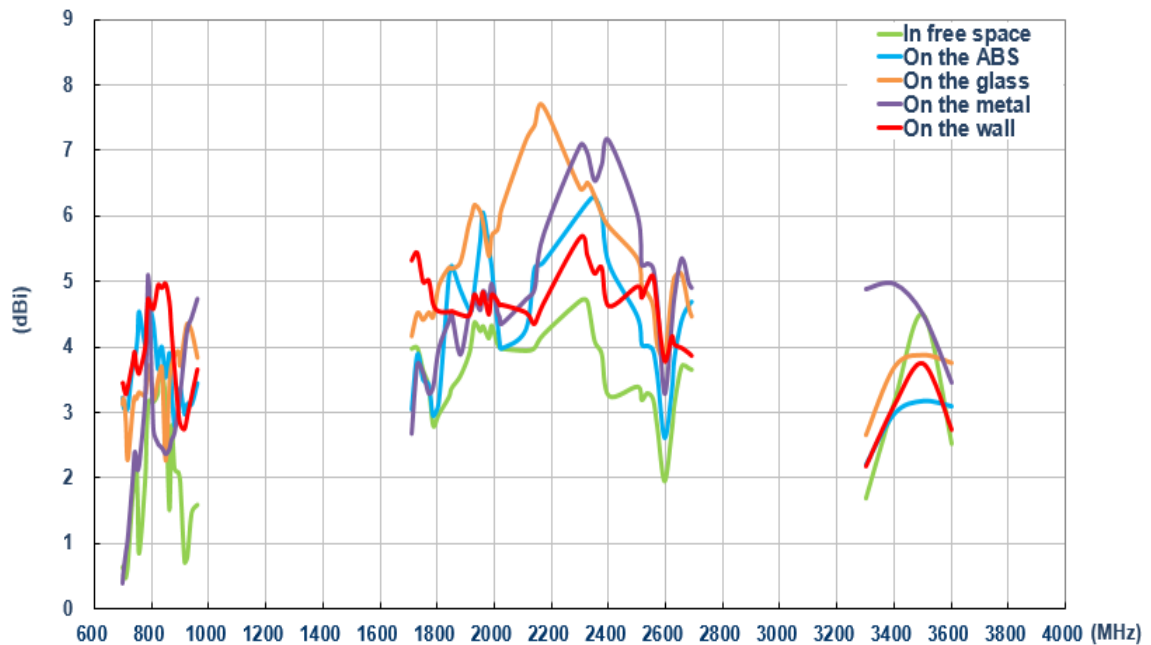
### 3.2.8 LTE\_2 Antenna Average Gain

Performance in different environments with 1 meter cable length



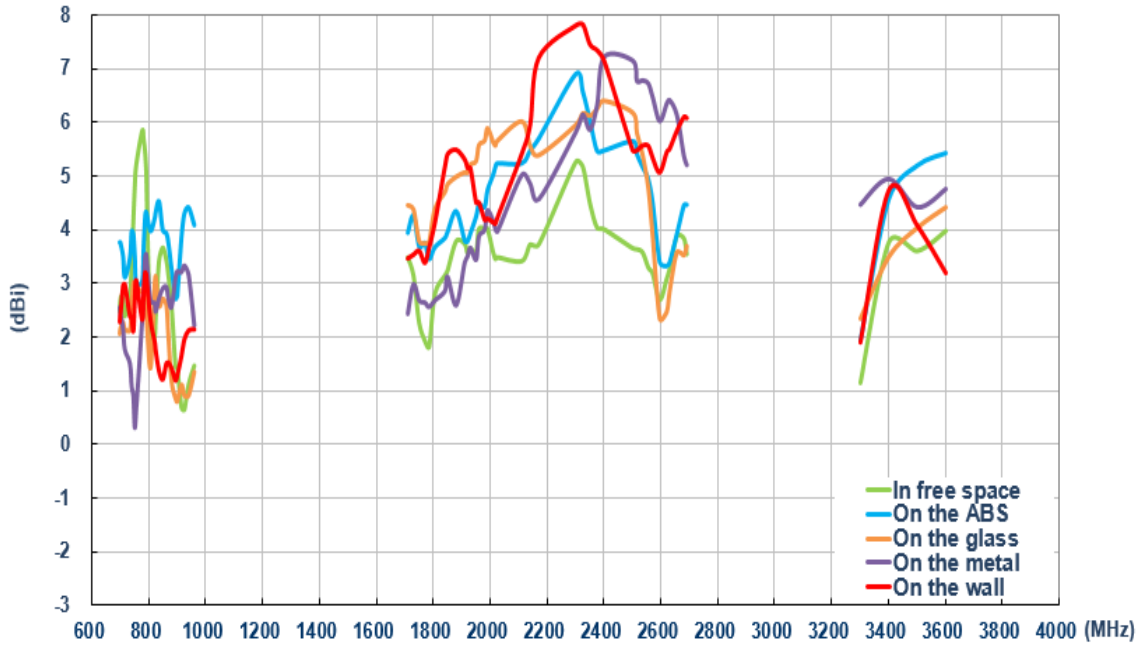
### 3.2.9 LTE\_1 Antenna Peak Gain

Performance in different environments with 1 meter cable length



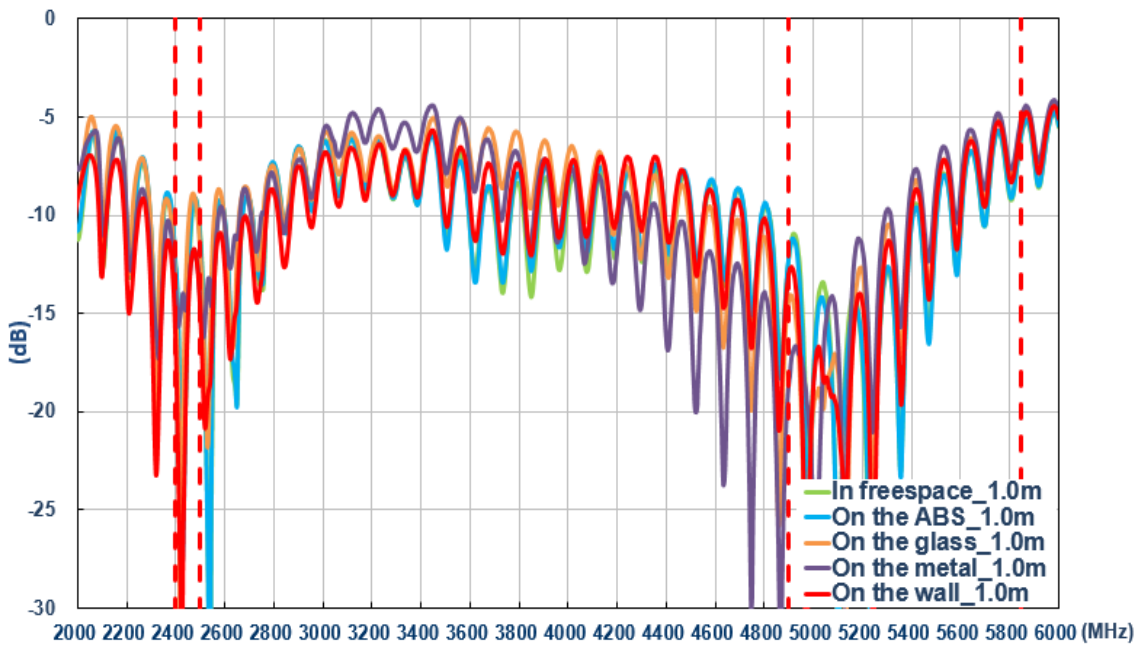
### 3.2.10 LTE\_2 Antenna Peak Gain

Performance in different environments with 1 meter cable length



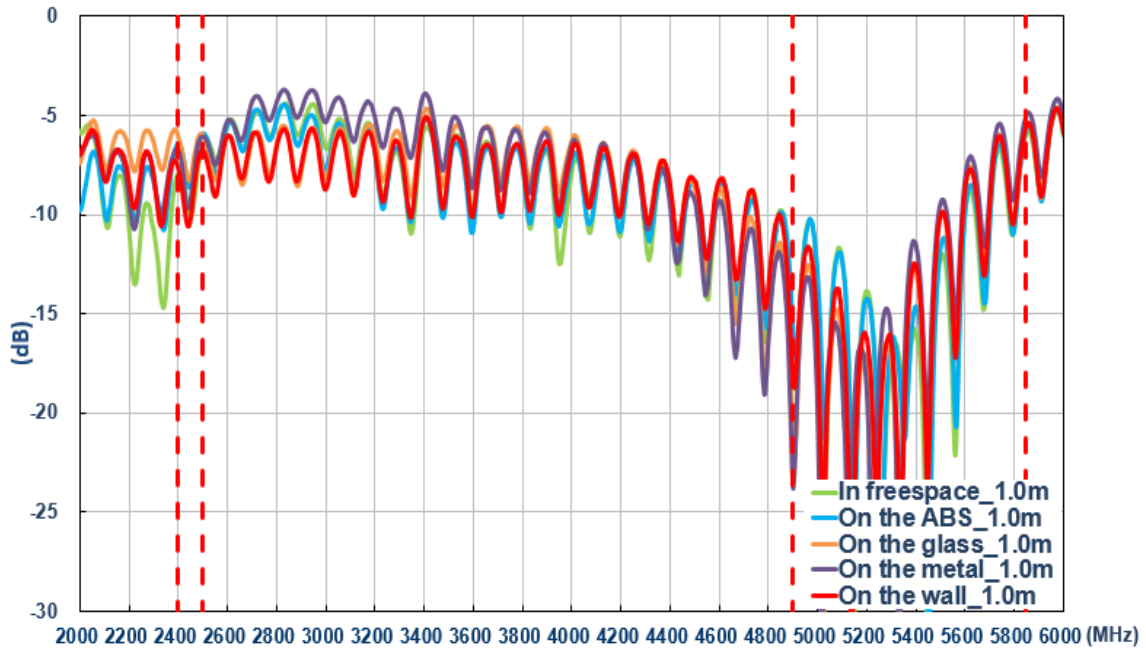
### 3.2.11 Wi-Fi\_1 Antenna Return Loss

Performance in different environments with 1 meter cable length



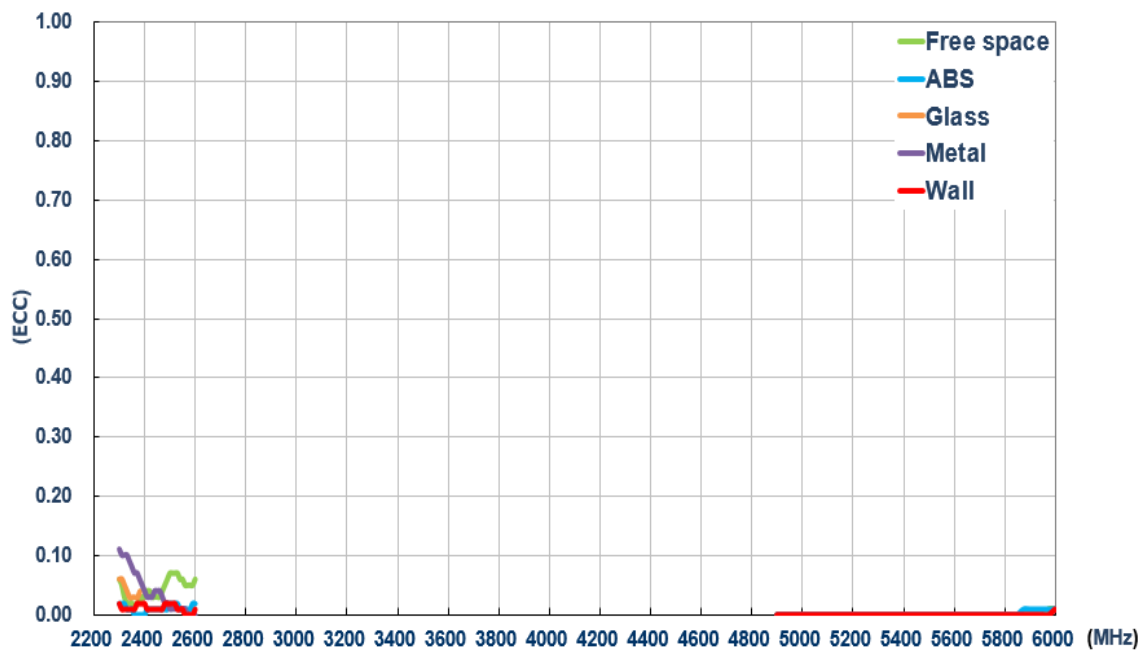
### 3.2.12 Wi-Fi\_2 Antenna Return Loss

Performance in different environments with 1 meter cable length



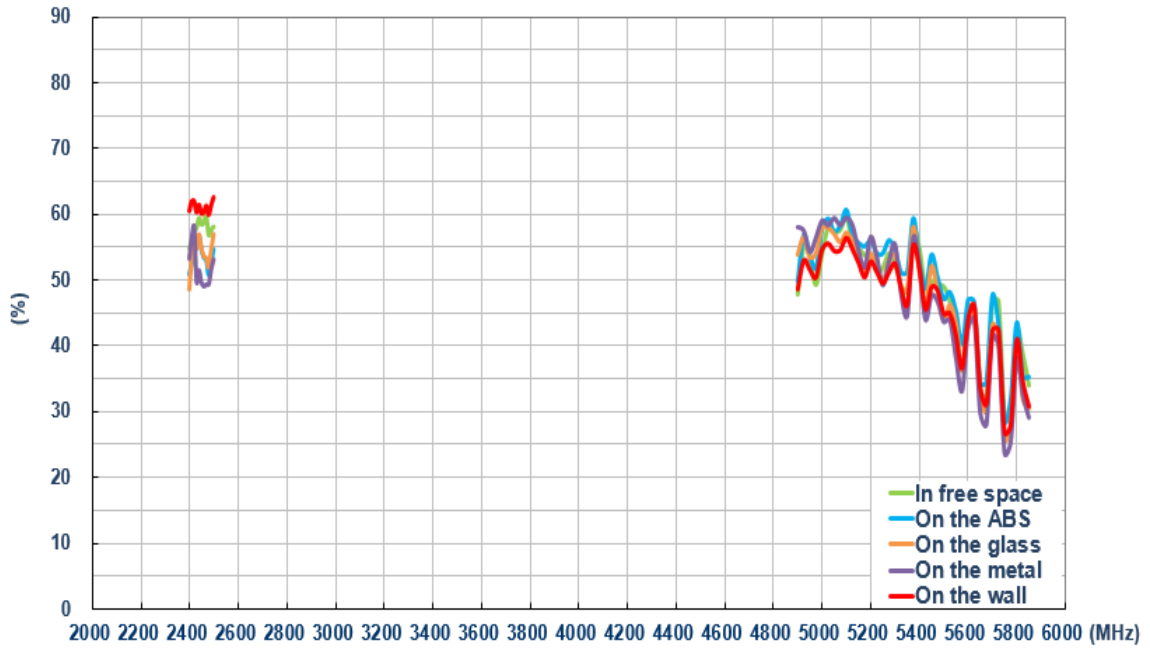
### 3.2.13 Wi-Fi Envelope Correlation Coefficient

Performance in different environments with 1 meter cable length



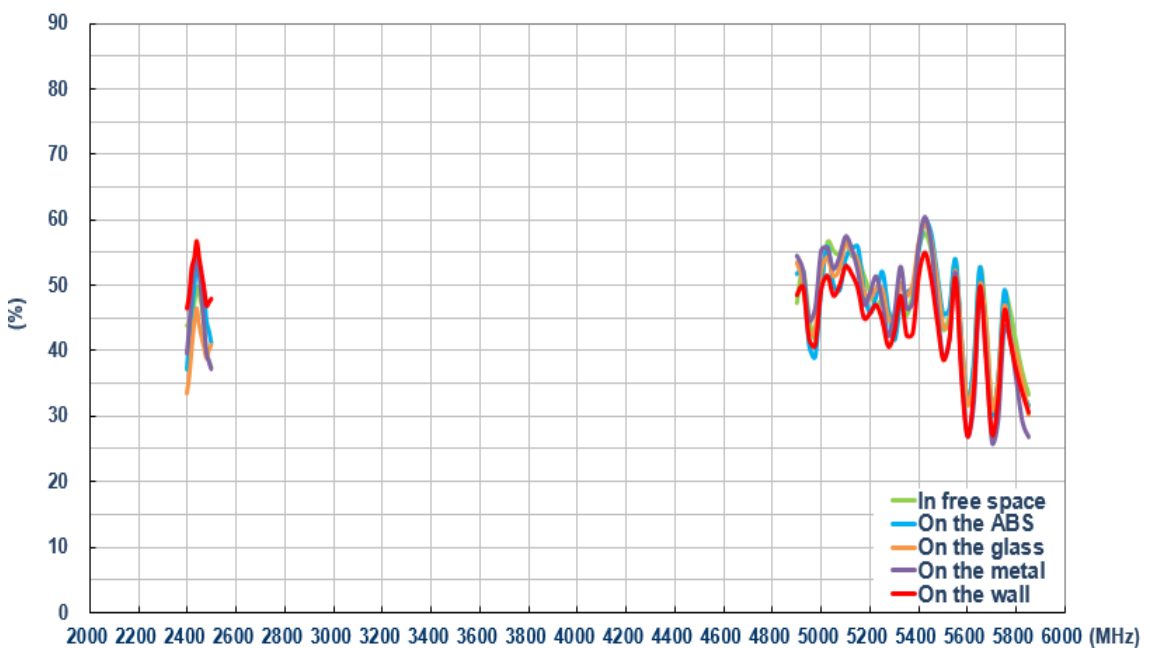
### 3.2.14 Wi-Fi\_1 Antenna Efficiency

Performance in different environments with 1 meter cable length



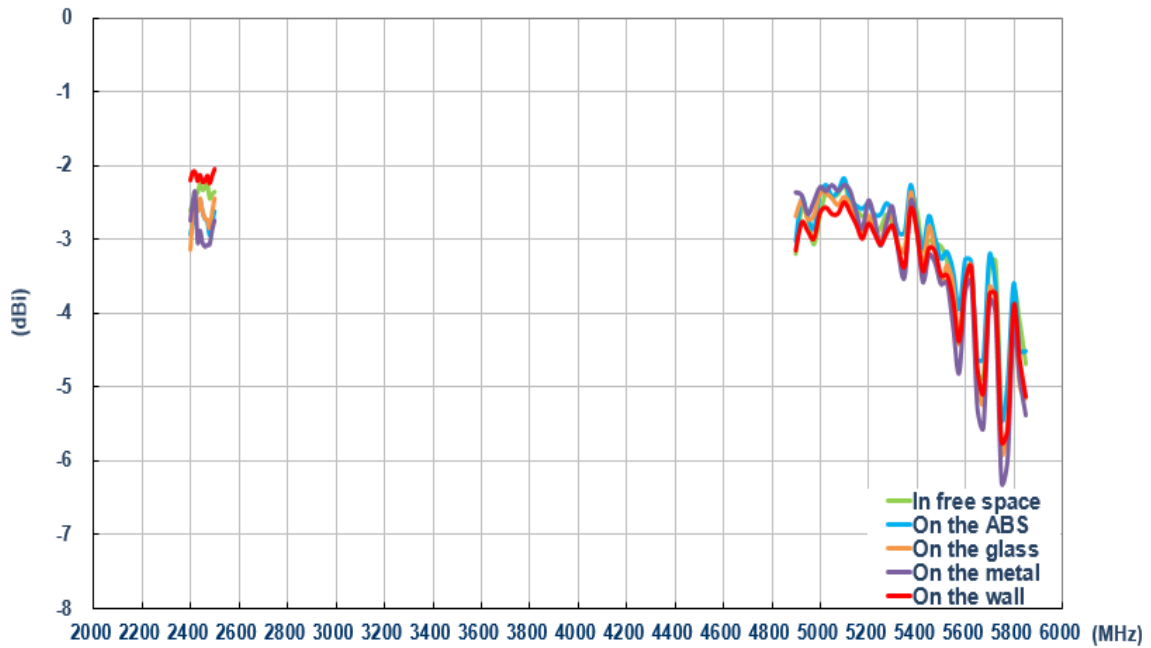
### 3.2.15 Wi-Fi\_2 Antenna Efficiency

Performance in different environments with 1 meter cable length



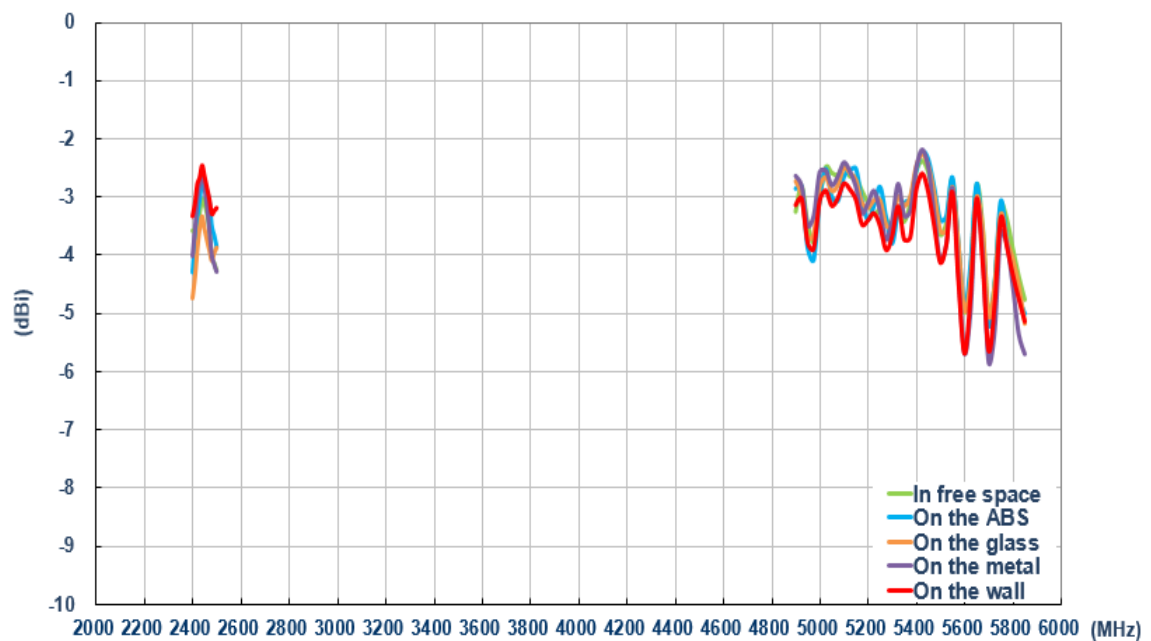
### 3.2.16 Wi-Fi\_1 Antenna Average Gain

Performance in different environments with 1 meter cable length



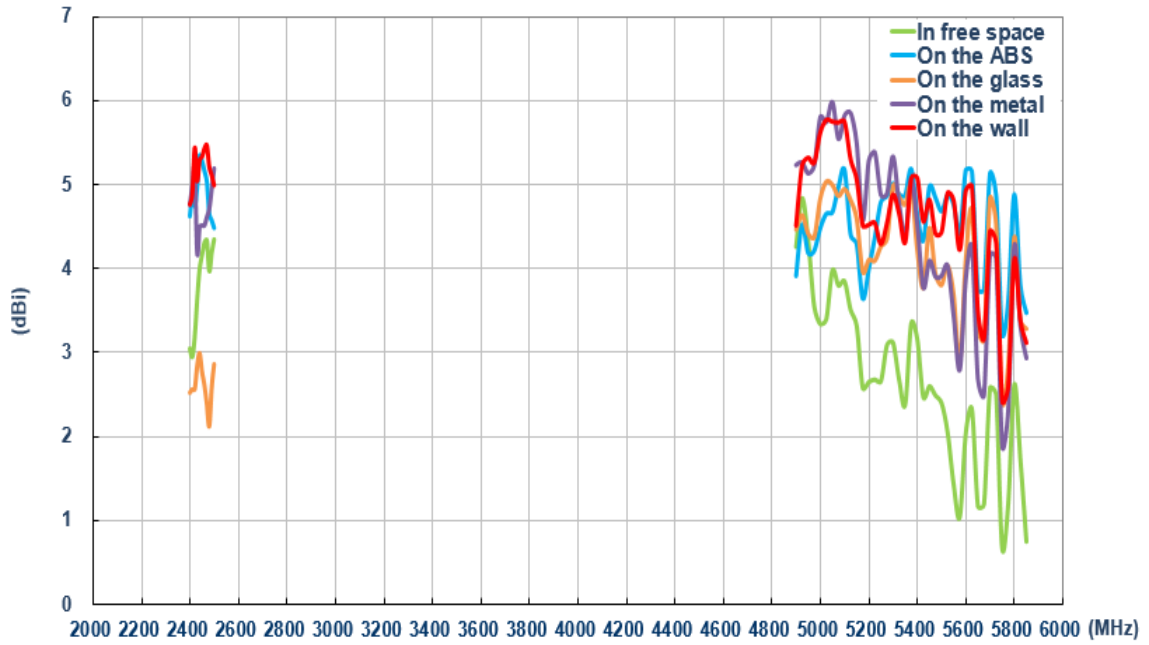
### 3.2.17 Wi-Fi\_2 Antenna Average Gain

Performance in different environments with 1 meter cable length



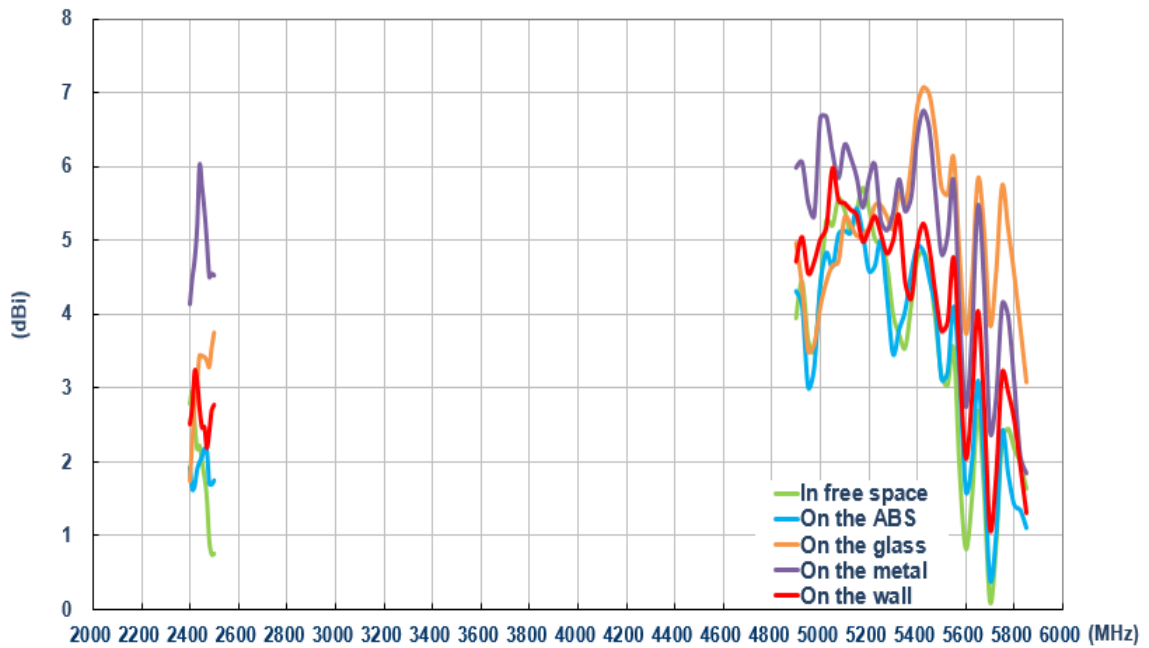
### 3.2.18 Wi-Fi\_1 Antenna Peak Gain

Performance in different environments with 1 meter cable length



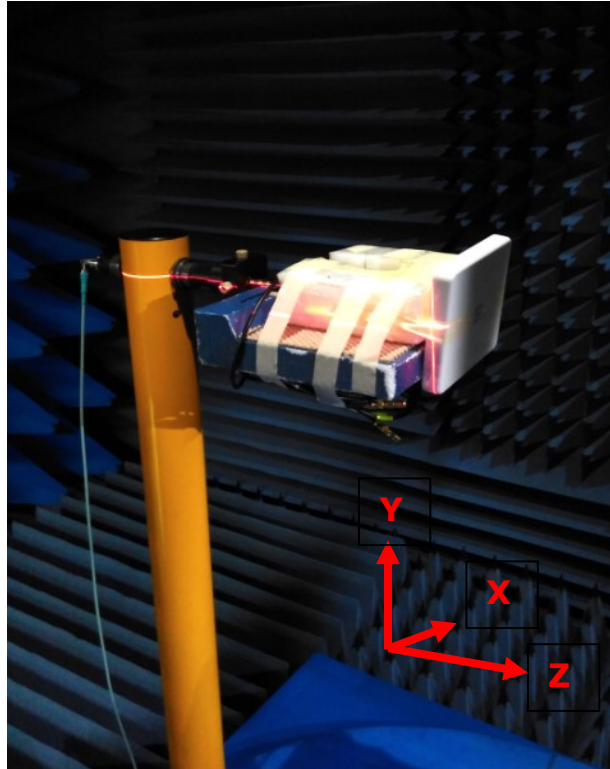
### 3.2.19 Wi-Fi\_2 Antenna Peak Gain

Performance in different environments with 1 meter cable length





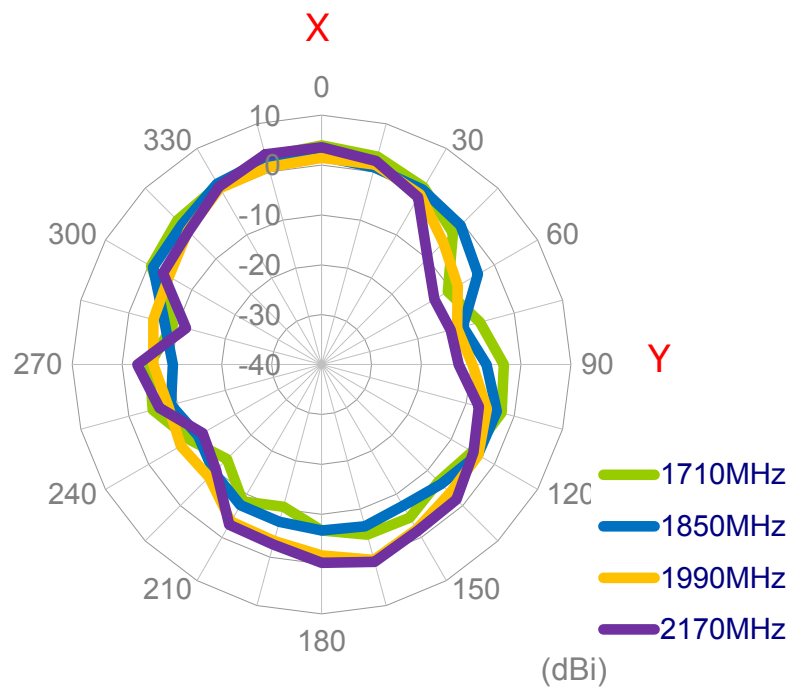
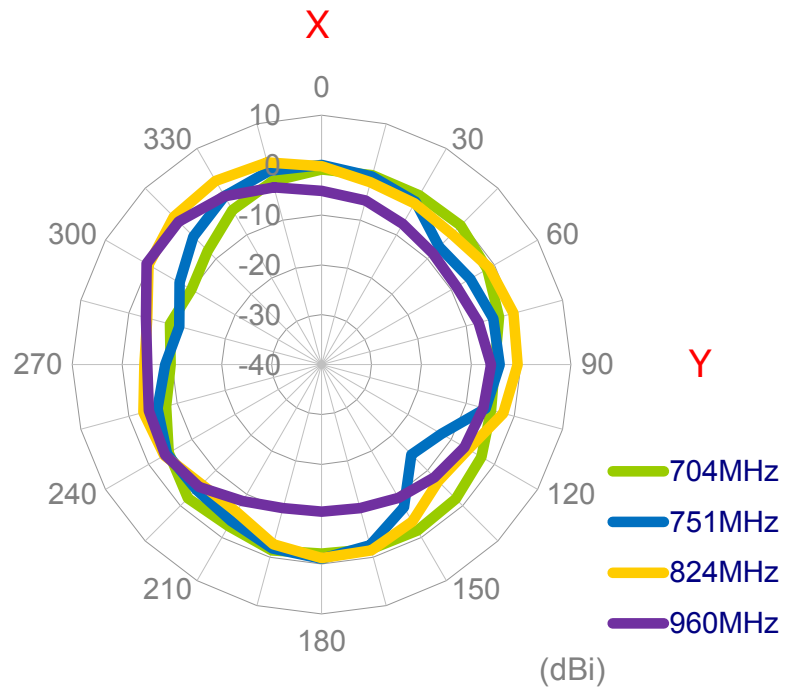
### 3.2.20 Test Setup For Antenna Radiation Pattern

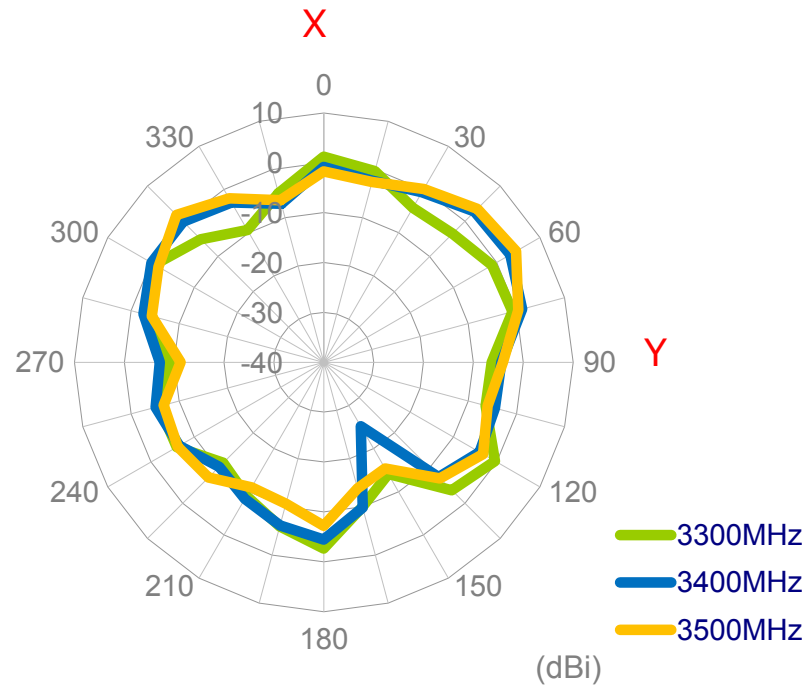
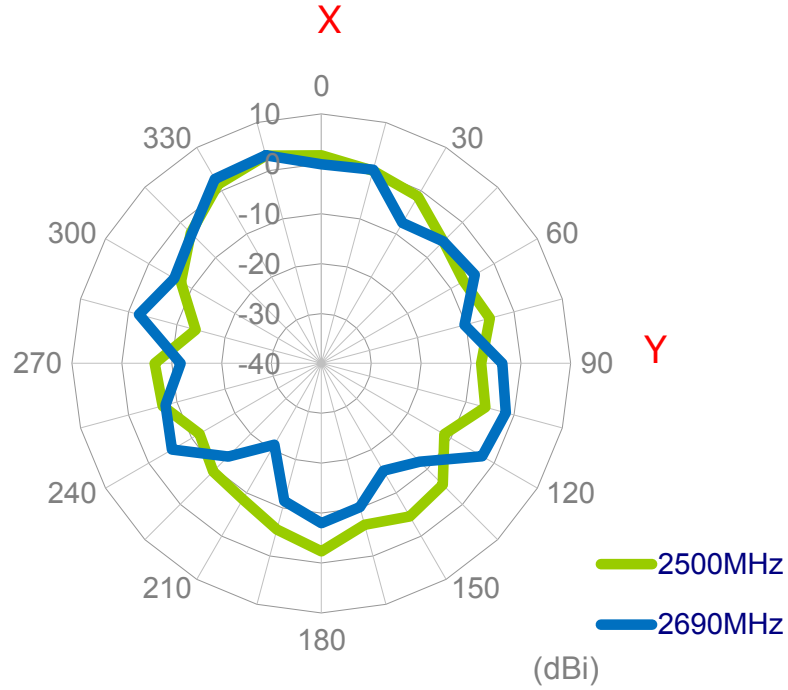


In free space

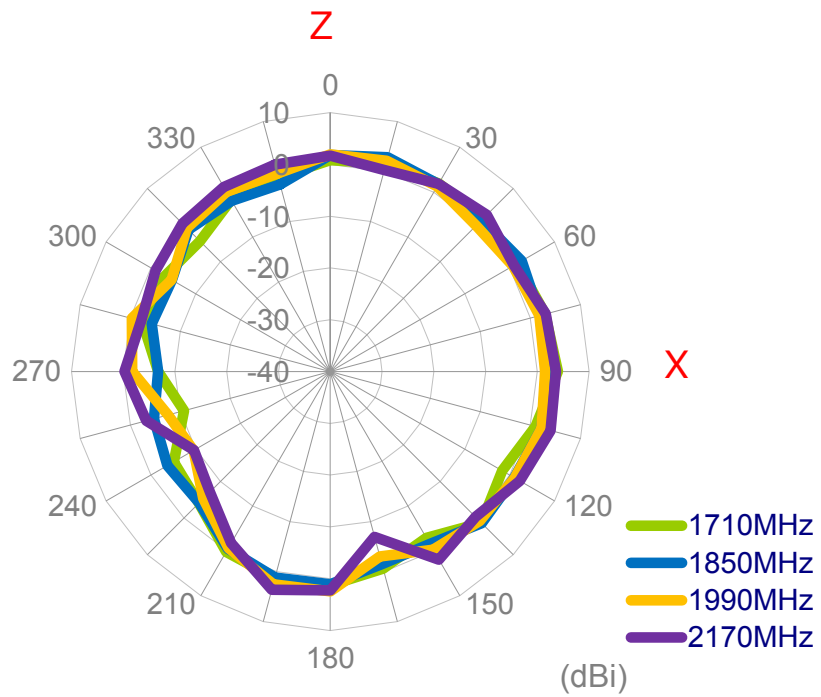
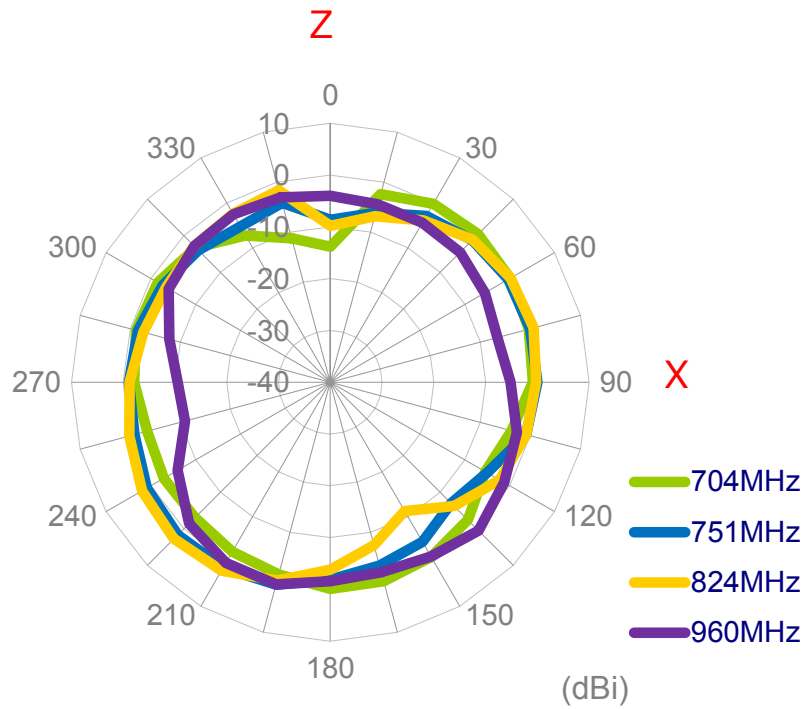
### 3.2.21 2D Radiation Pattern (LTE\_MIMO1 with 1M cable length in free space)

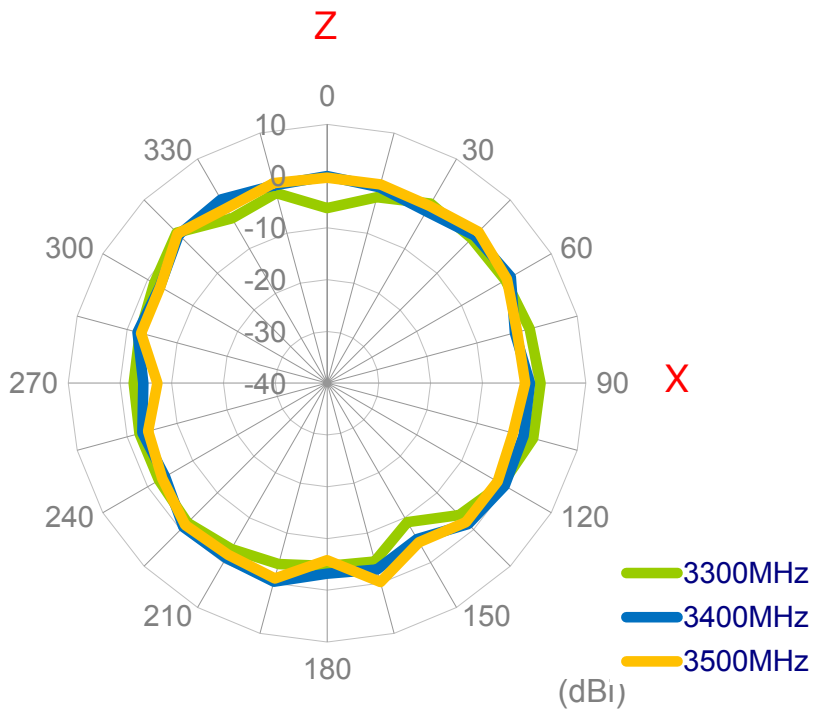
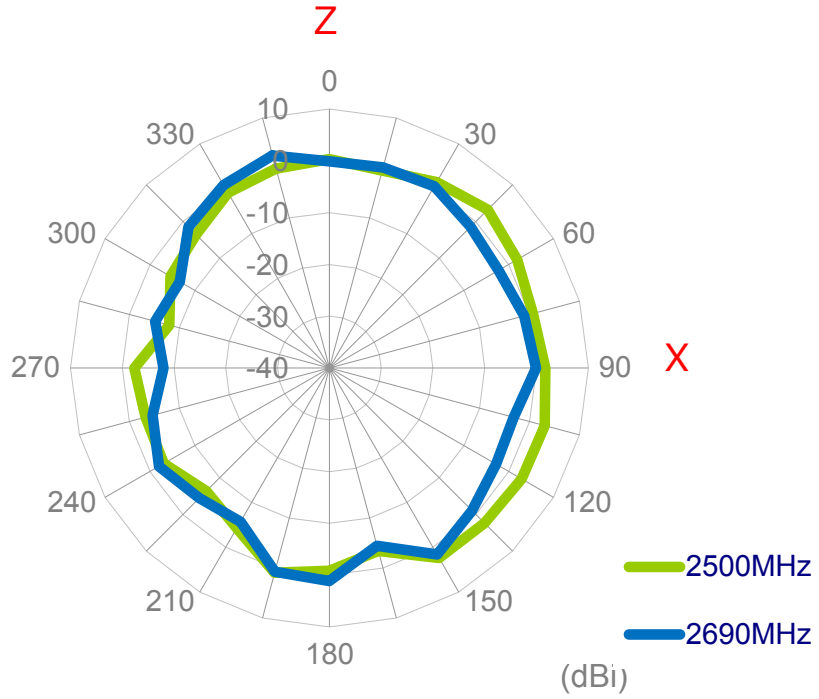
XY Plane



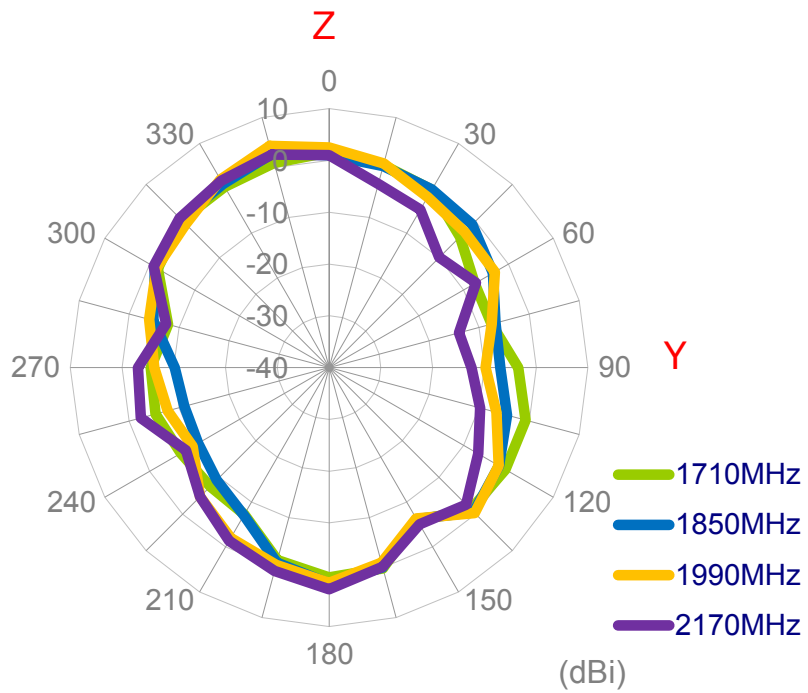
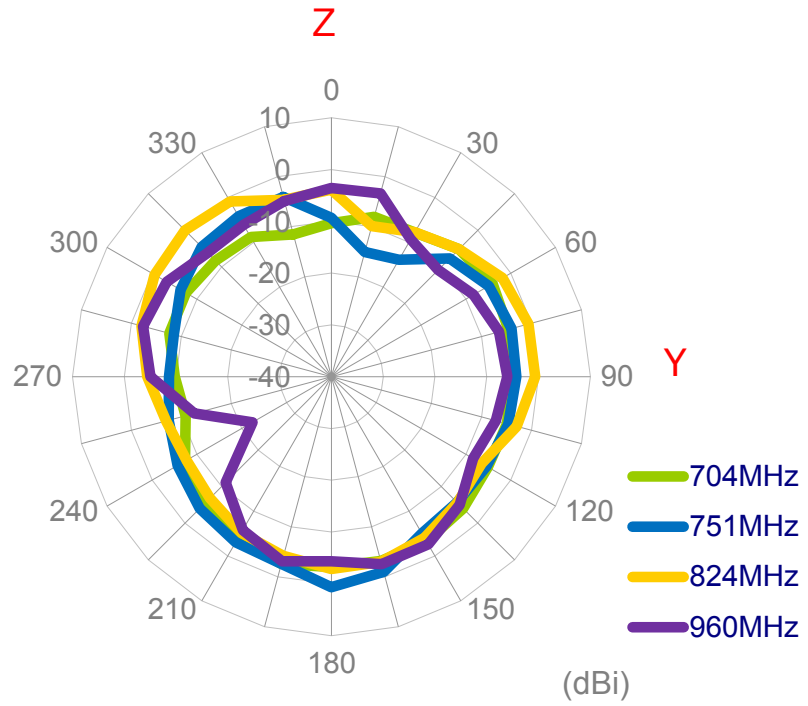


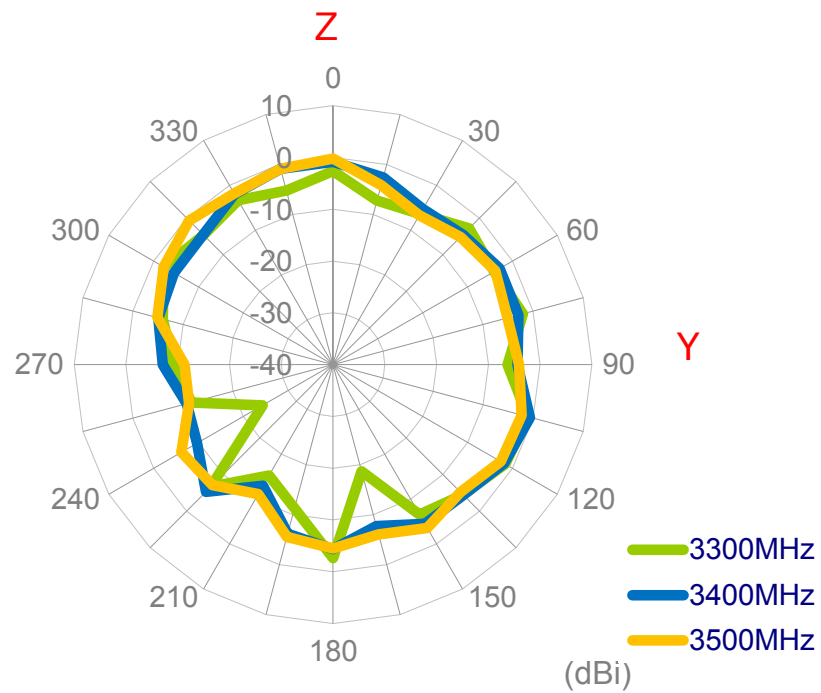
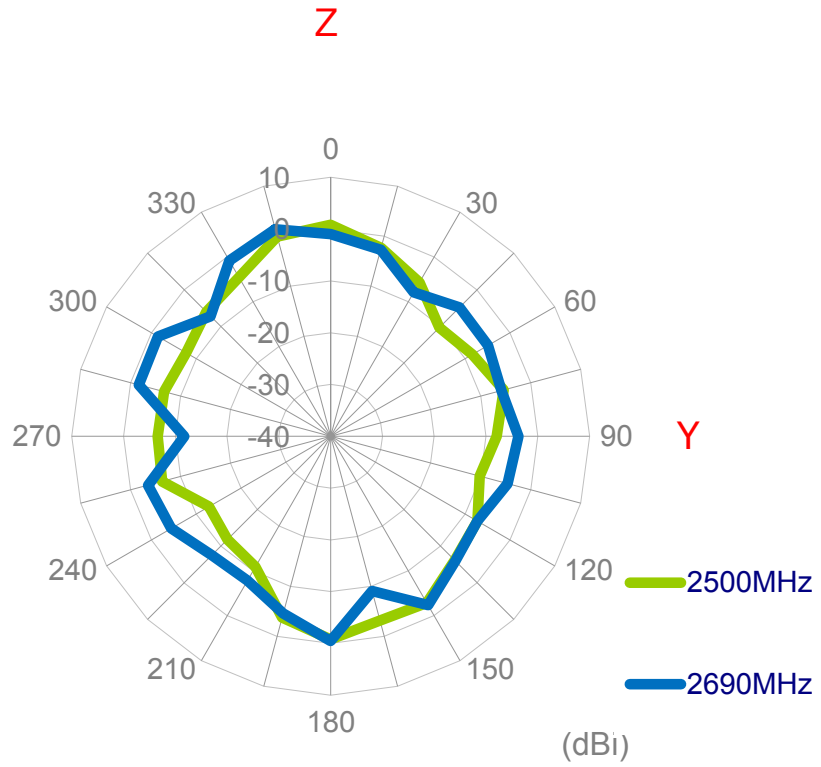
XZ Plane



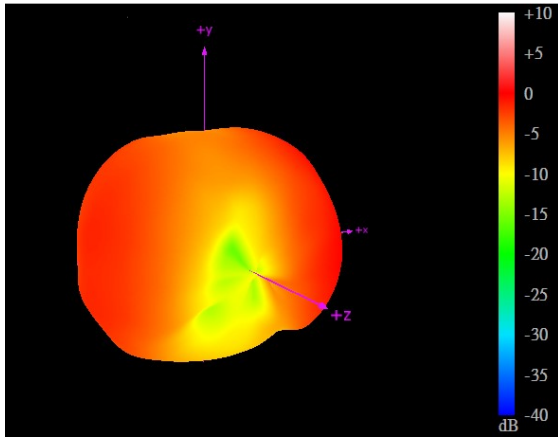


YZ Plane

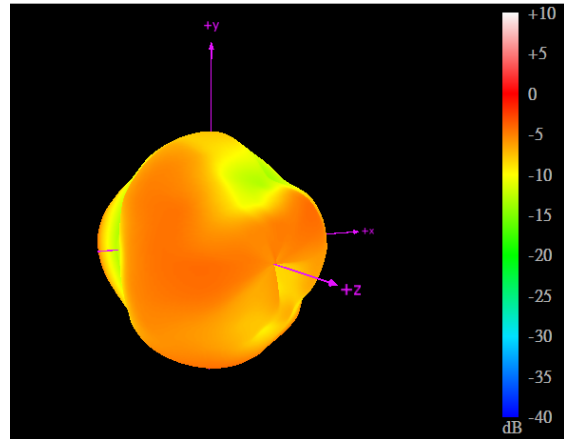




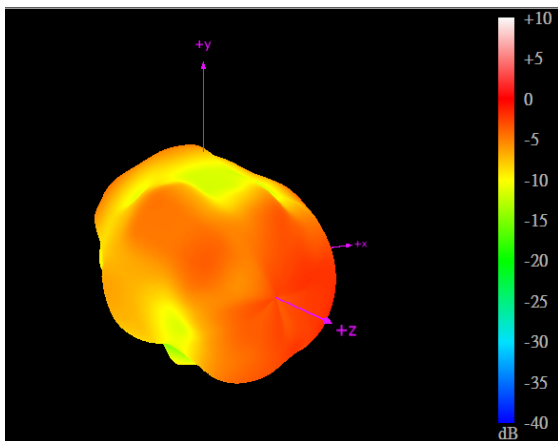
3.2.22 3D Radiation Pattern (LTE\_MIMO1 with 1M cable length in free space)



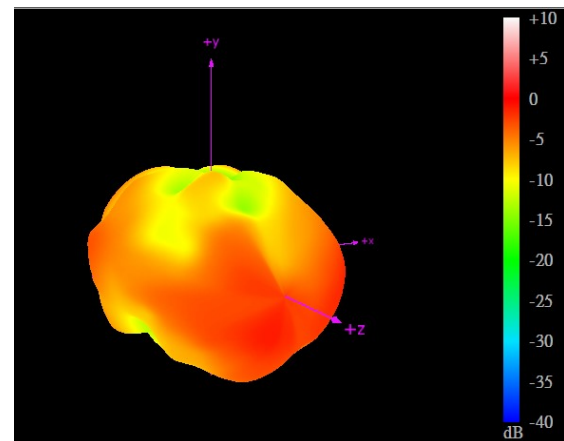
704MHz



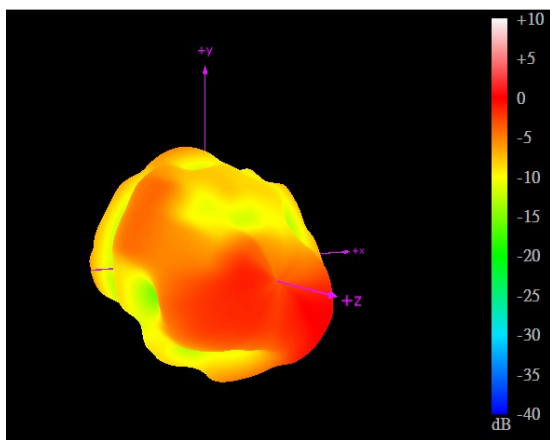
960MHz



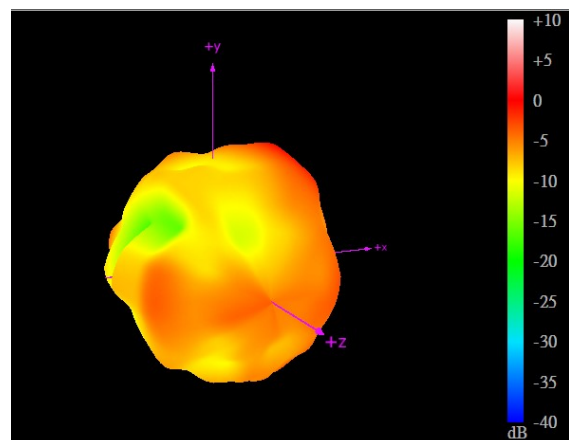
1710MHz



2170MHz



2690MHz

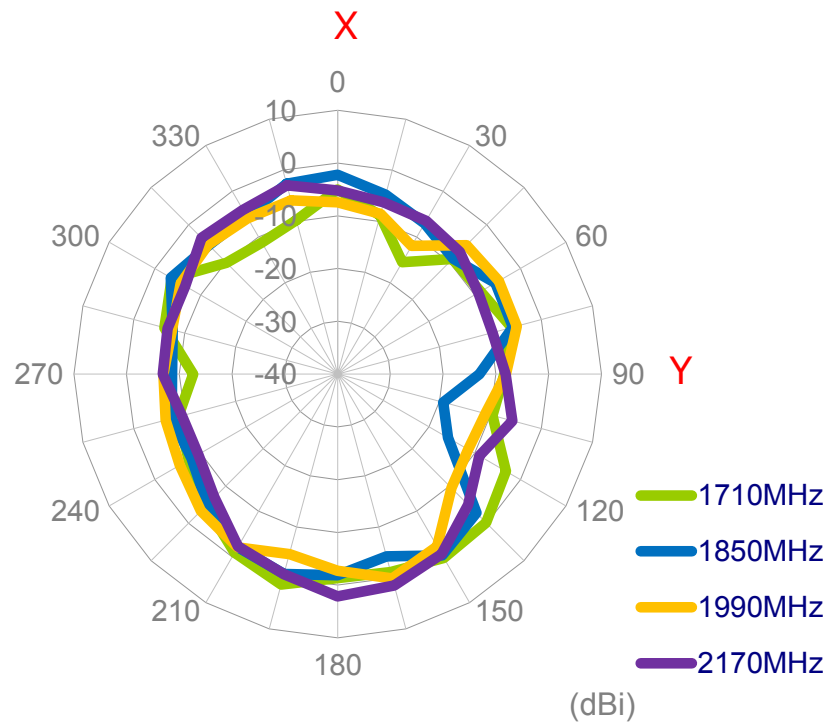
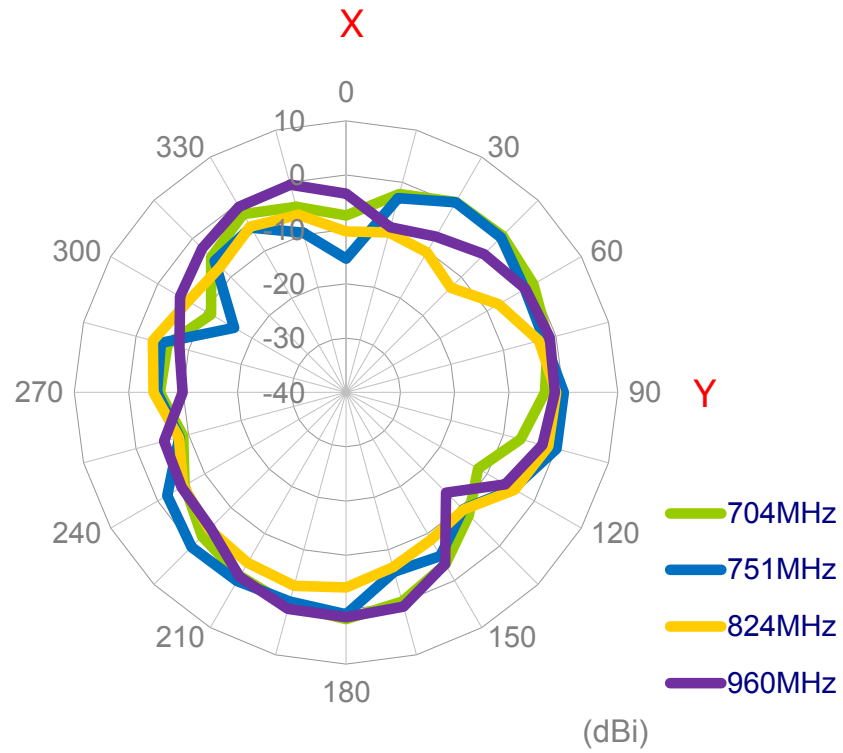


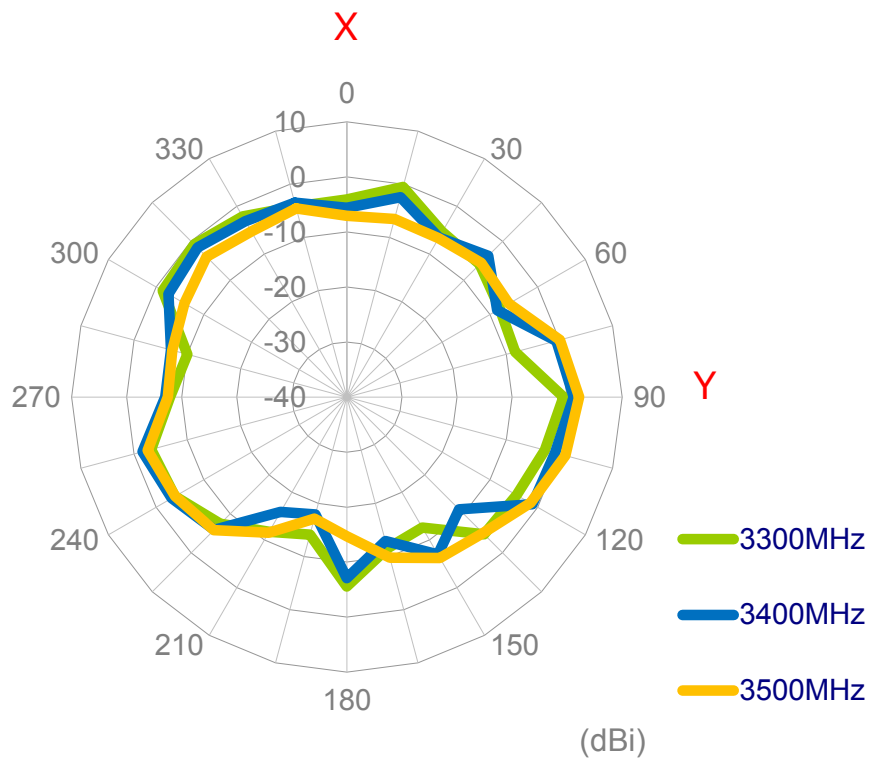
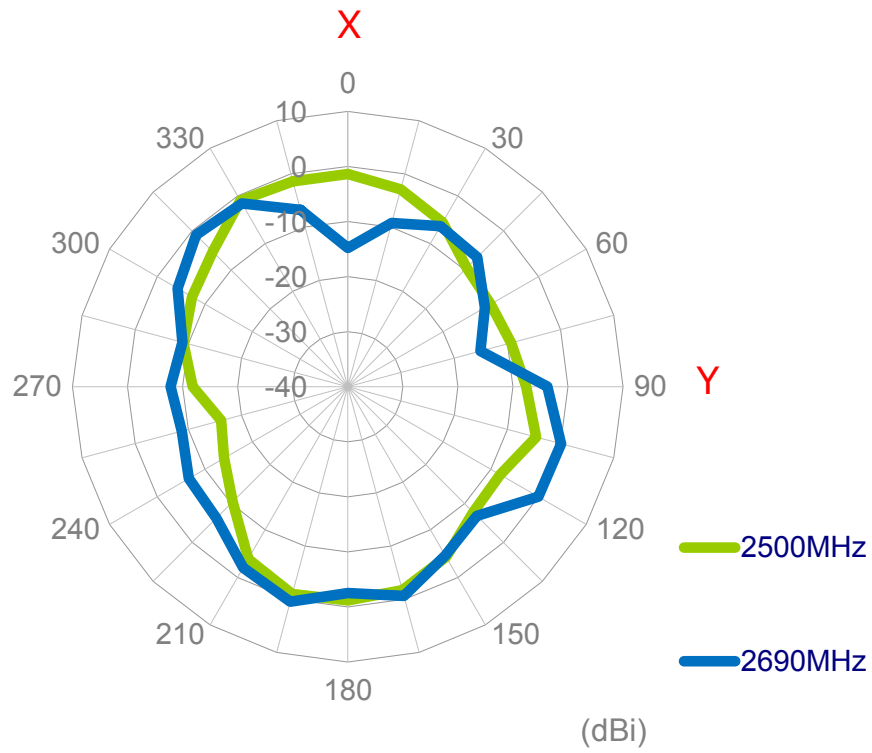
3500MHz



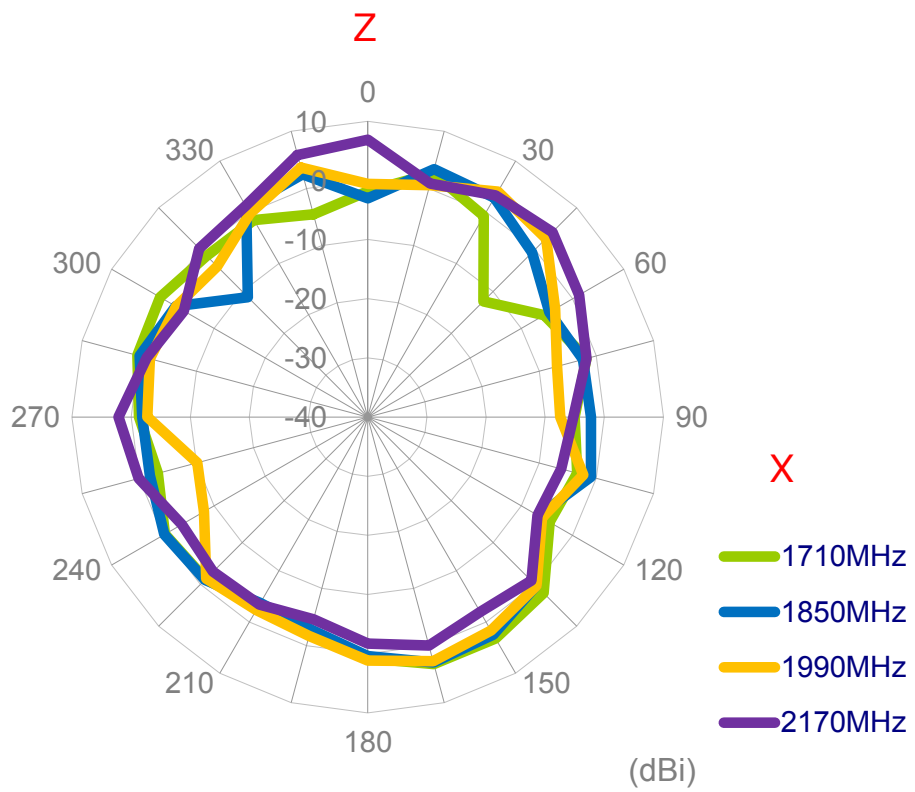
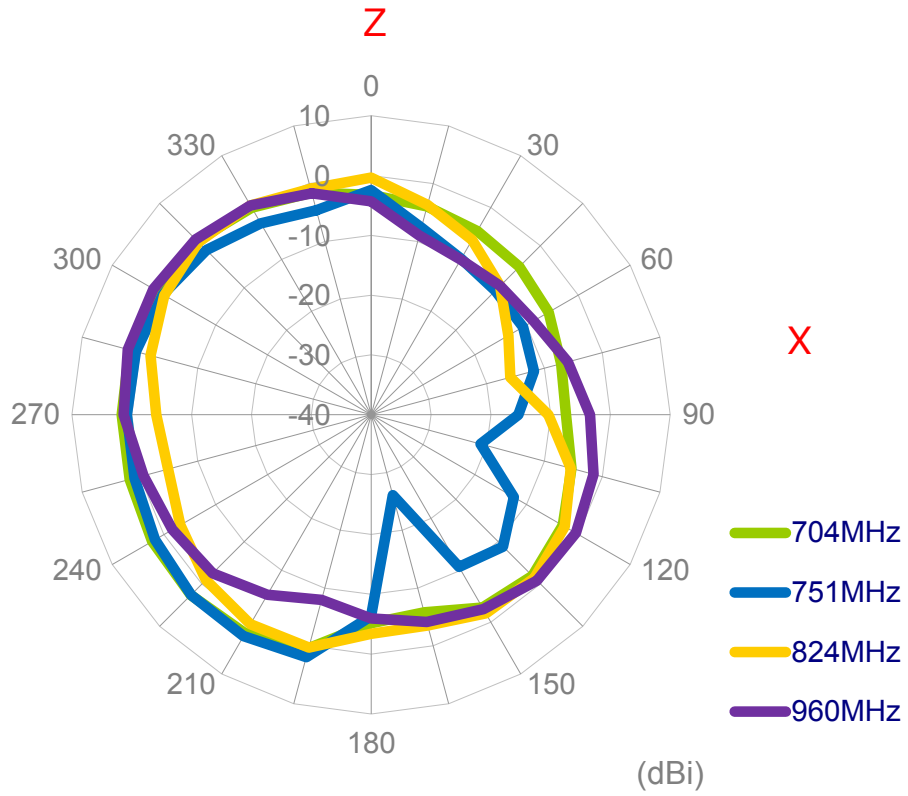
### 3.2.23 2D Radiation Pattern (LTE\_MIMO2 with 1M cable length in free space)

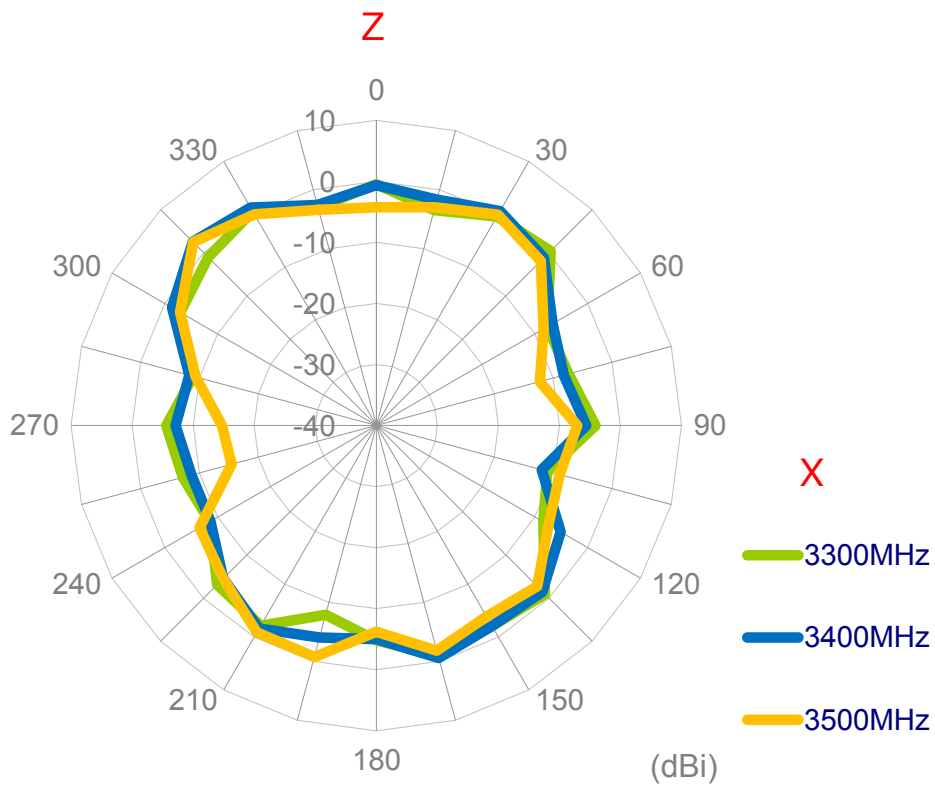
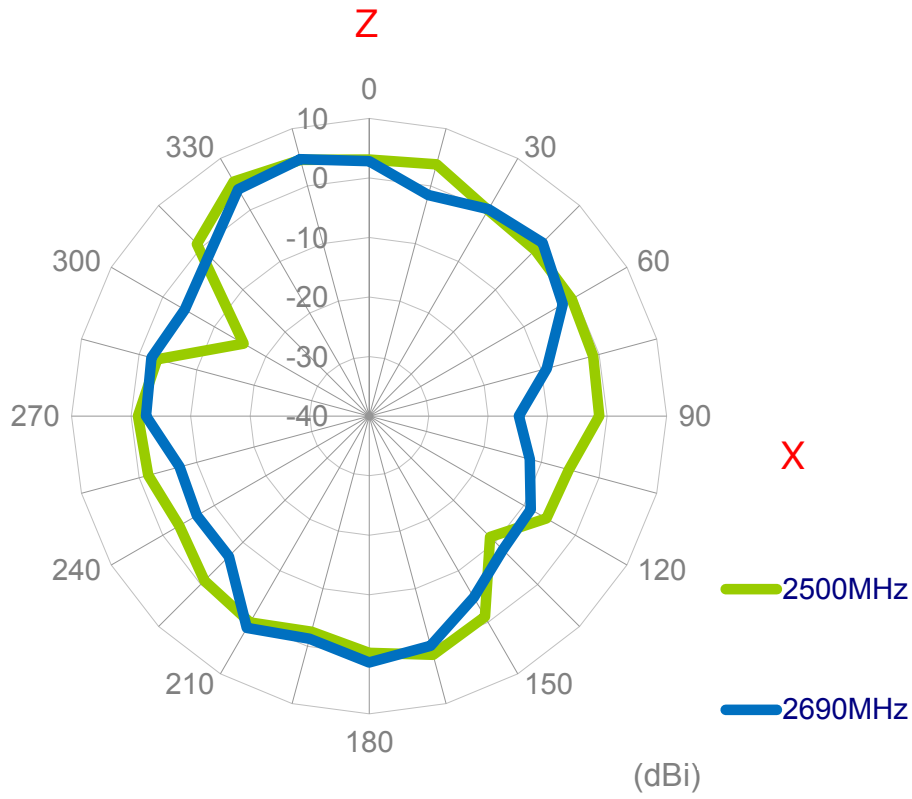
XY Plane



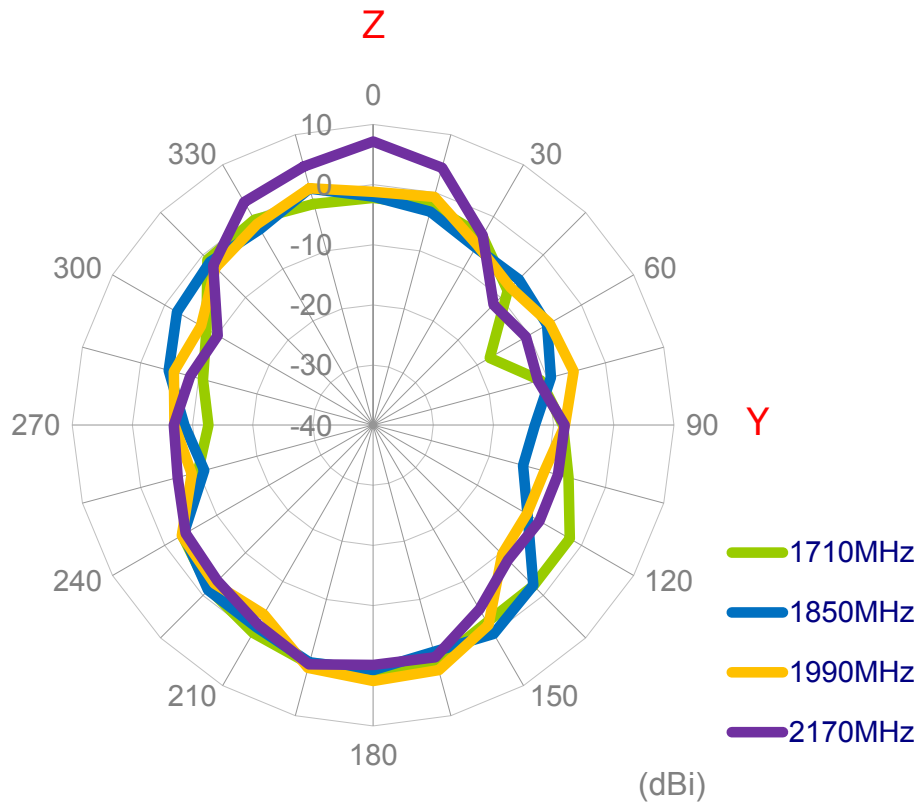
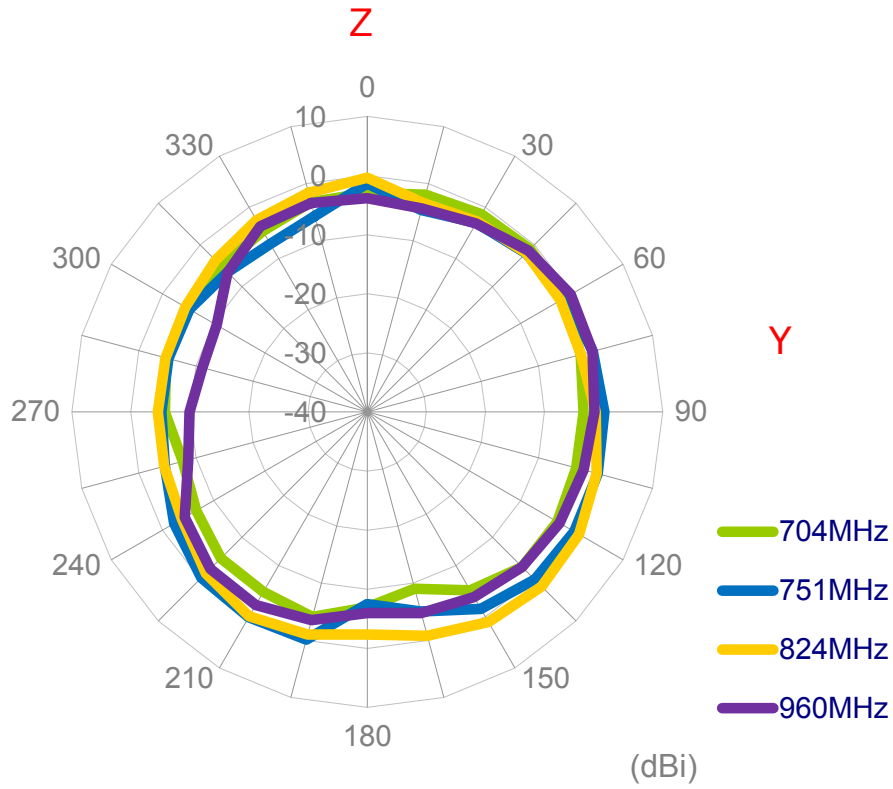


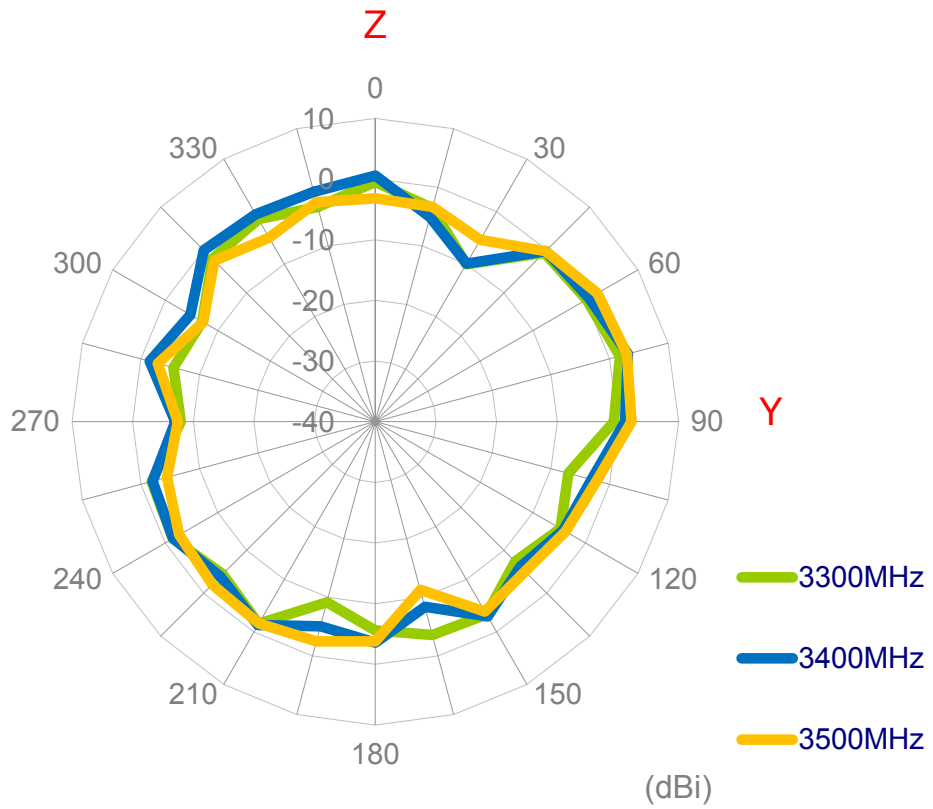
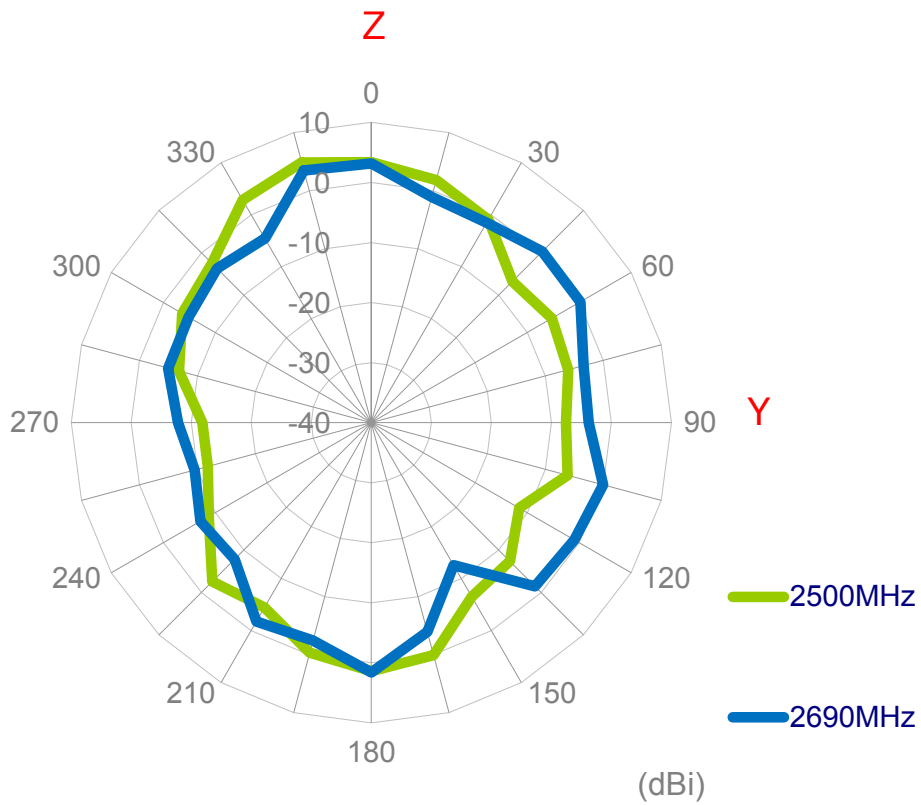
XZ Plane



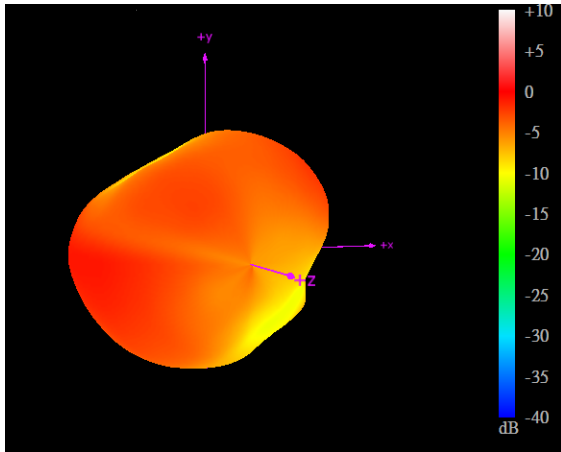


YZ Plane

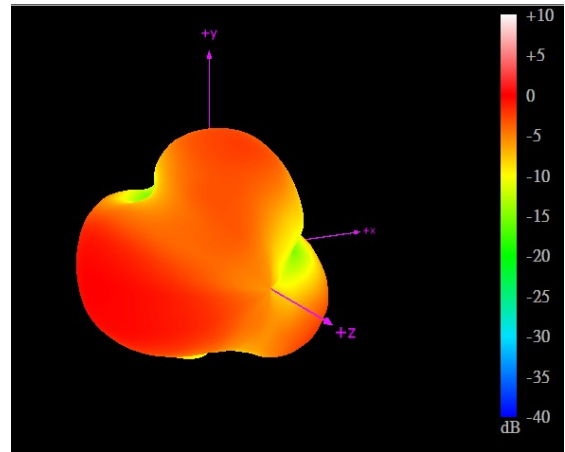




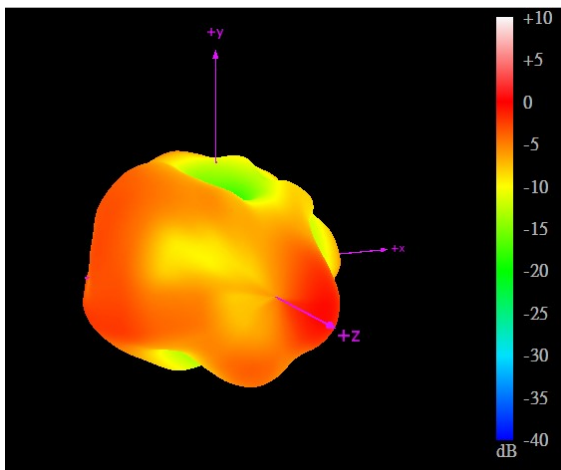
3.2.24 3D Radiation Pattern (LTE\_MIMO2 with 1M cable length in free space)



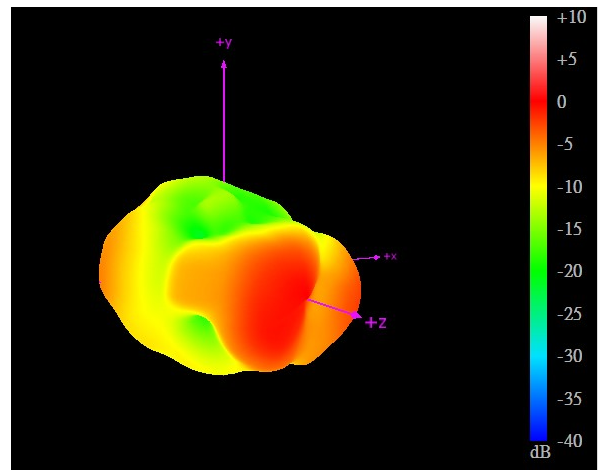
704MHz



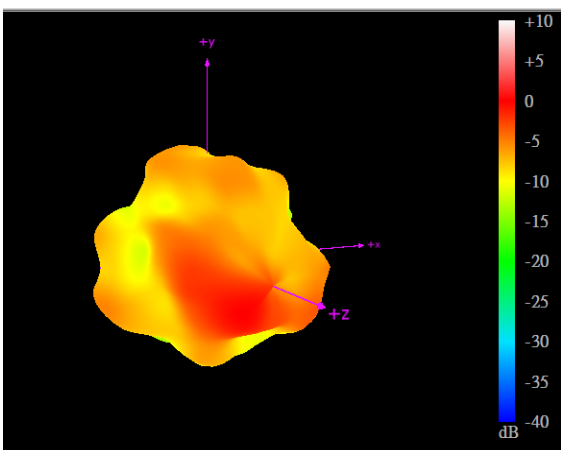
960MHz



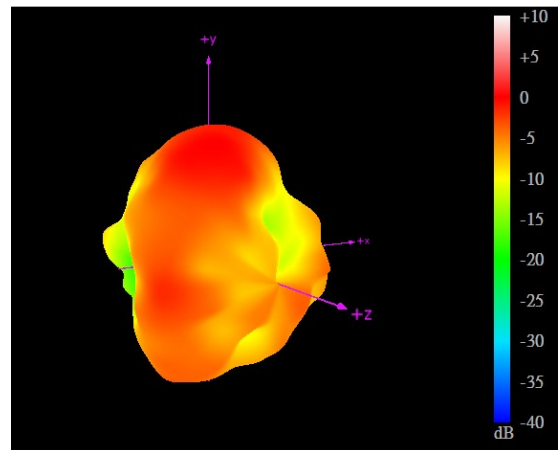
1710MHz



2170MHz



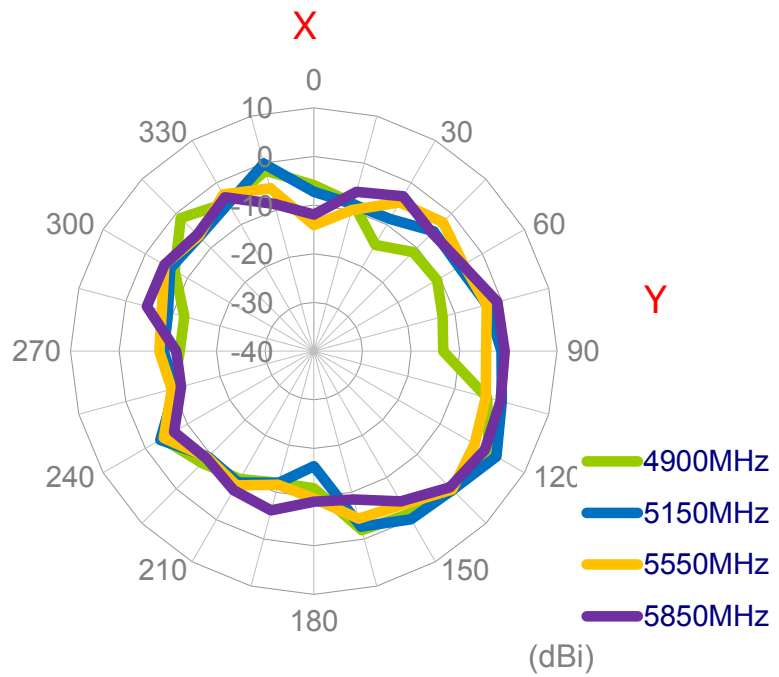
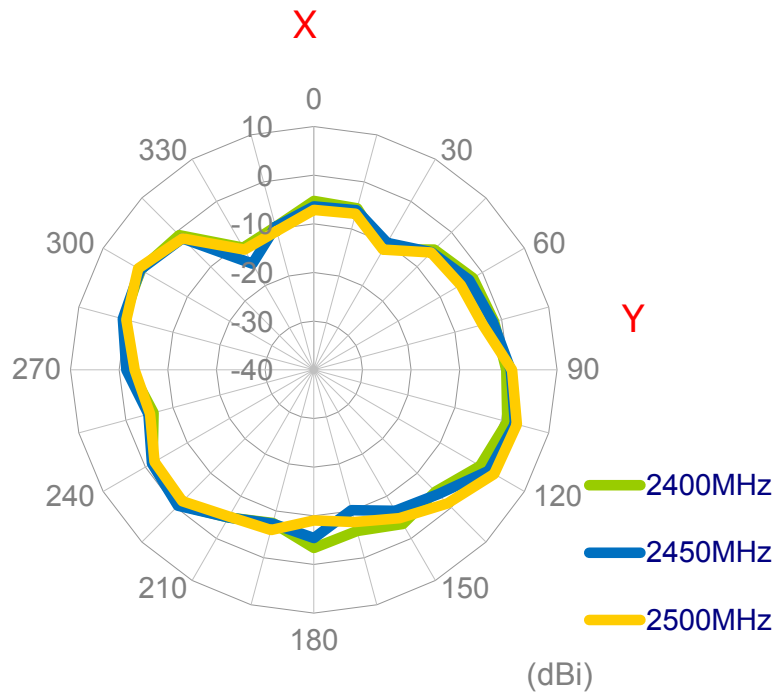
2690MHz



3500MHz

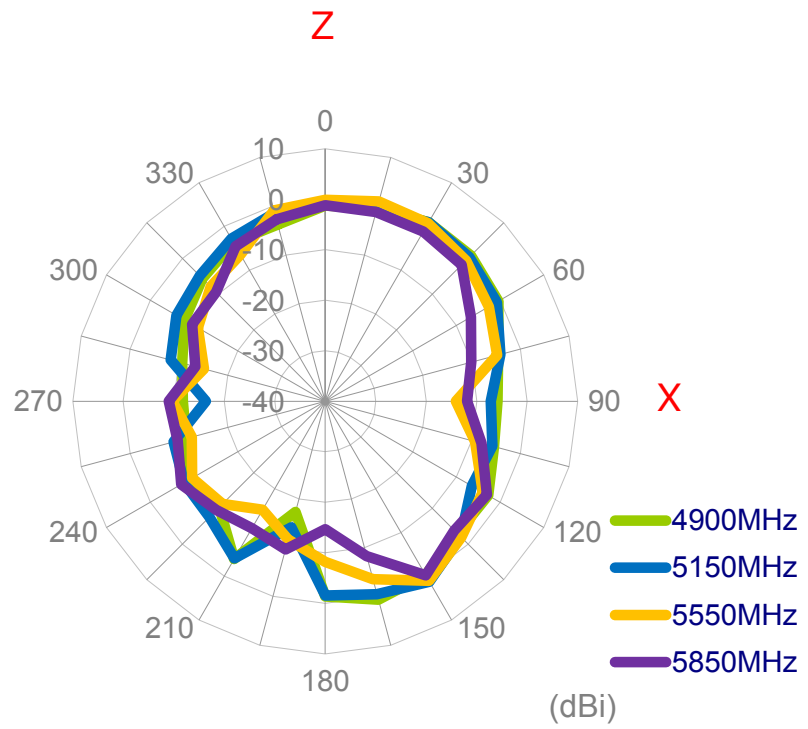
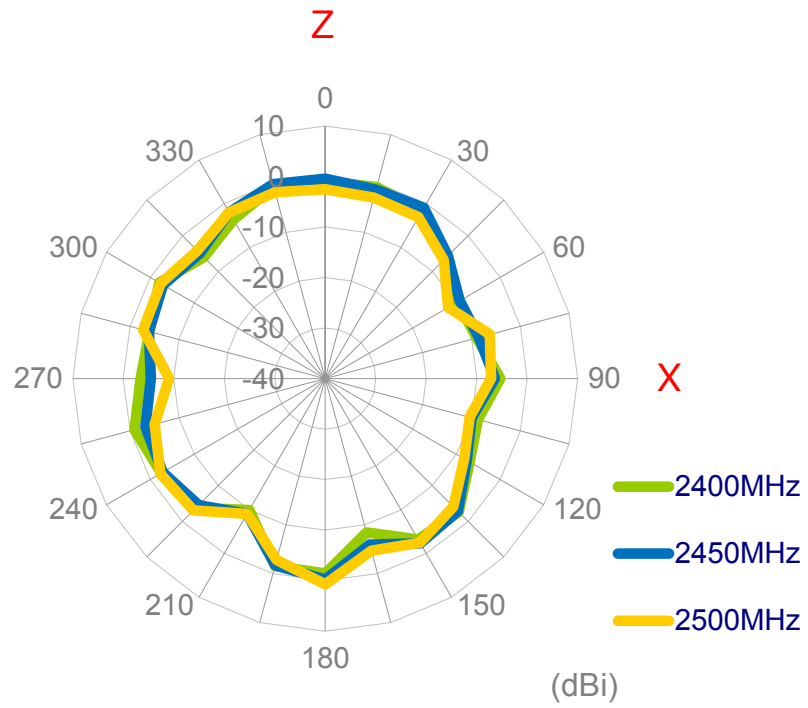
### 3.2.25 2D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length in free space)

XY Plane

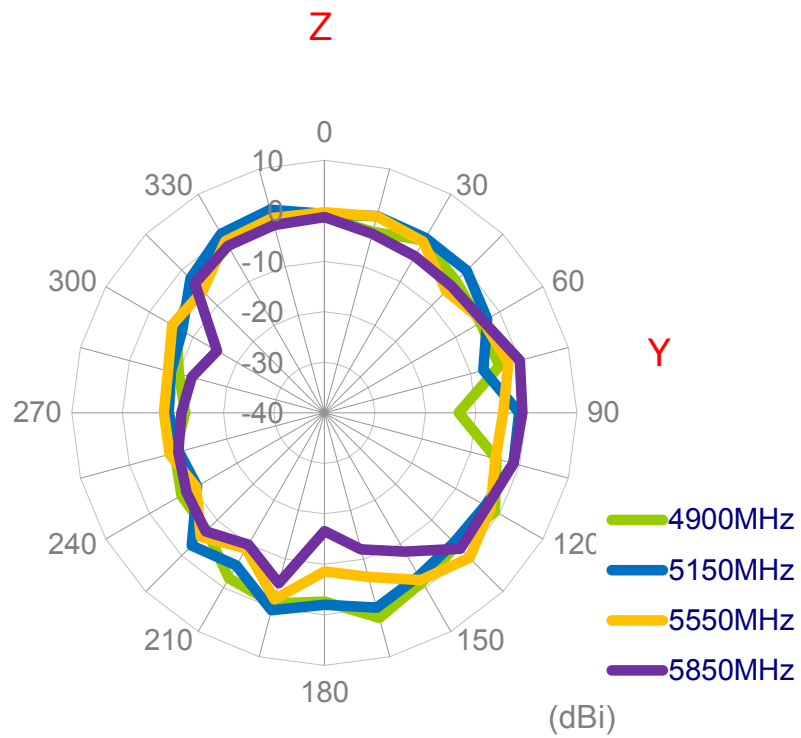
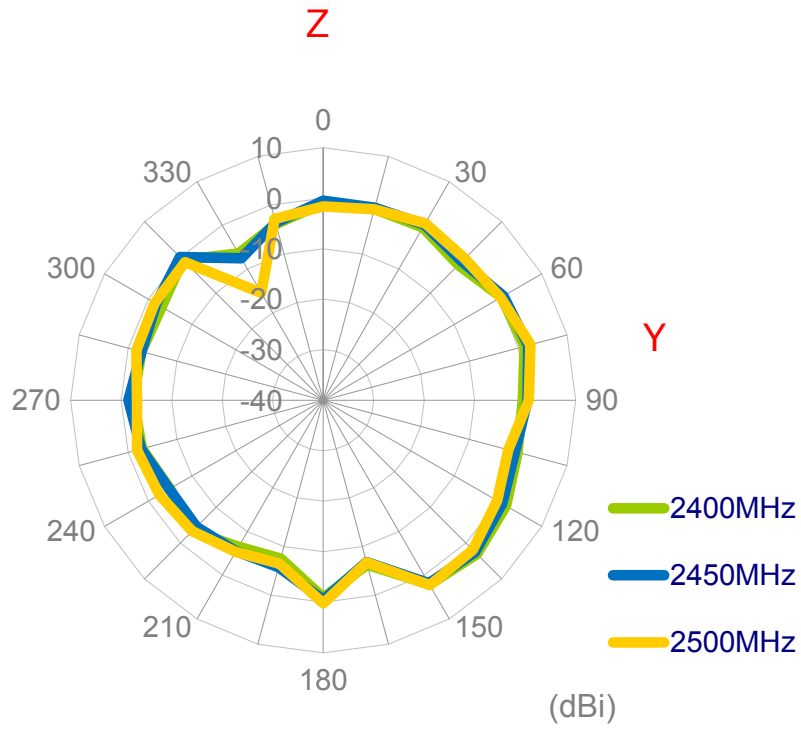




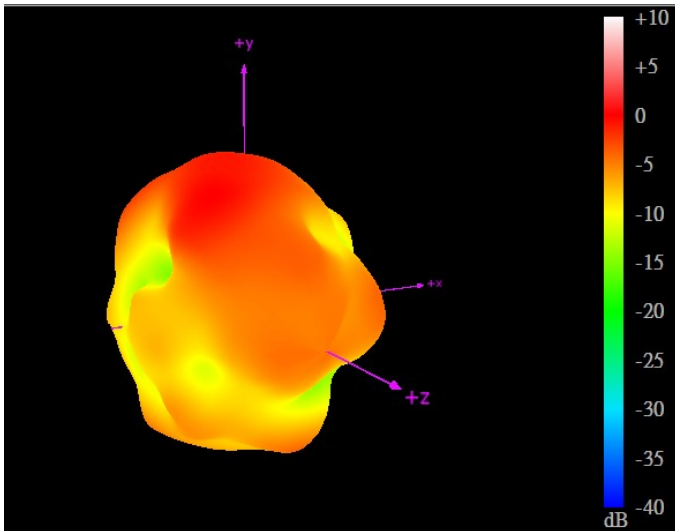
XZ Plane



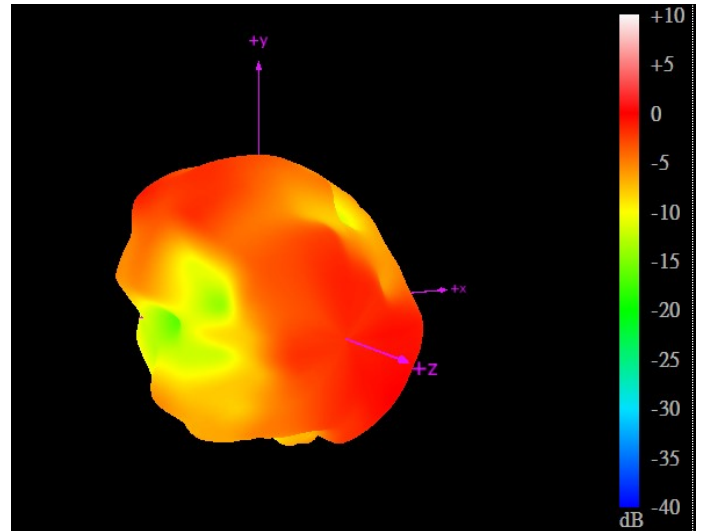
YZ Plane



### 3.2.26 3D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length in free space)



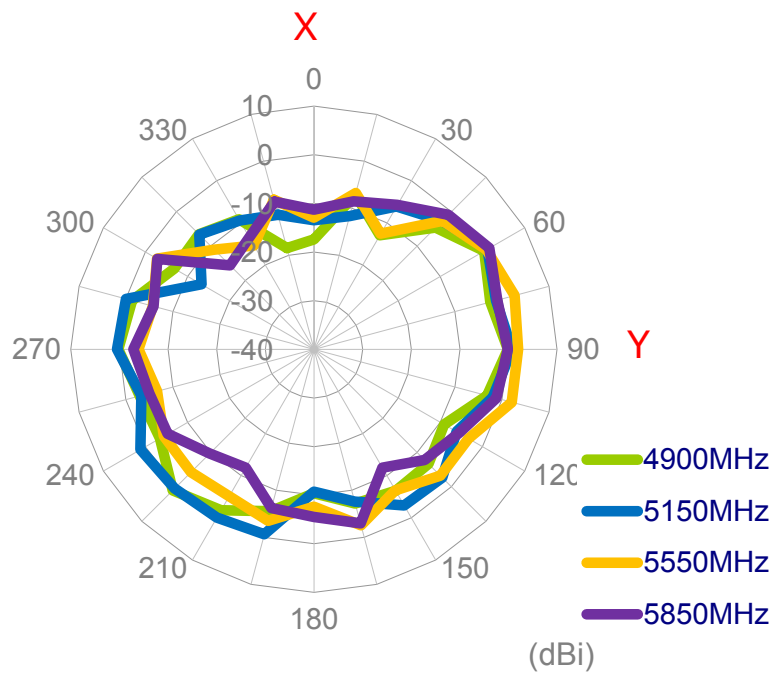
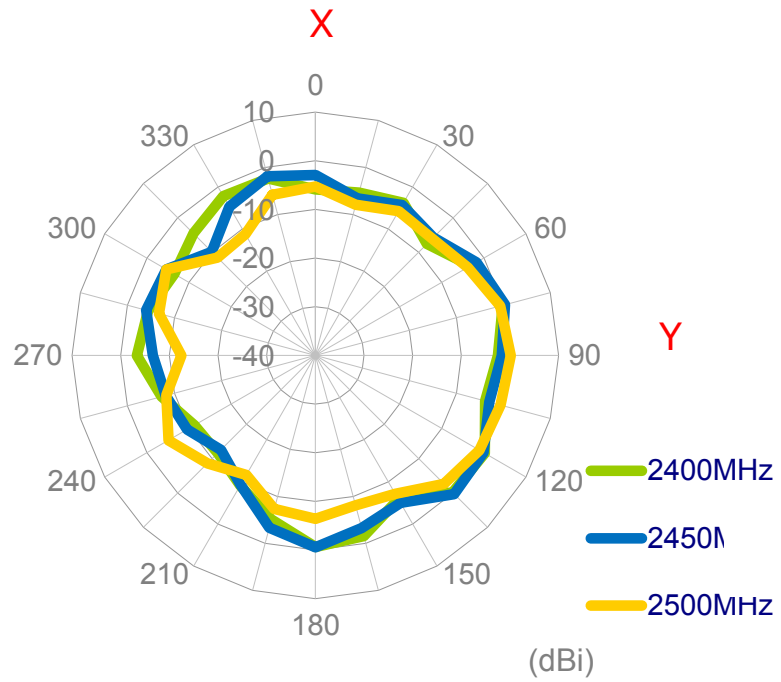
2450MHz



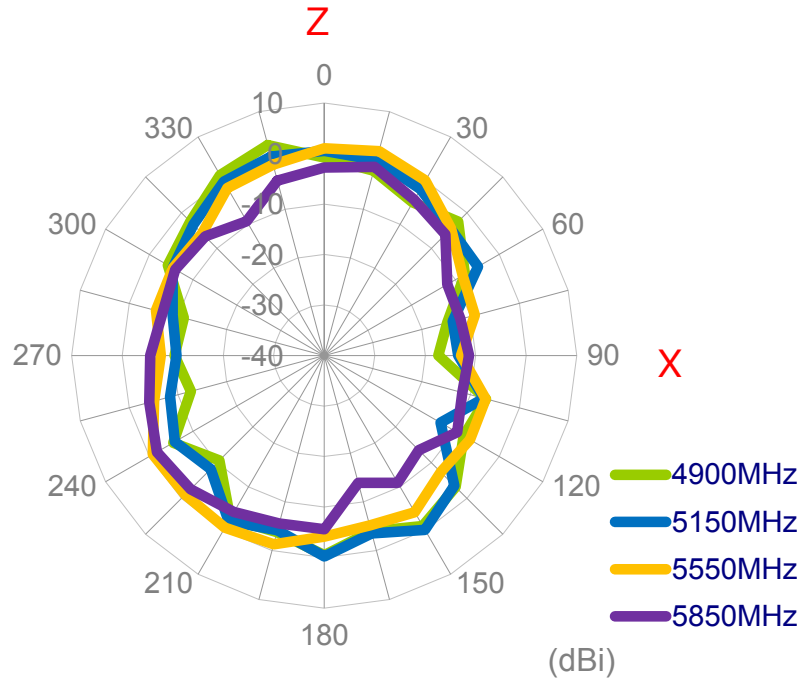
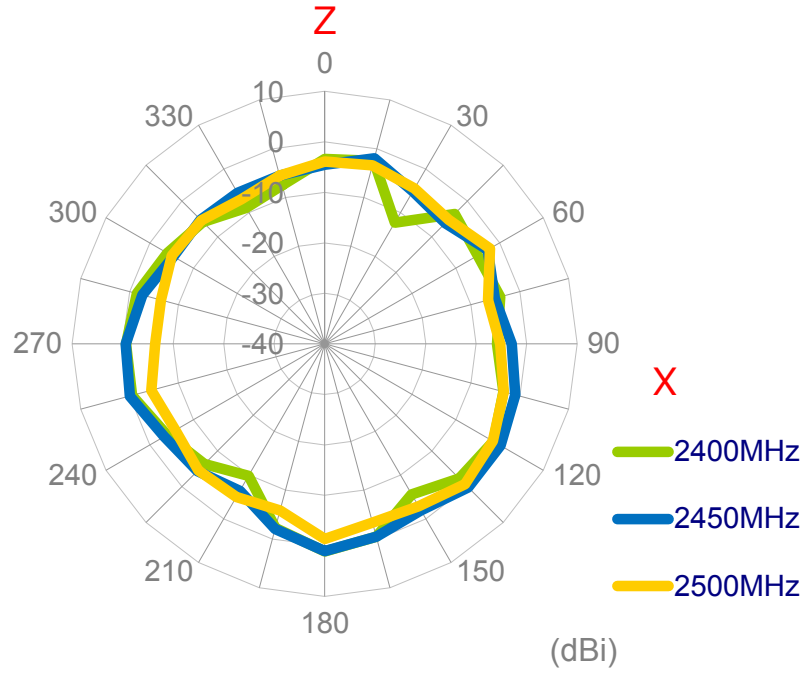
5550MHz

### 3.2.27 2D Radiation Pattern (Wi-Fi\_MIMO2 with 3M cable length in free space)

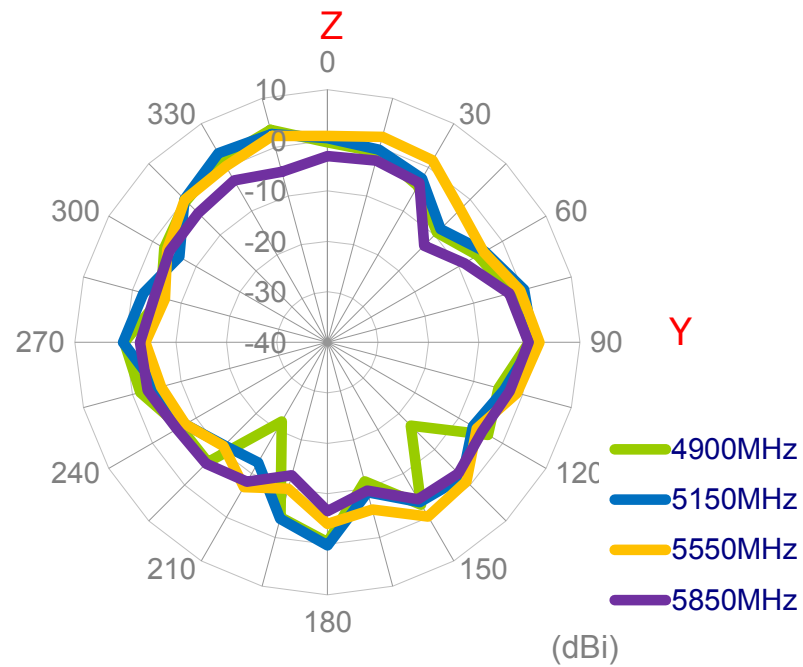
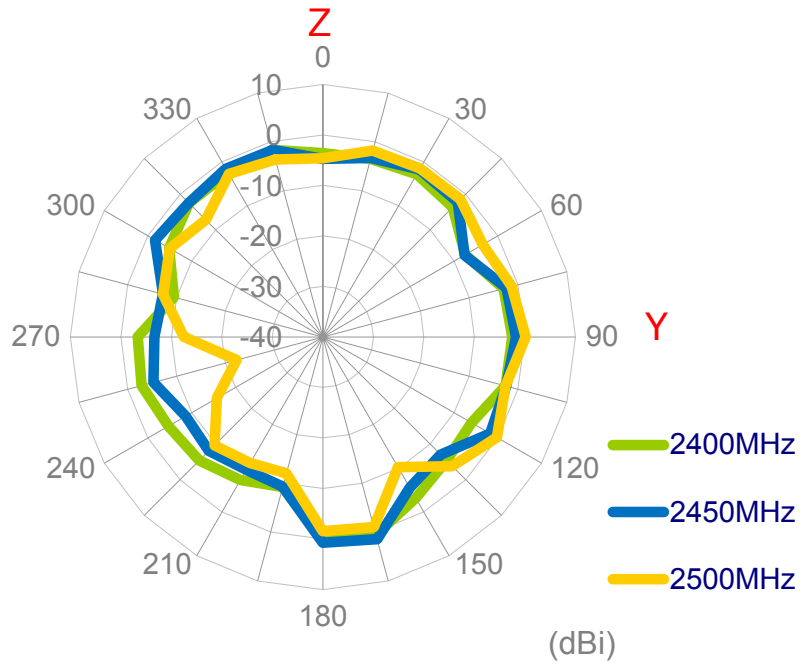
XY Plane



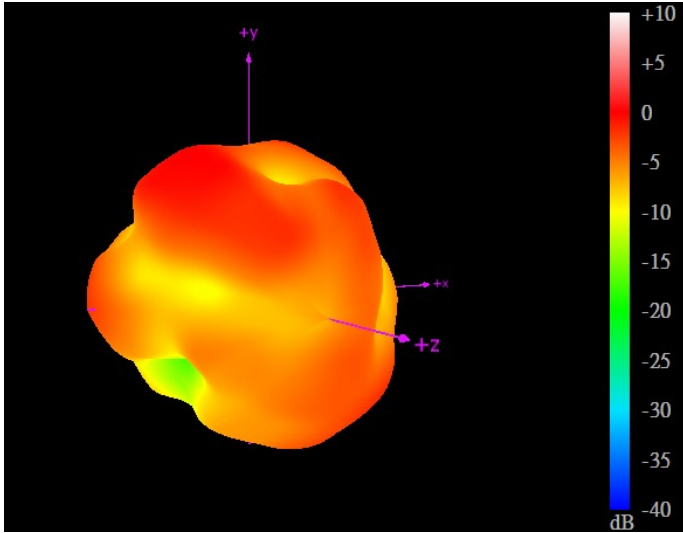
XZ Plane



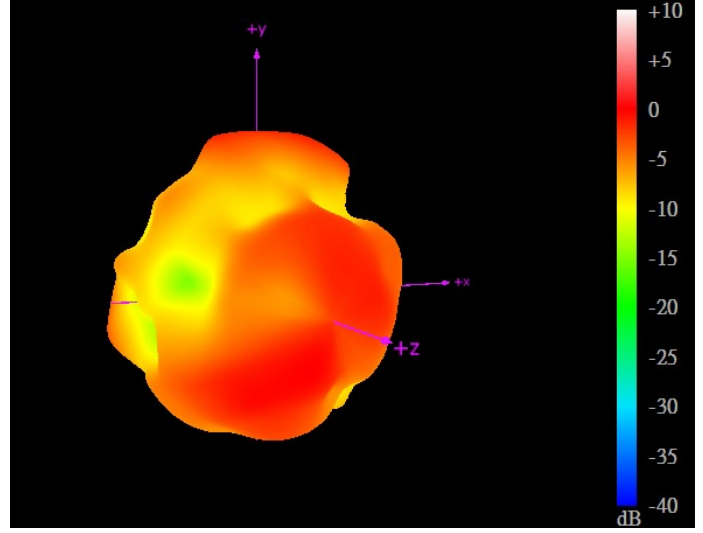
YZ Plane



3.2.28 3D Radiation Pattern (Wi-Fi\_MIMO2 with 1M cable length in free space)



2450MHz



5550MHz

### 3.2.29 Test Setup for Antenna Radiation Pattern

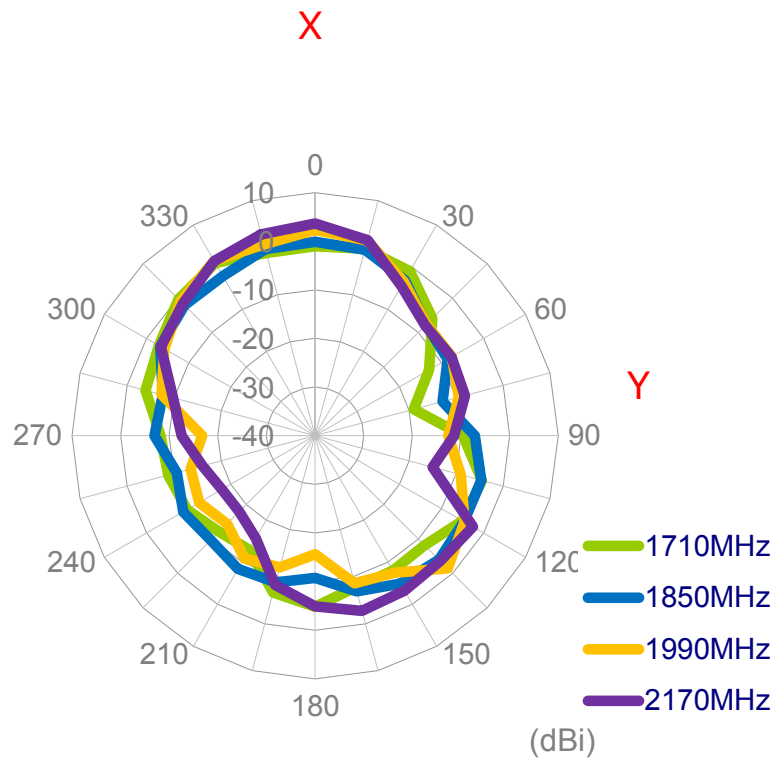
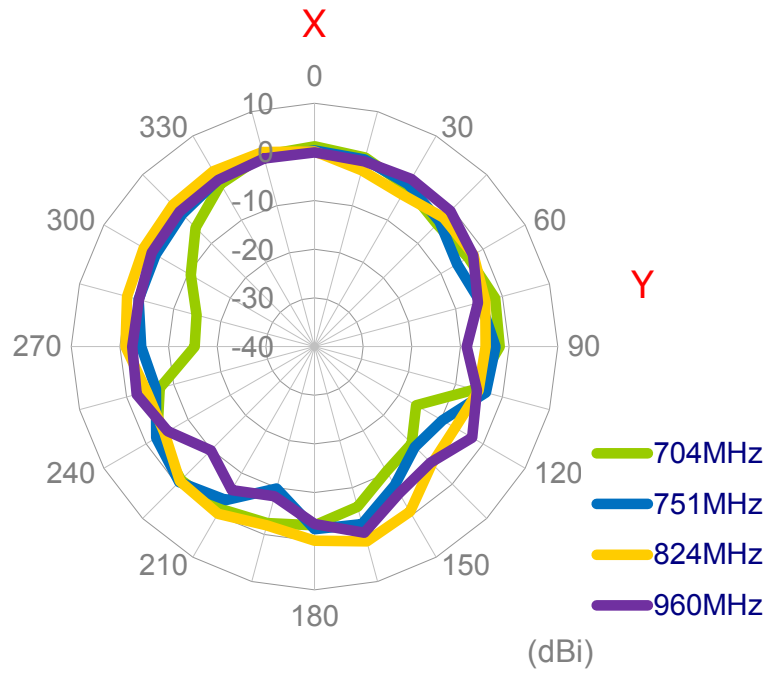


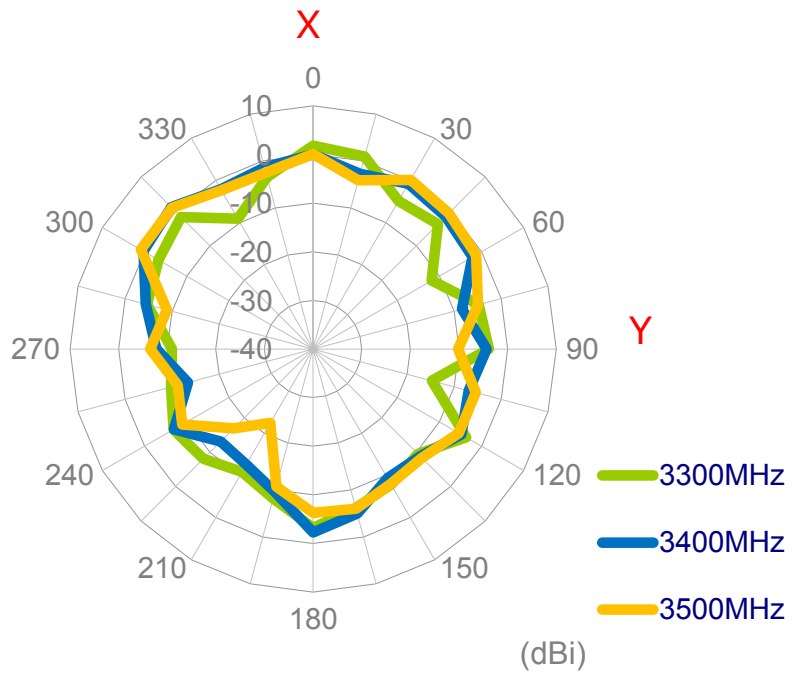
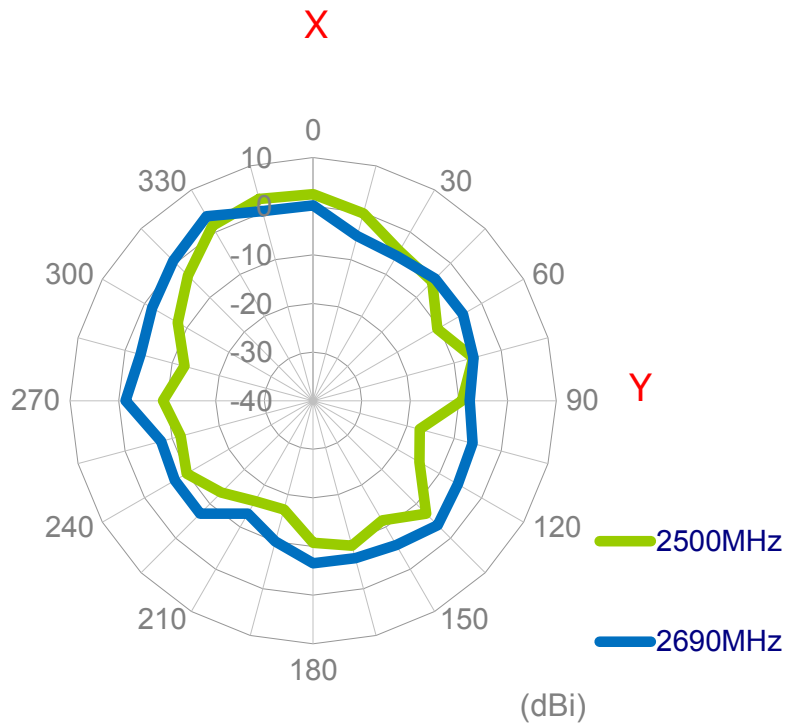
**On the ABS**



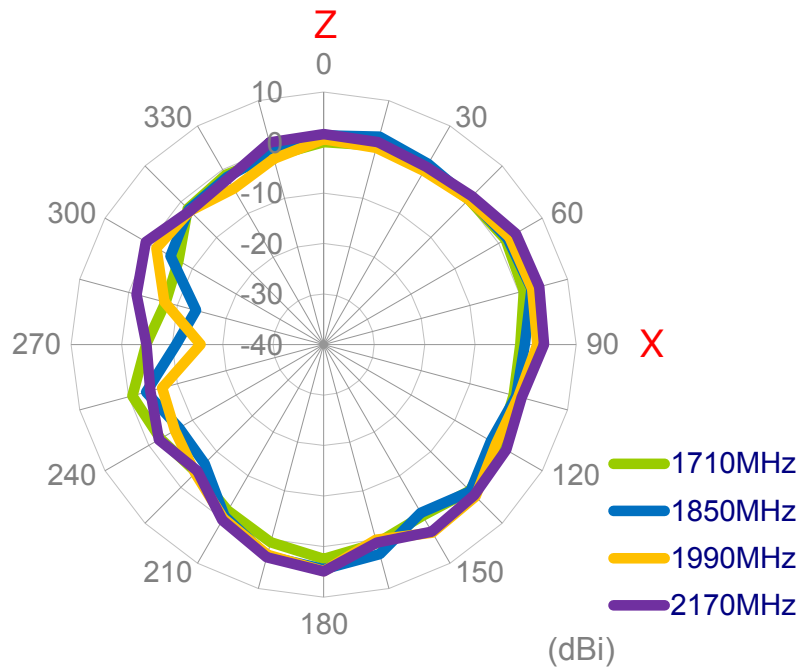
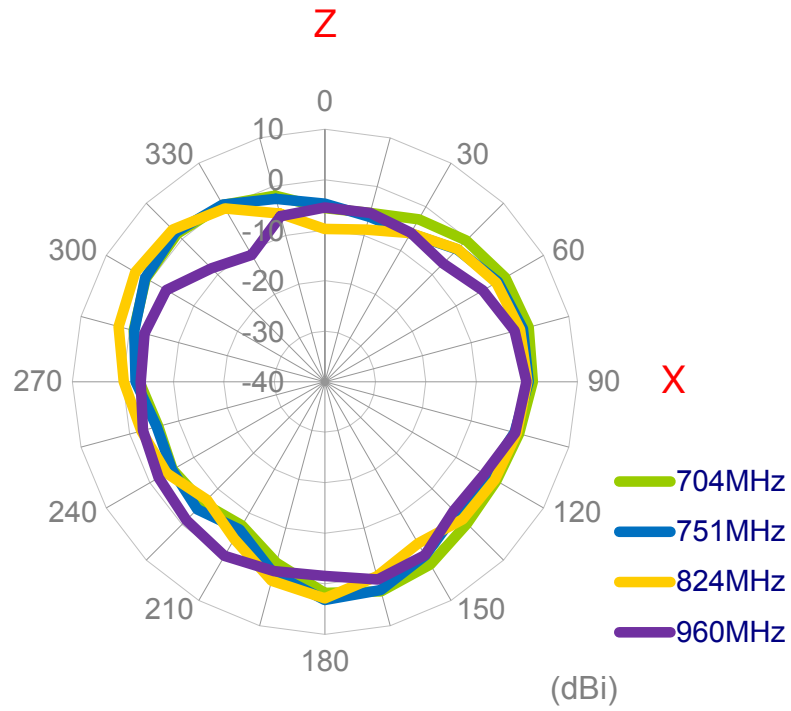
### 3.2.30 2D Radiation Pattern (LTE\_MIMO1 with 1M cable length on ABS)

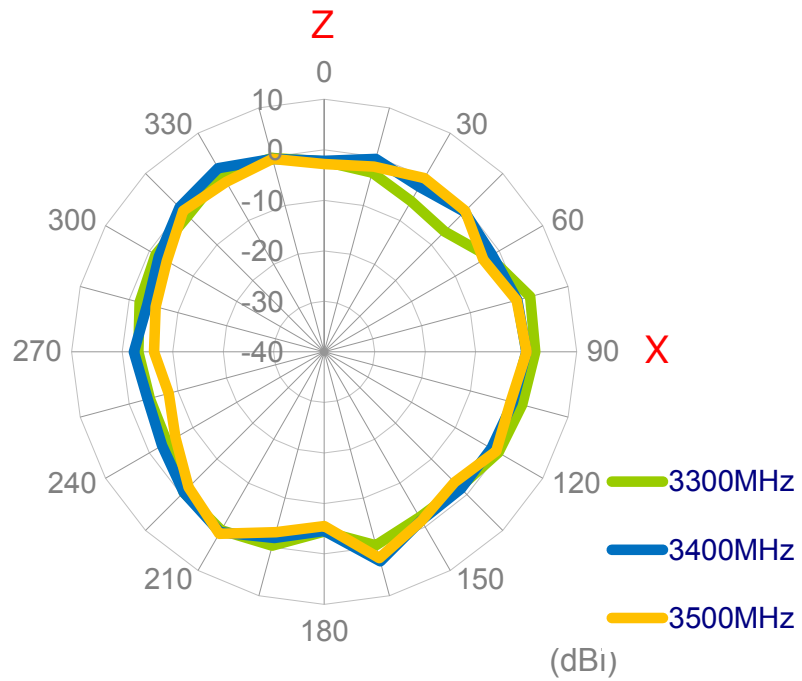
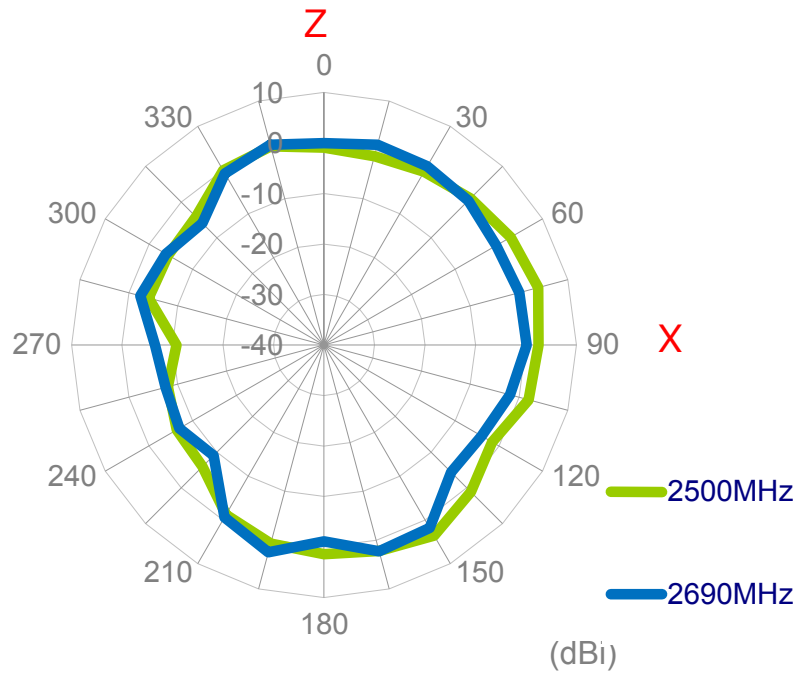
XY Plane



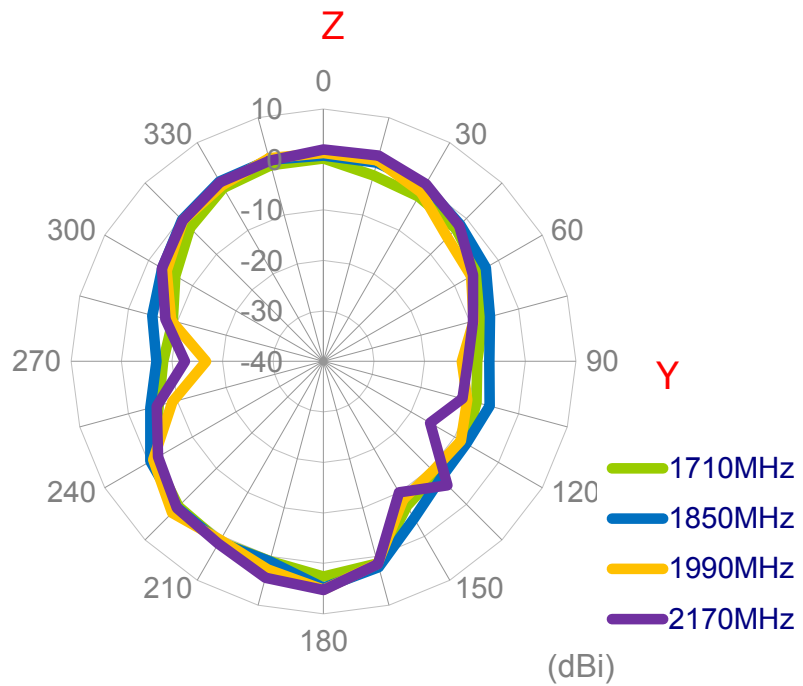
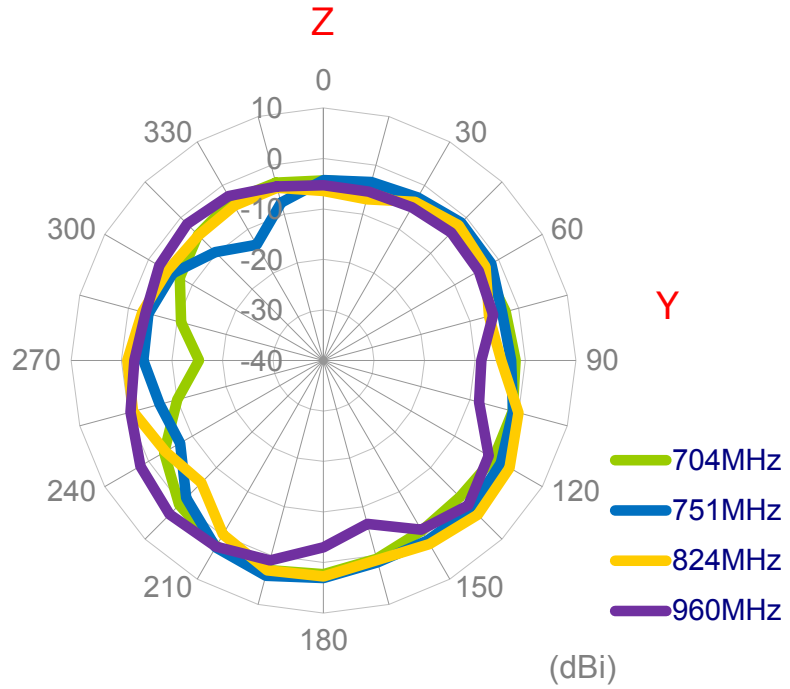


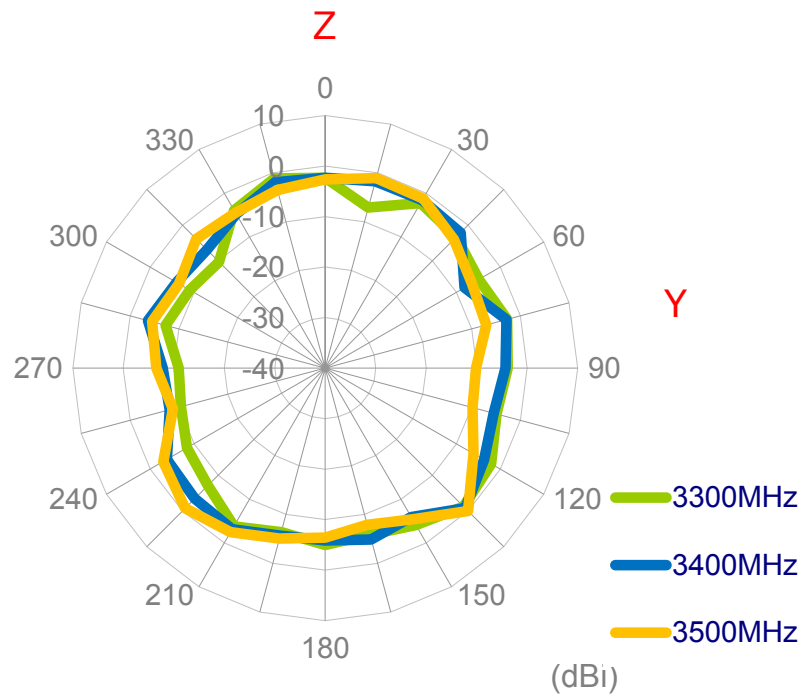
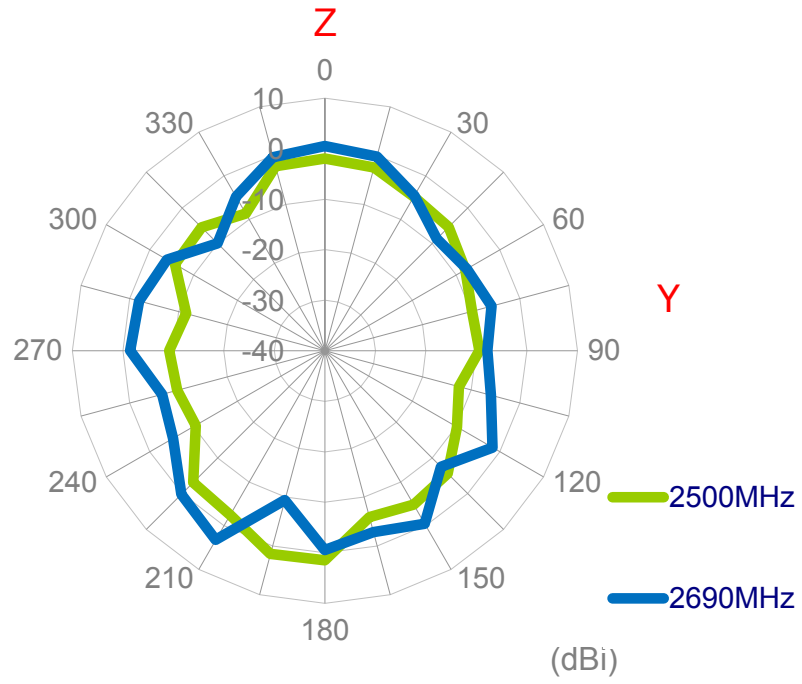
XZ Plane



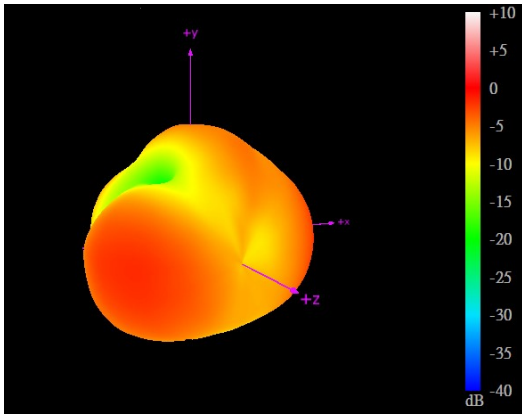


YZ Plane

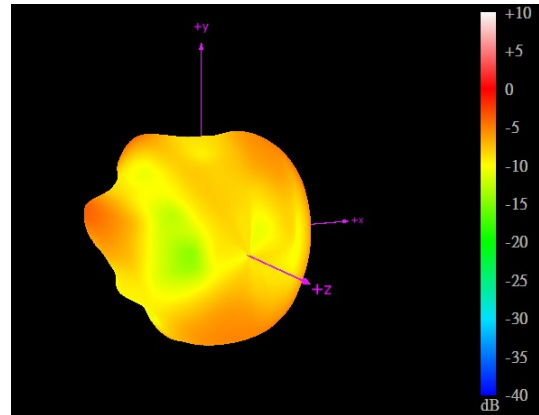




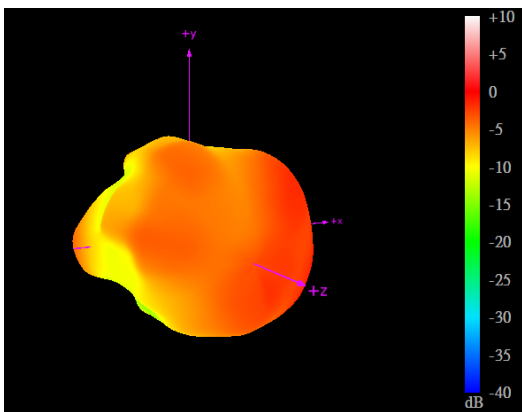
### 3.2.31 3D Radiation Pattern (LTE\_MIMO1 with 1M cable length on ABS)



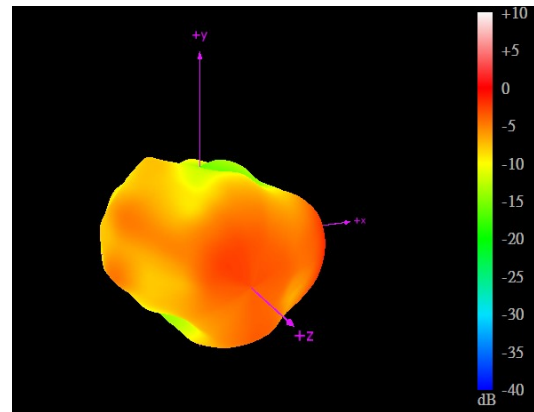
704MHz



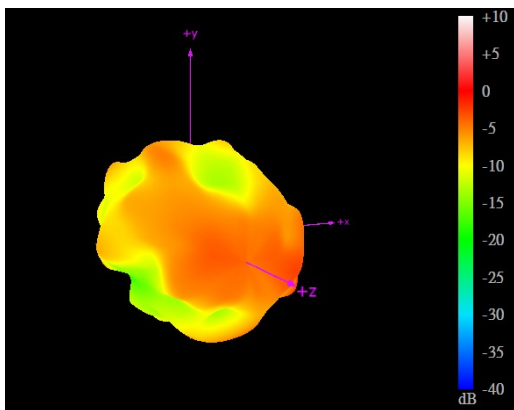
960MHz



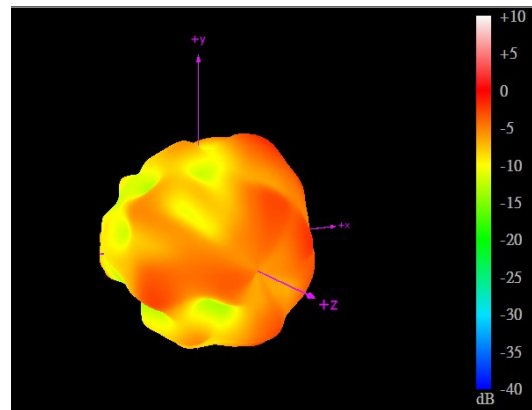
1710MHz



2170MHz



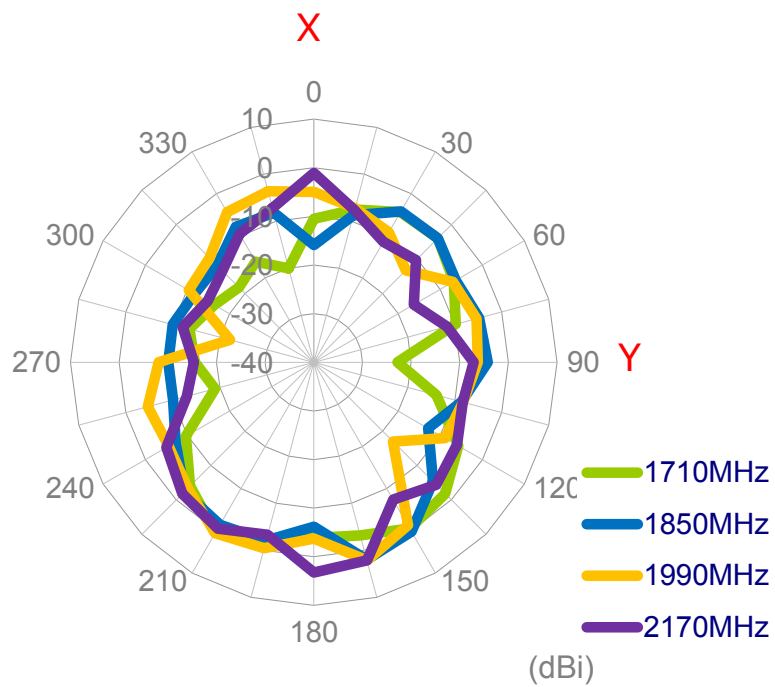
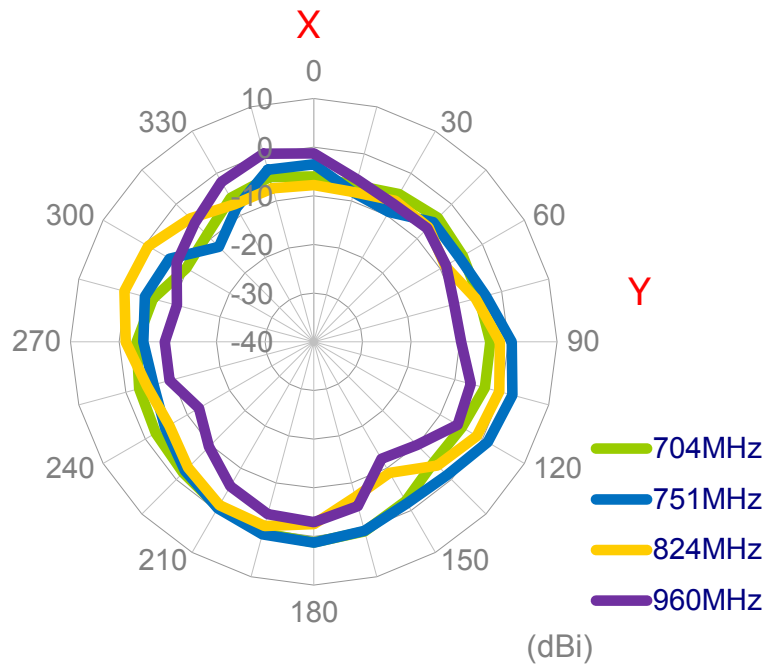
2690MHz



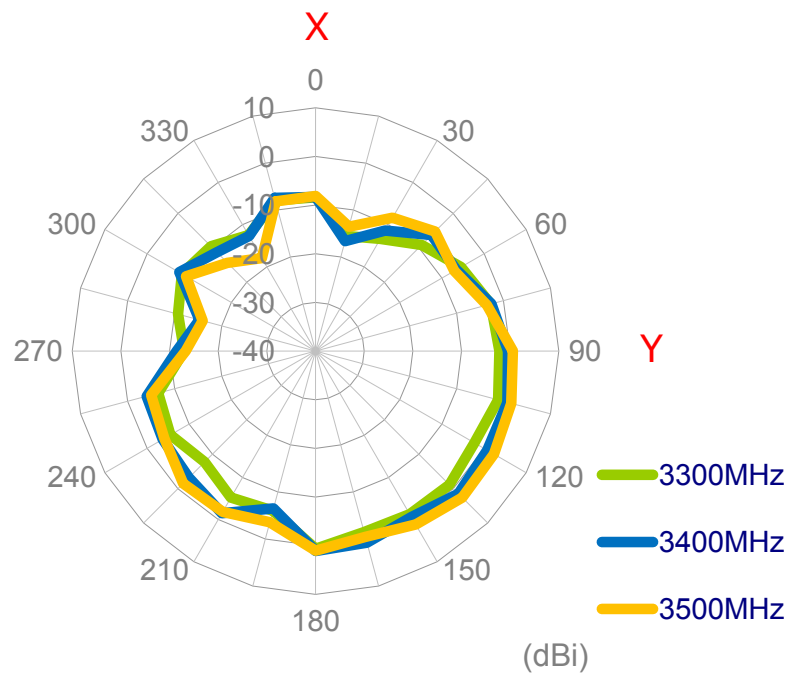
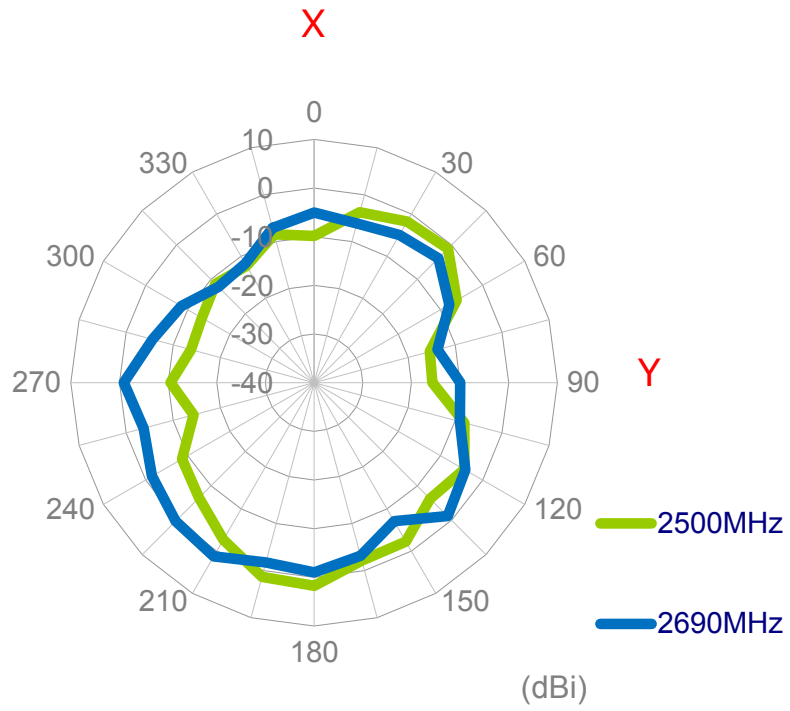
3500MHz

### 3.2.32 2D Radiation Pattern (LTE\_MIMO2 with 1M cable length on ABS)

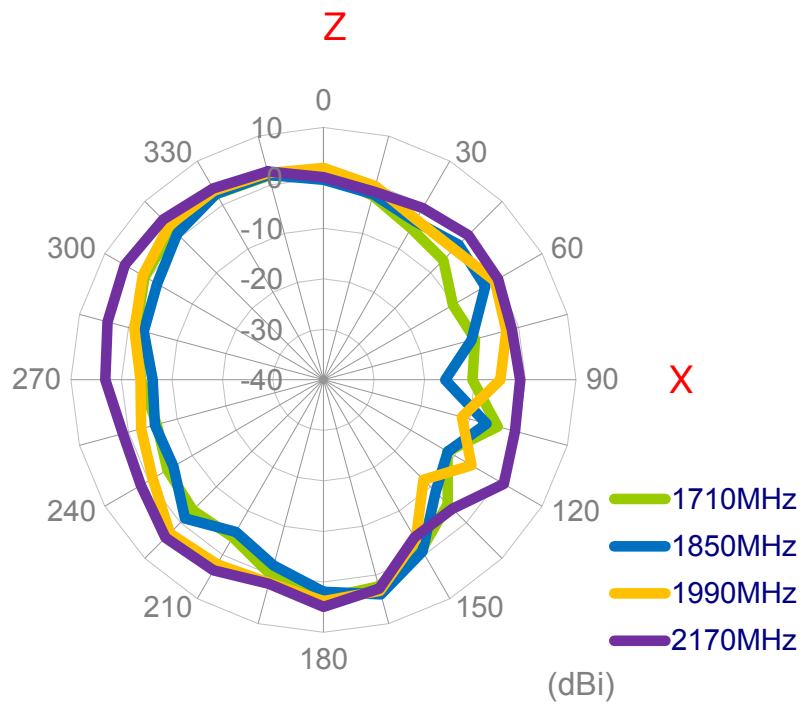
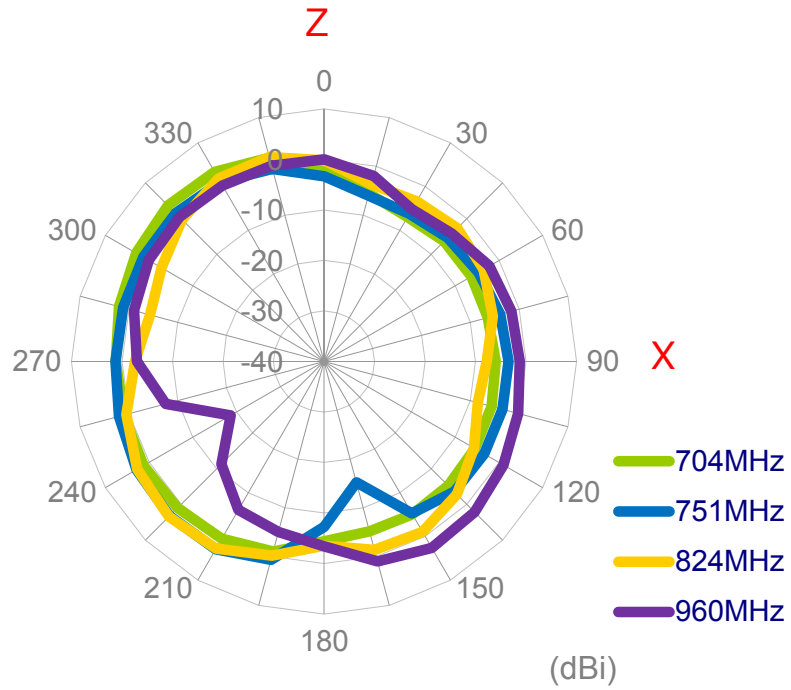
XY Plane

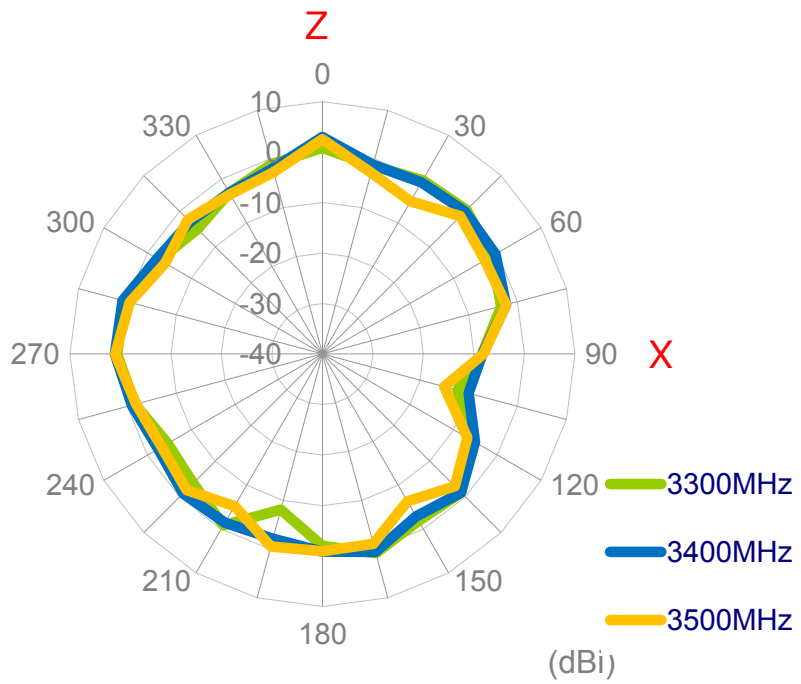
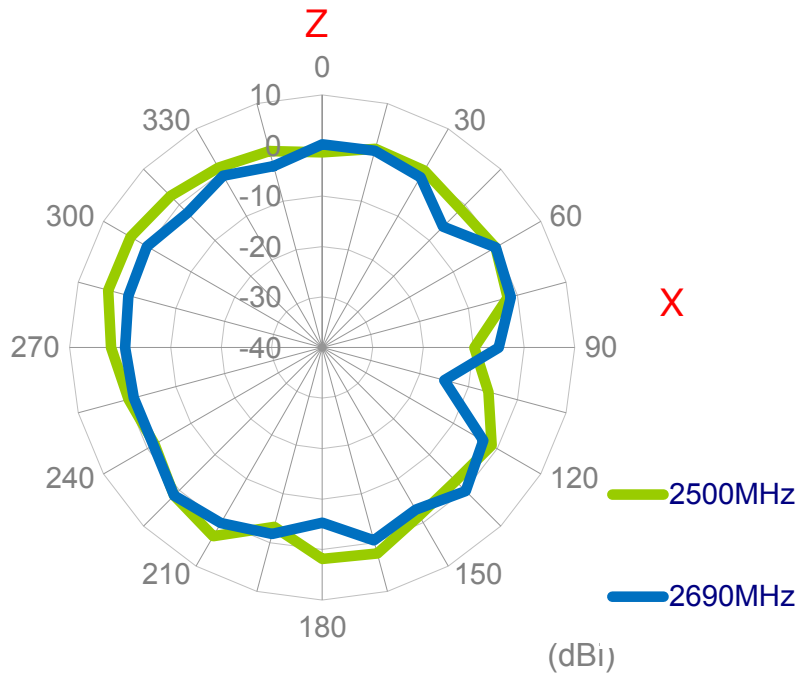




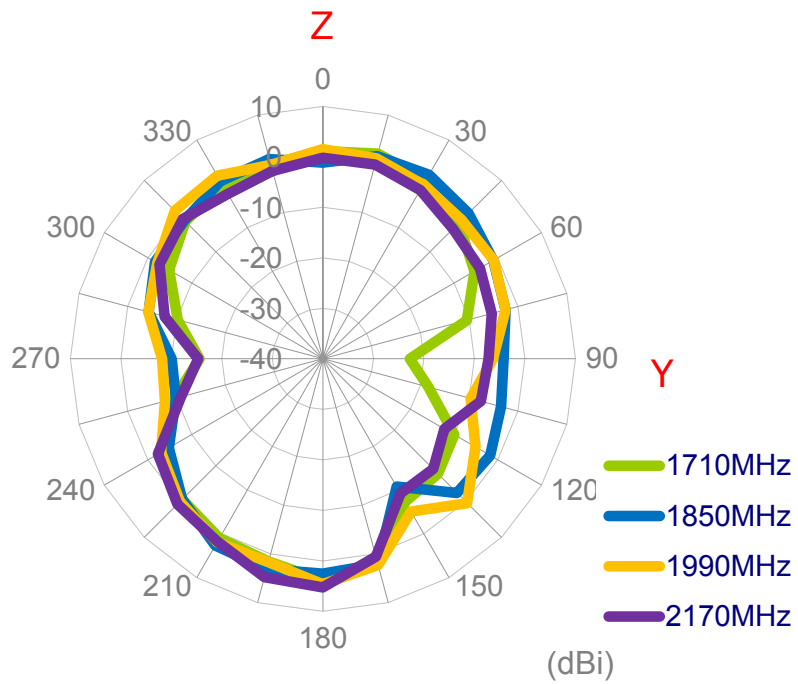
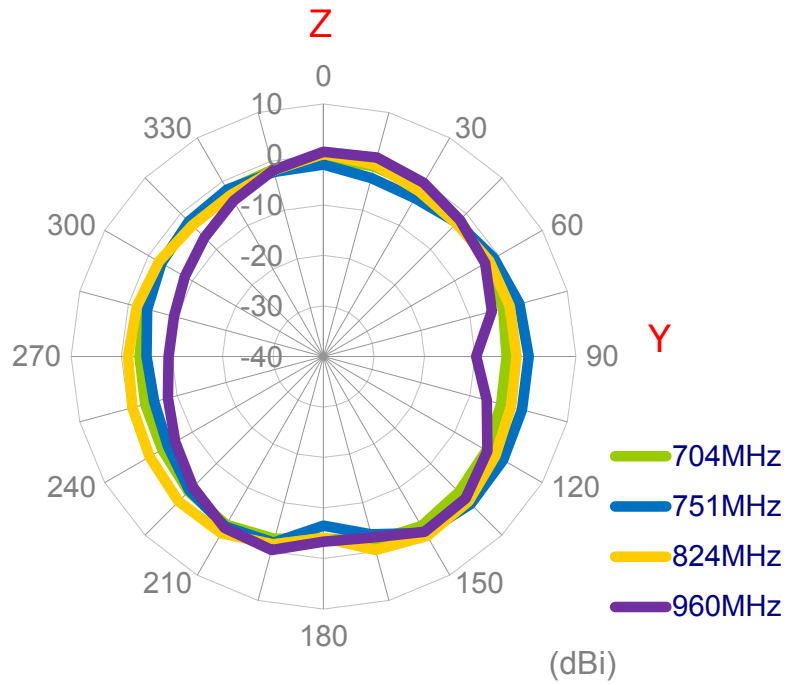


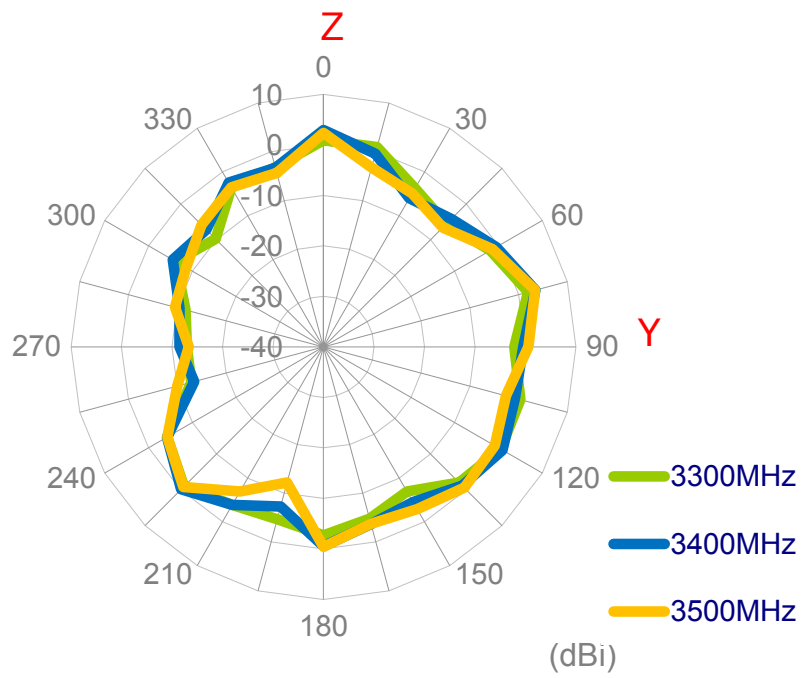
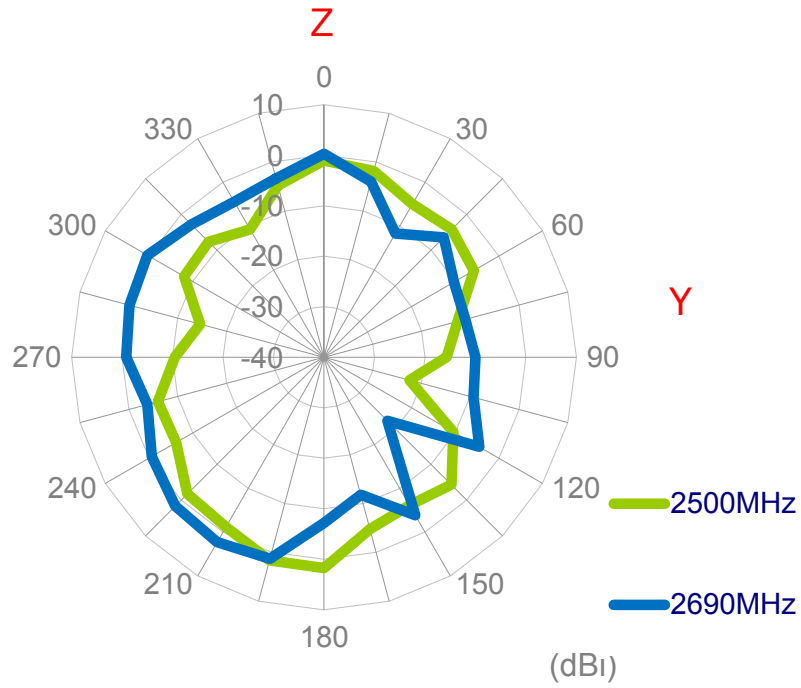
XZ Plane



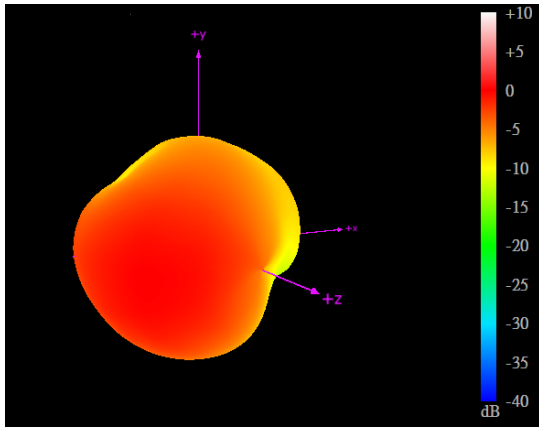


YZ Plane

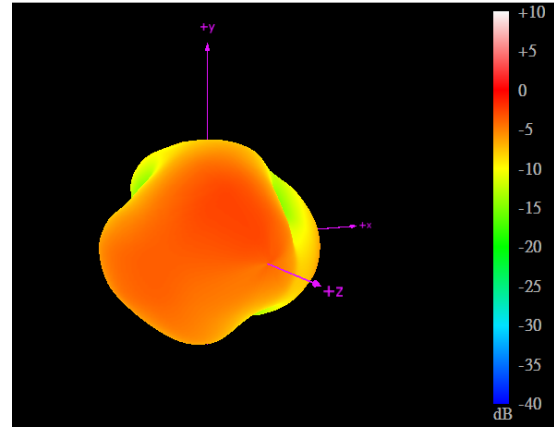




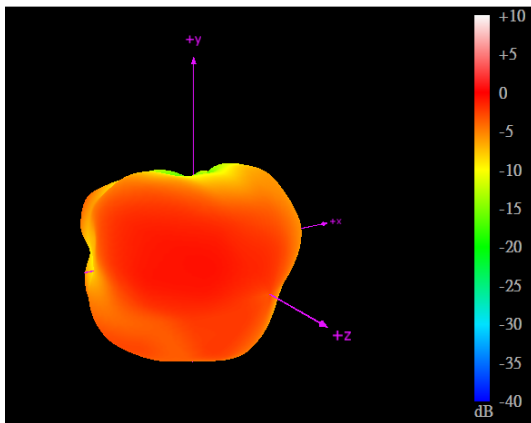
### 3.2.33 3D Radiation Pattern (LTE\_MIMO2 with 1M cable length on ABS)



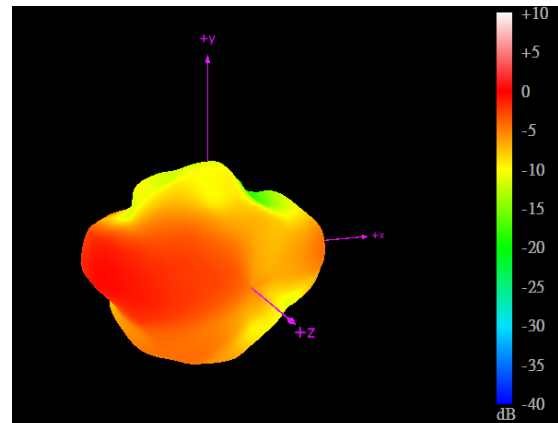
704MHz



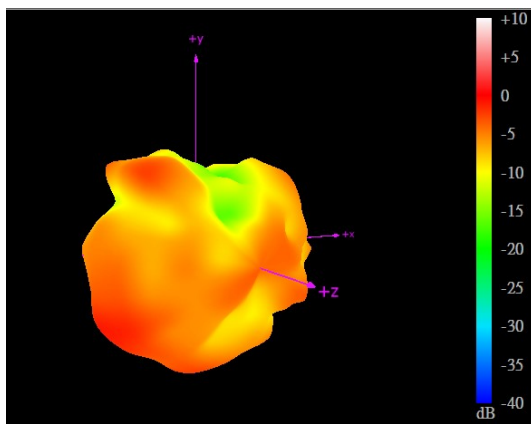
960MHz



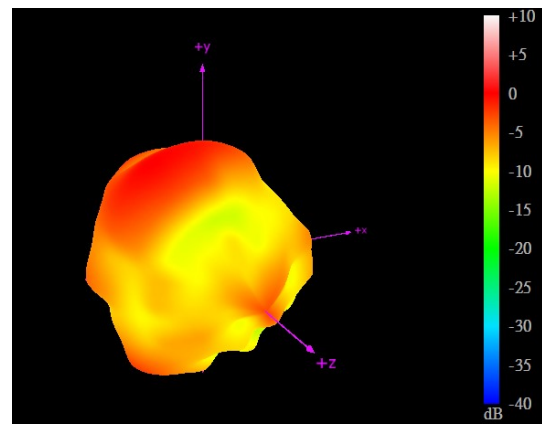
1710MHz



2170MHz



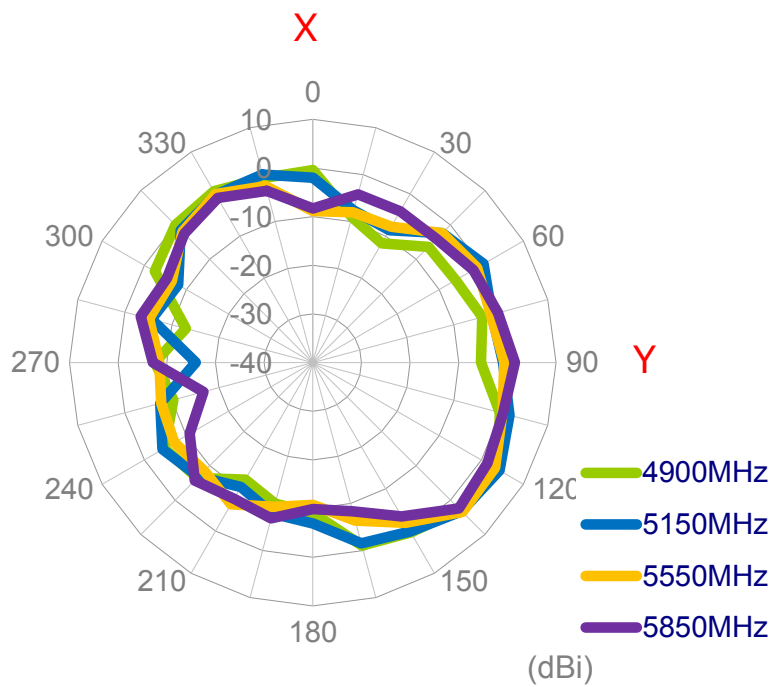
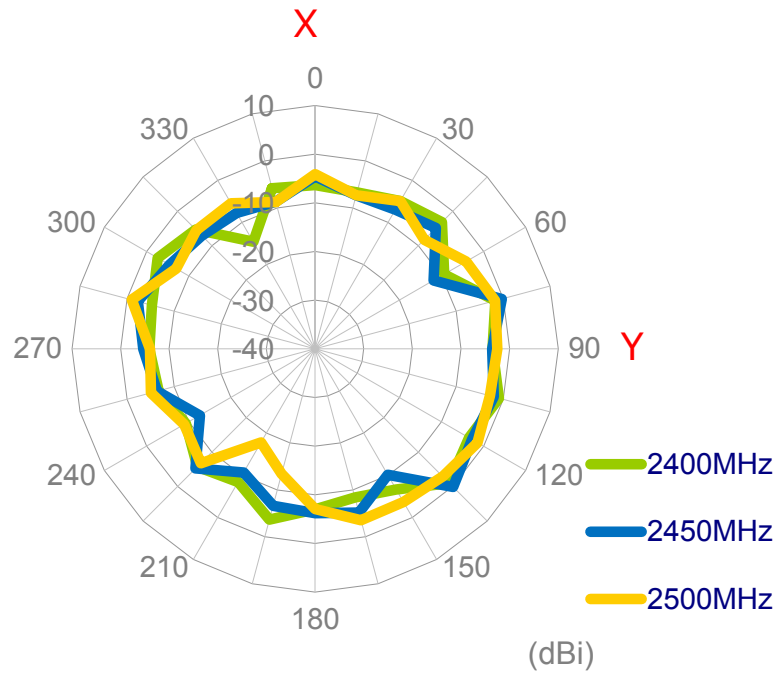
2690MHz



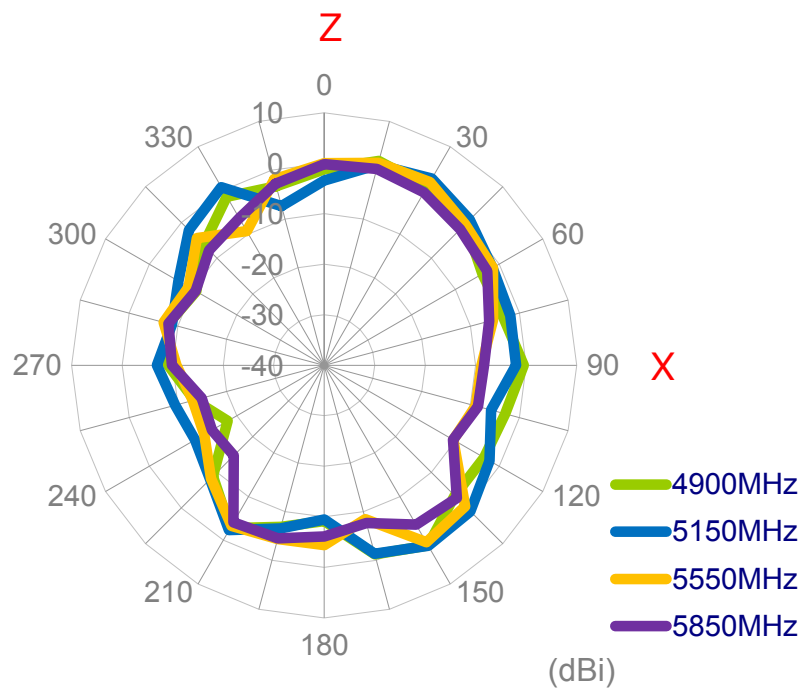
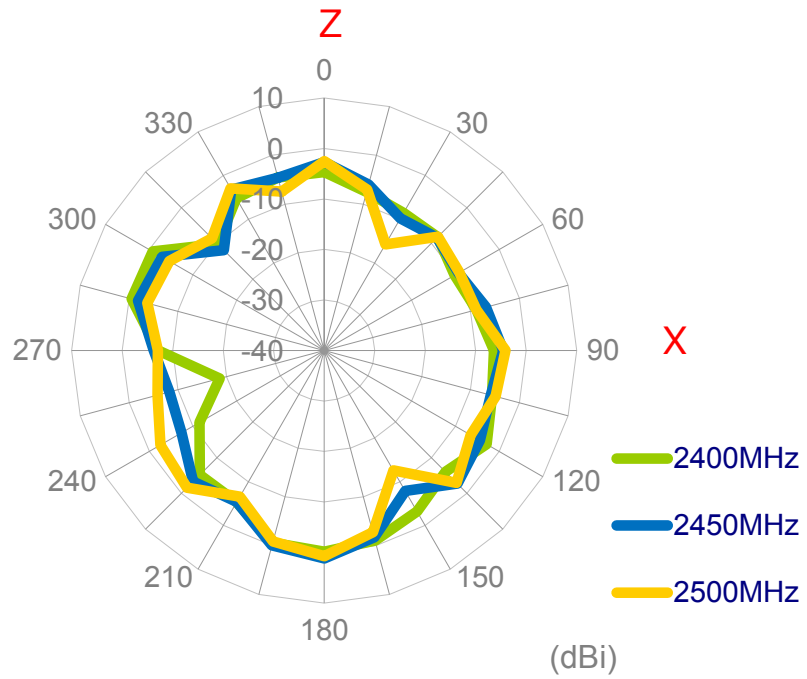
3500MHz

### 3.2.34 2D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length on ABS)

XY Plane

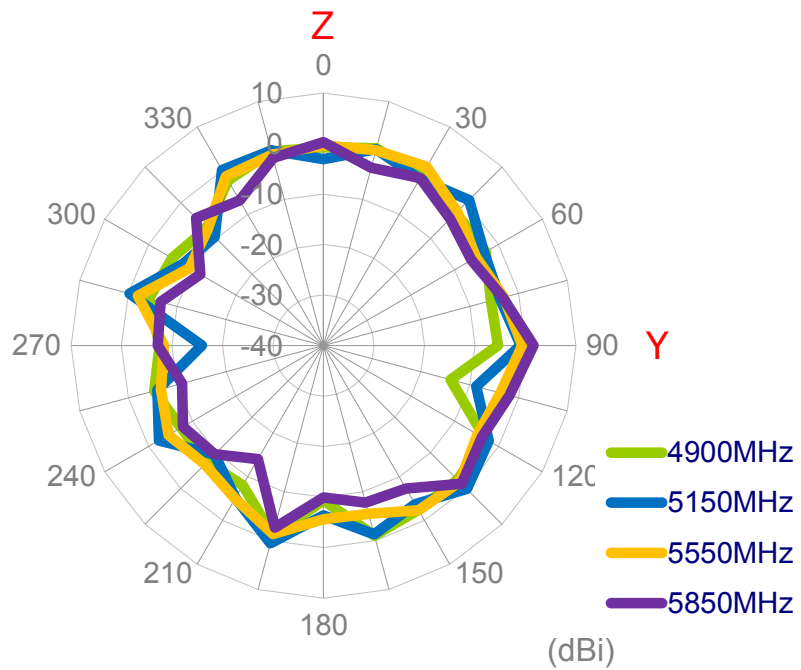
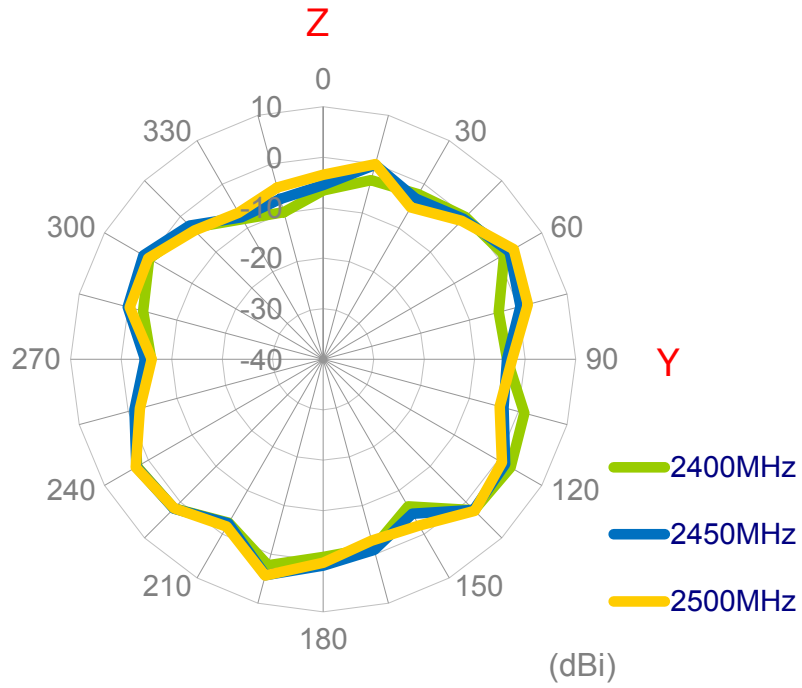


XZ Plane

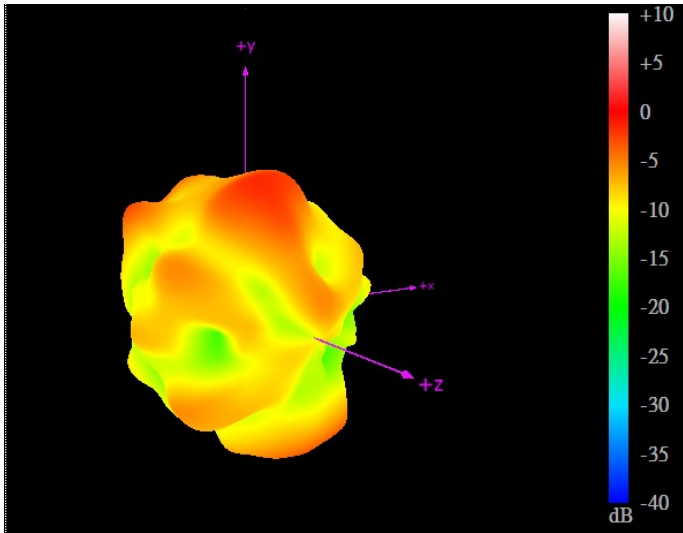




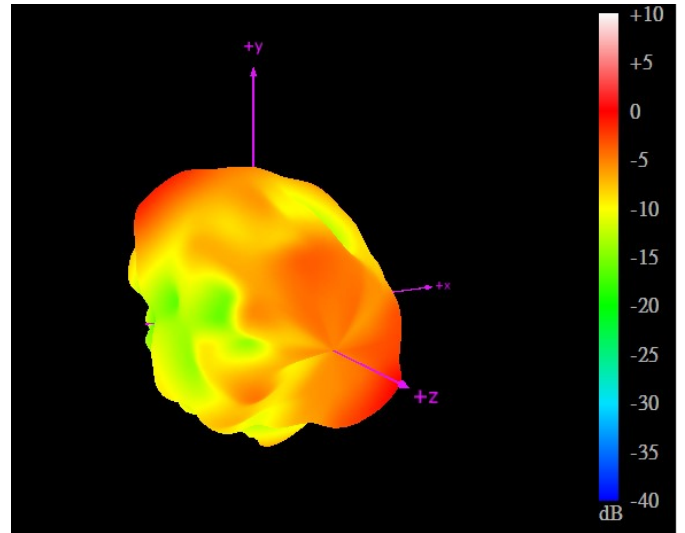
YZ Plane



### 3.2.35 3D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length o ABS)



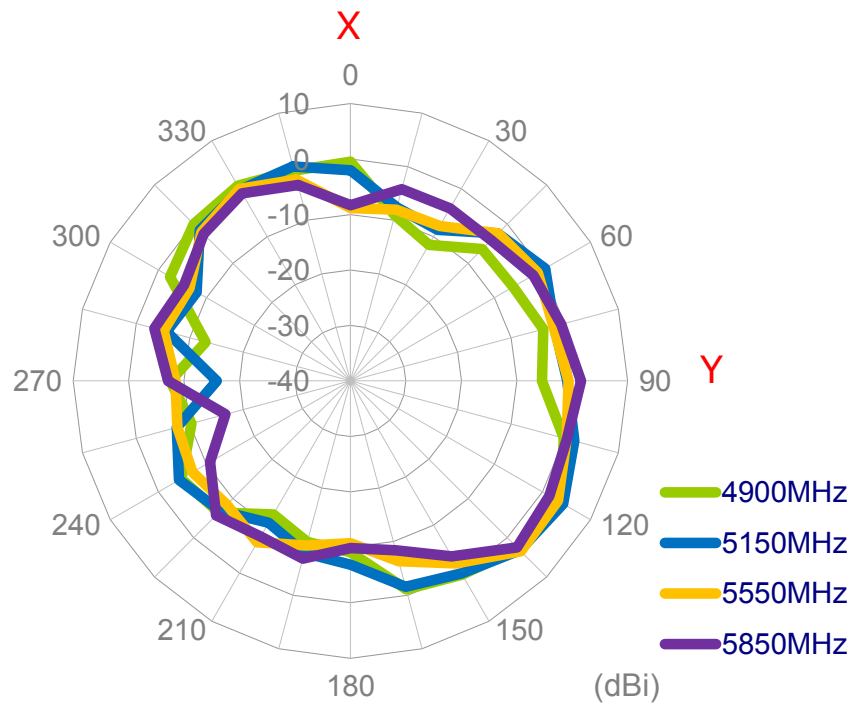
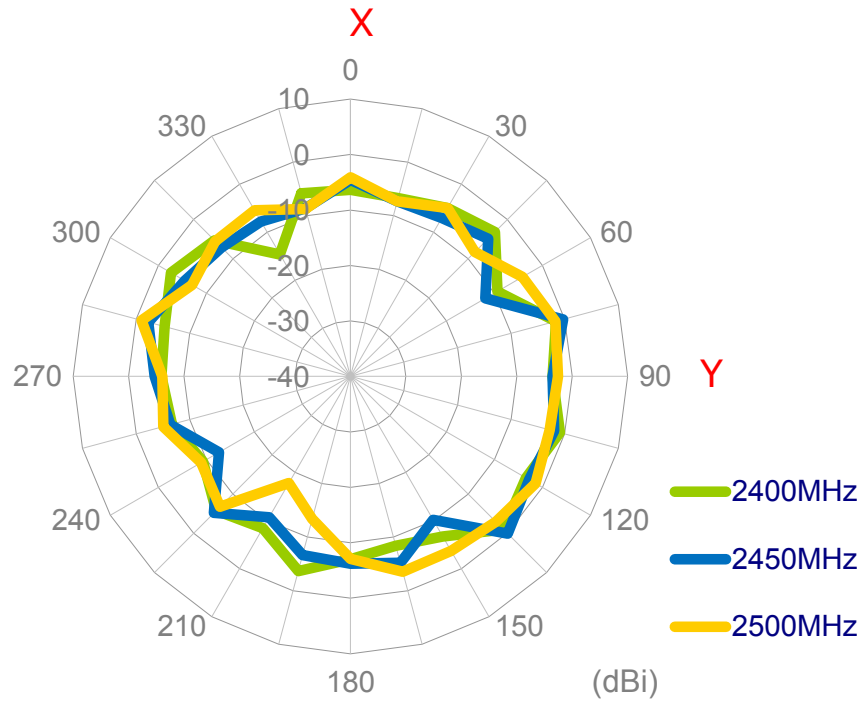
2450MHz



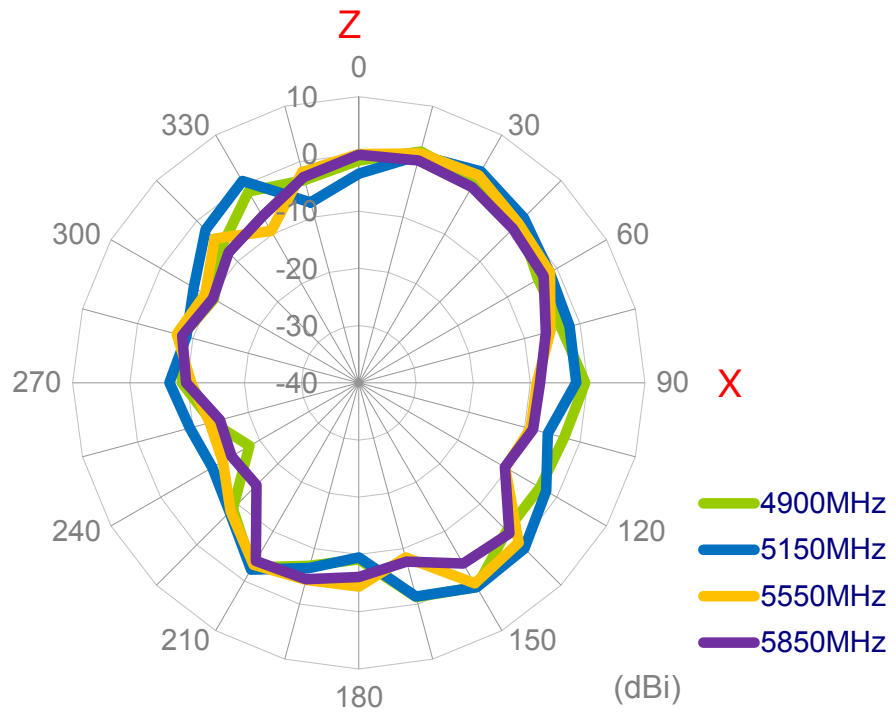
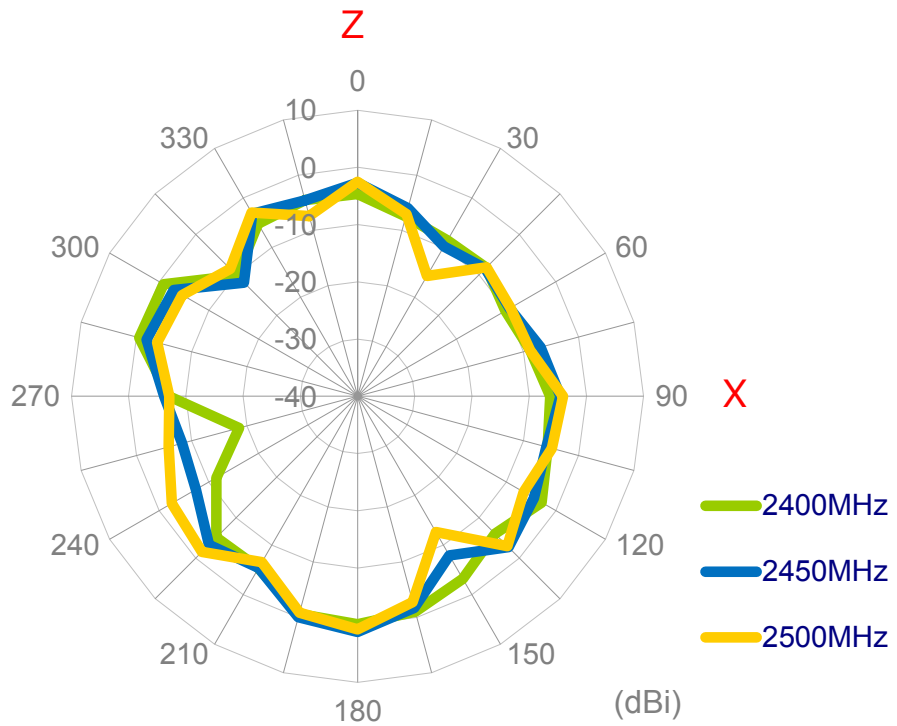
5550MHz

### 3.2.36 2D Radiation Pattern (Wi-Fi\_MIMO2 with 3M cable length o ABS)

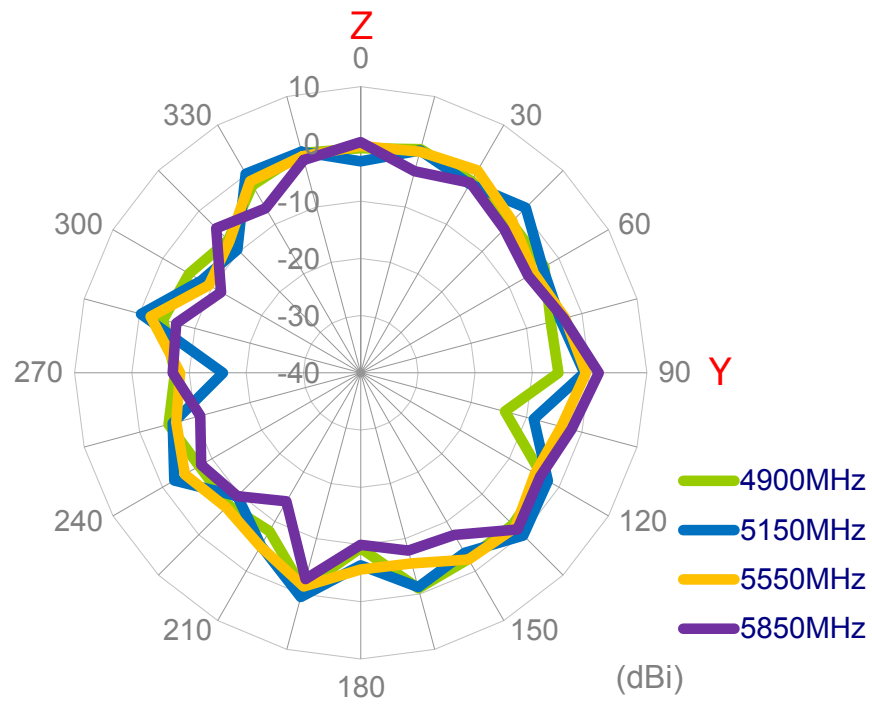
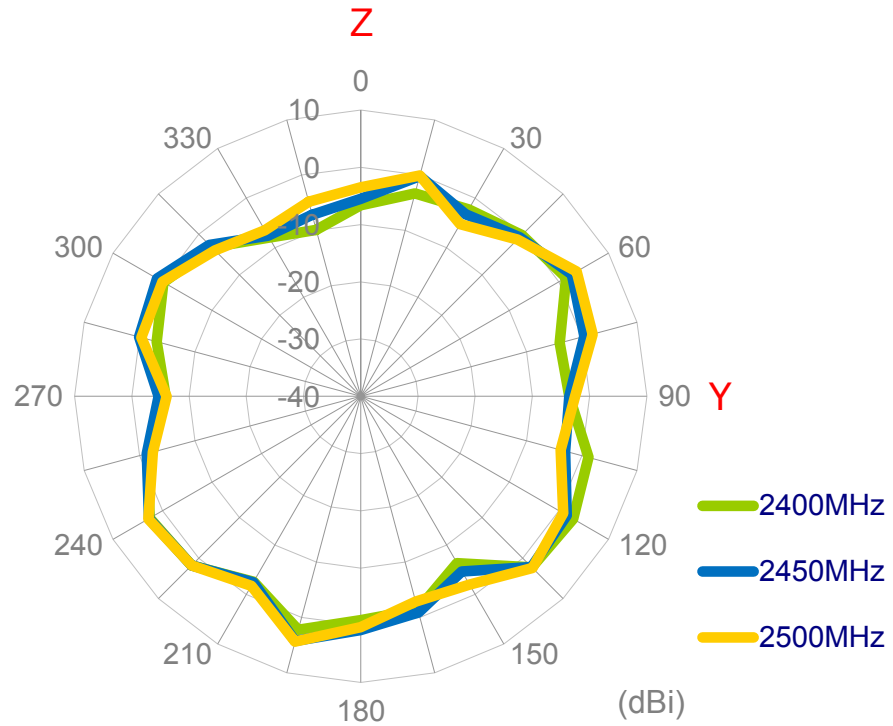
XY Plane



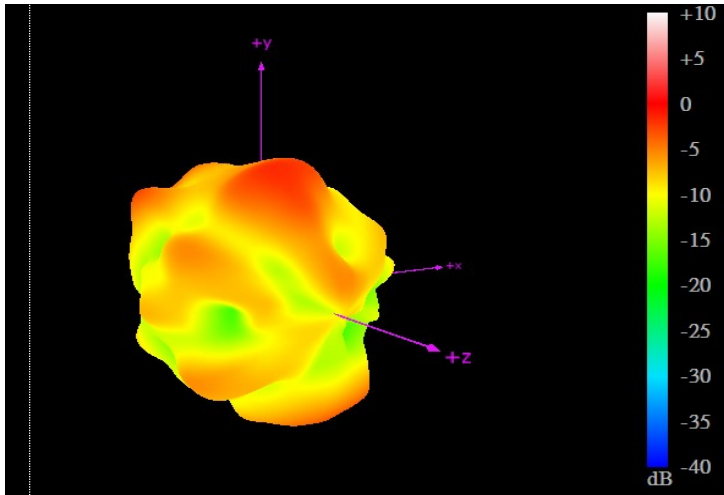
XZ Plane



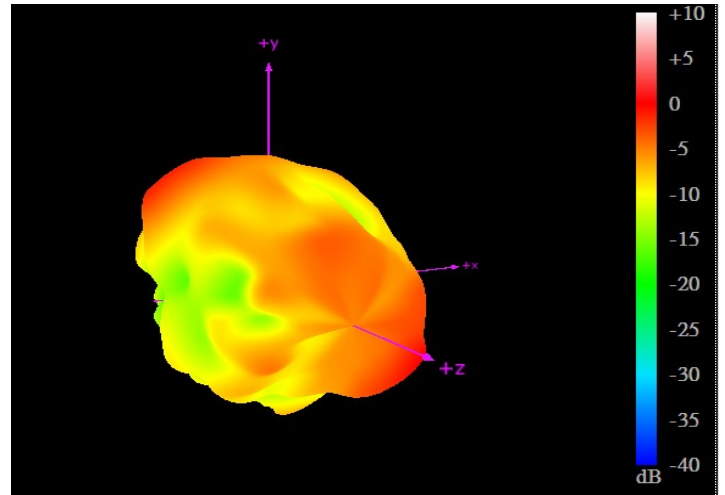
YZ Plane



### 3.2.37 3D Radiation Pattern (Wi-Fi\_MIMO2 with 1M cable length on ABS)

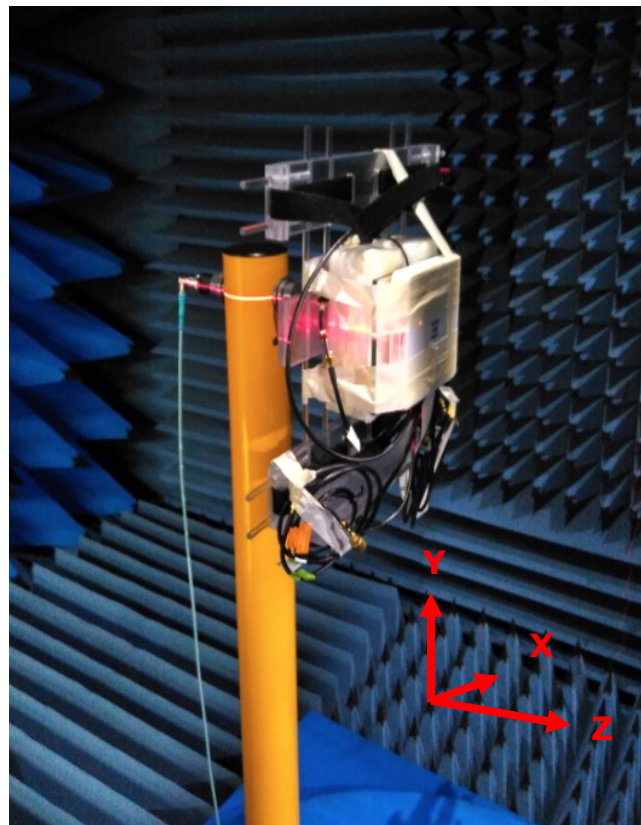


2450MHz



5550MHz

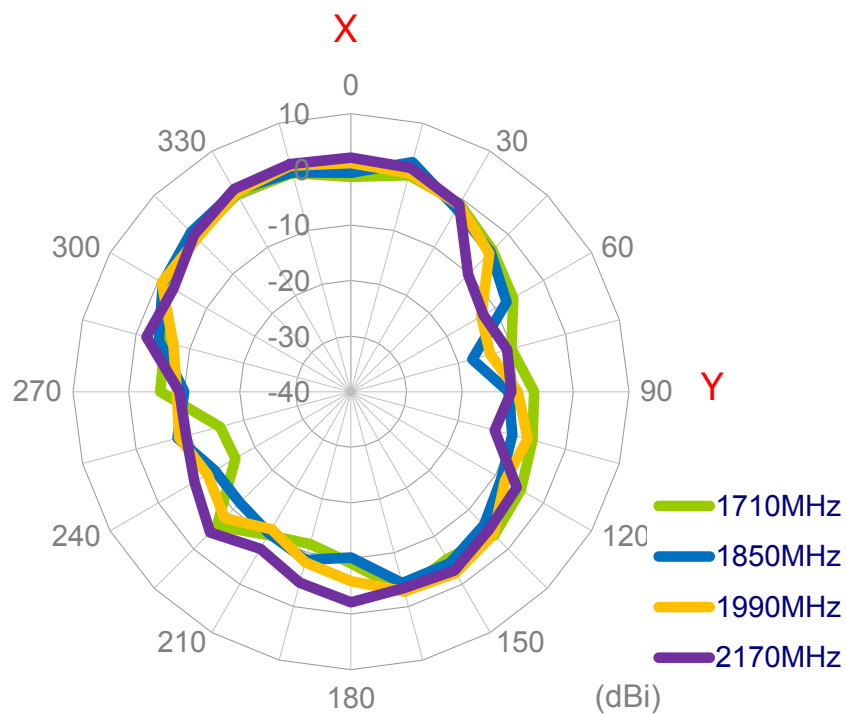
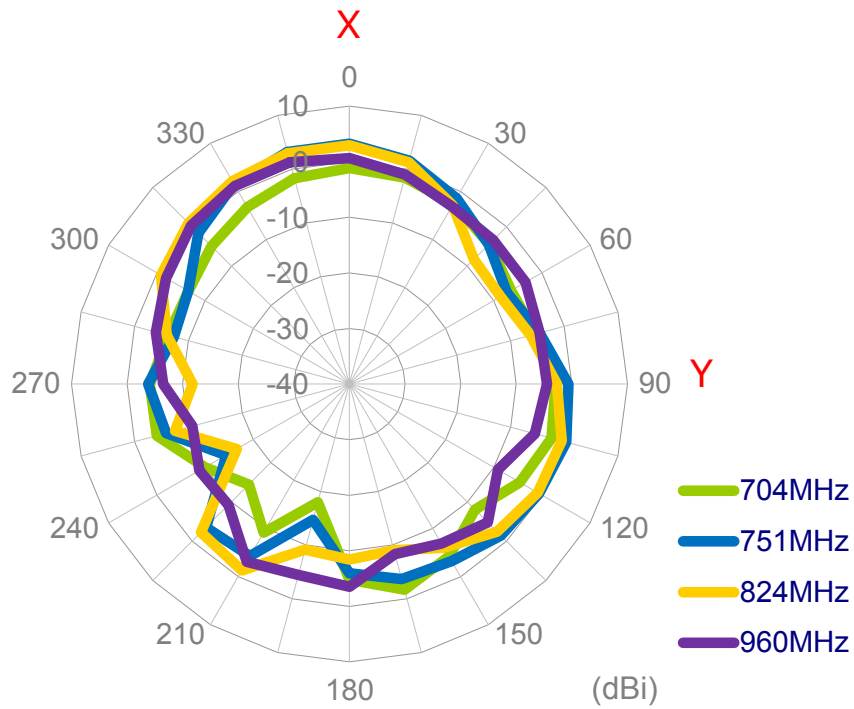
### 3.2.38 Test Setup For Antenna Radiation Pattern

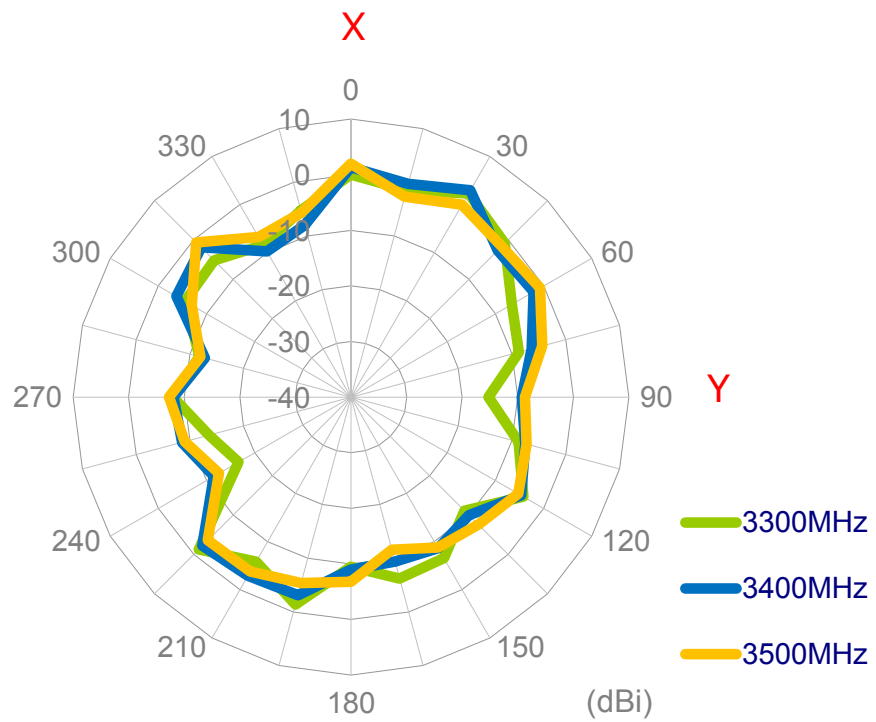
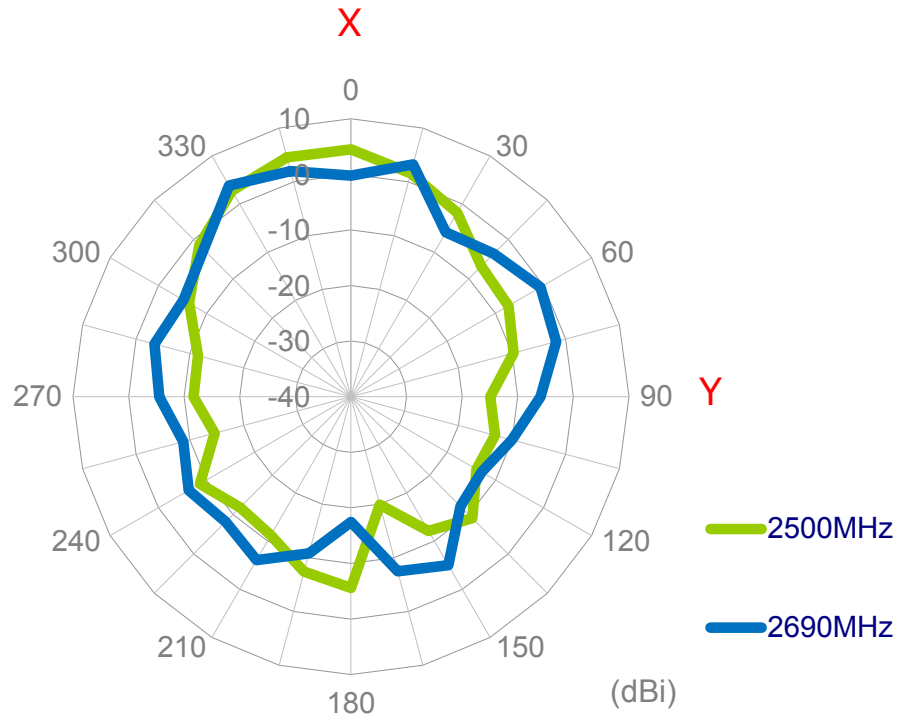


On glass

### 3.2.39 2D Radiation Pattern (LTE\_MIMO1 with 1M cable length on glass)

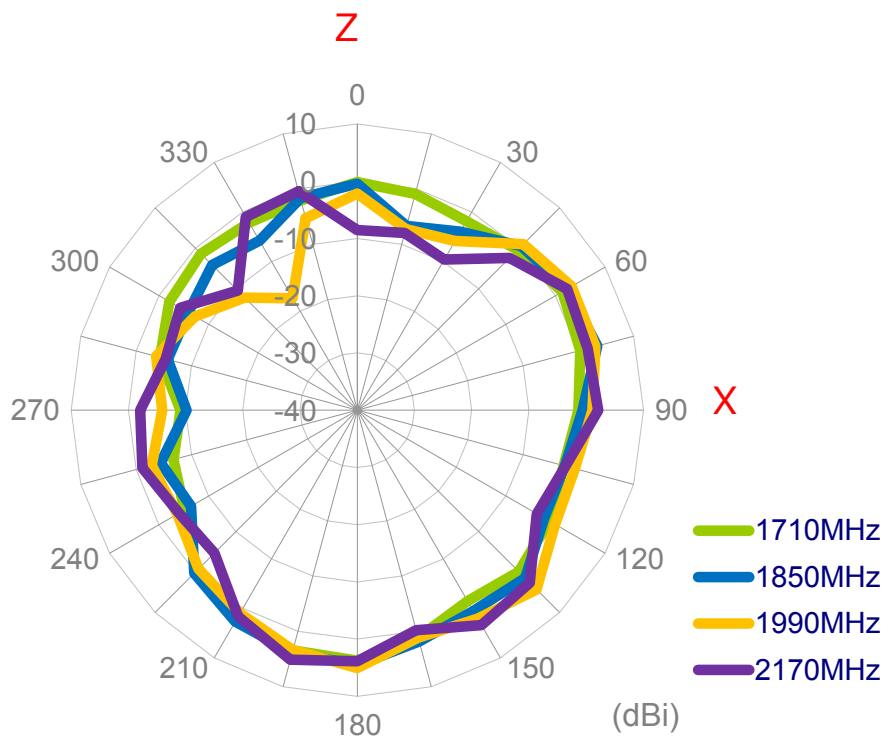
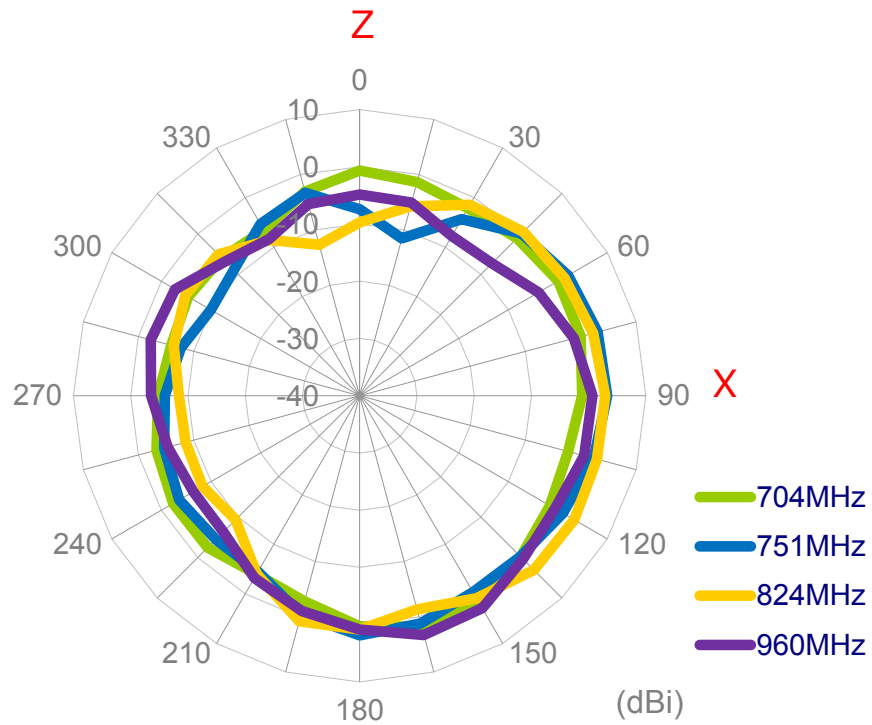
XY Plane

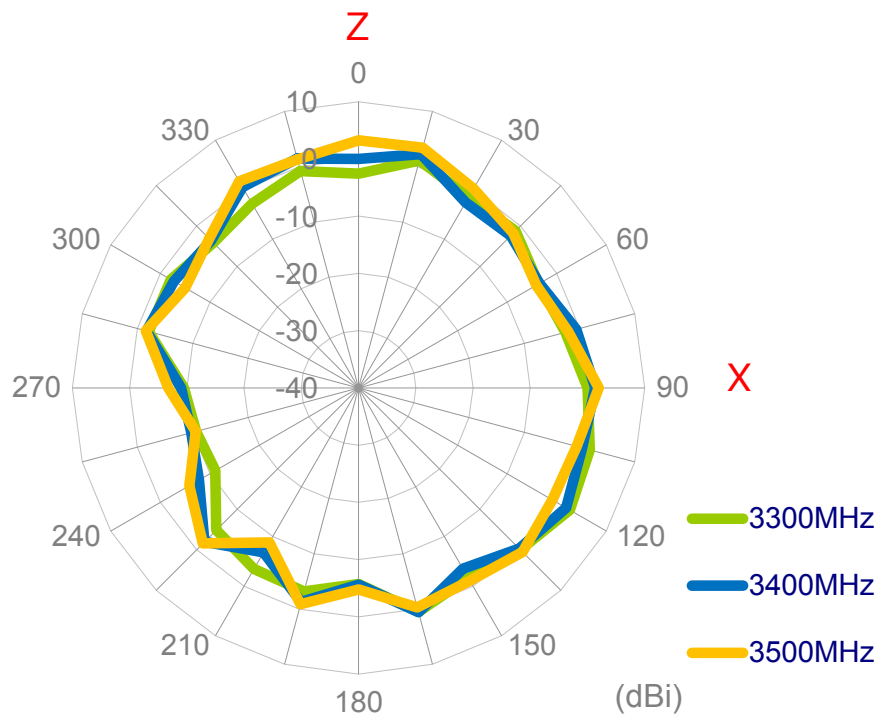
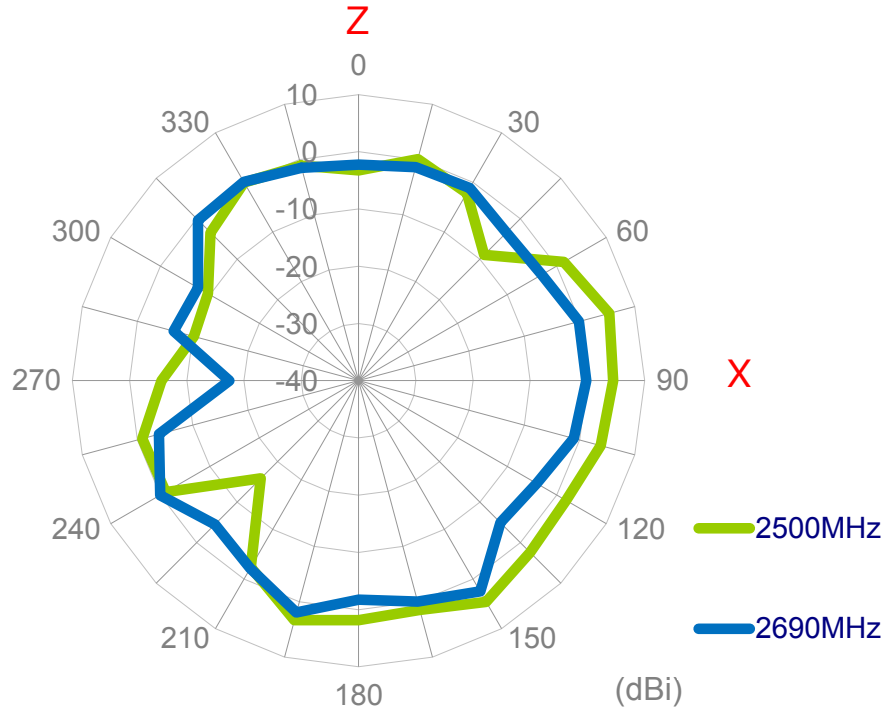




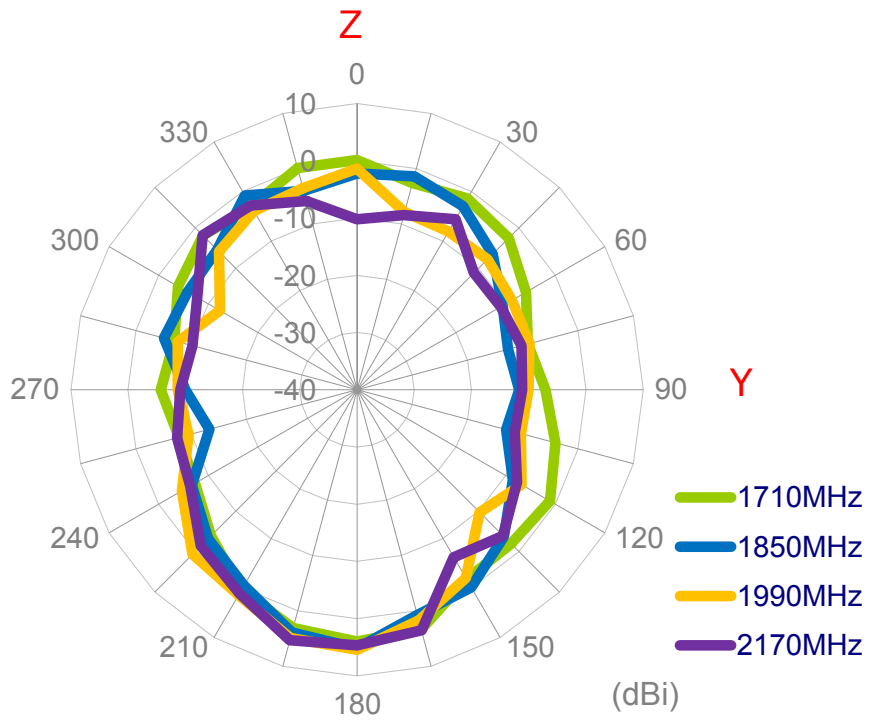
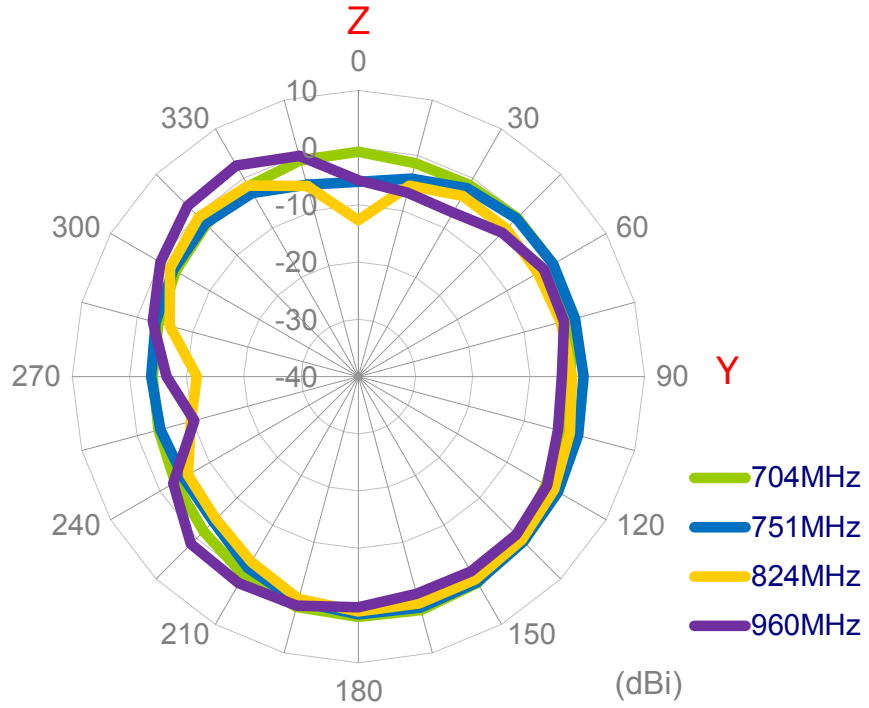


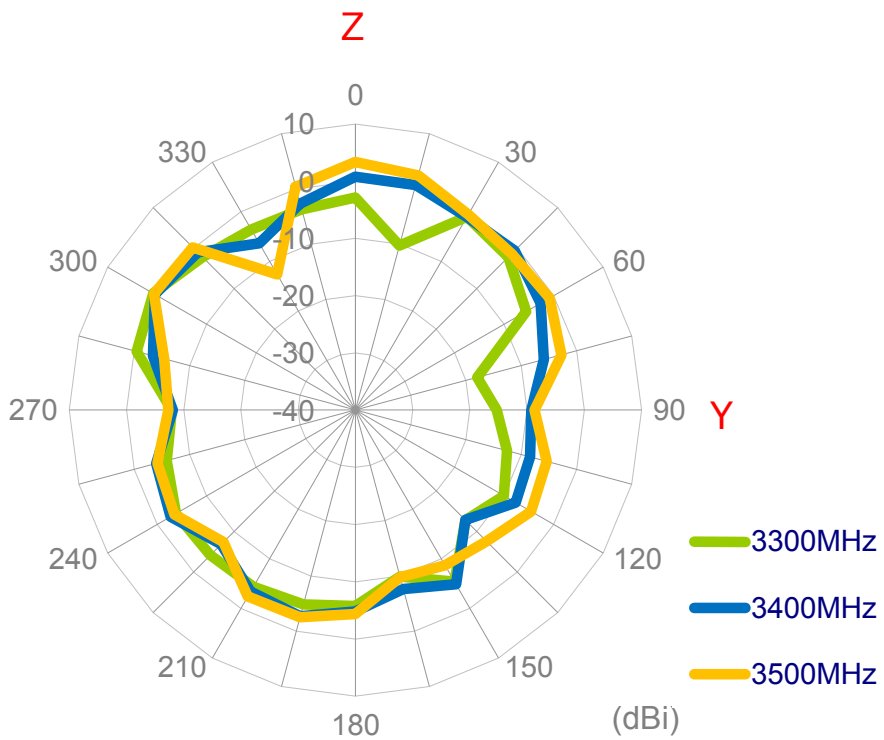
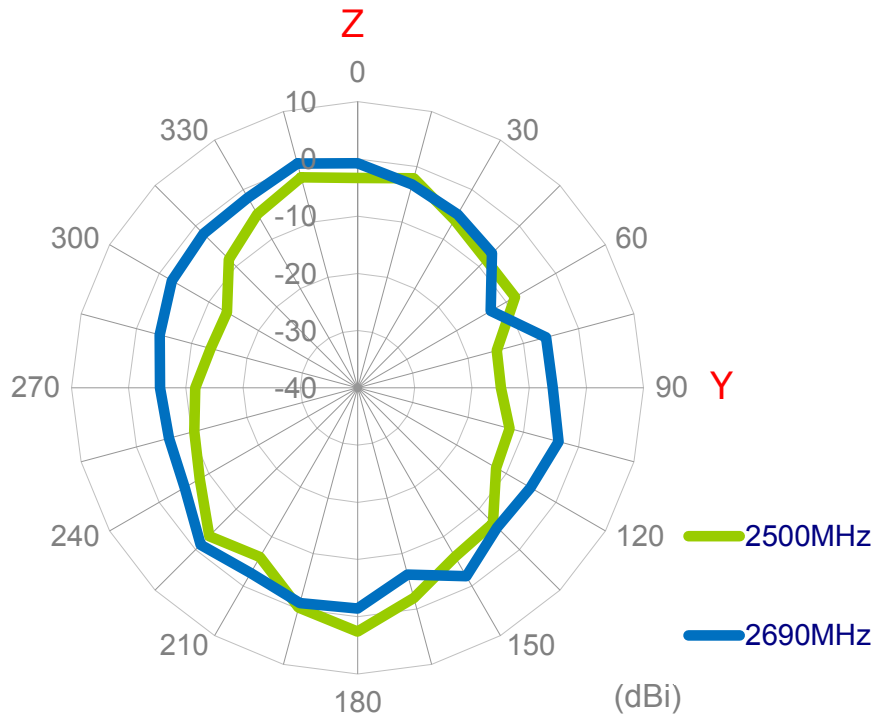
XZ Plane



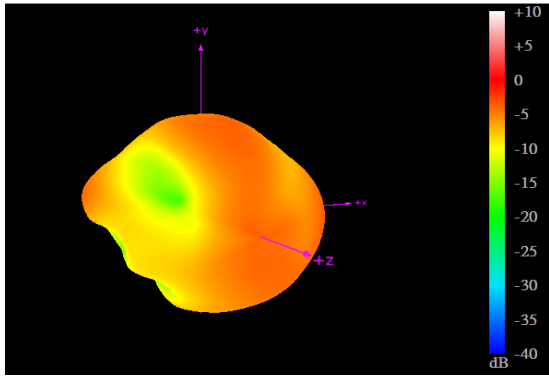


YZ Plane

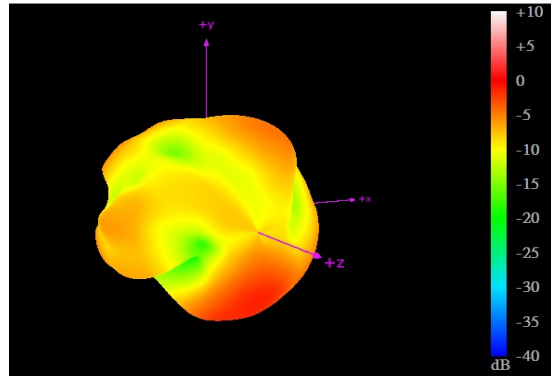




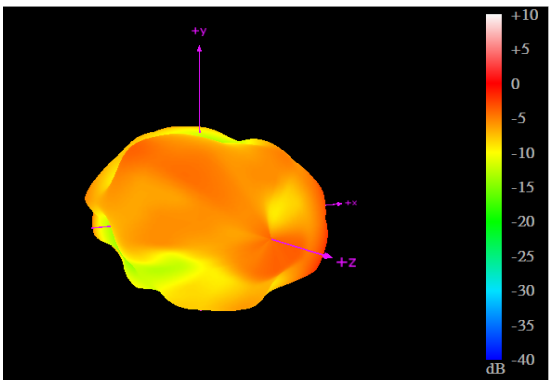
3.2.40 3D Radiation Pattern (LTE\_MIMO1 with 1M cable length o glass)



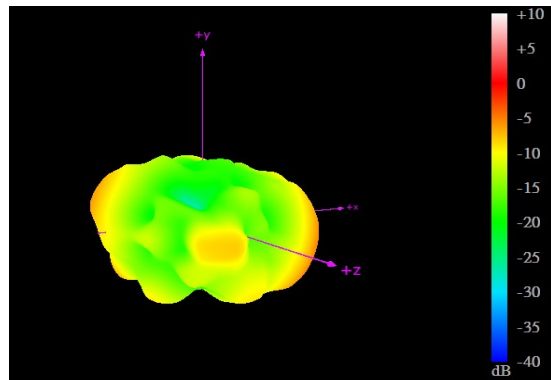
704MHz



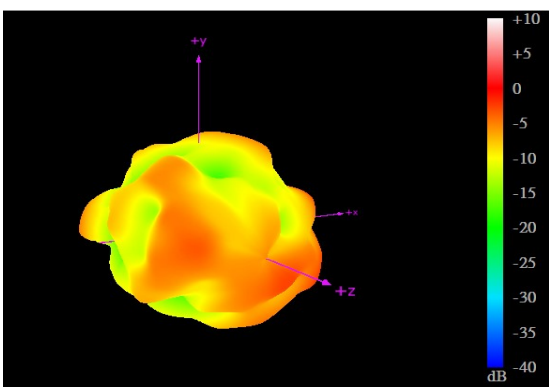
960MHz



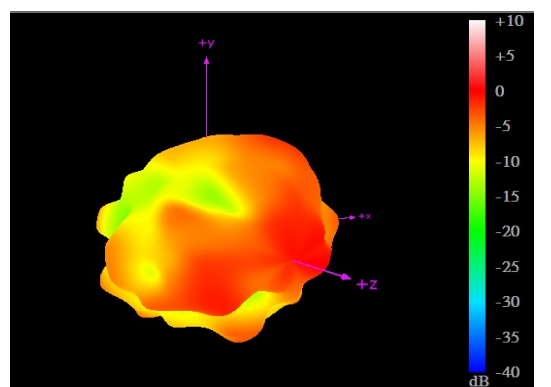
1710MHz



2170MHz



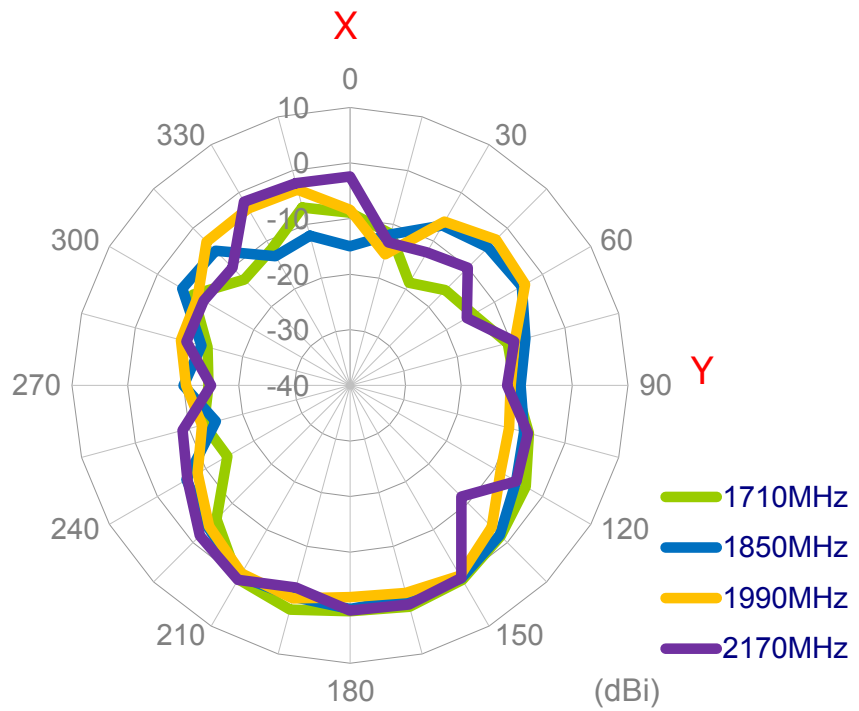
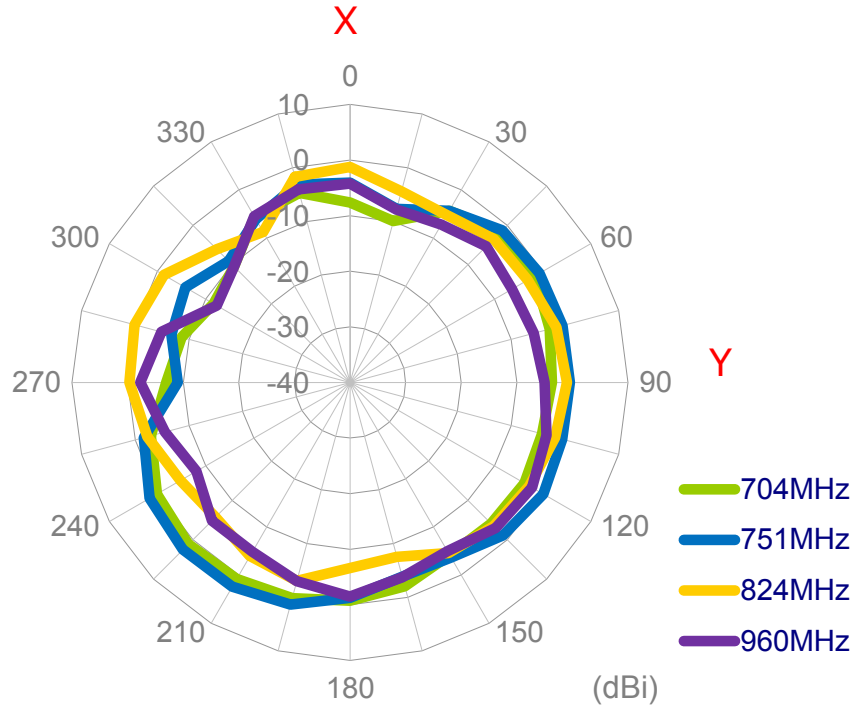
2690MHz

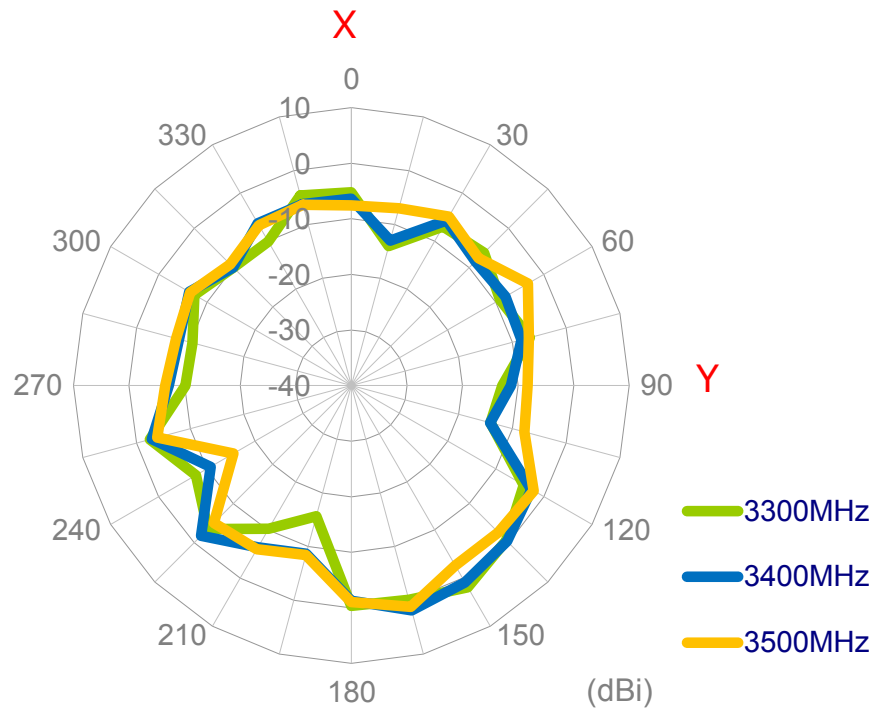
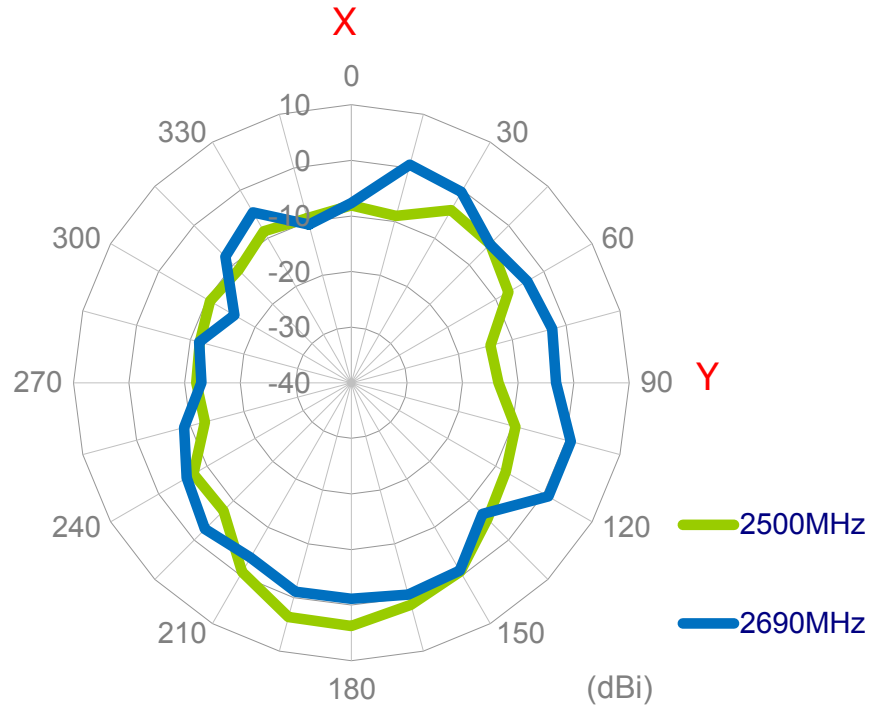


3500MHz

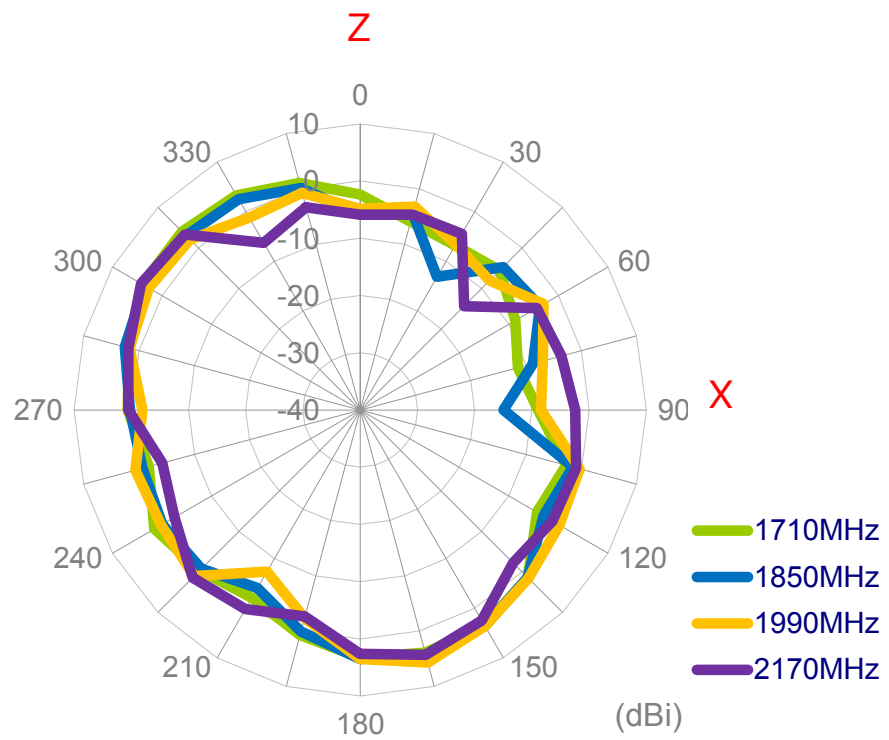
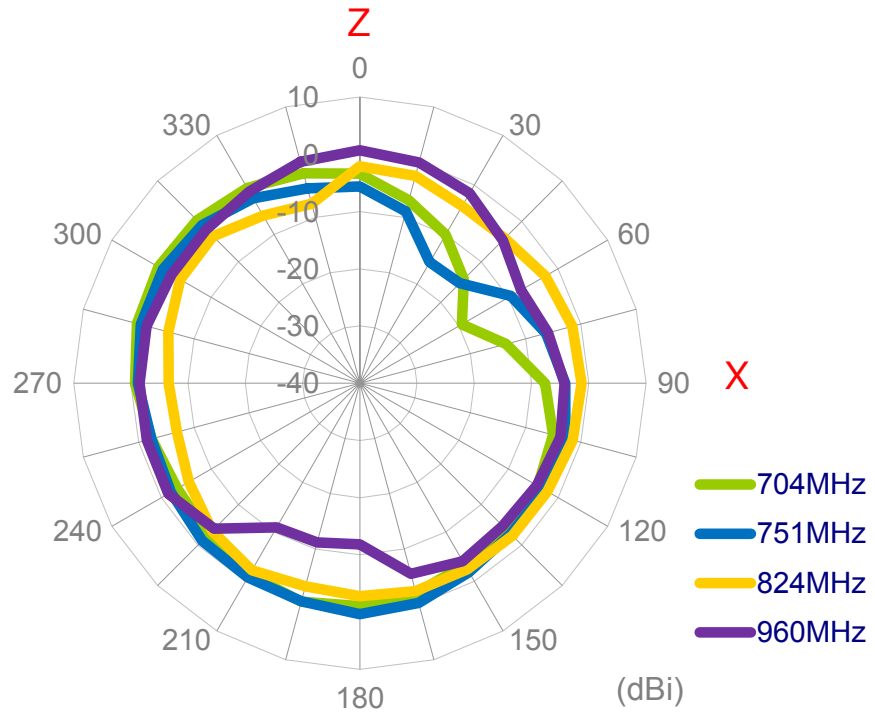
### 3.2.41 2D Radiation Pattern (LTE\_MIMO2 with 1M cable length on glass)

XY Plane

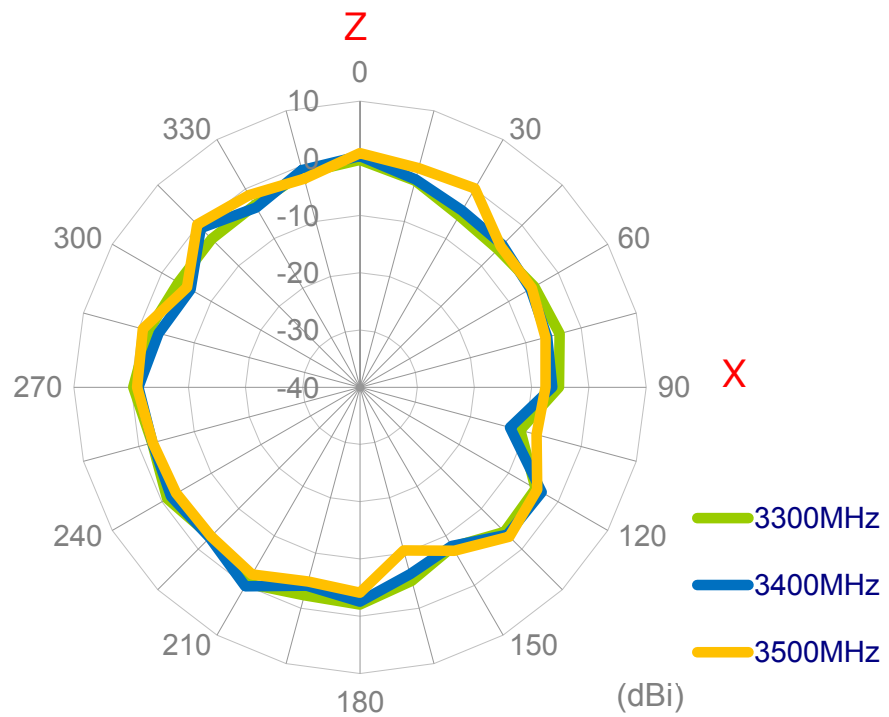
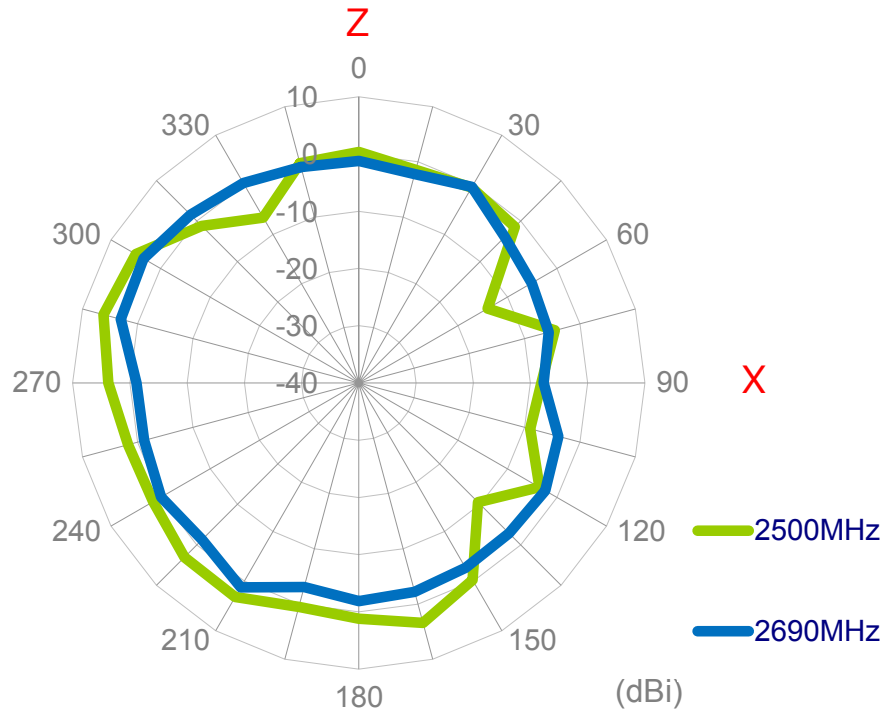




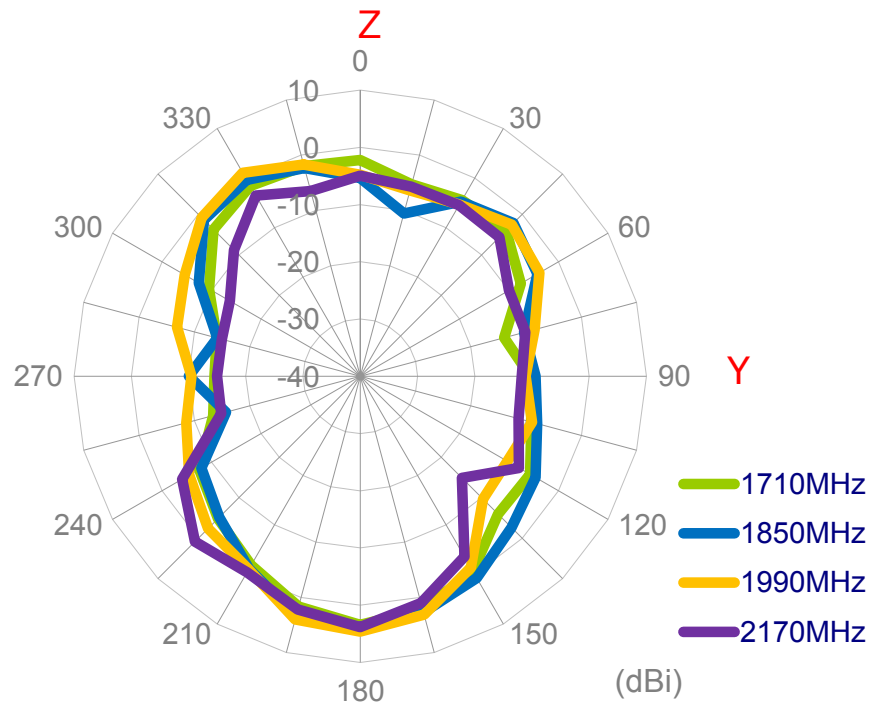
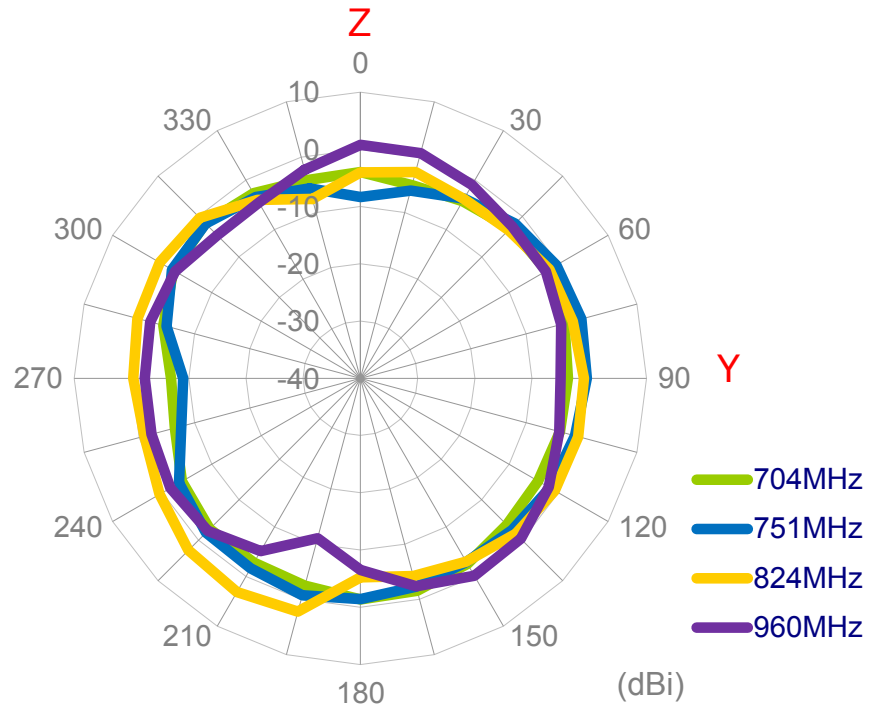
XZ Plane

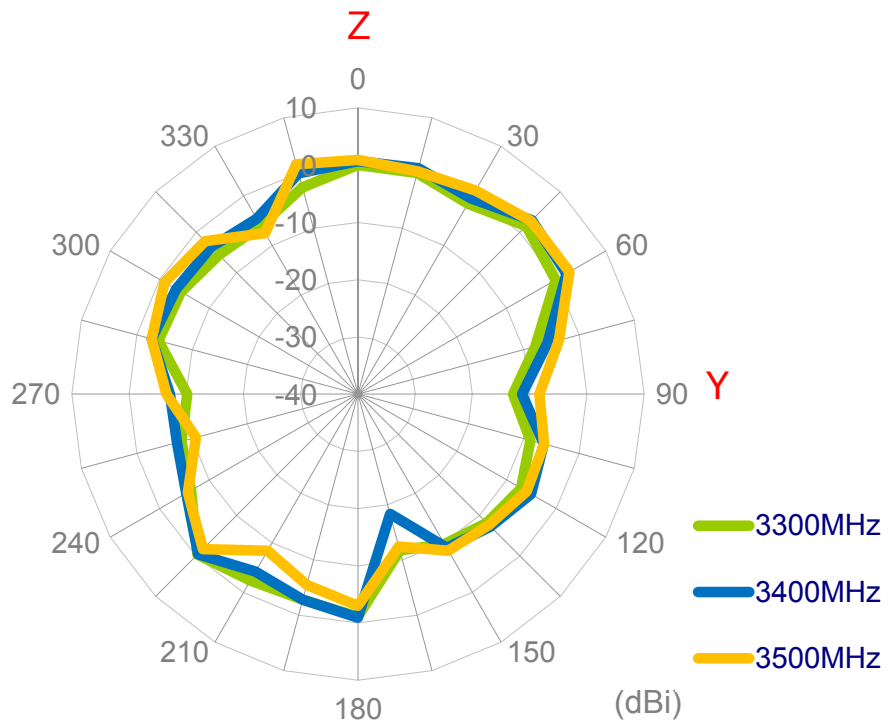
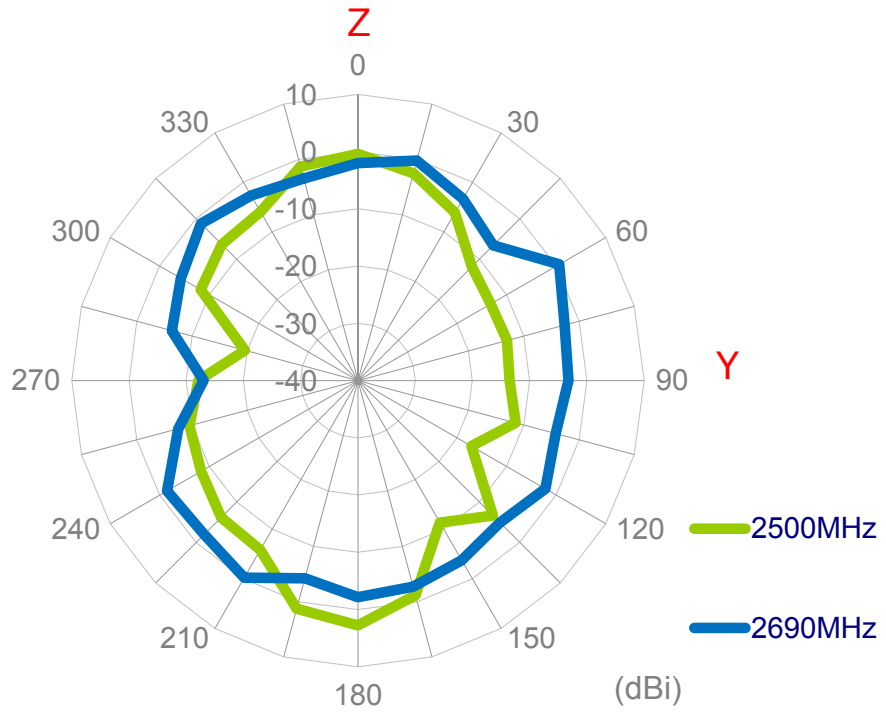




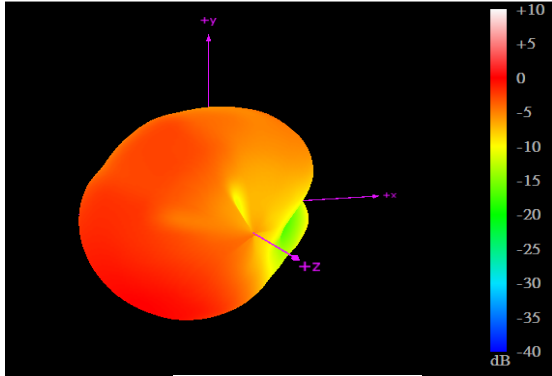


YZ Plane

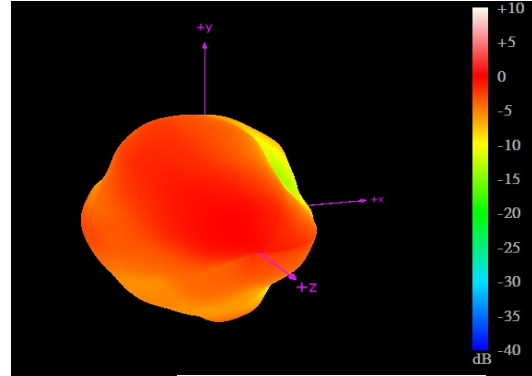




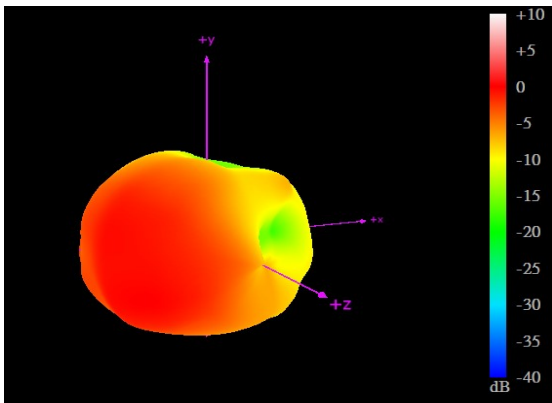
3.2.42 3D Radiation Pattern (LTE\_MIMO2 with 1M cable length on glass)



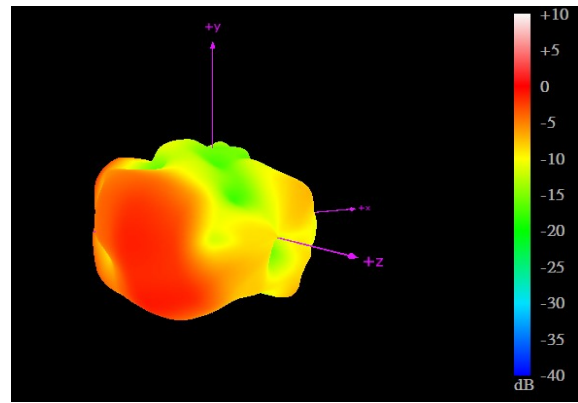
704MHz



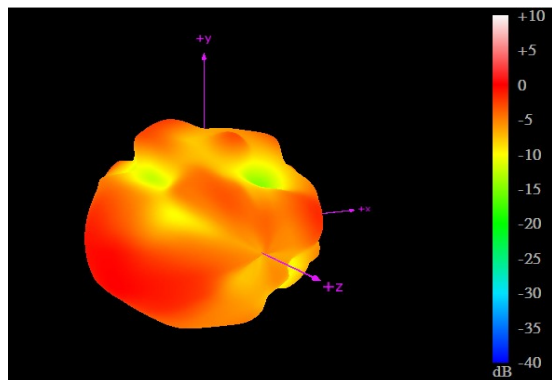
960MHz



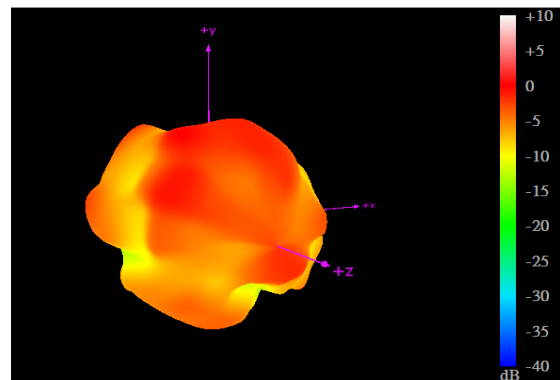
1710MHz



2170MHz



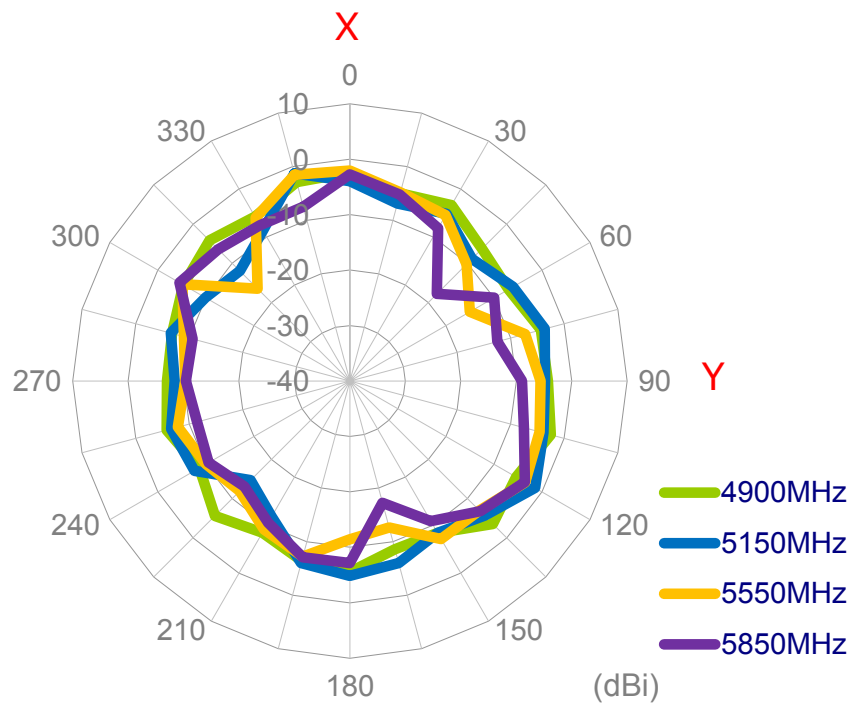
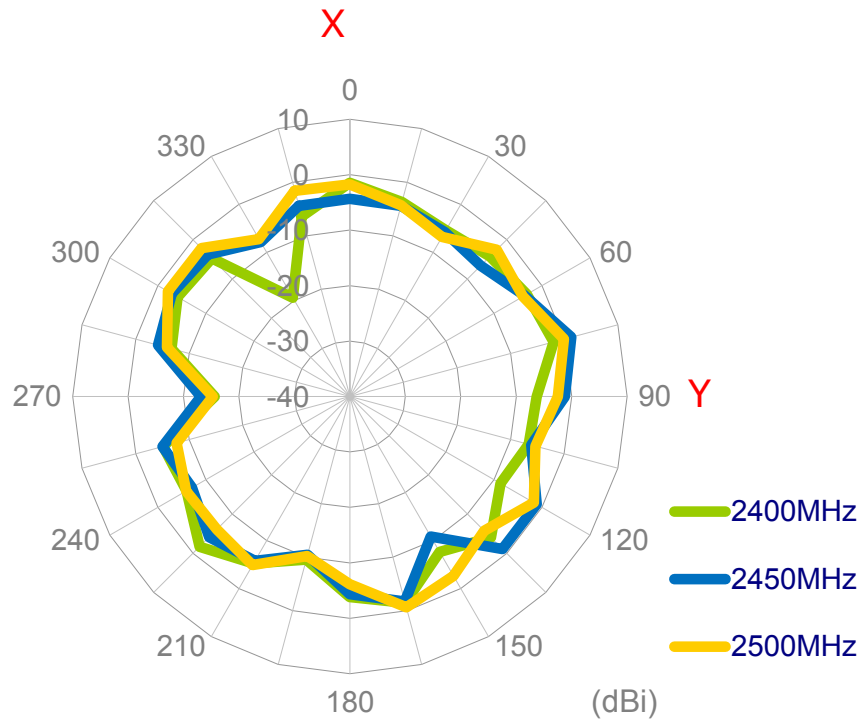
2690MHz



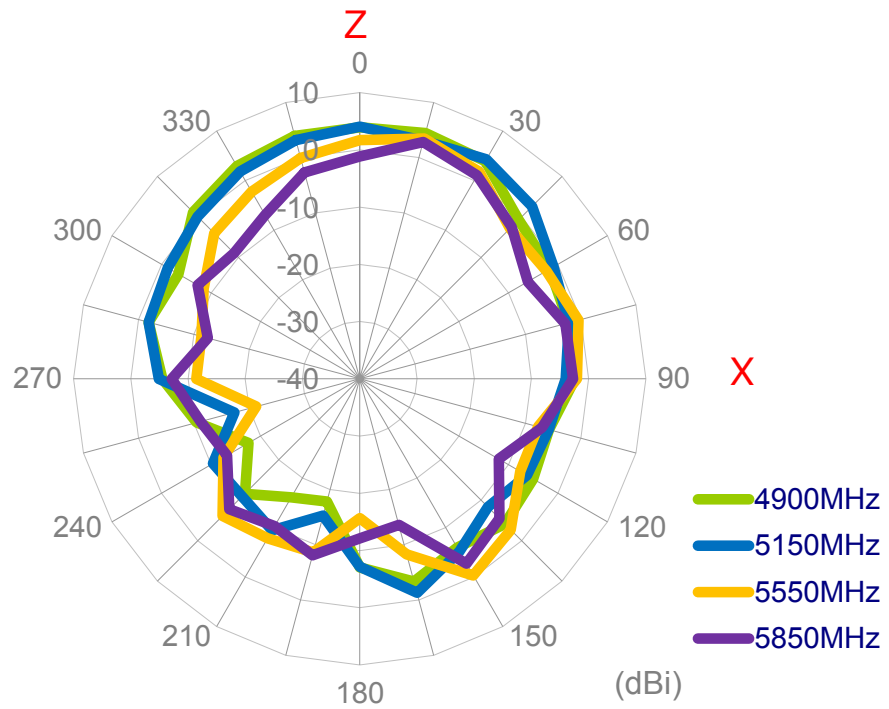
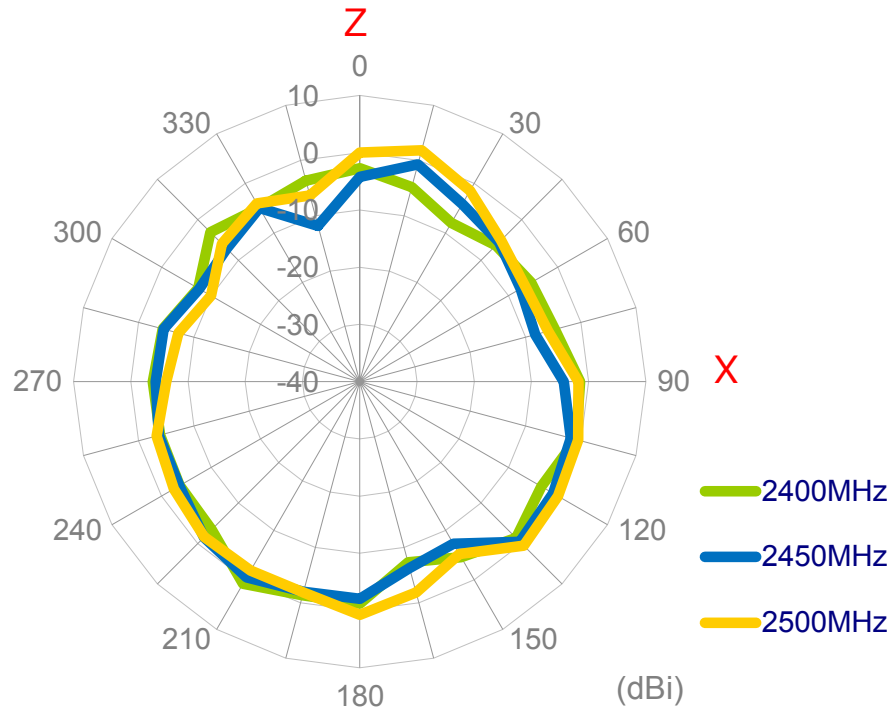
3500MHz

### 3.2.43 2D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length on glass)

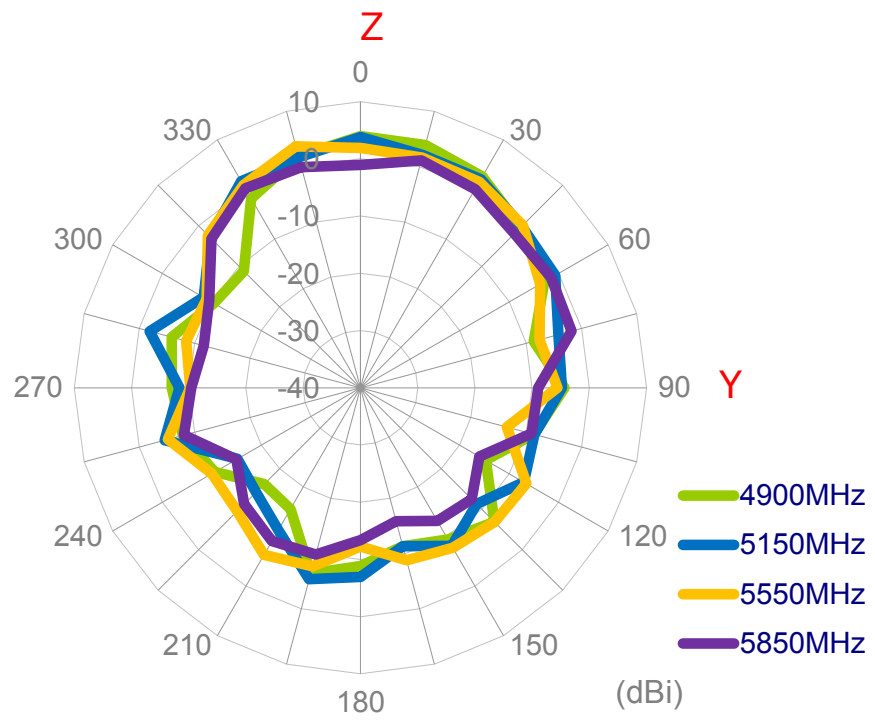
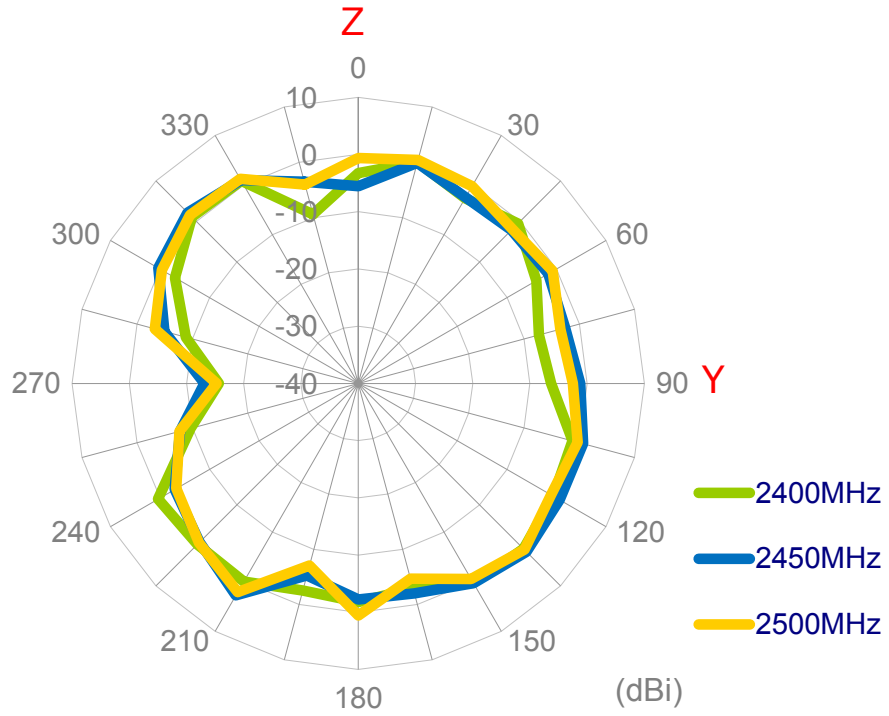
XY Plane



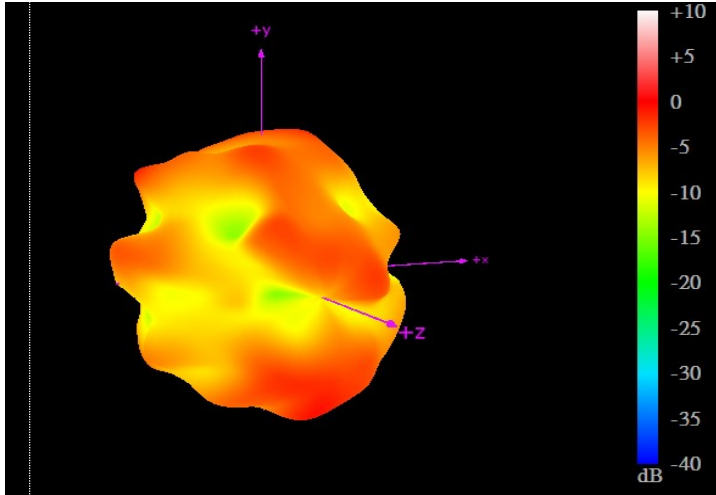
XZ Plane



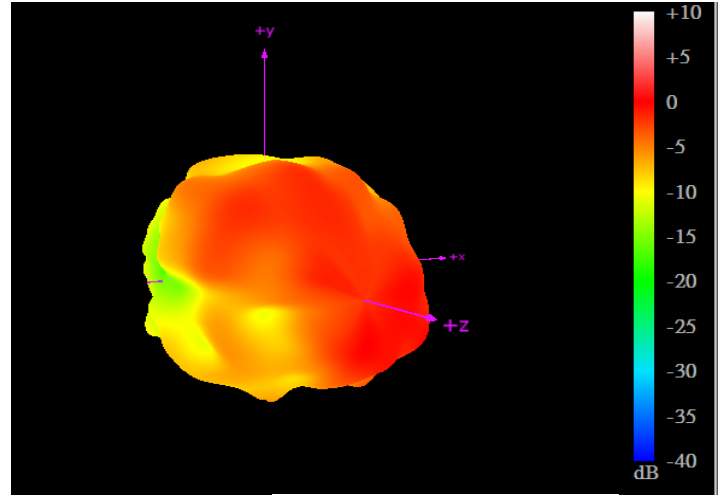
YZ Plane



### 3.2.44 3D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length on glass)



2450MHz

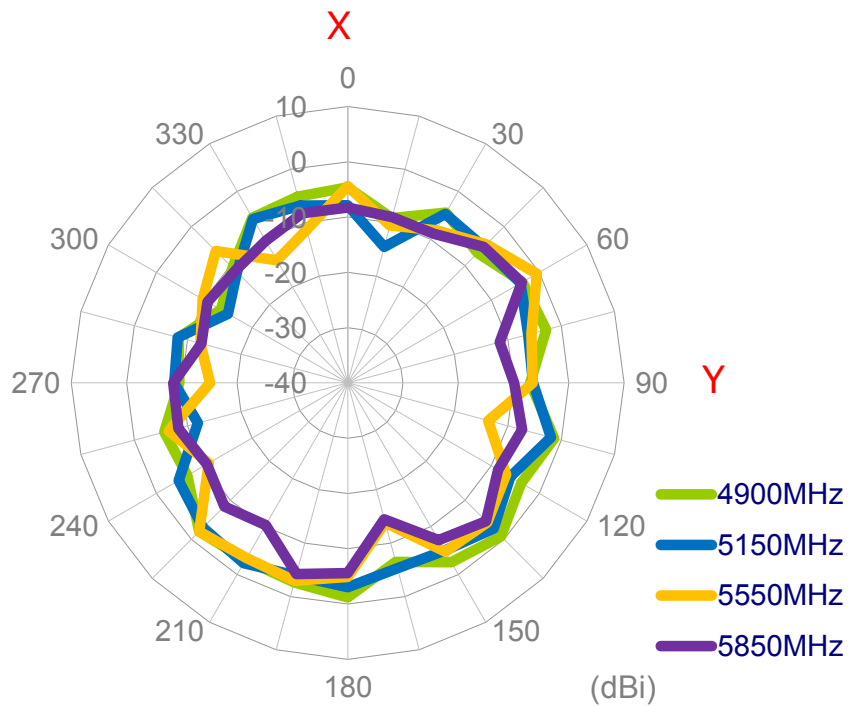
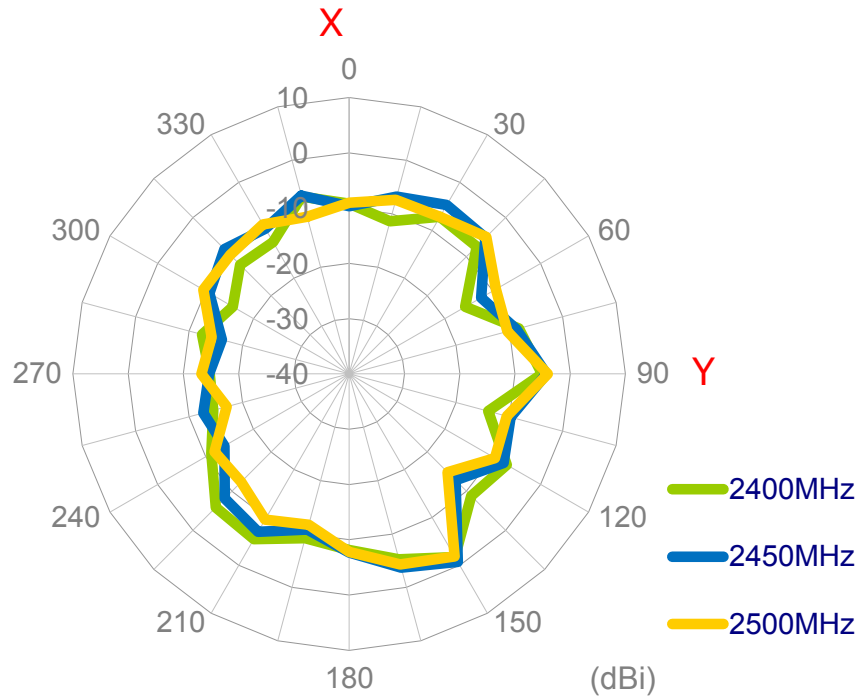


5550MHz

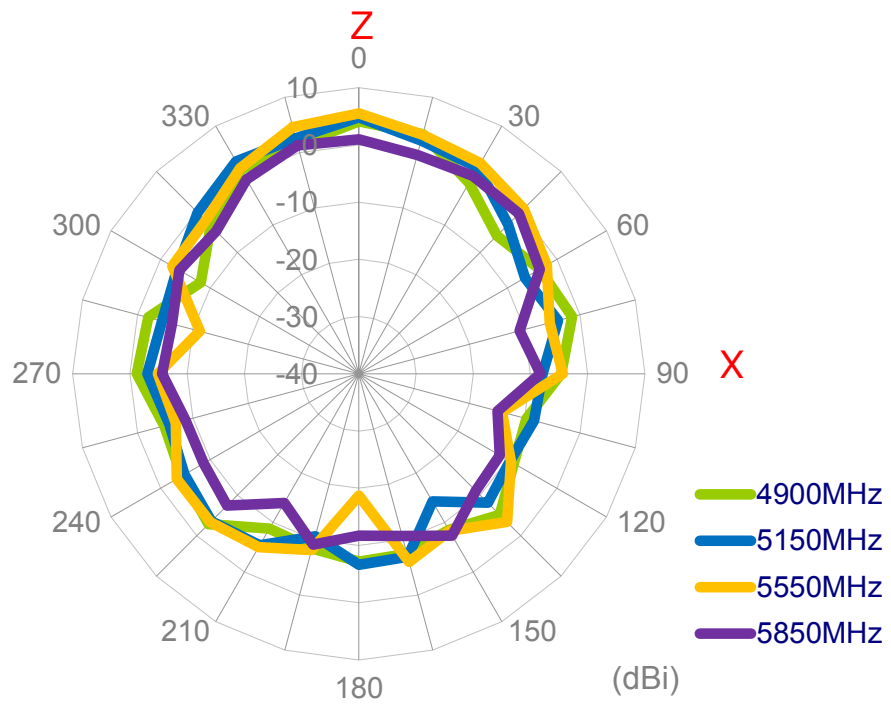
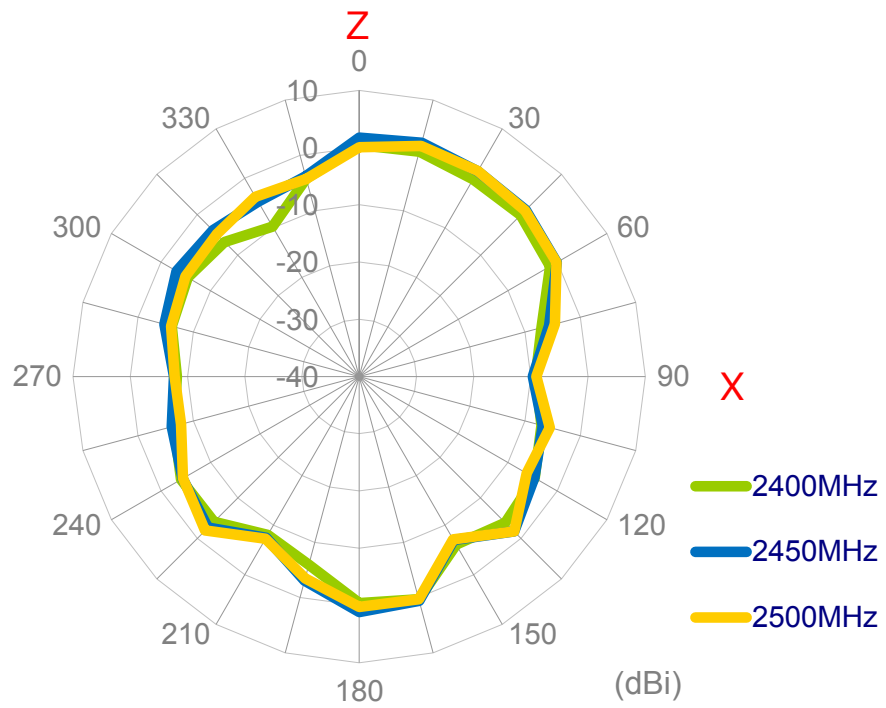


### 3.2.45 2D Radiation Pattern (Wi-Fi\_MIMO2 with 3M cable length on glass)

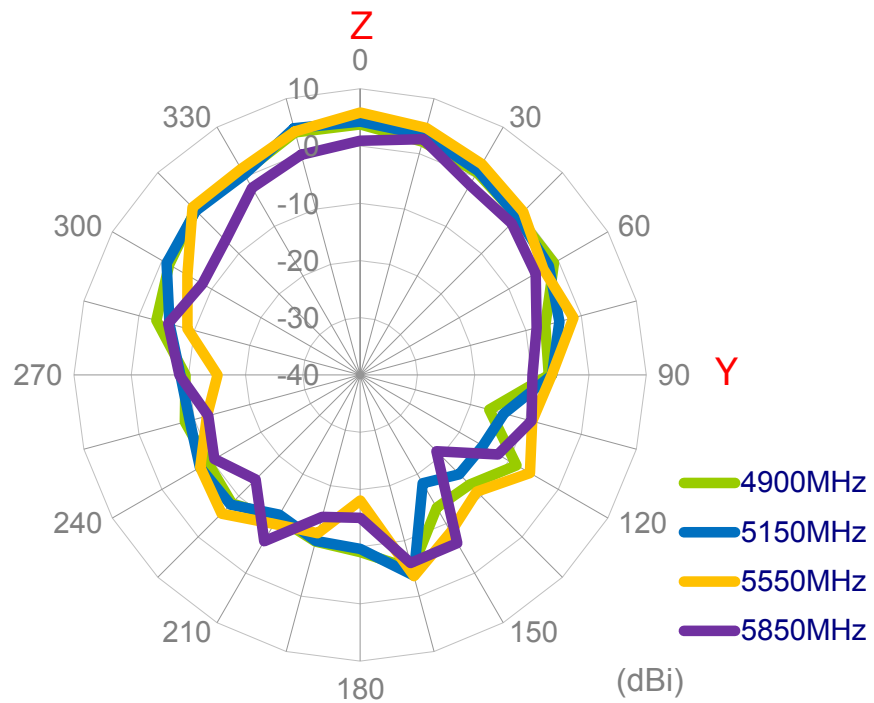
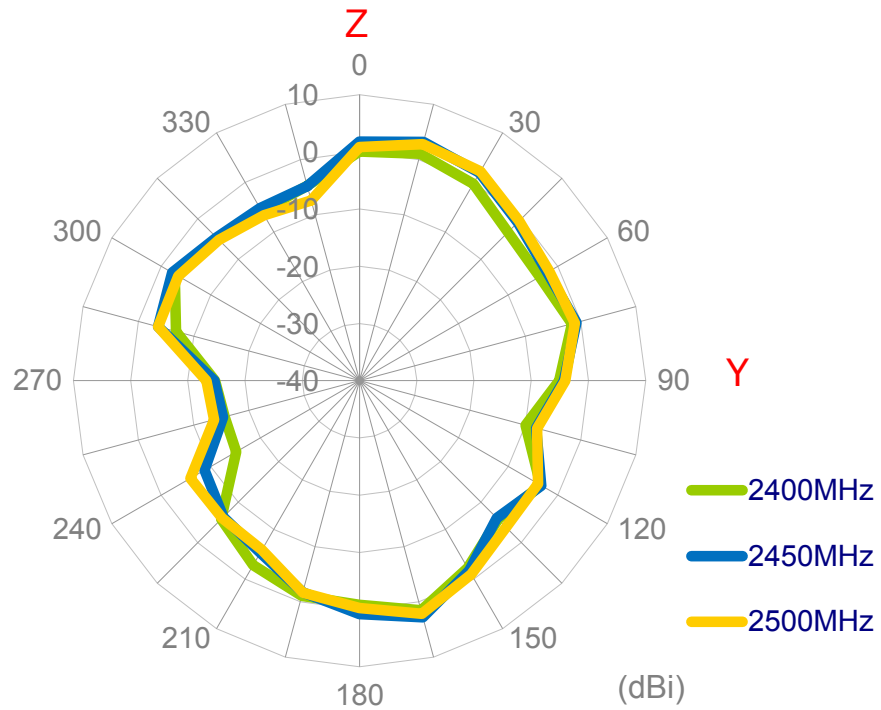
XY Plane



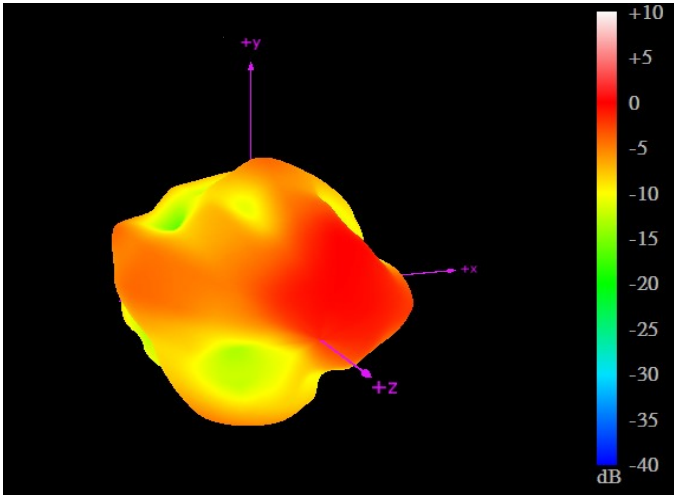
XZ Plane



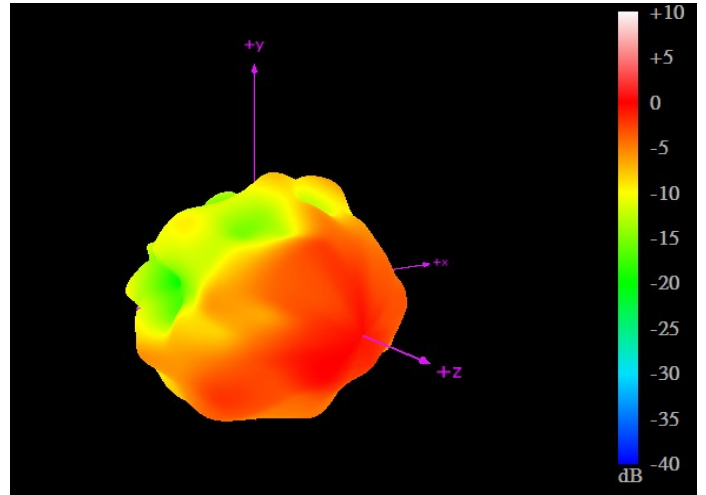
YZ Plane



### 3.2.46 3D Radiation Pattern (Wi-Fi\_MIMO2 with 1M cable length on glass)

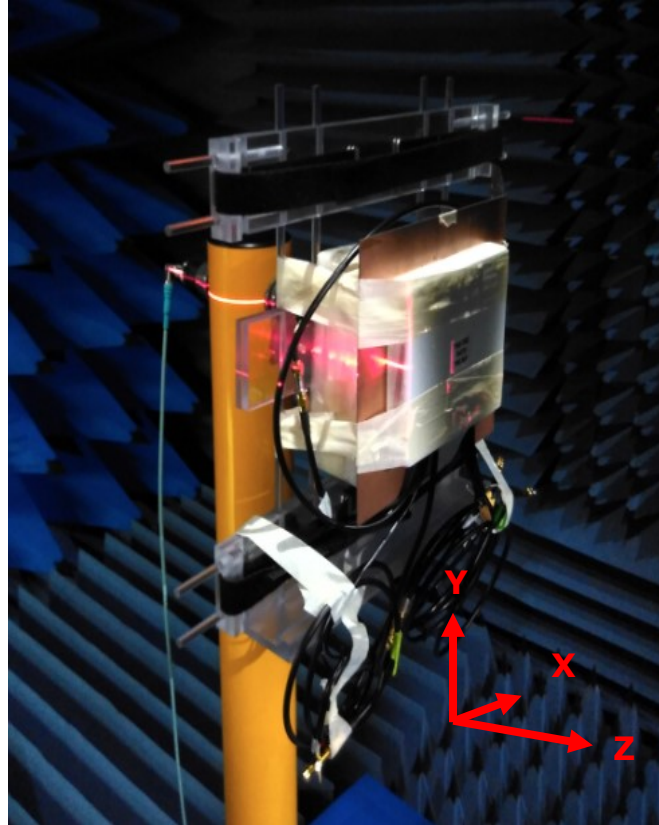


2450MHz



5550MHz

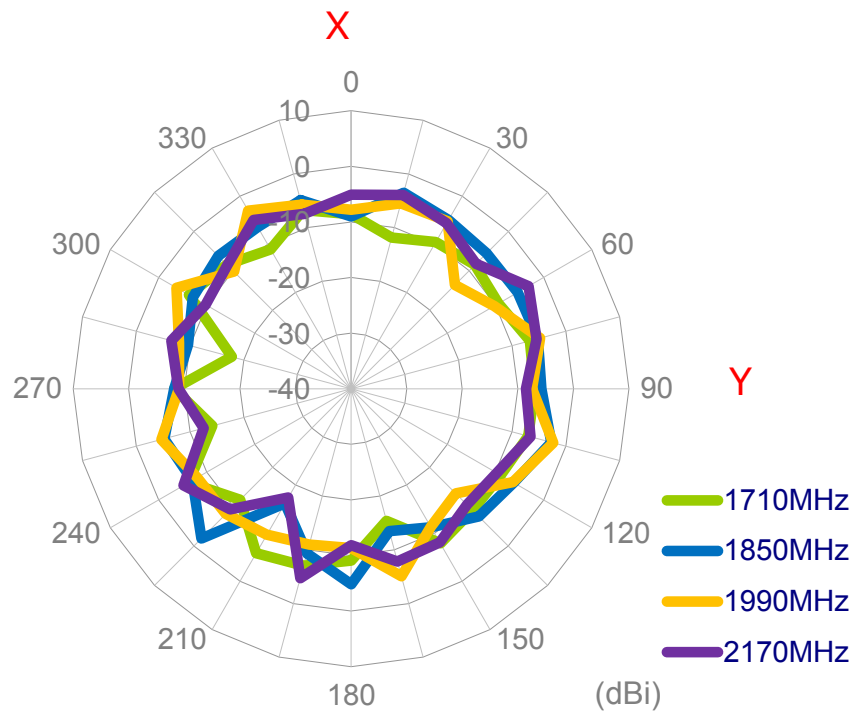
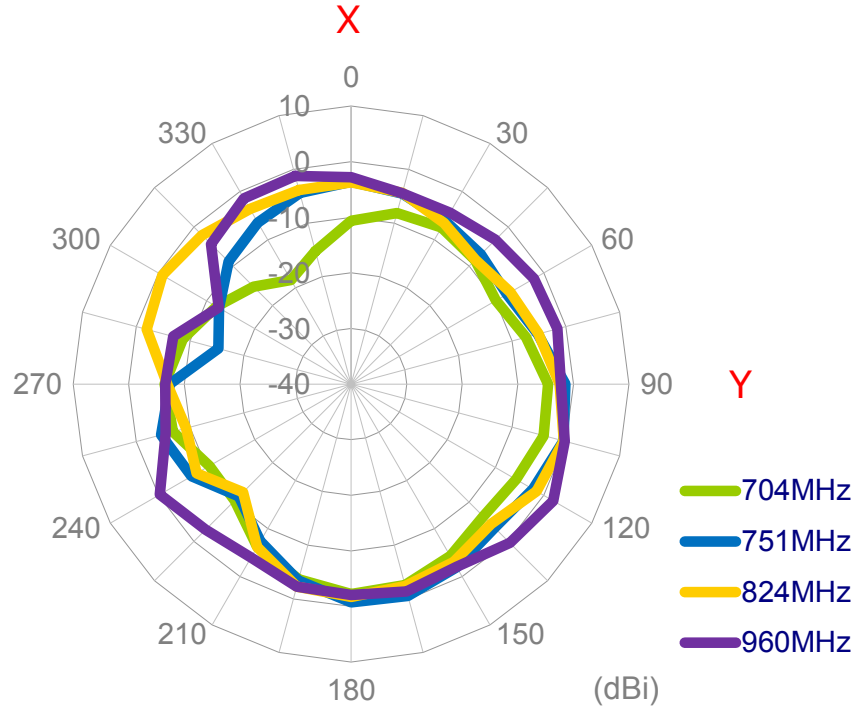
### 3.2.47 Test Setup For Antenna Radiation Pattern

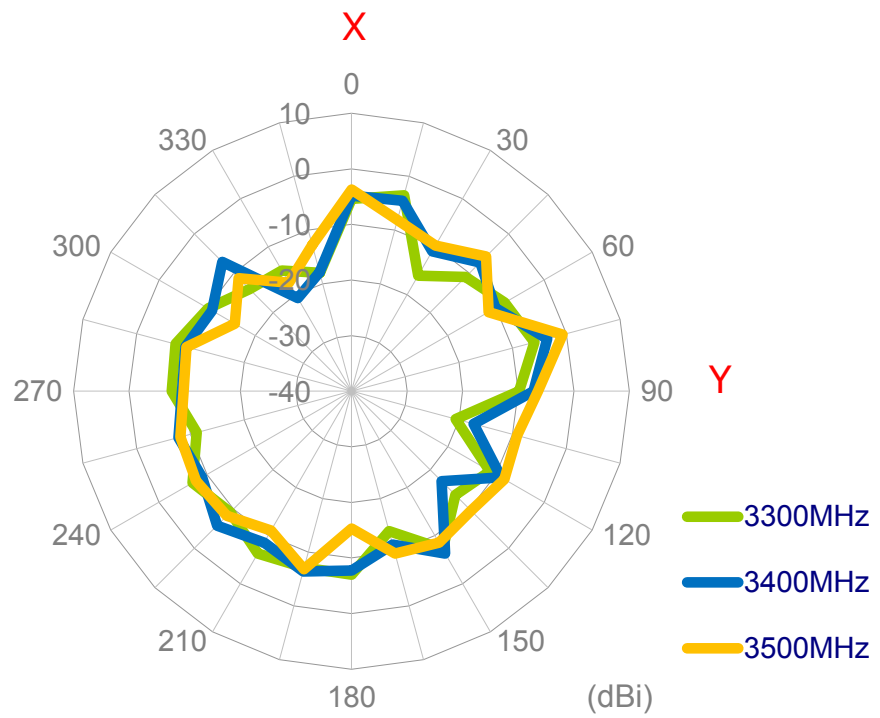
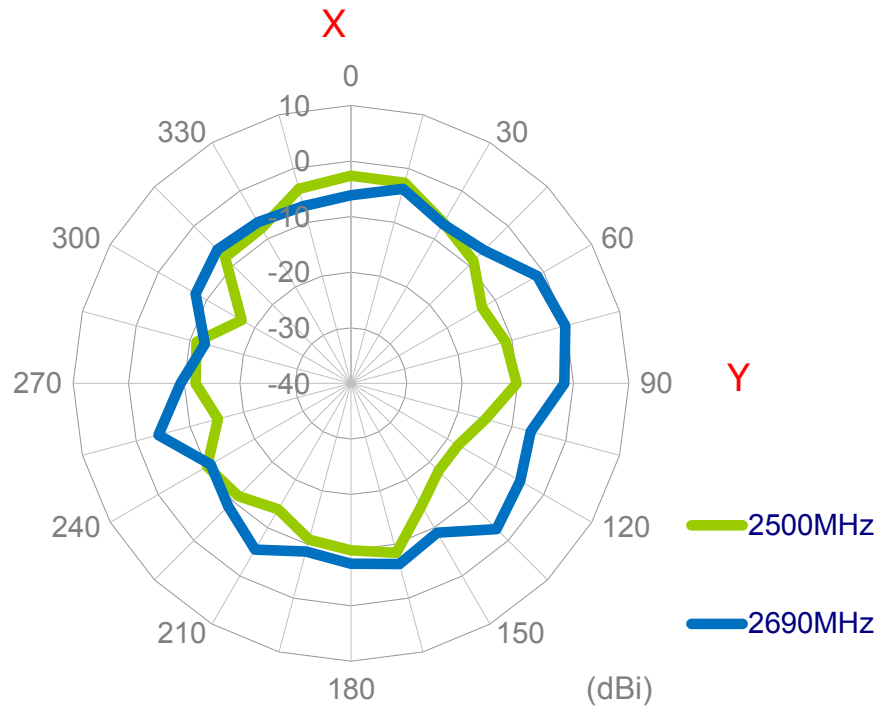


On metal

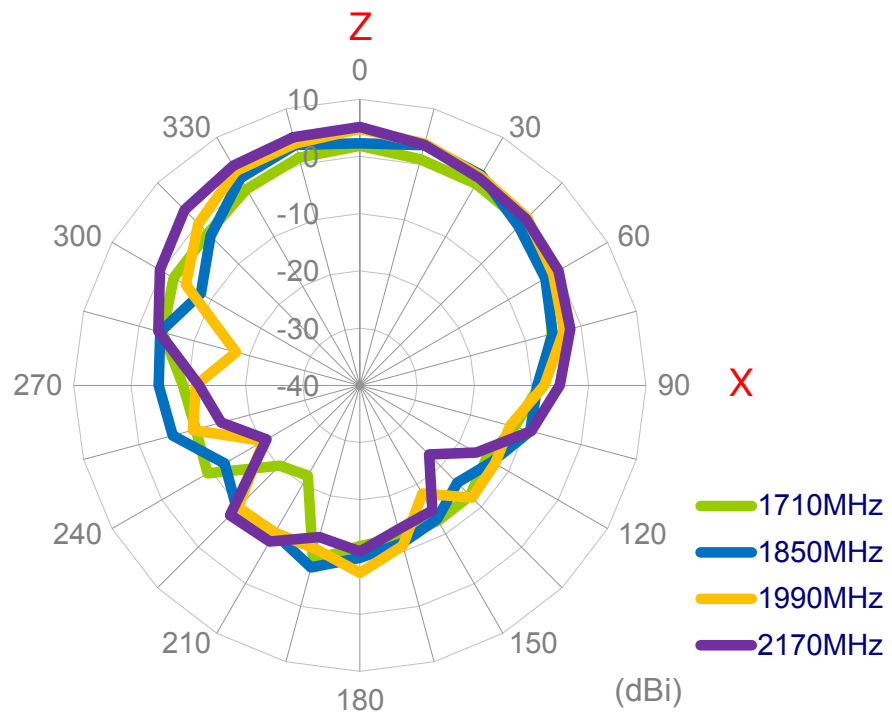
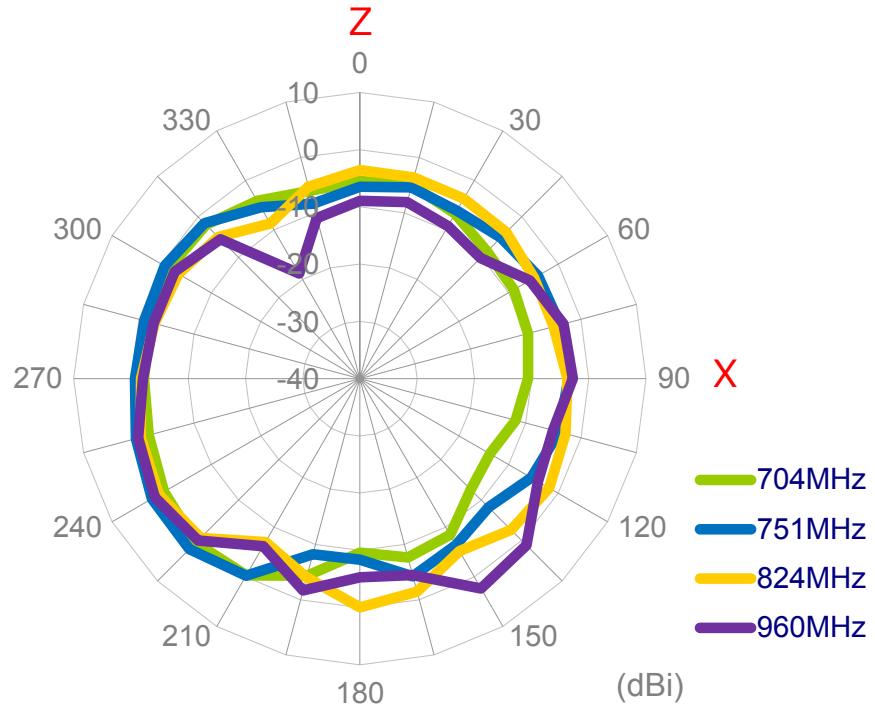
### 3.2.48 2D Radiation Pattern (LTE\_MIMO1 with 1M cable length on metal)

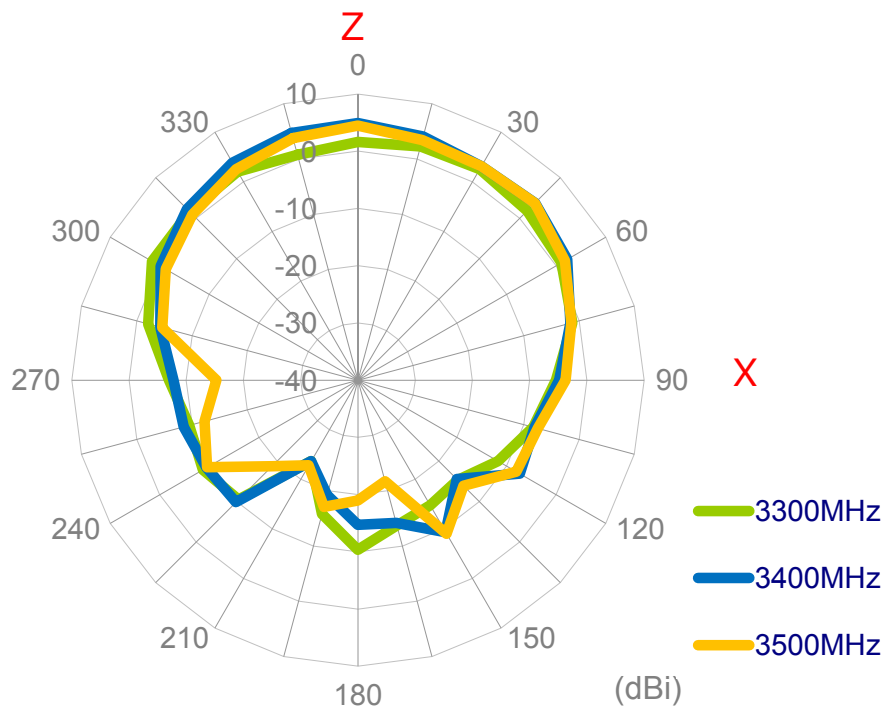
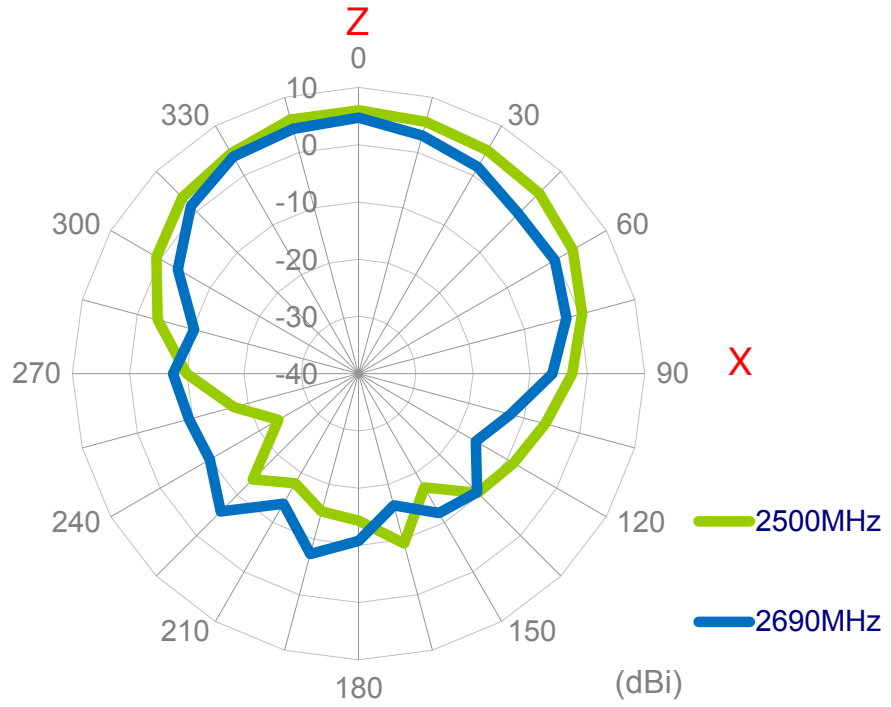
XY Plane





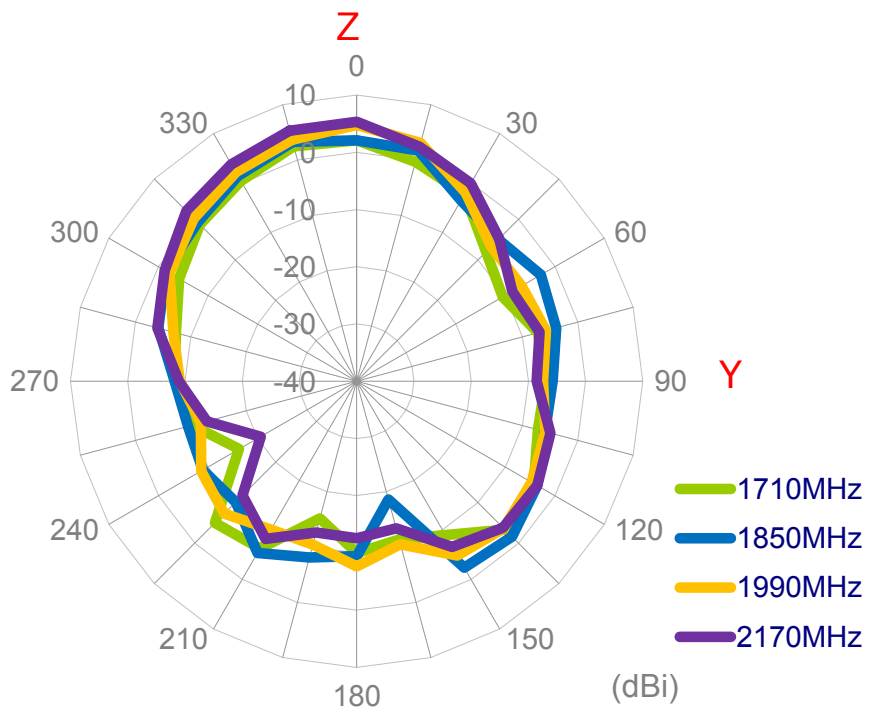
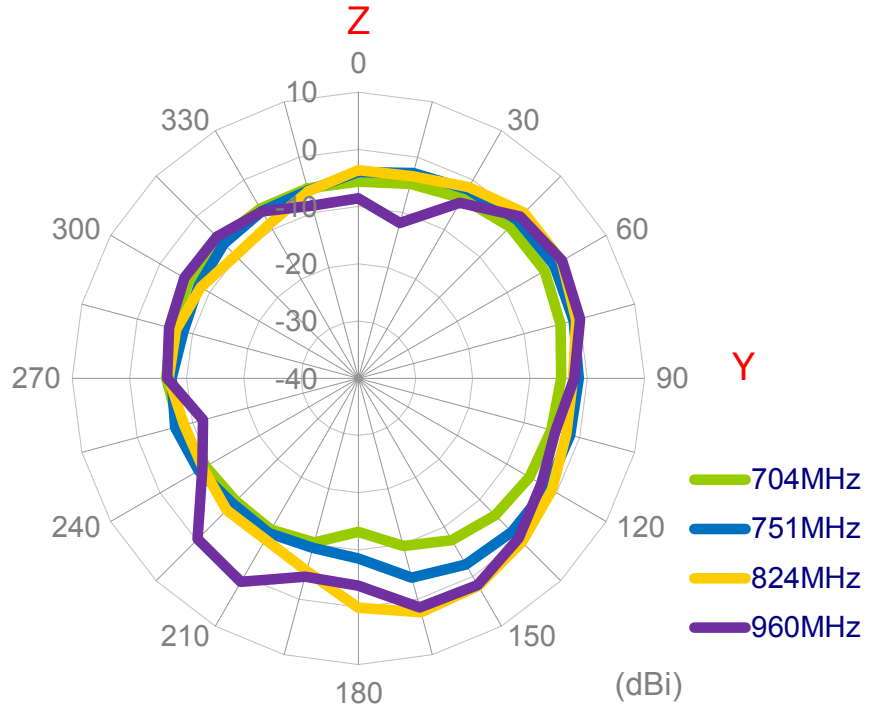
XZ Plane

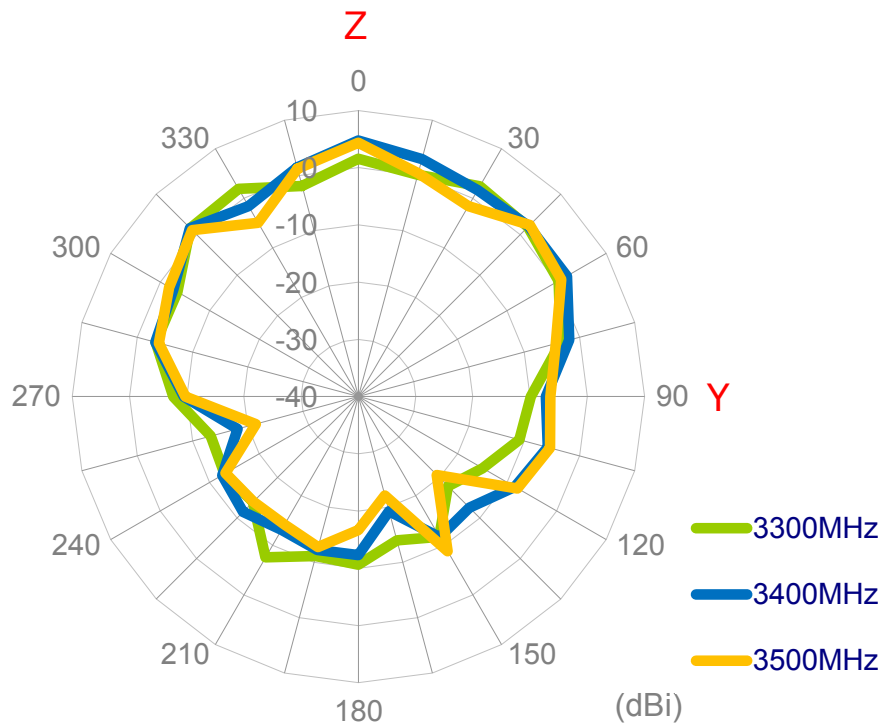
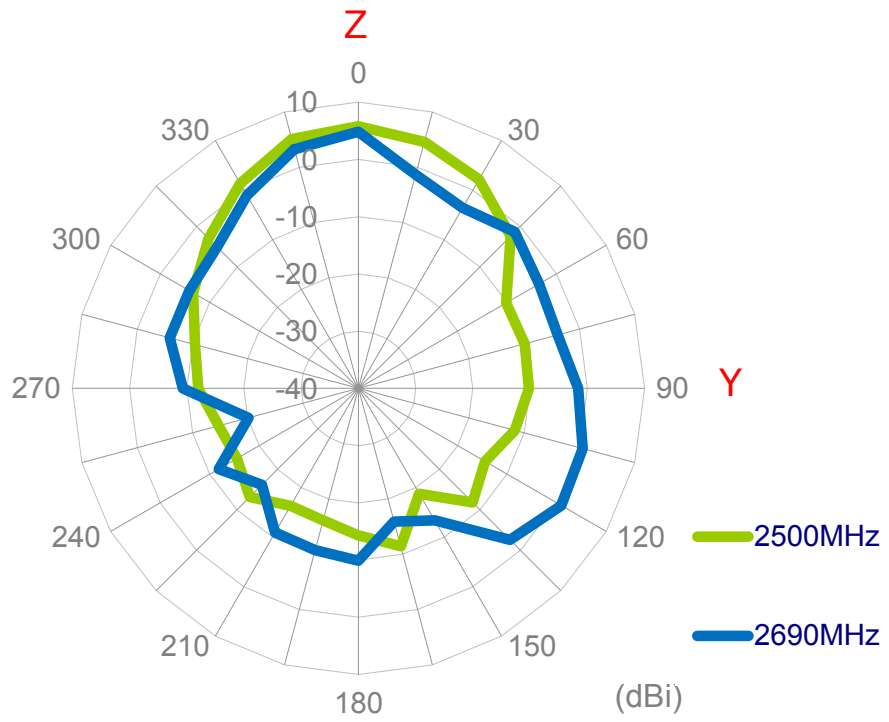




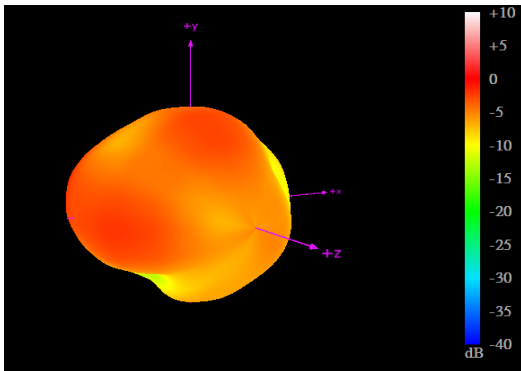


YZ Plane

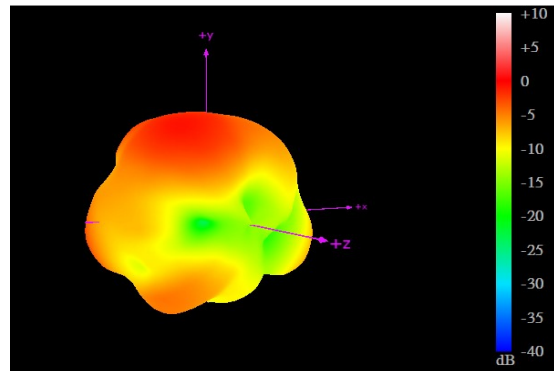




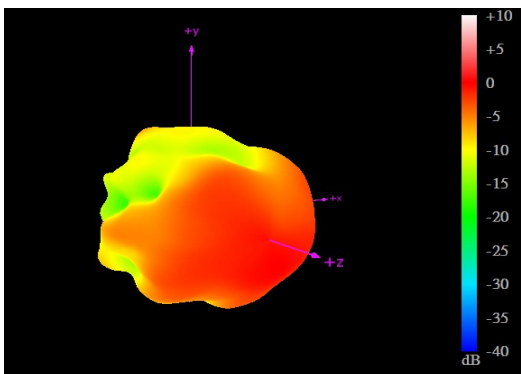
3.2.49 3D Radiation Pattern (LTE\_MIMO1 with 1M cable length on metal)



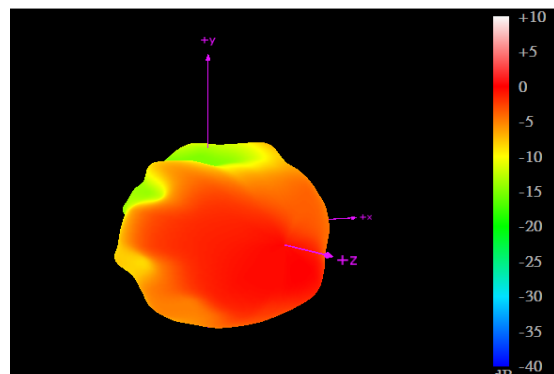
704MHz



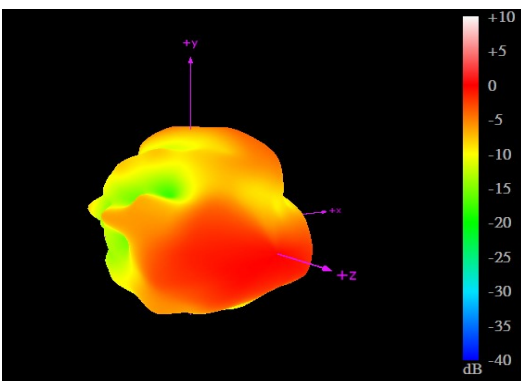
960MHz



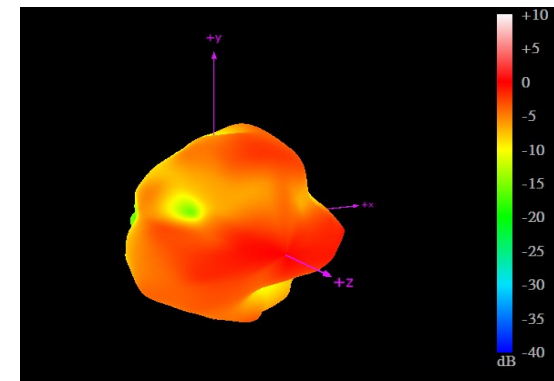
1710MHz



2170MHz

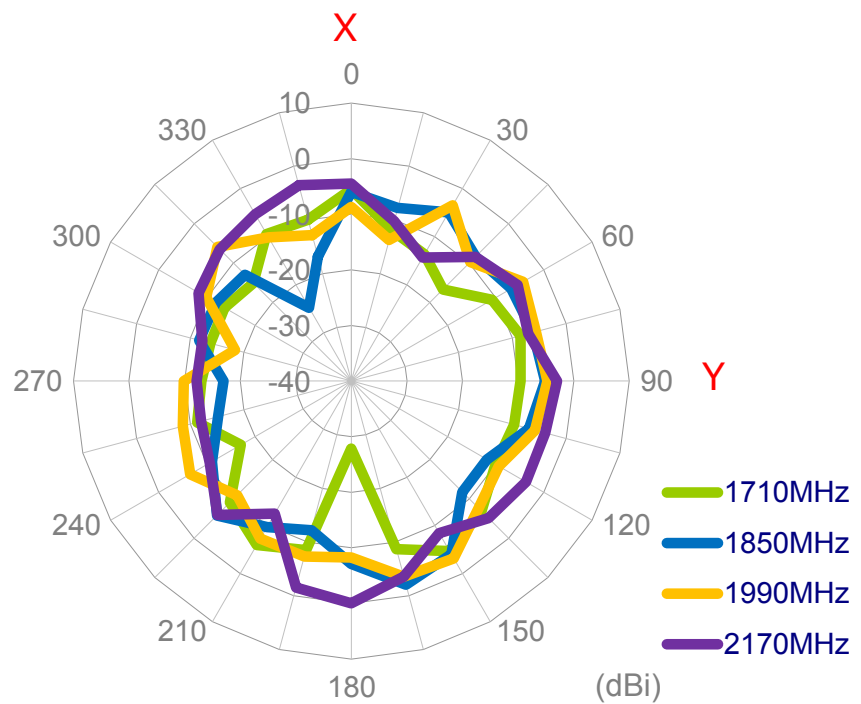
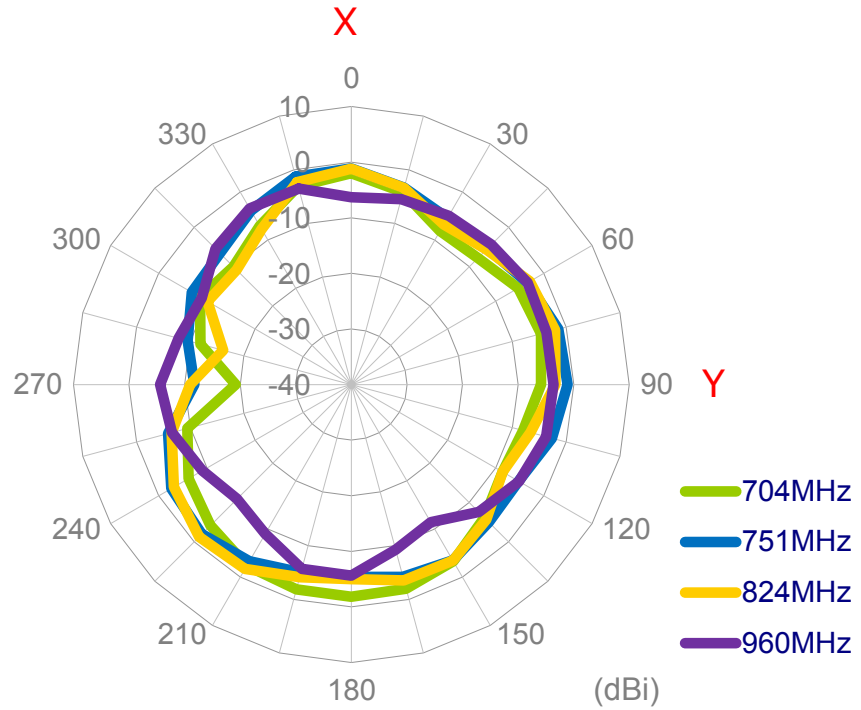


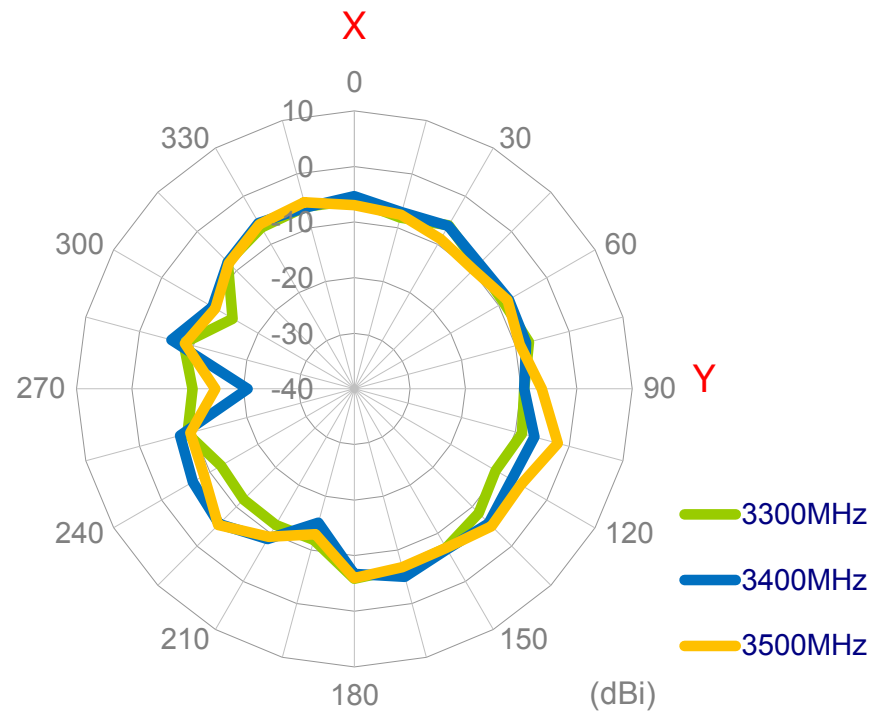
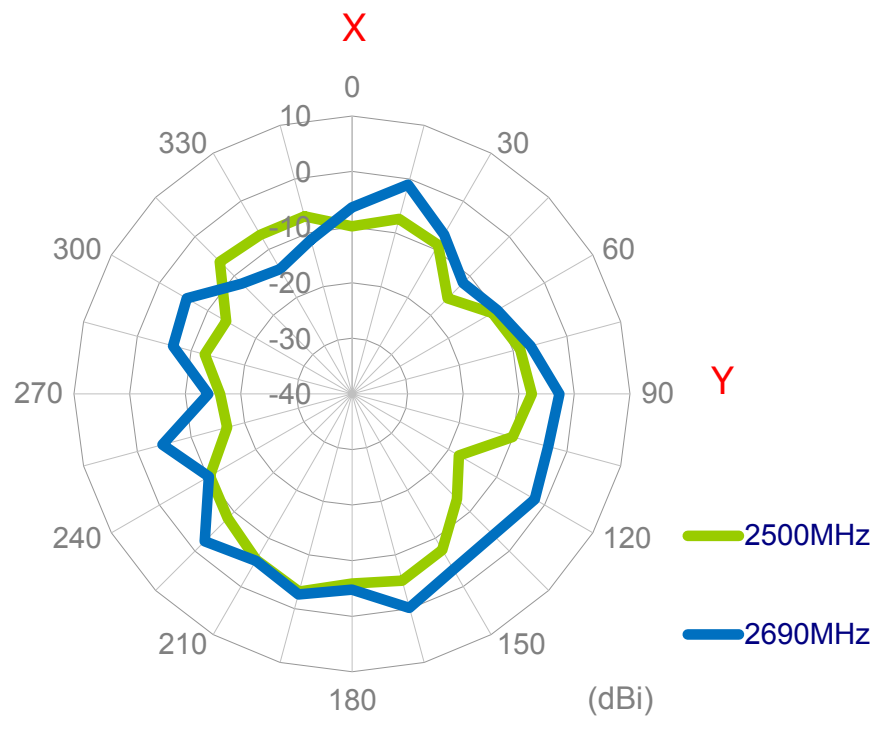
2690MHz



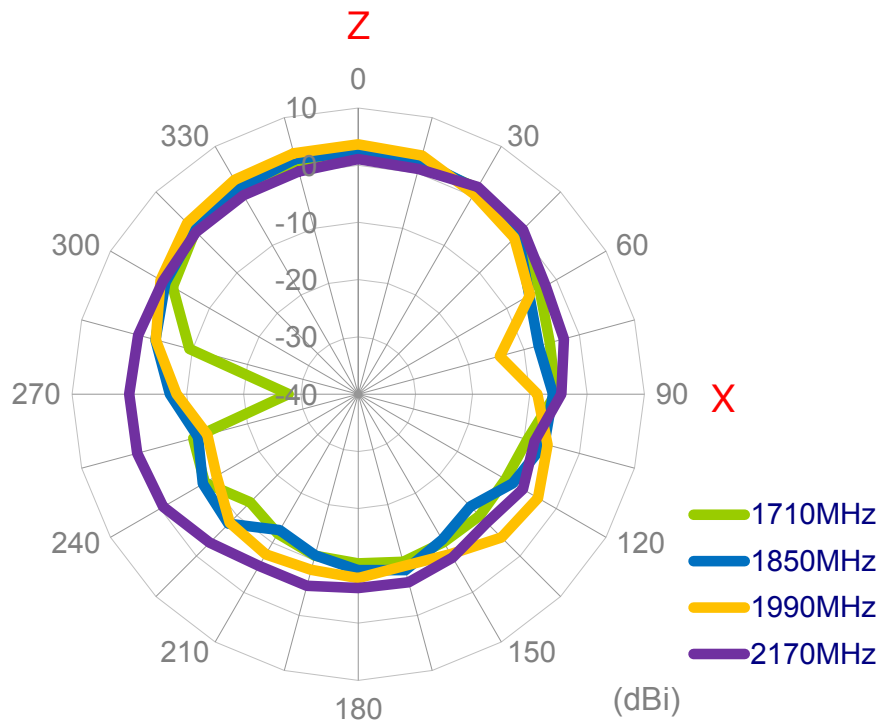
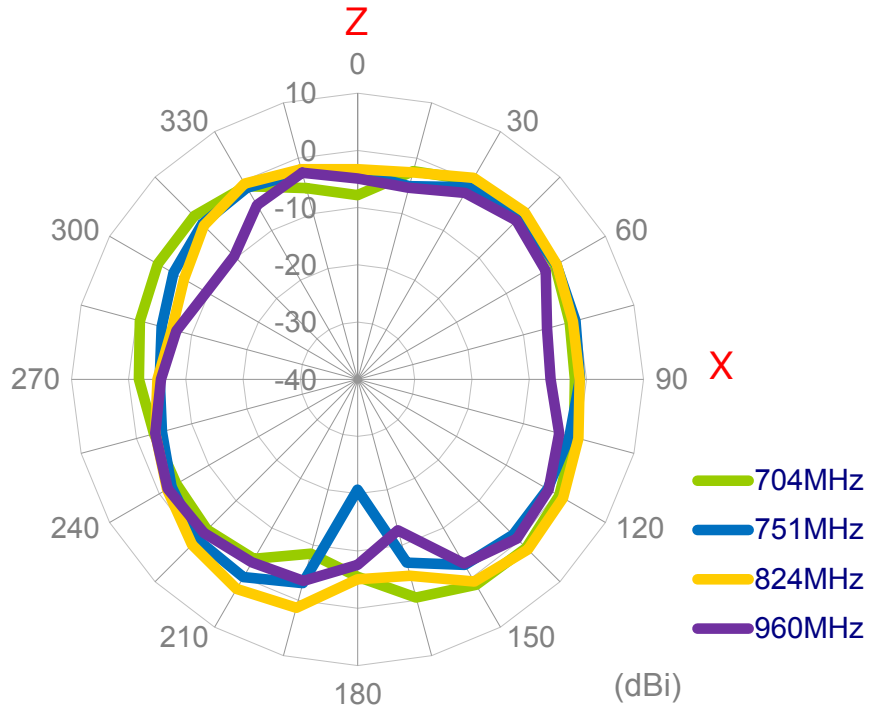
3500MHz

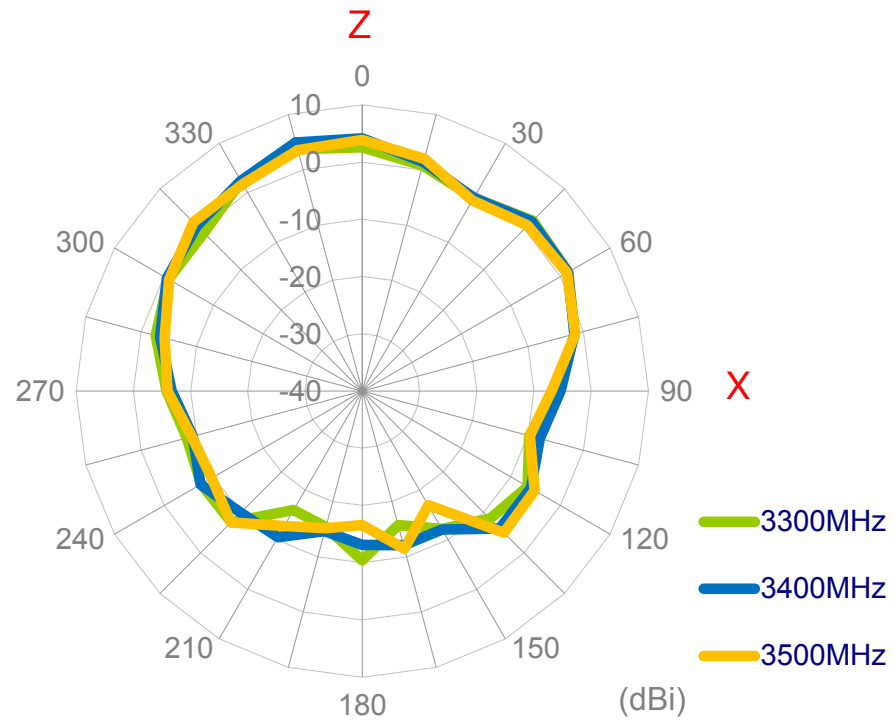
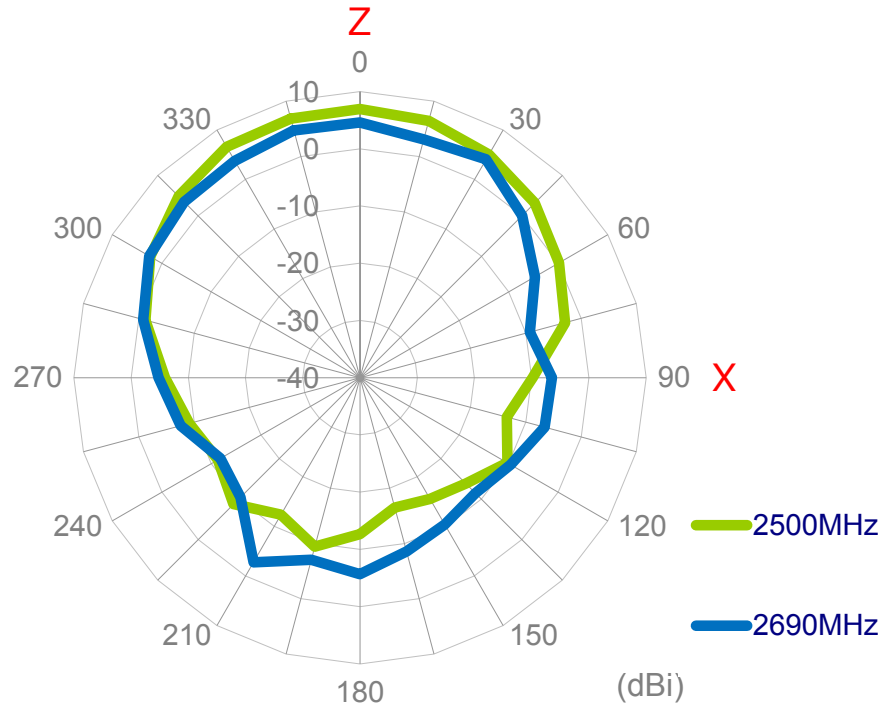
### 3.2.50 2D Radiation Pattern (LTE\_MIMO2 with 1M cable length on metal) XY Plane



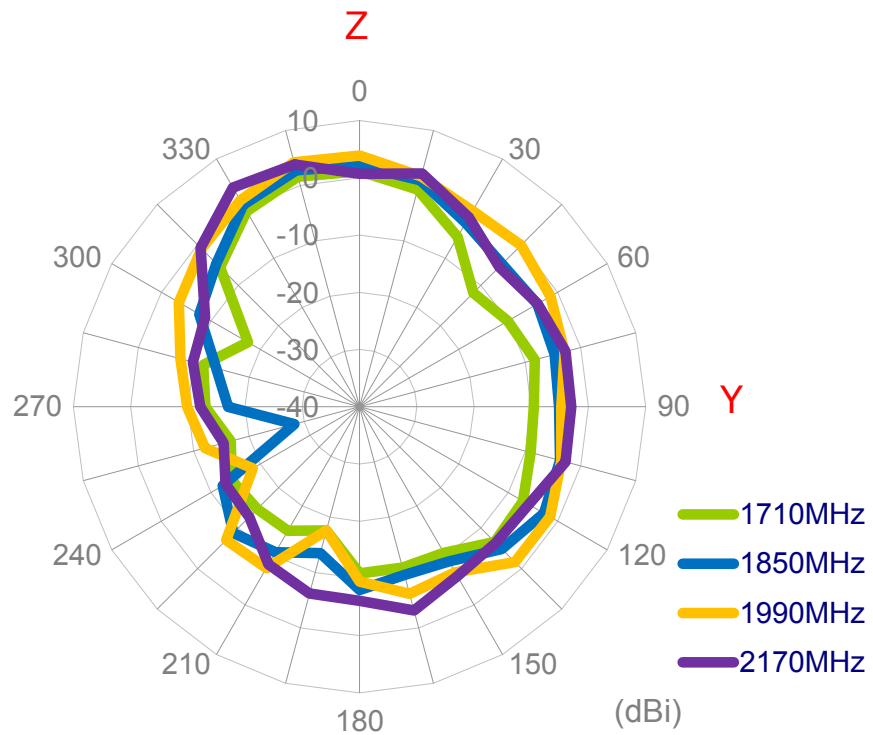
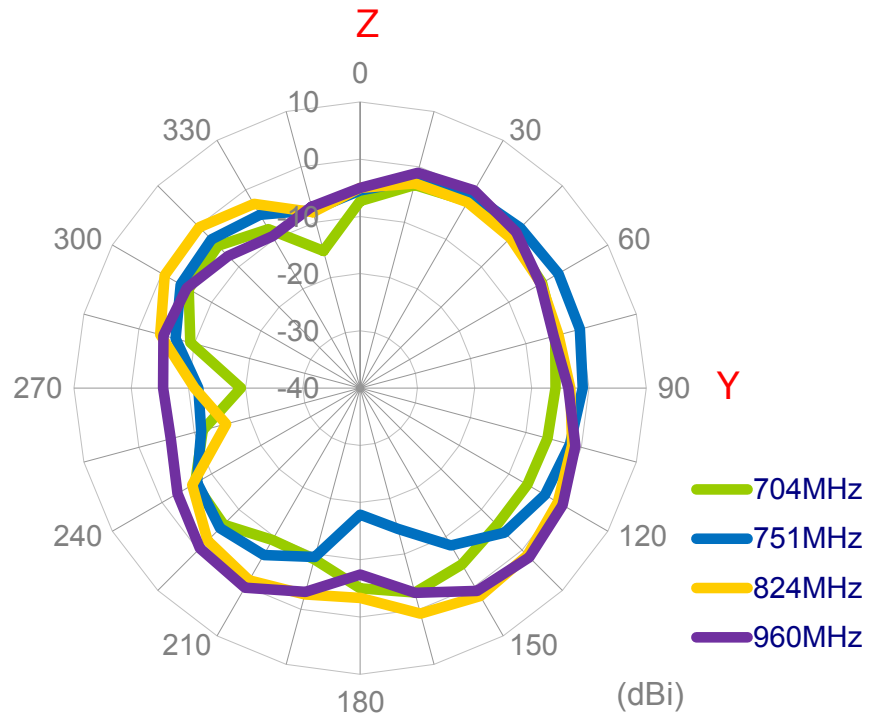


XZ Plane

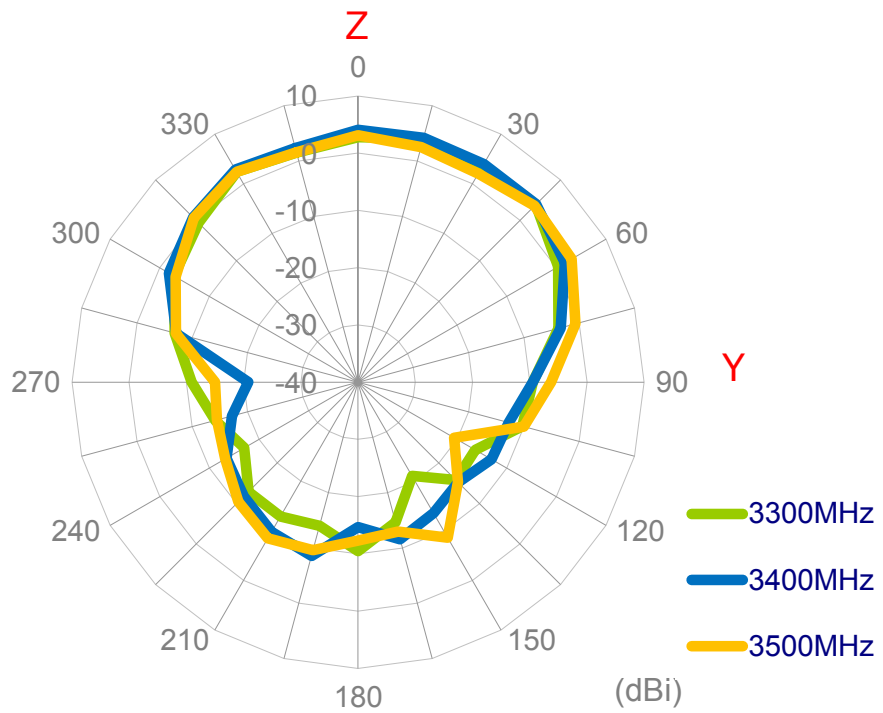
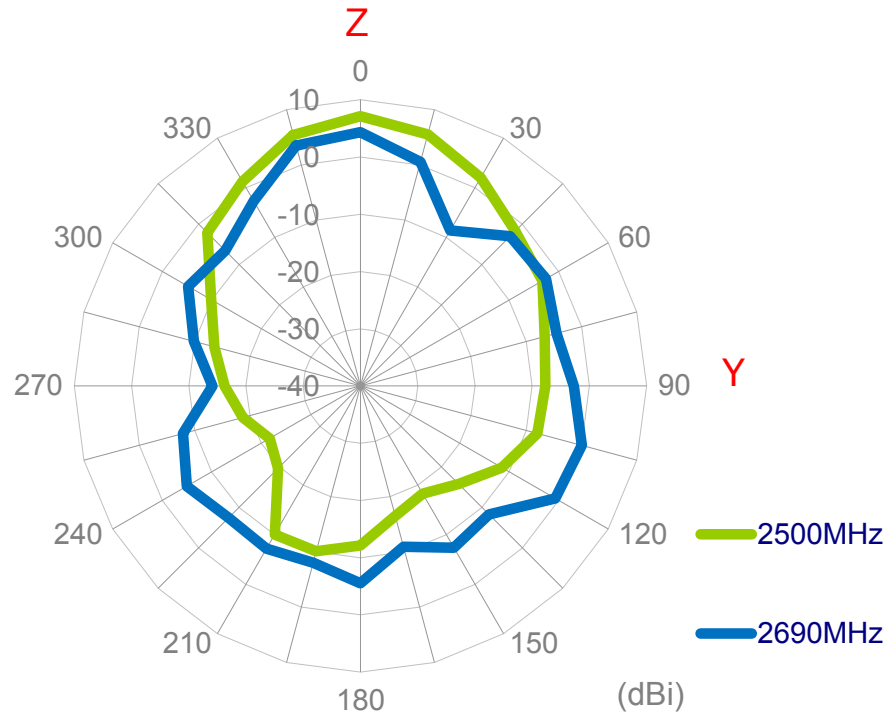




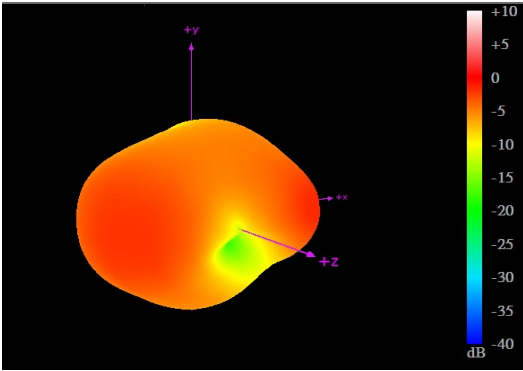
YZ Plane



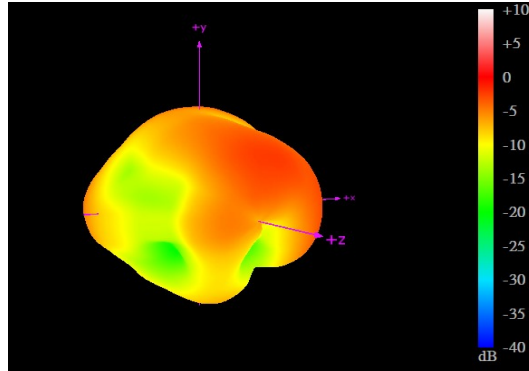




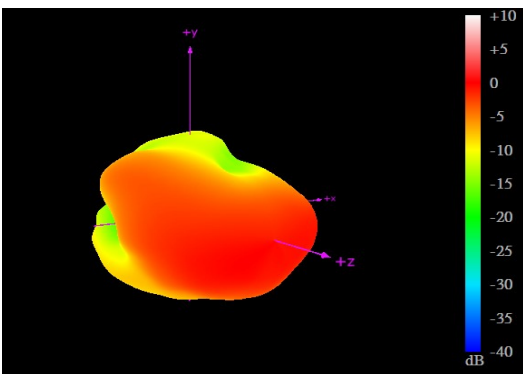
3.2.51 3D Radiation Pattern (LTE\_MIMO2 with 1M cable length on metal)



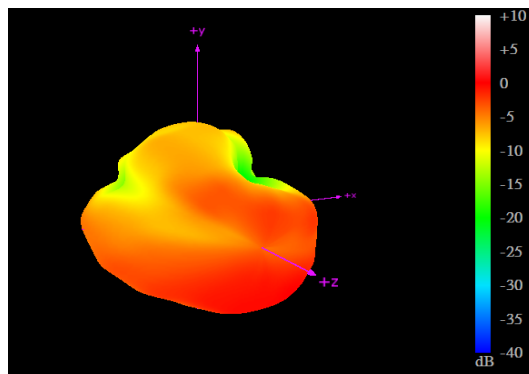
704MHz



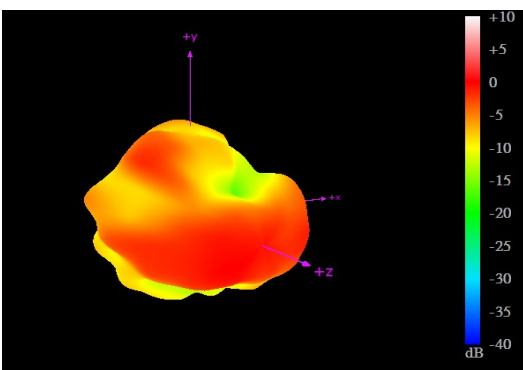
960MHz



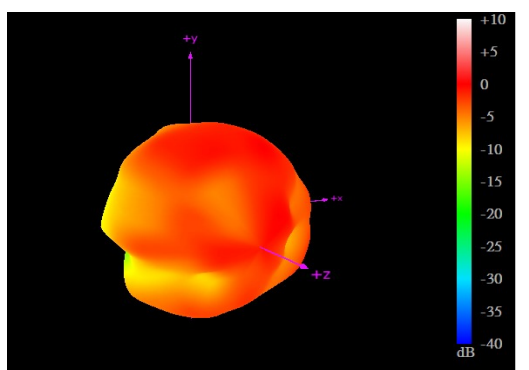
1710MHz



2170MHz



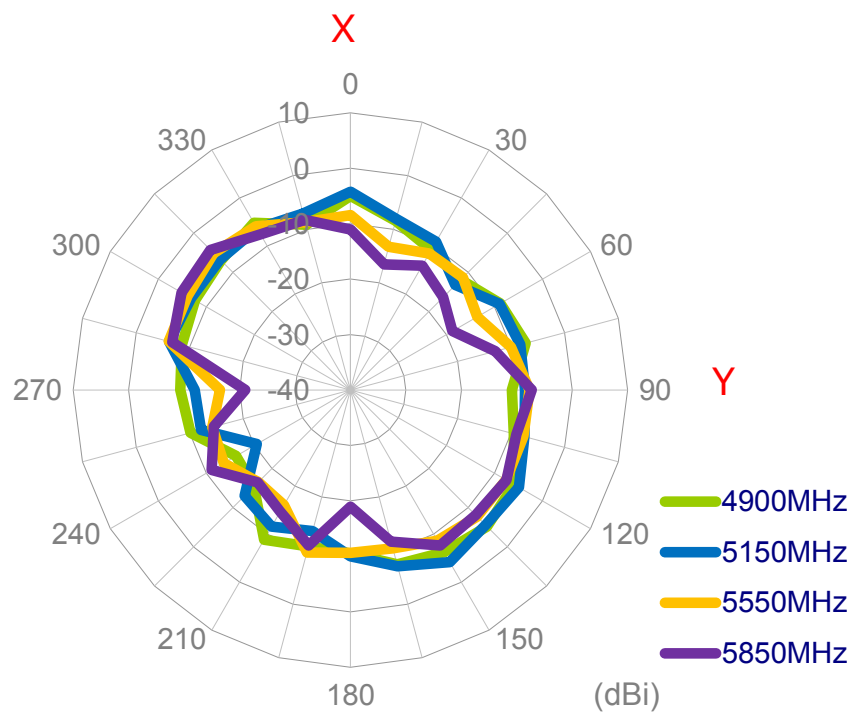
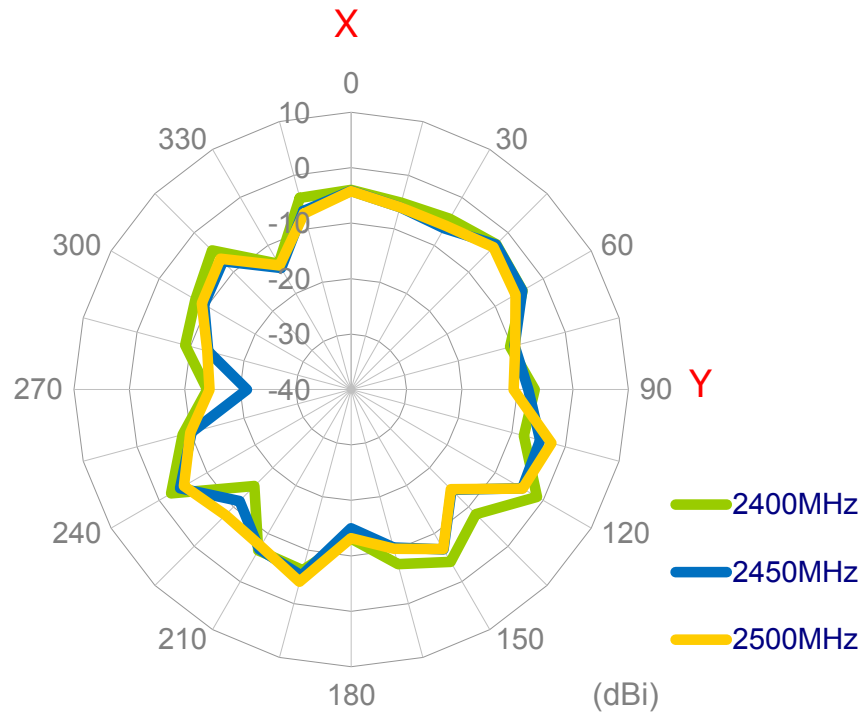
2690MHz



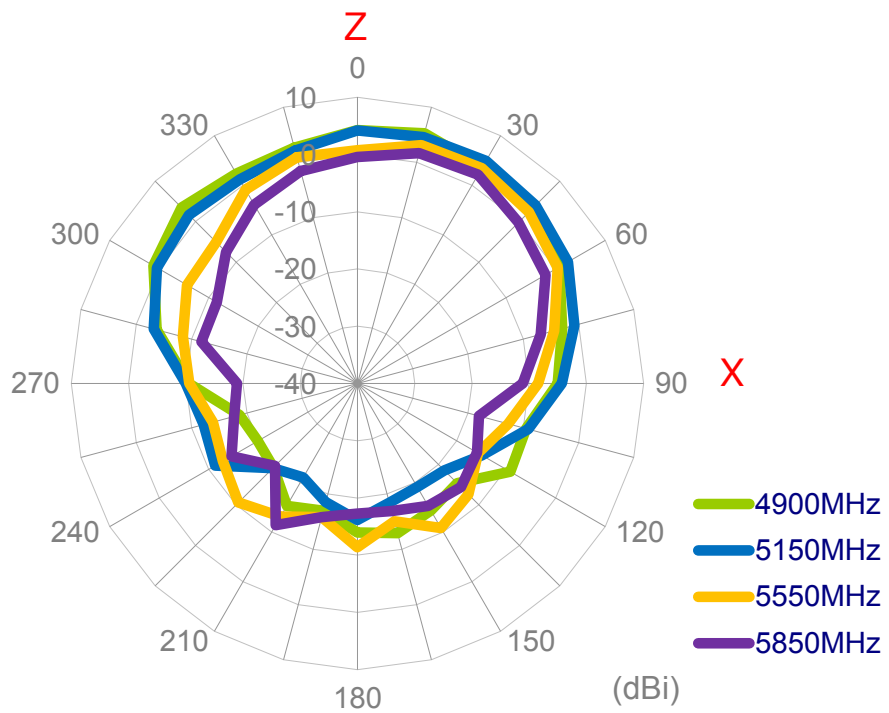
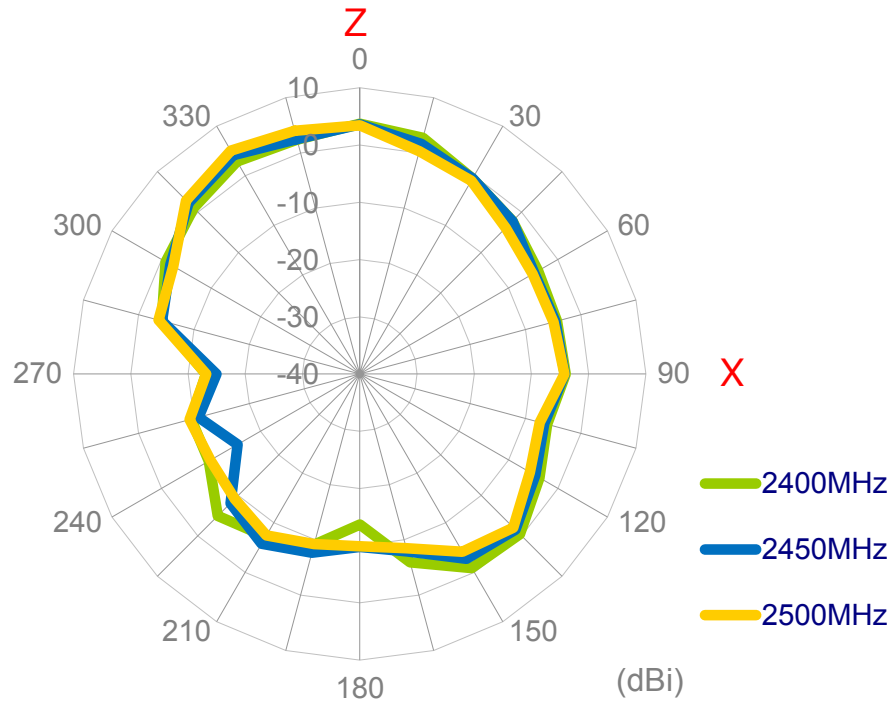
3500MHz

### 3.2.52 2D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length on metal)

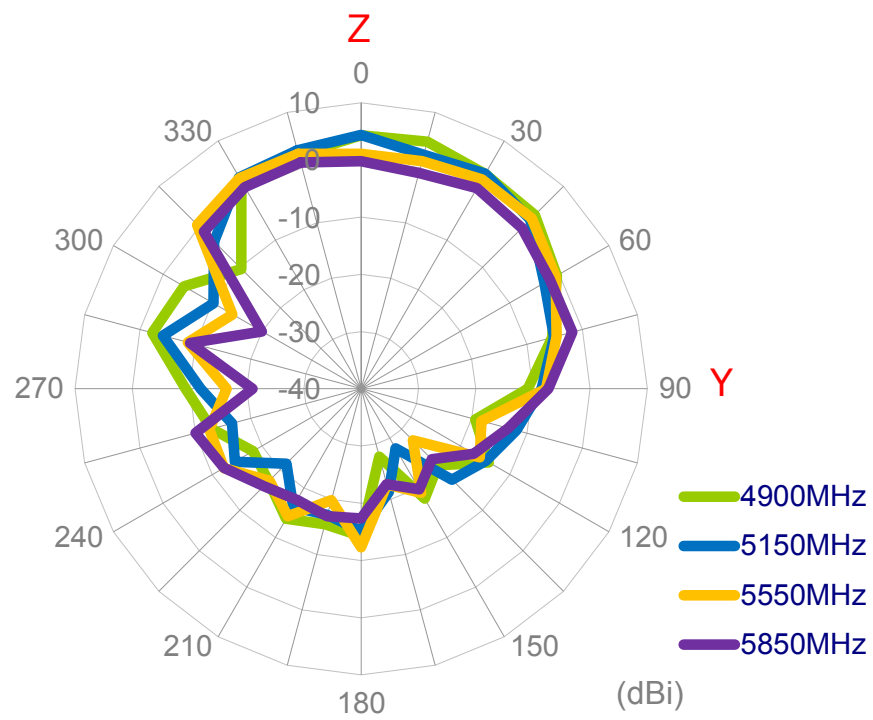
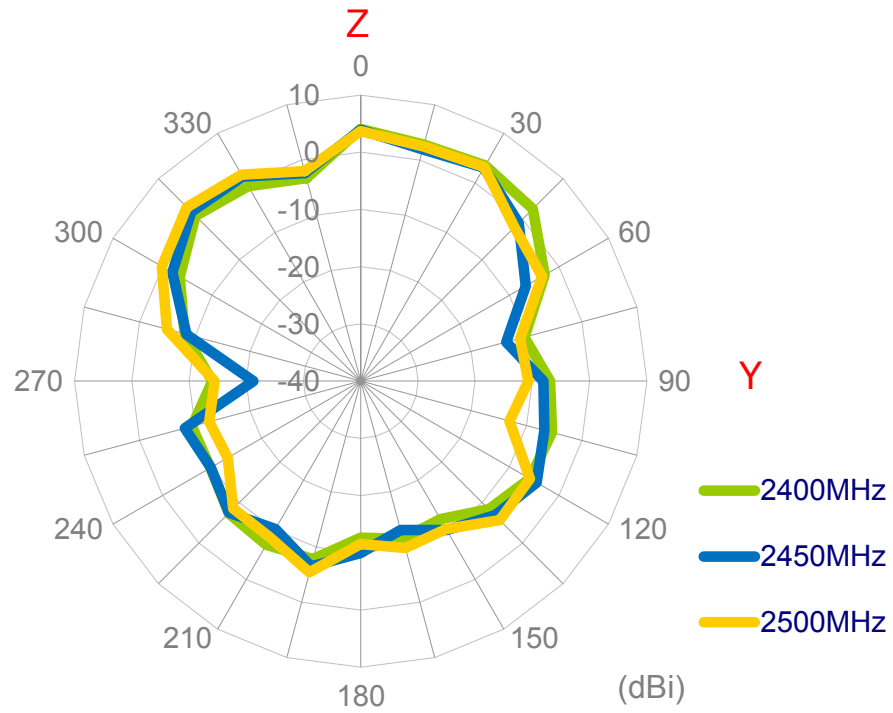
XY Plane



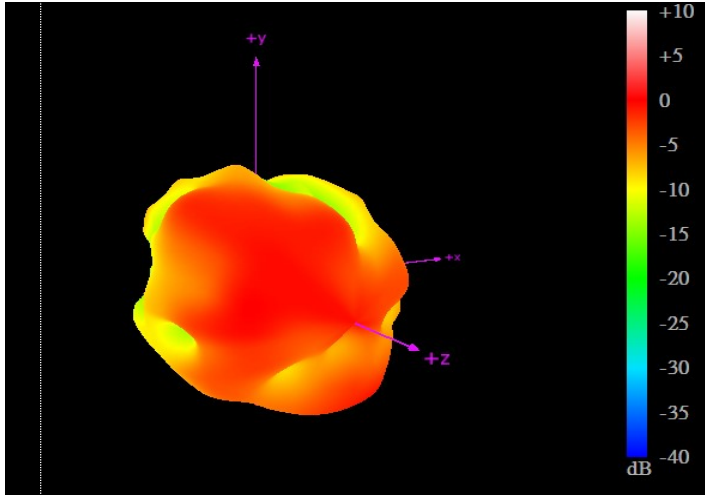
XZ Plane



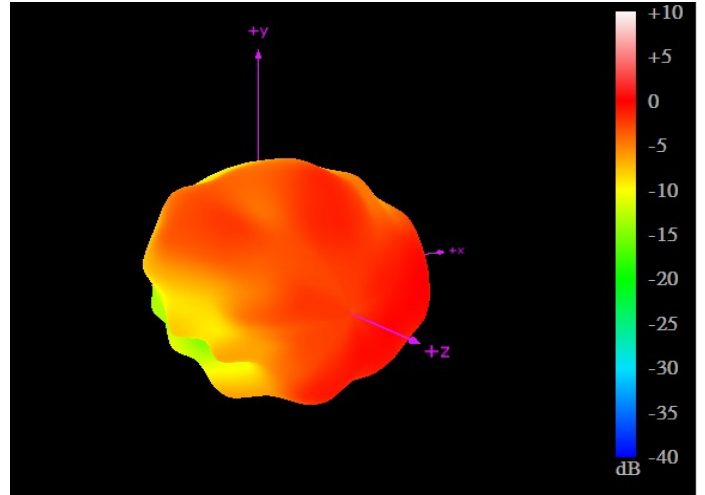
YZ Plane



### 3.2.53 3D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length on metal)



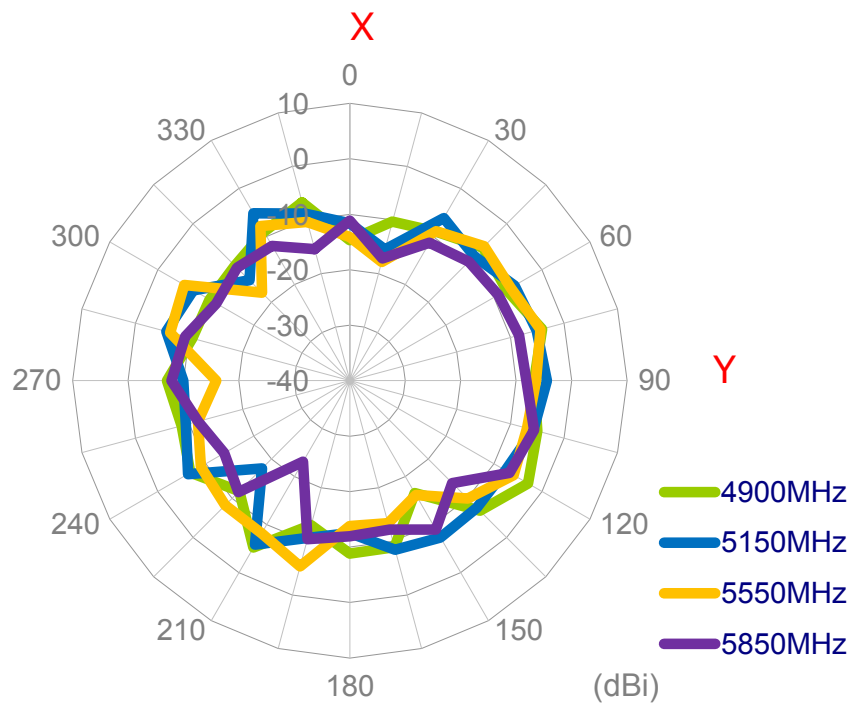
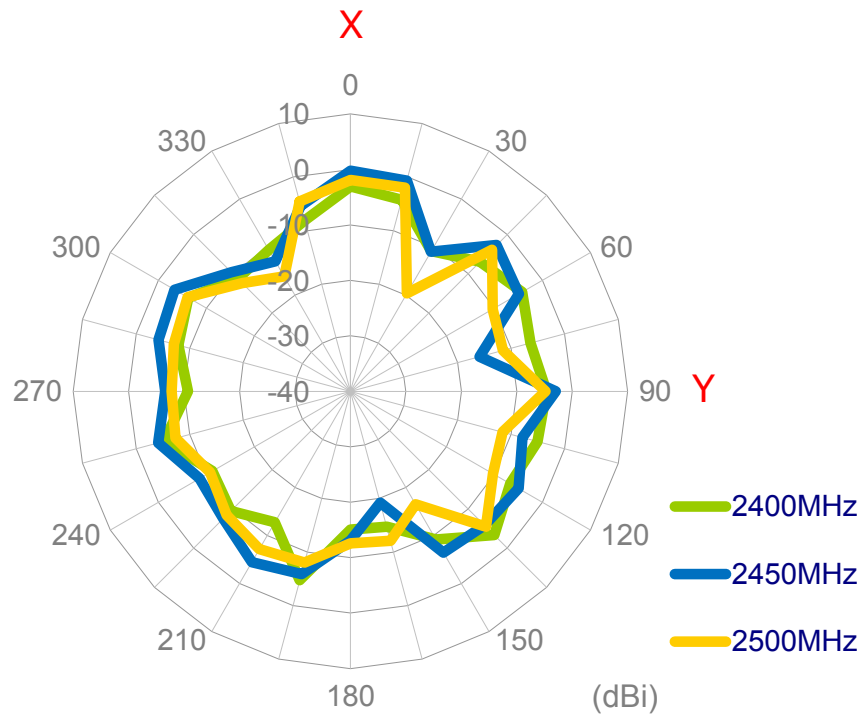
2450MHz



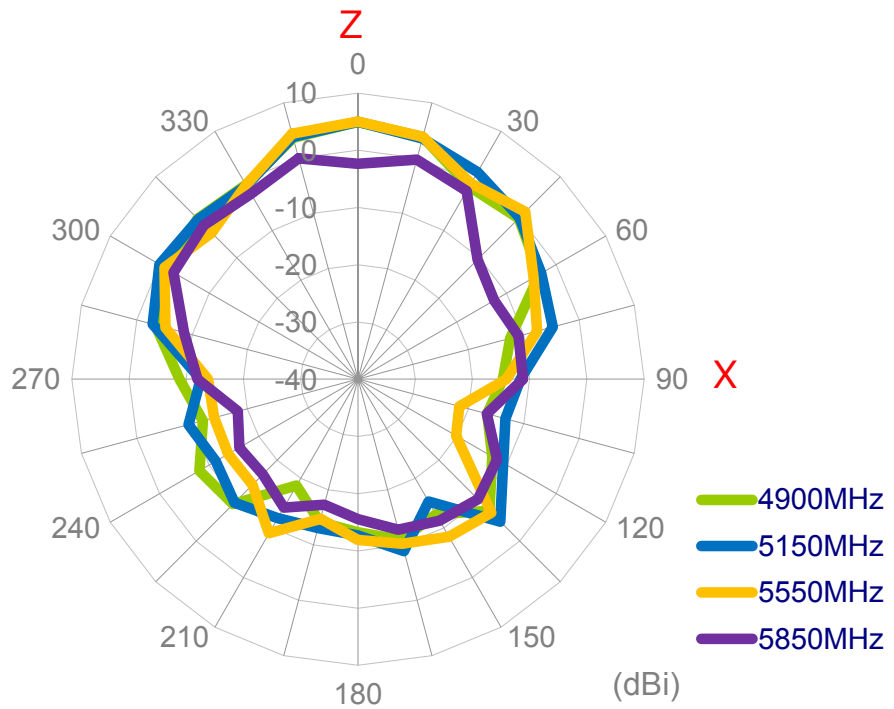
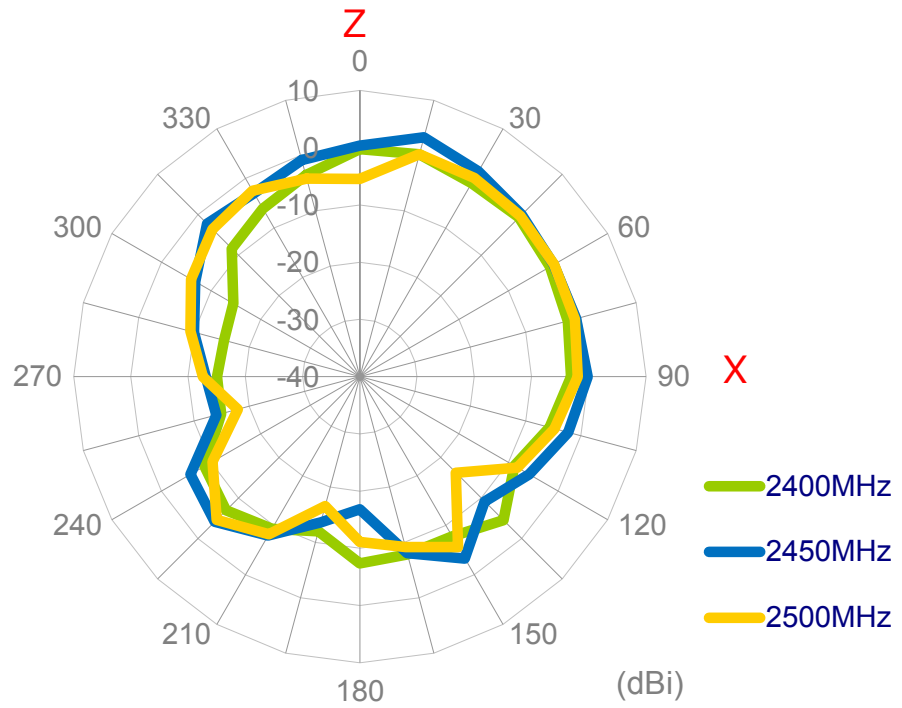
5550MHz

### 3.2.54 2D Radiation Pattern (Wi-Fi\_MIMO2 with 3M cable length on metal)

XY Plane

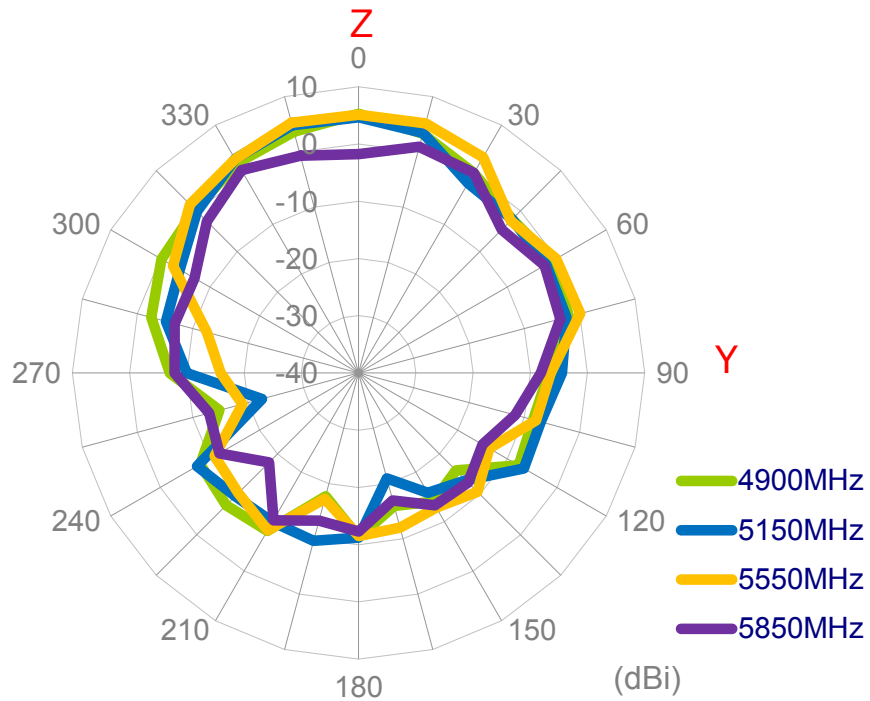
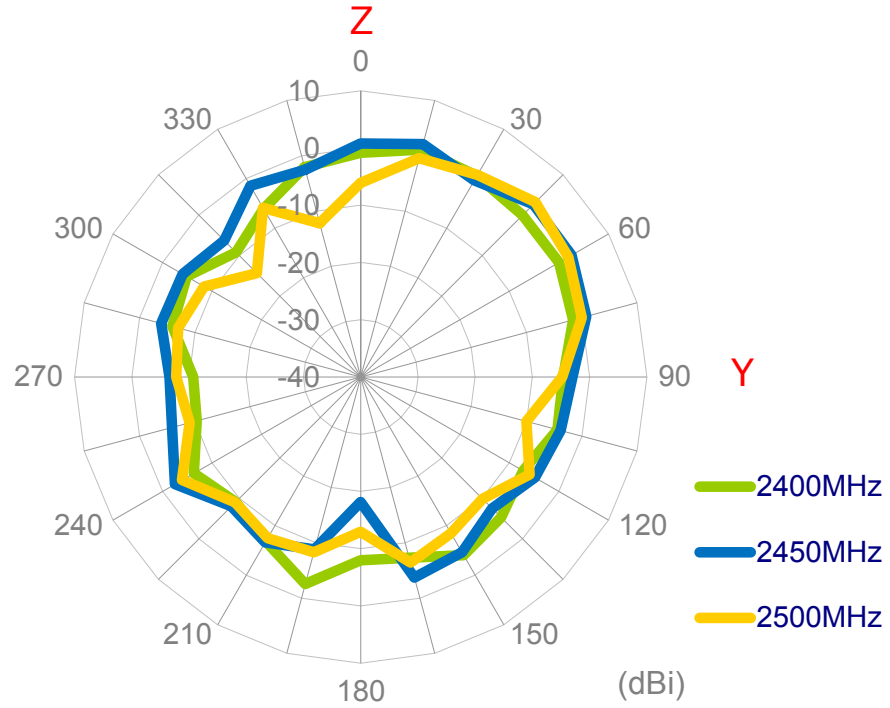


XZ Plane

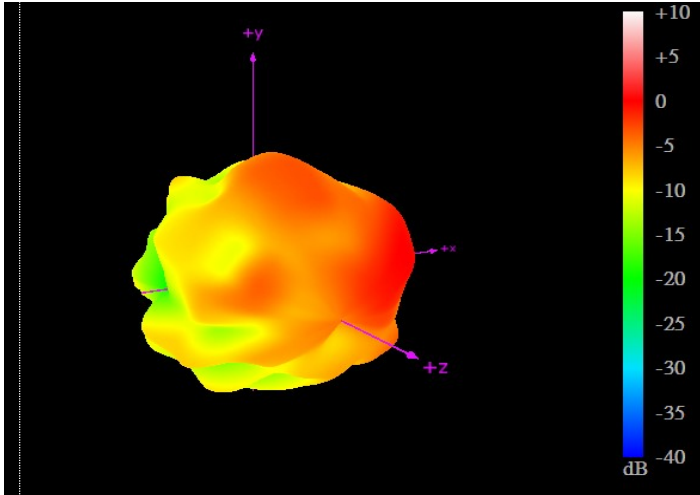




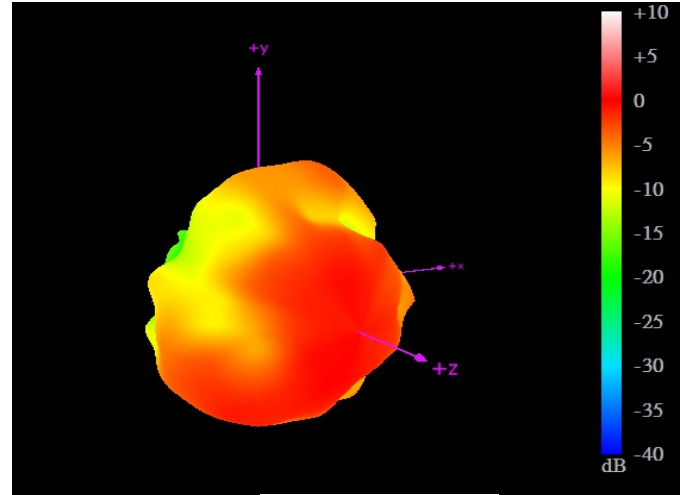
YZ Plane



### 3.2.55 3D Radiation Pattern (Wi-Fi\_MIMO2 with 1M cable length on metal)

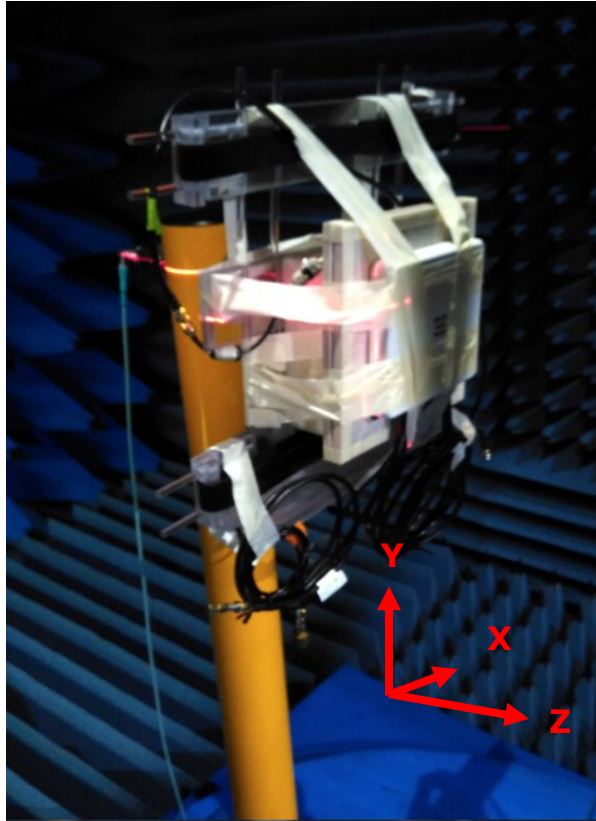


2450MHz



5550MHz

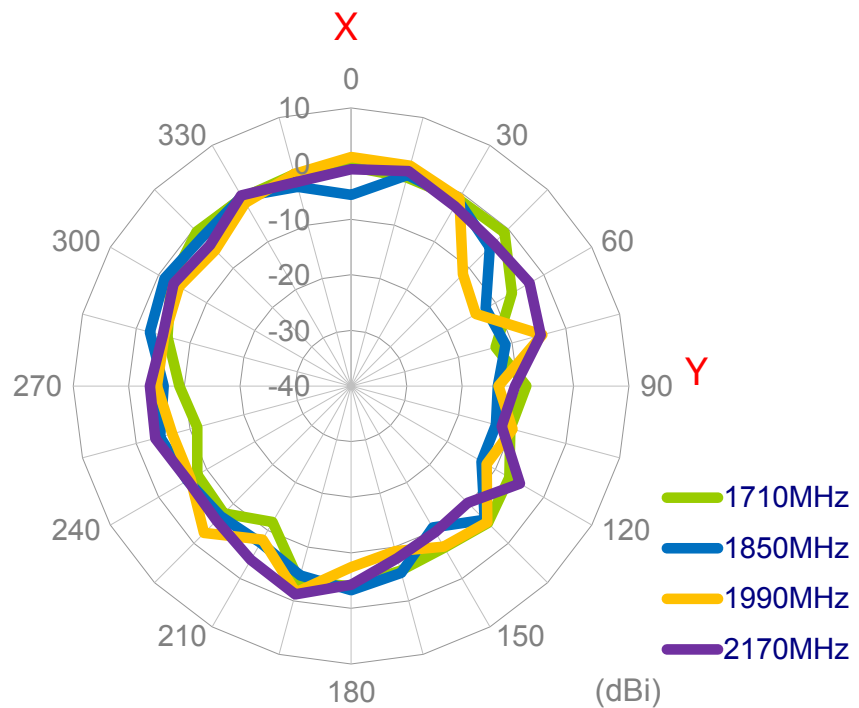
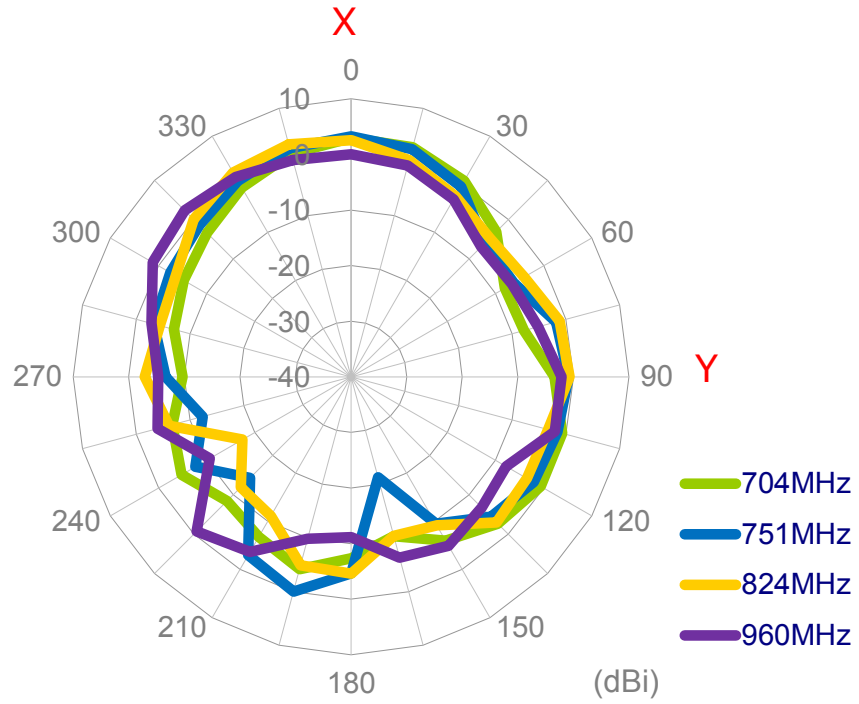
### 3.2.56 Test Setup for Antenna Radiation Pattern

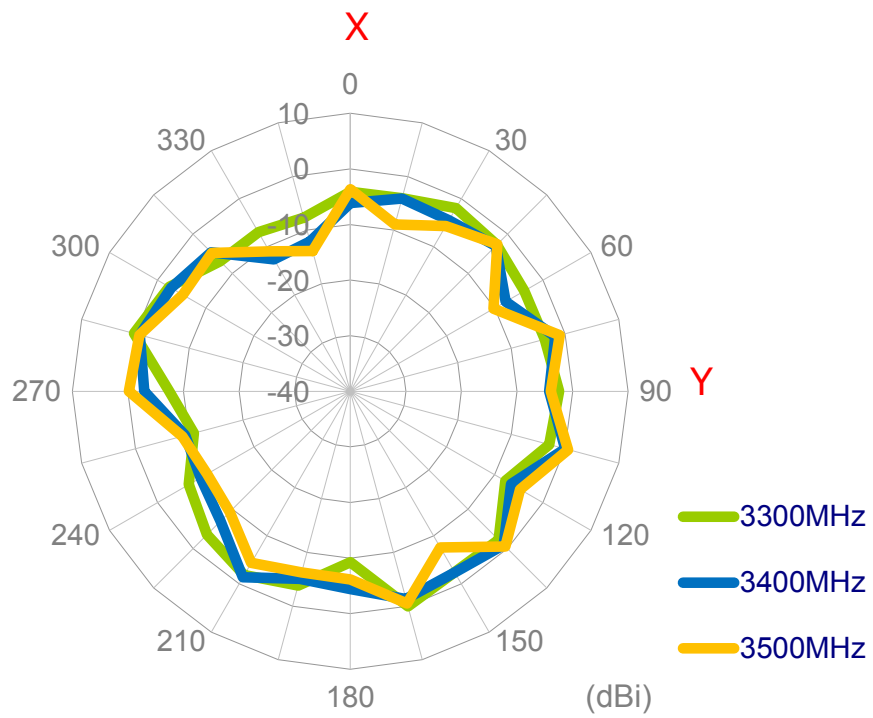
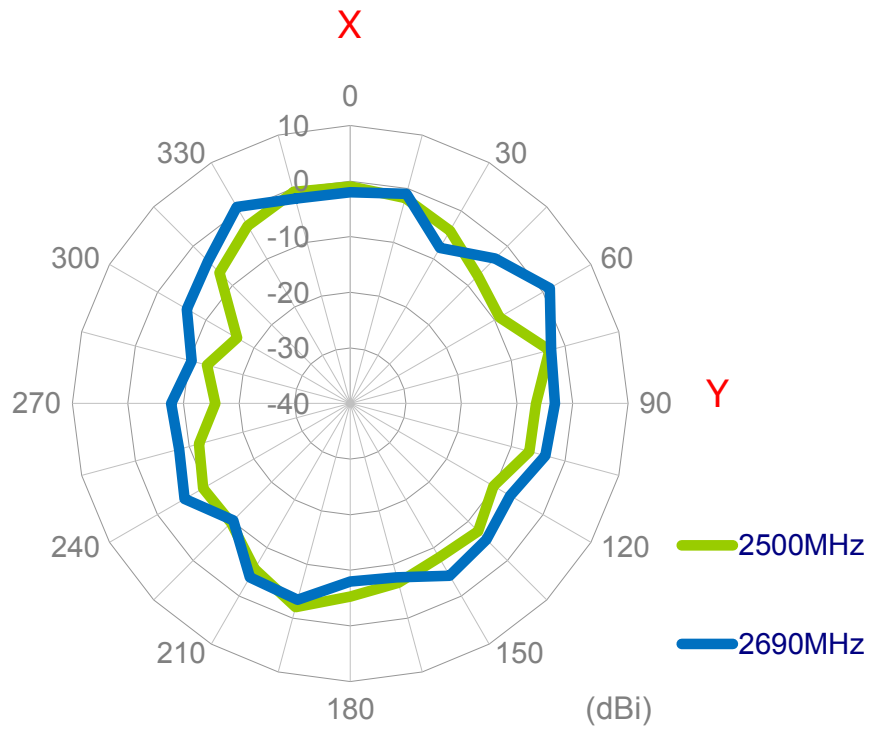


On the Wall

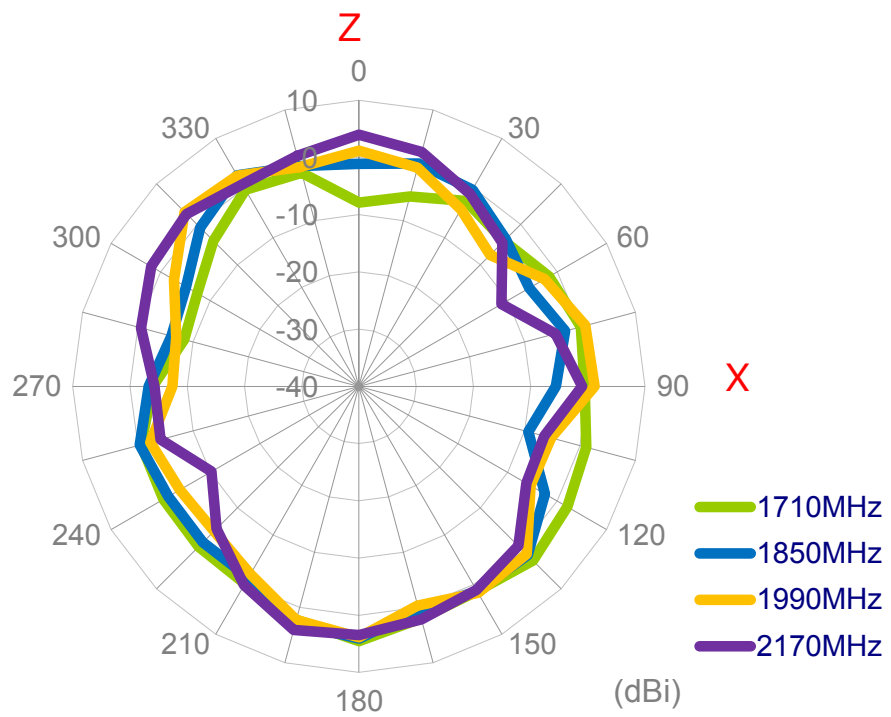
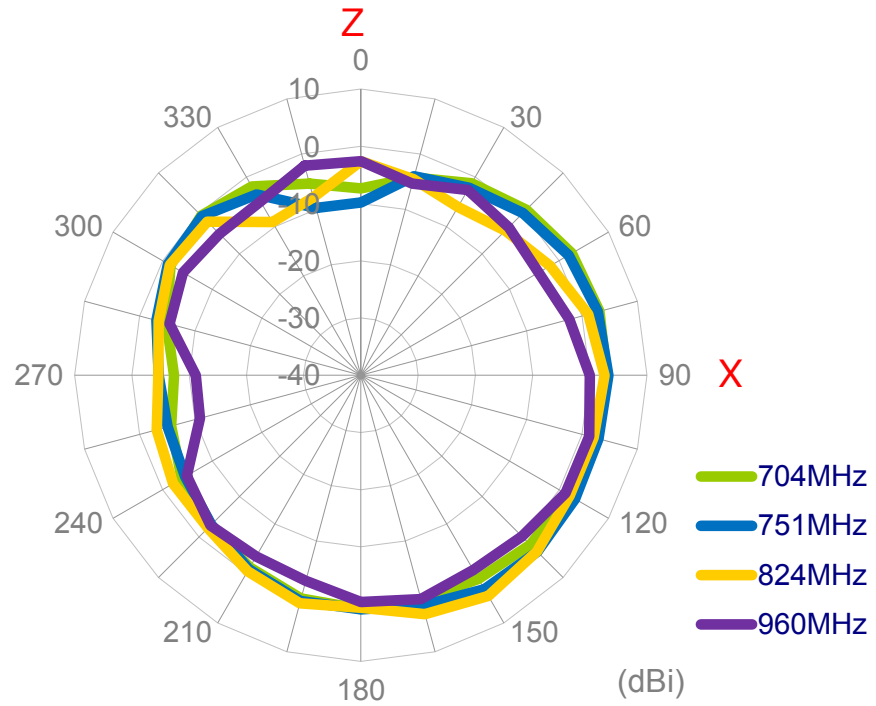
### 3.2.57 2D Radiation Pattern (LTE\_MIMO1 with 1M cable length on the wall)

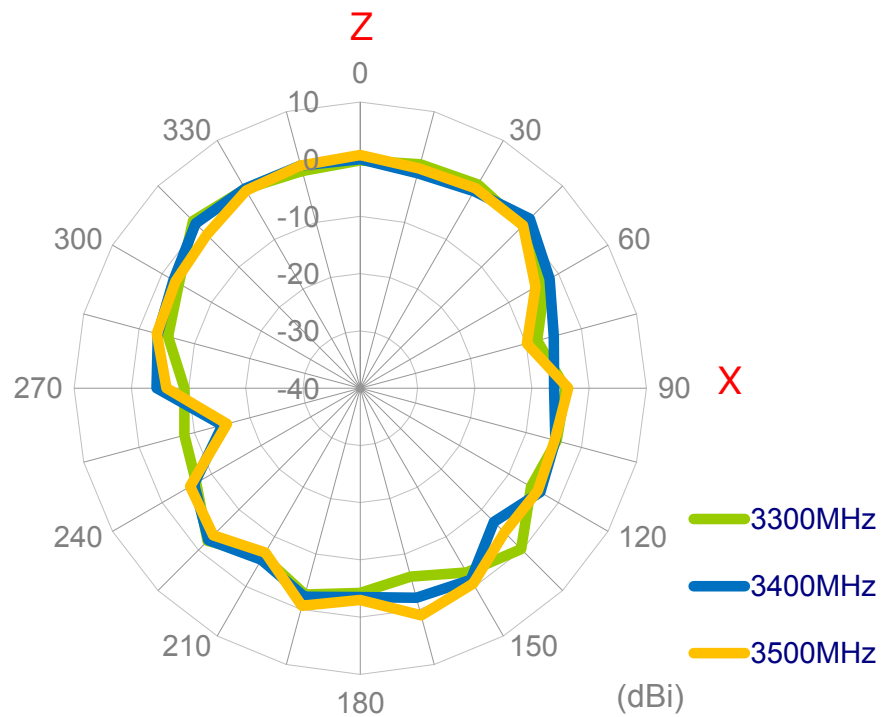
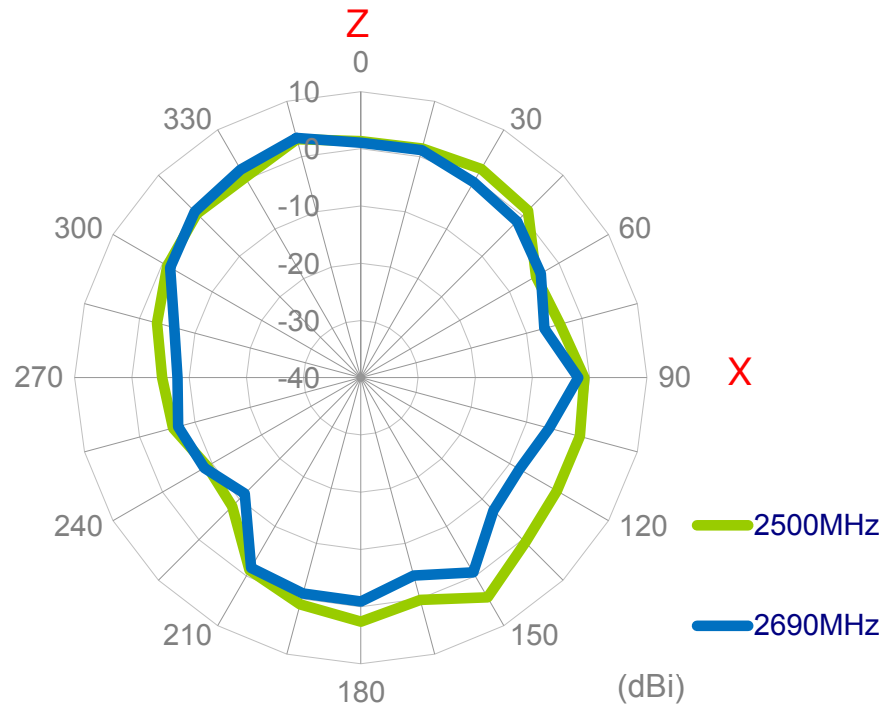
XY Plane



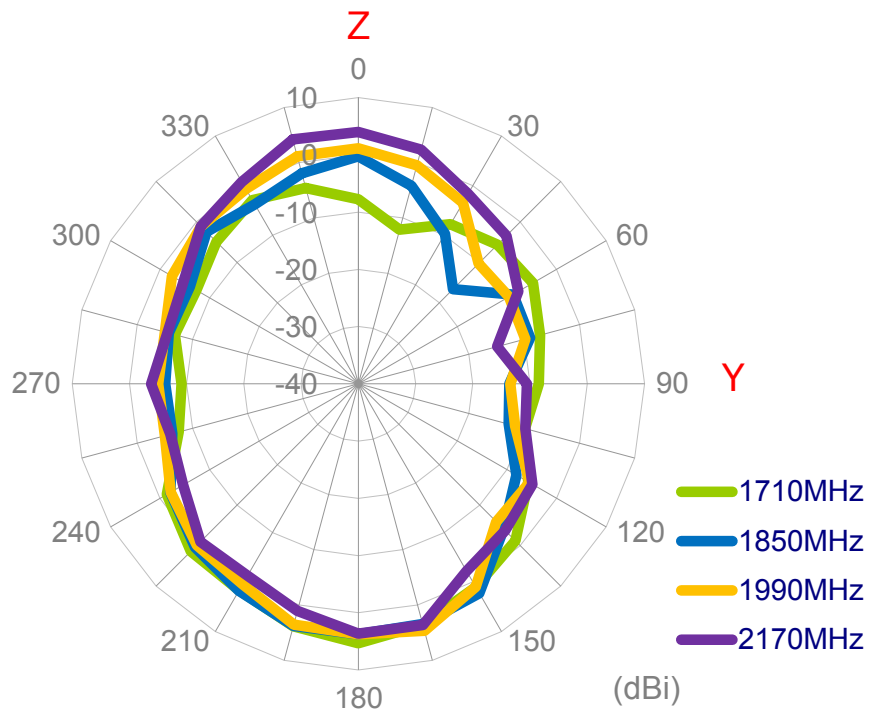
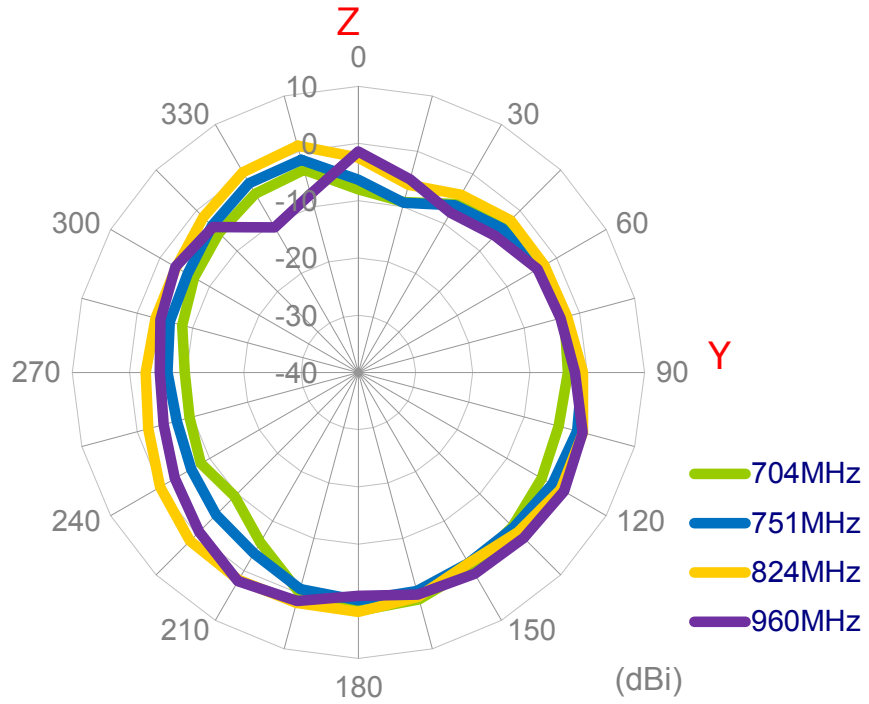


XZ Plane

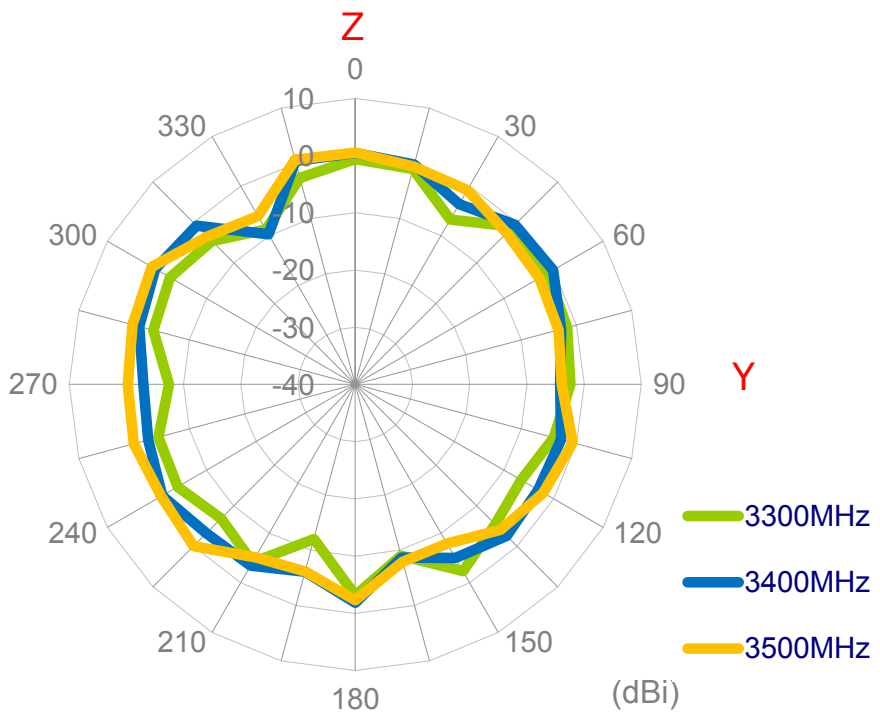
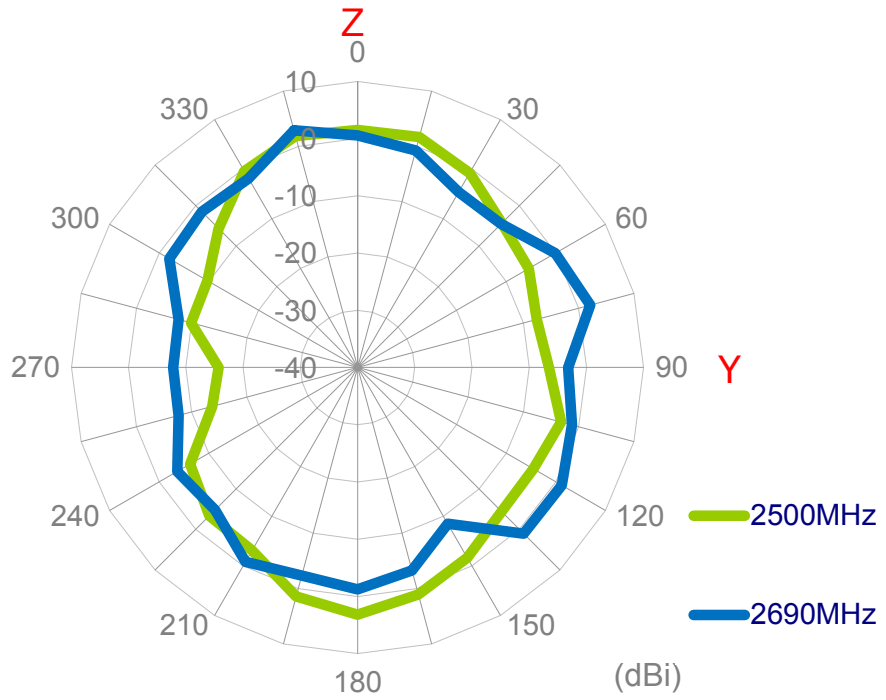




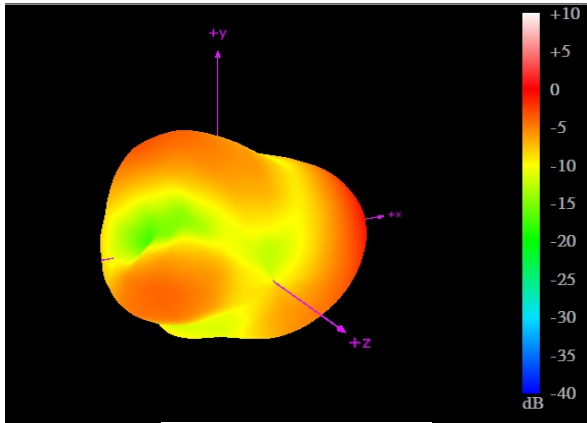
YZ Plane



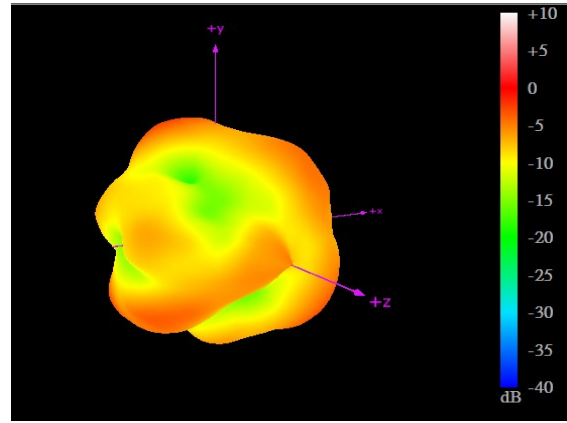




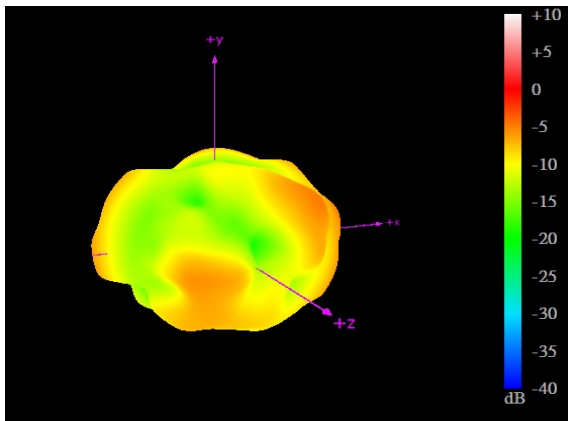
### 3.2.58 3D Radiation Pattern (LTE\_MIMO1 with 1M cable length on the wall)



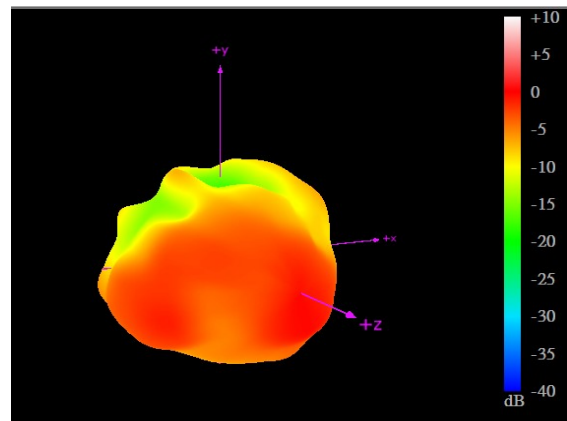
704MHz



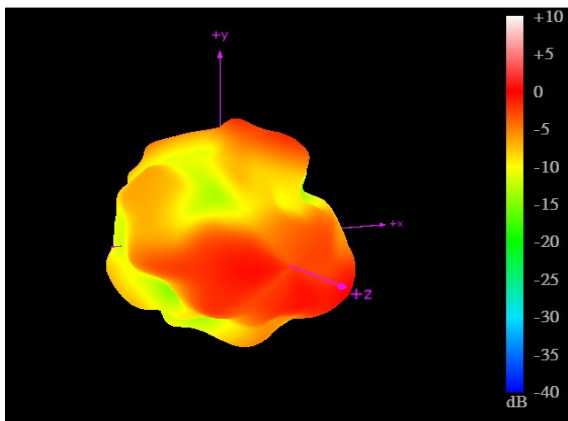
960MHz



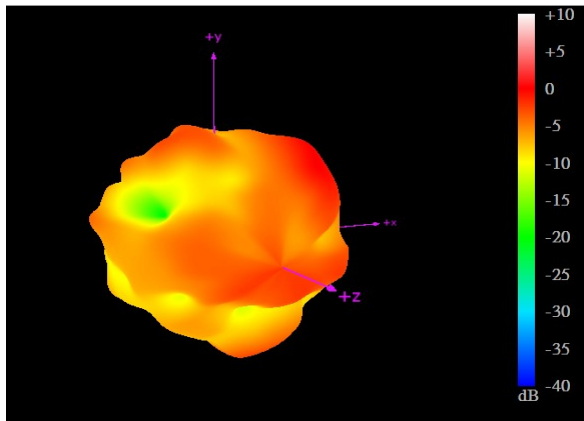
1710MHz



2170MHz



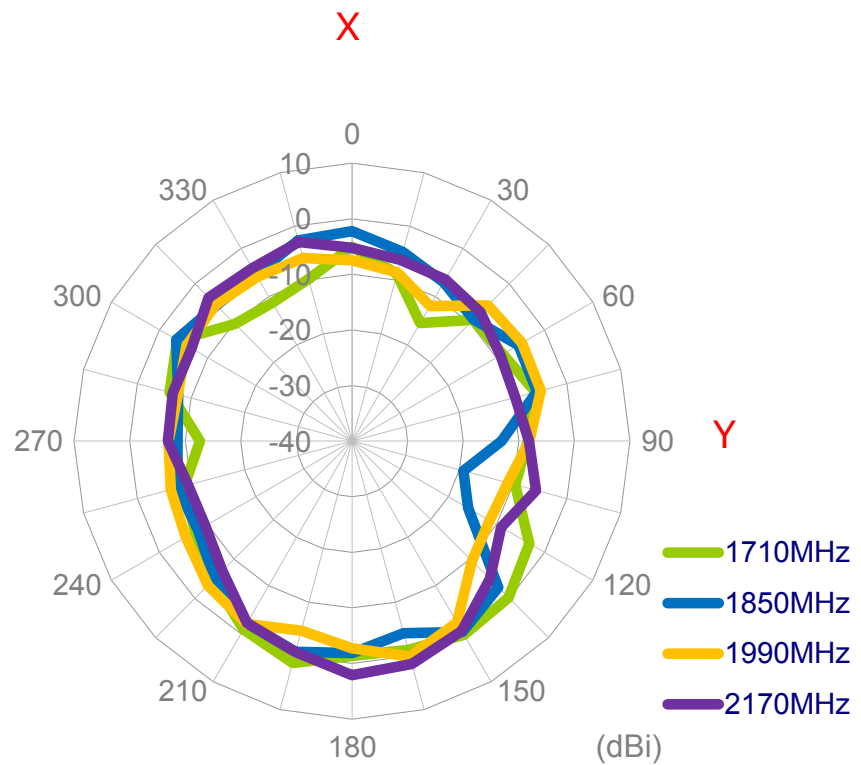
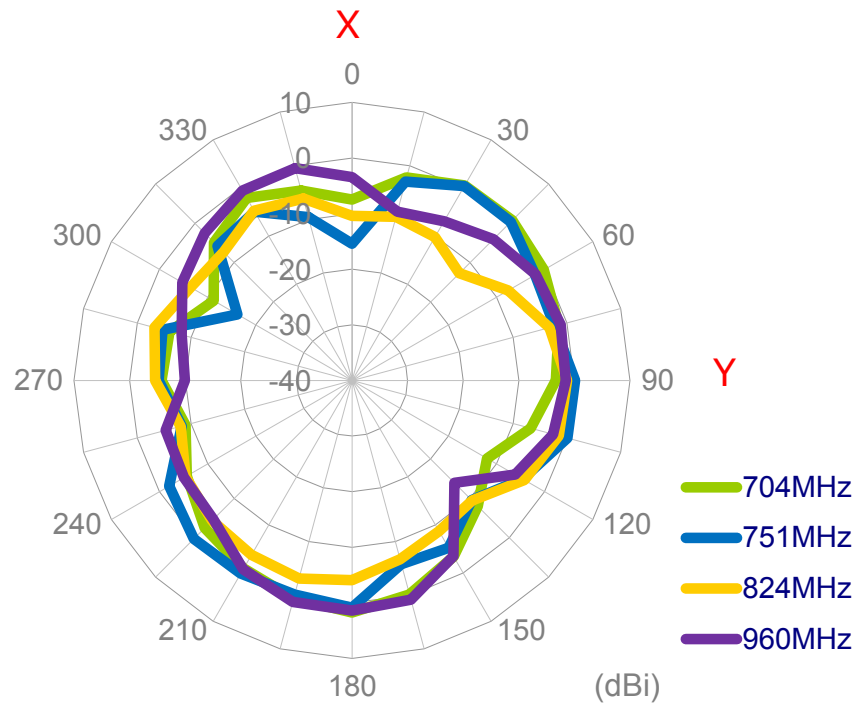
2690MHz

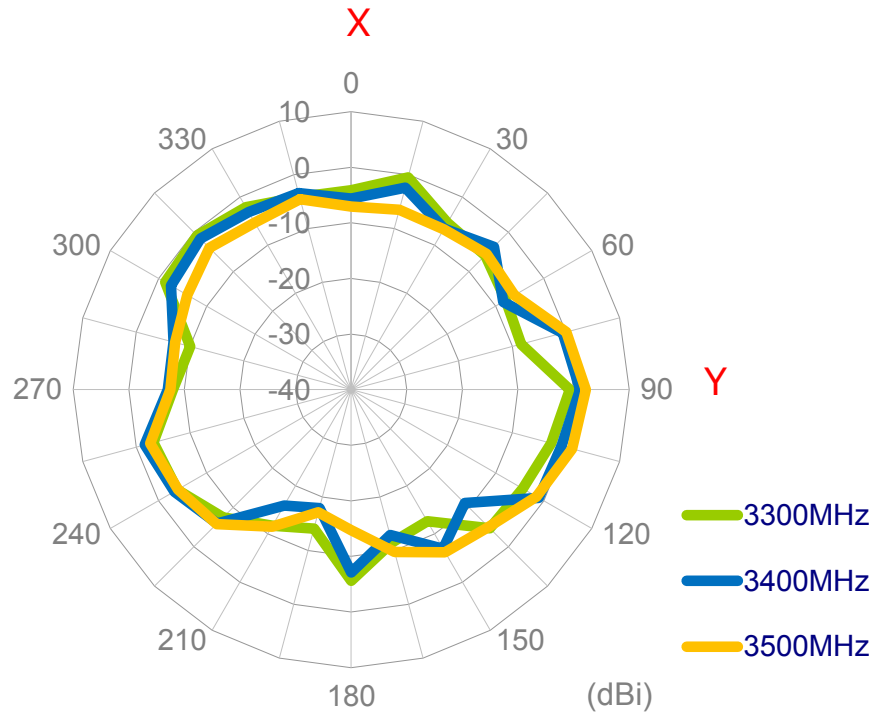
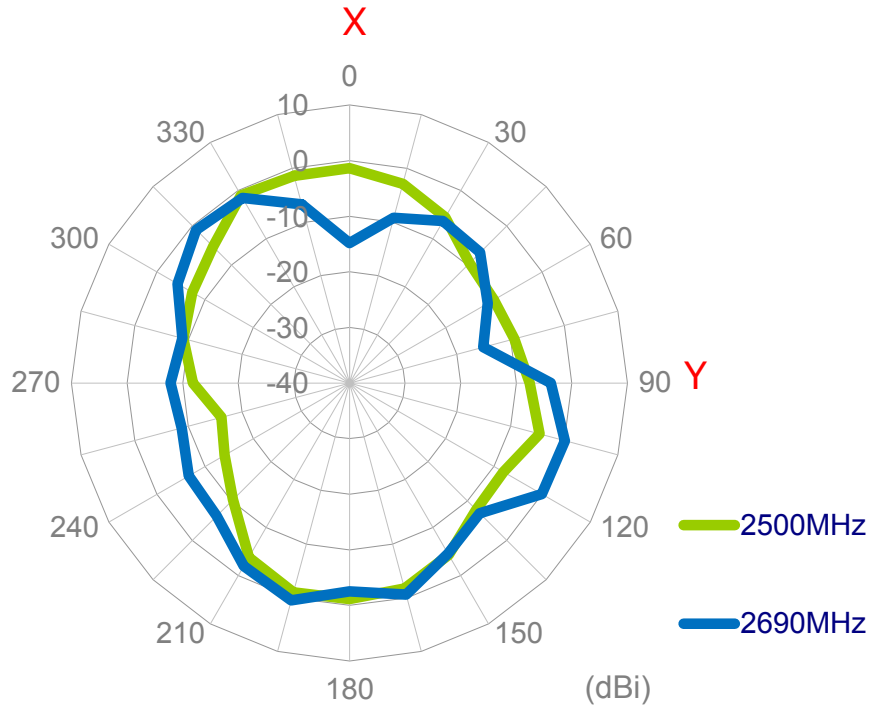


3500MHz

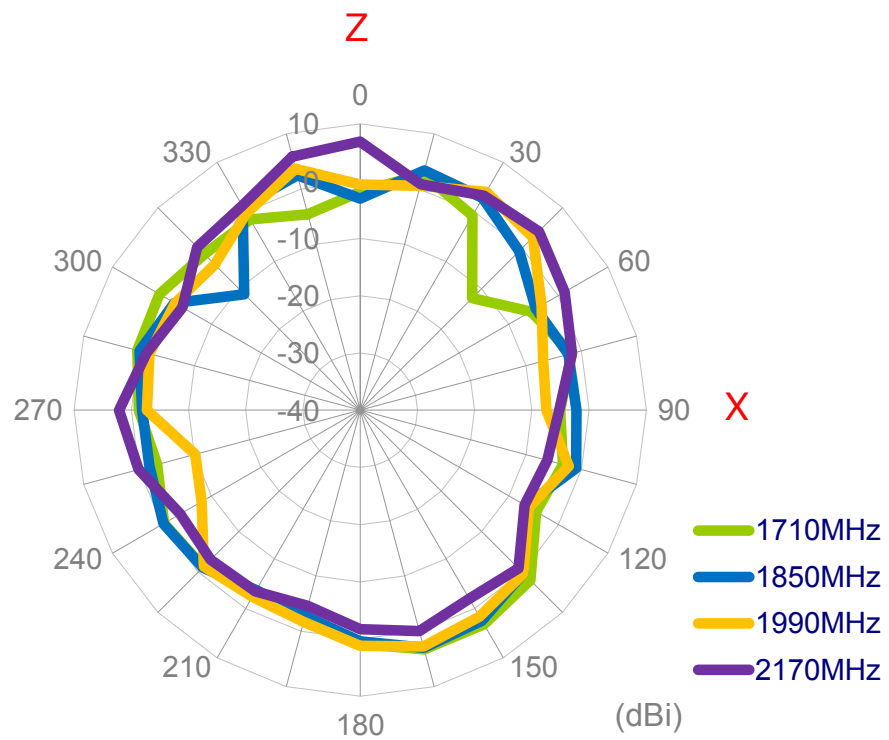
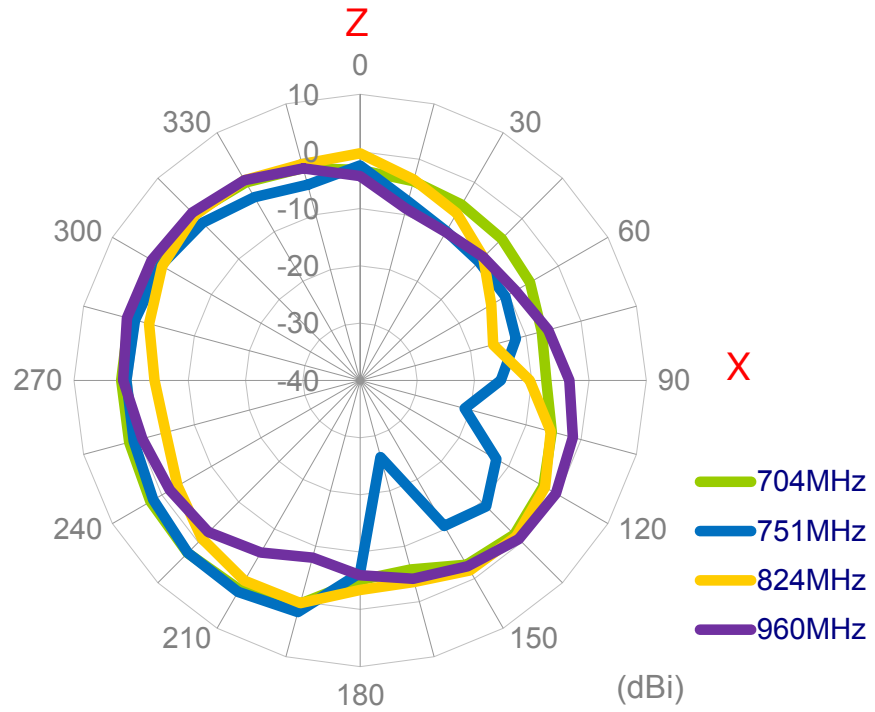
### 3.2.59 2D Radiation Pattern (LTE\_MIMO2 with 1M cable length on the wall)

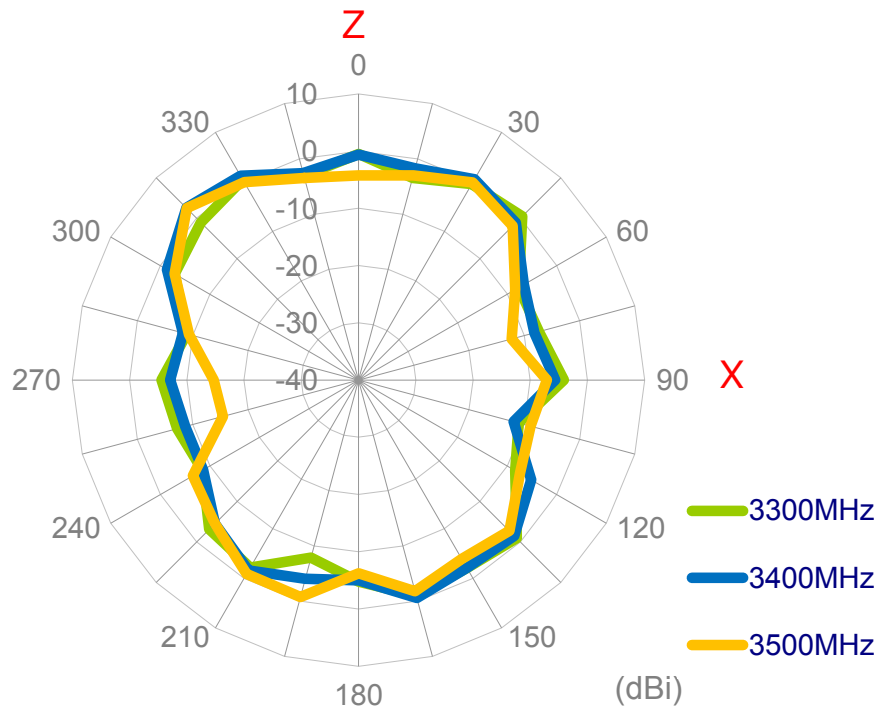
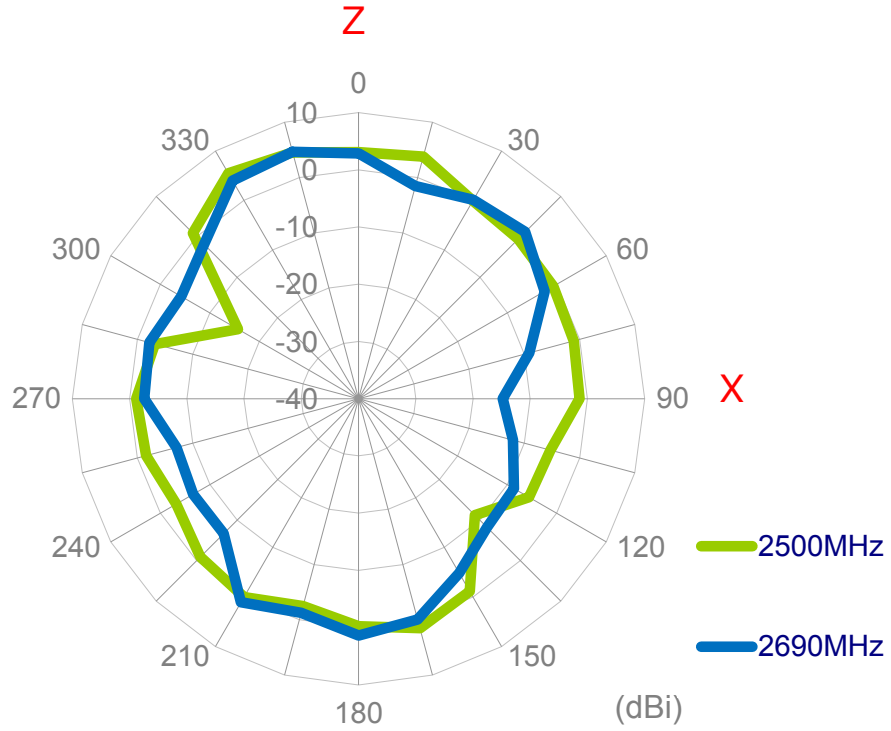
XY Plane



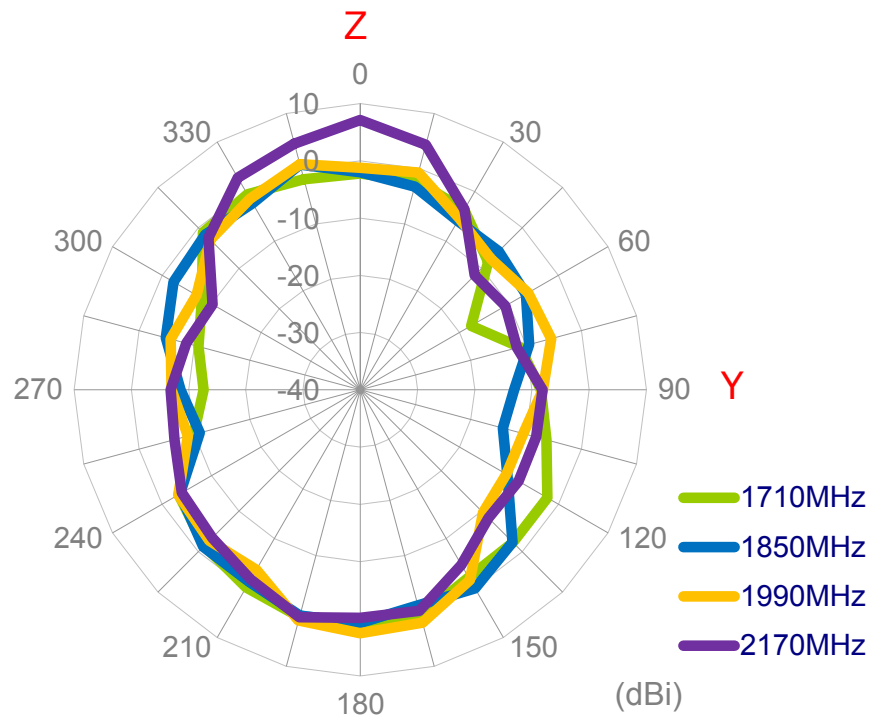
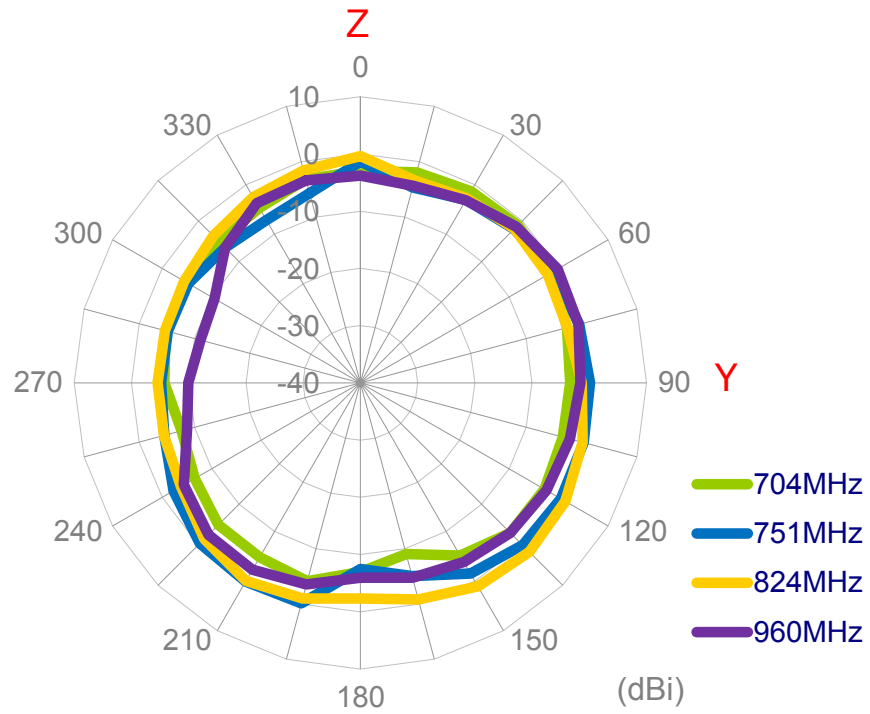


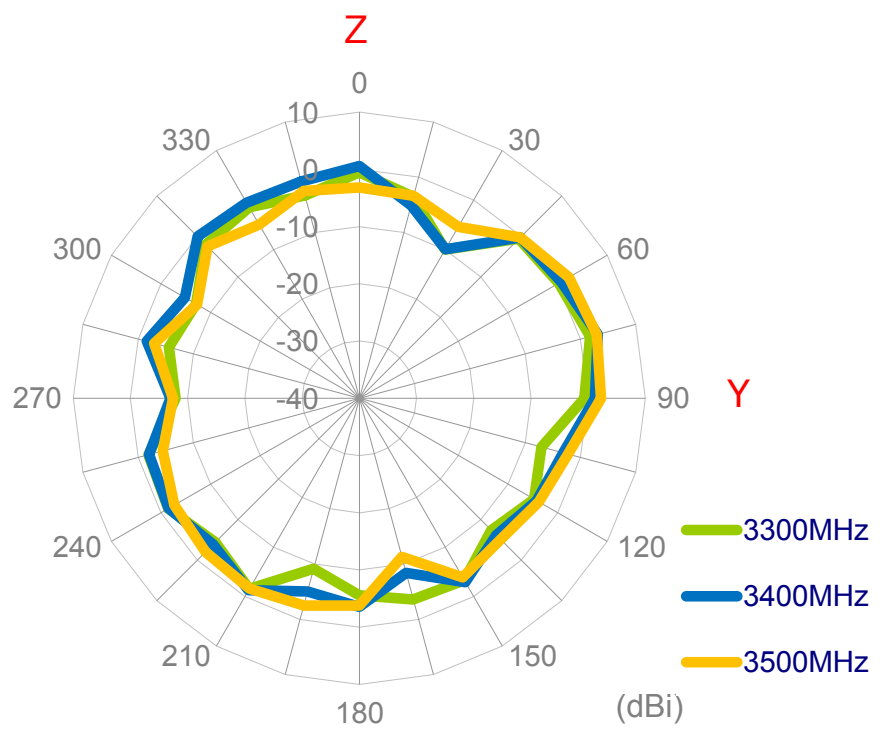
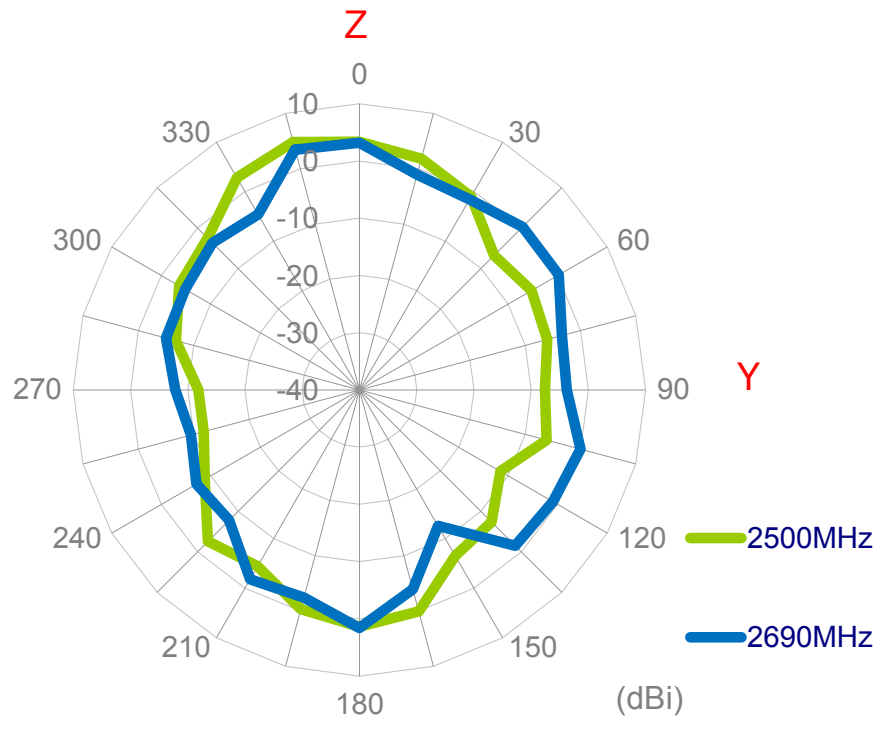
XZ Plane





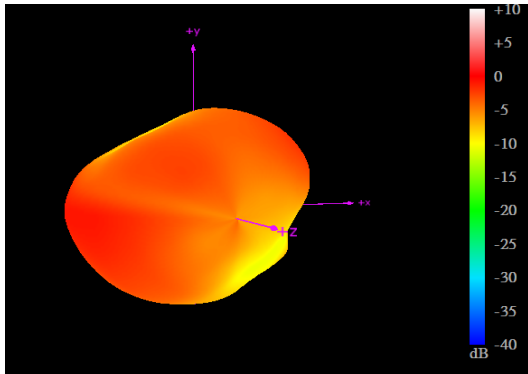
YZ Plane



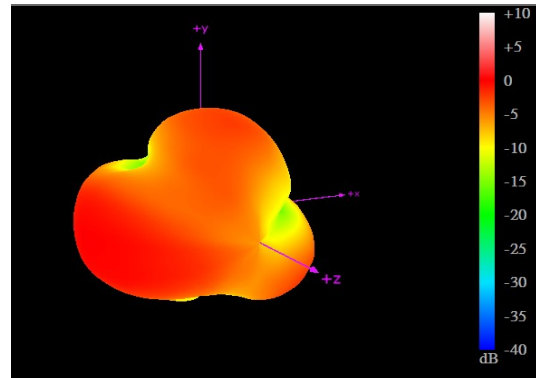




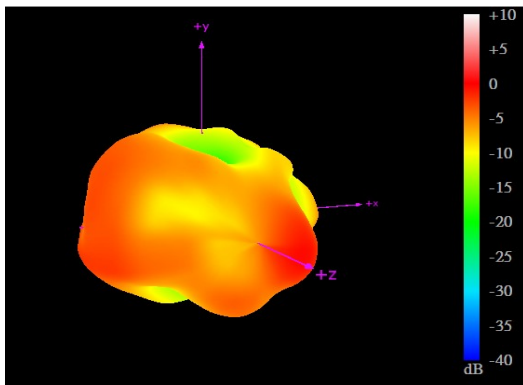
3.2.60 3D Radiation Pattern (LTE\_MIMO2 with 1M cable length on the wall)



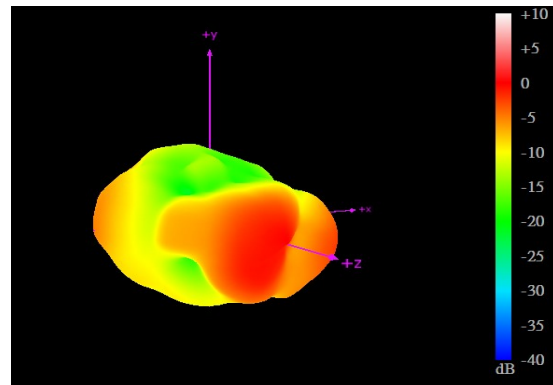
704MHz



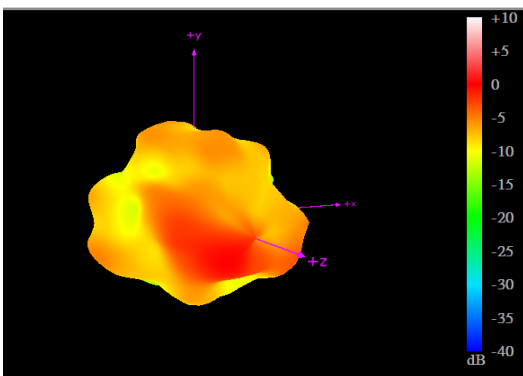
960MHz



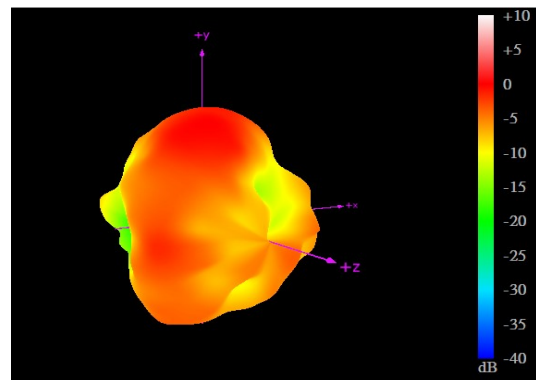
1710MHz



2170MHz



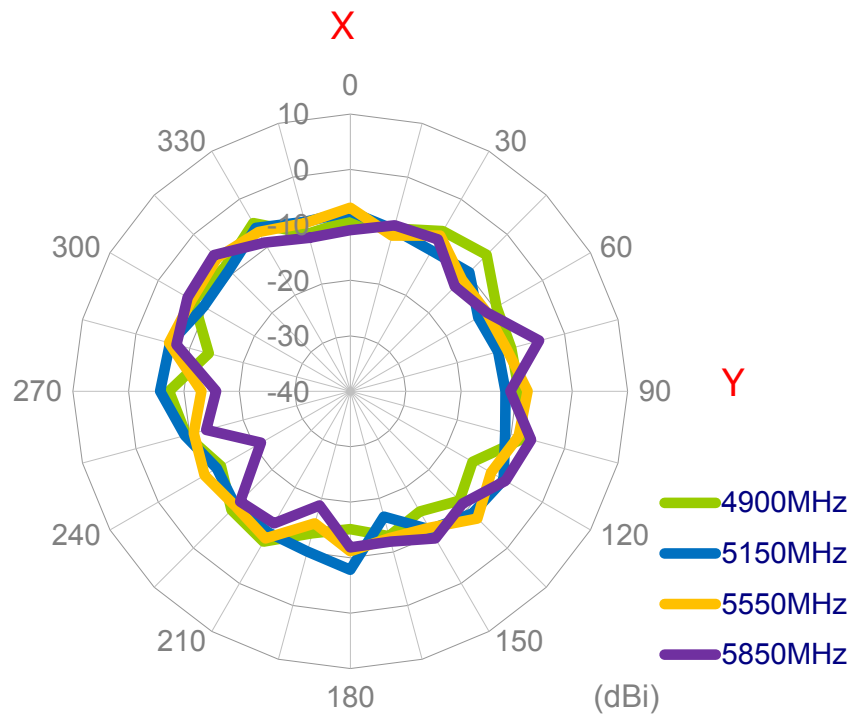
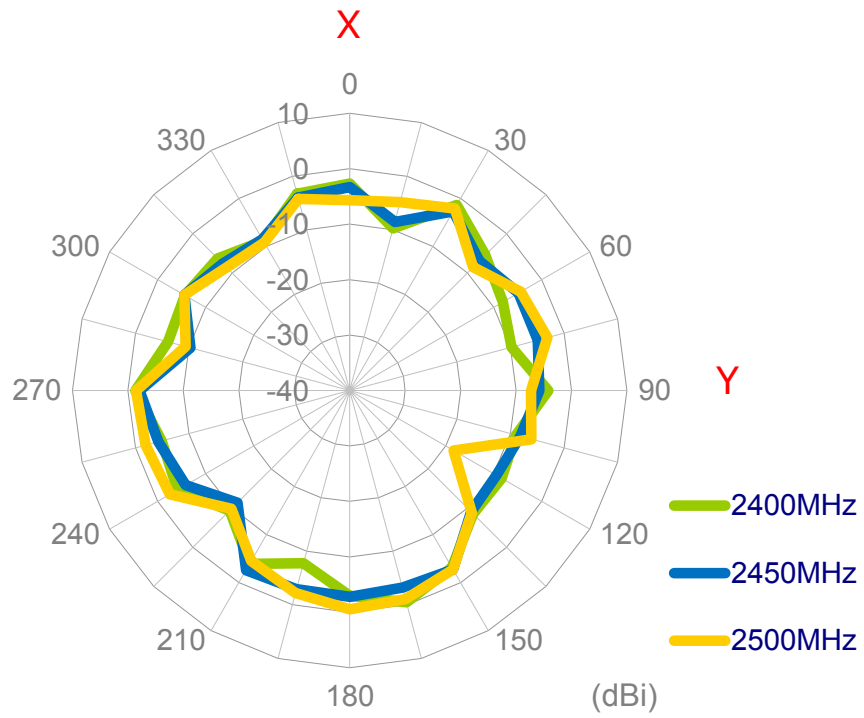
2690MHz



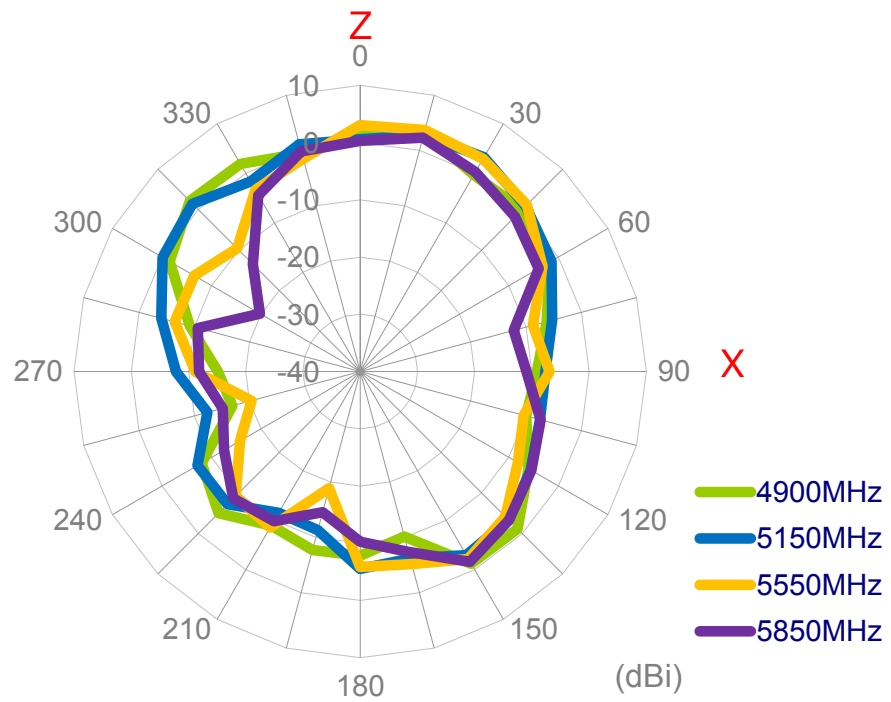
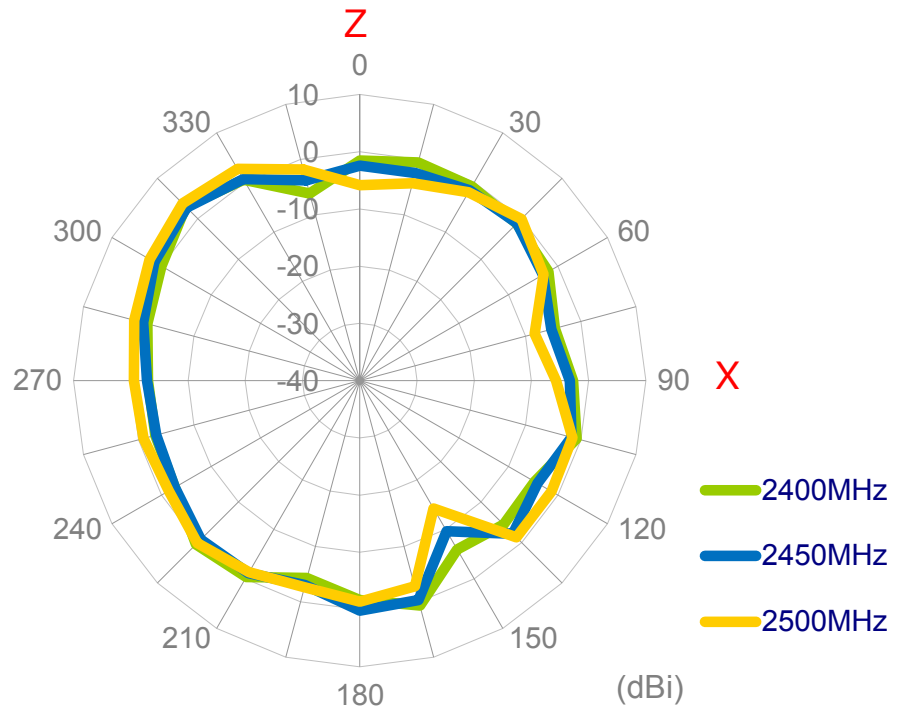
3500MHz

### 3.2.61 2D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length in free space)

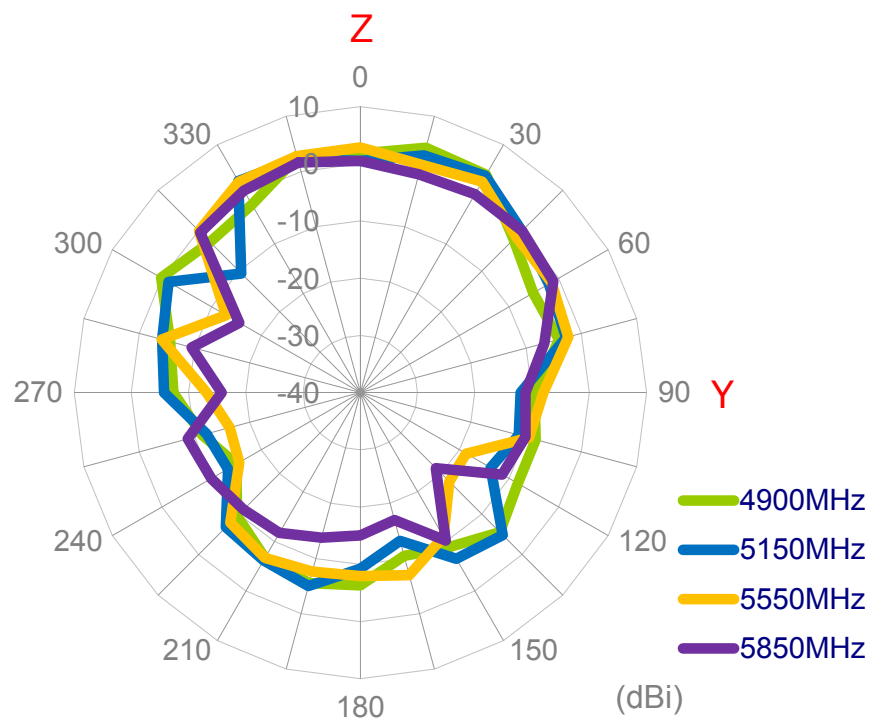
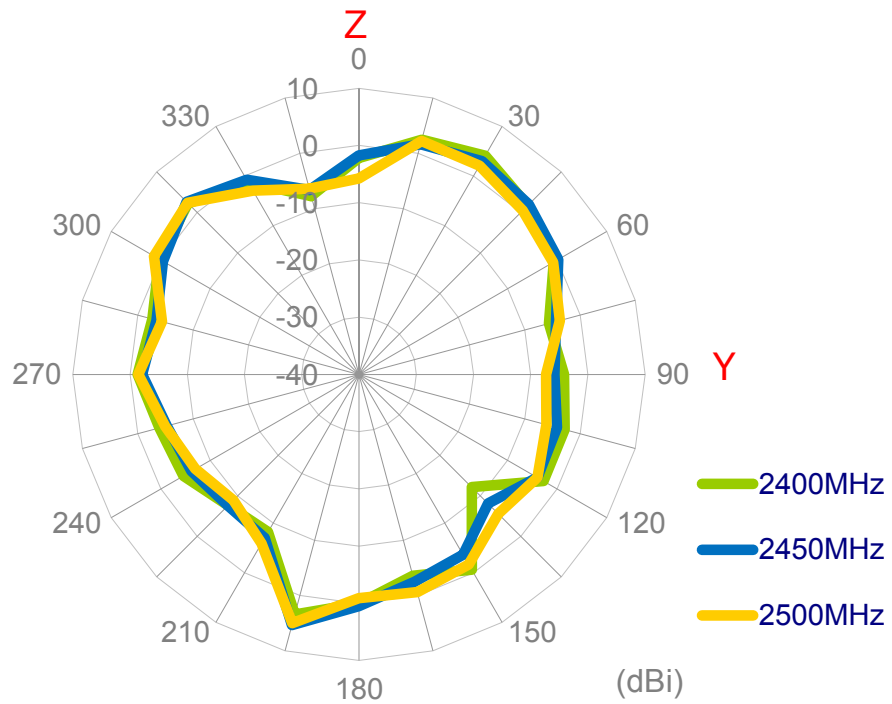
XY Plane



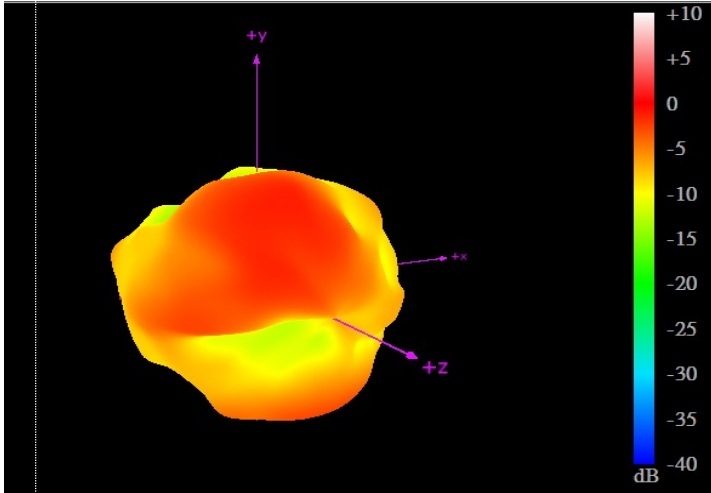
XZ Plane



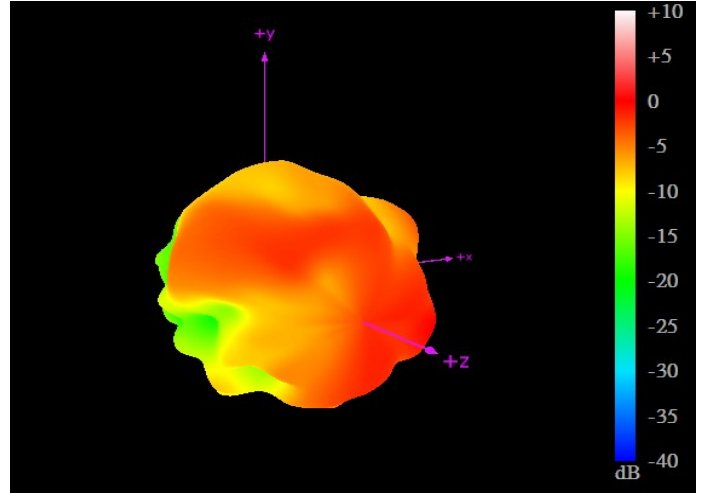
YZ Plane



### 3.2.62 3D Radiation Pattern (Wi-Fi\_MIMO1 with 1M cable length in free space)



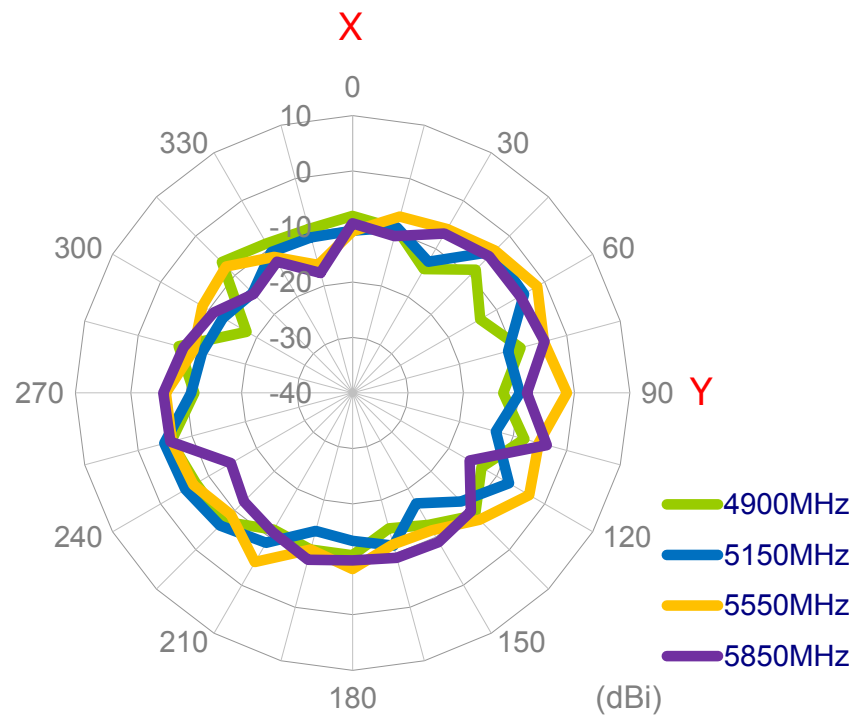
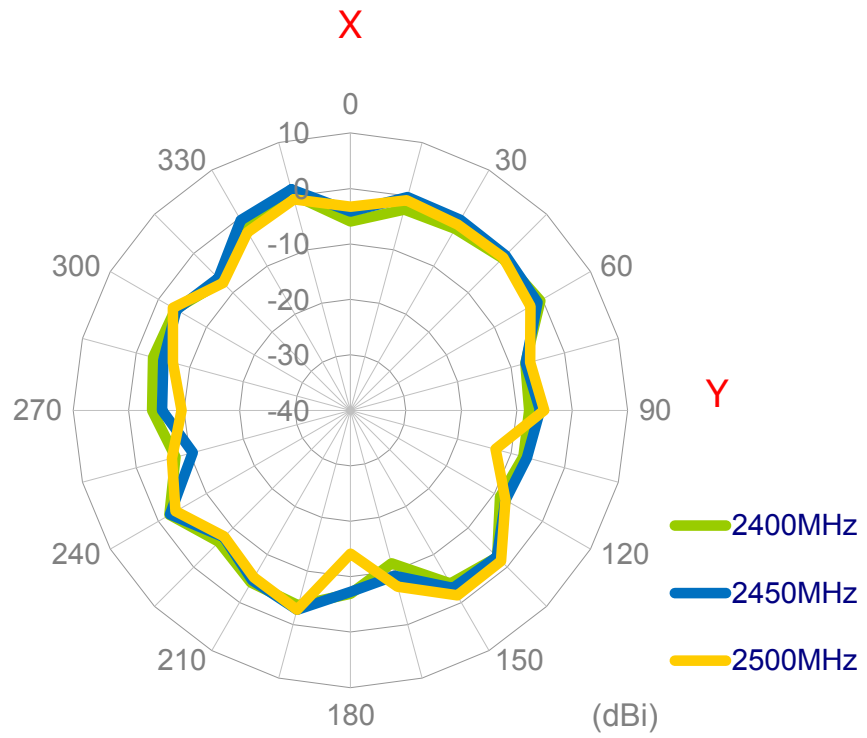
2450MHz



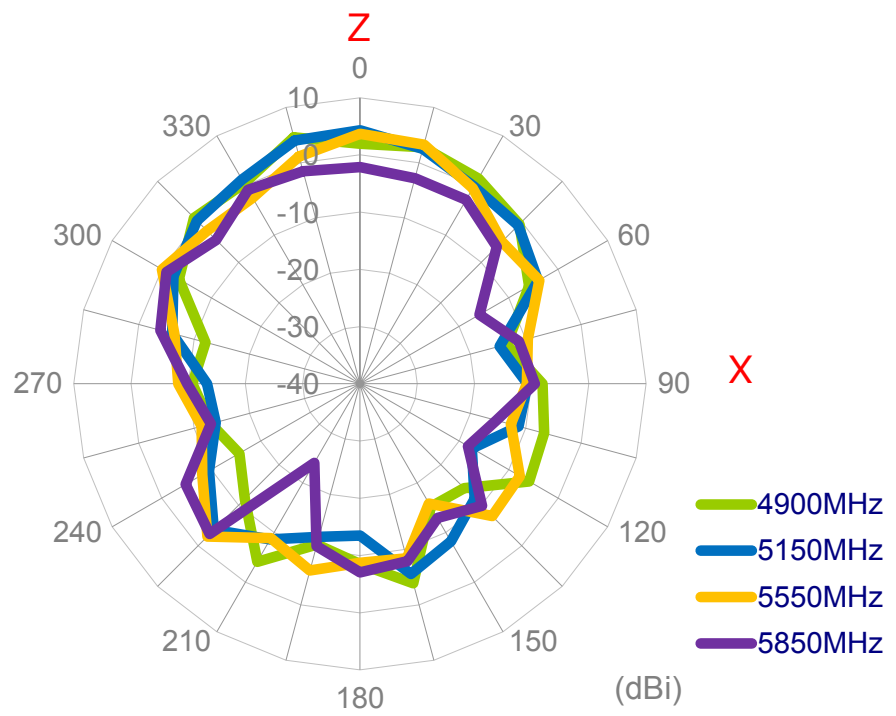
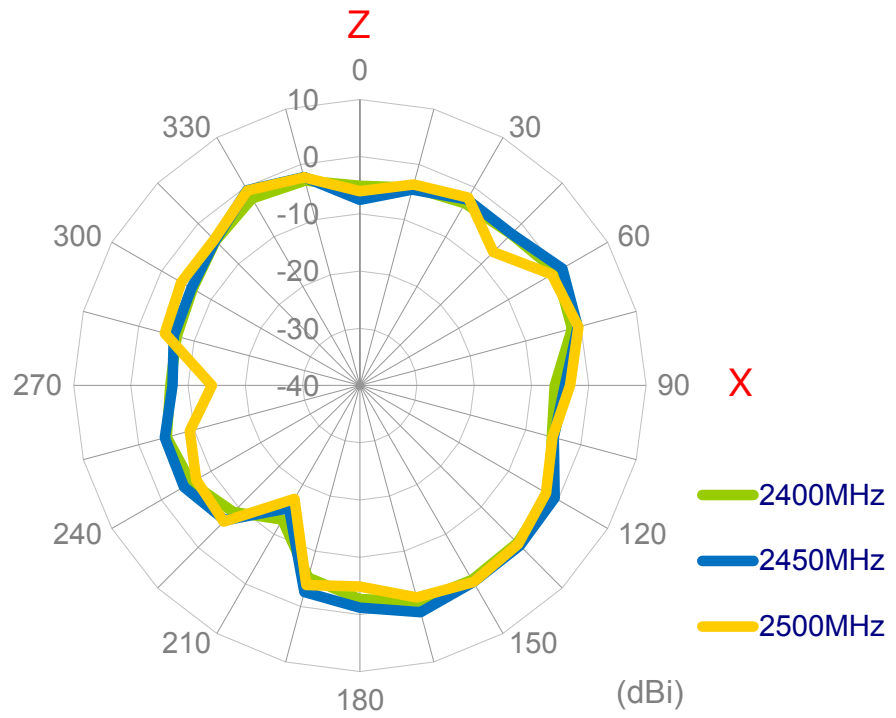
5550MHz

### 3.2.63 2D Radiation Pattern (Wi-Fi\_MIMO2 with 3M cable length in free space)

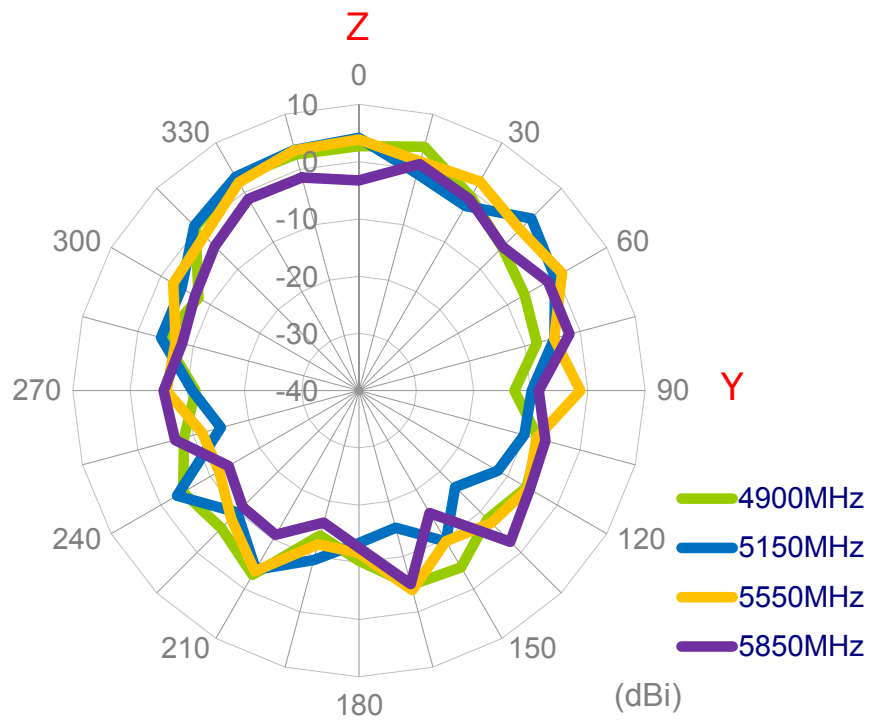
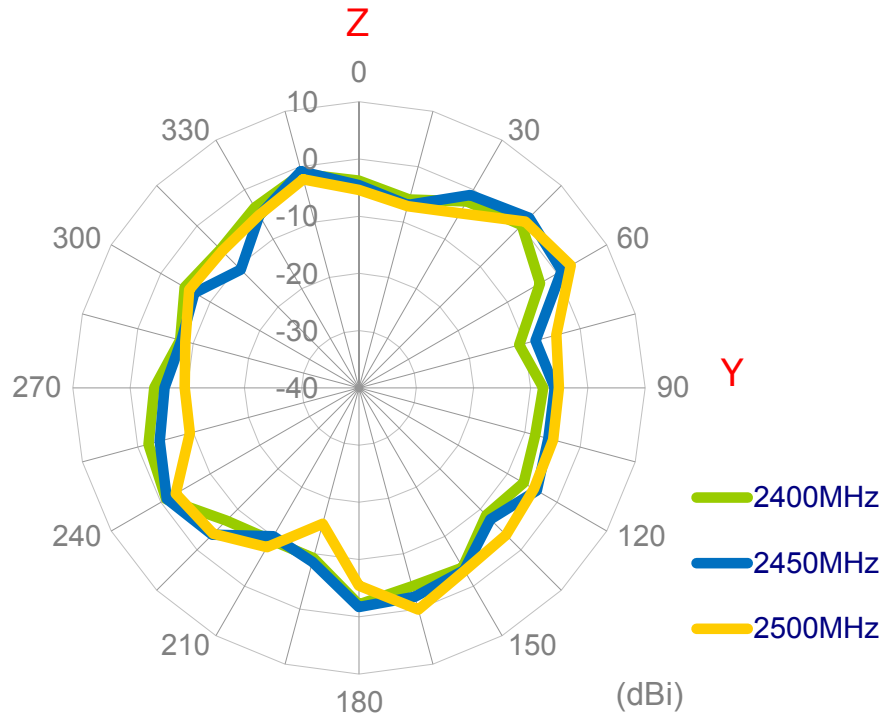
XY Plane



XZ Plane

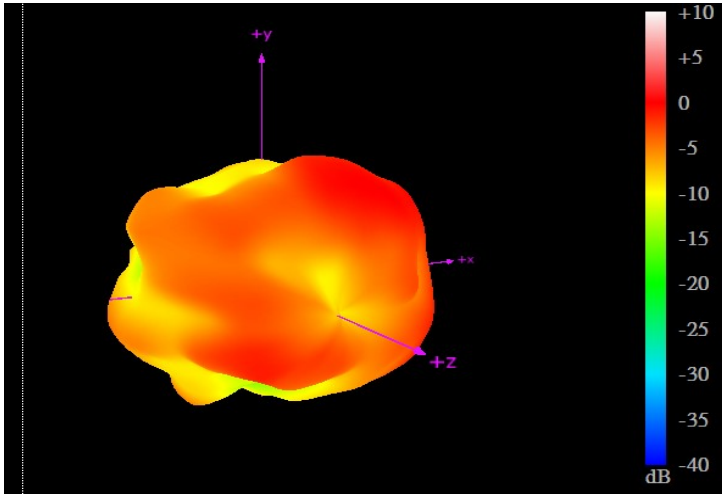


YZ Plane

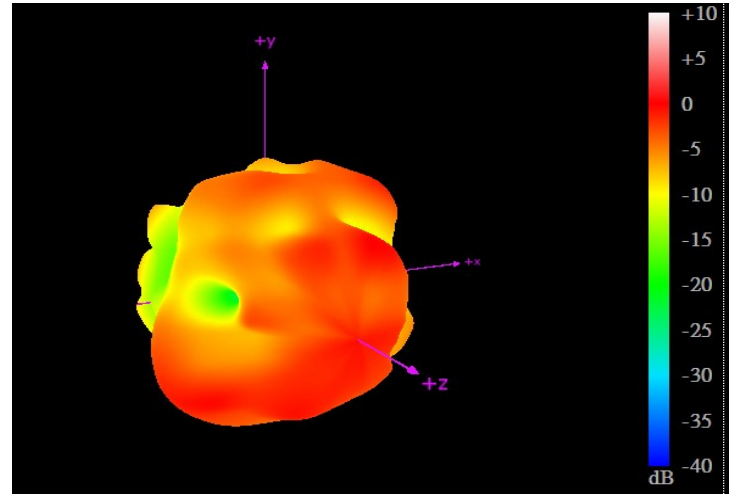




### 3.2.64 3D Radiation Pattern (Wi-Fi\_MIMO2 with 1M cable length in free space)

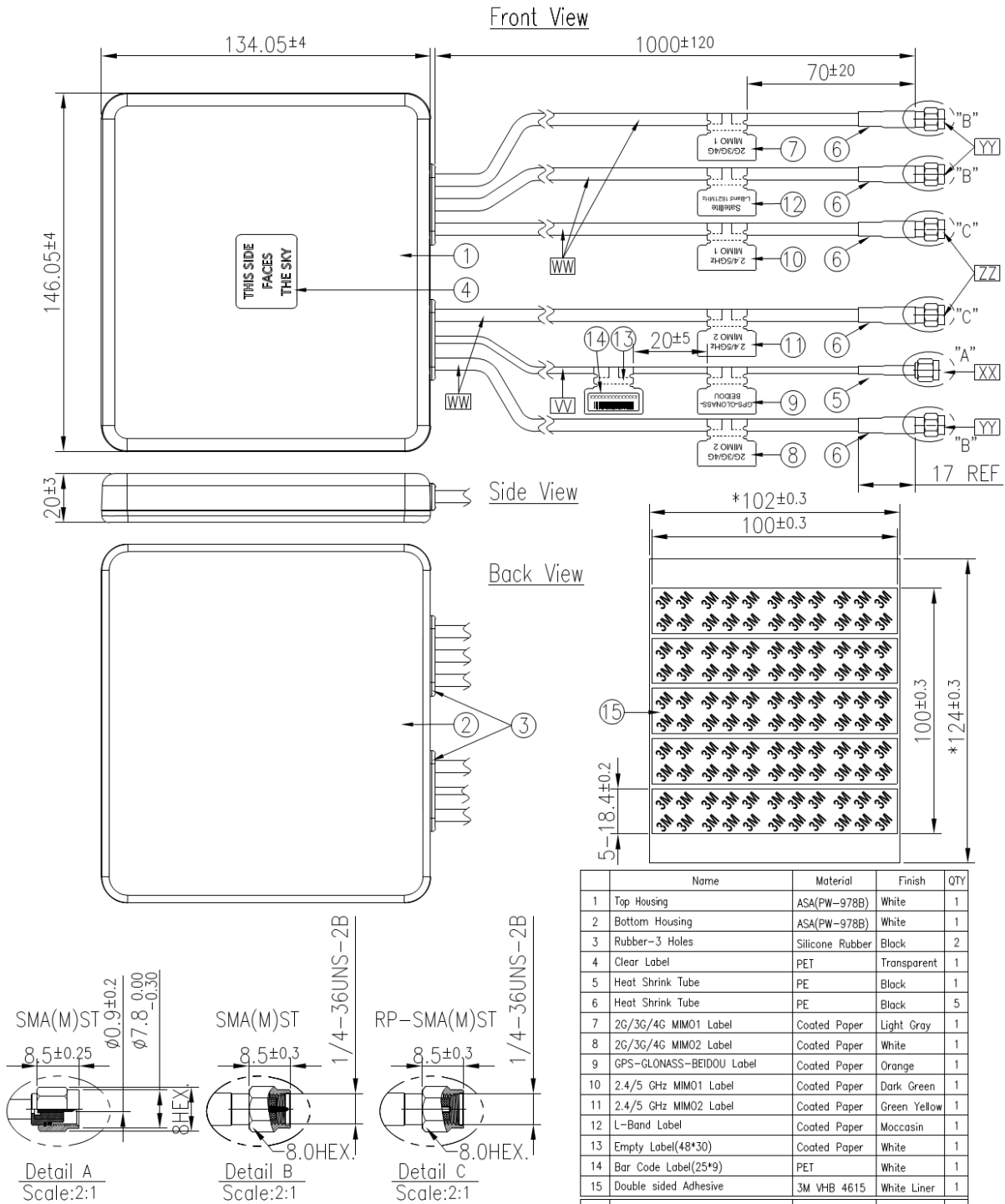


2450MHz



5550MHz

## 4. Mechanical Drawing (Unit: mm)





## 5. Packaging

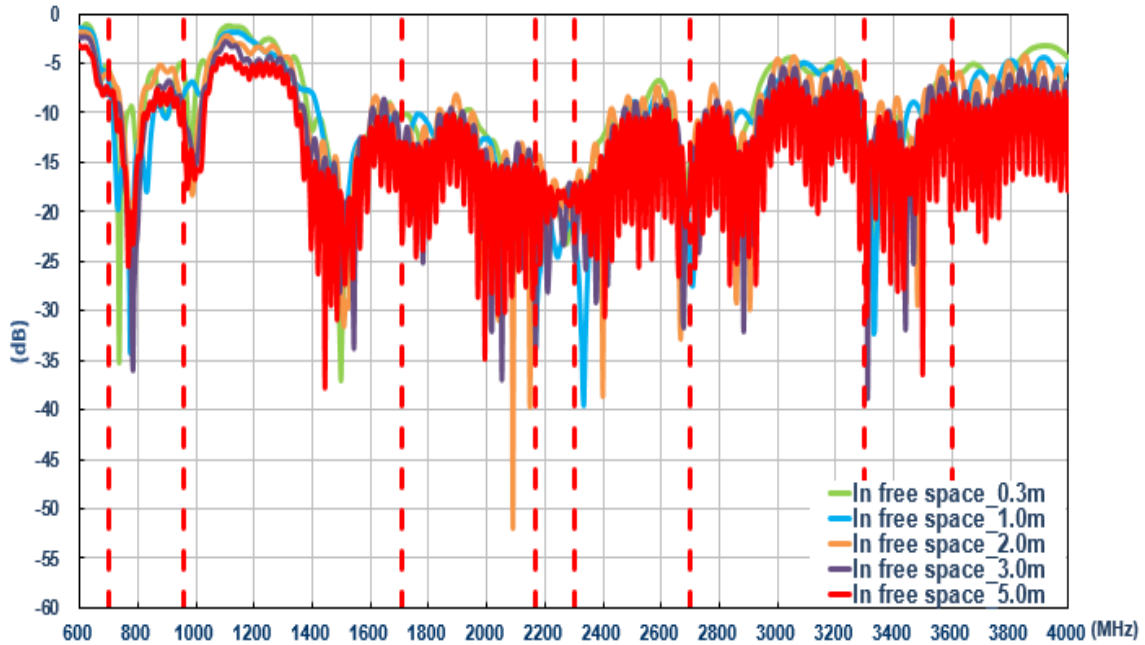
Packaging details to follow.

## 6. Application Note

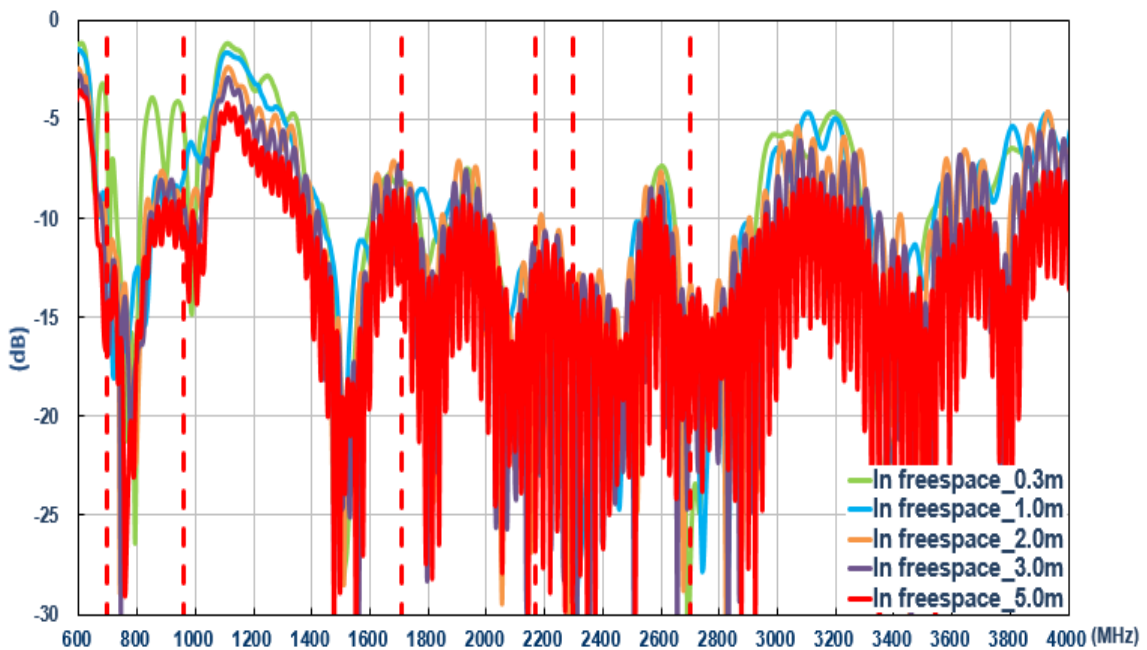
The MA931 antenna performance with different cable lengths is shown below.

### 6.1 In free space (LTE)

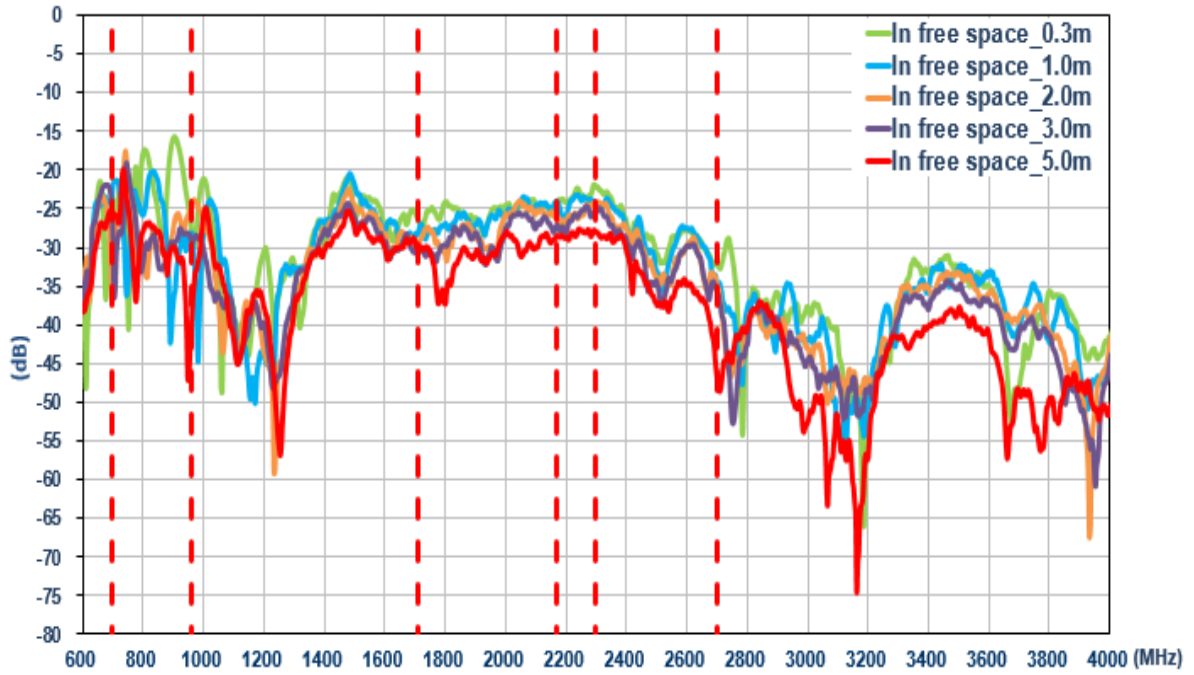
#### 6.1.1 Return Loss (LTE\_MIMO\_1)



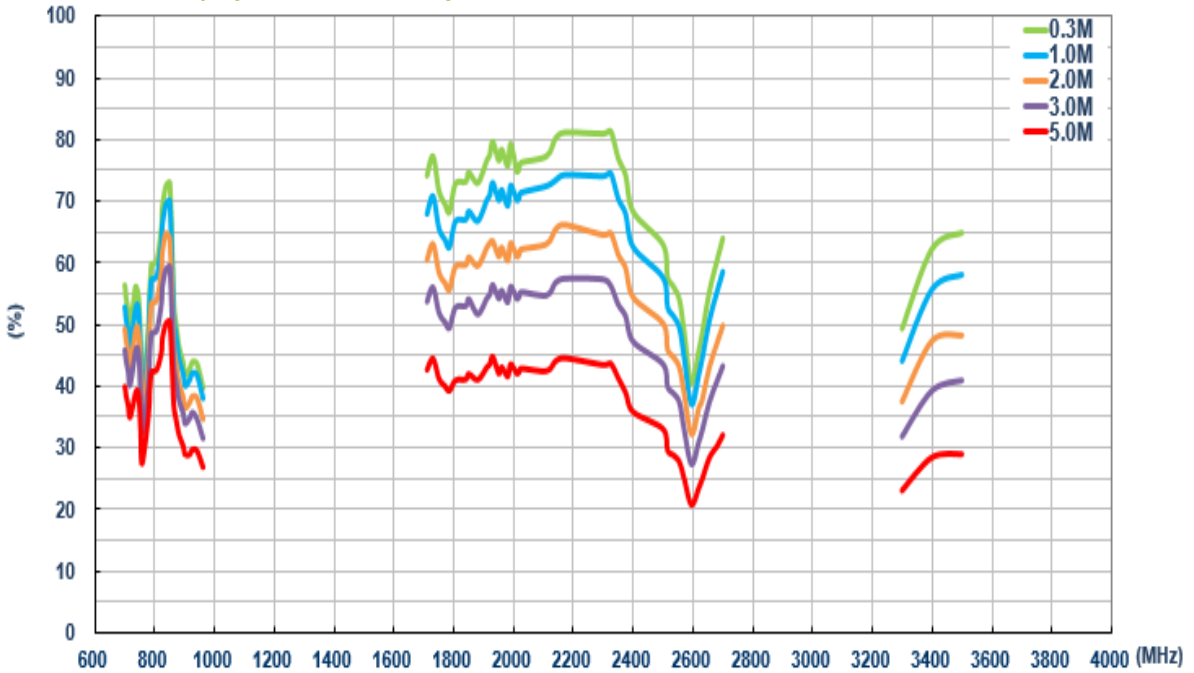
#### 6.1.2 Return Loss (LTE\_MIMO\_2)



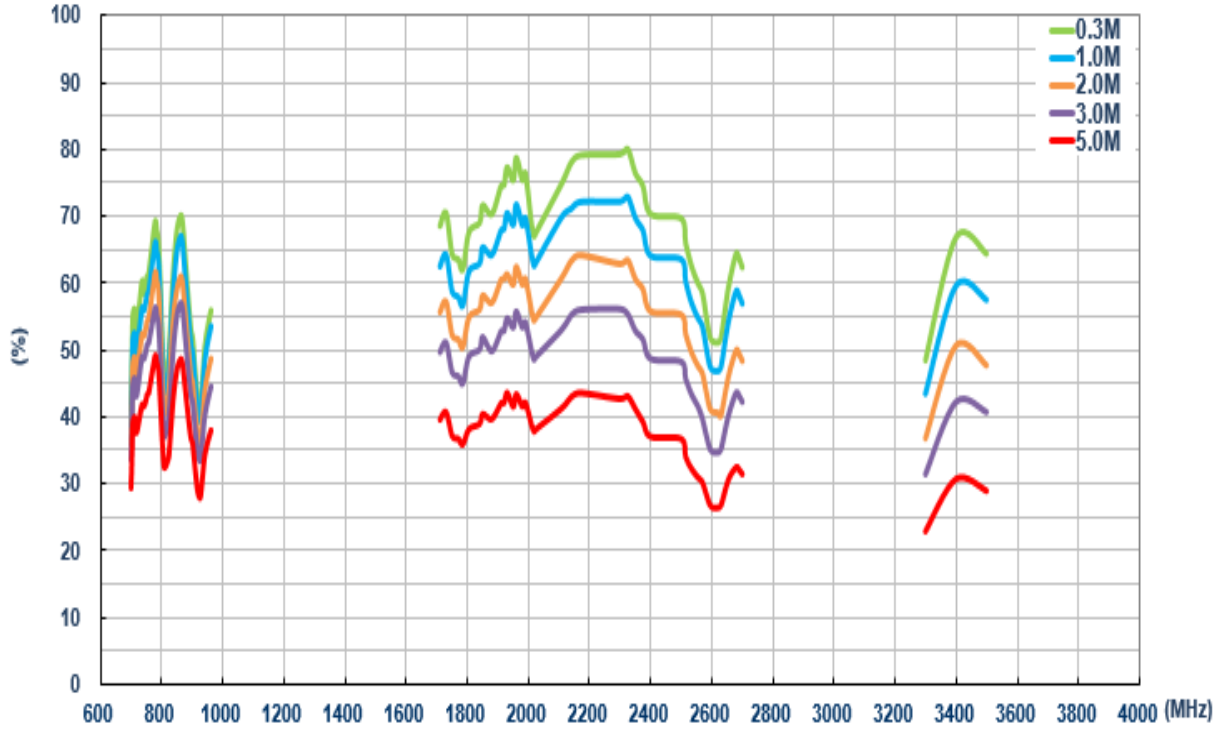
### 6.1.3 Isolation (LTE antenna)



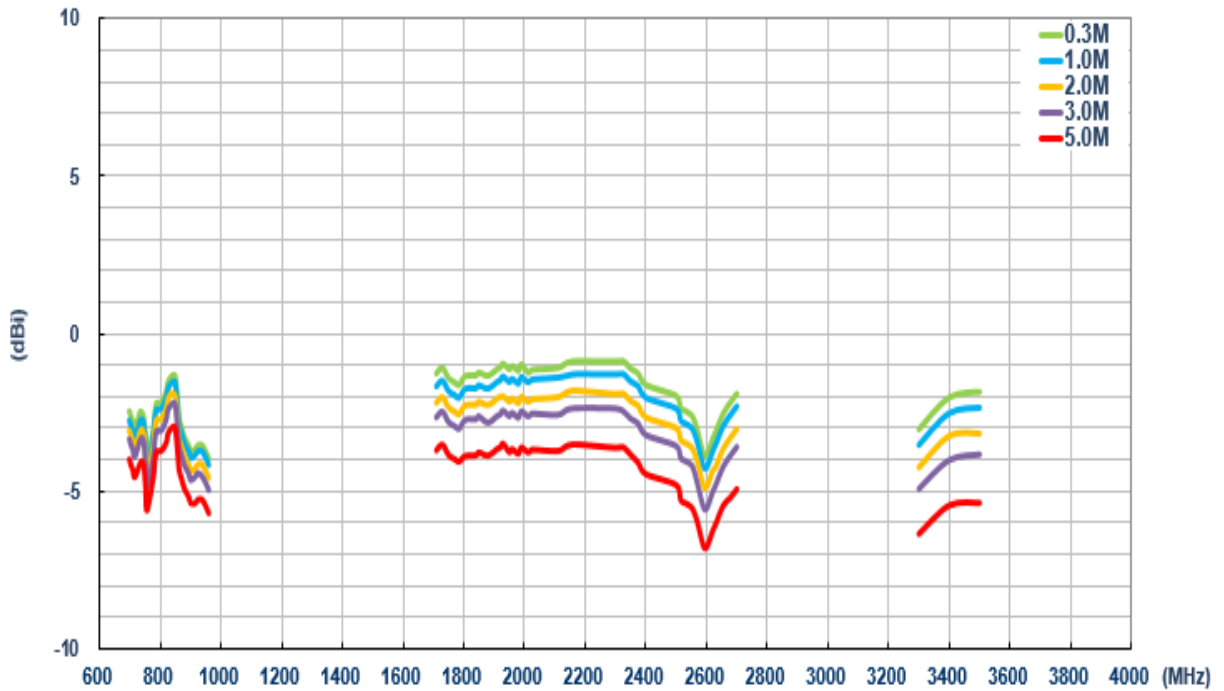
### 6.1.4 Efficiency (LTE MIMO\_1)



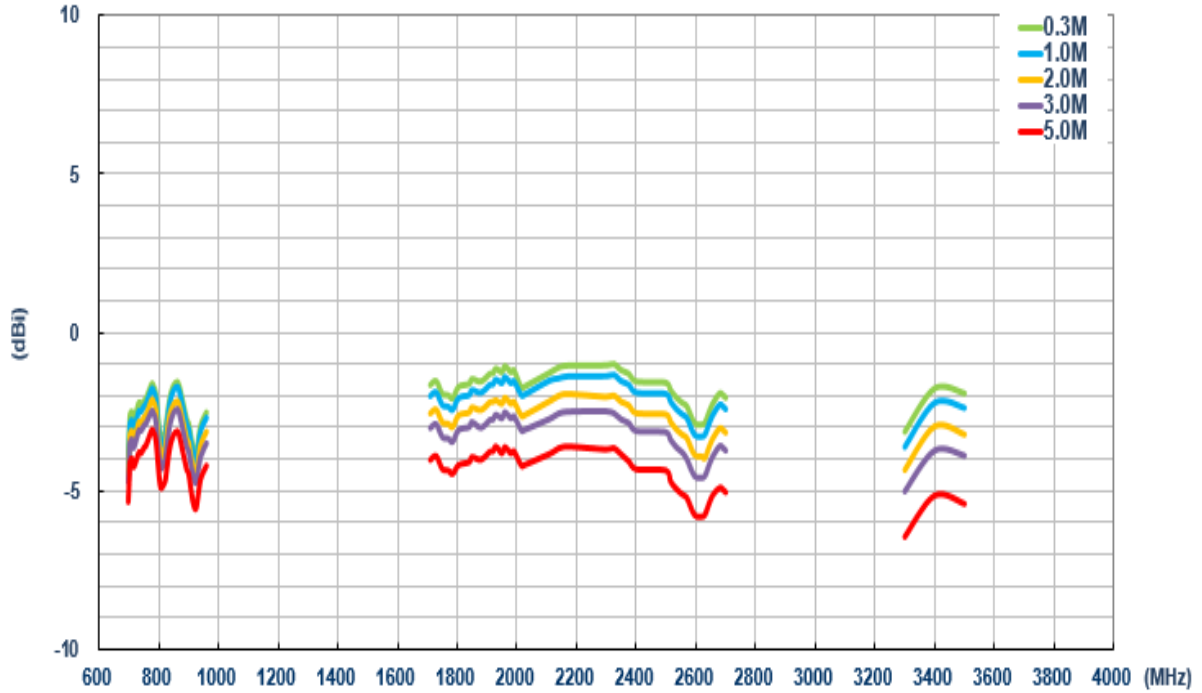
### 6.1.5 Efficiency (LTE MIMO\_2)



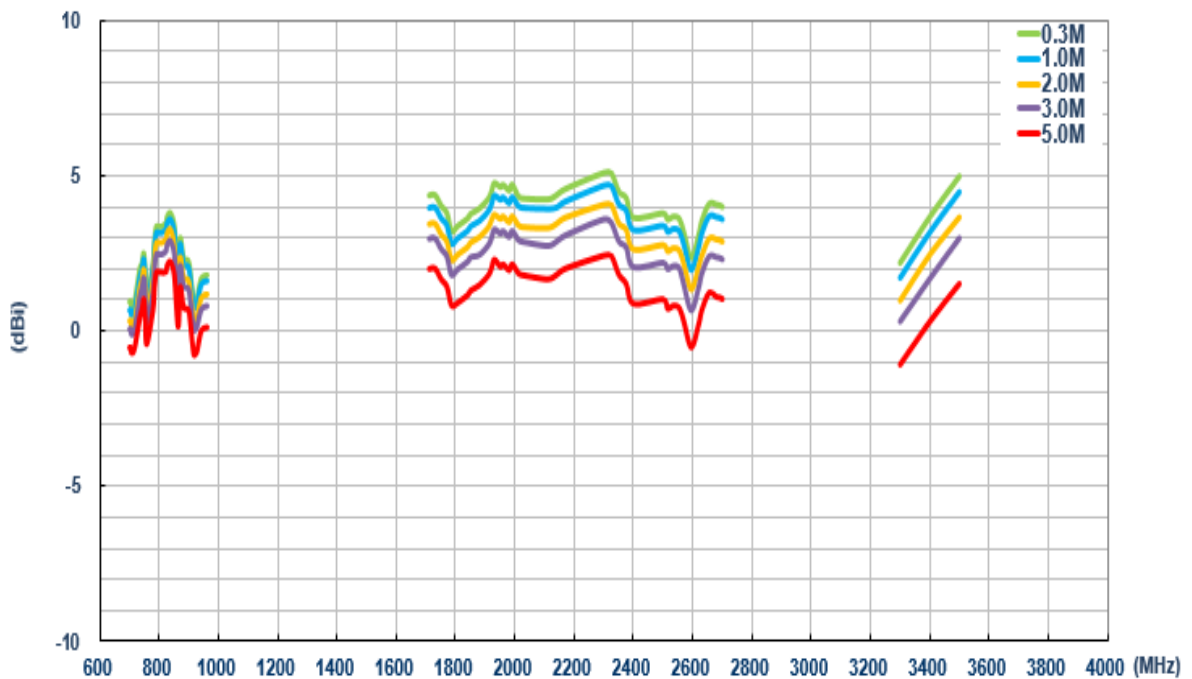
### 6.1.6 Average Gain (LTE MIMO\_1)



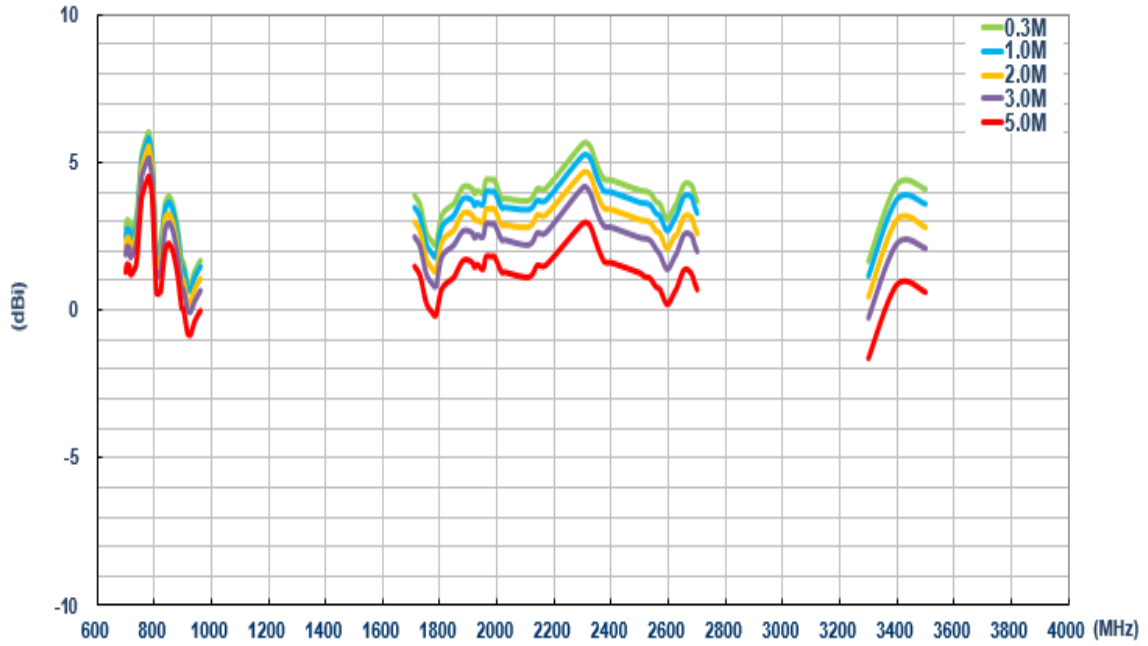
### 6.1.7 Average Gain (LTE MIMO\_2)



### 6.1.8 Peak Gain (LTE MIMO\_1)

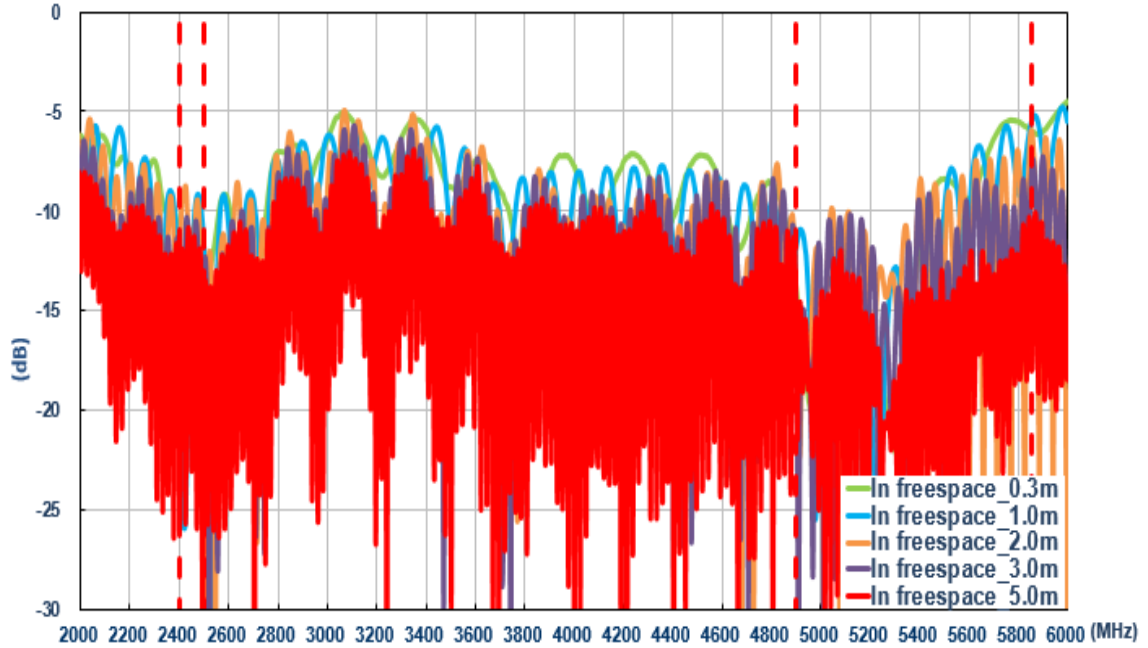


### 6.1.9 Peak Gain (LTE MIMO\_2)



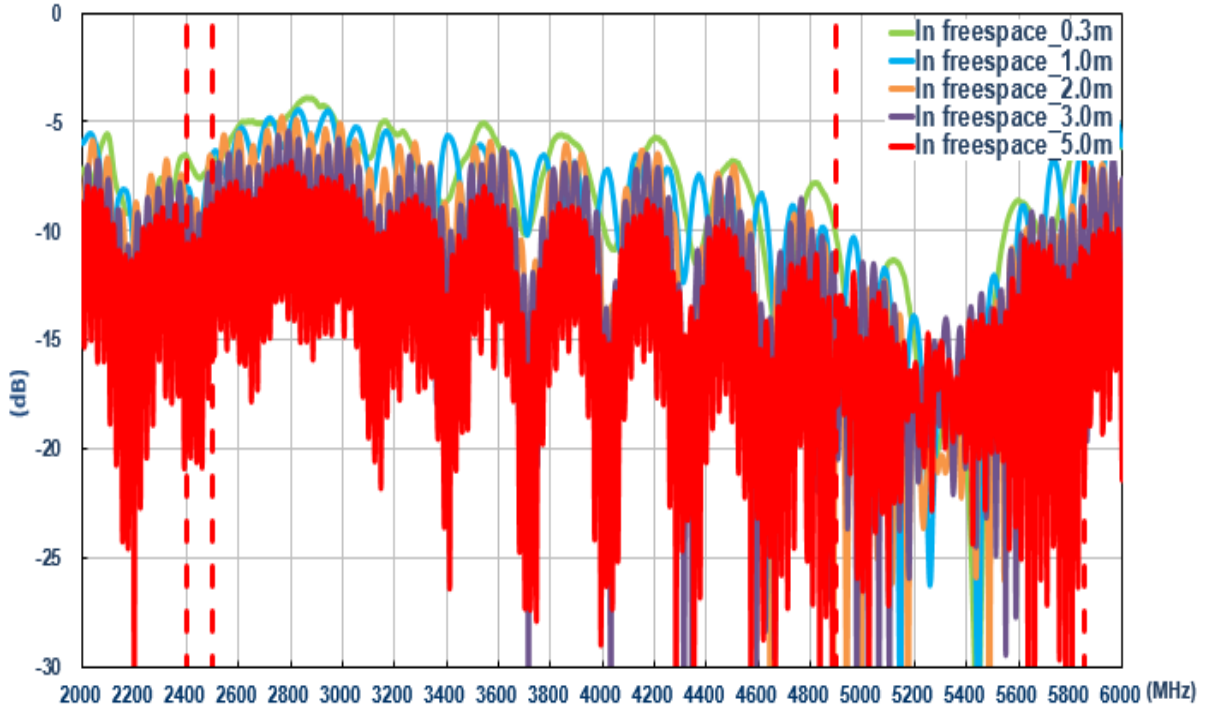
## 6.2 In free space (Wi-Fi)

### 6.2.1 Return Loss (Wi-Fi\_MIMO\_1)

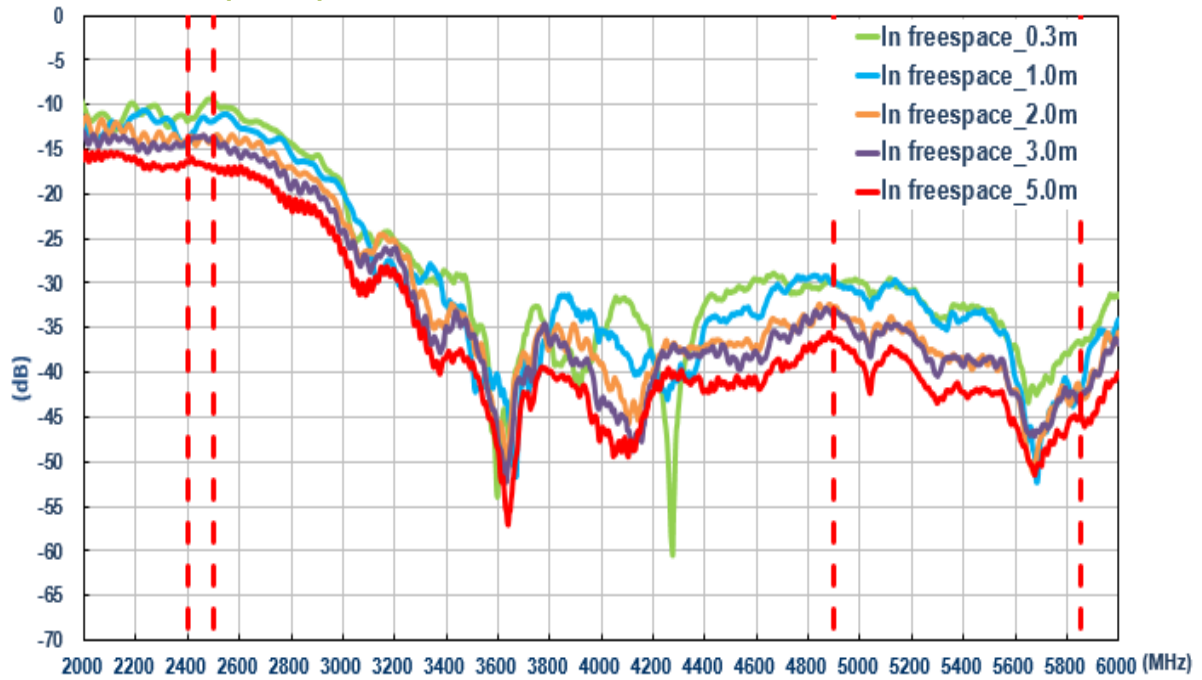




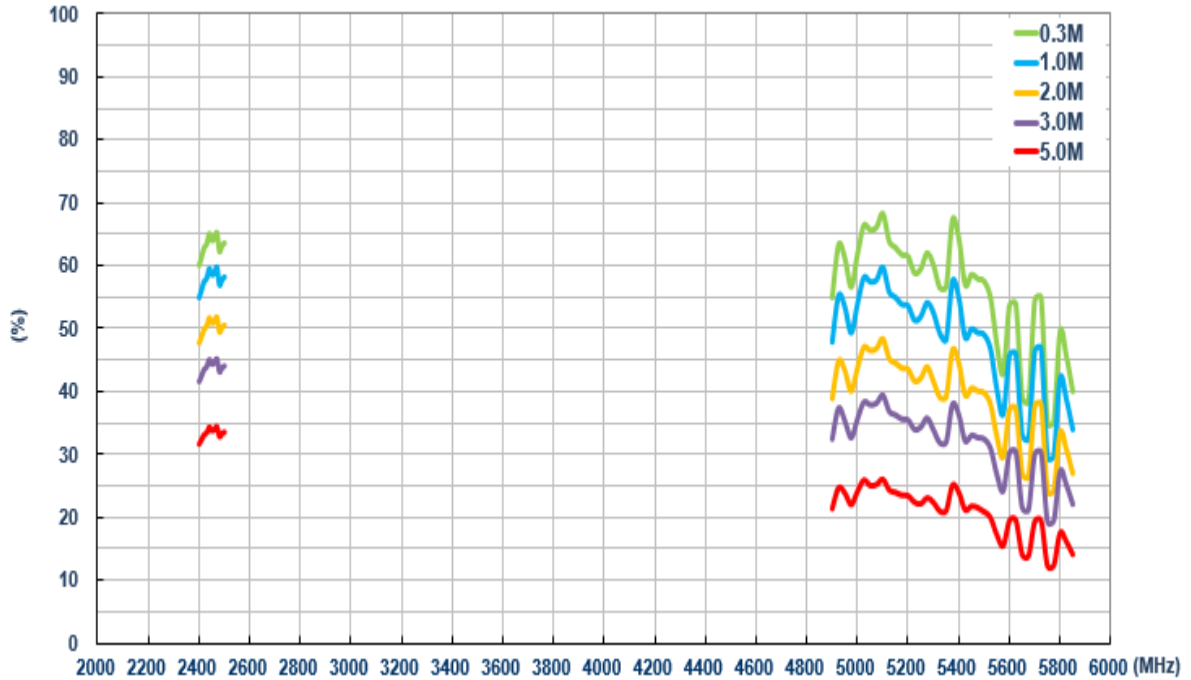
### 6.2.2 Return Loss (Wi-Fi\_MIMO\_2)



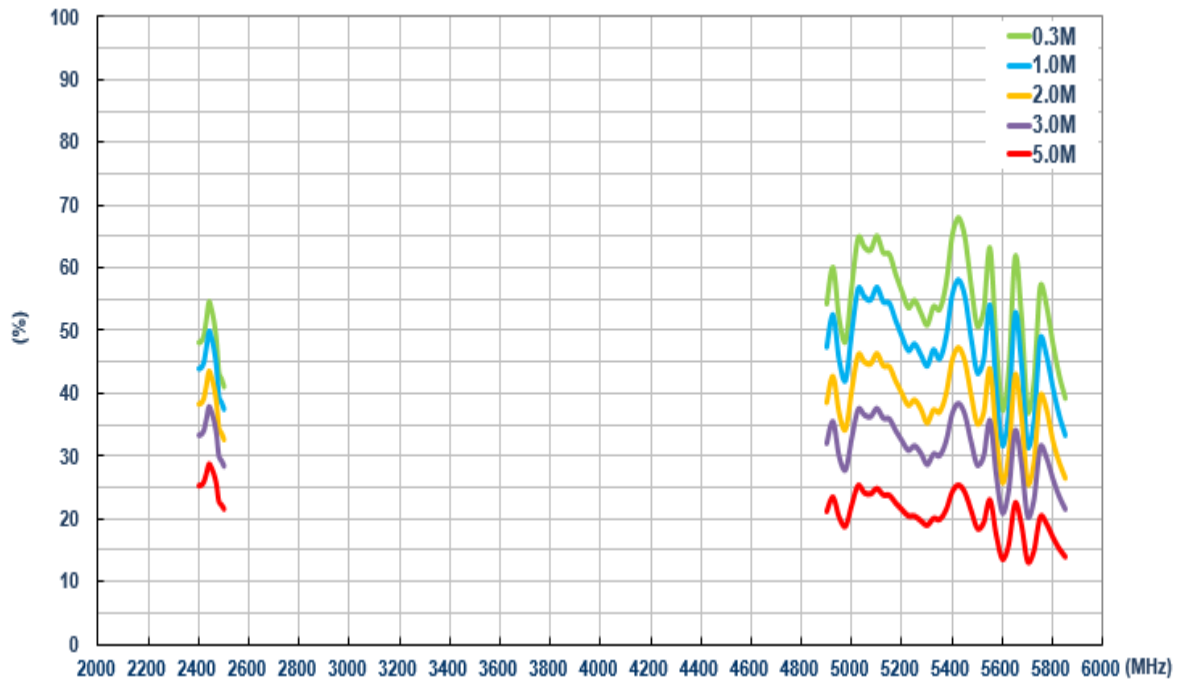
### 6.2.3 Isolation (Wi-Fi)



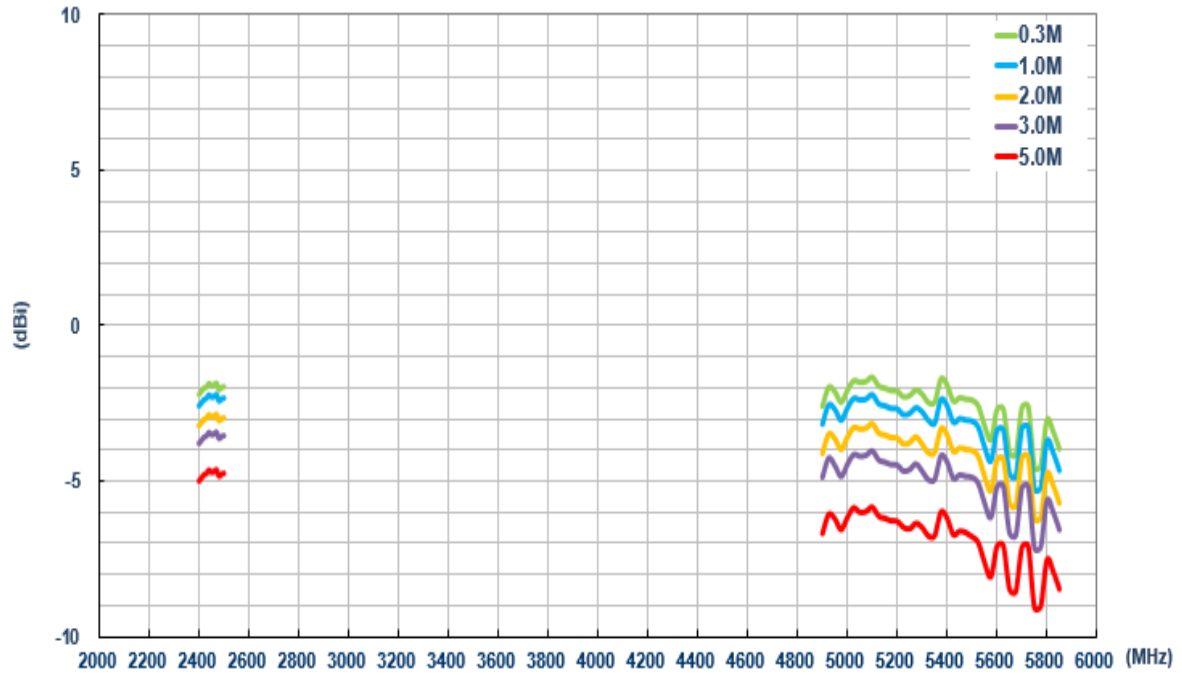
### 6.2.4 Efficiency (Wi-Fi MIMO\_1)



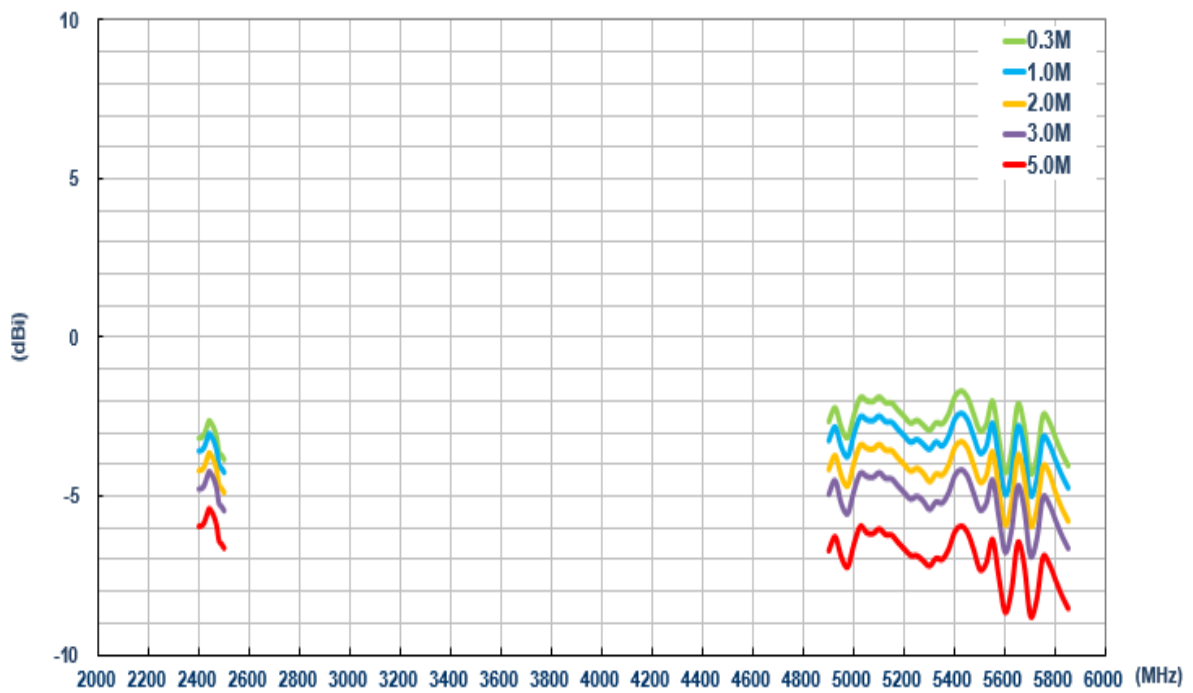
### 6.2.5 Efficiency (Wi-Fi MIMO\_2)



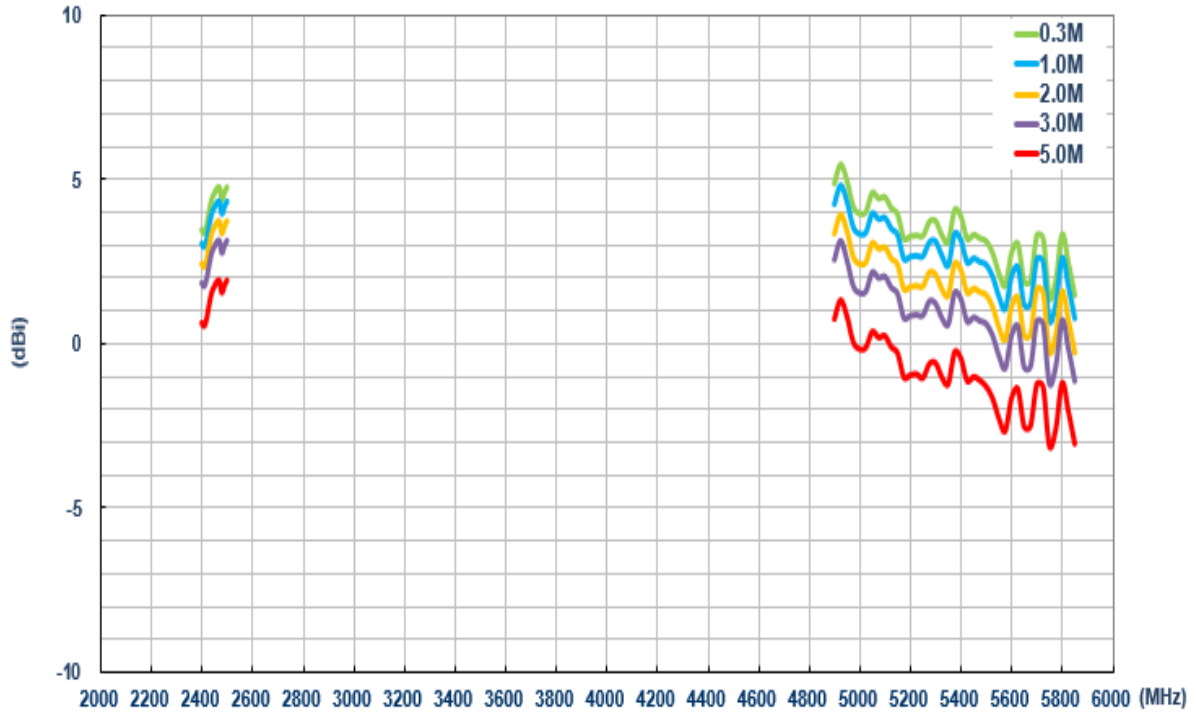
### 6.2.6 Average Gain (Wi-Fi MIMO\_1)



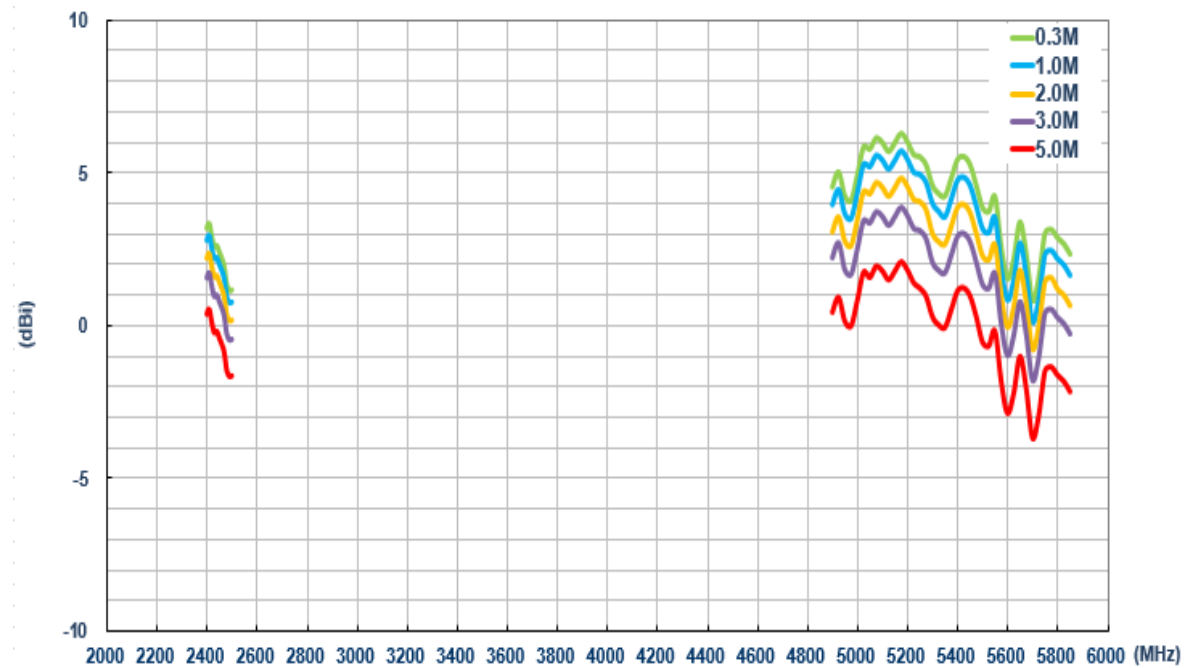
### 6.2.7 Average Gain (Wi-Fi MIMO\_2)



### 6.2.8 Peak Gain (Wi-Fi MIMO\_1)

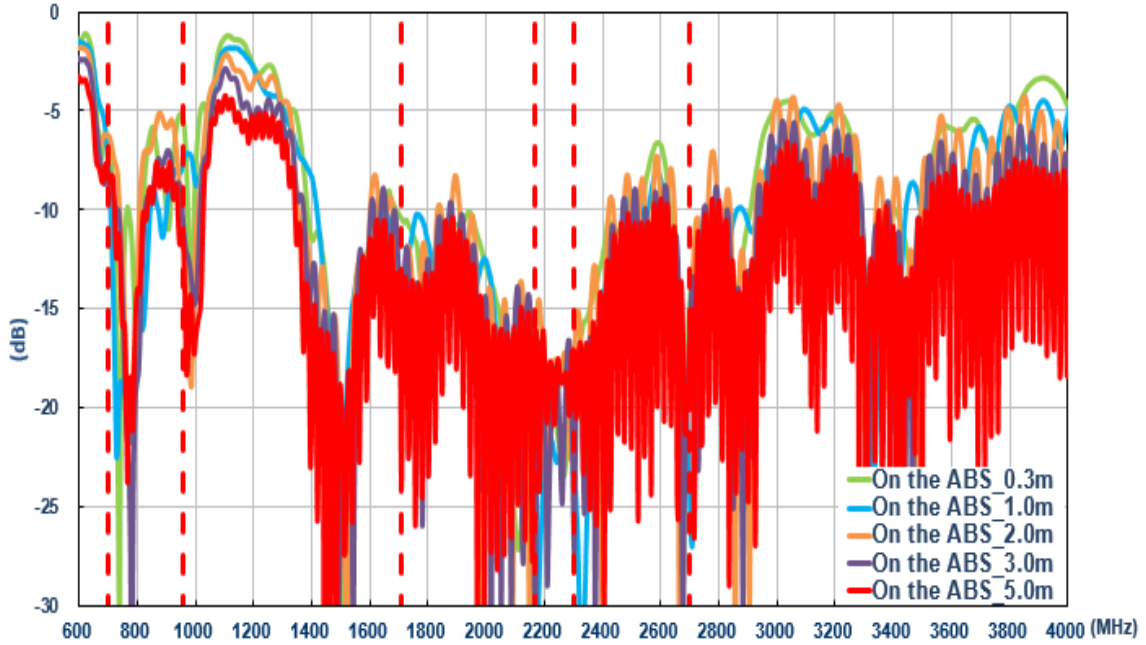


### 6.2.9 Peak Gain (Wi-Fi MIMO\_2)

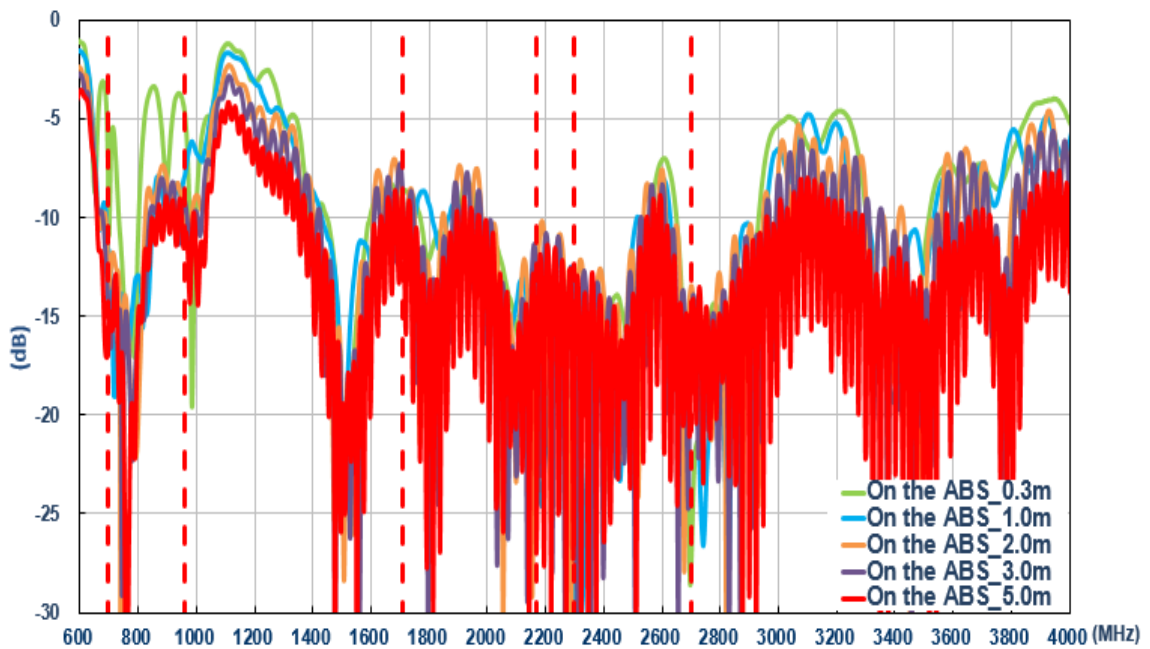


### 6.3 On the ABS (LTE)

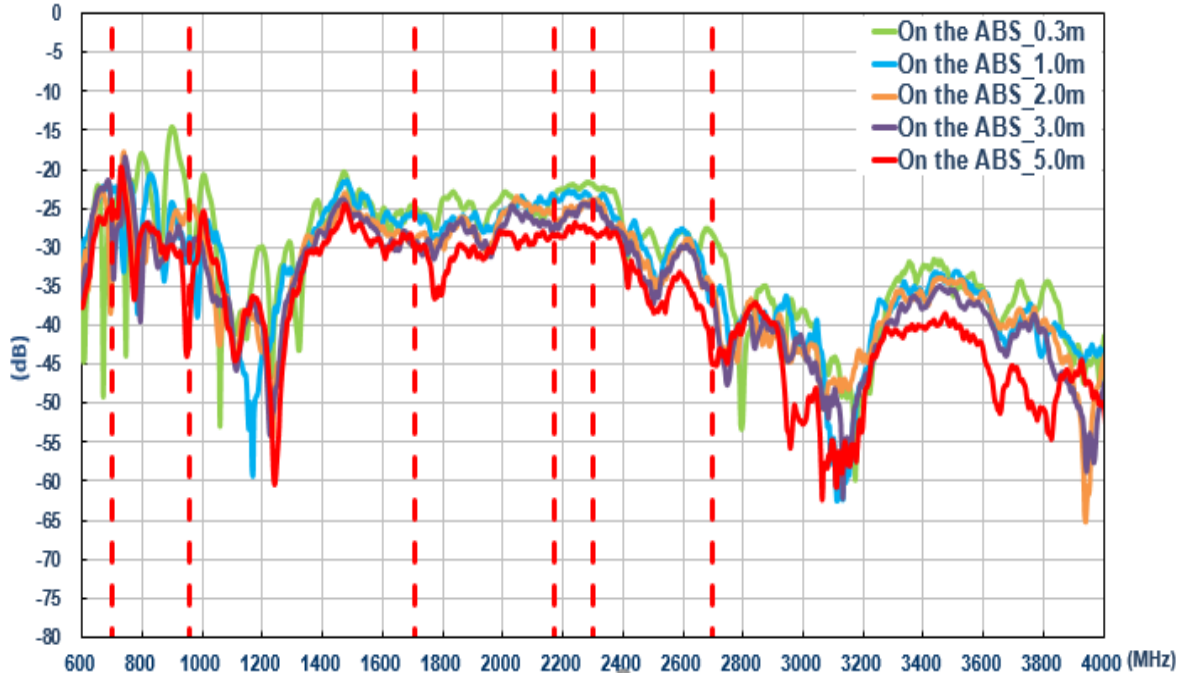
#### 6.3.1 Return Loss (LTE\_MIMO\_1)



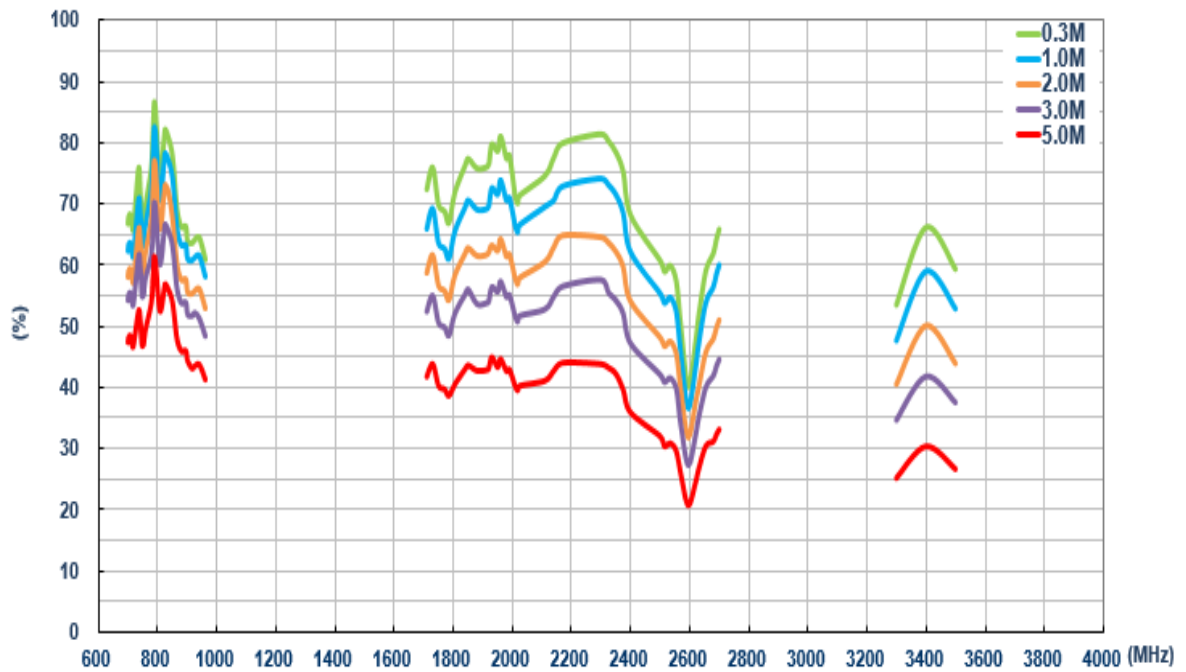
#### 6.3.2 Return Loss (LTE\_MIMO\_2)



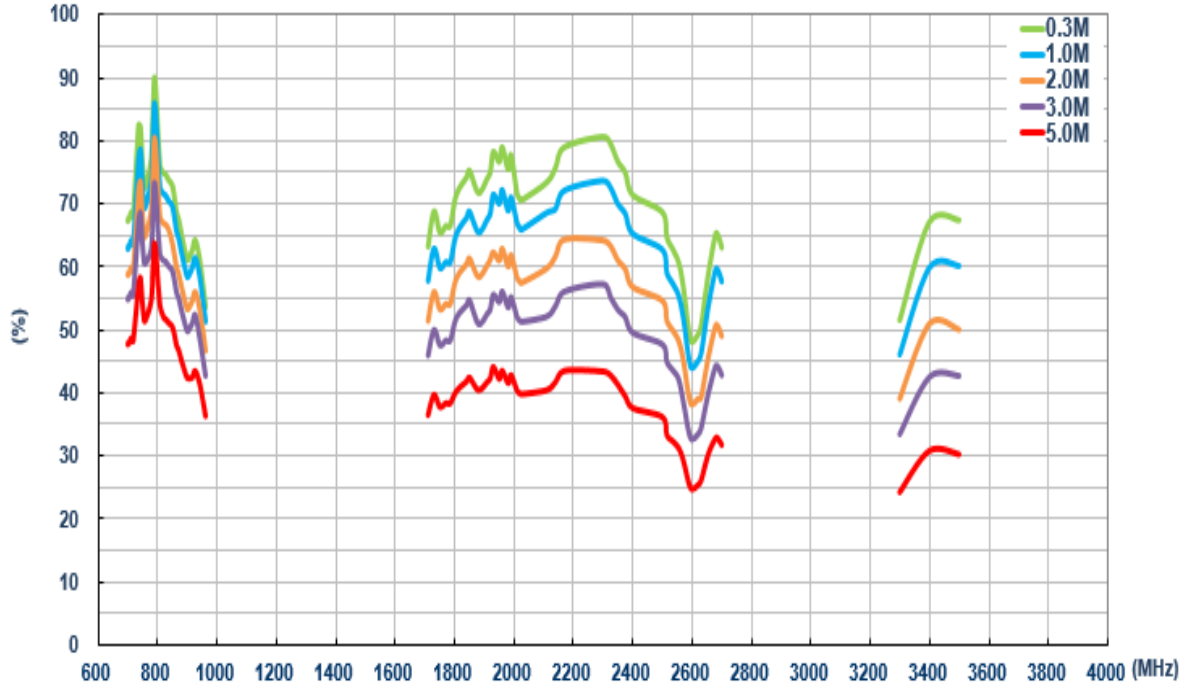
### 6.3.3 Isolation (LTE antenna)



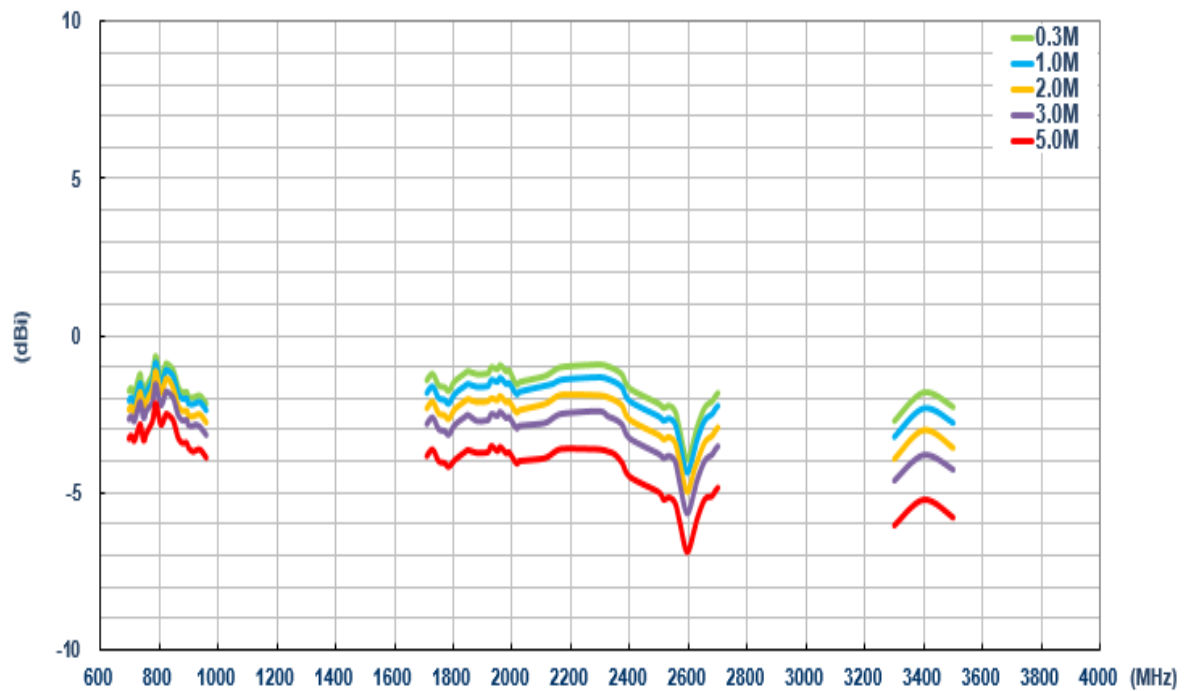
### 6.3.4 Efficiency (LTE MIMO\_1)



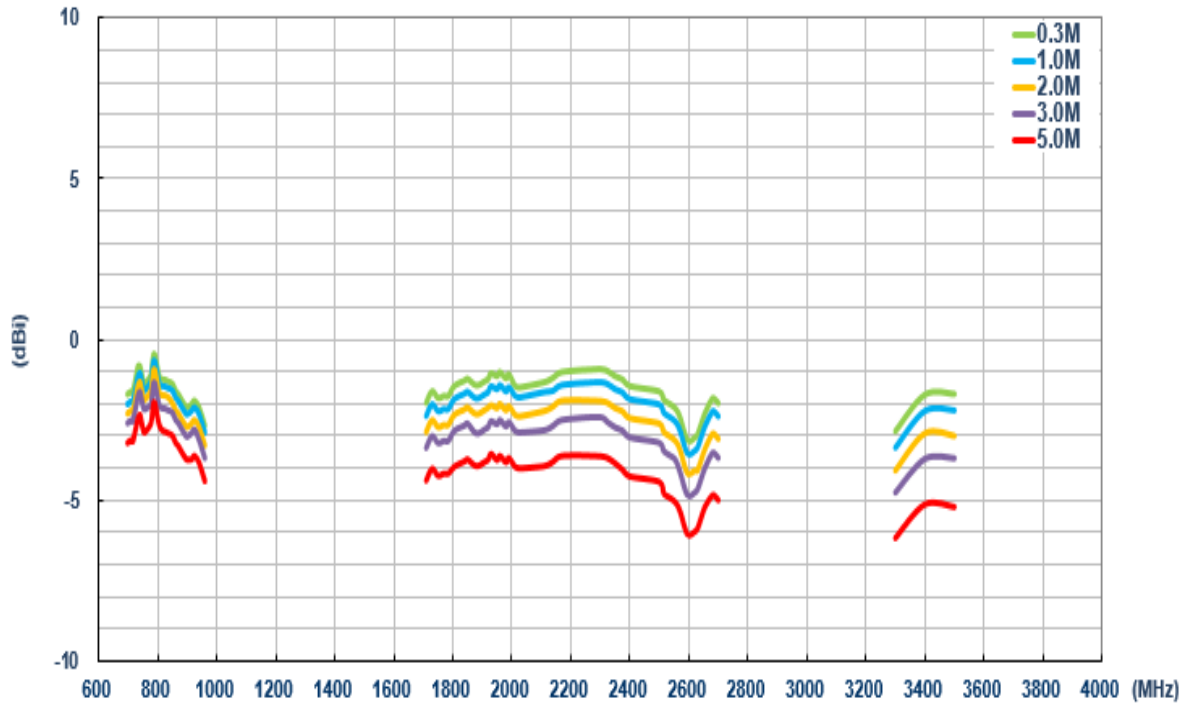
### 6.3.5 Efficiency (LTE MIMO\_2)



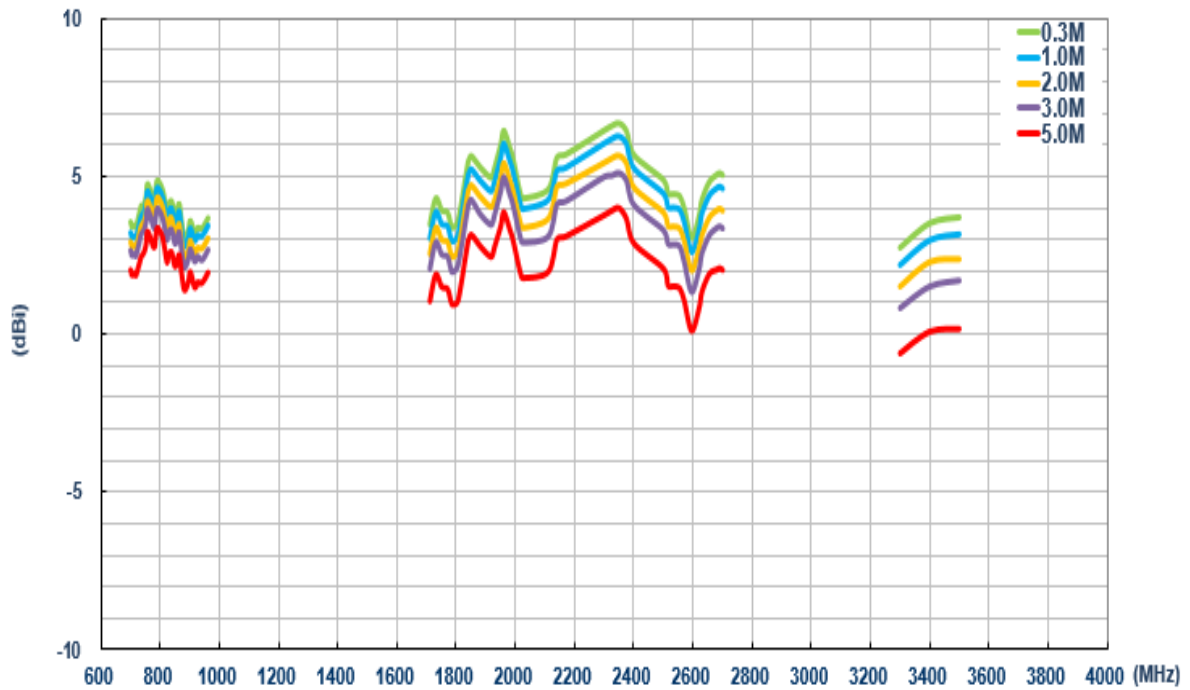
### 6.3.6 Average Gain (LTE MIMO\_1)



### 6.3.7 Average Gain (LTE MIMO\_2)

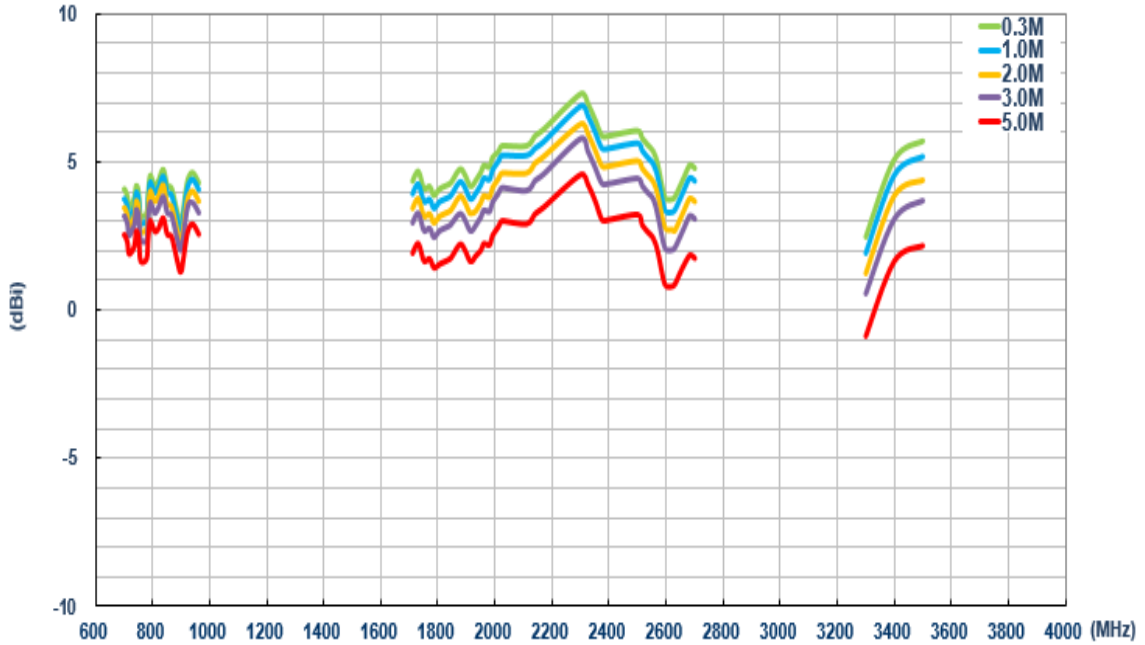


### 6.3.8 Peak Gain (LTE MIMO\_1)



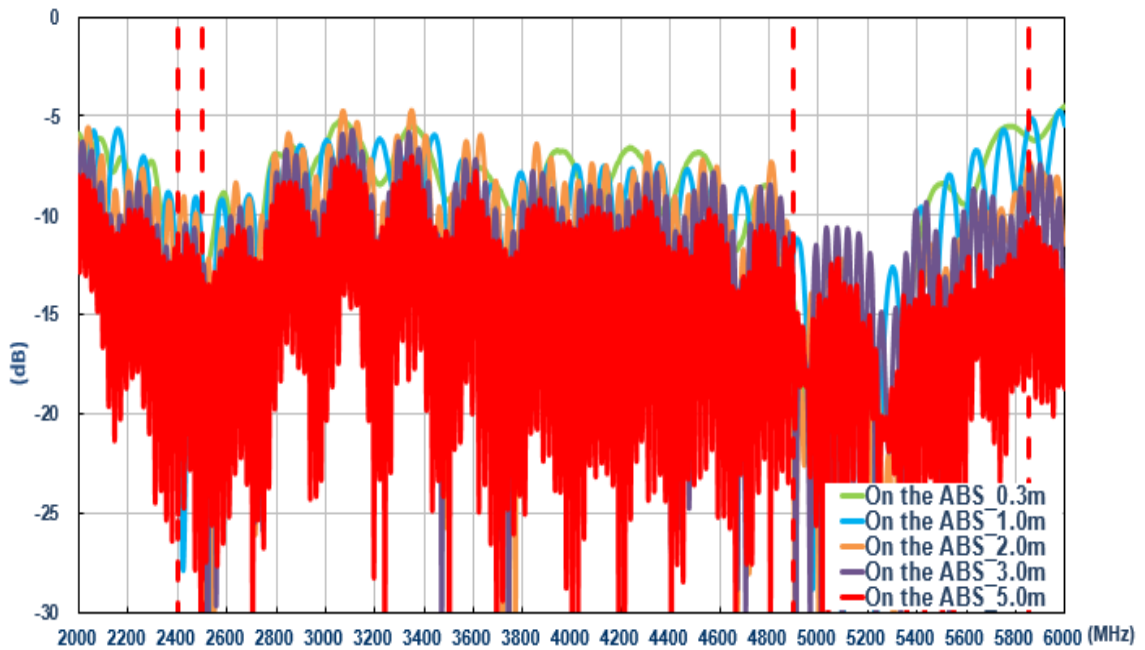


### 6.3.9 Peak Gain (LTE MIMO\_2)

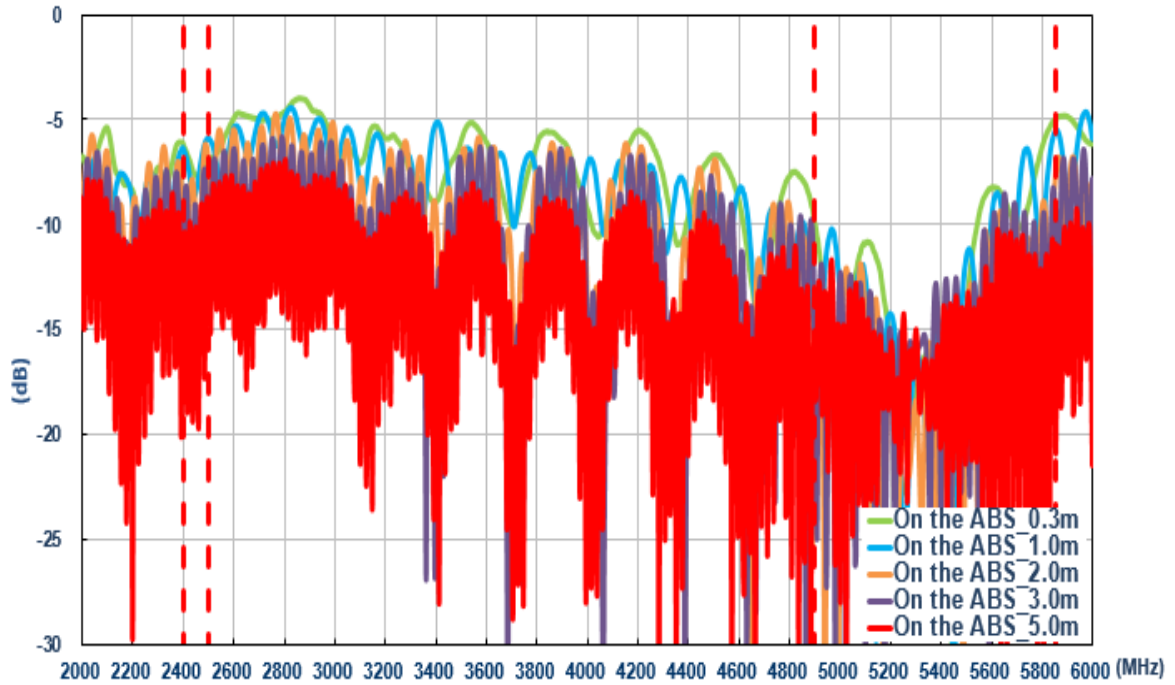


## 6.4 On ABS (Wi-Fi)

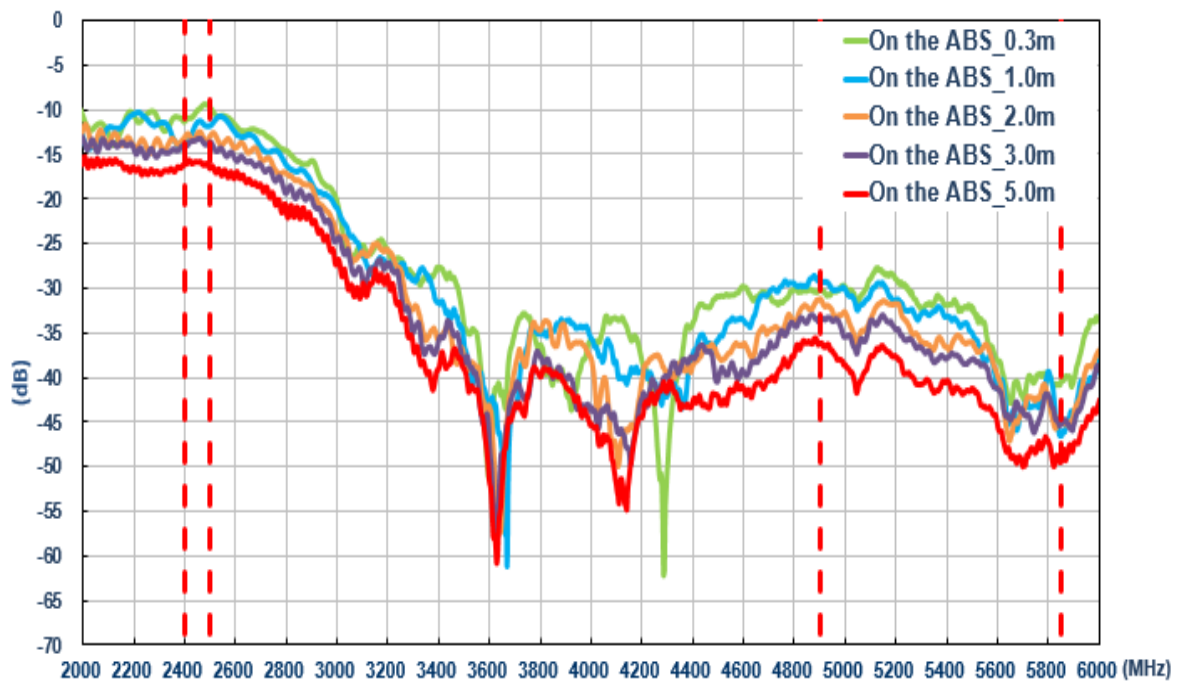
### 6.4.1 Return Loss (Wi-Fi\_MIMO\_1)



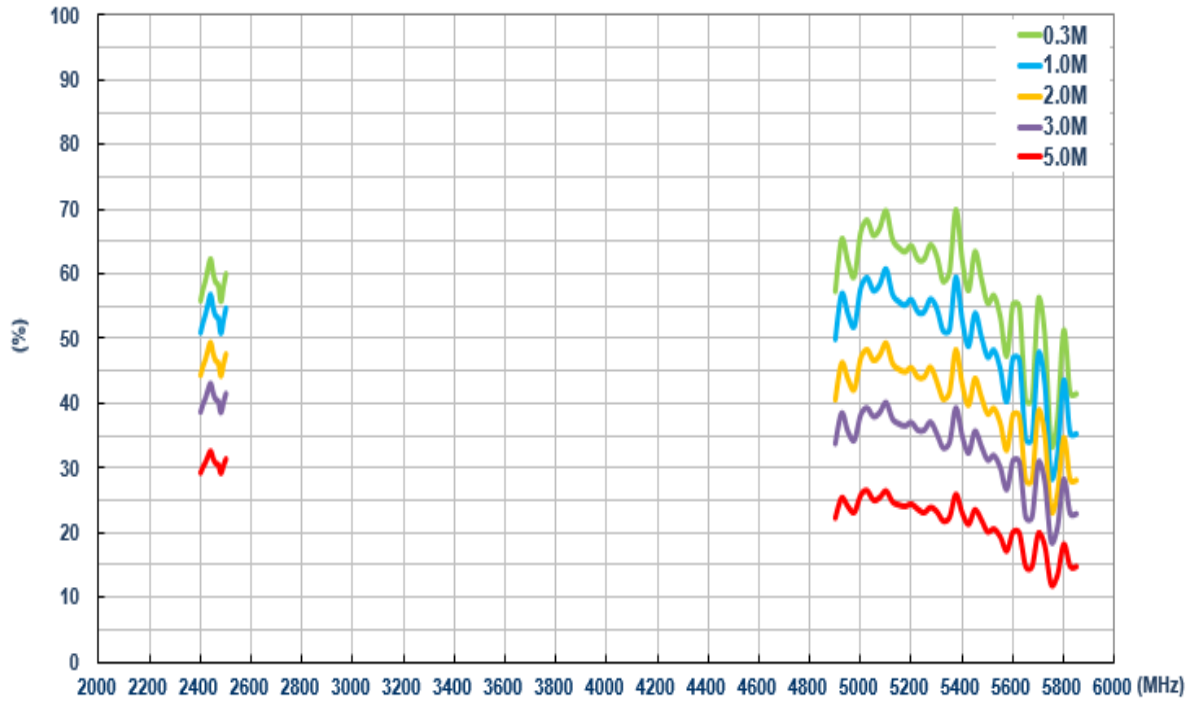
### 6.4.2 Return Loss (Wi-Fi\_MIMO\_2)



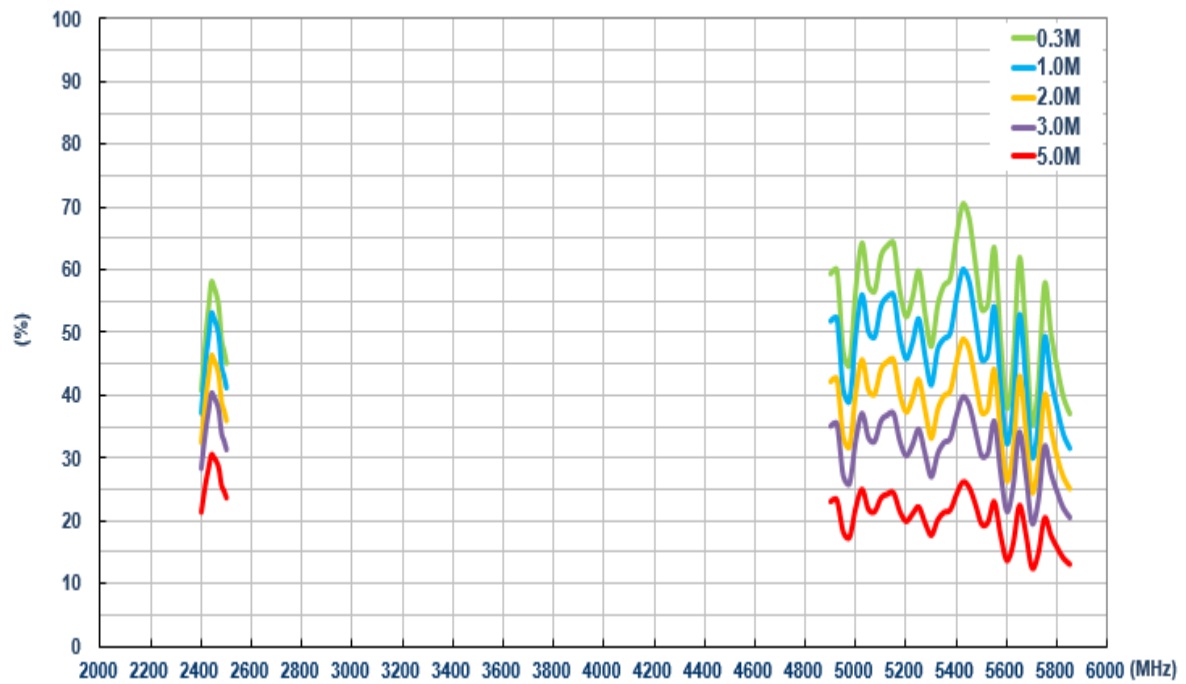
### 6.4.3 Isolation (Wi-Fi)



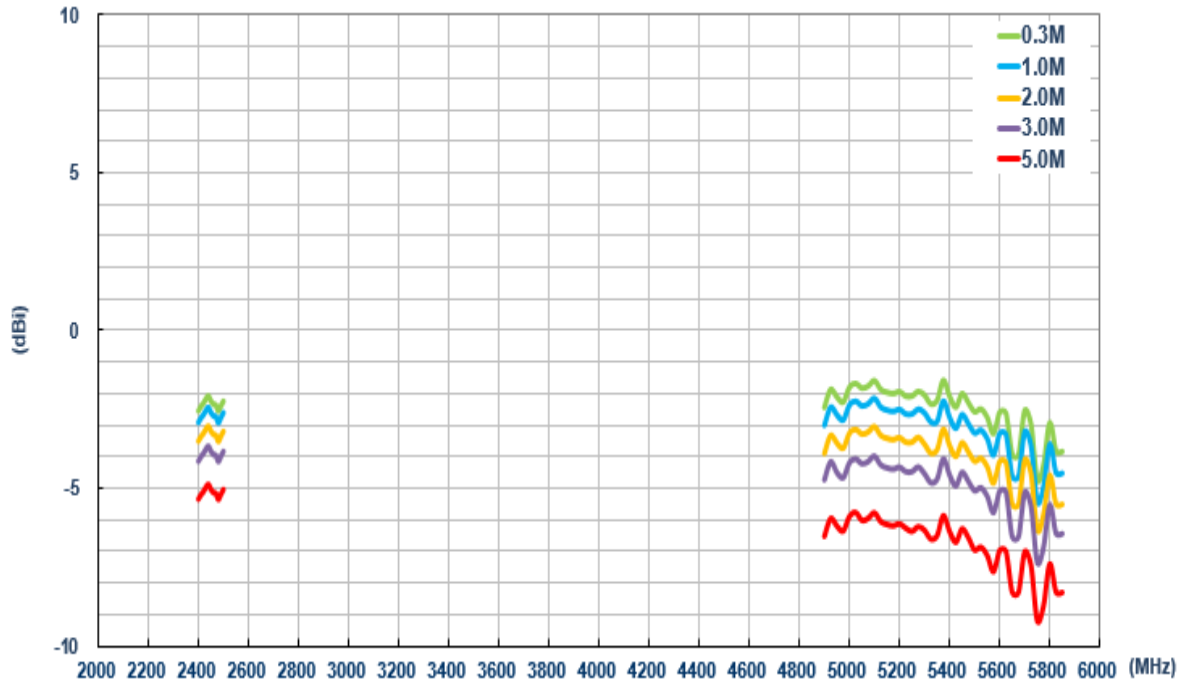
### 6.4.4 Efficiency (Wi-Fi MIMO\_1)



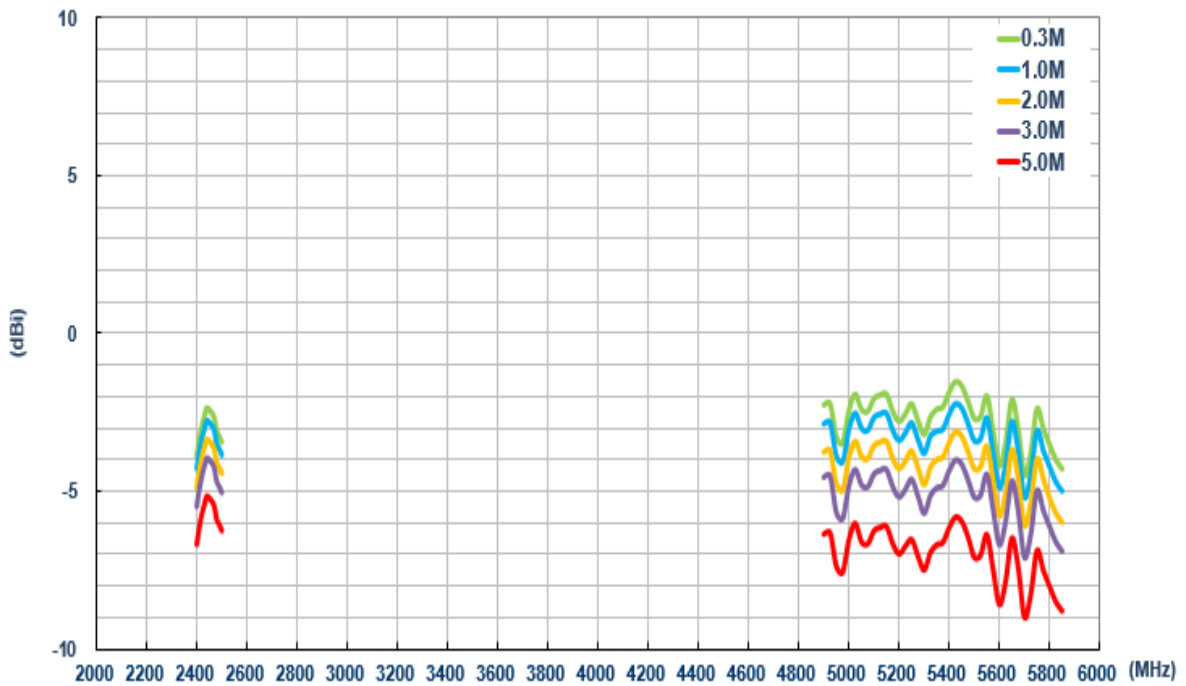
### 6.4.5 Efficiency (Wi-Fi MIMO\_2)



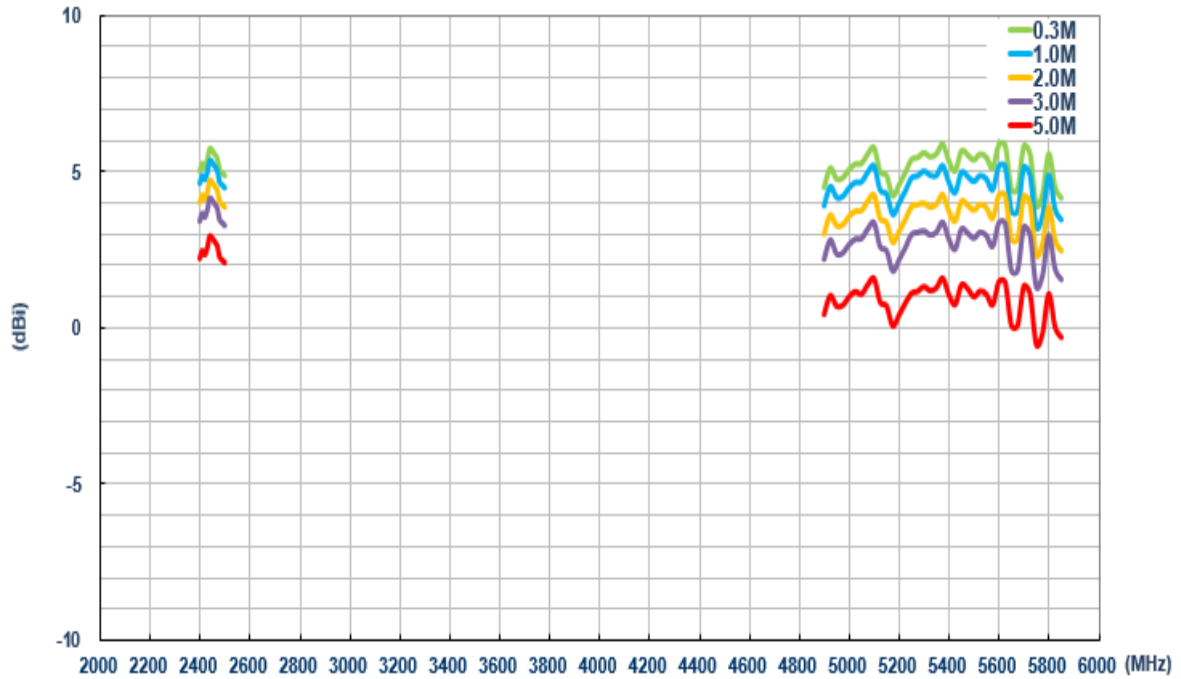
### 6.4.6 Average Gain (Wi-Fi MIMO\_1)



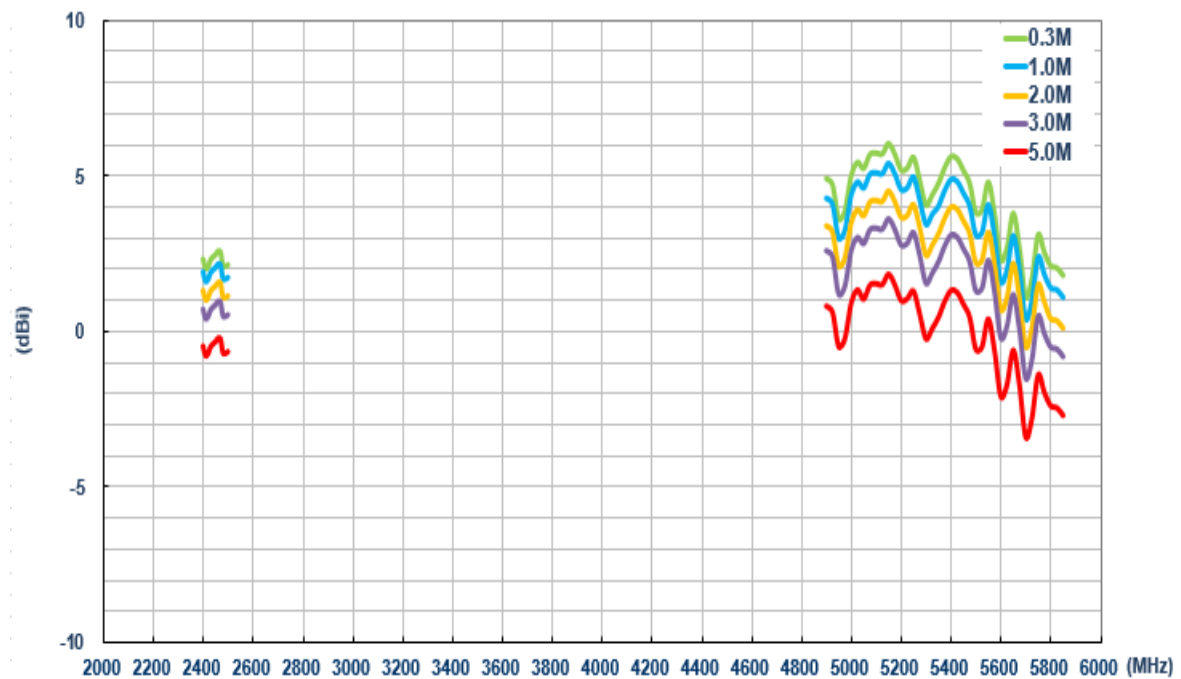
### 6.4.7 Average Gain (Wi-Fi MIMO\_2)



### 6.4.8 Peak Gain (Wi-Fi MIMO\_1)

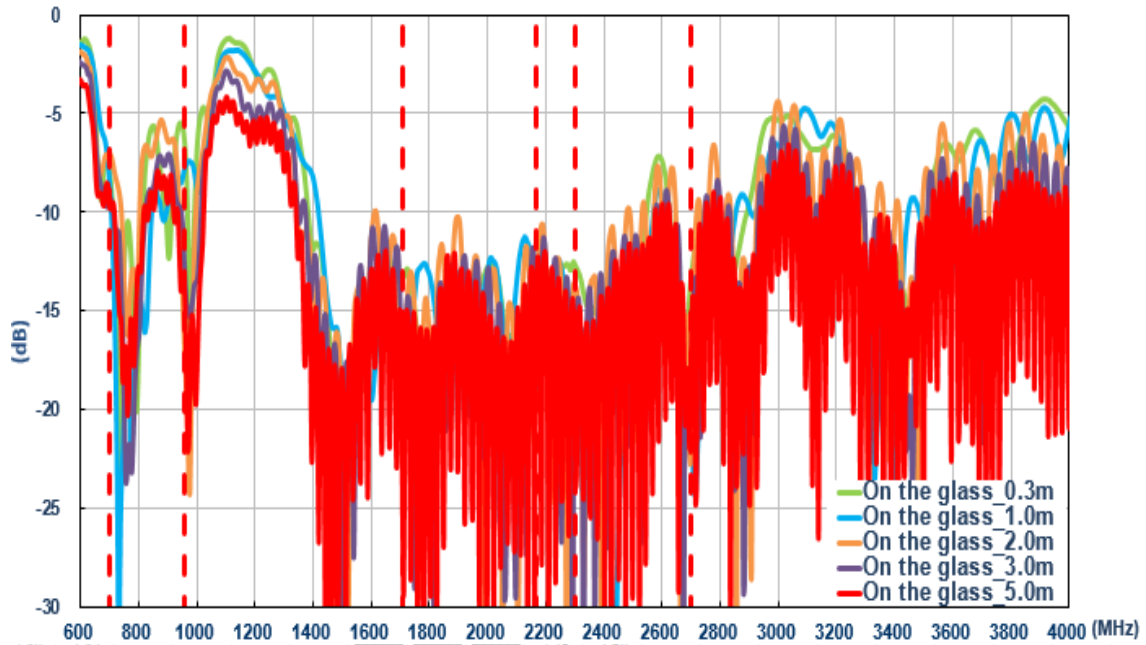


### 6.4.9 Peak Gain (Wi-Fi MIMO\_2)

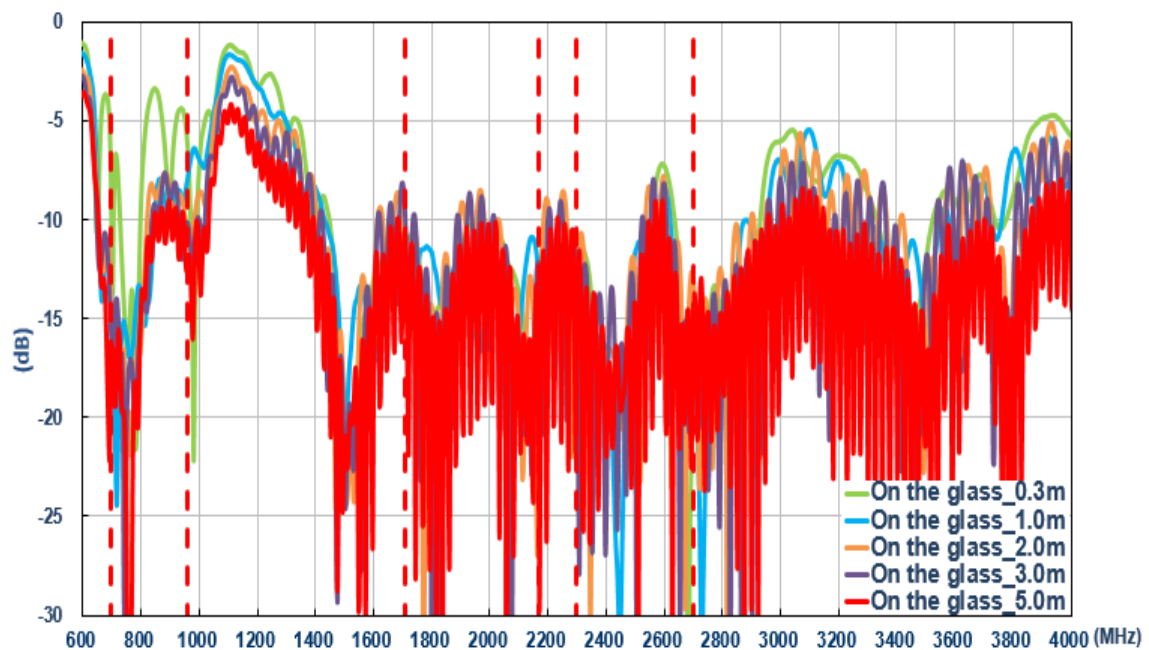


## 6.5 On glass (LTE)

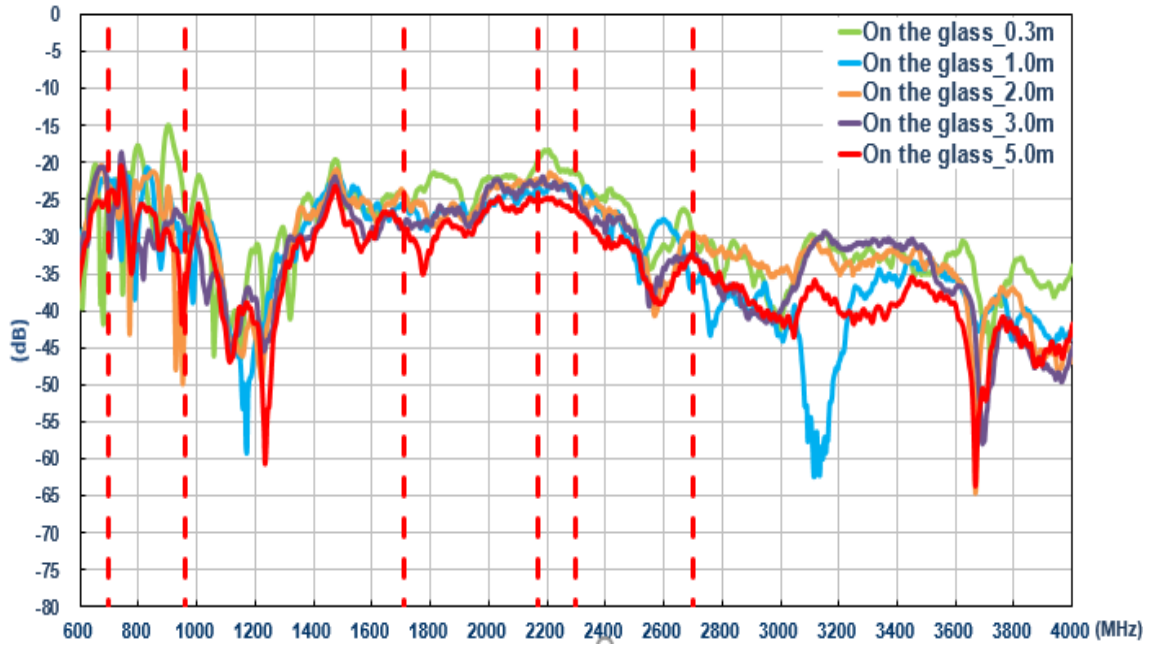
### 6.5.1 Return Loss (LTE\_MIMO\_1)



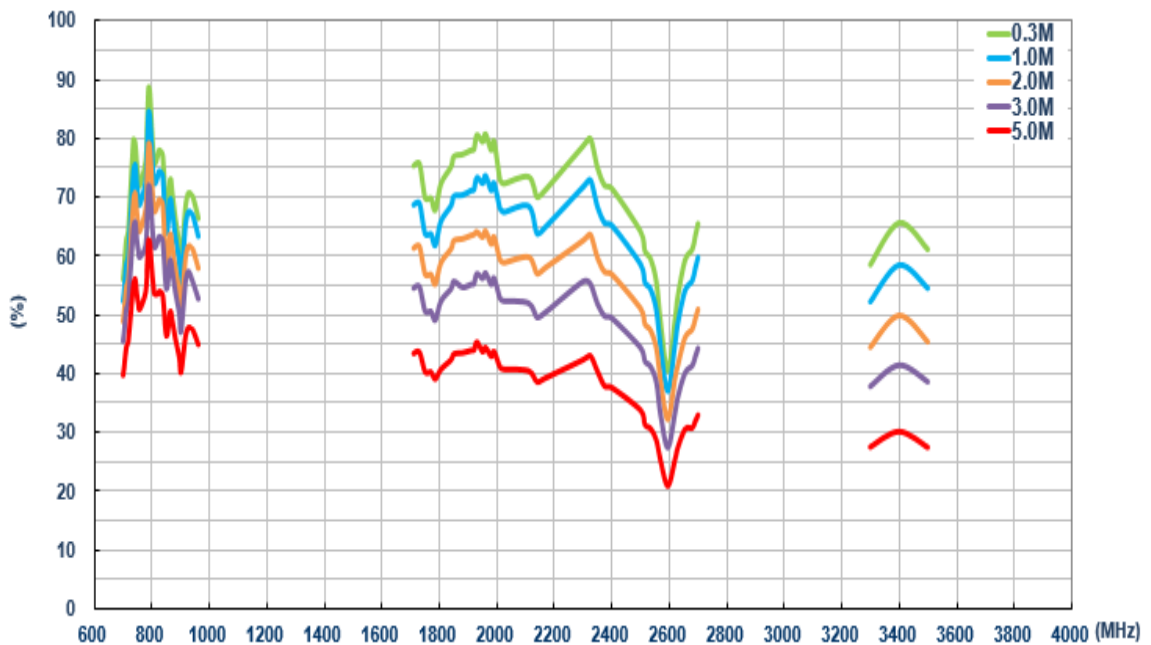
### 6.5.2 Return Loss (LTE\_MIMO\_2)



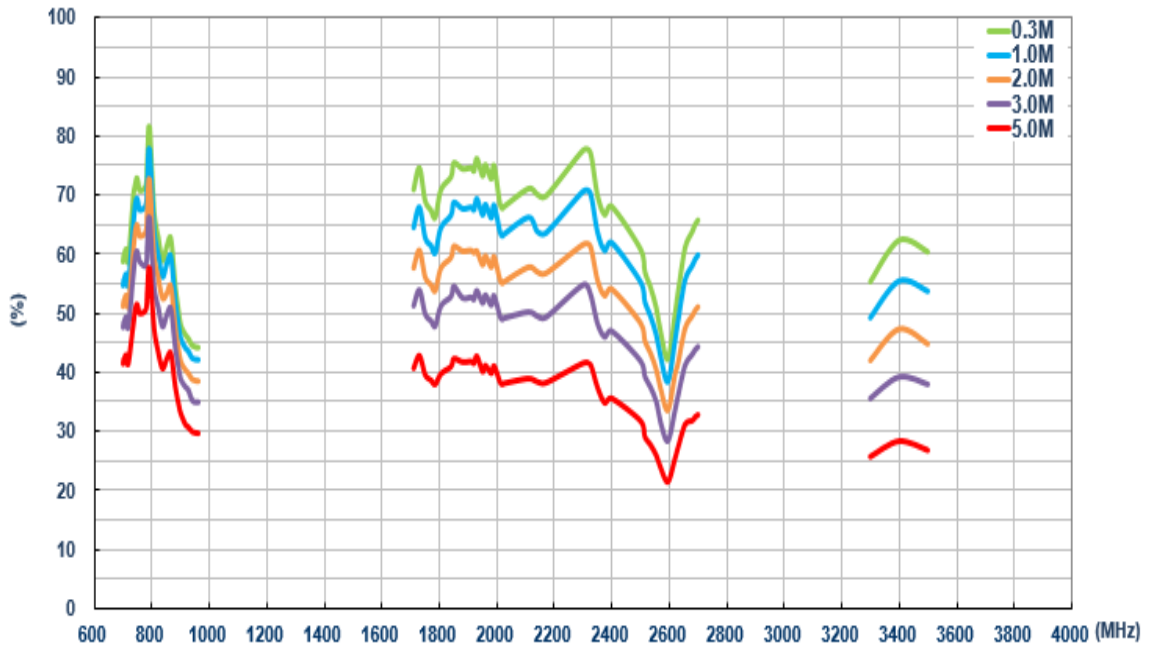
### 6.5.3 Isolation (LTE antenna)



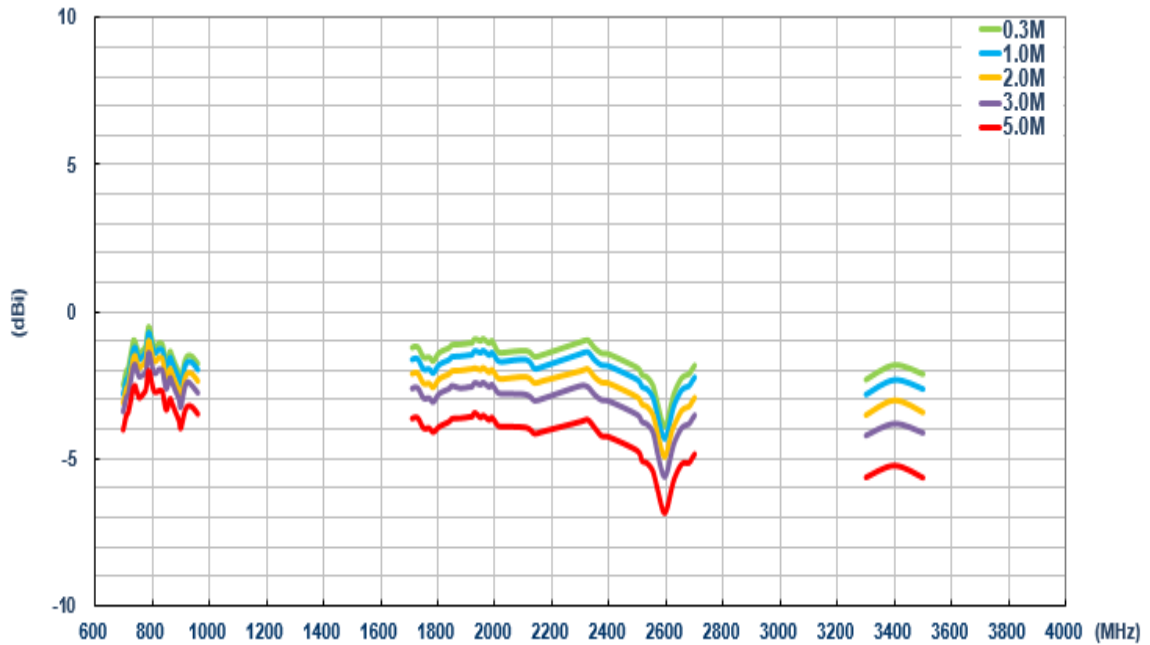
### 6.5.4 Efficiency (LTE MIMO\_1)



### 6.5.5 Efficiency (LTE MIMO\_2)

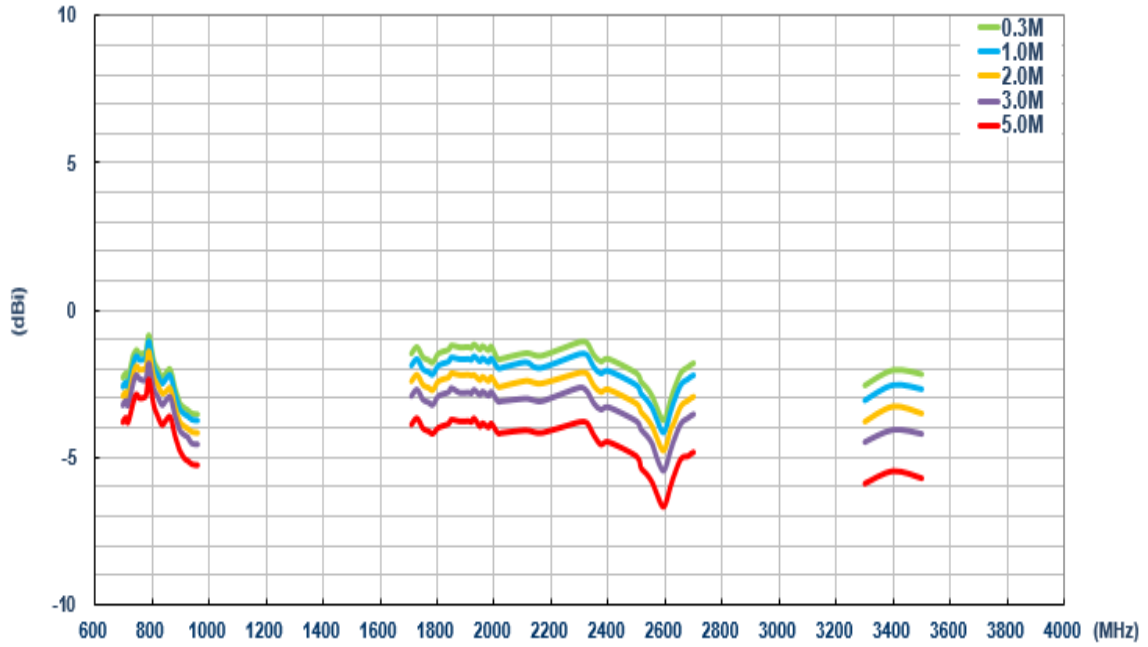


### 6.5.6 Average Gain (LTE MIMO\_1)

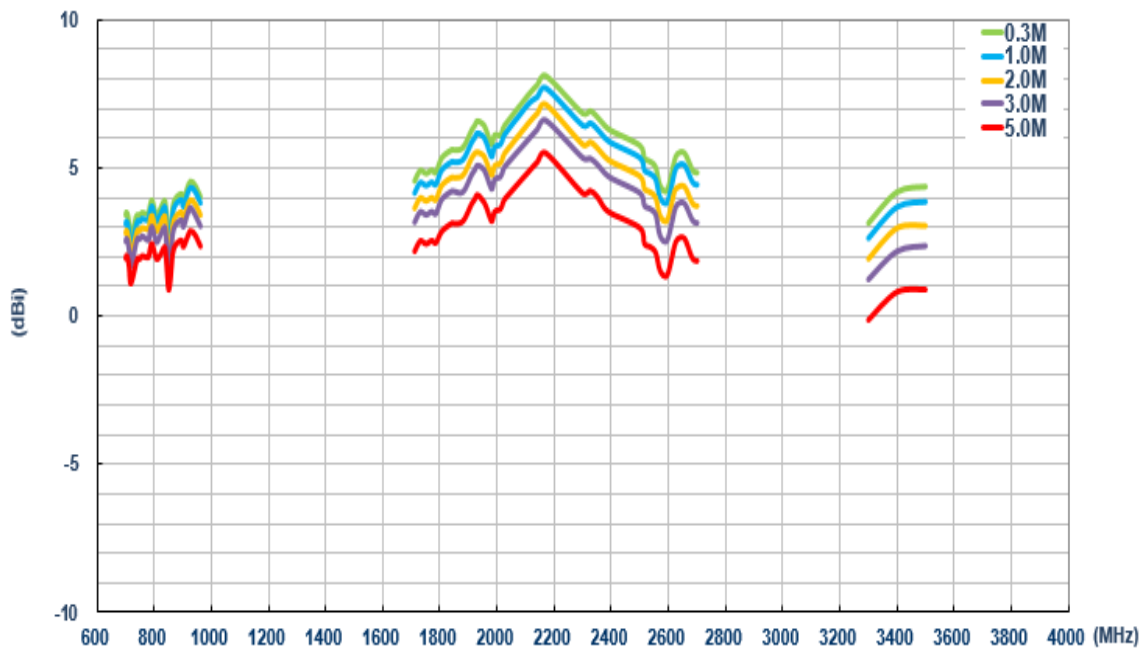




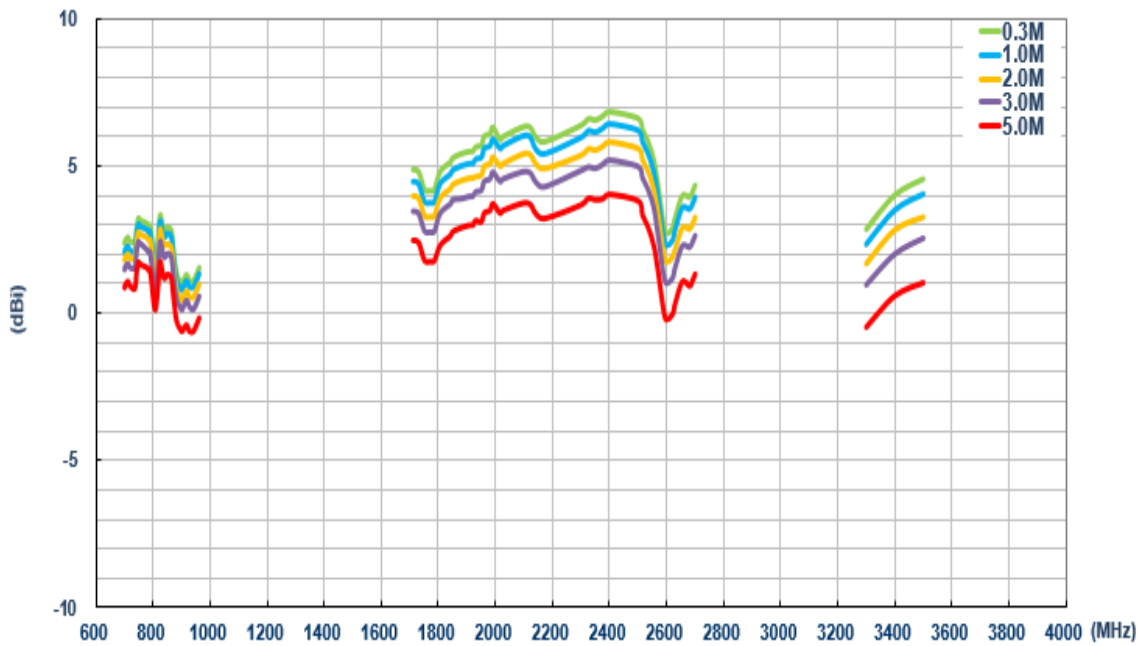
### 6.5.7 Average Gain (LTE MIMO\_2)



### 6.5.8 Peak Gain (LTE MIMO\_1)

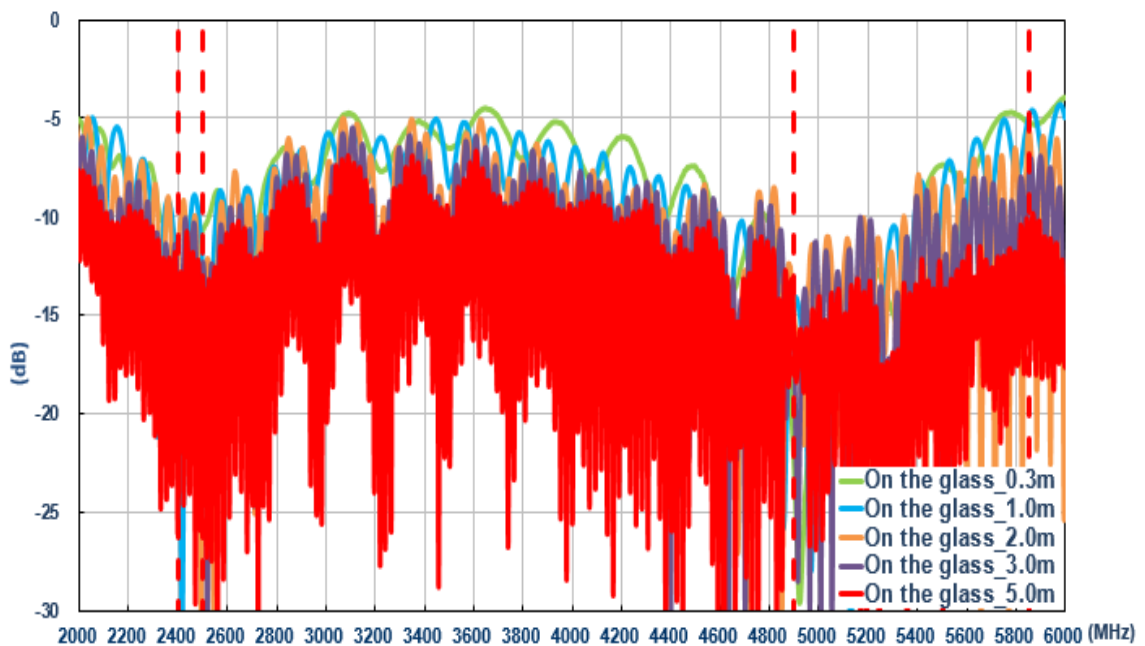


### 6.5.9 Peak Gain (LTE MIMO\_2)

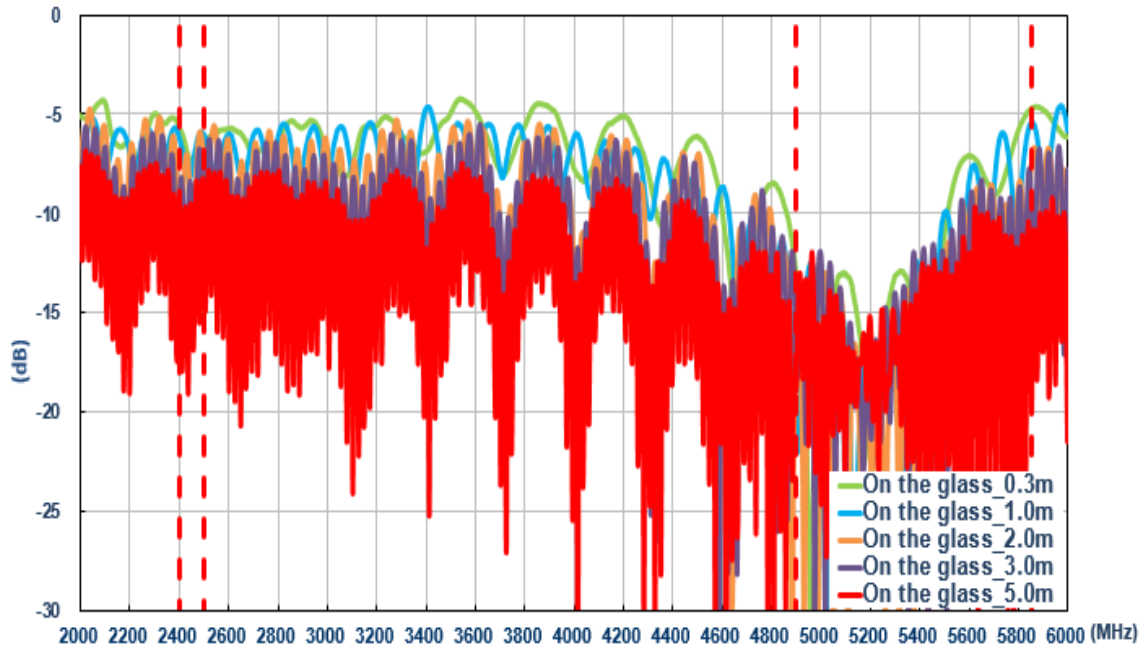


## 6.6 On glass (Wi-Fi)

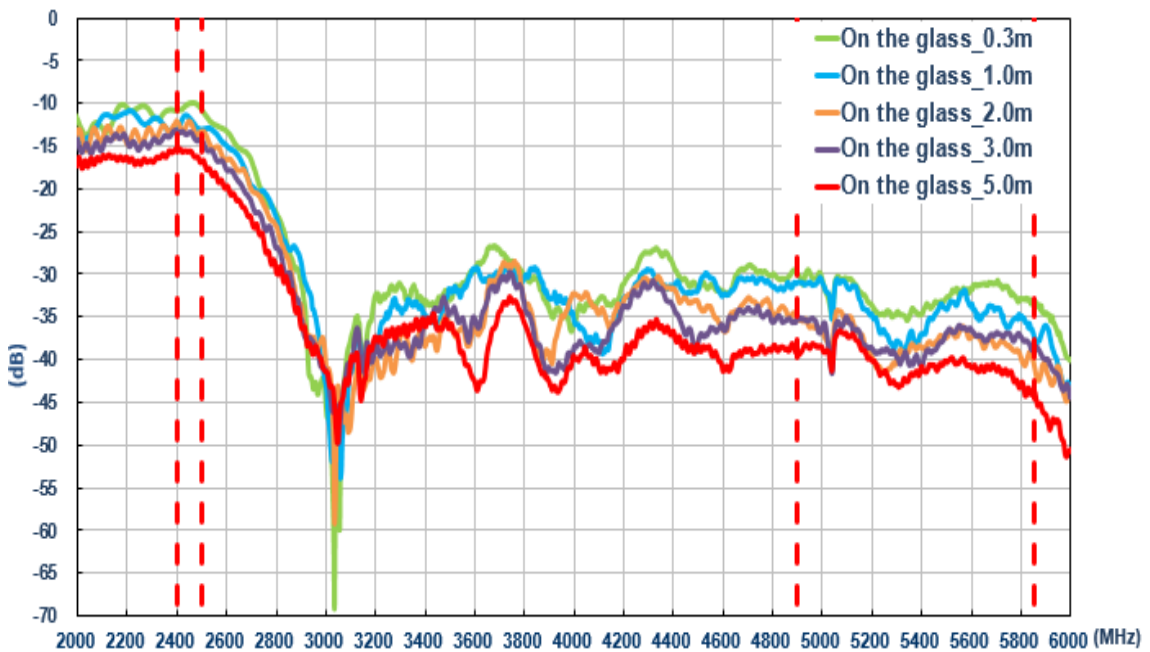
### 6.6.1 Return Loss (Wi-Fi \_MIMO\_1)



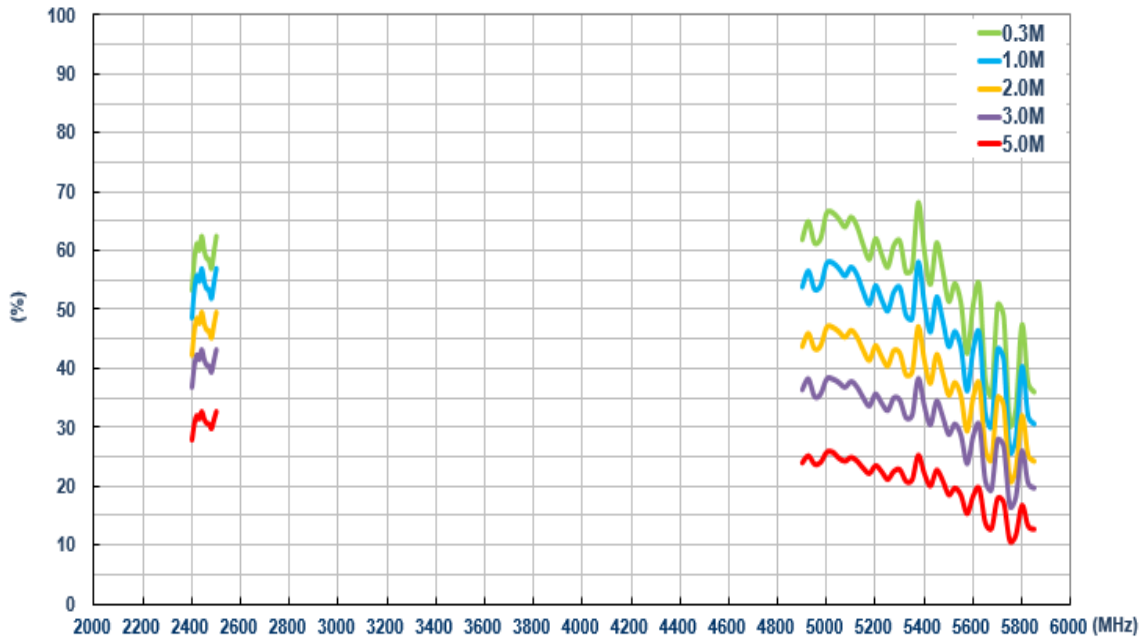
### 6.6.2 Return Loss (Wi-Fi \_MIMO\_2)



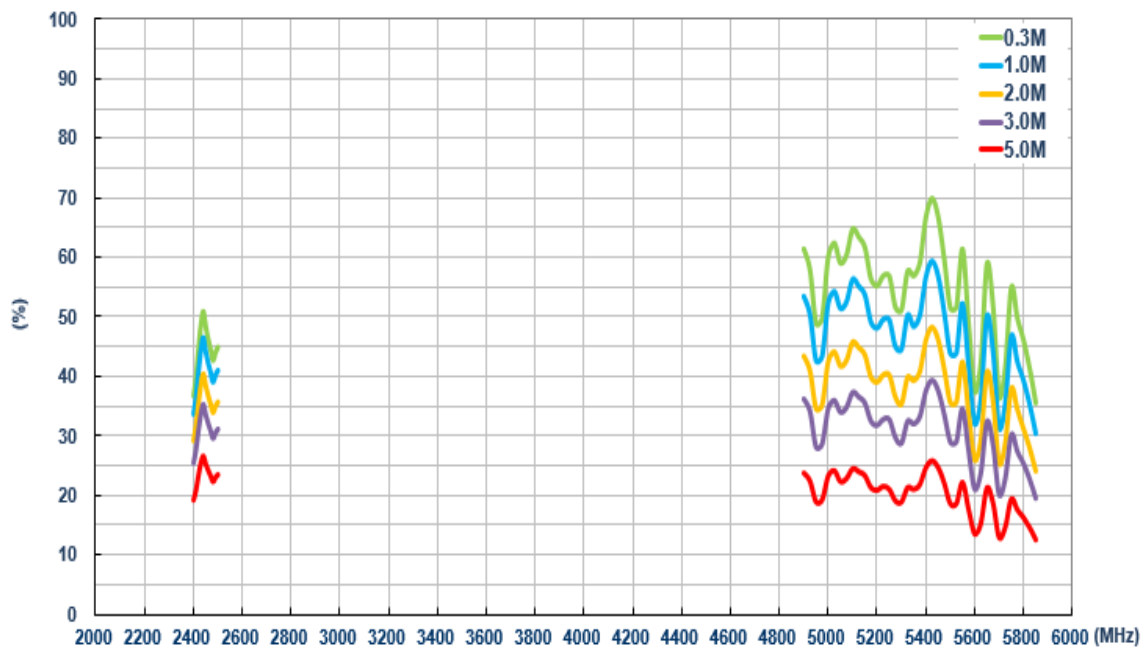
### 6.6.3 Isolation (Wi-Fi)



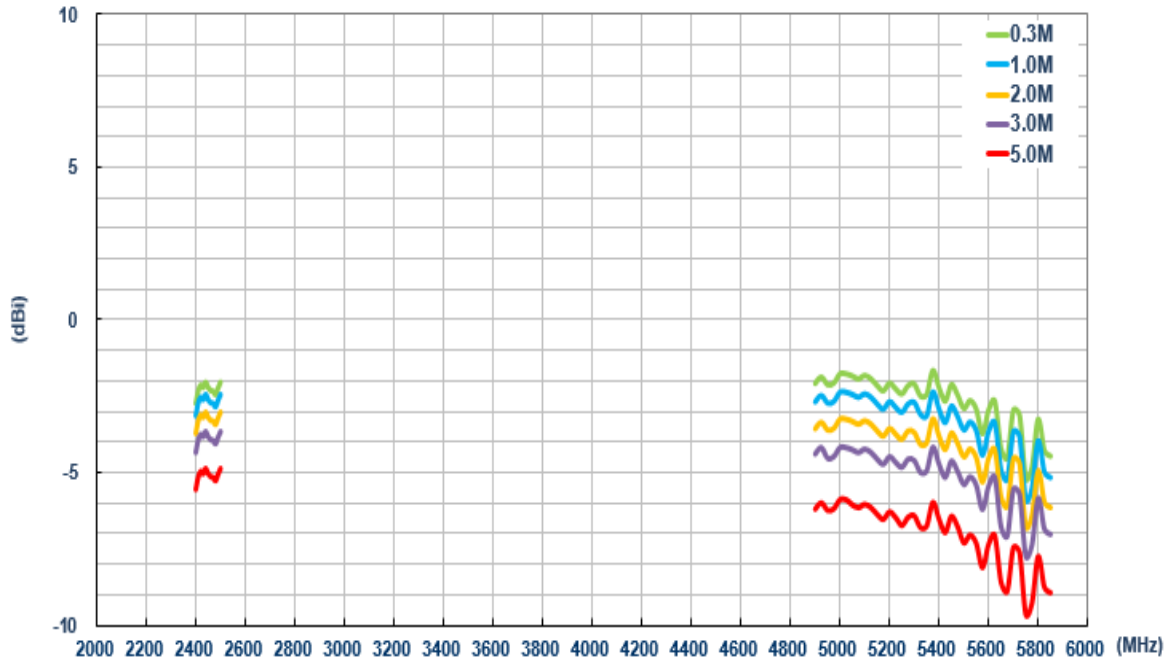
### 6.6.4 Efficiency (Wi-Fi\_MIMO\_1)



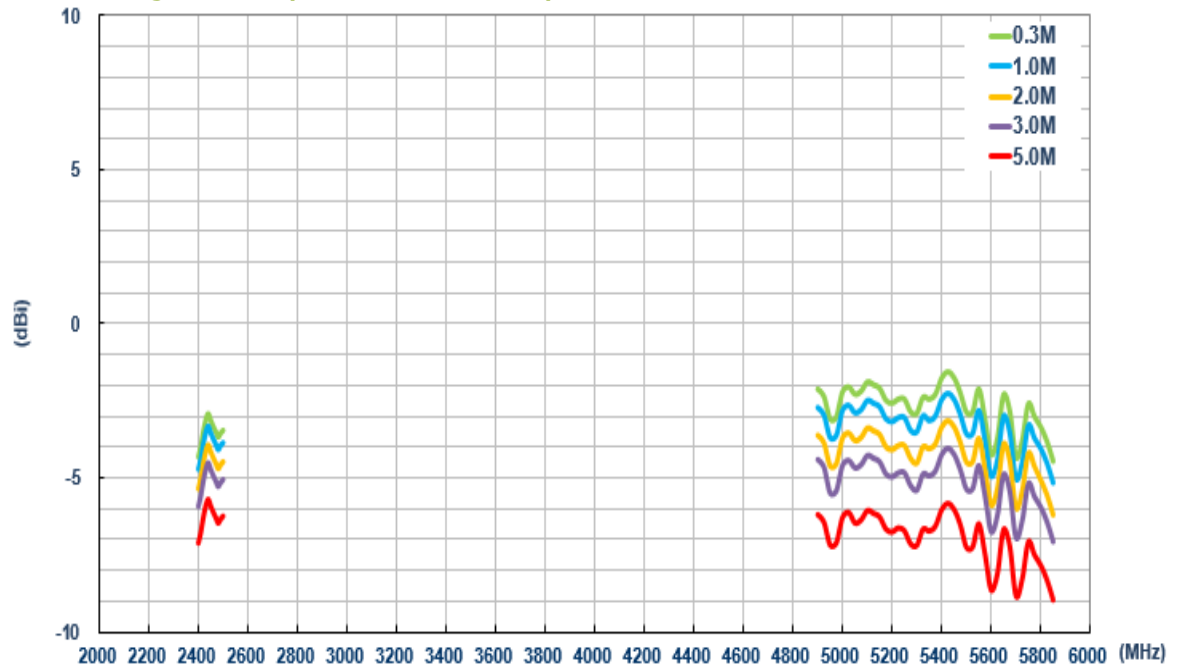
### 6.6.5 Efficiency (Wi-Fi\_MIMO\_2)



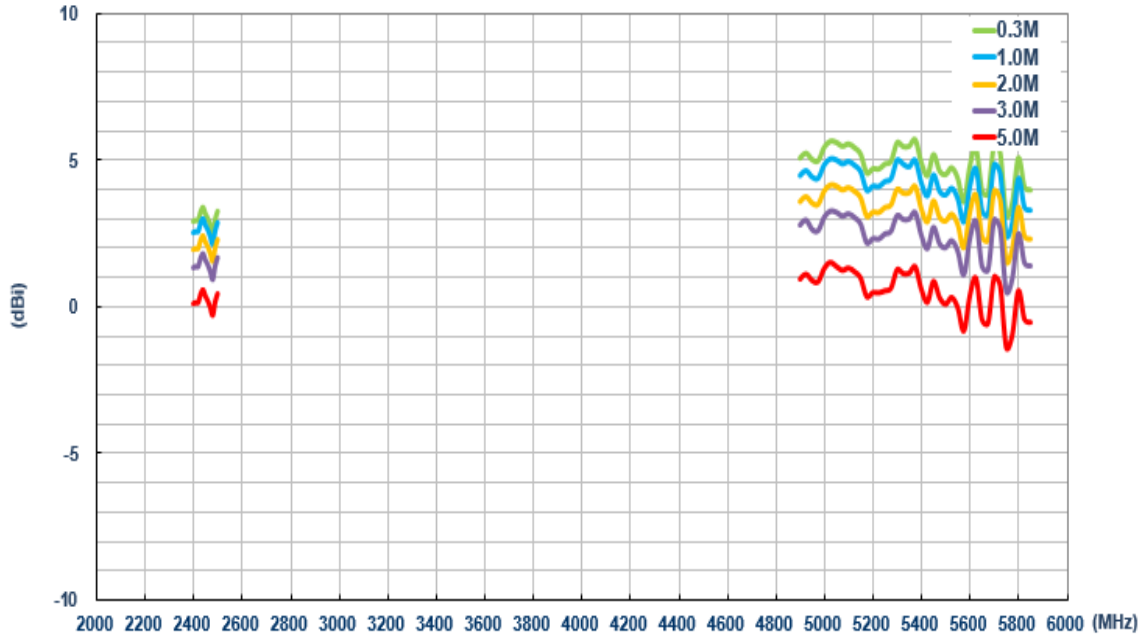
### 6.6.6 Average Gain (Wi-Fi\_MIMO\_1)



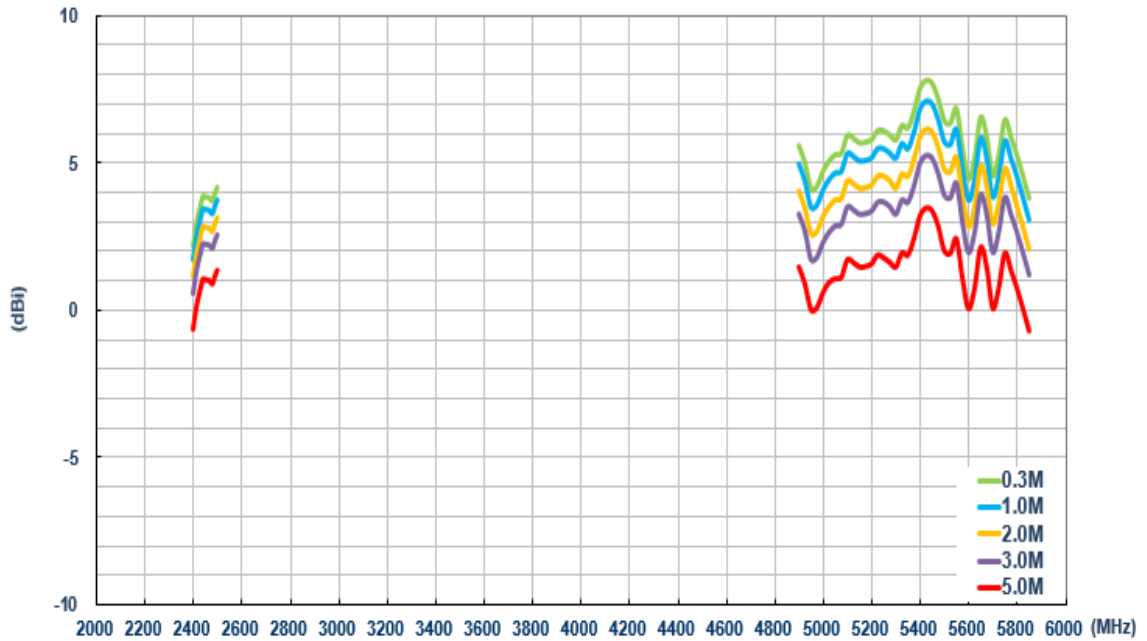
### 6.6.7 Average Gain (Wi-Fi\_MIMO\_2)



### 6.6.8 Peak Gain (Wi-Fi \_MIMO\_1)

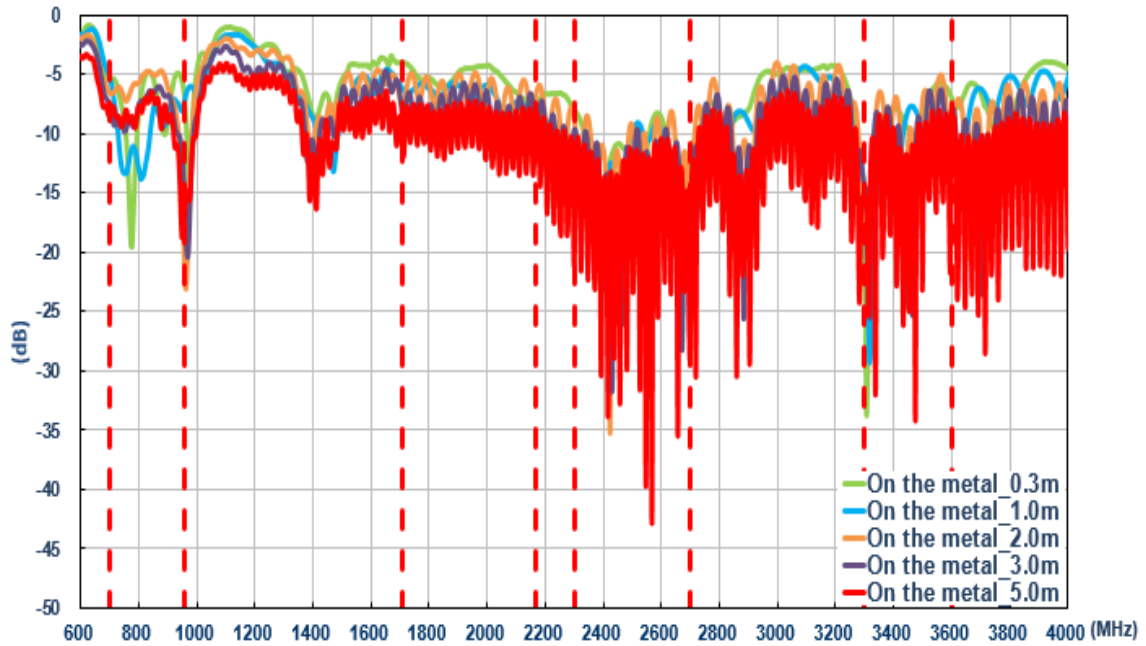


### 6.6.9 Peak Gain (Wi-Fi \_MIMO\_2)

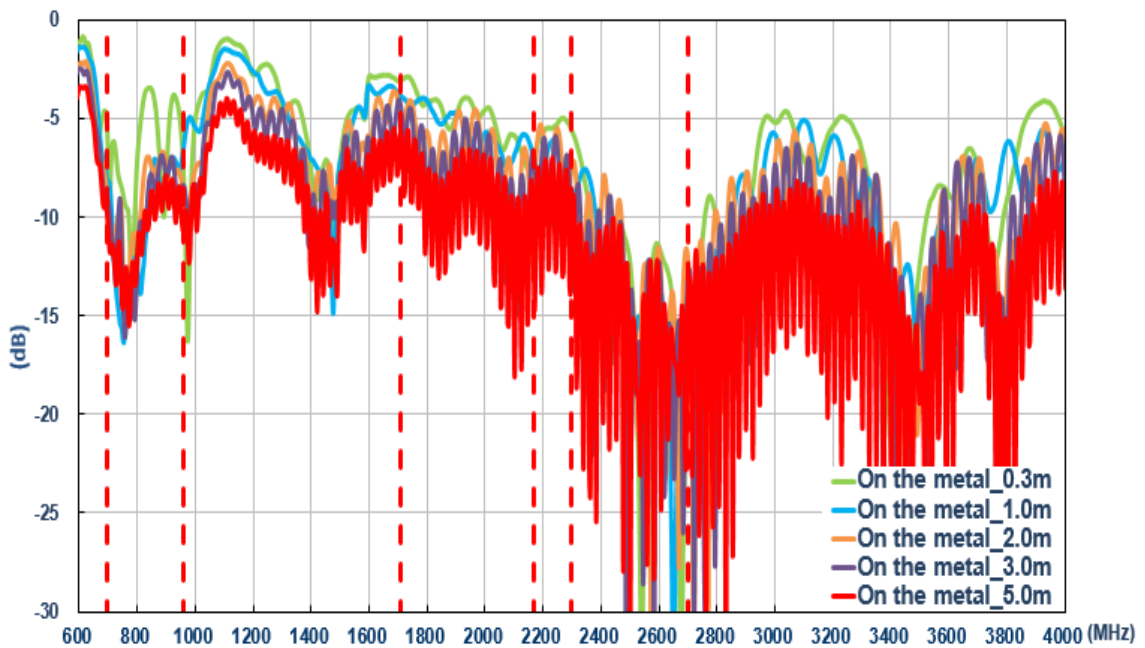


## 6.7 On metal (LTE)

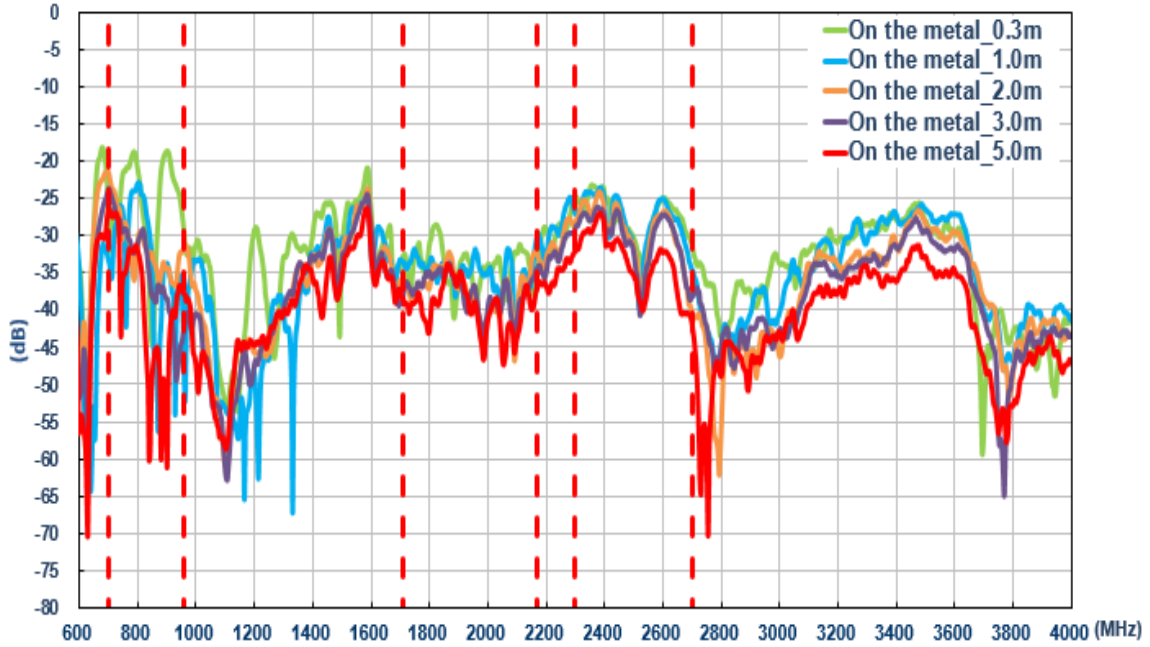
### 6.7.1 Return Loss (LTE\_MIMO\_1)



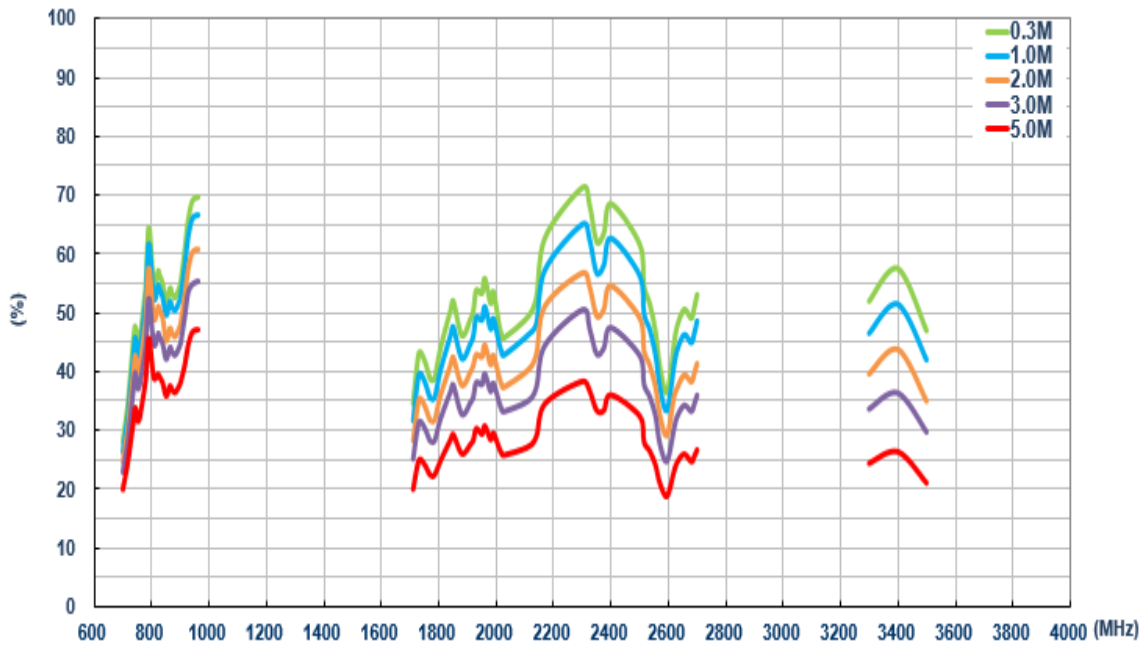
### 6.7.2 Return Loss (LTE\_MIMO\_2)



### 6.7.3 Isolation (LTE antenna)

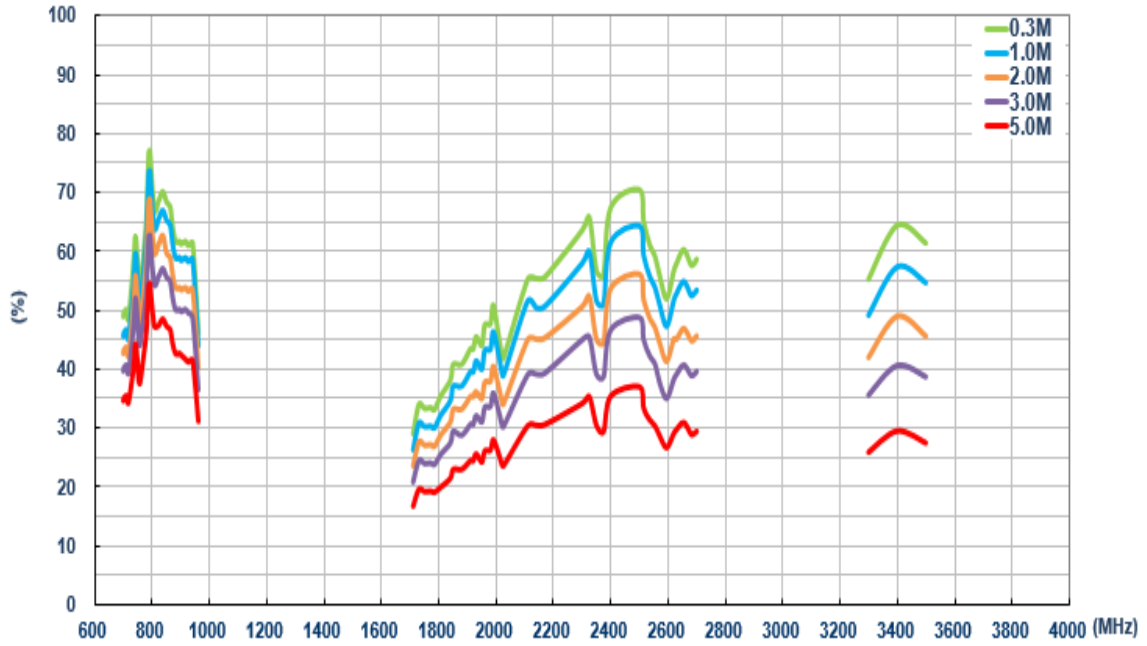


### 6.7.4 Efficiency (LTE\_MIMO\_1)

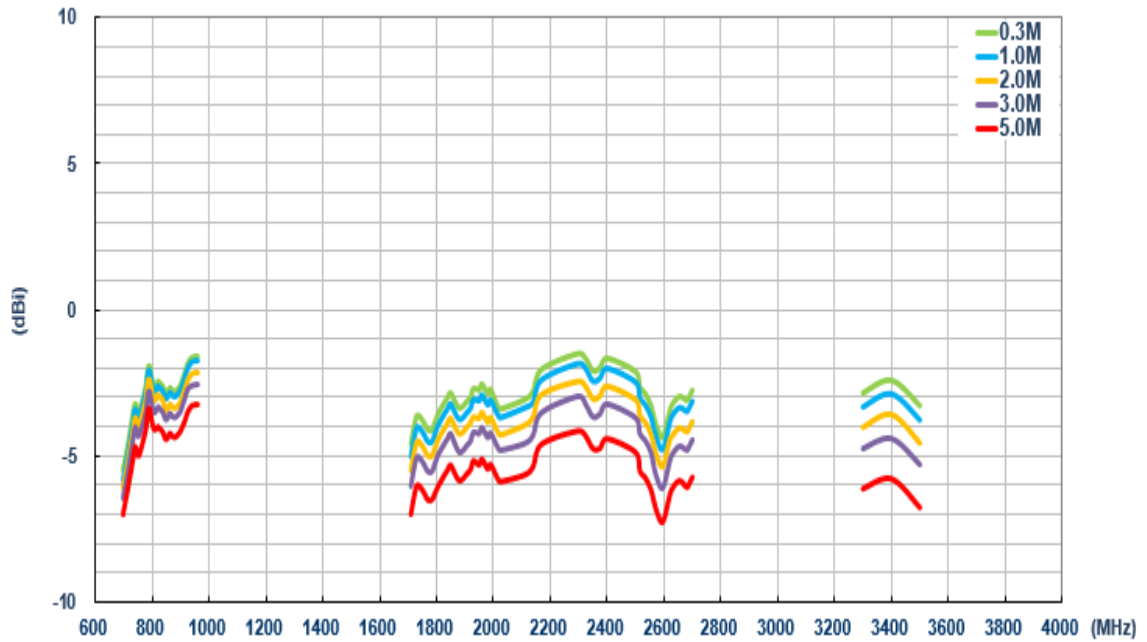




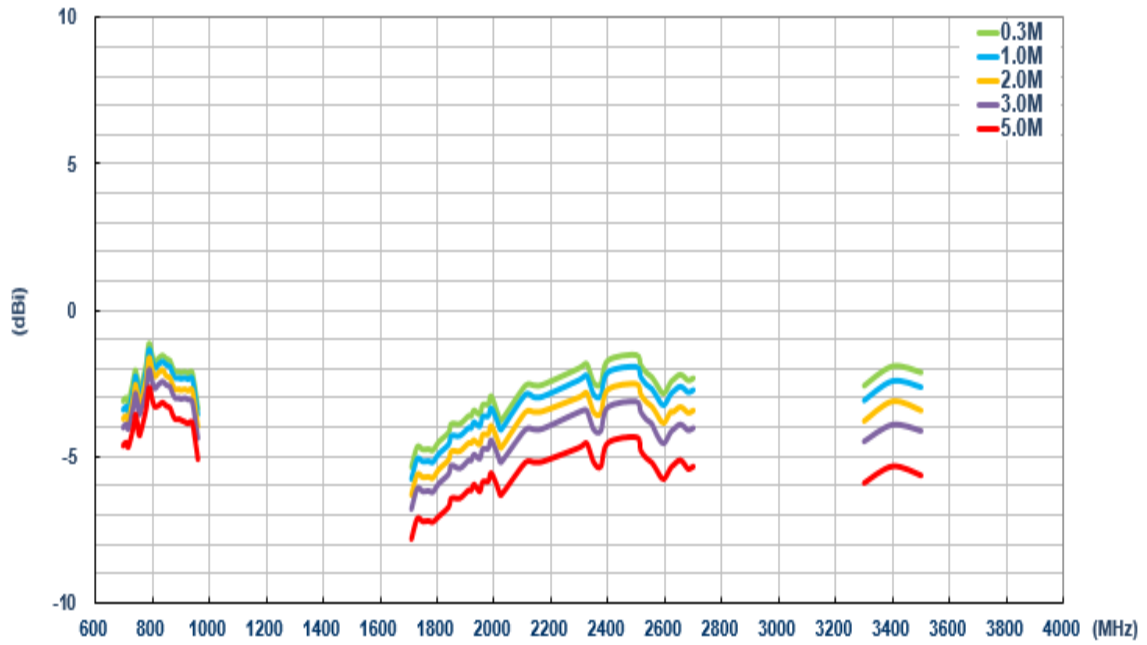
### 6.7.5 Efficiency (LTE\_MIMO\_2)



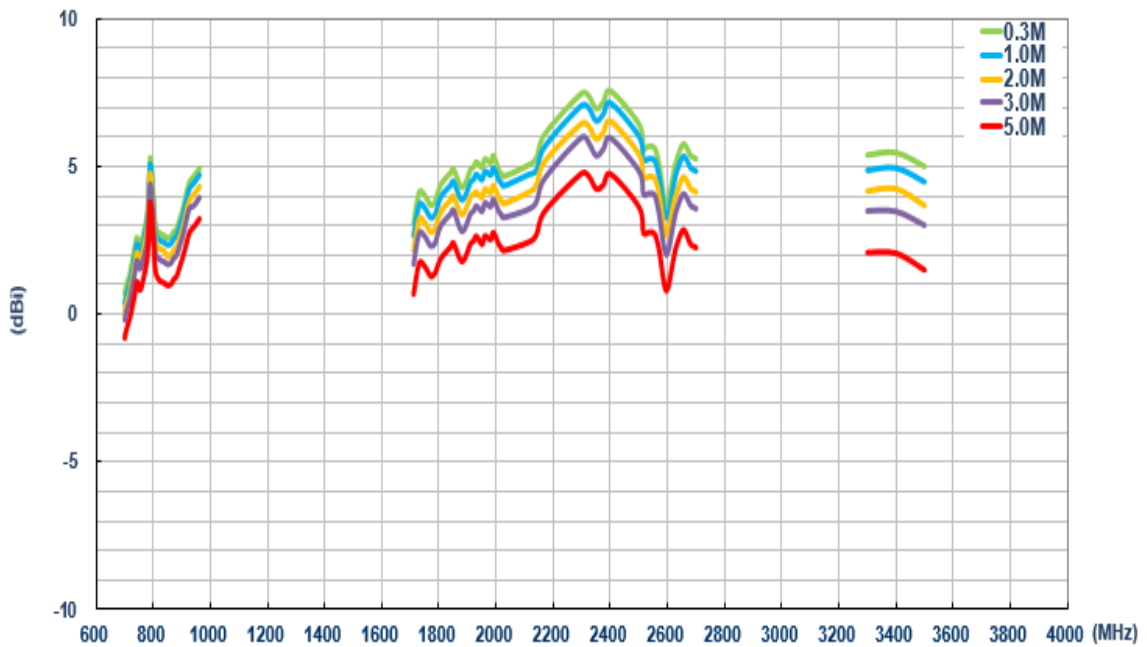
### 6.7.6 Average Gain (LTE\_MIMO\_1)



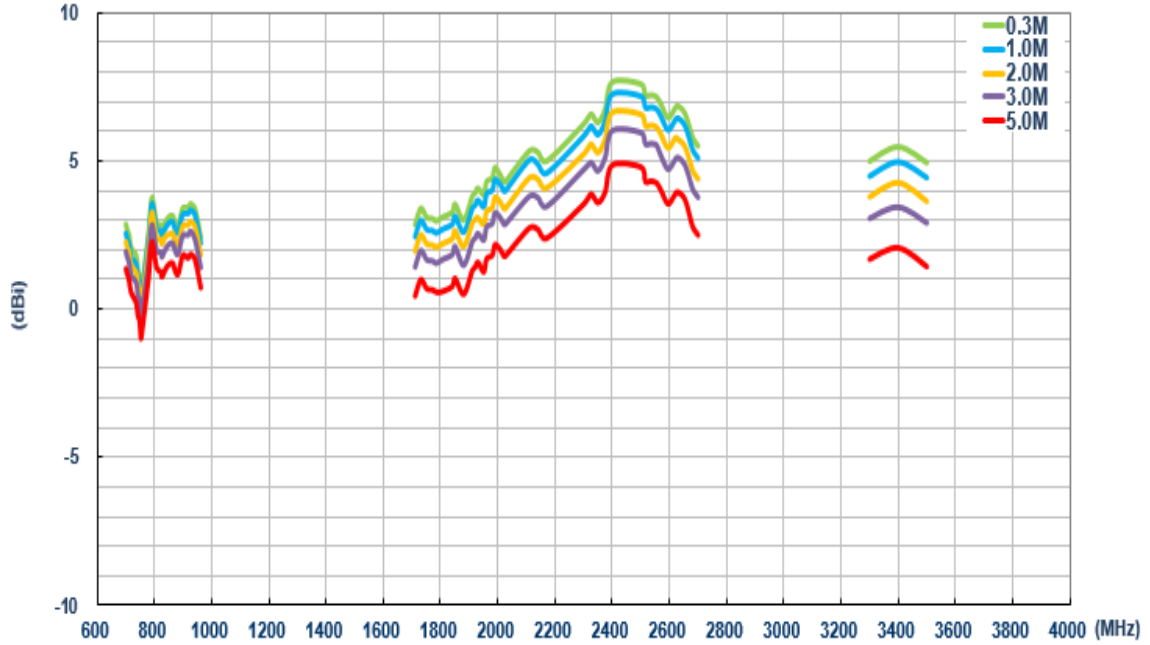
### 6.7.7 Average Gain (LTE\_MIMO\_2)



### 6.7.8 Peak Gain (LTE\_MIMO\_1)

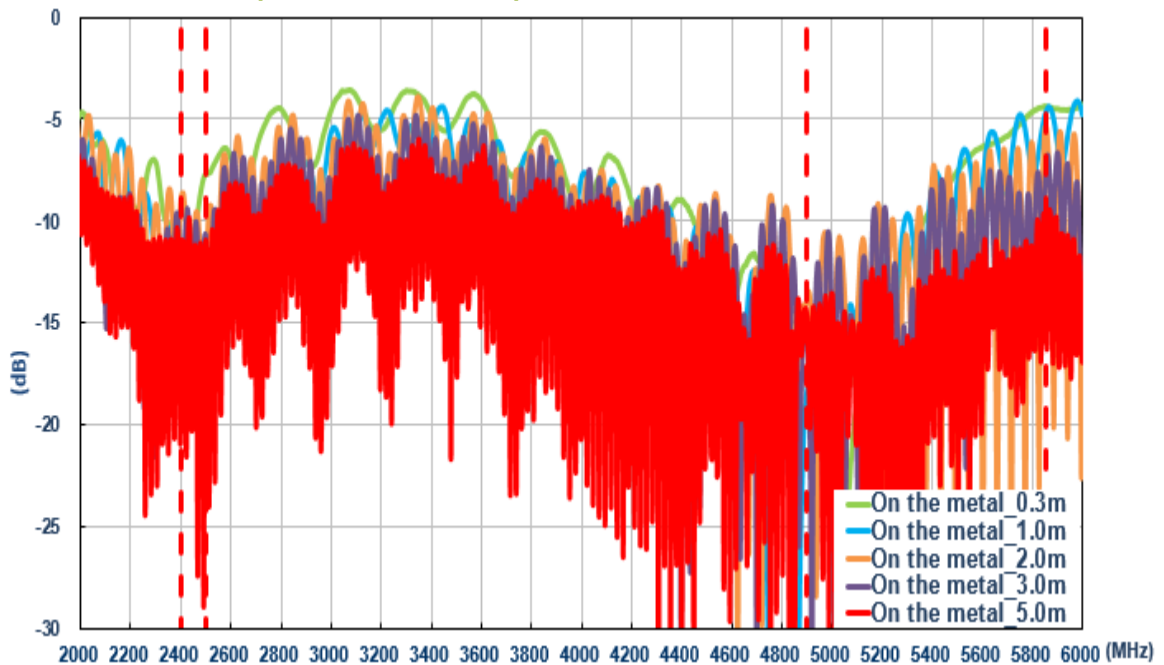


### 6.7.9 Peak Gain (LTE\_MIMO\_2)

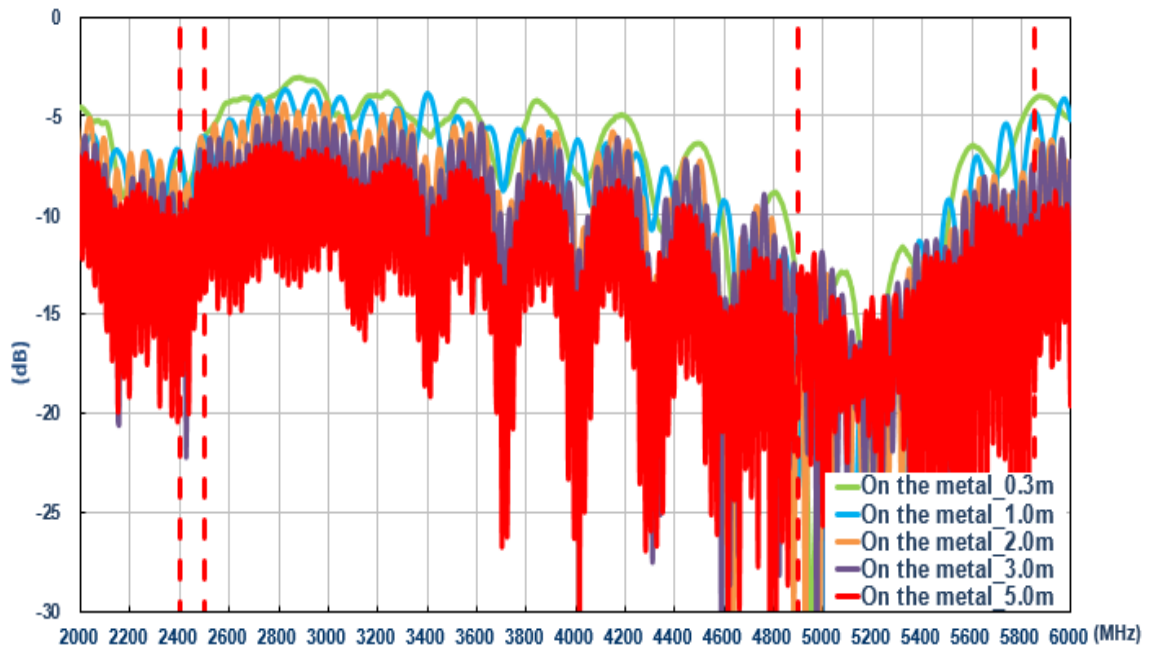


## 6.8 On metal (Wi-Fi)

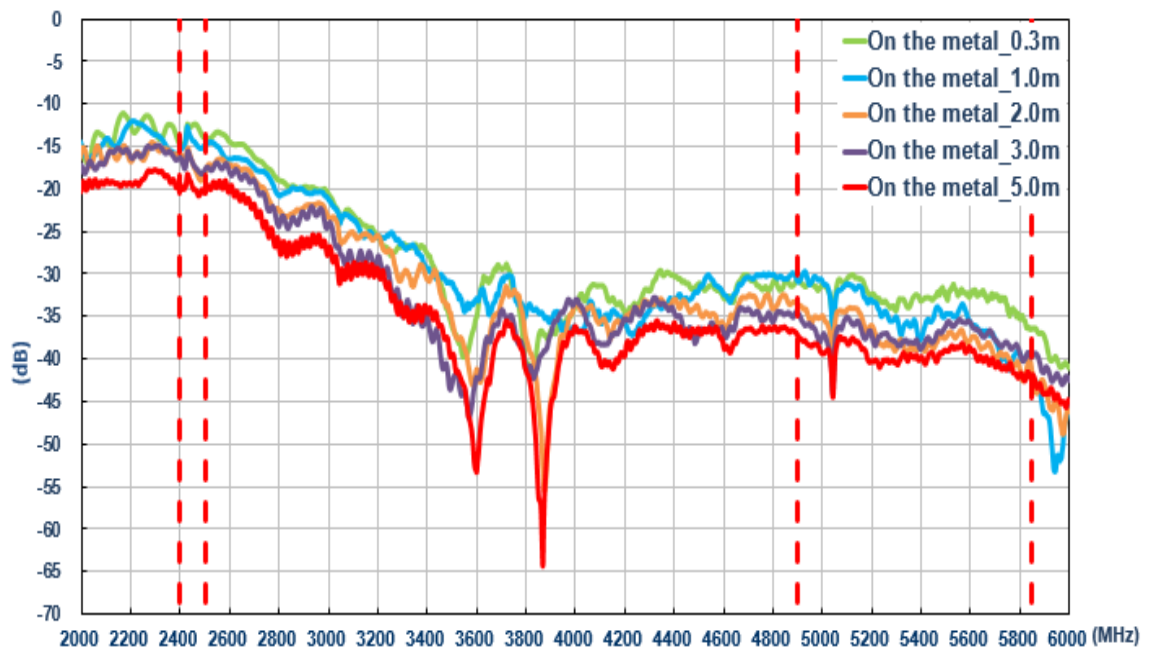
### 6.8.1 Return Loss (Wi-Fi\_MIMO\_1)



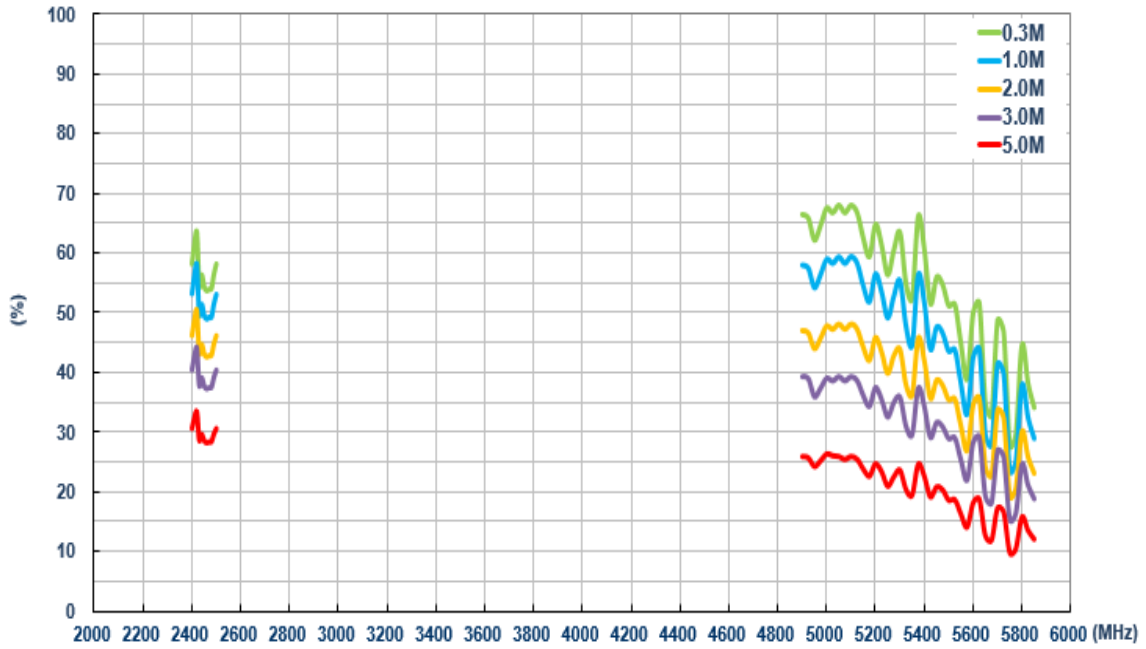
### 6.8.2 Return Loss (Wi-Fi\_MIMO\_2)



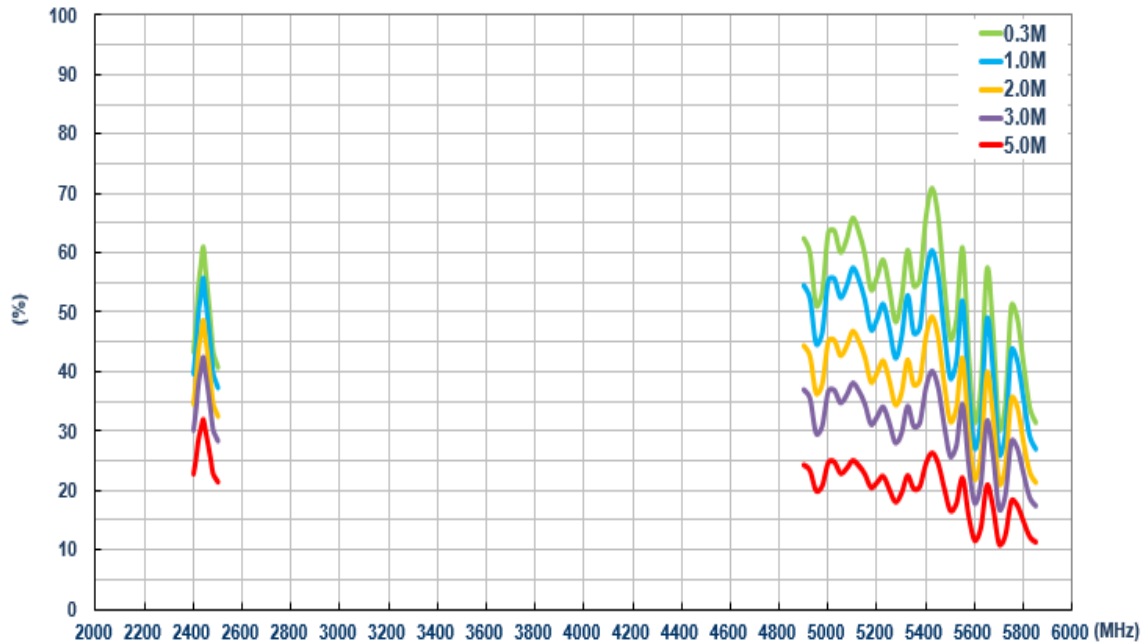
### 6.8.3 Isolation (Wi-Fi)



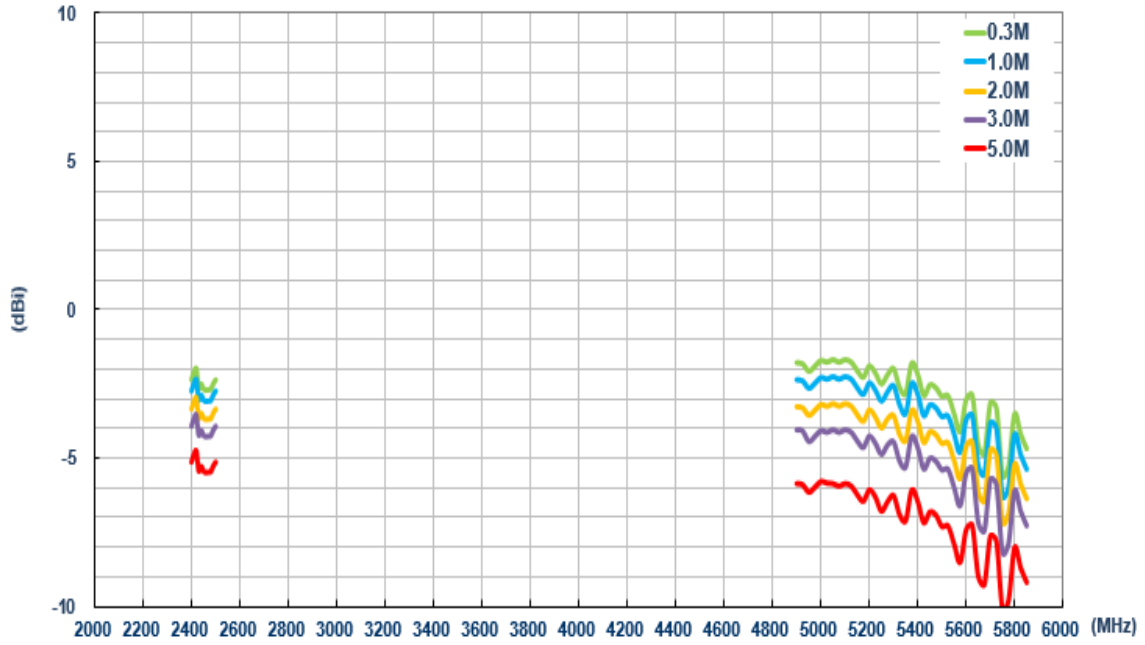
### 6.8.4 Efficiency (Wi-Fi\_MIMO\_1)



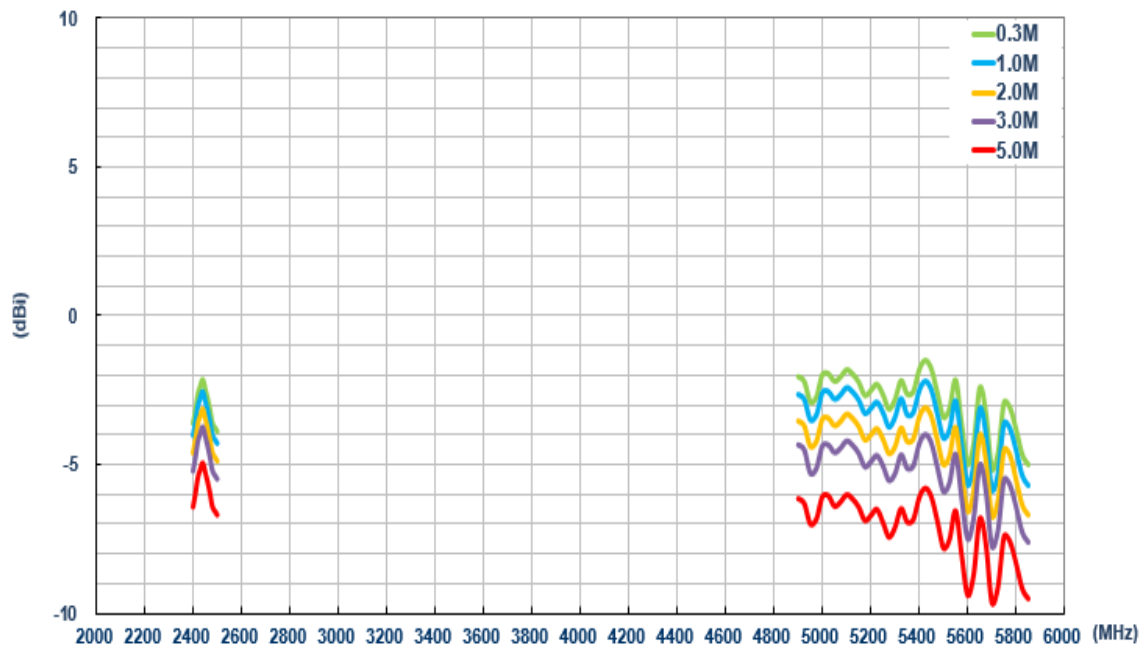
### 6.8.5 Efficiency (Wi-Fi\_MIMO\_2)



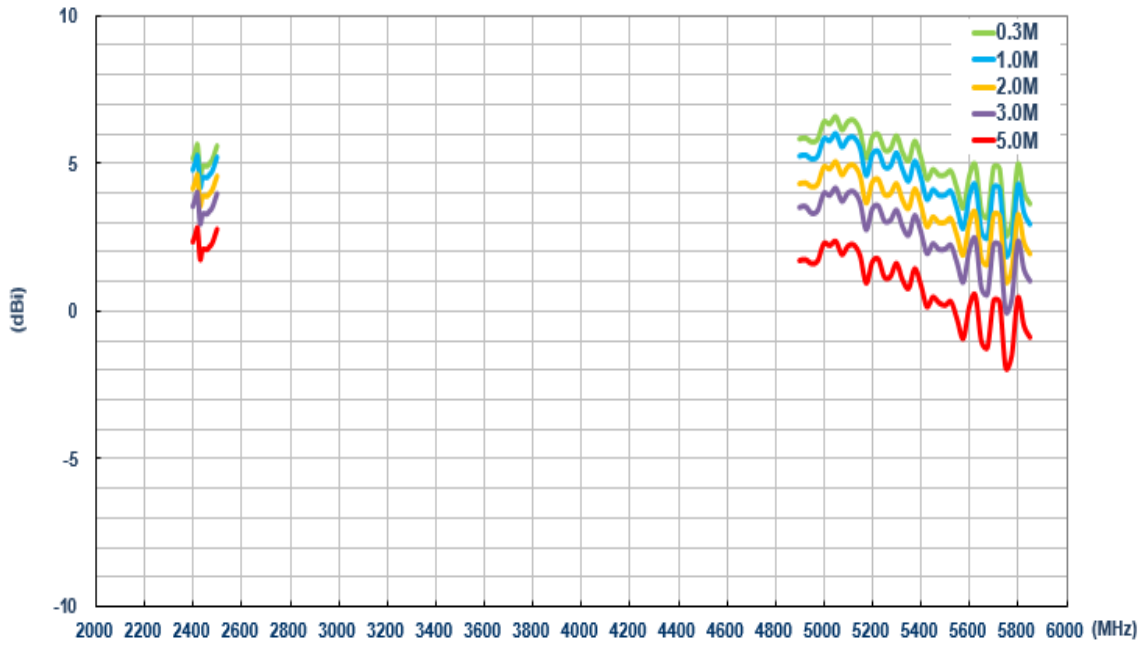
### 6.8.6 Average Gain (Wi-Fi\_MIMO\_1)



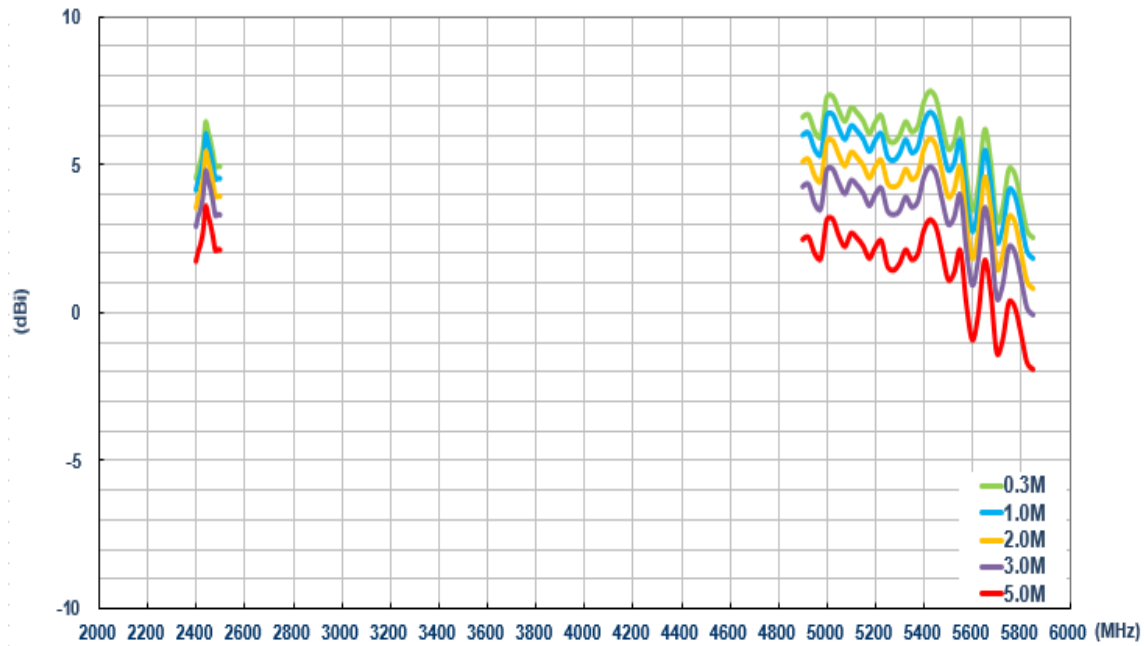
### 6.8.7 Average Gain (Wi-Fi\_MIMO\_2)



### 6.8.8 Peak Gain (Wi-Fi\_MIMO\_1)

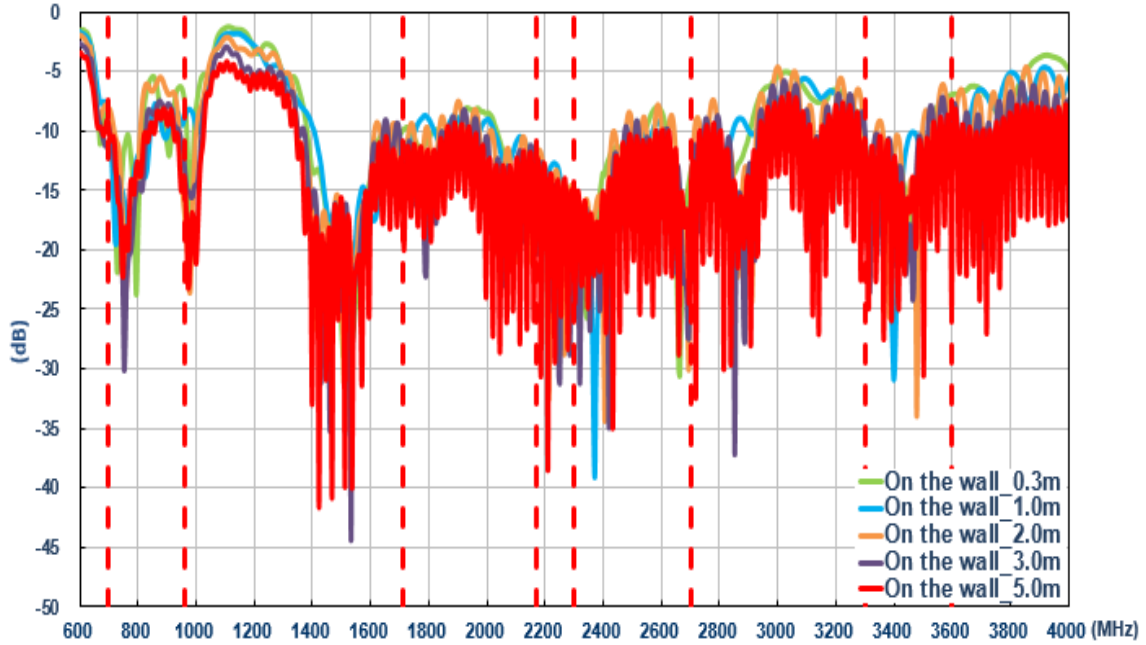


### 6.8.9 Peak Gain (Wi-Fi\_MIMO\_2)

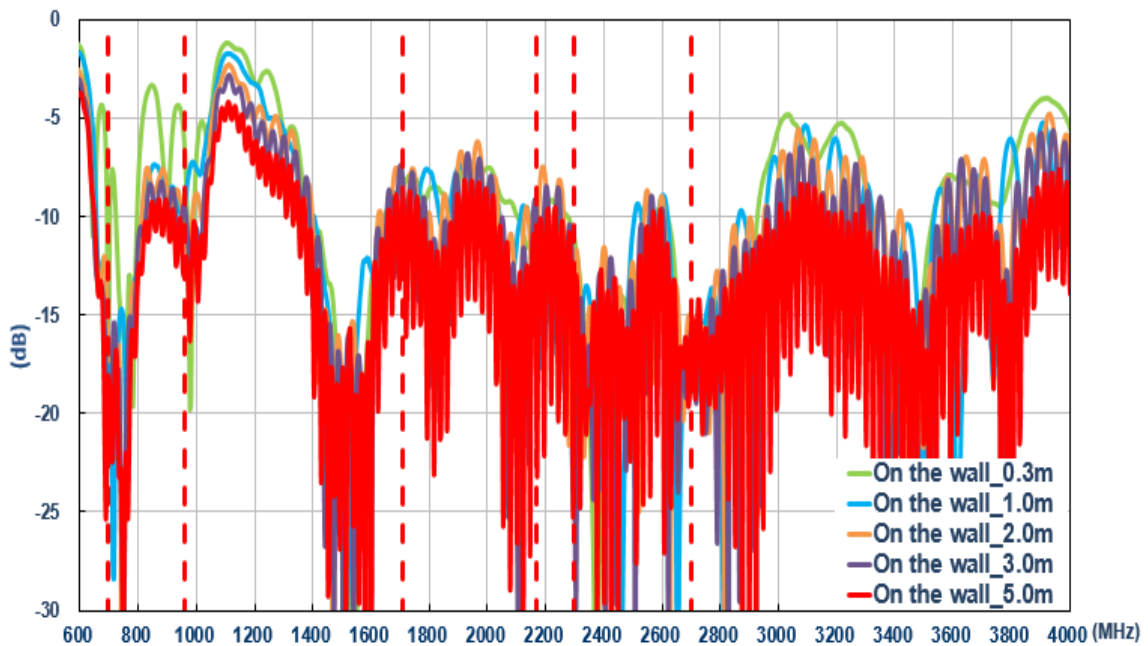


## 6.9 On the wall (LTE)

### 6.9.1 Return Loss (LTE\_MIMO\_1)

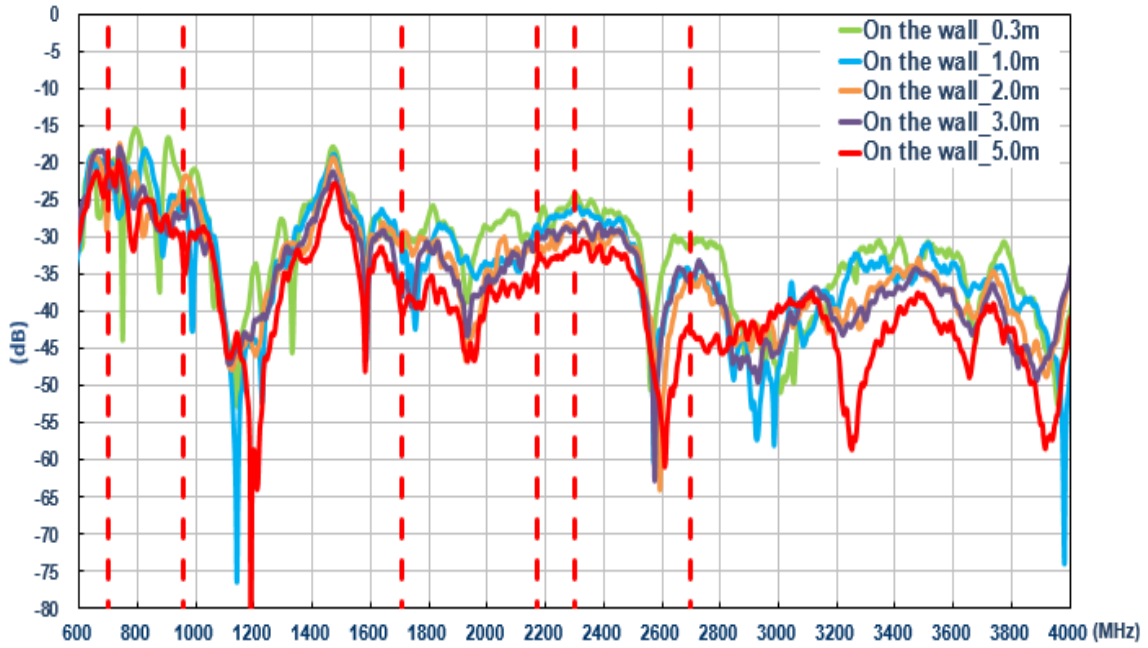


### 6.9.2 Return Loss (LTE\_MIMO\_2)

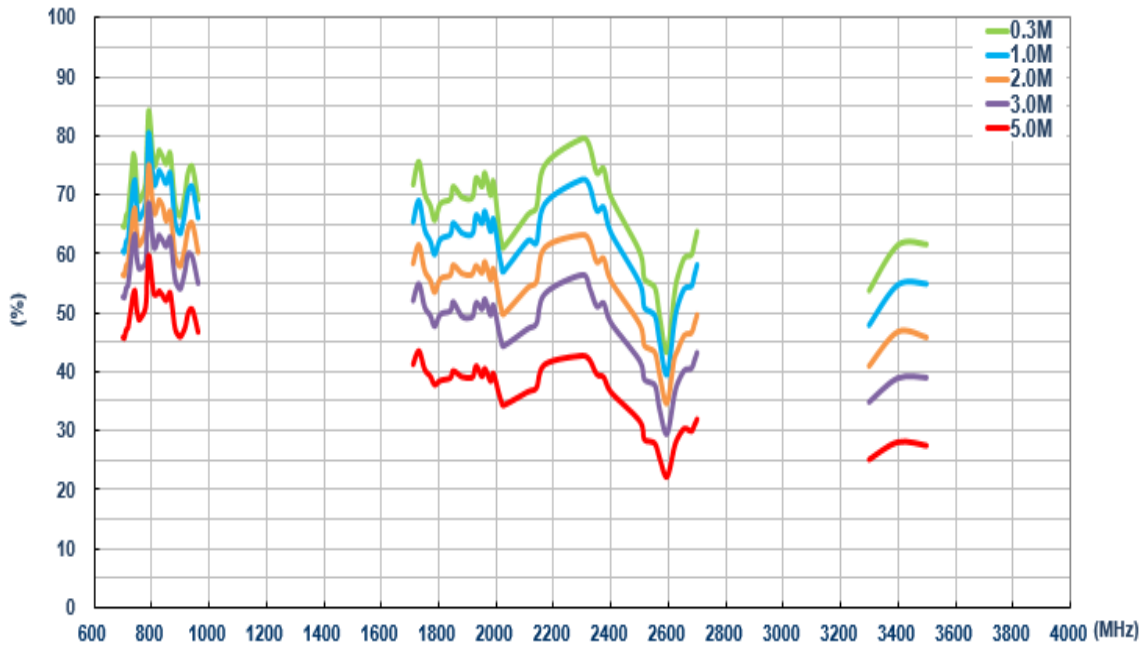




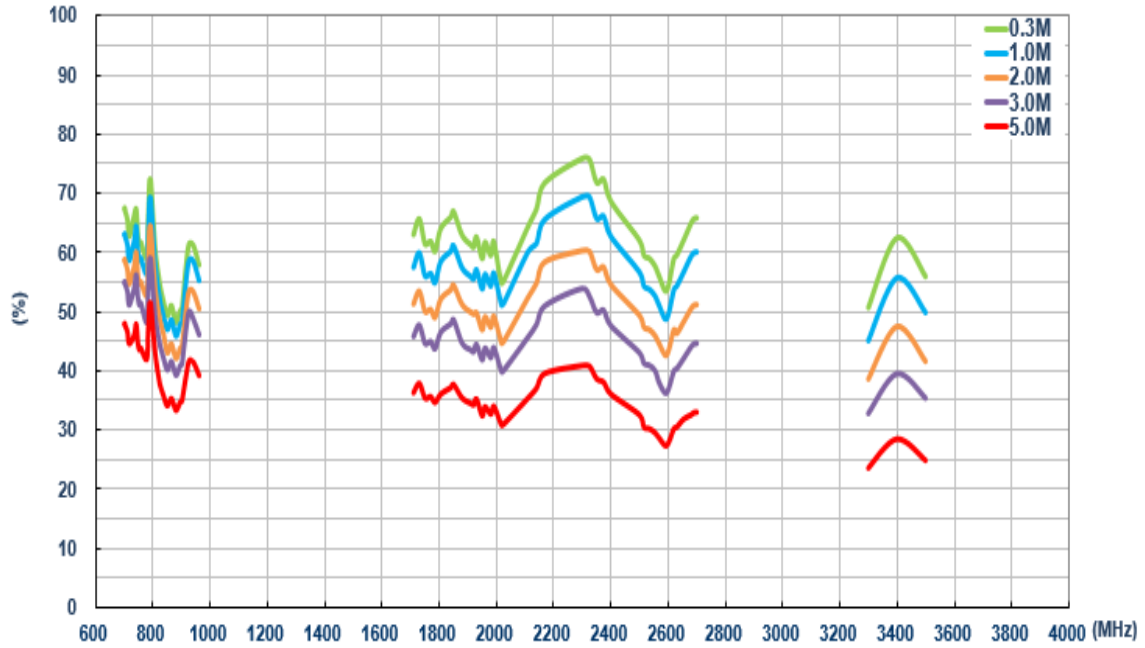
### 6.9.3 Isolation (LTE antenna)



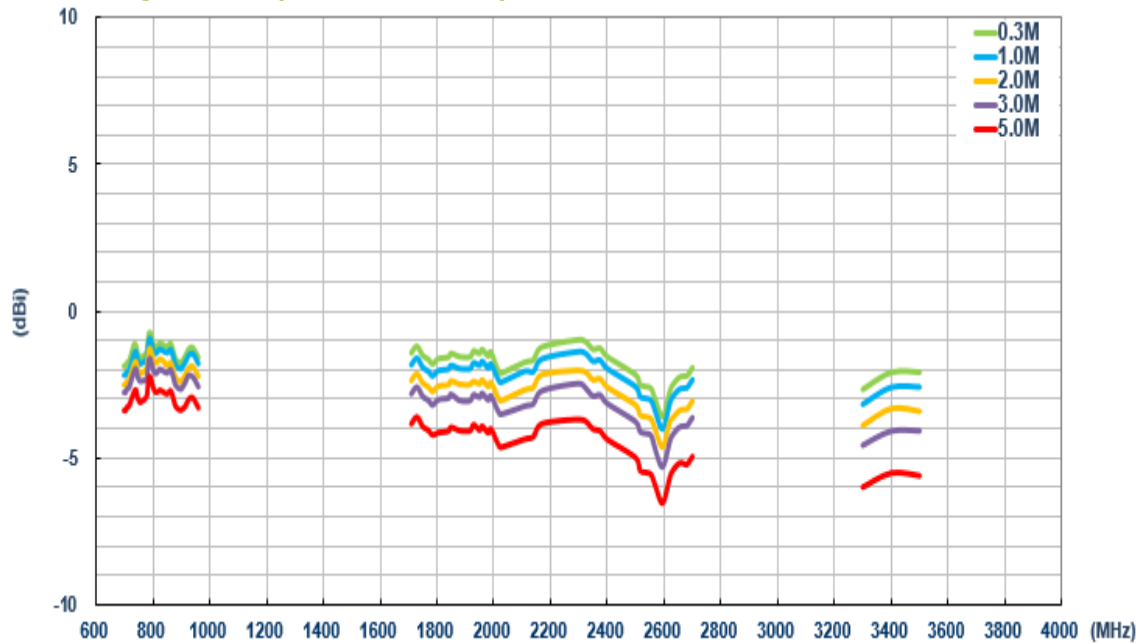
### 6.9.4 Efficiency (LTE\_MIMO\_1)



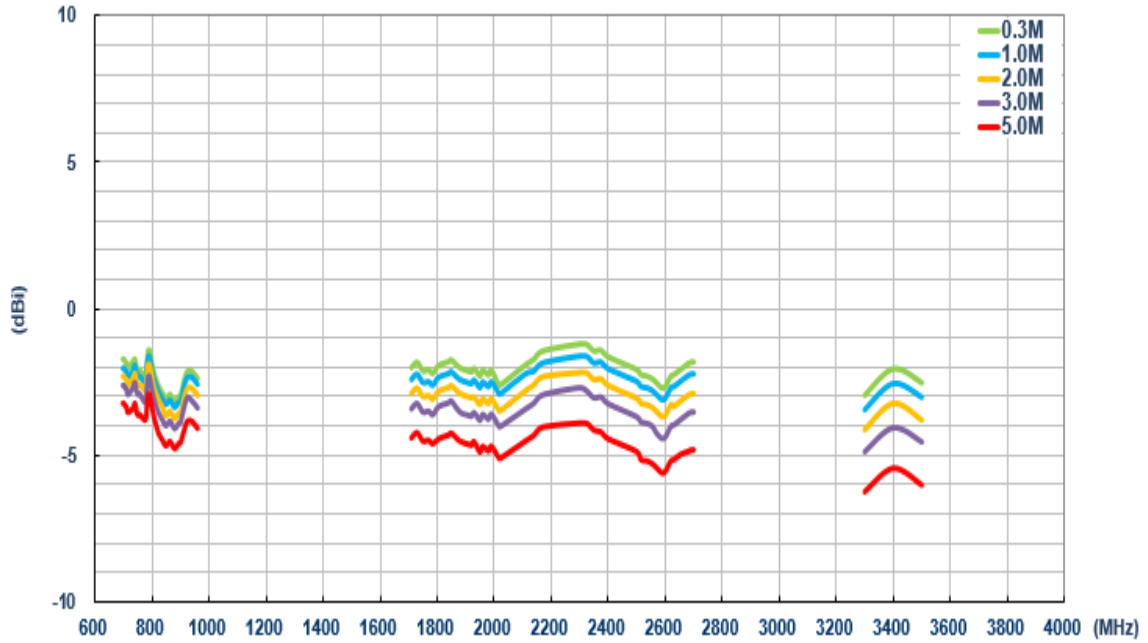
### 6.9.5 Efficiency (LTE\_MIMO\_2)



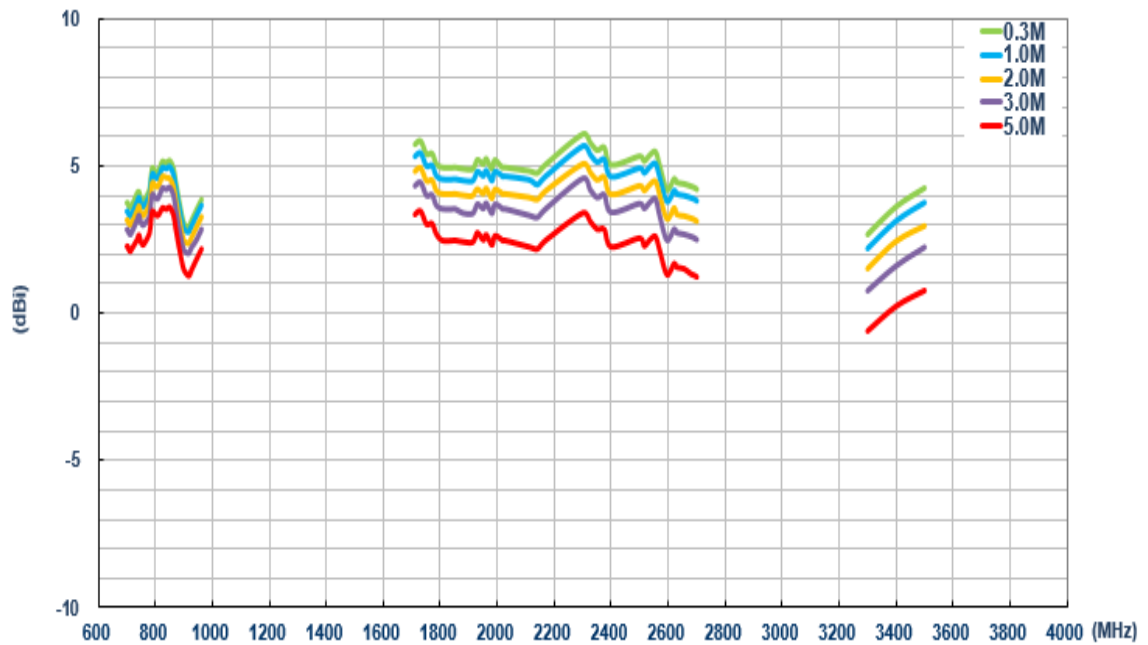
### 6.9.6 Average Gain (LTE\_MIMO\_1)



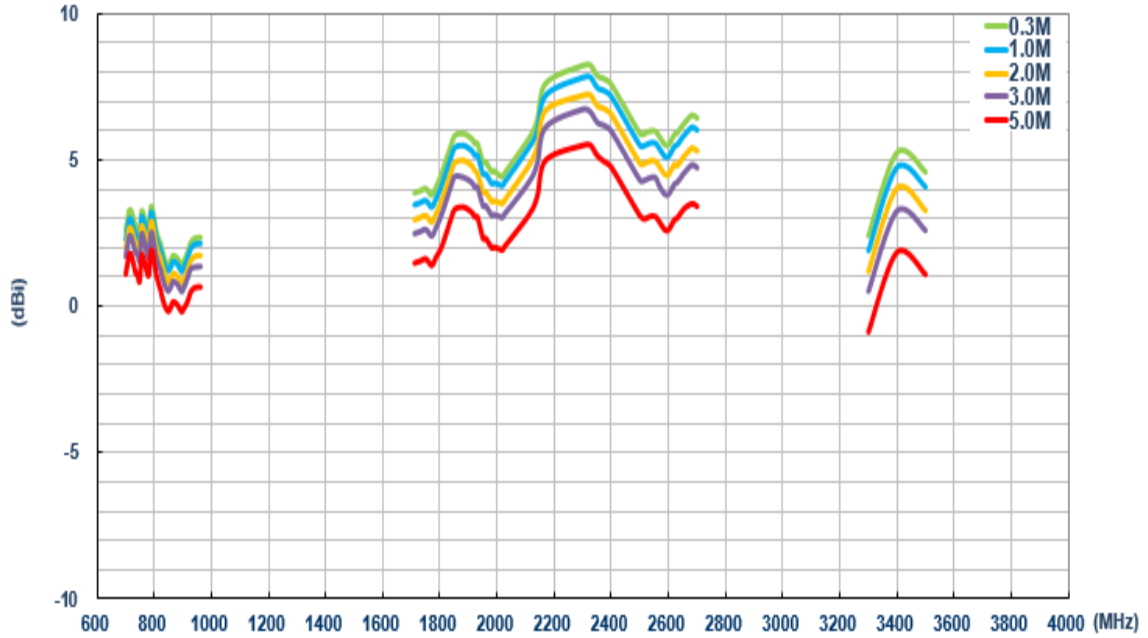
### 6.9.7 Average Gain (LTE\_MIMO\_2)



### 6.9.8 Peak Gain (LTE\_MIMO\_1)

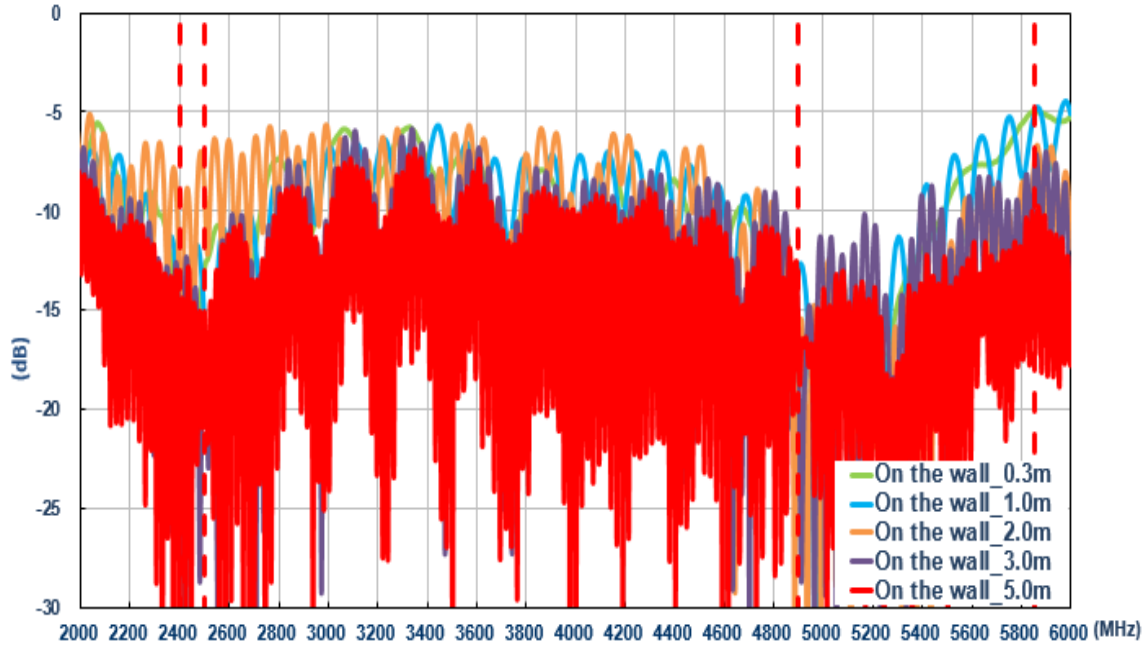


### 6.1.9 Peak Gain (LTE\_MIMO\_2)

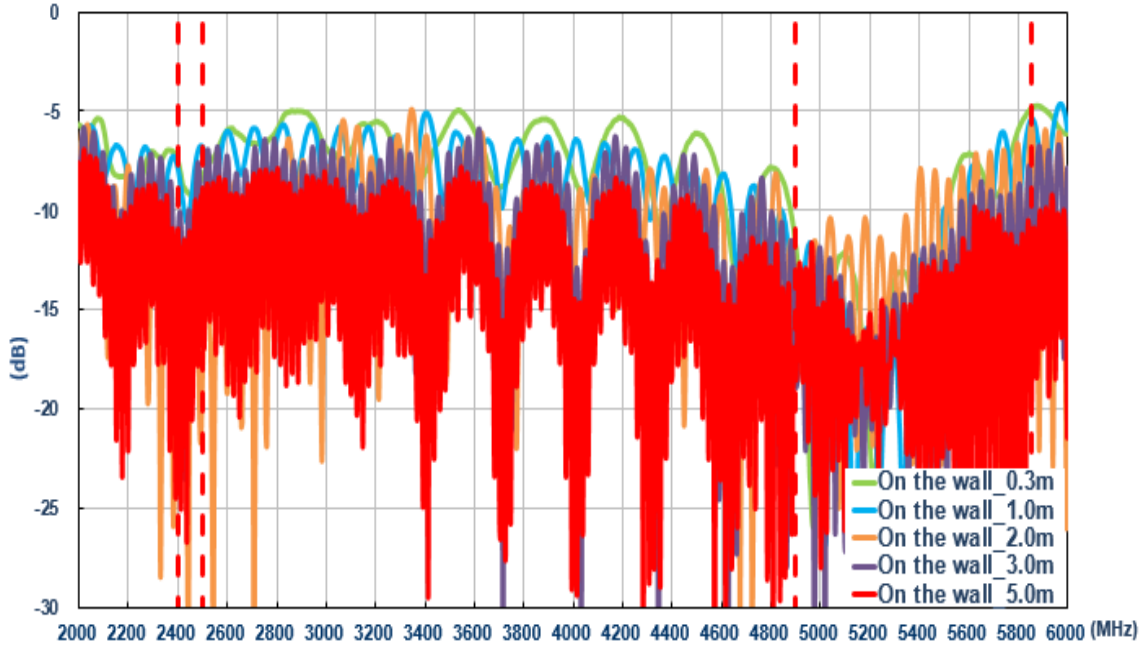


## 6.10 On the wall (Wi-Fi)

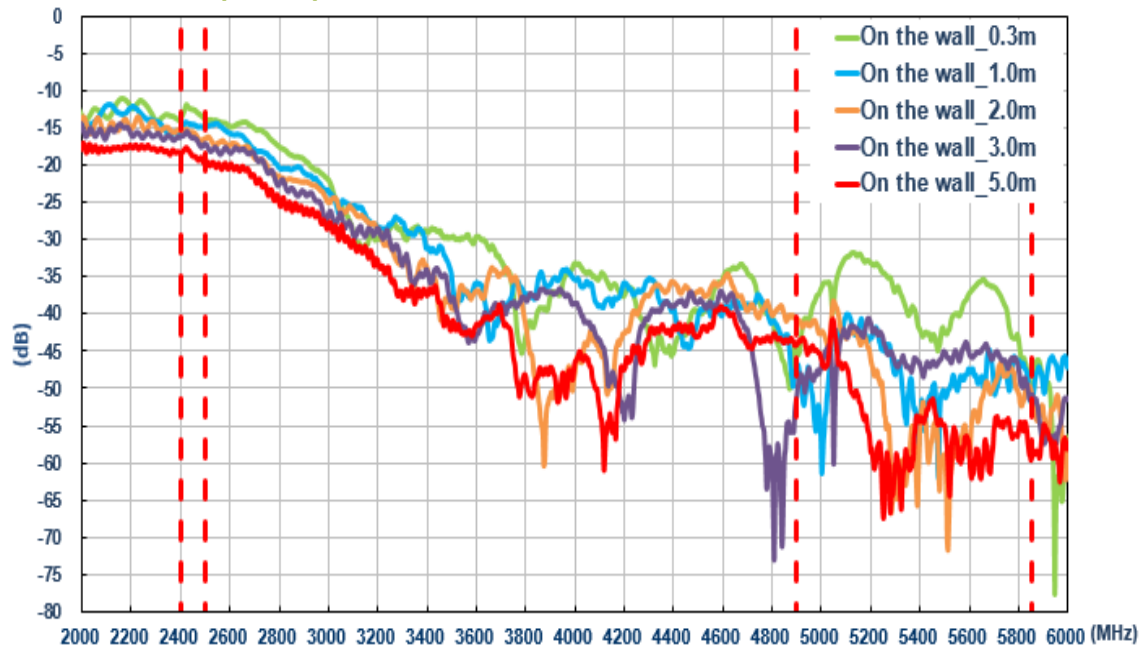
### 6.10.1 Return Loss (Wi-Fi\_MIMO\_1)



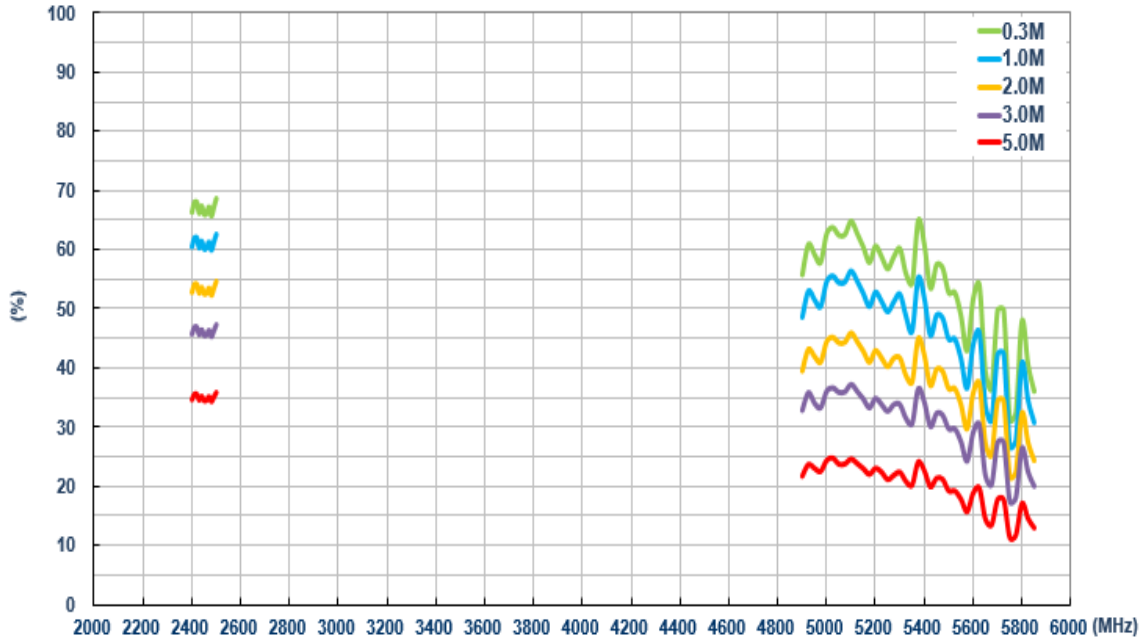
### 6.10.2 Return Loss (Wi-Fi\_MIMO\_2)



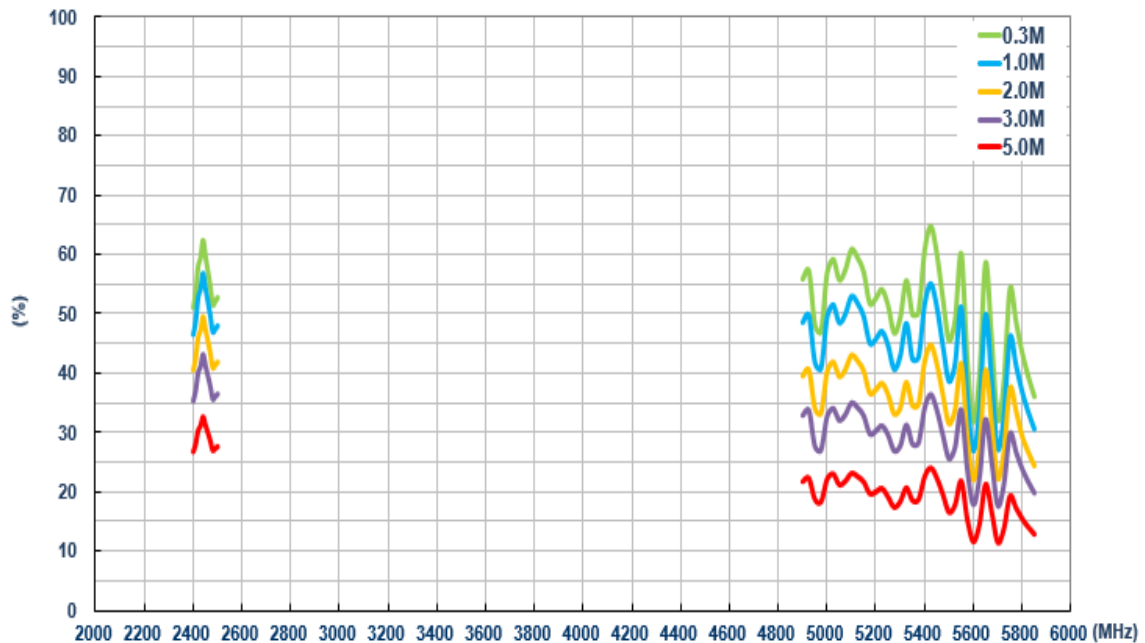
### 6.10.3 Isolation (Wi-Fi)



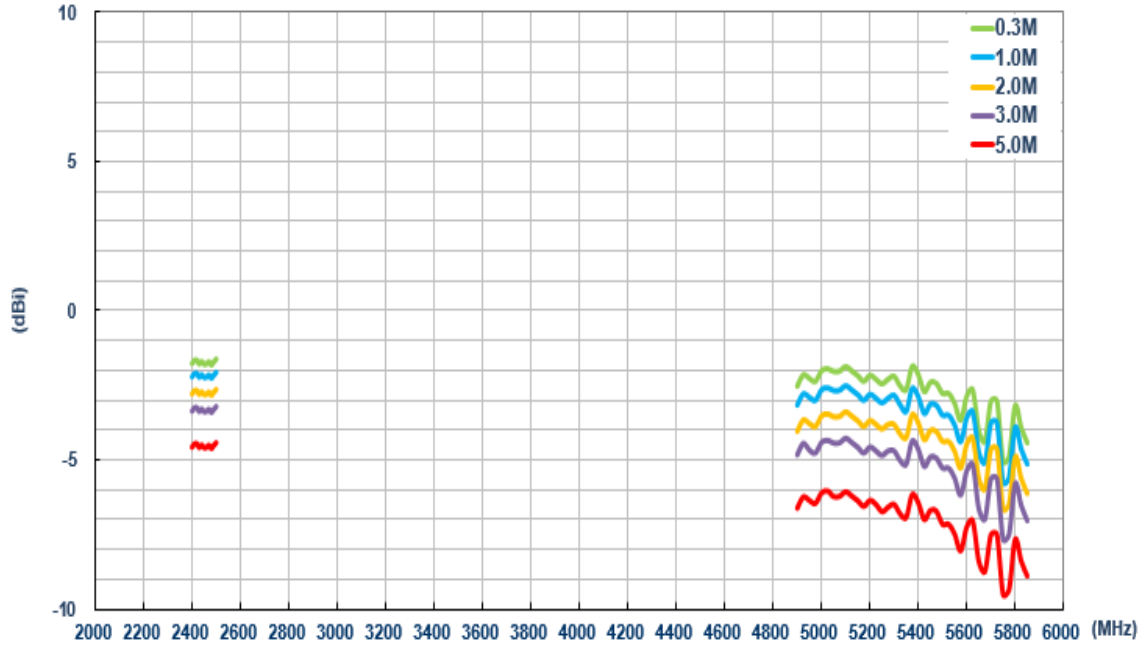
### 6.10.4 Efficiency (Wi-Fi\_MIMO\_1)



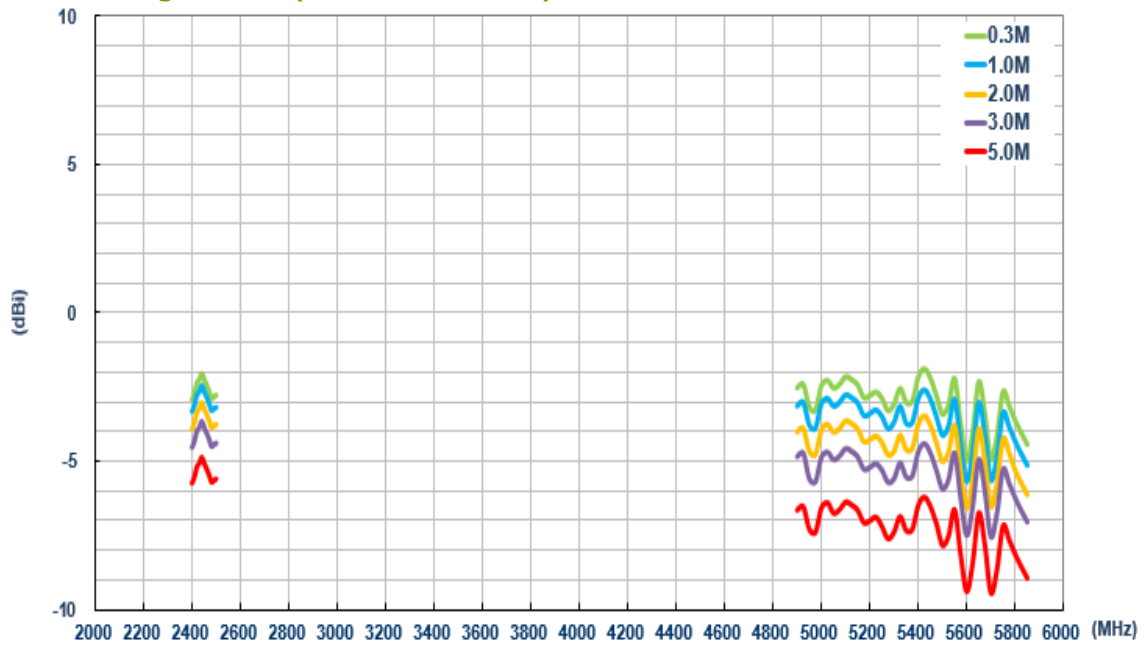
### 6.10.5 Efficiency (Wi-Fi\_MIMO\_2)



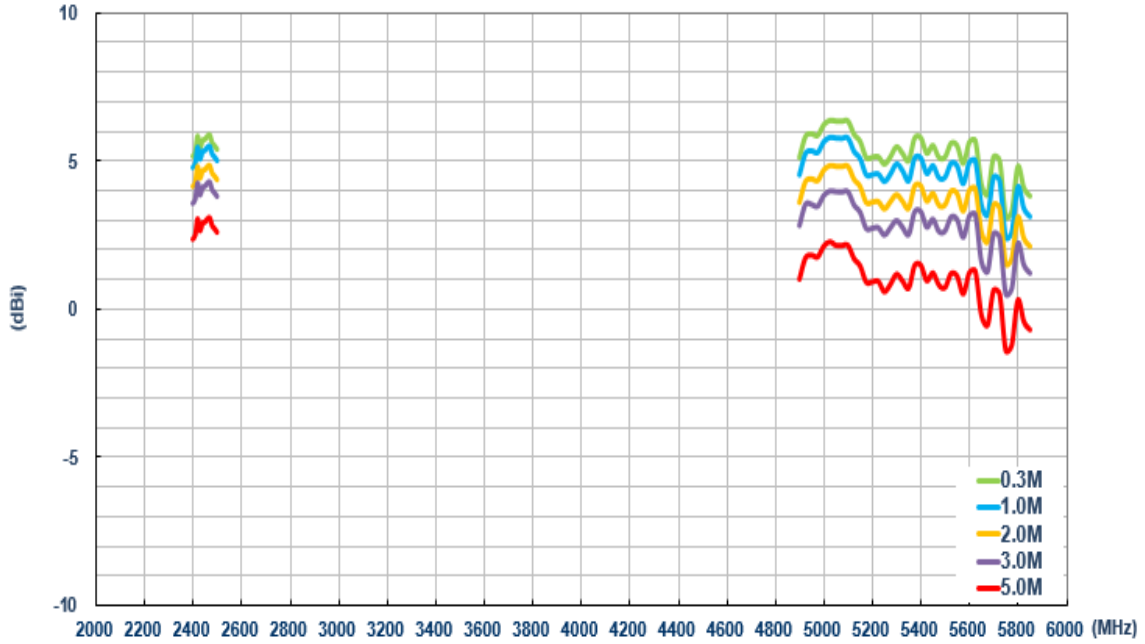
### 6.10.6 Average Gain (Wi-Fi\_MIMO\_1)



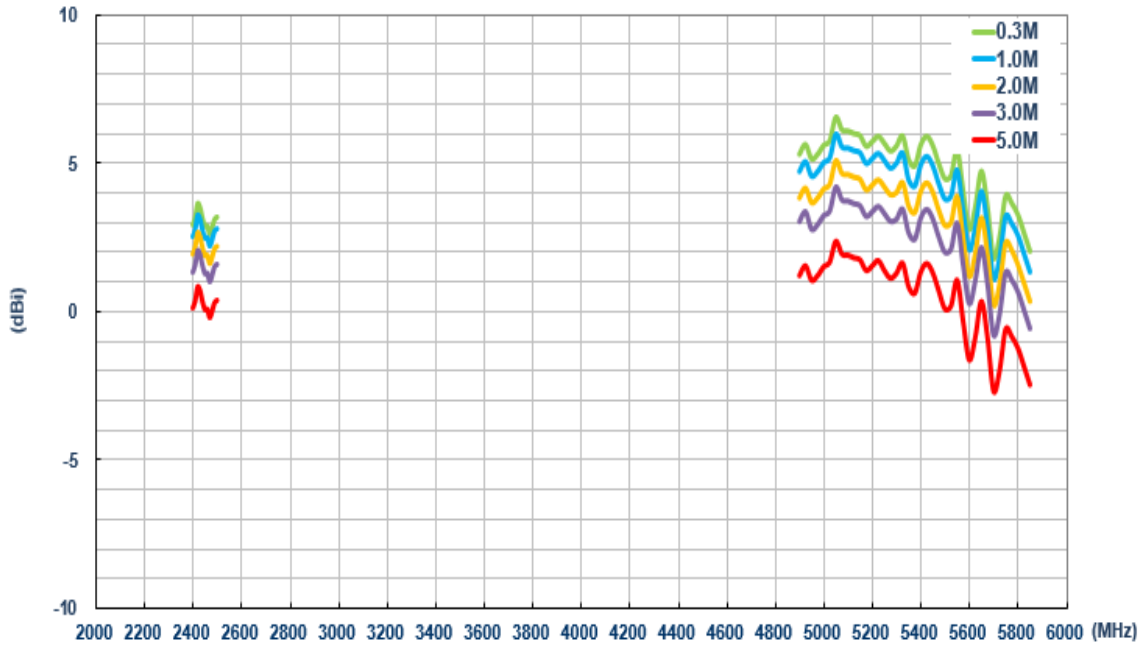
### 6.10.7 Average Gain (Wi-Fi\_MIMO\_2)



### 6.10.8 Peak Gain (Wi-Fi\_MIMO\_1)



### 6.10.9 Peak Gain (Wi-Fi\_MIMO\_2)





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