SPECIFICATION

Part No. : **MA412.A.BI.001**

Product Name : MA412 Storm 2in1 Screwmount Antenna
LTE MIMO 2in1

Features : 2* LTE MIMO 698 to 960MHz/1710 to 2170MHz/
2490 to 2690MHz Antenna
Screw-Mount [Permanent Mount]
Worldwide 4G Bands including 3G and 2G
Suitable for worldwide HSPA/GSM/GPRS/CDMA/UMTS
Aerodynamic, Super Low-profile Vandal Resistant Housing
IP67 Enclosure
Dims: 216.24*93.25*30.95mm
0.3M CFD-200 with Fakra connectors as standard
Custom Cables and Connectors Available
RoHS Compliant

Side view

Top view

1. Introduction

The Storm MA412 LTE MIMO antenna is a low profile, heavy-duty, fully IP67 waterproof external M2M antenna for use in worldwide telematics applications which require best in class LTE performance.

This unique product, only 30mm high, delivers powerful worldwide 4G LTE MIMO antenna technology at 700MHz / 800MHz / 900MHz / 1700MHz / 1800MHz / 1900MHz / 2600MHz.

Typical applications
- HD Video over LTE
- First Responder and Emergency Services
-Intelligent Transport Systems
-Internet of Things (IoT market)
-High Definition Video Broadcast Systems
-Wireless LTE MIMO M2M Devices
-Digital Signage

LTE 4G 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 between the two MIMO antennas to prevent self-interference. Low loss cables are used to keep efficiency high over long cable lengths. In contrast, smaller MIMO antennas with poorer quality thinner cables will have much reduced efficiency and isolation, which would lead to a large drop in system throughput or drops, and may indeed not make a system connection at all.

We have a version with SMA(M) also as standard MA412.A.BI.003. Cable length and connector types are customizable. Contact your regional Taoglas sales office for support.

2. Specification

2G/3G/4G MIMO1 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
Efficiency (%)									
On the 50*50cm ground plane	30cm	62.06	41.76	49.16	44.93	59.56	59.39	55.42	37.39
	1M	59.27	39.88	46.95	40.98	54.46	54.71	50.55	33.33
	2M	55.31	36.93	42.81	36.86	48.53	48.56	43.53	27.99
	3M	51.62	34.20	39.76	32.65	42.73	42.47	36.84	23.59
	5M	44.25	28.85	33.36	25.50	32.98	32.90	28.22	16.96
In free space	30cm	65.08	48.08	55.44	49.41	57.62	59.92	54.98	38.19
	1M	62.15	45.91	52.95	45.06	52.69	55.18	50.14	34.83
	2M	58.00	42.54	48.29	40.62	46.96	48.99	43.17	29.65
	3M	54.13	39.46	44.80	35.92	41.31	42.84	36.53	24.66
	5M	46.39	33.24	37.60	28.10	31.89	33.19	27.99	19.14
Average Gain(dBi)									
On the 50*50cm ground plane	30cm	-2.22	-3.98	-3.20	-3.55	-2.27	-2.27	-2.57	-4.36
	1M	-2.42	-4.18	-3.40	-3.95	-2.66	-2.63	-2.97	-4.86
	2M	-2.72	-4.51	-3.80	-4.40	-3.16	-3.14	-3.62	-5.61
	3M	-3.02	-4.84	-4.13	-4.94	-3.72	-3.73	-4.35	-6.36
	5M	-3.70	-5.58	-4.88	-6.00	-4.84	-4.84	-5.50	-7.79
In free space	30cm	-2.02	-3.19	-2.60	-3.11	-2.42	-2.23	-2.62	-4.25
	1M	-2.22	-3.39	-2.80	-3.51	-2.81	-2.59	-3.02	-4.65
	2M	-2.52	-3.72	-3.20	-3.97	-3.31	-3.10	-3.67	-5.35
	3M	-2.82	-4.05	-3.52	-4.50	-3.86	-3.69	-4.39	-6.15
	5M	-3.50	-4.79	-4.28	-5.57	-4.98	-4.80	-5.55	-7.25
Peak Gain(dBi)									
On the 50*50cm ground plane	30cm	5.37	3.66	4.35	6.24	7.04	7.11	7.91	6.46
	1M	5.17	3.46	4.15	5.84	6.64	6.81	7.51	5.96
	2M	4.87	3.06	3.75	5.34	6.14	6.31	6.91	5.16
	3M	4.57	2.76	3.45	4.84	5.64	5.71	6.21	4.46
	5M	3.87	2.06	2.65	3.74	4.44	4.61	5.11	4.82
In free space	30cm	3.54	4.07	4.13	4.67	6.57	6.69	8.11	6.27
	1M	3.34	3.87	3.93	4.27	6.17	6.35	7.71	5.87
	2M	3.04	3.47	3.53	3.77	5.67	5.79	7.11	5.17
	3M	2.74	3.17	3.23	3.27	5.07	5.19	6.41	4.37
	5M	2.04	2.37	2.43	2.17	3.97	4.09	5.31	3.27

2G/3G/4G MIMO2 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
Efficiency (%)									
On the 50*50cm ground plane	30cm	64.02	46.23	45.95	66.28	61.93	55.94	67.23	32.20
	1M	61.13	44.15	43.91	60.45	56.58	51.48	61.32	28.70
	2M	57.05	40.91	40.05	54.37	50.43	45.69	52.80	24.24
	3M	53.25	37.91	37.20	48.10	44.46	39.97	44.69	20.32
	5M	45.57	31.95	31.19	37.61	34.31	30.95	34.23	14.73
In free space	30cm	55.35	40.93	43.23	62.98	59.12	53.24	67.13	31.79
	1M	52.86	39.09	41.29	57.44	54.01	49.00	61.23	28.99
	2M	49.33	36.19	37.65	51.67	48.14	43.49	52.73	24.68
	3M	46.04	33.55	34.96	45.71	42.45	38.04	44.63	20.53
	5M	39.41	28.29	29.34	35.75	32.75	29.46	34.18	15.93
Average Gain(dBi)									
On the 50*50cm ground plane	30cm	-2.17	-3.38	-3.48	-1.84	-2.17	-2.57	-1.73	-5.25
	1M	-2.37	-3.58	-3.68	-2.24	-2.56	-2.93	-2.13	-5.75
	2M	-2.67	-3.91	-4.08	-2.69	-3.06	-3.44	-2.78	-6.50
	3M	-2.97	-4.23	-4.41	-3.23	-3.62	-4.03	-3.50	-7.25
	5M	-3.64	-4.98	-5.17	-4.29	-4.74	-5.14	-4.66	-8.68
In free space	30cm	-2.87	-3.93	-3.71	-2.04	-2.39	-2.80	-1.73	-5.28
	1M	-3.07	-4.13	-3.91	-2.44	-2.78	-3.16	-2.13	-5.68
	2M	-3.37	-4.46	-4.31	-2.90	-3.28	-3.67	-2.78	-6.38
	3M	-3.67	-4.79	-4.63	-3.43	-3.84	-4.26	-3.51	-7.18
	5M	-4.35	-5.53	-5.39	-4.50	-4.96	-5.37	-4.67	-8.28
Peak Gain(dBi)									
On the 50*50cm ground plane	30cm	6.51	4.09	3.82	7.93	8.06	7.89	8.16	5.48
	1M	6.31	3.89	3.62	7.53	7.66	7.49	7.76	4.98
	2M	6.01	3.59	3.22	7.03	7.16	6.99	7.16	4.28
	3M	5.71	3.19	2.92	6.53	6.66	6.49	6.46	3.48
	5M	5.01	2.49	2.22	5.43	5.46	5.29	5.36	2.18
In free space	30cm	5.21	2.85	3.16	7.48	7.48	7.29	8.13	5.37
	1M	5.01	2.65	2.96	7.08	7.08	6.89	7.73	4.97
	2M	4.71	2.25	2.56	6.58	6.58	6.39	7.13	4.27
	3M	4.41	1.95	2.26	6.08	6.08	5.88	6.43	3.47
	5M	3.71	1.15	1.46	4.98	4.98	4.69	5.33	2.37

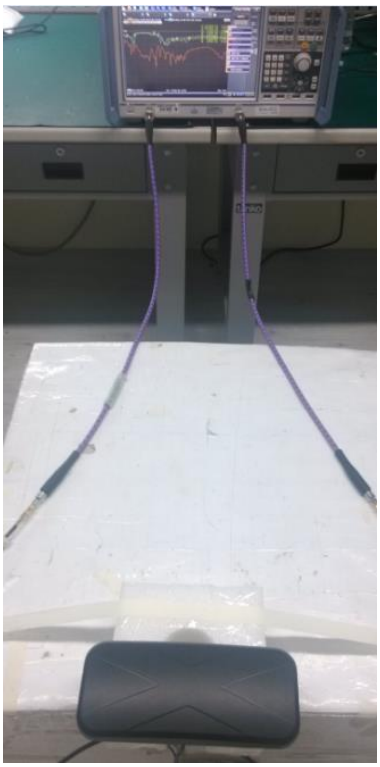
Impedance	50Ω
Polarization	Linear
VSWR	< 3.5
Cable	0.3 meter CFD200 standard, fully customizable
Connector	Fakra(Jack) standard connector , fully customizable

MECHANICAL	
Antenna Dimensions	216.24*93.25*30.95mm
Casing	ABS+PC
Base and thread	Nickel Plated Aluminum
Weight	400g
Ingress Protection Rating	IP67
Maximum Assembly Torque	39.2 N-m
ENVIRONMENTAL	
Operation Temperature	-40°C to 85°C
Storage Temperature	-40°C to 90°C
Humidity	Non-condensing 65°C 95% RH

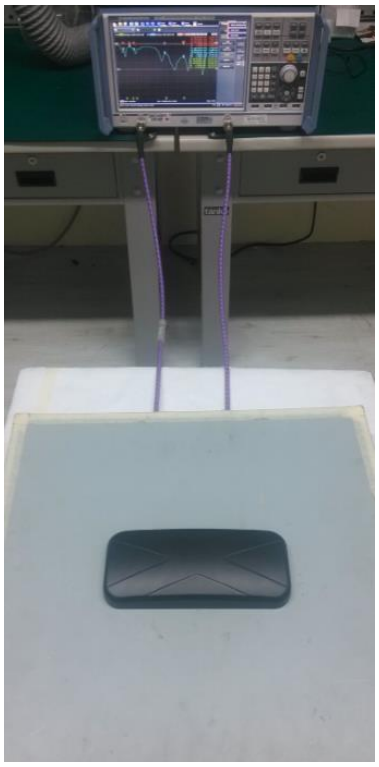
3. Antenna Characteristics

3.1 LTE MIMO Antenna

3.1.1 Test Setup



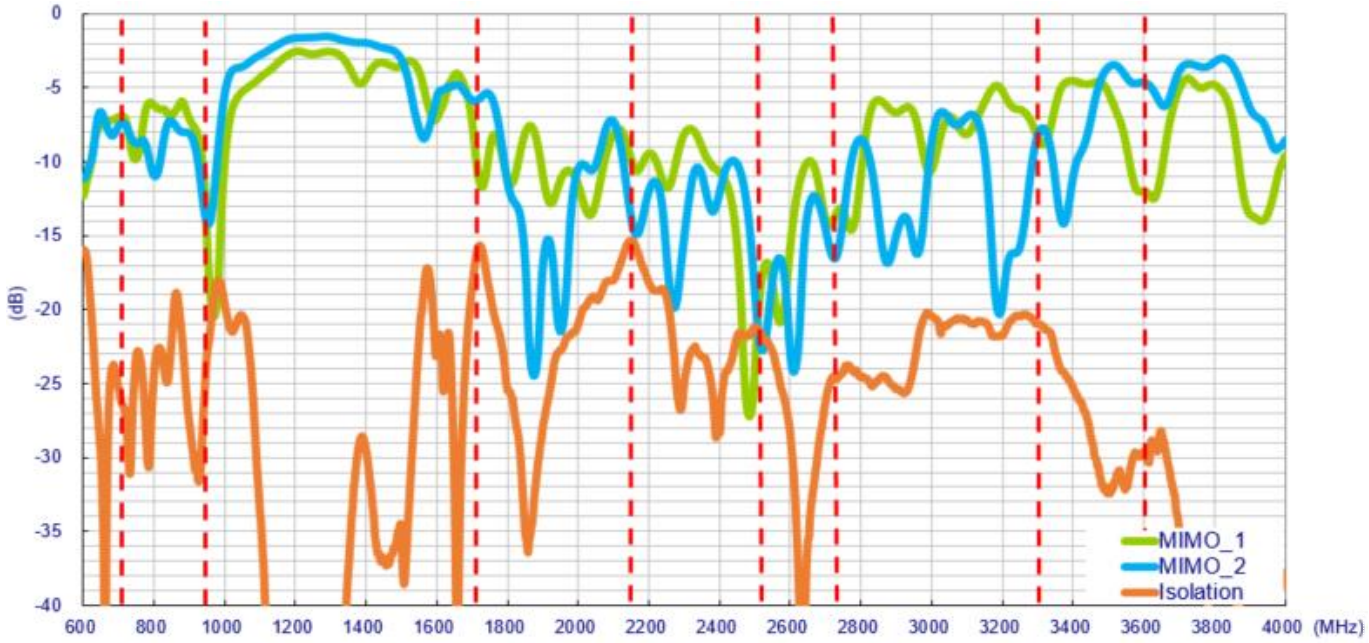
In free space



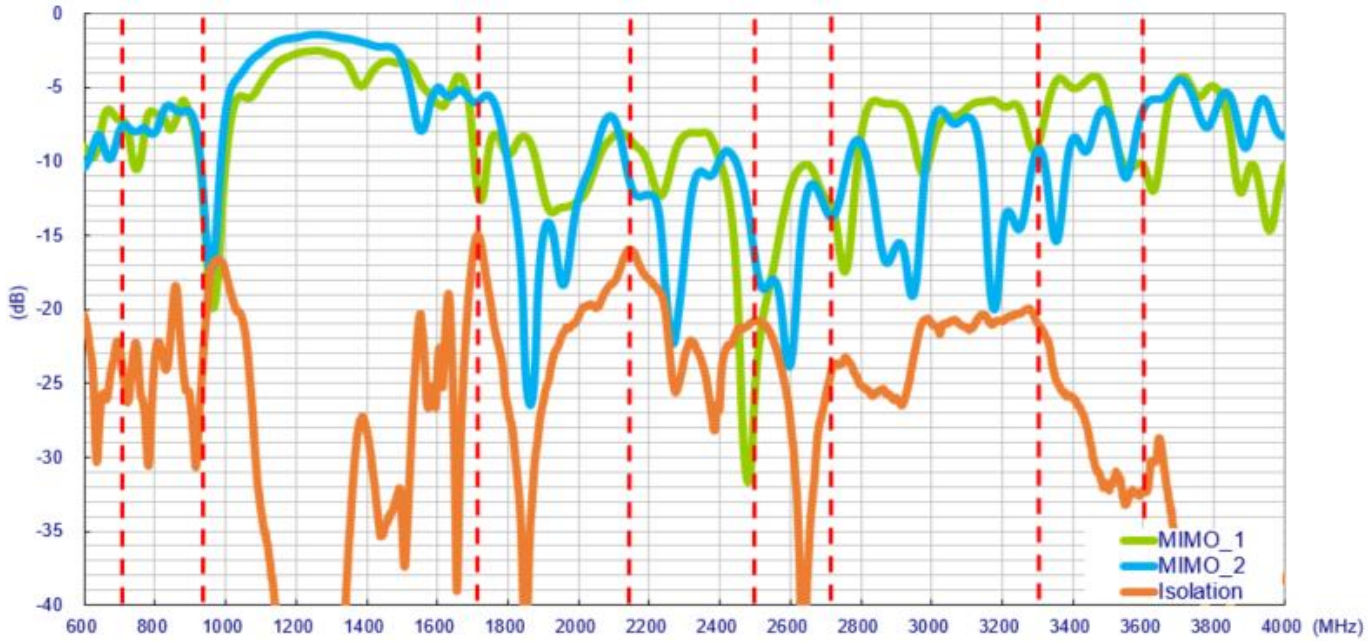
on the 50*50cm ground plane

3.1.2 LTE Antenna Return Loss

Setup on the 50*50cm ground plane with 0.3 meter cable length

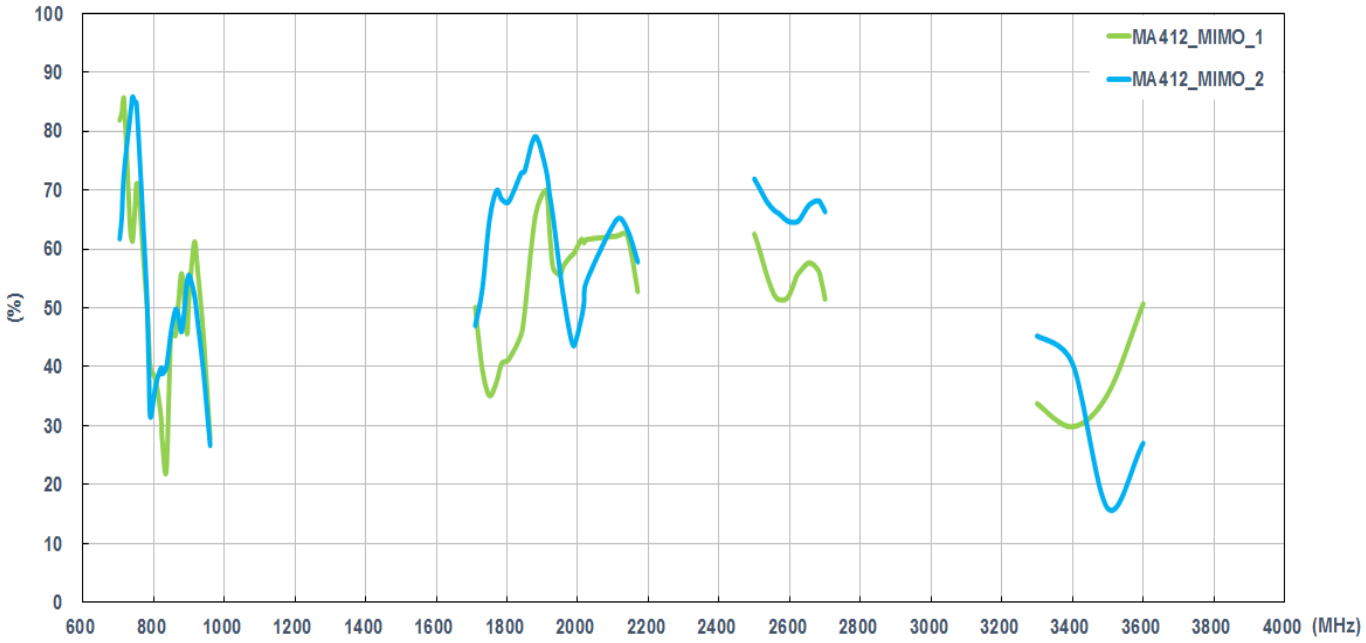


Setup in free space with 0.3 meter cable length

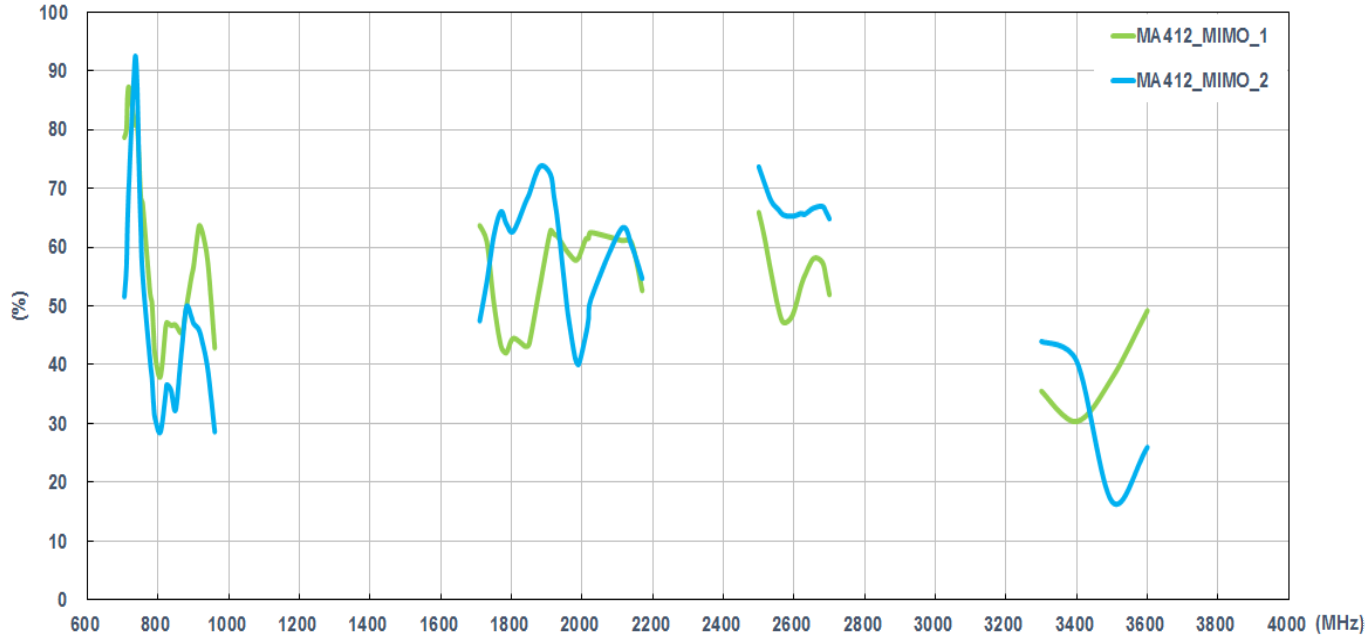


3.1.3 LTE Antenna Efficiency

Setup on the 50*50cm ground plane with 0.3 meter cable length

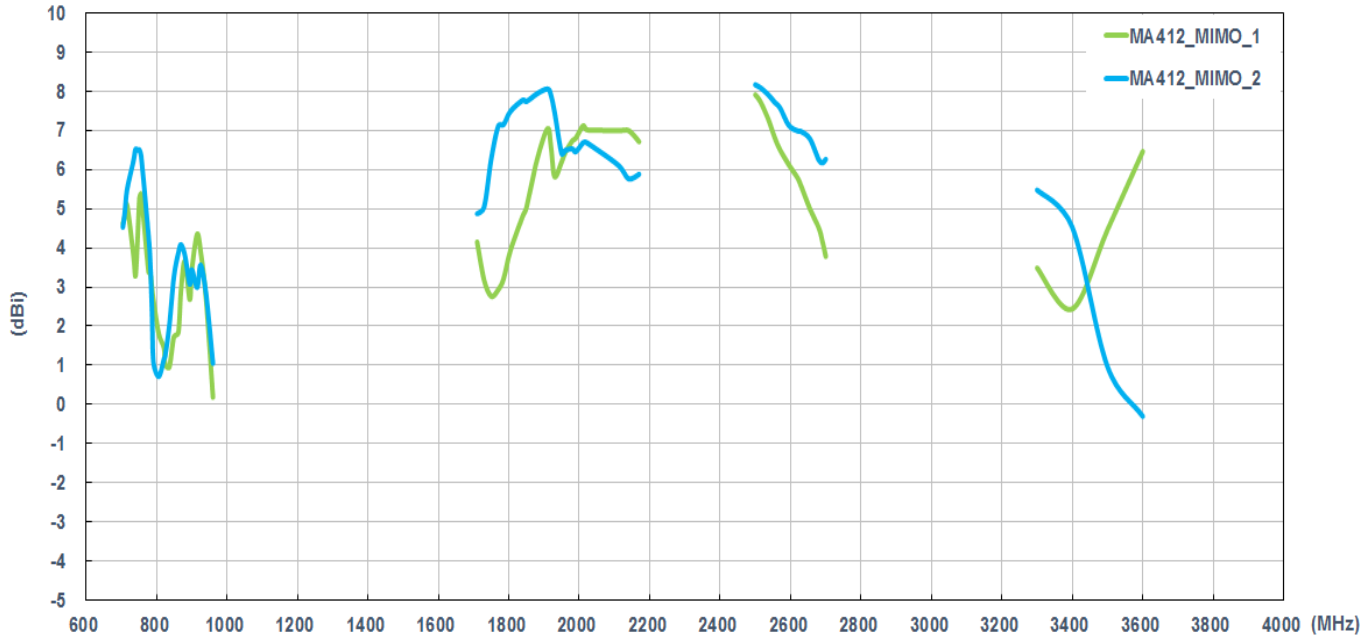


Setup in free space with 0.3 meter cable length

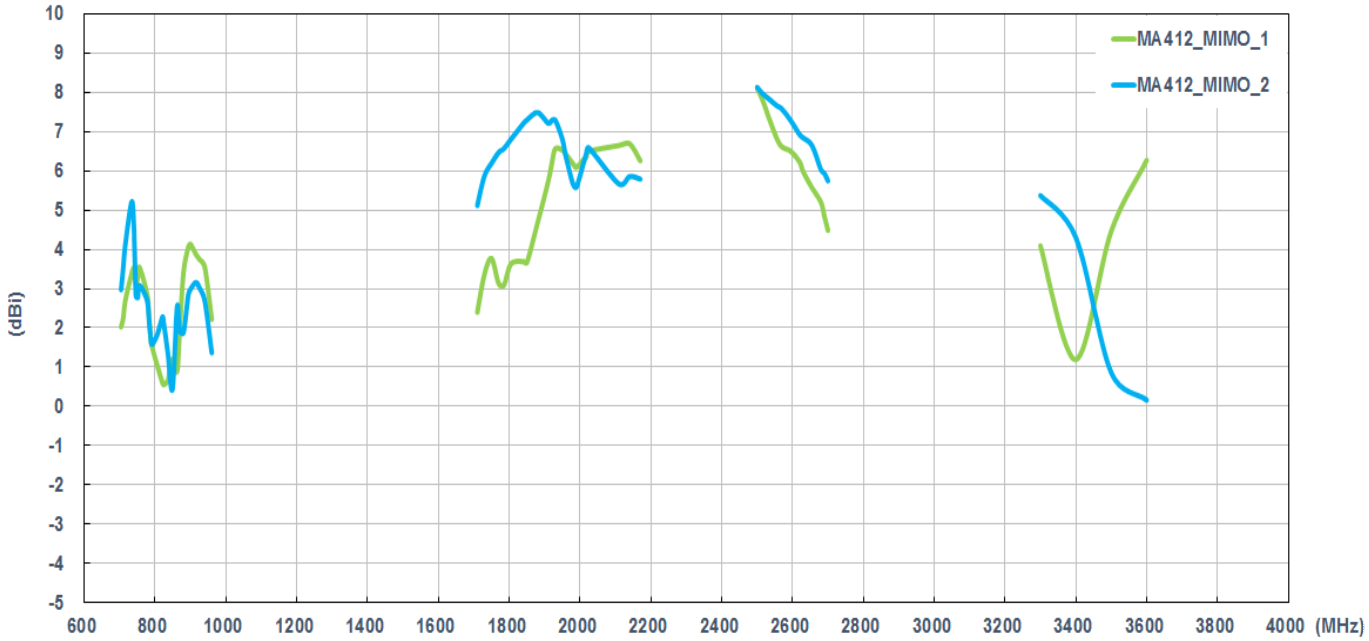


3.1.4 LTE Antenna Peak Gain

Setup on the 50*50cm ground plane with 0.3 meter cable length

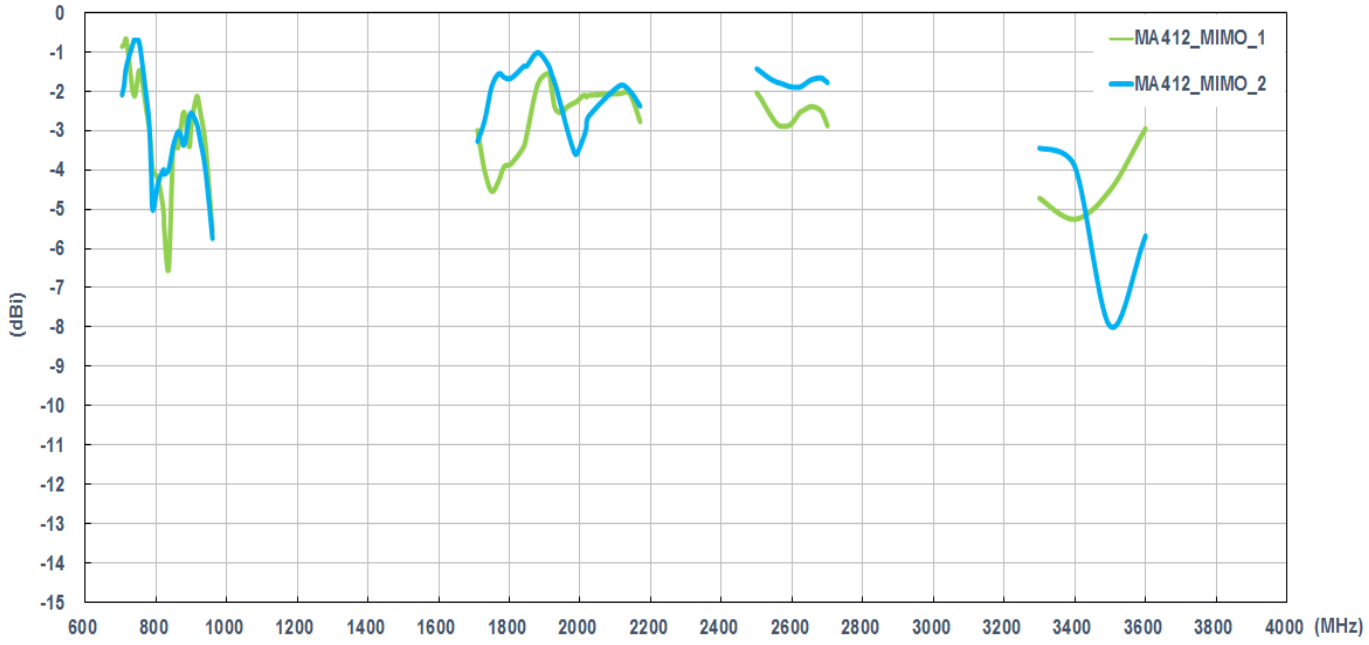


Setup in free space with 0.3 meter cable length

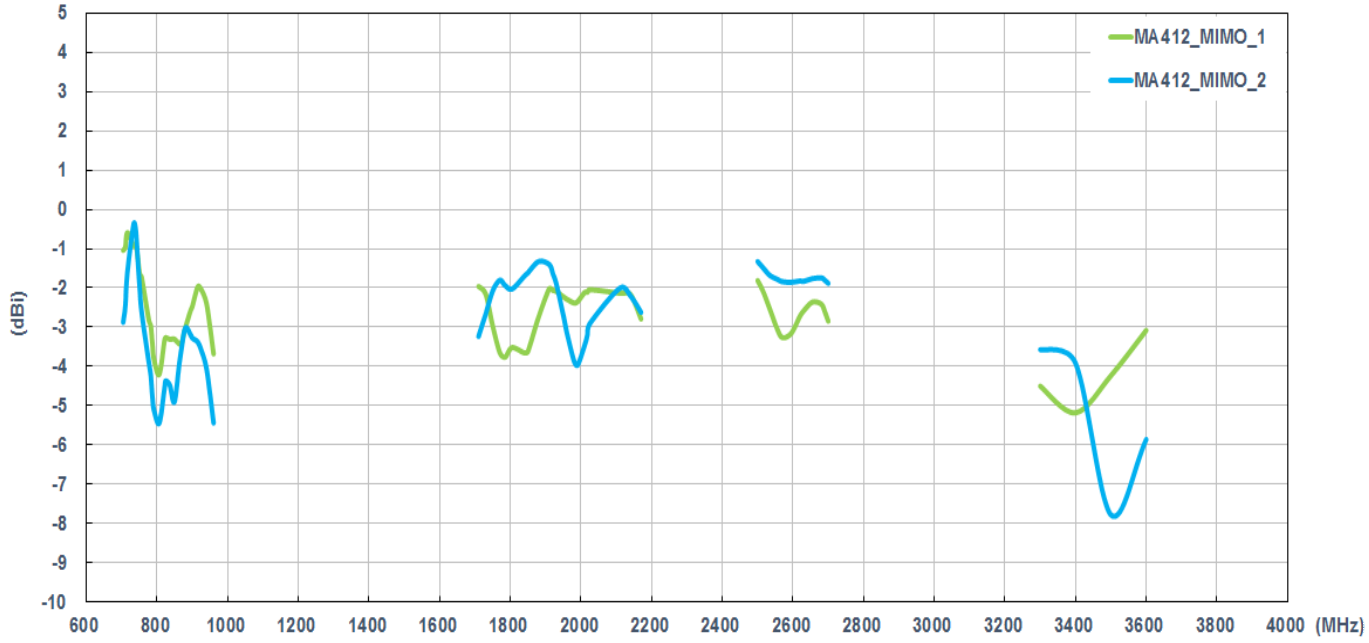


3.1.5 LTE Antenna Average gain

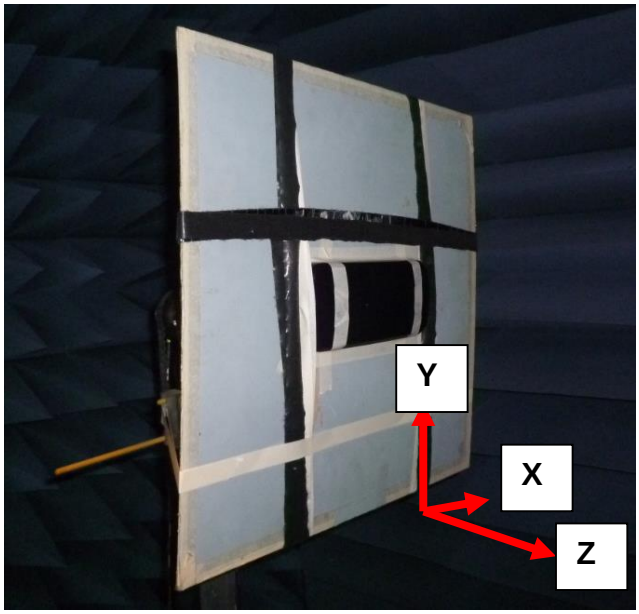
Setup on the 50*50cm ground plane with 0.3 meter cable length



Setup in free space with 0.3 meter cable length



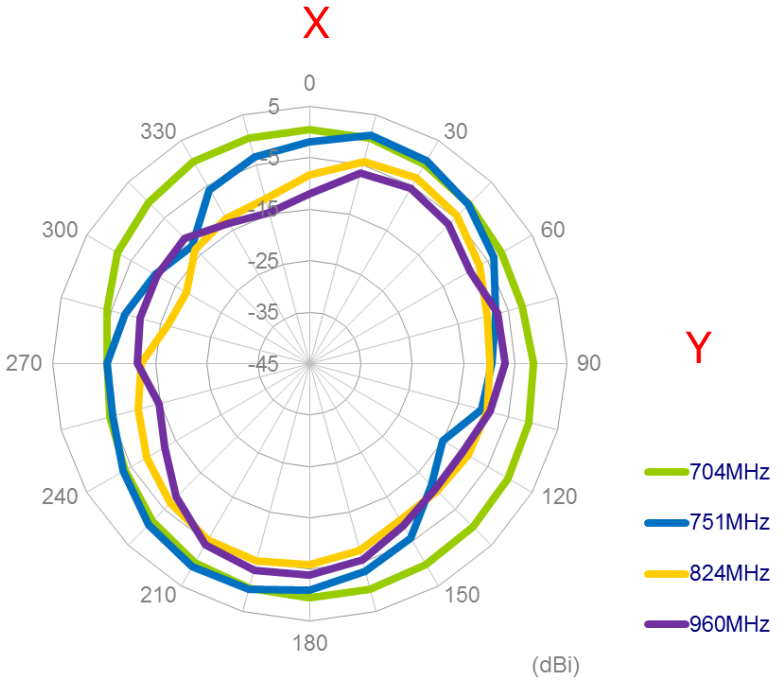
3.1.6 Test Setup For Antenna Radiation Pattern (ETS Anechoic chamber)

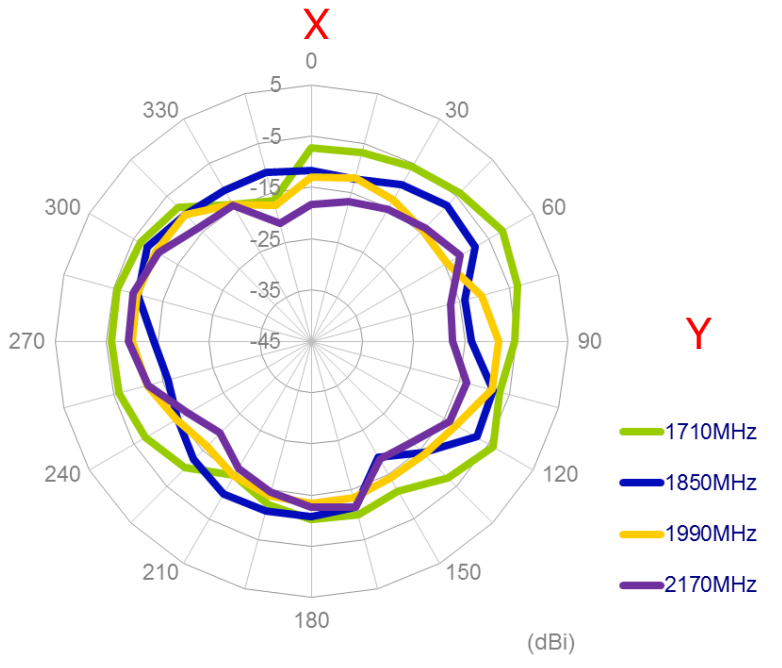


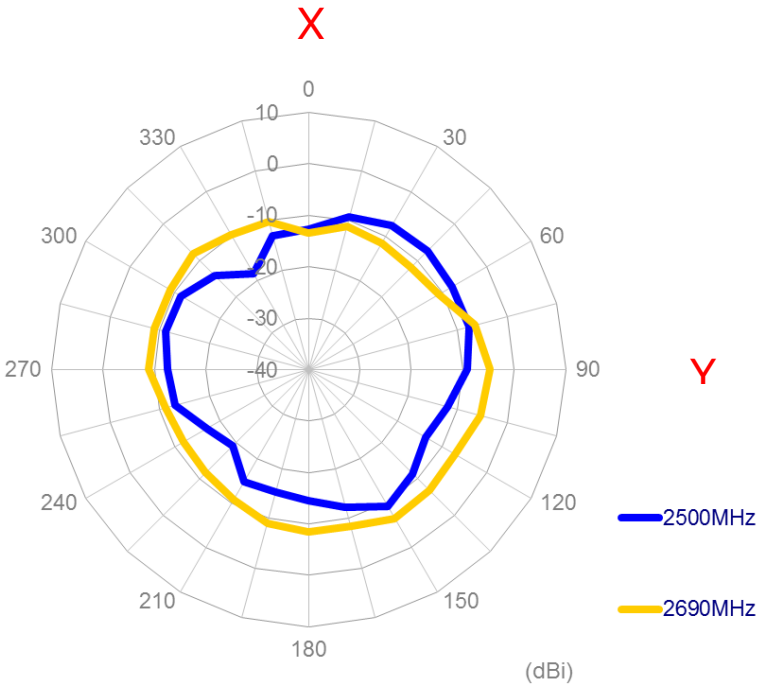
On the 50*50cm ground plane

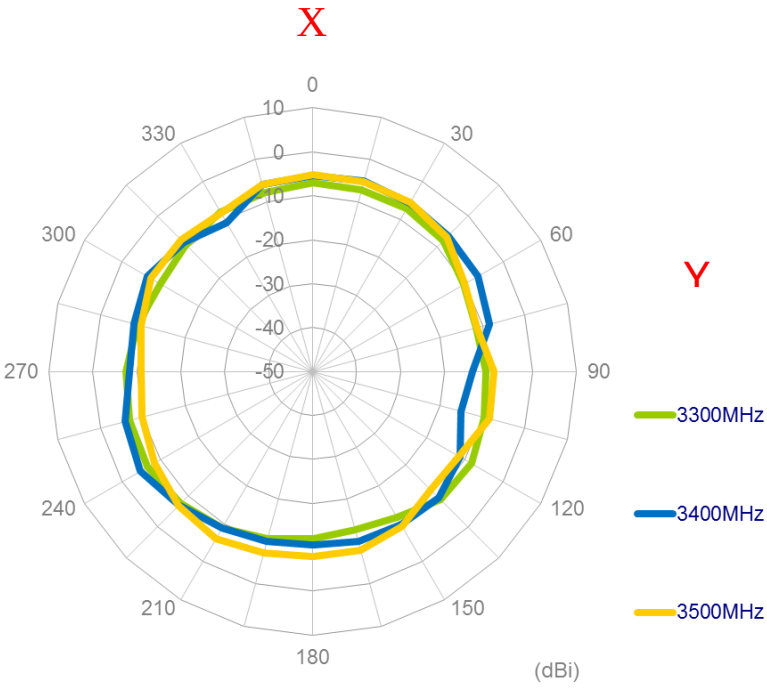
3.1.7 2D Radiation pattern (MIMO1 with 0.3M cable length on the 50*50 ground plane)

XY Plane

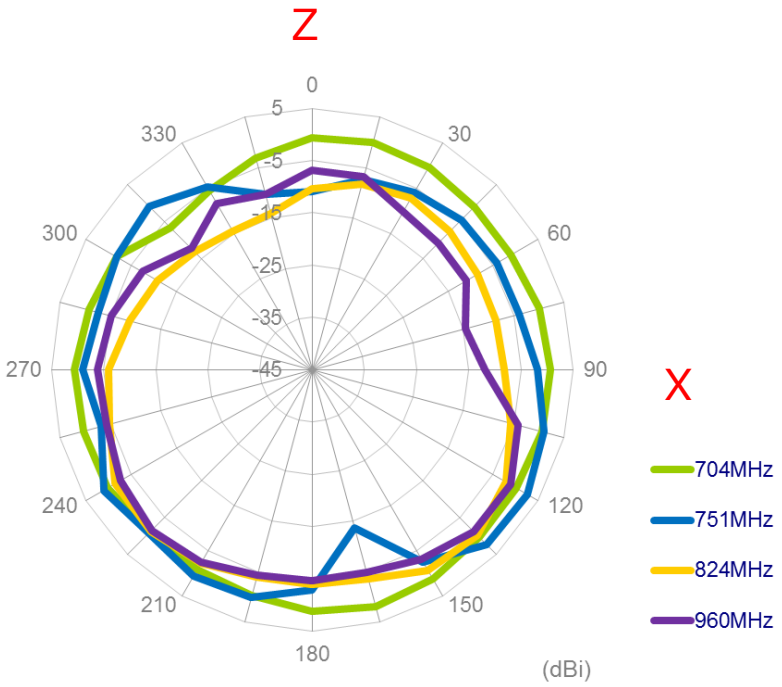


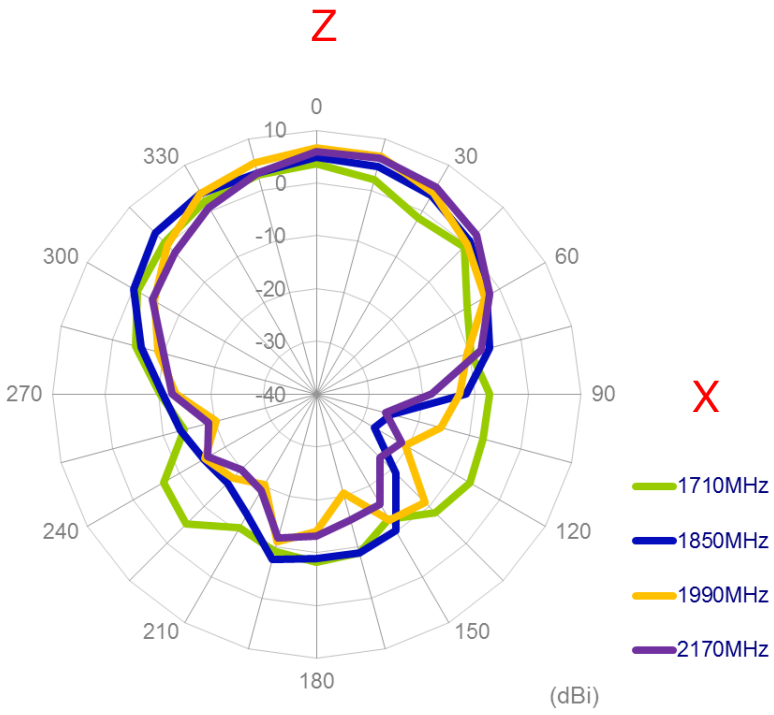


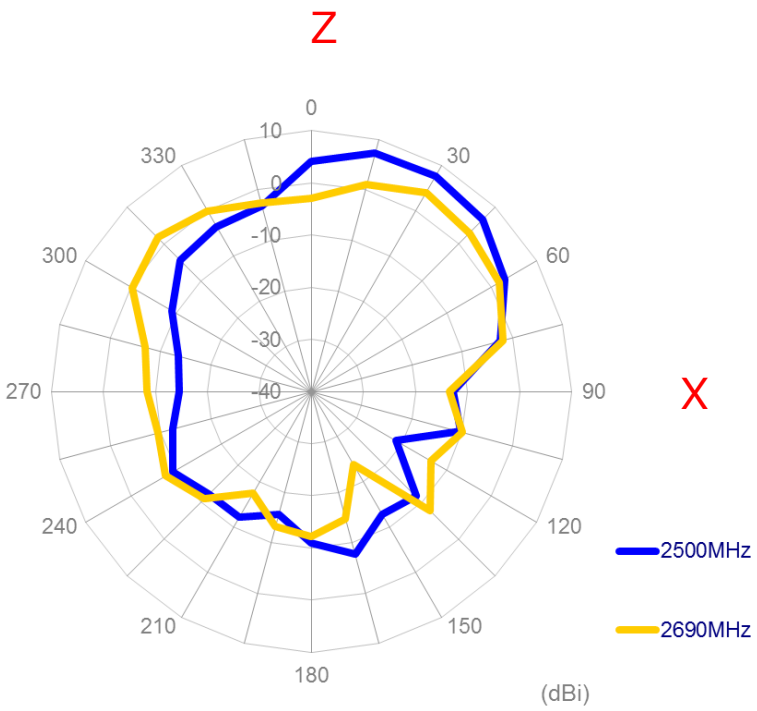

X
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
Y
2500MHz
2690MHz
(dBi)

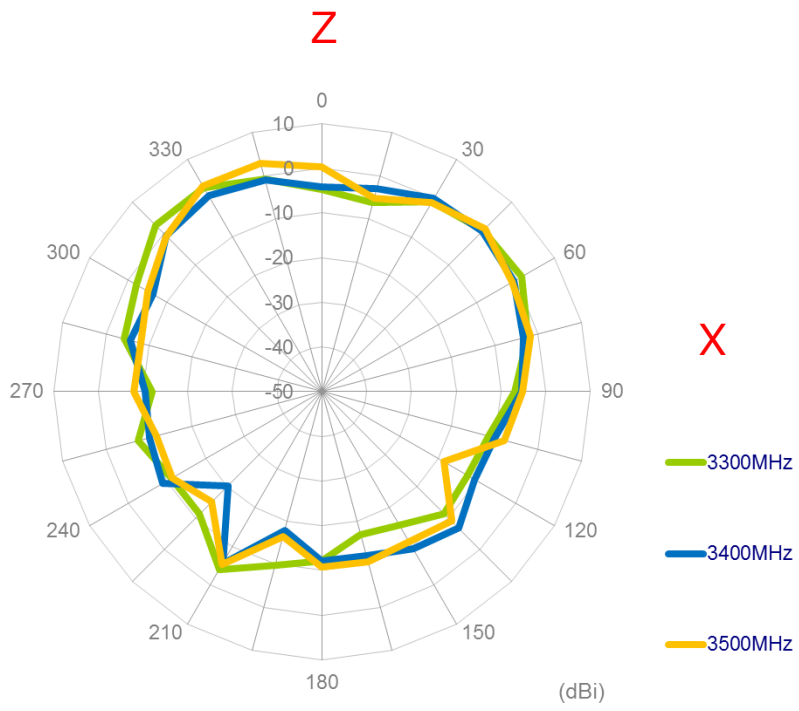

X
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
-50
Y
3300MHz
3400MHz
3500MHz
(dBi)

XZ Plane

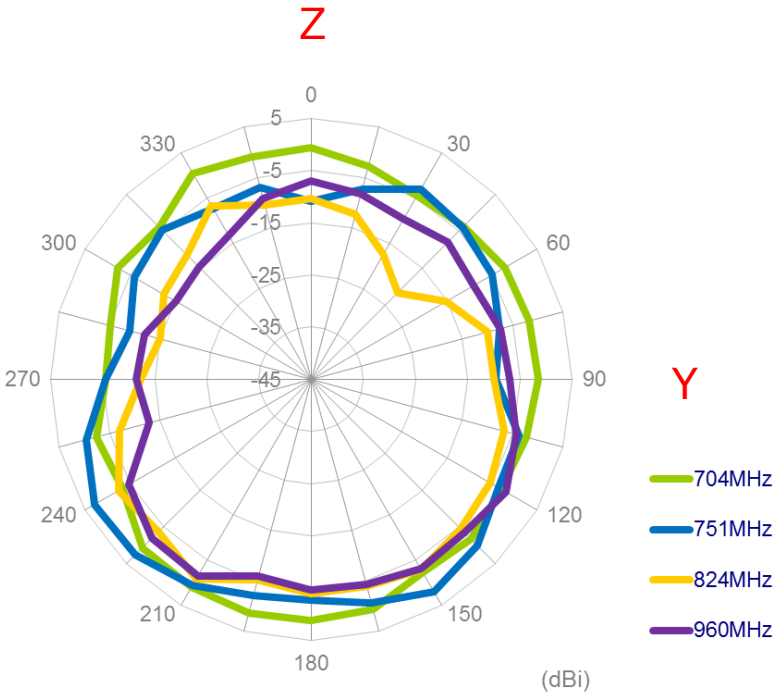

Z
0
30
60
90
120
150
180
210
240
270
300
330
5
-5
-15
-25
-35
-45
X
704MHz
751MHz
824MHz
960MHz
(dBi)

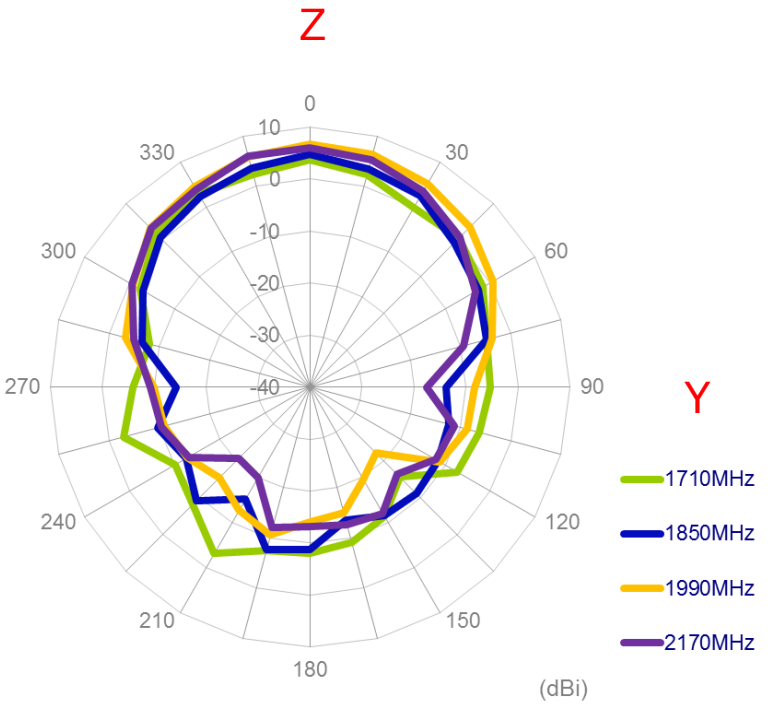

Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
X
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

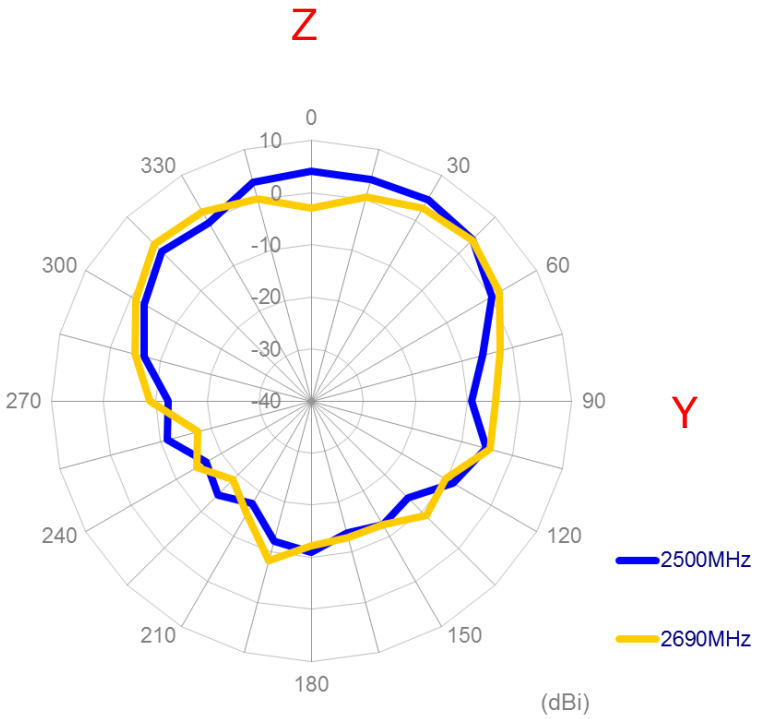

Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
X
2500MHz
2690MHz
(dBi)

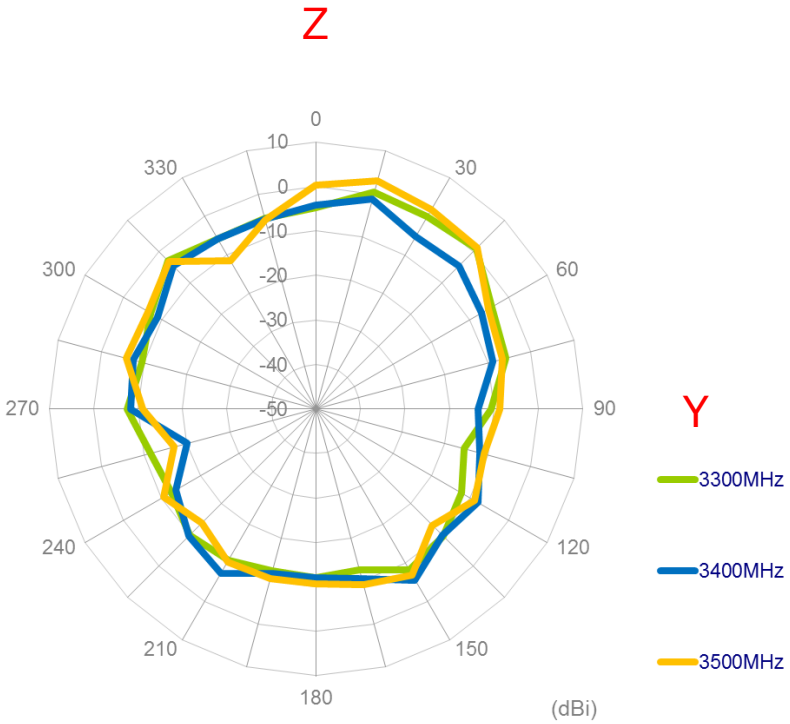

Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
-50
X
3300MHz
3400MHz
3500MHz
(dBi)

YZ Plane

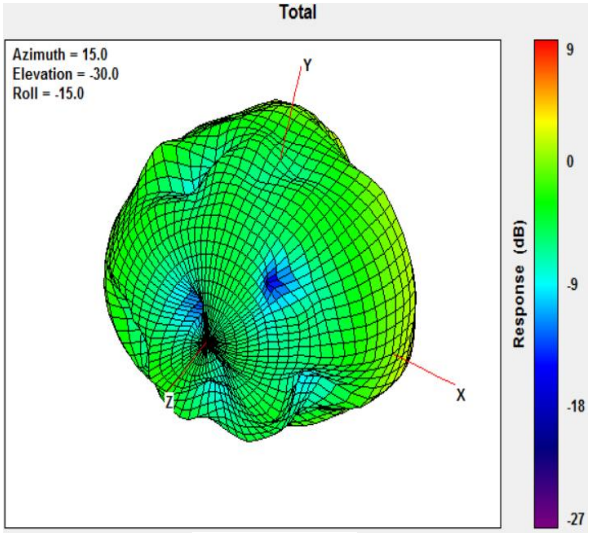

Z
0
30
60
90
120
150
180
210
240
270
300
330
5
-5
-15
-25
-35
-45
Y
704MHz
751MHz
824MHz
960MHz
(dBi)


Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
Y
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

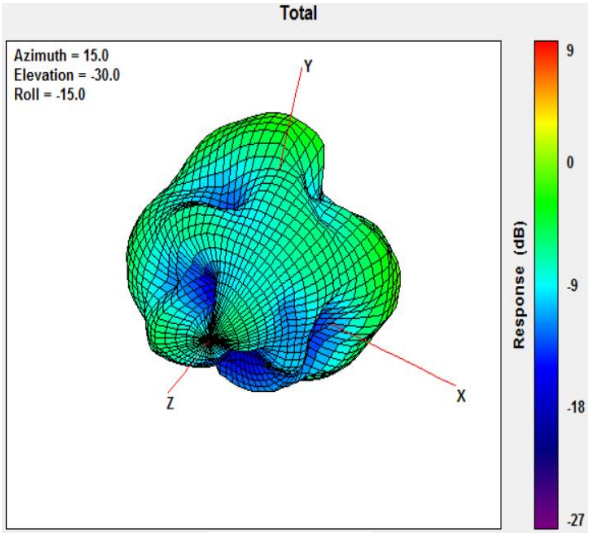

Z
0
10
30
60
90
120
150
180
210
240
270
300
330
0
-10
-20
-30
-40
Y
2500MHz
2690MHz
(dBi)


Z
0
10
30
60
90
120
150
180
210
240
270
300
330
0
-10
-20
-30
-40
-50
Y
3300MHz
3400MHz
3500MHz
(dBi)

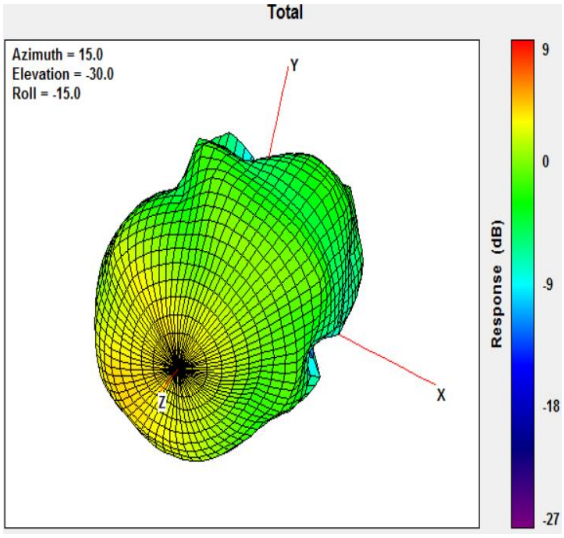
3.1.8 3D Radiation pattern (MIMO1 with 0.3M cable length on the 50*50 ground plane



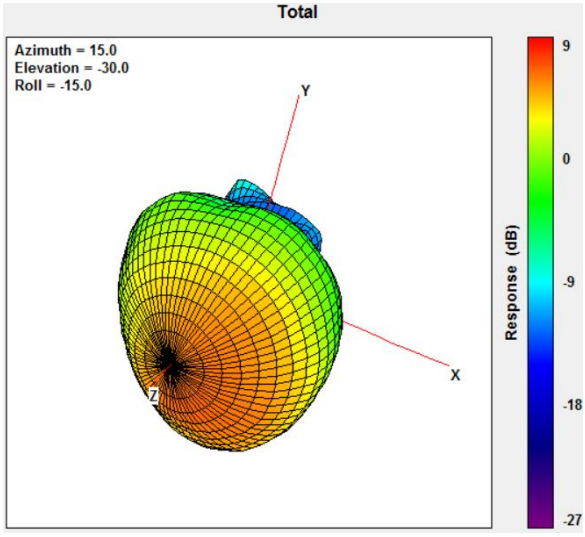
704MHz



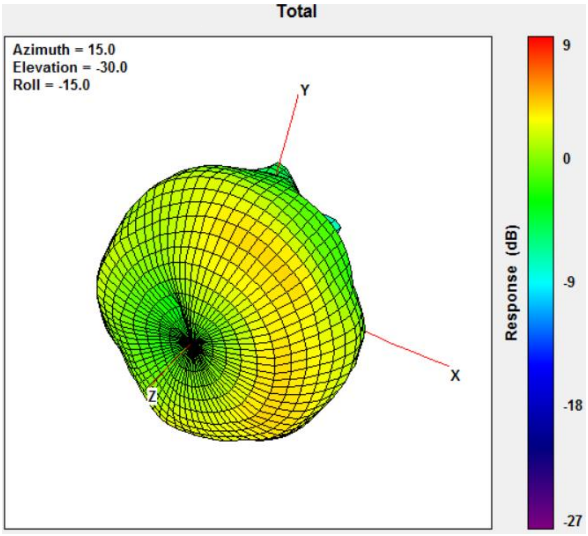
960MHz



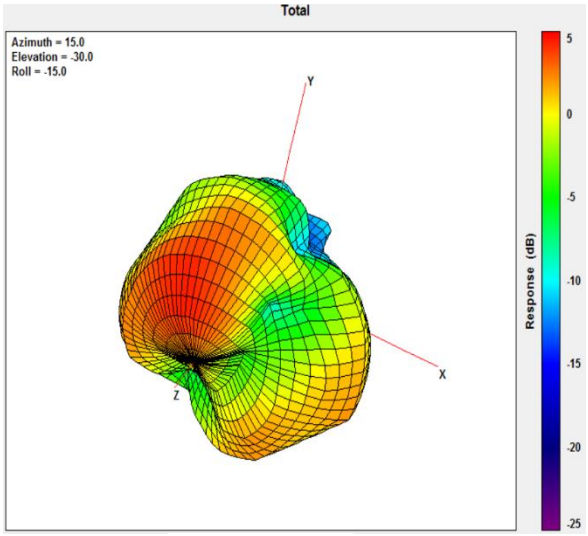
1710MHz



2170MHz



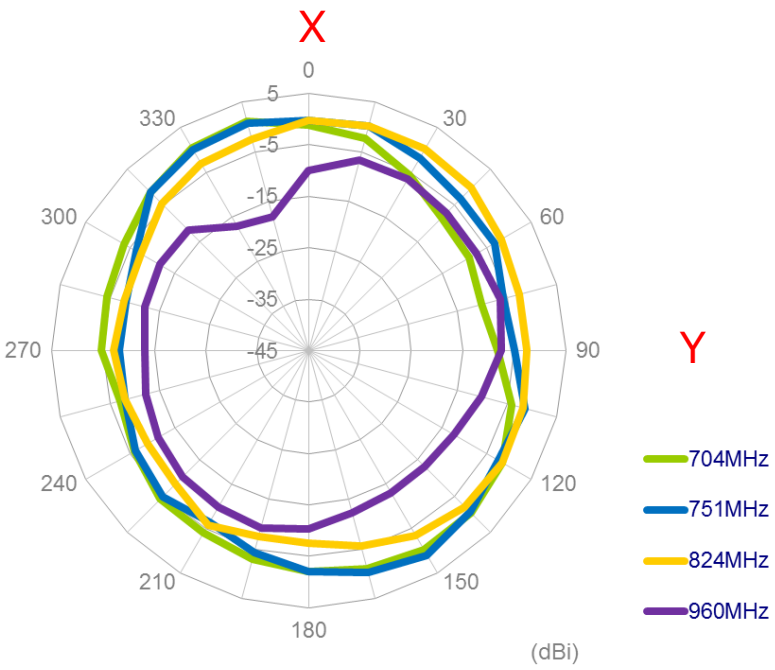
2690MHz

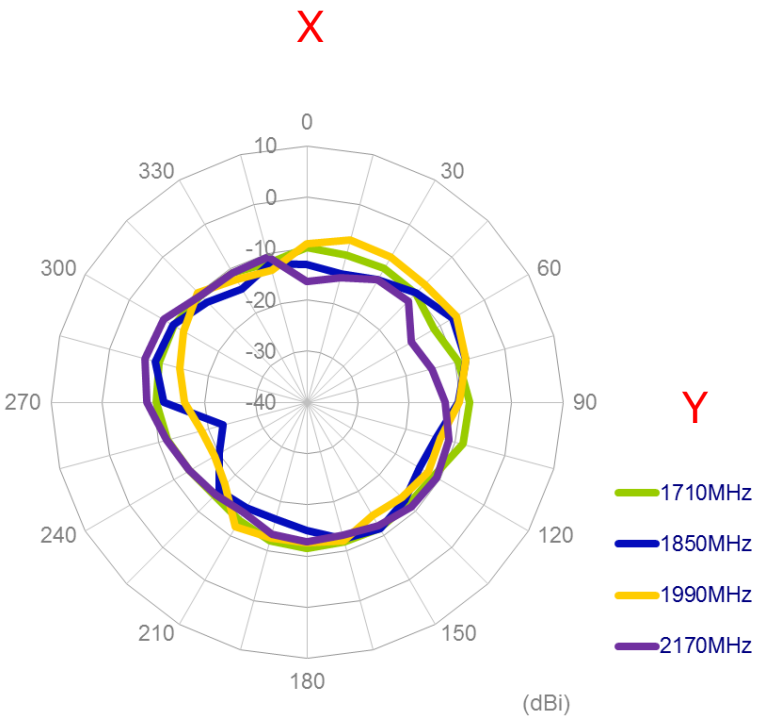


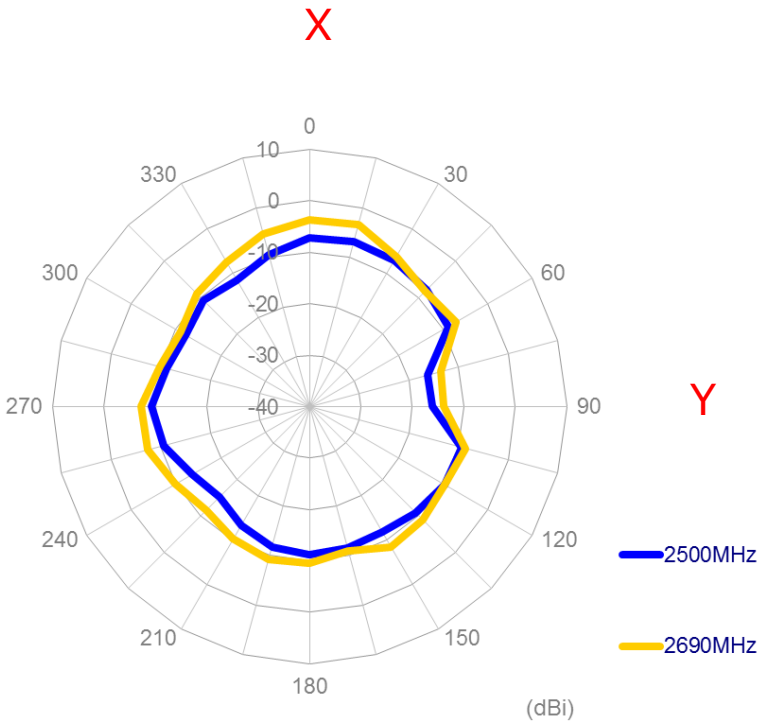
3500MHz

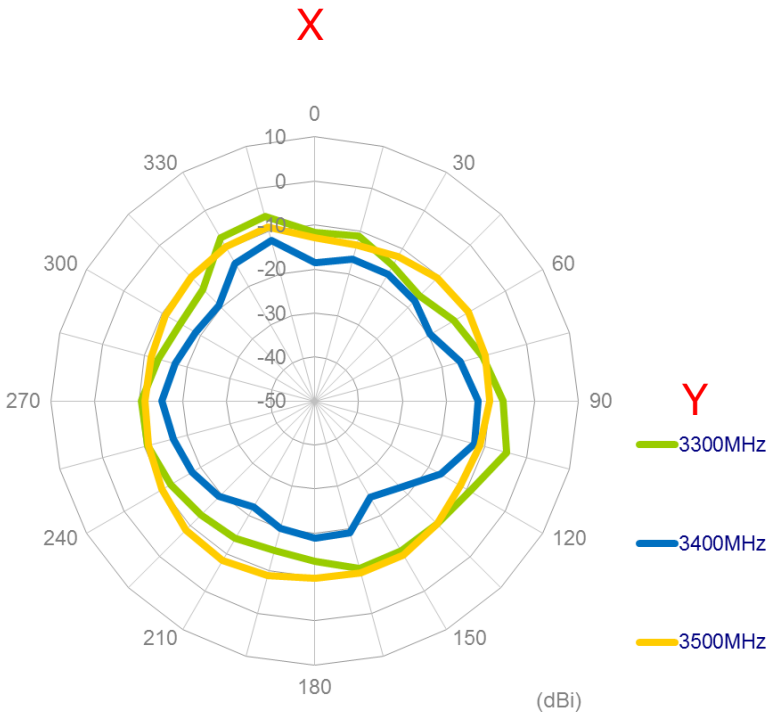
3.1.9 2D Radiation pattern (MIMO2 with 0.3M cable length on the 50*50 ground plane

XY Plane

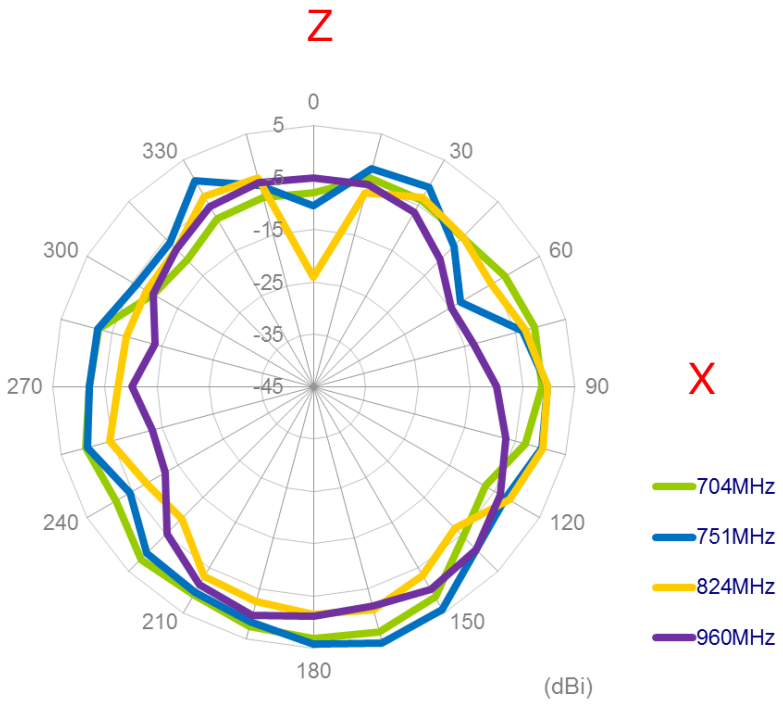


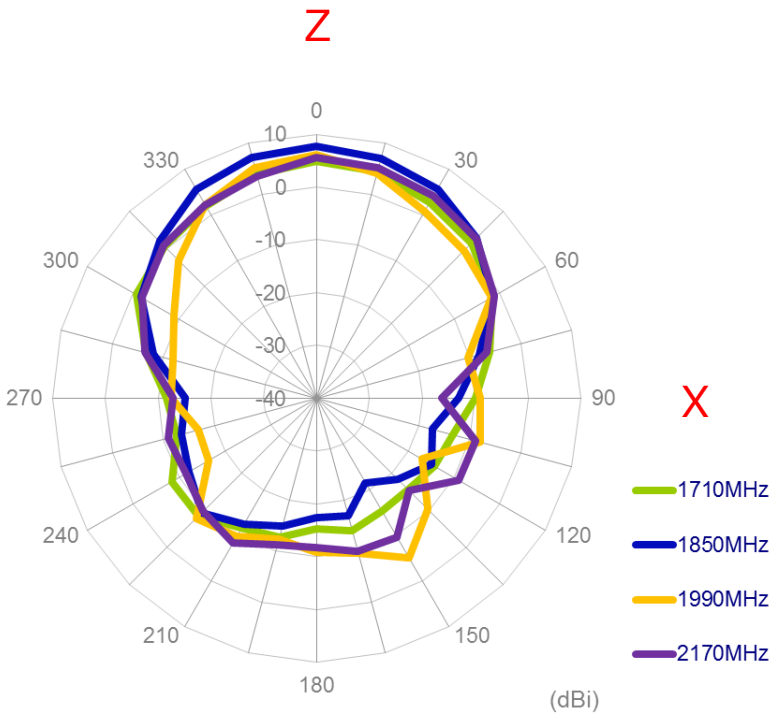


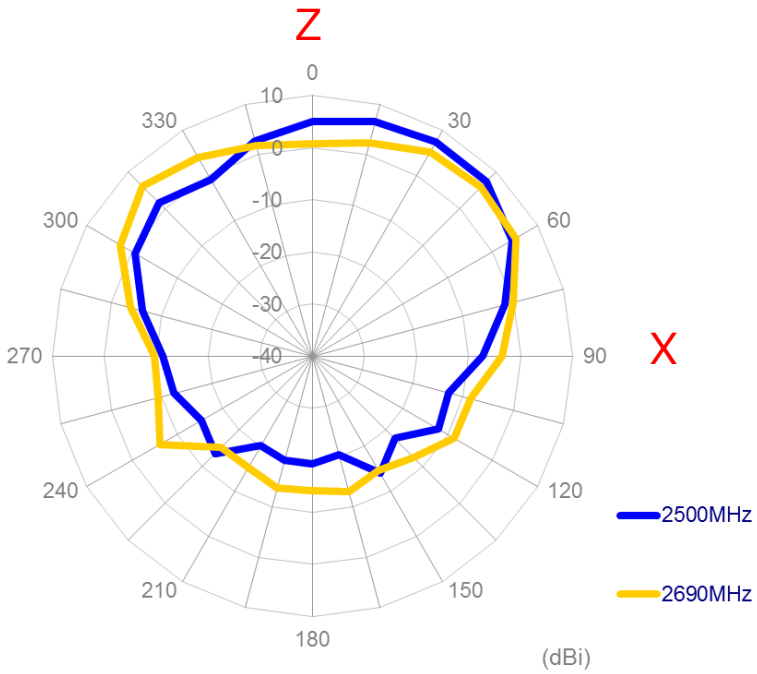

X
0
10
30
330
0
60
300
-10
-20
-30
270
-40
90
240
120
210
150
180
(dBi)
Y
2500MHz
2690MHz

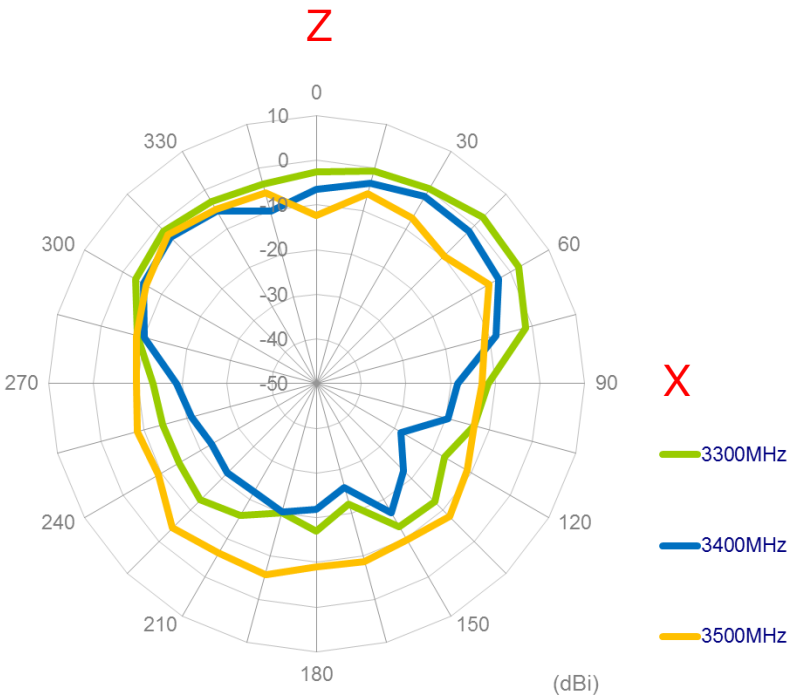

X
0
10
30
330
0
60
300
-10
-20
-30
-40
270
-50
90
240
120
210
150
180
(dBi)
Y
3300MHz
3400MHz
3500MHz

XZ Plane

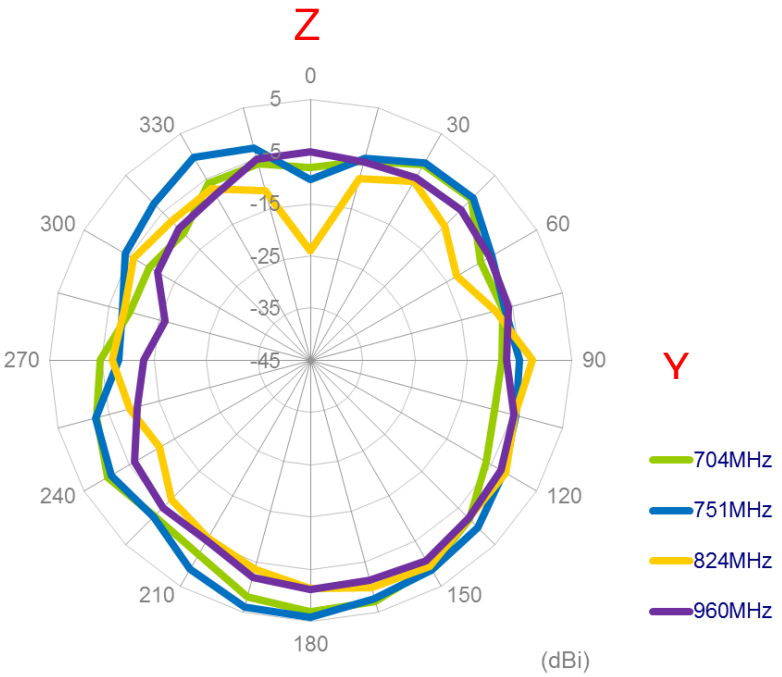

Z
0
5
-5
-15
-25
-35
-45
30
60
90
120
150
180
210
240
270
300
330
X
704MHz
751MHz
824MHz
960MHz
(dBi)

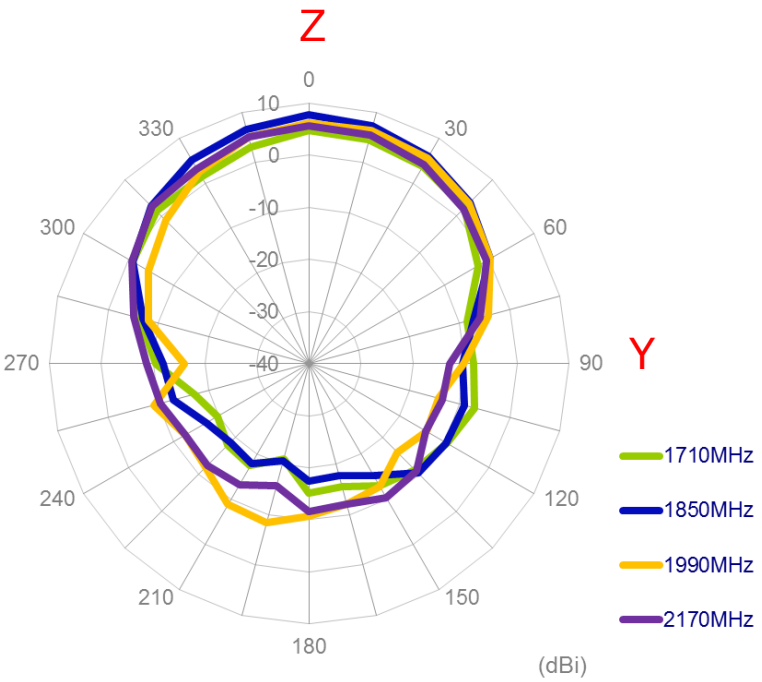

Z
0
10
0
-10
-20
-30
-40
30
60
90
120
150
180
210
240
270
300
330
X
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

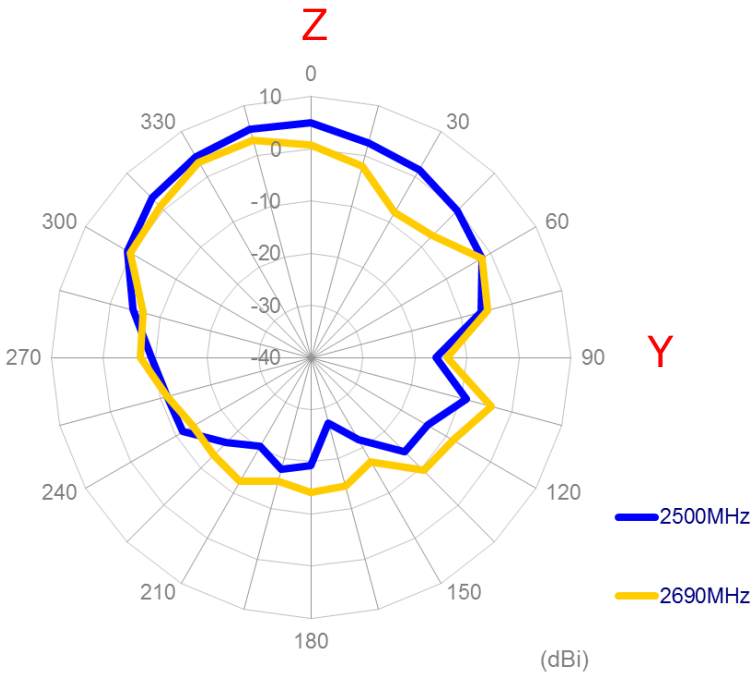

Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
X
2500MHz
2690MHz
(dBi)

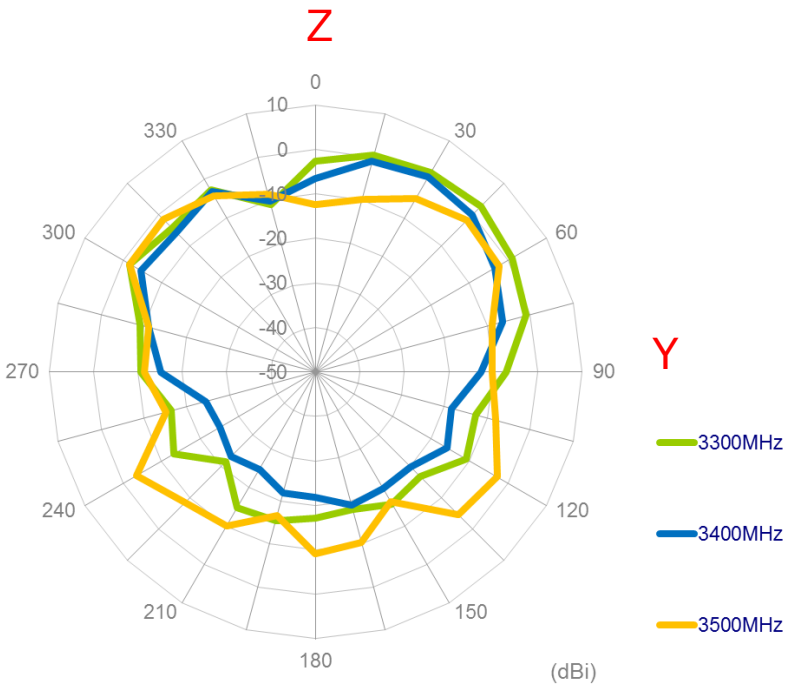

Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
-50
X
3300MHz
3400MHz
3500MHz
(dBi)

YZ Plane

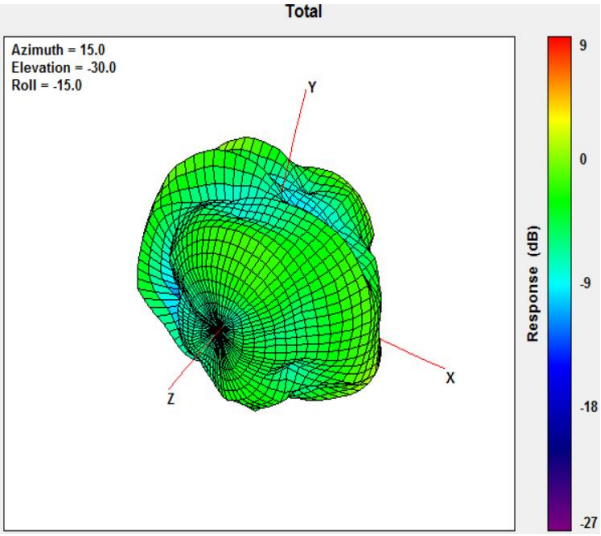

Z
0
30
60
90
120
150
180
210
240
270
300
330
5
-5
-15
-25
-35
-45
Y
704MHz
751MHz
824MHz
960MHz
(dBi)


Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
Y
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

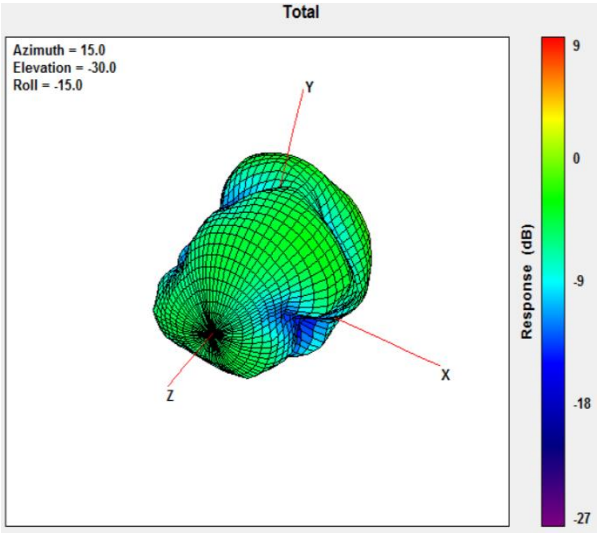

Z
0
10
30
330
0
-10
60
300
-20
-30
270
-40
90
Y
240
120
2500MHz
210
150
2690MHz
180
(dBi)


Z
0
10
330
30
0
-10
300
60
-20
-30
-40
270
-50
90
Y
240
120
3300MHz
210
150
3400MHz
180
3500MHz
(dBi)

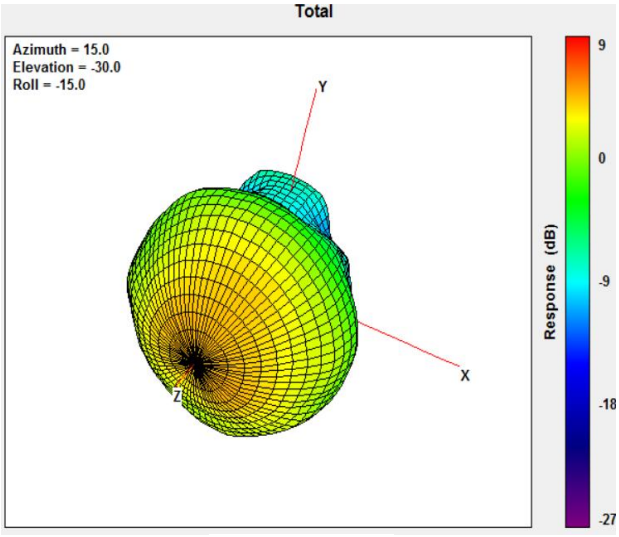
3.1.10 3D Radiation pattern (MIMO2 with 0.3M cable length on the 50*50 ground plane



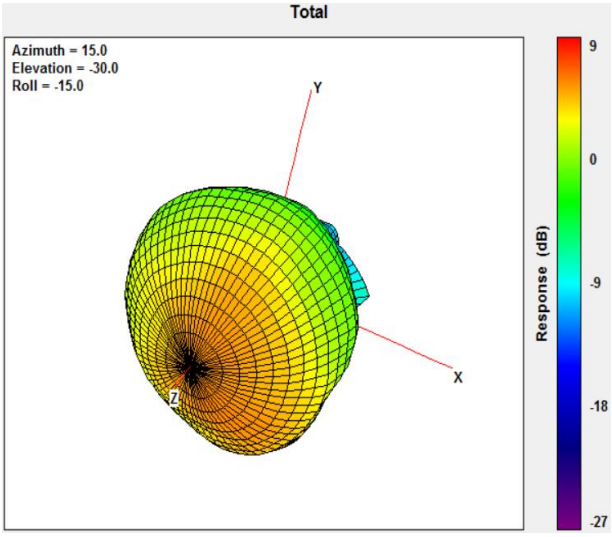
704MHz



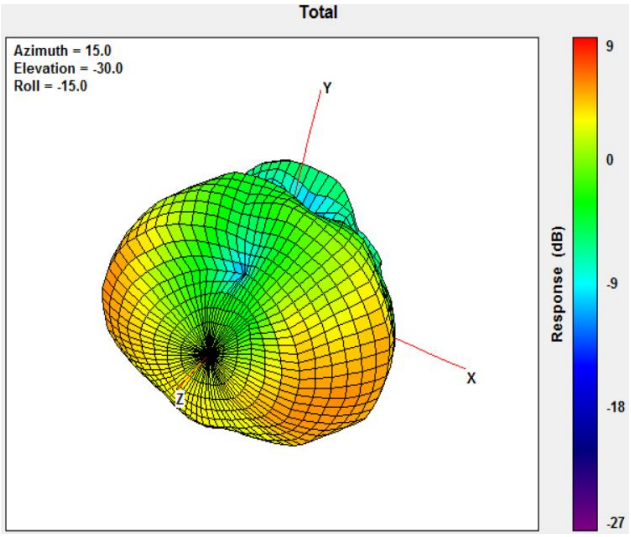
960MHz



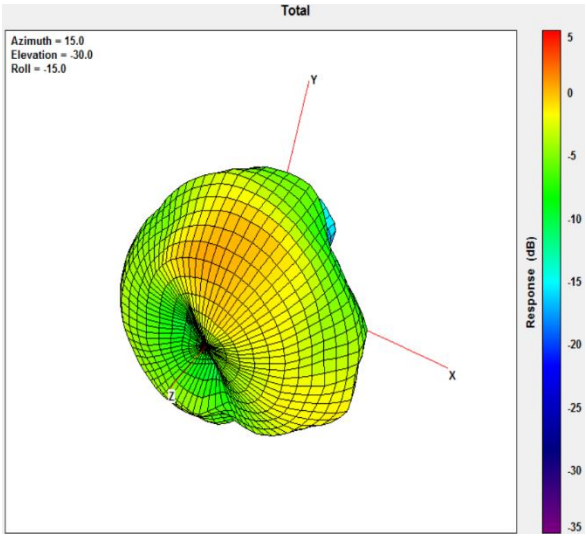
1710MHz



2170MHz

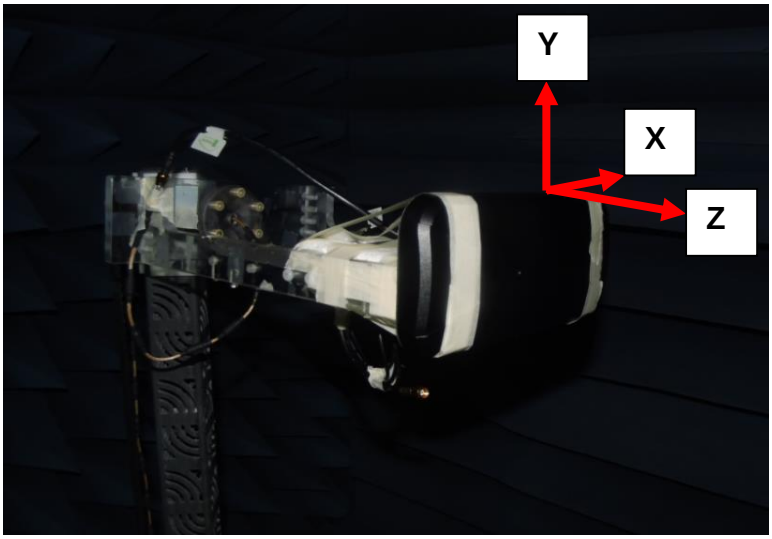


2690MHz



3500MHz

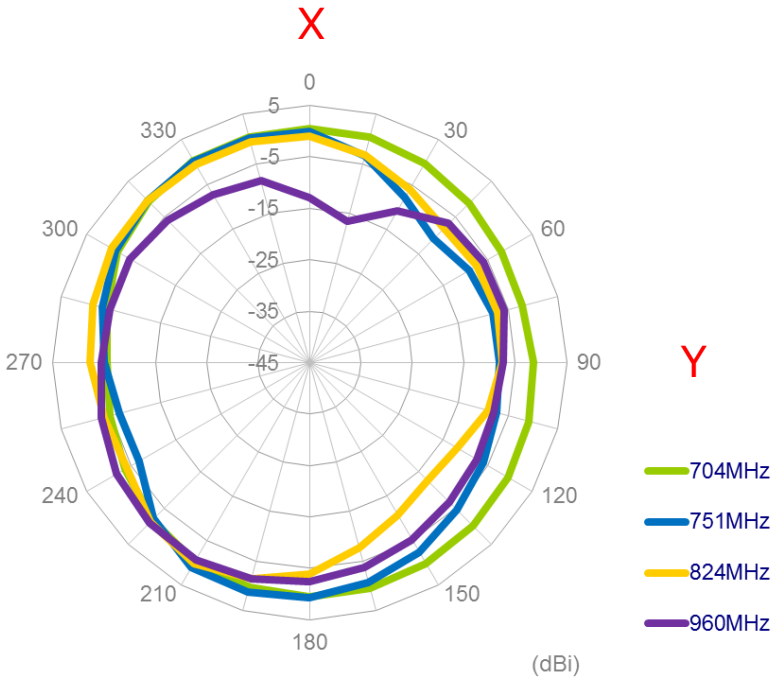
3.1.11 Test Setup For Antenna Radiation Pattern (ETS Anechoic chamber)

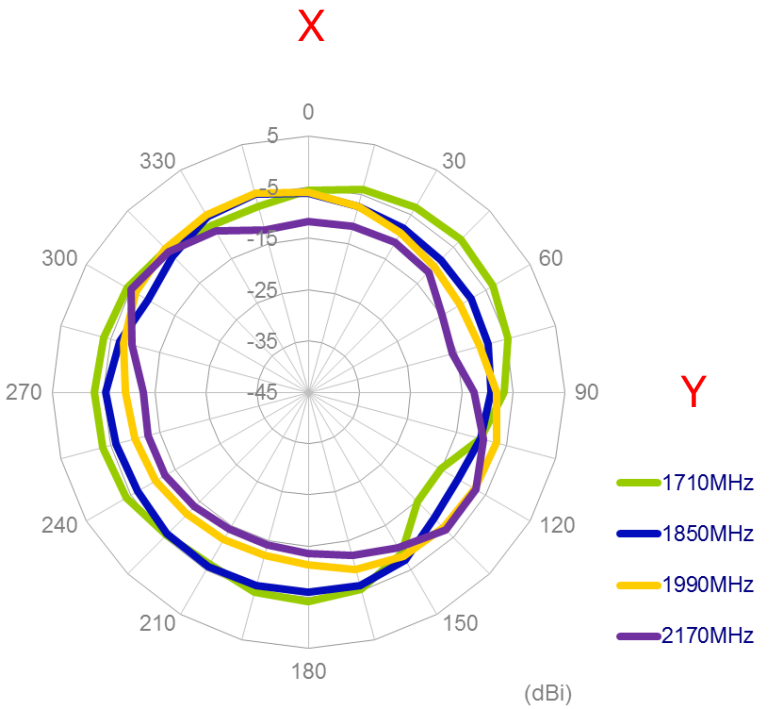


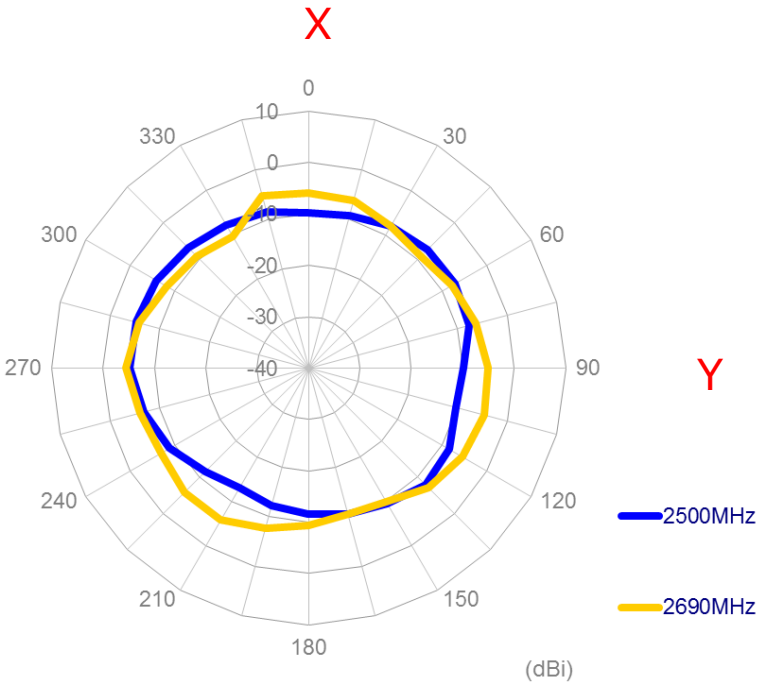
In free space

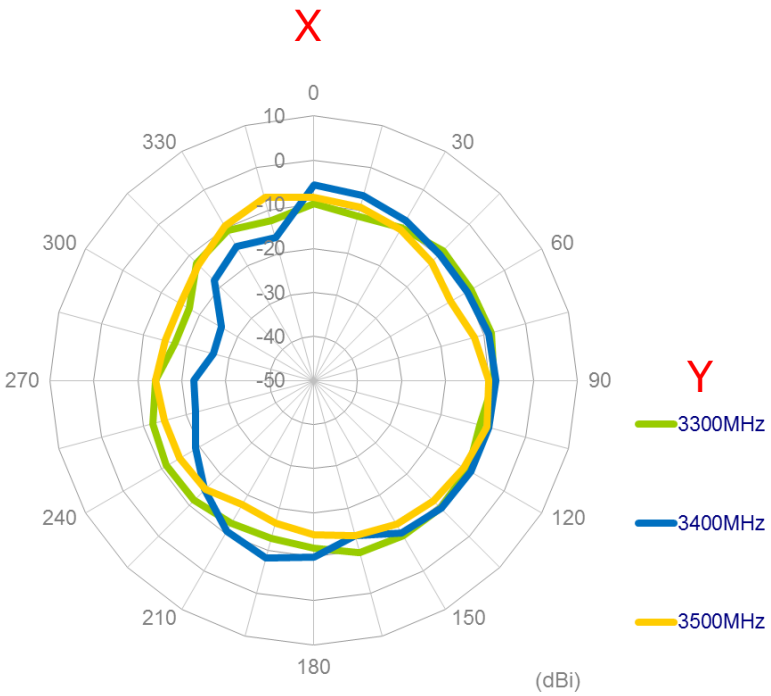
3.1.12 2D Radiation pattern (MIMO1 with 0.3M cable length in free space)

XY Plane

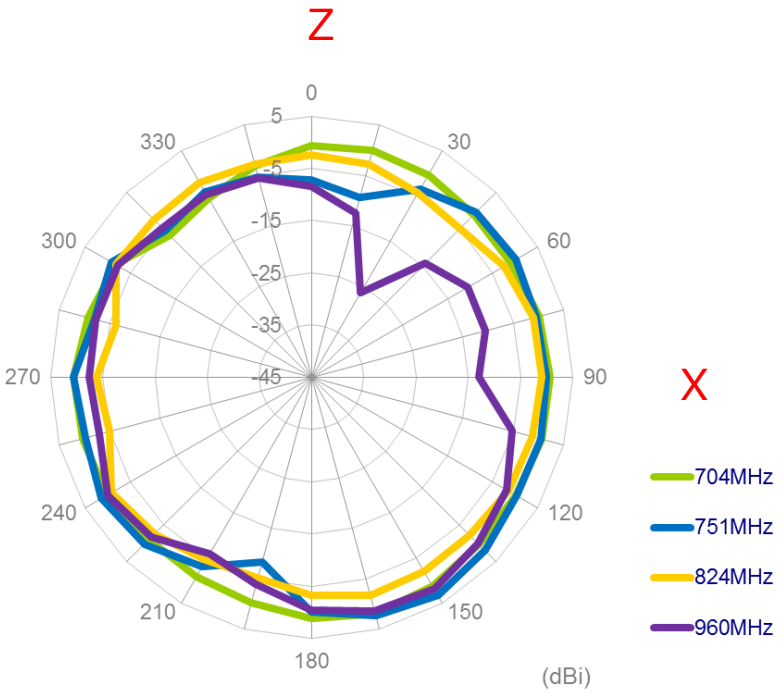


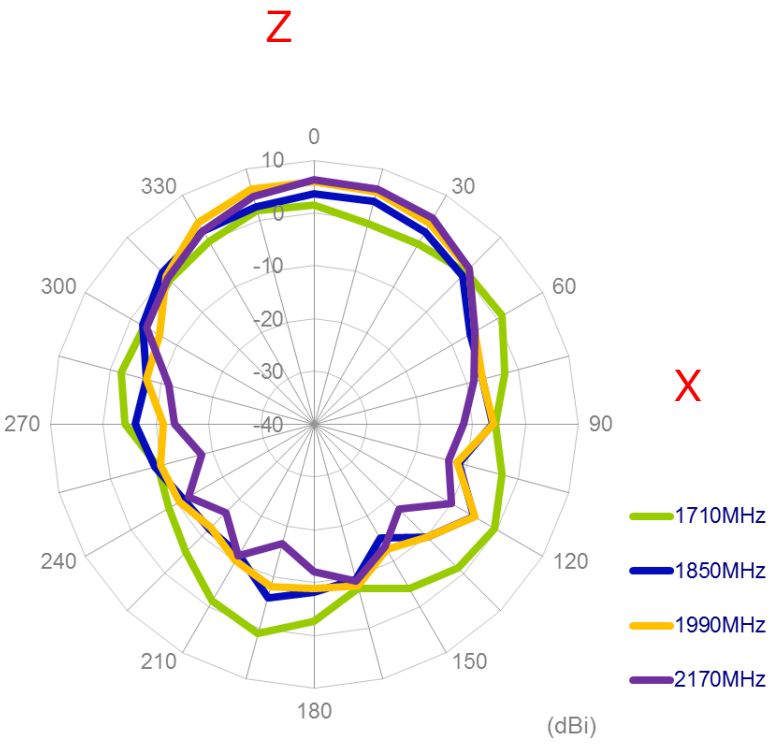


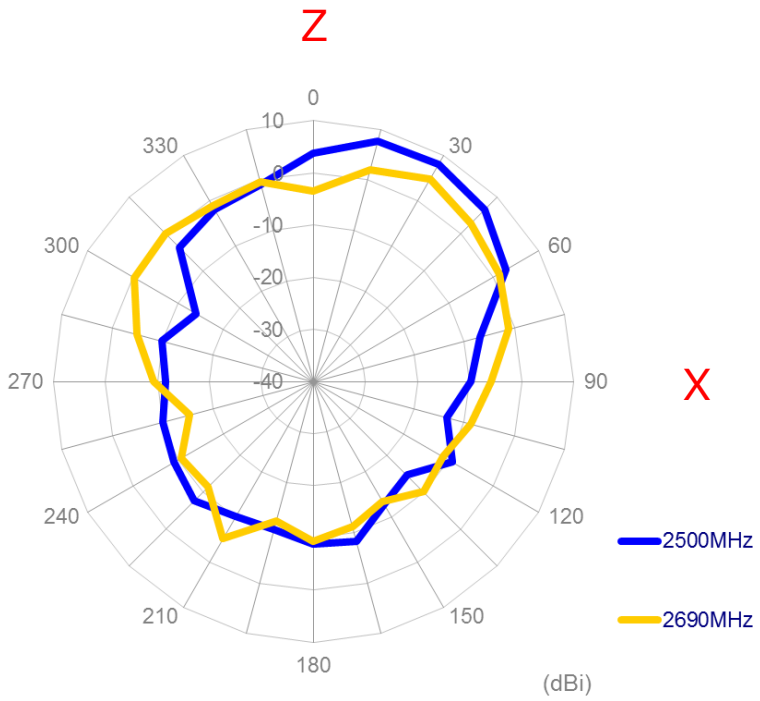

X
0
10
30
330
0
60
300
-10
-20
-30
270
-40
90
Y
240
120
2500MHz
210
150
2690MHz
180
(dBi)

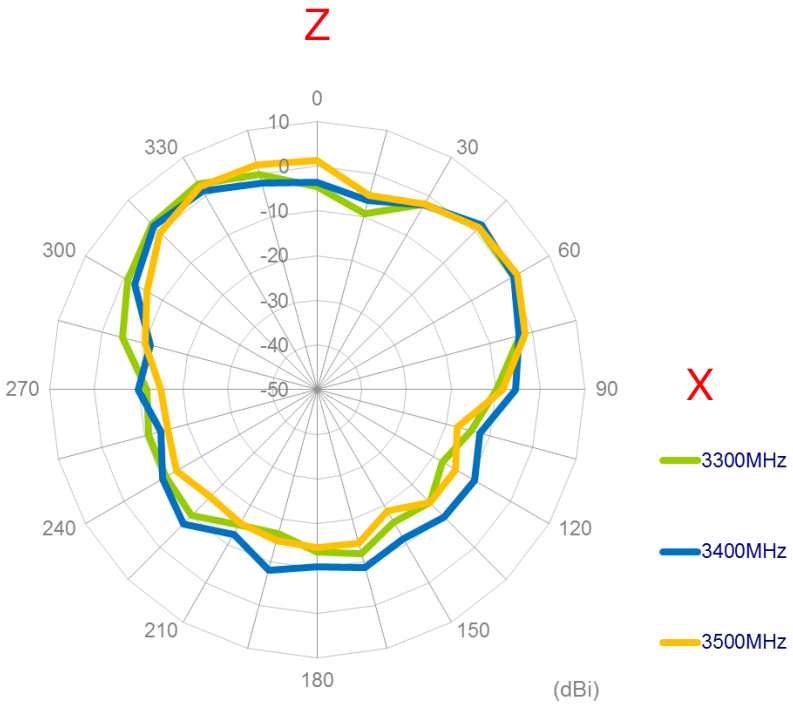

X
0
10
330
30
0
-10
300
60
-20
-30
-40
270
-50
90
Y
240
120
3300MHz
210
150
3400MHz
180
3500MHz
(dBi)

XZ Plane

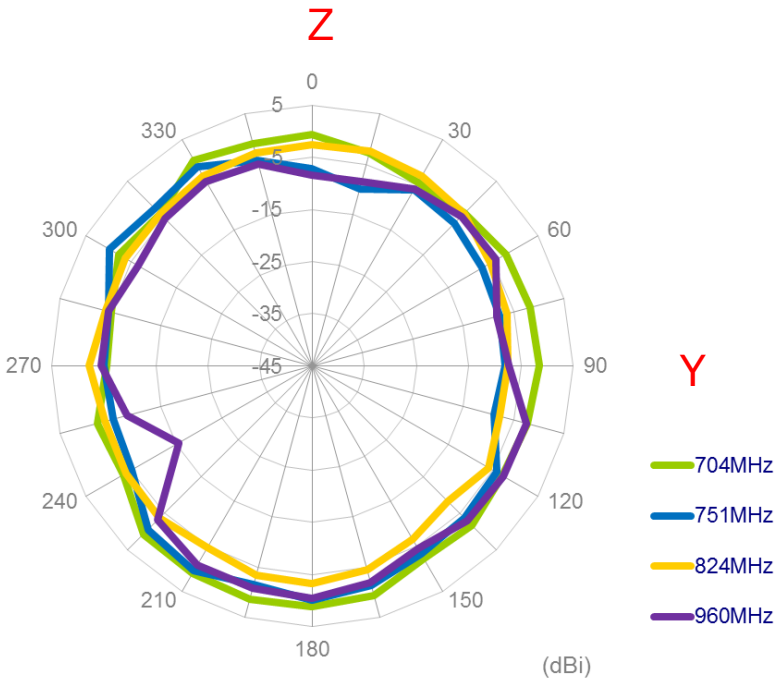

Z
0
30
60
90
120
150
180
210
240
270
300
330
5
-5
-15
-25
-35
-45
X
704MHz
751MHz
824MHz
960MHz
(dBi)

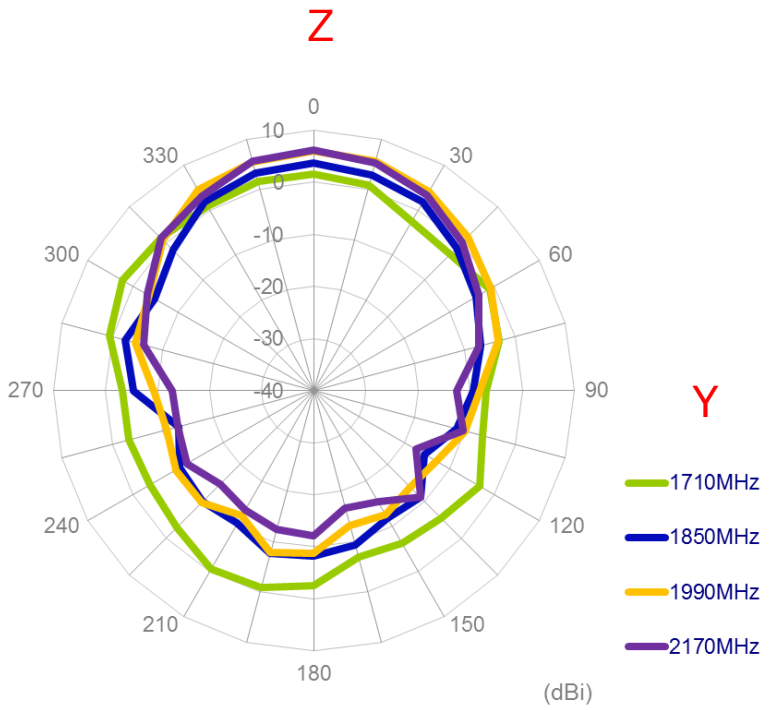

Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
X
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

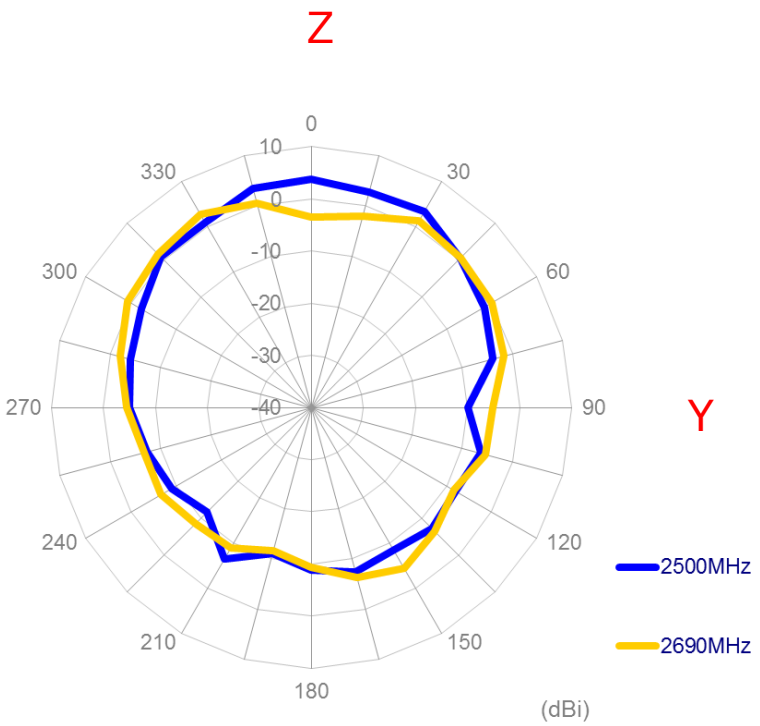

Z
0
10
30
60
90
120
150
180
210
240
270
300
330
-10
-20
-30
-40
X
2500MHz
2690MHz
(dBi)

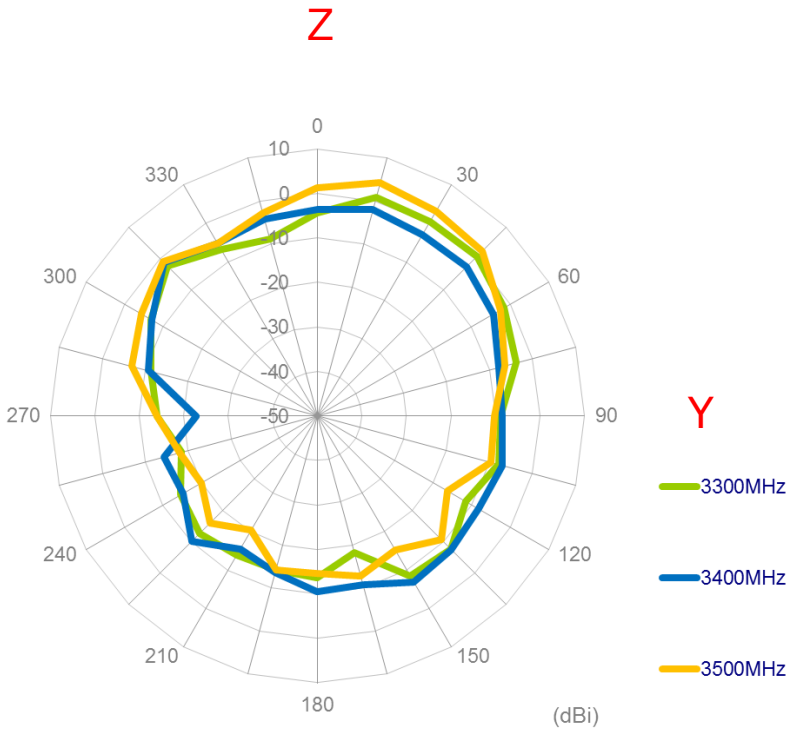

Z
0
10
30
60
90
120
150
180
210
240
270
300
330
-10
-20
-30
-40
-50
X
3300MHz
3400MHz
3500MHz
(dBi)

YZ Plane

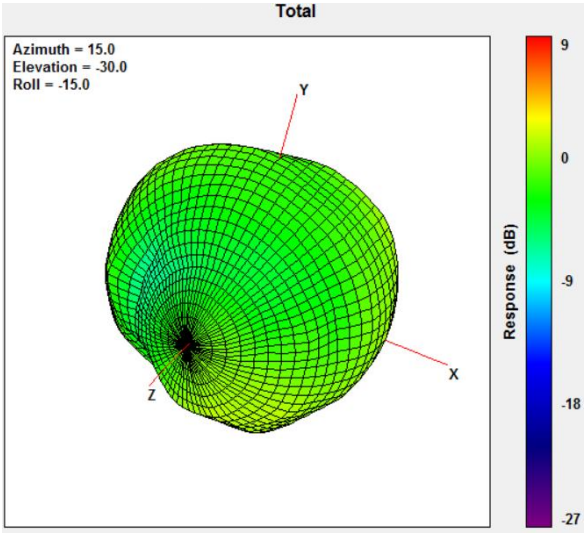

Z
0
30
60
90
120
150
180
210
240
270
300
330
5
-5
-15
-25
-35
-45
Y
704MHz
751MHz
824MHz
960MHz
(dBi)


Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
Y
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

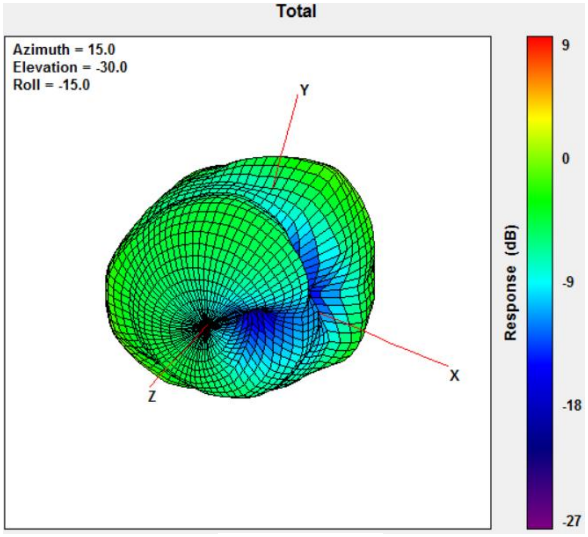

Z
0
10
30
330
0
-10
300
60
-20
-30
270
-40
90
Y
240
120
2500MHz
210
150
2690MHz
180
(dBi)


Z
0
10
330
30
0
-10
300
60
-20
-30
-40
270
-50
90
Y
240
120
3300MHz
210
150
3400MHz
180
3500MHz
(dBi)

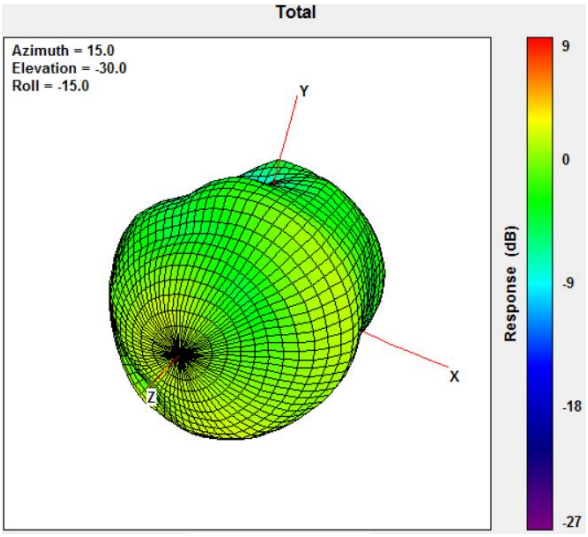
3.1.13 3D Radiation pattern (MIMO1 with 0.3M cable length in free space)



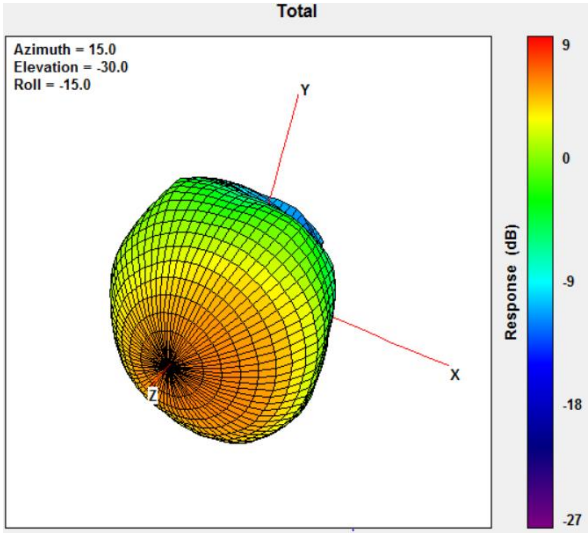
704MHz



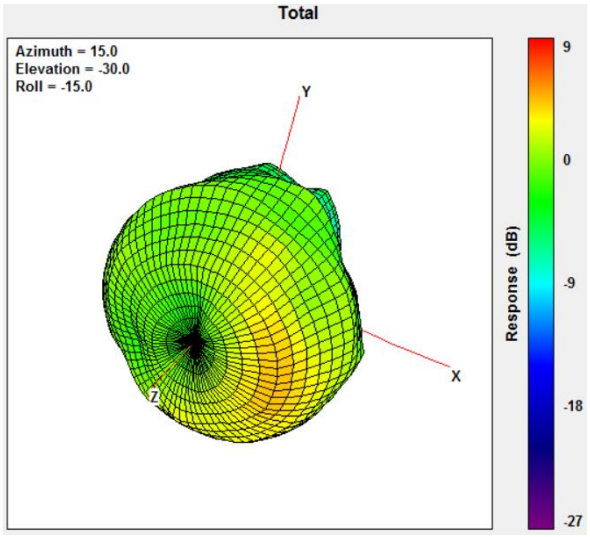
960MHz



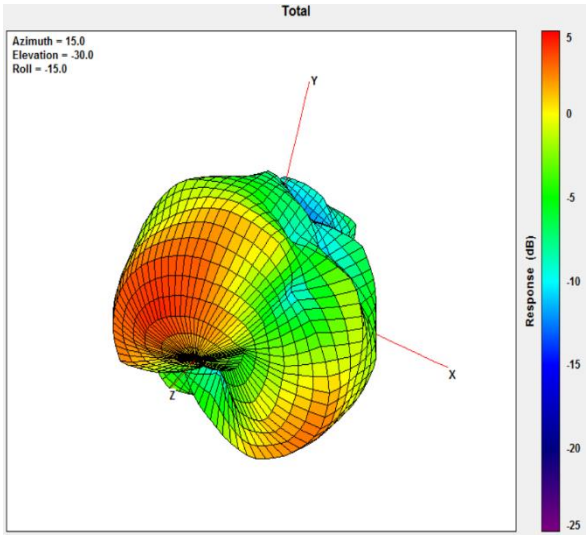
1710MHz



2170MHz



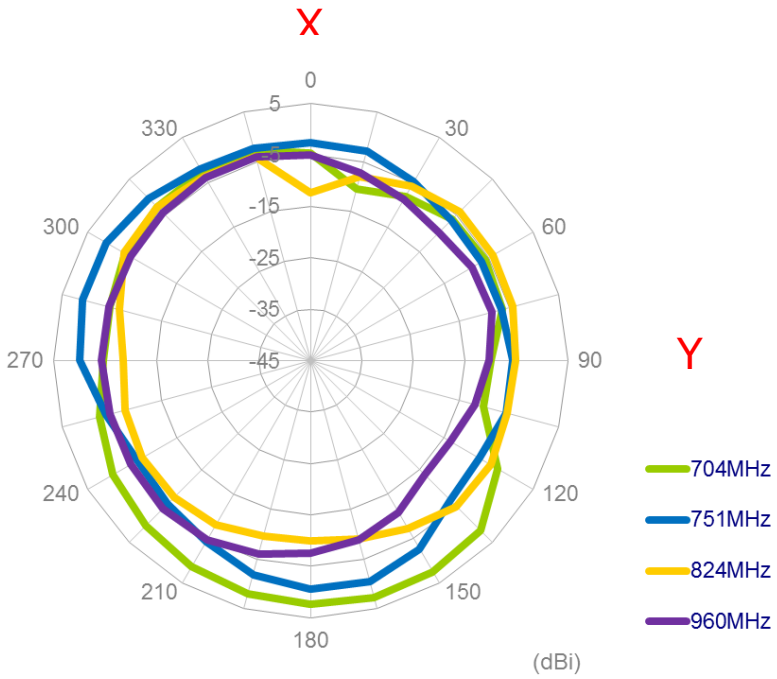
2690MHz

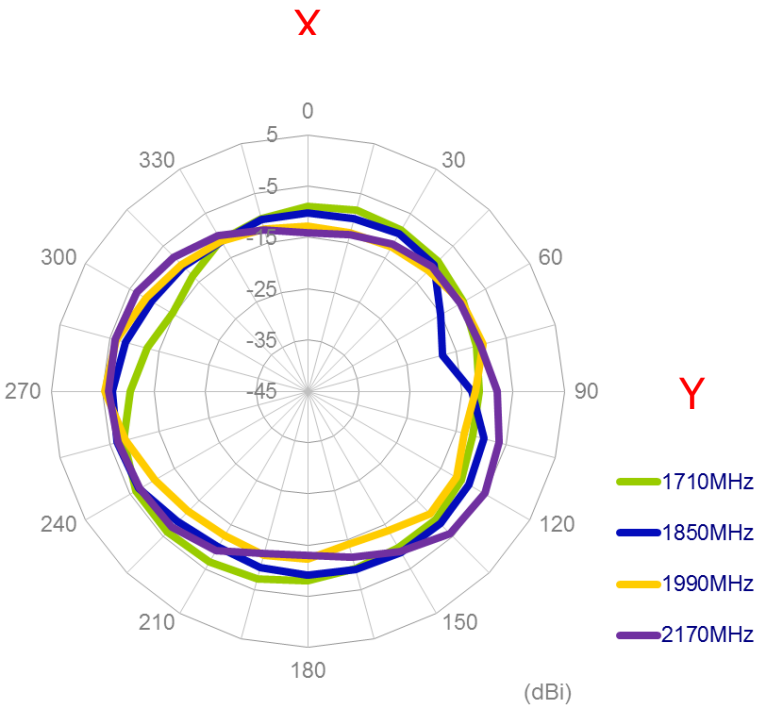


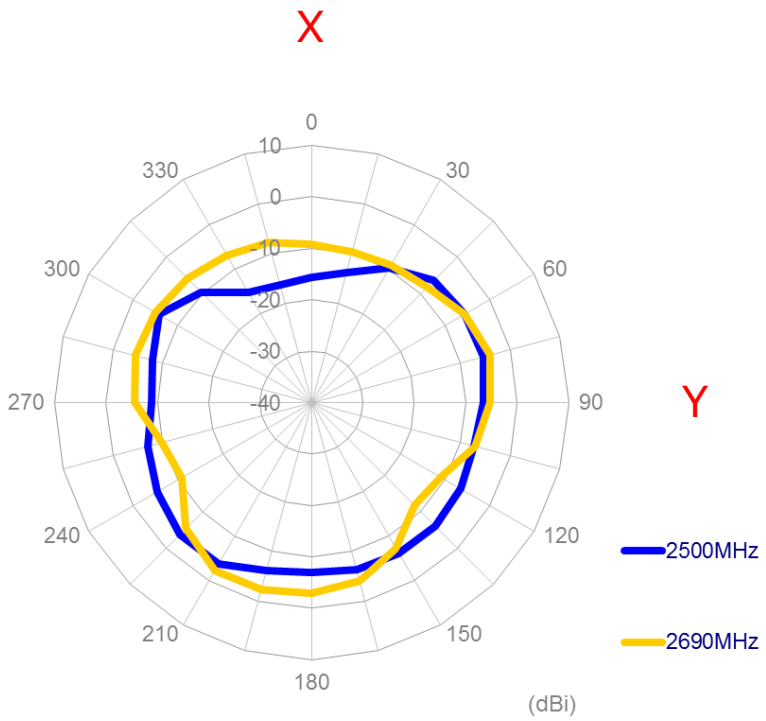
3500MHz

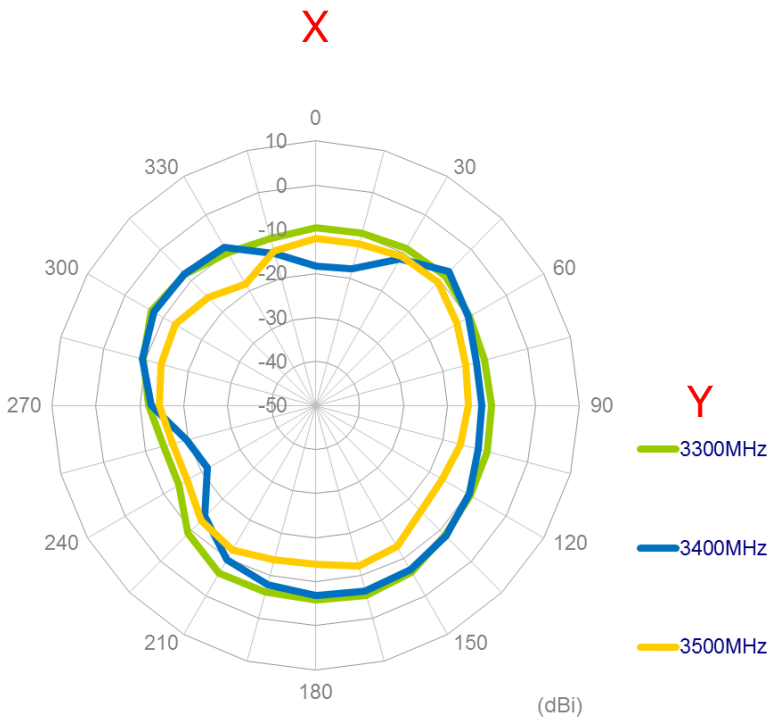
3.1.14 2D Radiation pattern (MIMO2 with 0.3M cable length in free space)

XY Plane

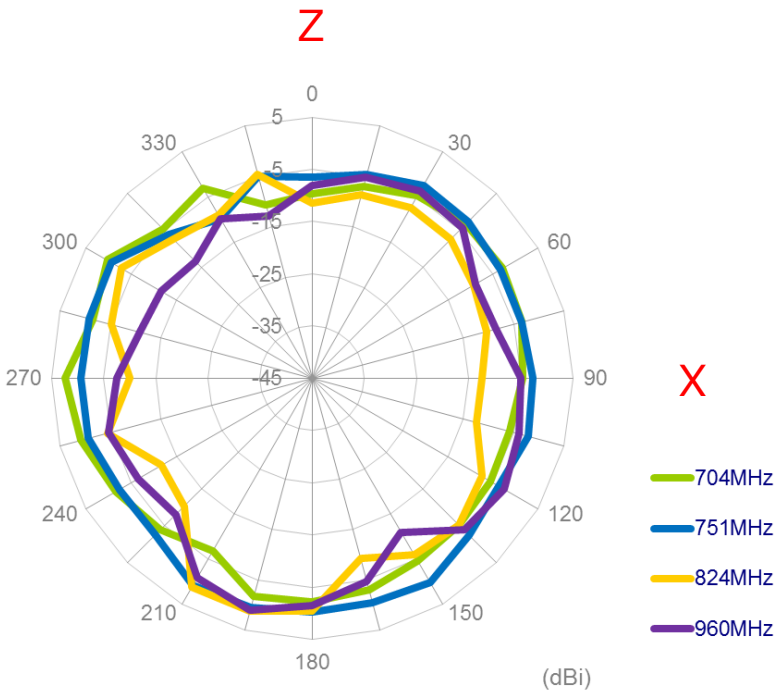


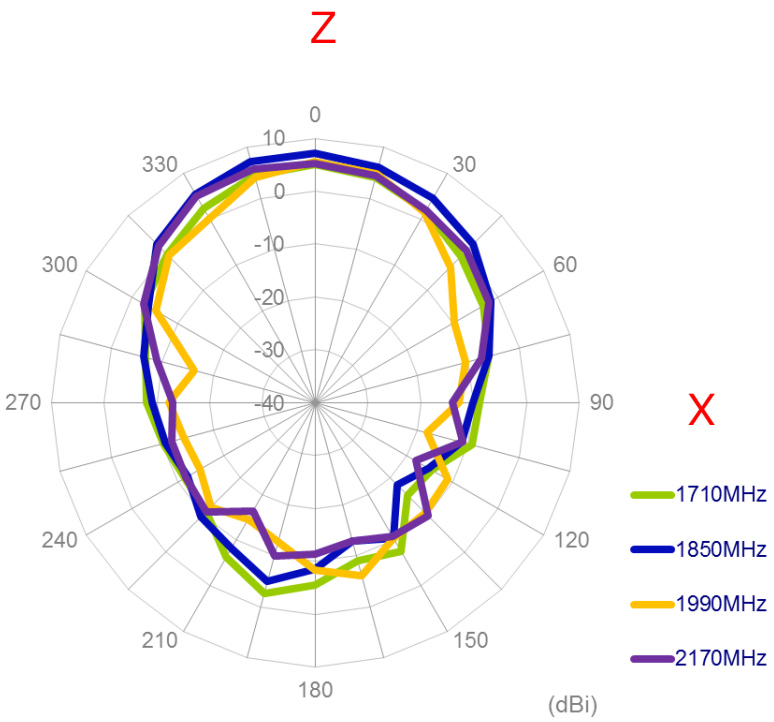


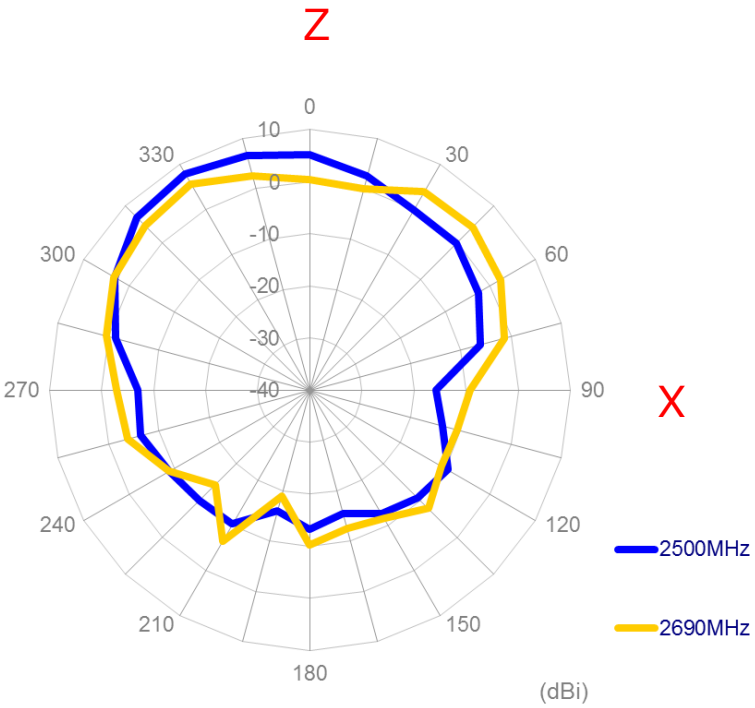

X
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
Y
2500MHz
2690MHz
(dBi)

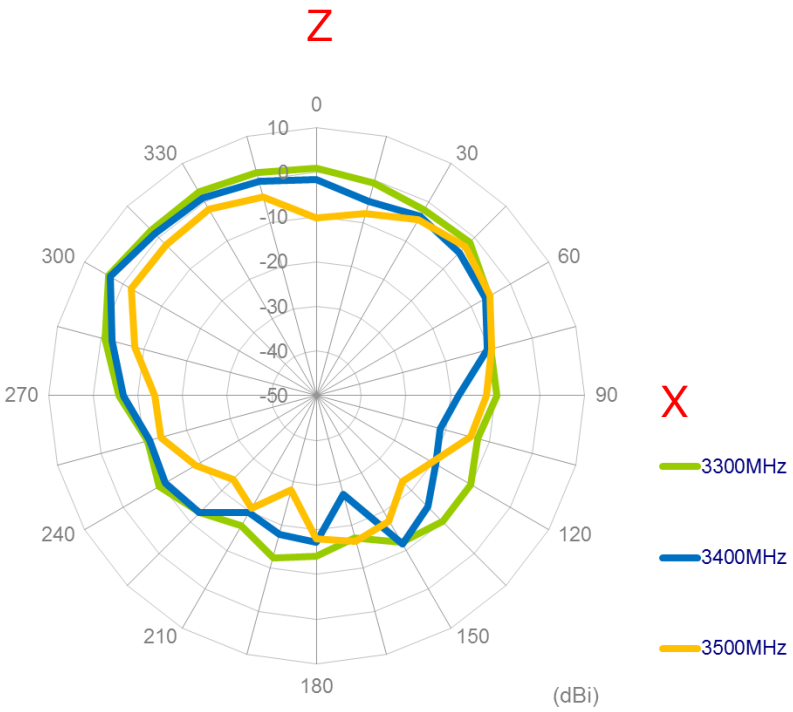

X
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
-50
Y
3300MHz
3400MHz
3500MHz
(dBi)

XZ Plane

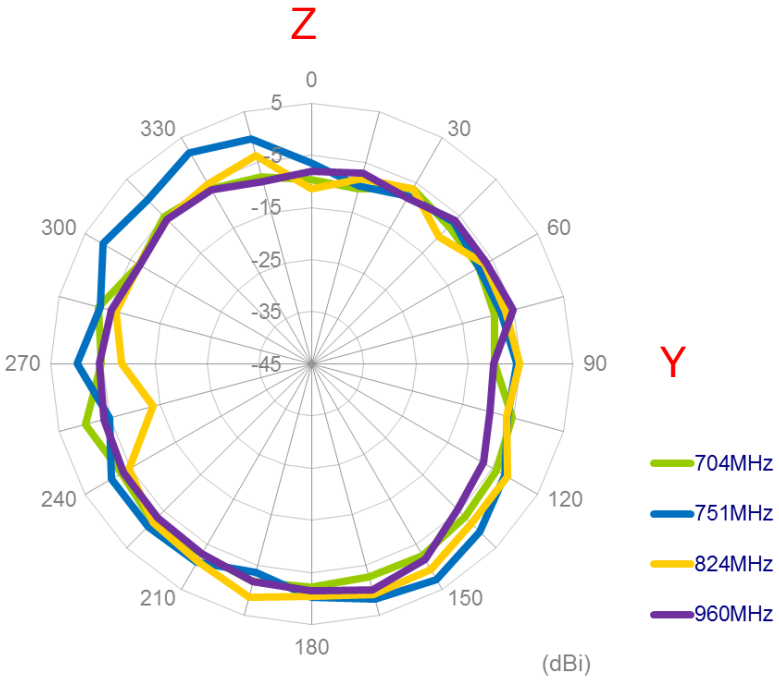

Z
0
30
60
90
120
150
180
210
240
270
300
330
5
-5
-15
-25
-35
-45
X
704MHz
751MHz
824MHz
960MHz
(dBi)

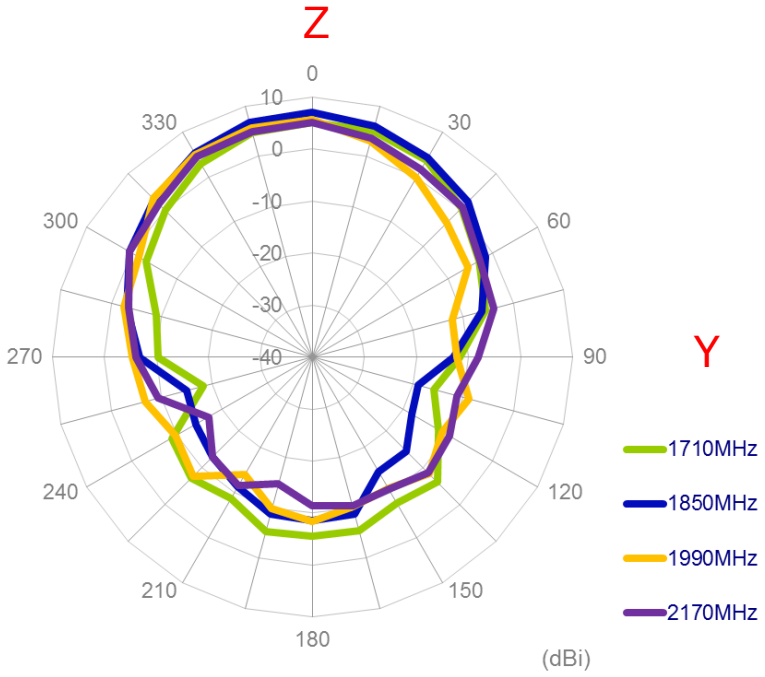

Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
X
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

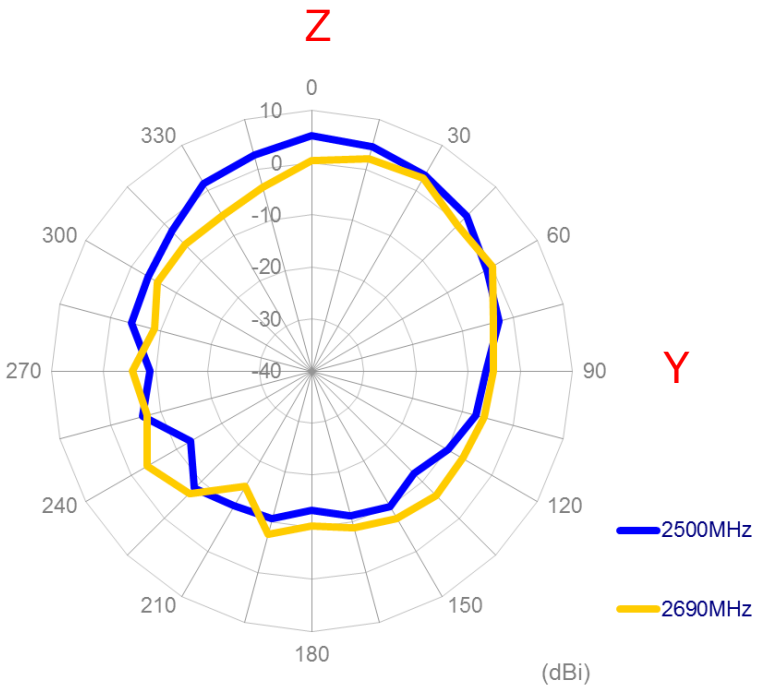

Z
0
10
30
330
0
-10
60
300
-20
-30
270
-40
90
X
240
120
2500MHz
210
150
2690MHz
180
(dBi)

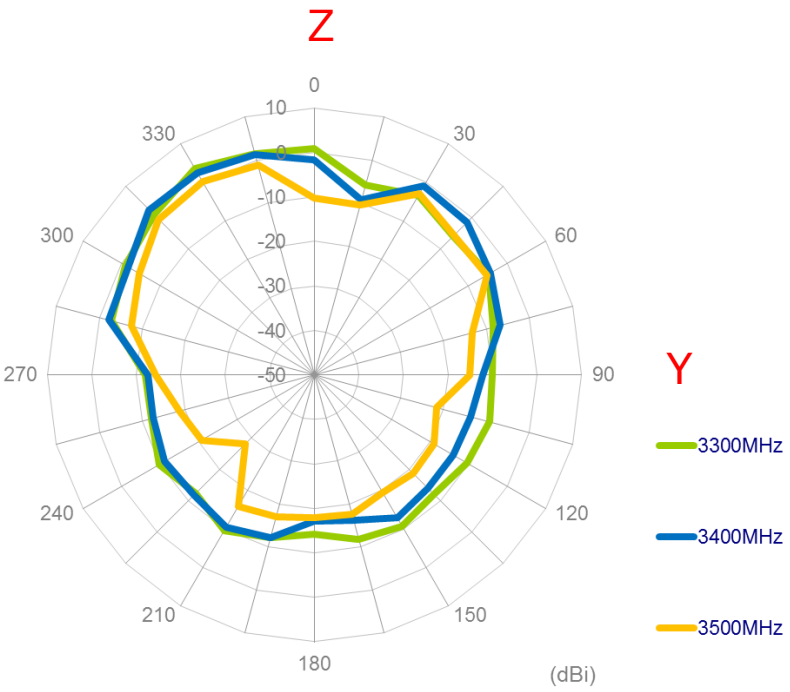

Z
0
10
330
30
0
-10
300
60
-20
-30
-40
270
-50
90
X
240
120
3300MHz
3400MHz
210
150
3500MHz
180
(dBi)

YZ Plane

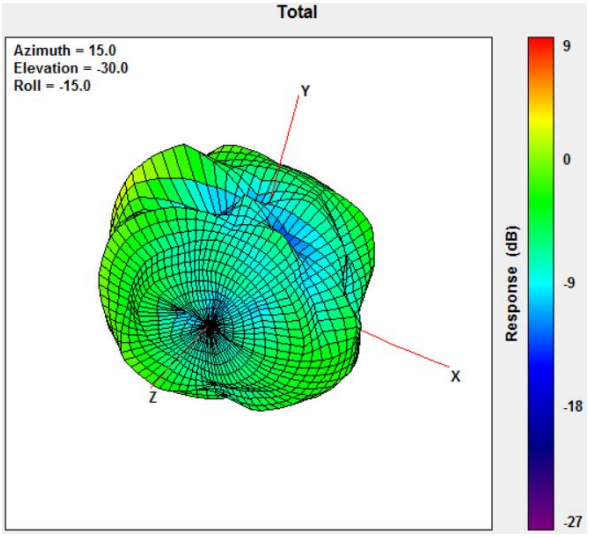

Z
0
30
60
90
120
150
180
210
240
270
300
330
5
-5
-15
-25
-35
-45
Y
704MHz
751MHz
824MHz
960MHz
(dBi)


Z
0
30
60
90
120
150
180
210
240
270
300
330
10
0
-10
-20
-30
-40
Y
1710MHz
1850MHz
1990MHz
2170MHz
(dBi)

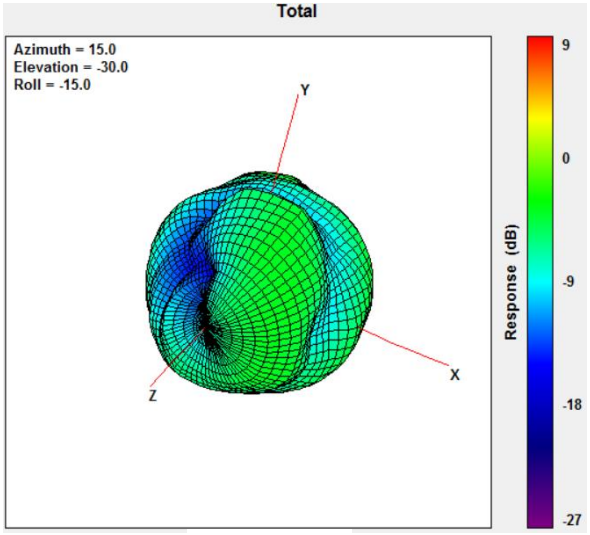

Z
0
10
30
60
90
120
150
180
210
240
270
300
330
0
-10
-20
-30
-40
Y
2500MHz
2690MHz
(dBi)


Z
0
10
30
60
90
120
150
180
210
240
270
300
330
-10
-20
-30
-40
-50
Y
3300MHz
3400MHz
3500MHz
(dBi)

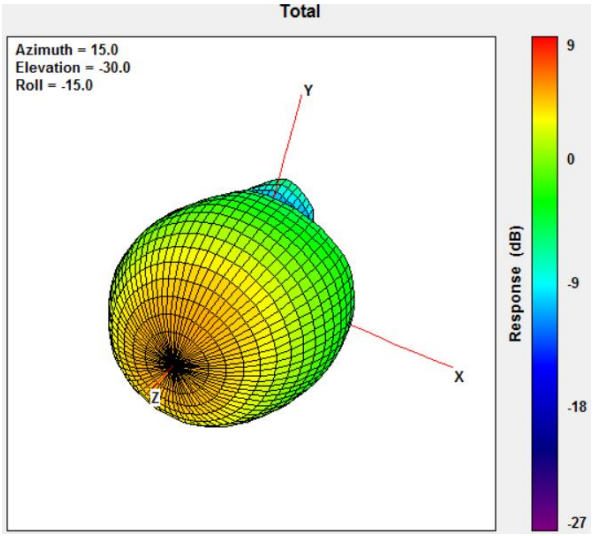
3.1.15 2D Radiation pattern (MIMO2 with 0.3M cable length in free space)



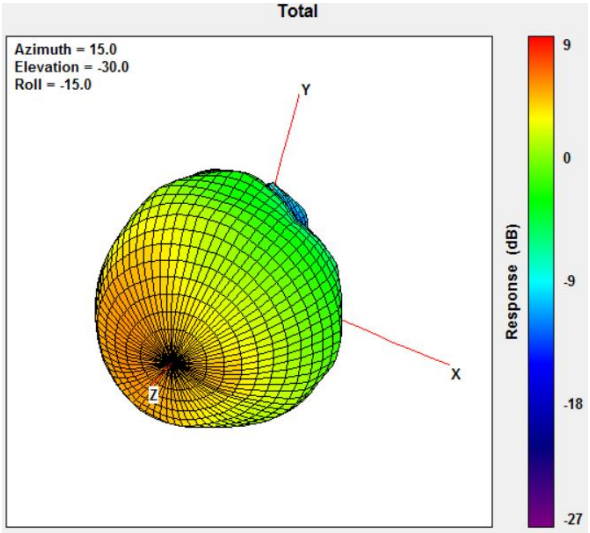
704MHz



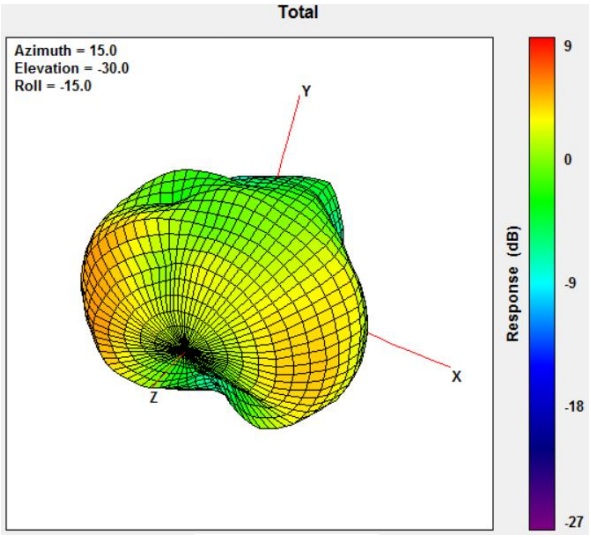
960MHz



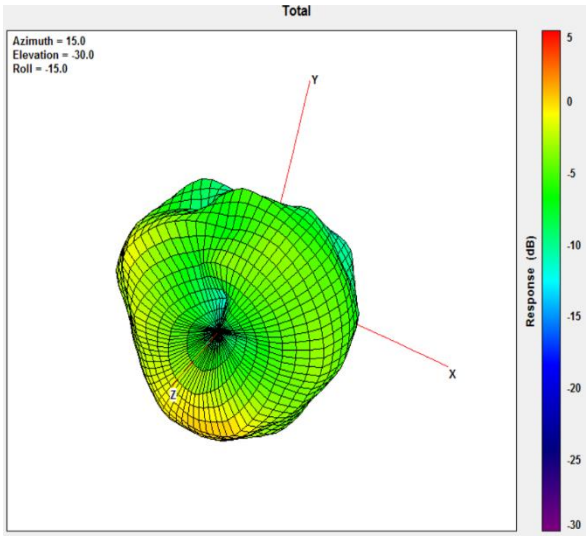
1710MHz



2170MHz

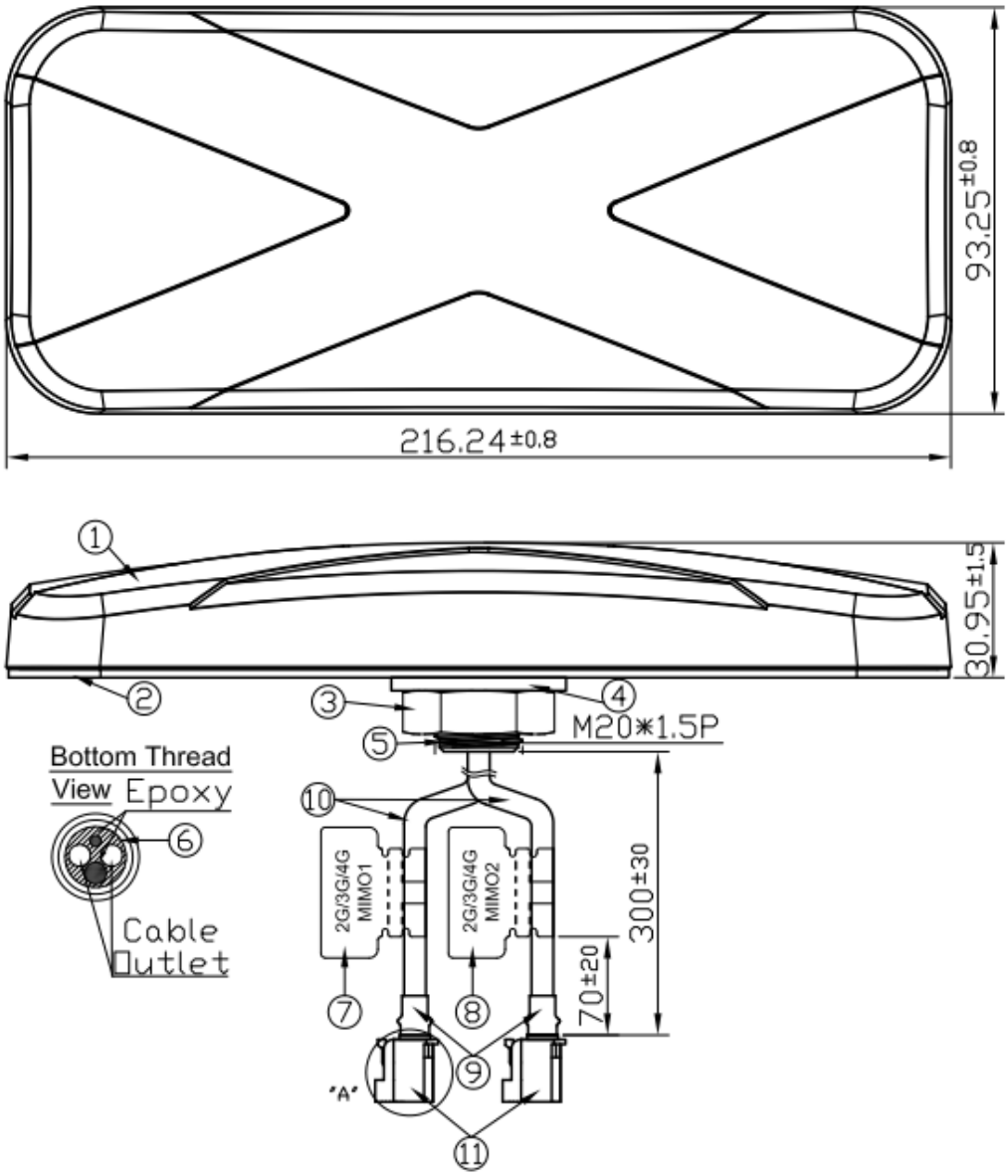


2690MHz



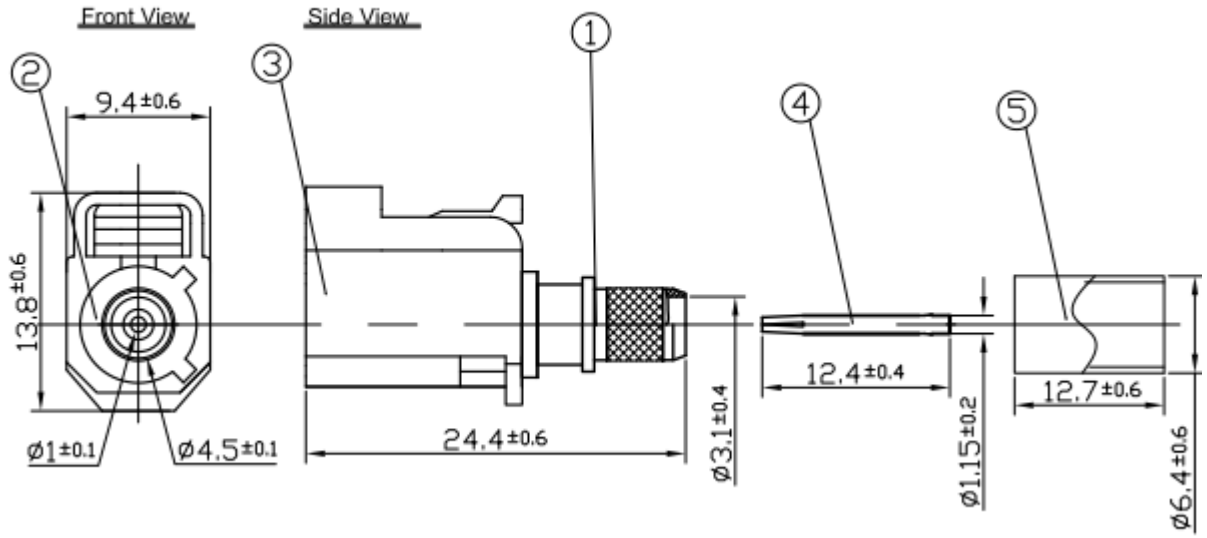
3500MHz

4. Mechanical Drawing (units: mm)



4.1 Conne

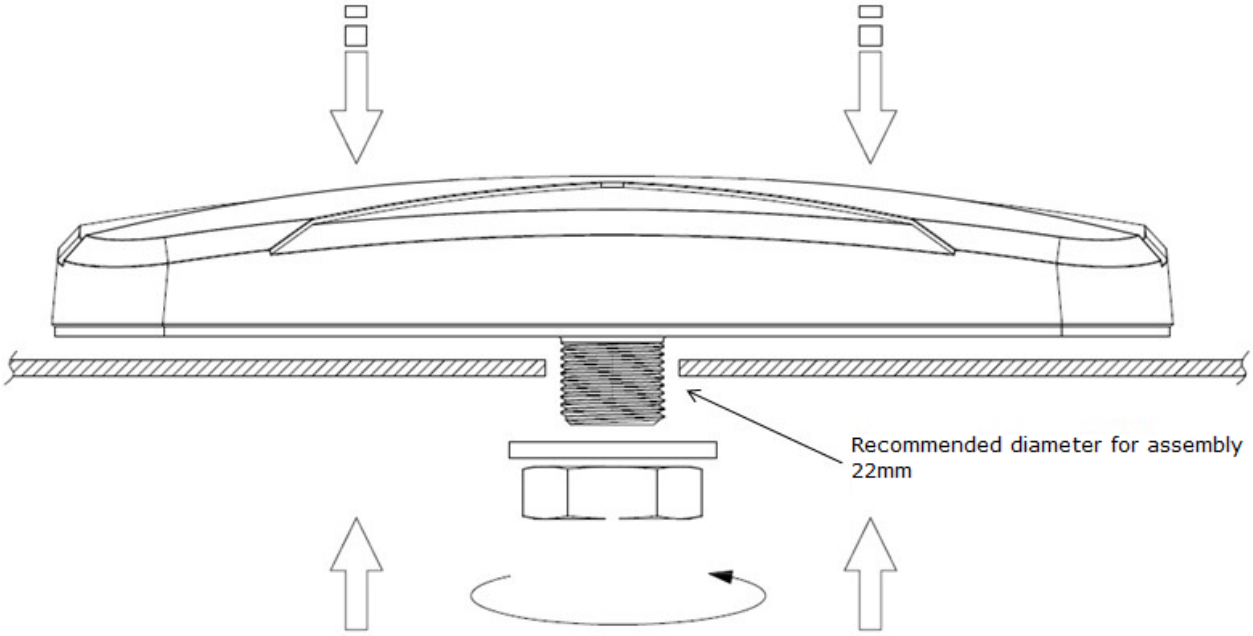
	Name	Material	Finish	
1	Housing	ABS & PC	Black	1
2	Closed Cell Foam and Adhesive Tape	3M 9448+CR-4305	Black	1
3	Nut_M20*1.5P*10H Cut	Steel	Ni Plated	1
4	Washer_Cut	Steel	Ni Plated	1
5	Metal Base	AL	Ni Plated	1
6	Cable Rubber	Silicone Rubber	Black	1
7	2G/3G/4G MIMO1 Label	Coated Paper	Grey	1
8	2G/3G/4G MIMO2 Label	Coated Paper	White	1
9	Heat Shrink Tube	PE	Black	2
10	CFD200 Coaxial Cable	PVC	Black	2
11	Fakra Code D Jack	PA66	Violet	2



- Detail "A"

	Name	Material	Finish	QTY
1	Body	Copper	Ni Plated	1
2	Insulator	Teflon	White	1
3	Shell	PA66	Violet	1
4	Female contact	P.B	Gold Plated	1
5	Ferrule	Copper	Ni Plated	1

5. Installation



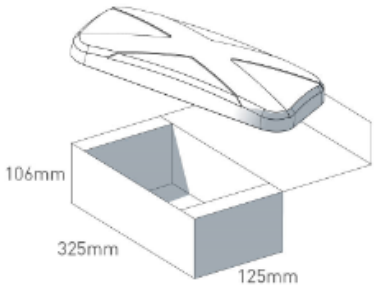
Recommended torque for mounting is 29.4 N.m
Maximum torque for mounting is 39.2 N.m

6. Packaging

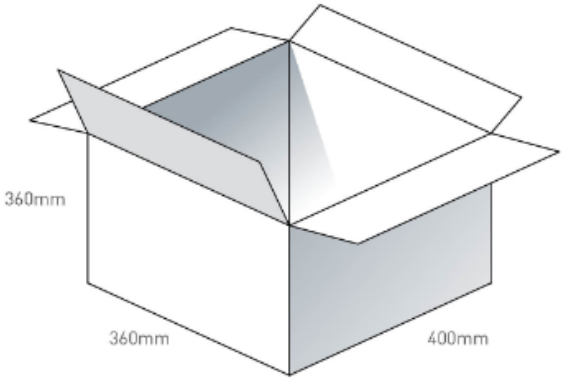
MA412.A.BI.001

Packaging Specifications

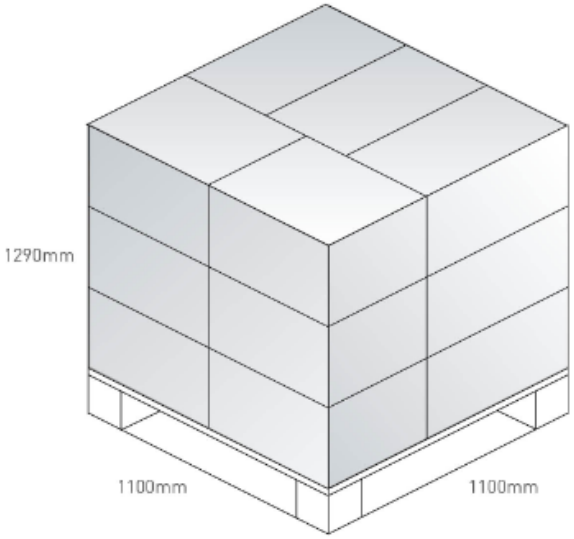
1pc MA412.A.BI.001 per small box
Box Dimensions - 325x125x106mm
Weight - 630g



9 small boxes in one carton
Carton Dimensions - 360x360x400mm
Weight - 6.57Kg



Pallet Dimensions 1080x720x1350mm
15 Cartons per Pallet
5 Cartons per layer
3 Layers

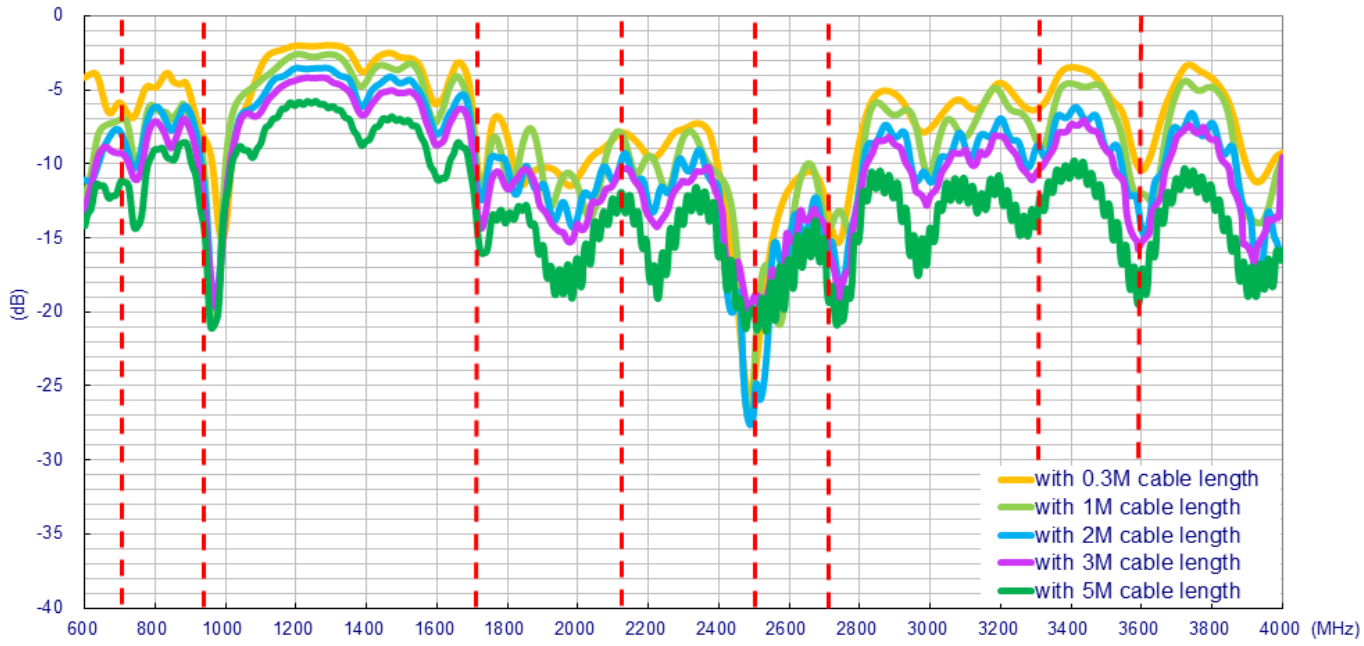


7. Application Note (LTE MIMO Antenna)

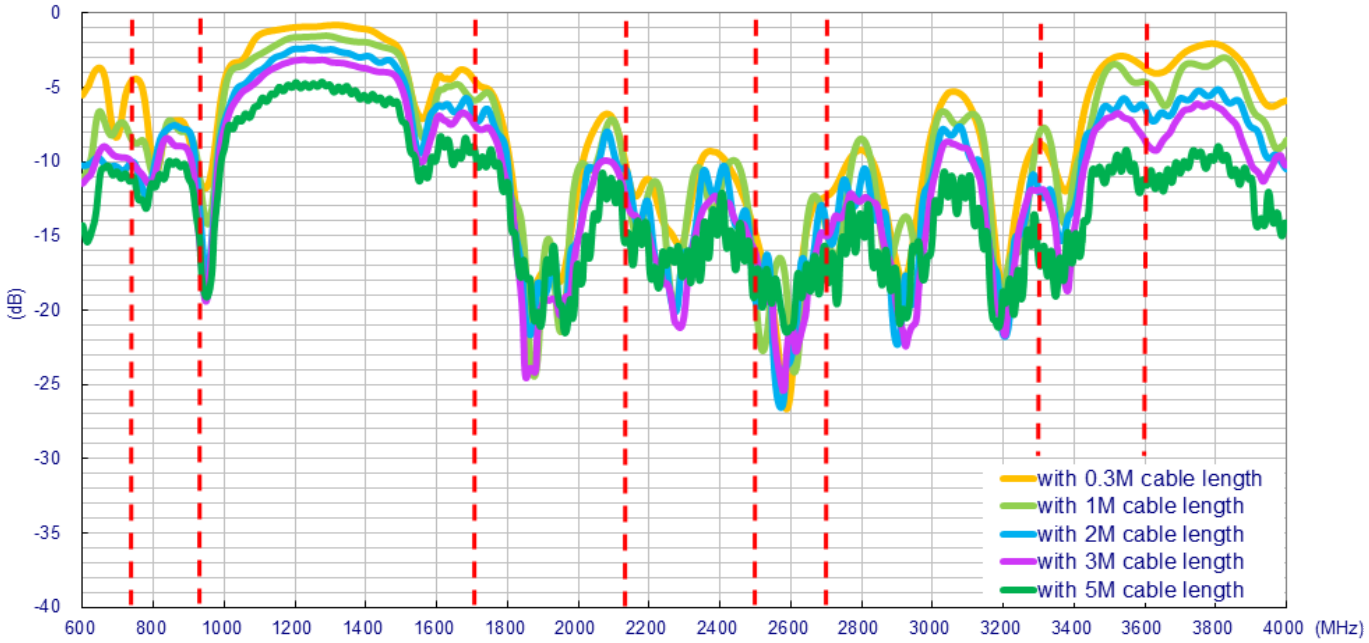
The MA412 antenna performance with different cable lengths and different environments is shown below.

7.1 On the 50*50cm ground plane

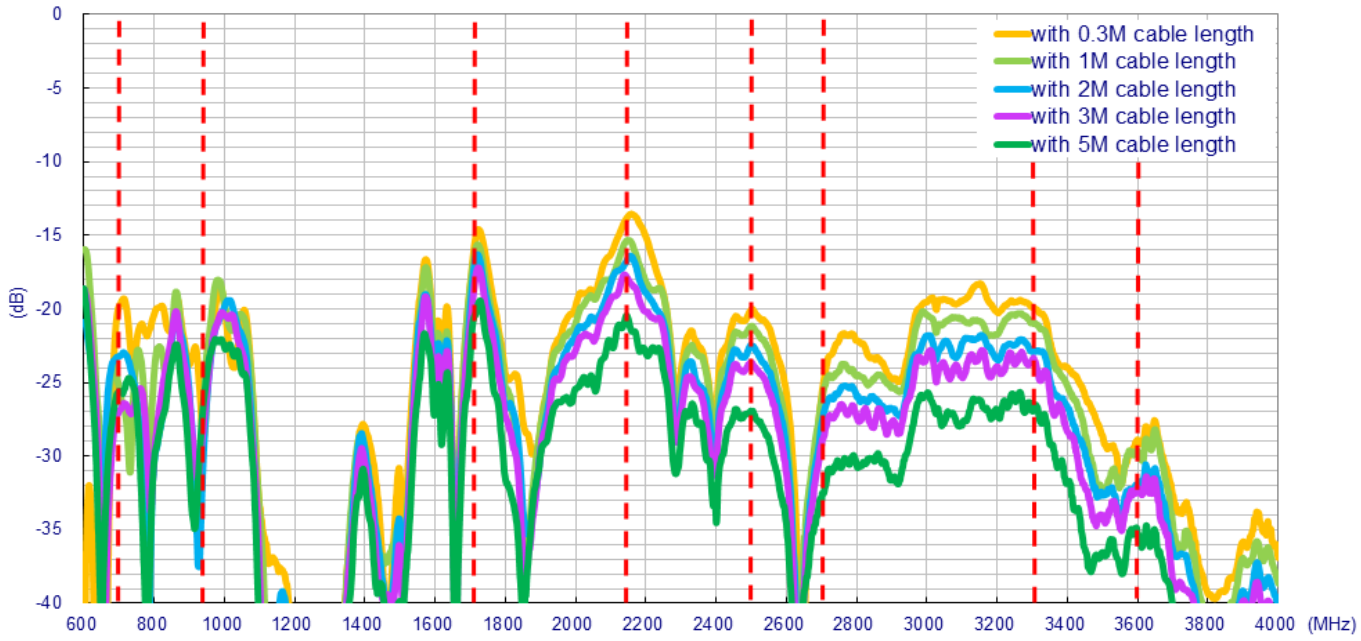
7.1.1 Return Loss (MIMO_1 on the 50*50cm ground plane)



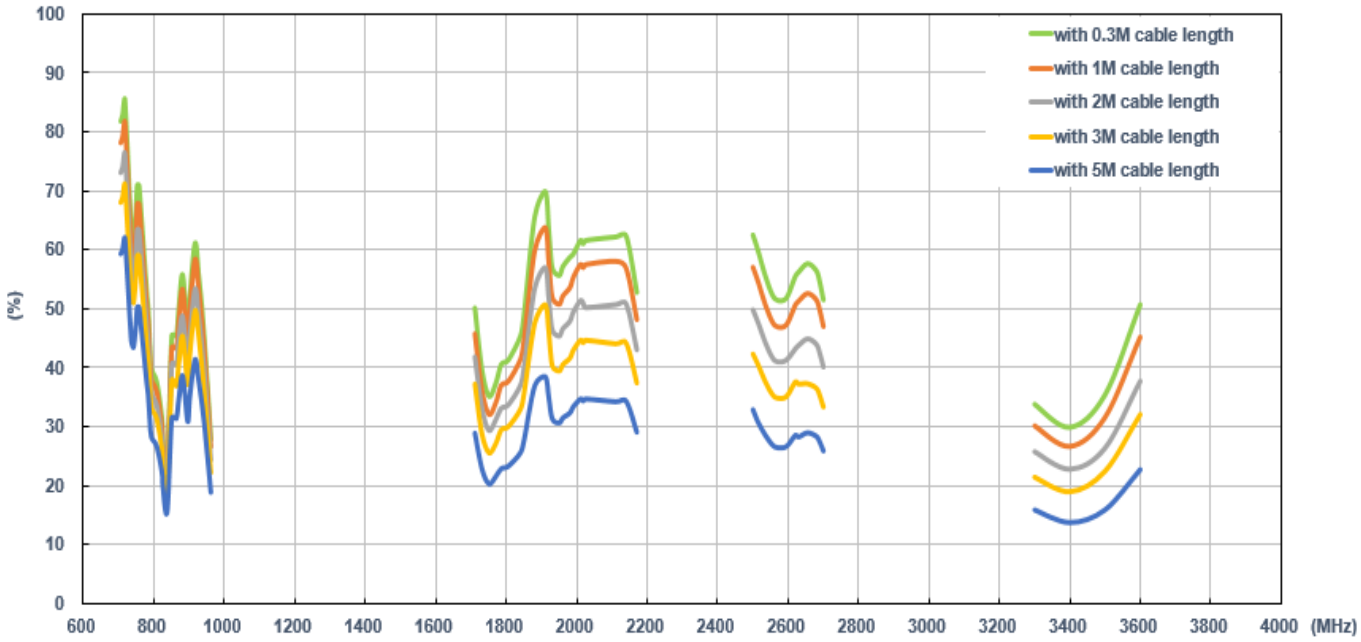
7.1.2 Return Loss (MIMO_2 on the 50*50cm ground plane)



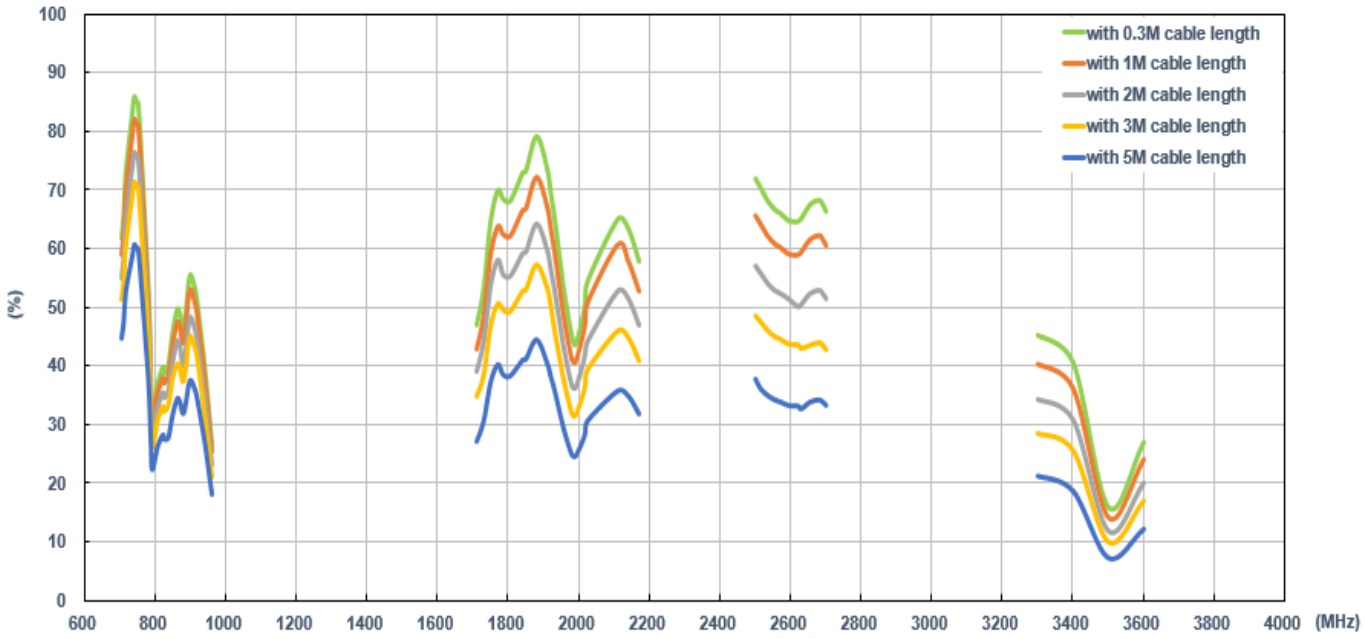
7.1.3 Insertion Loss (on the 50*50cm ground plane)



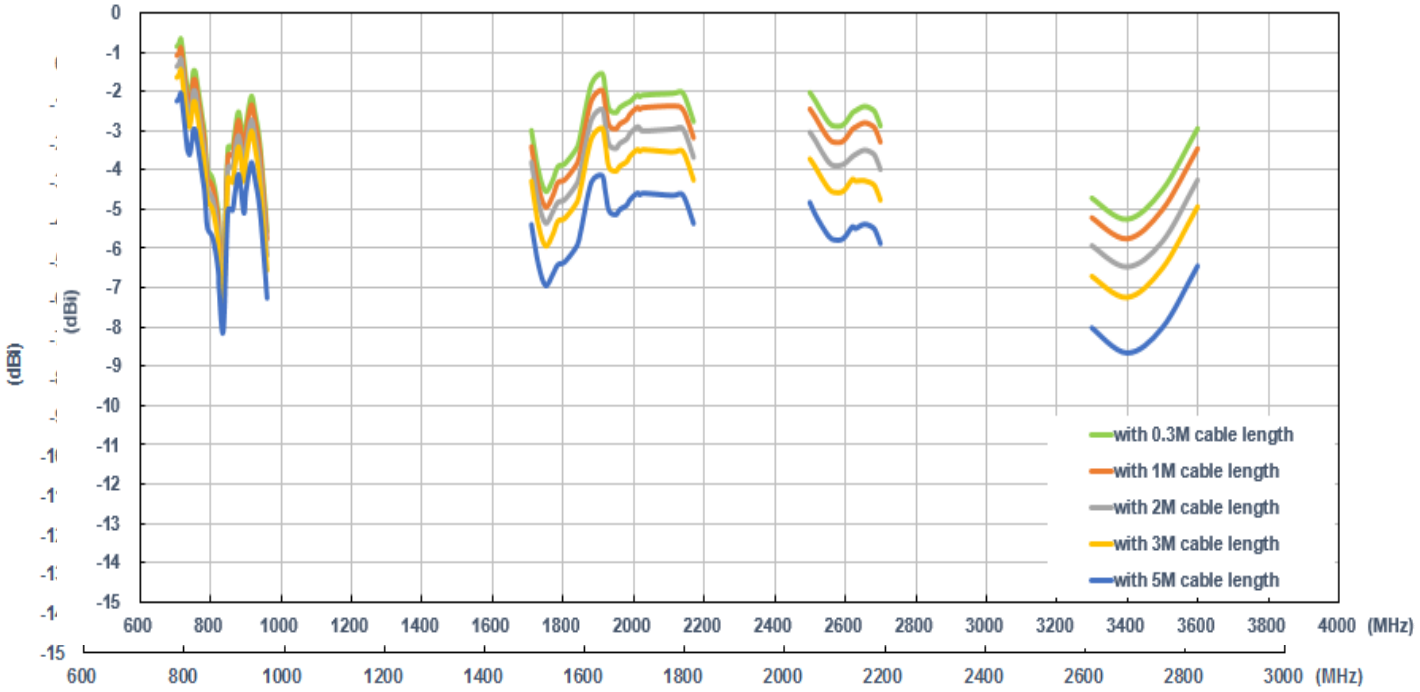
7.1.4 Efficiency (MIMO_1 on the 50*50cm ground plane)



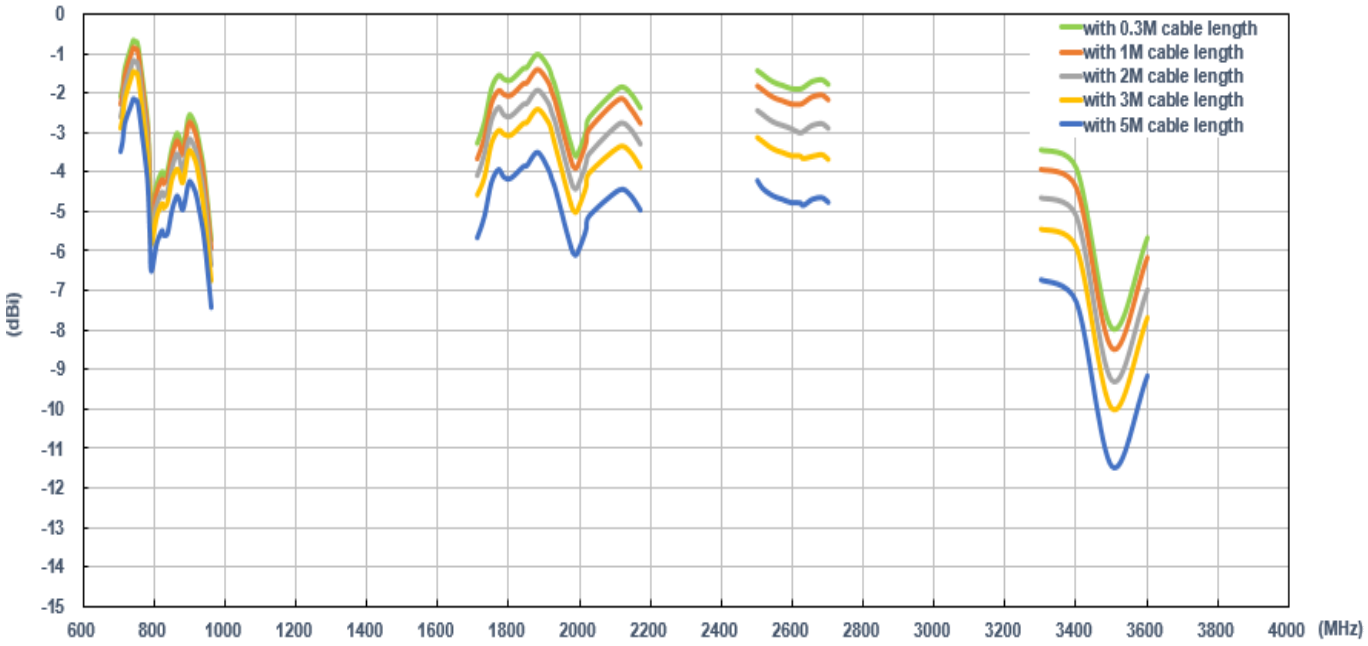
7.1.5 Efficiency (MIMO_2 on the 50*50cm ground plane)



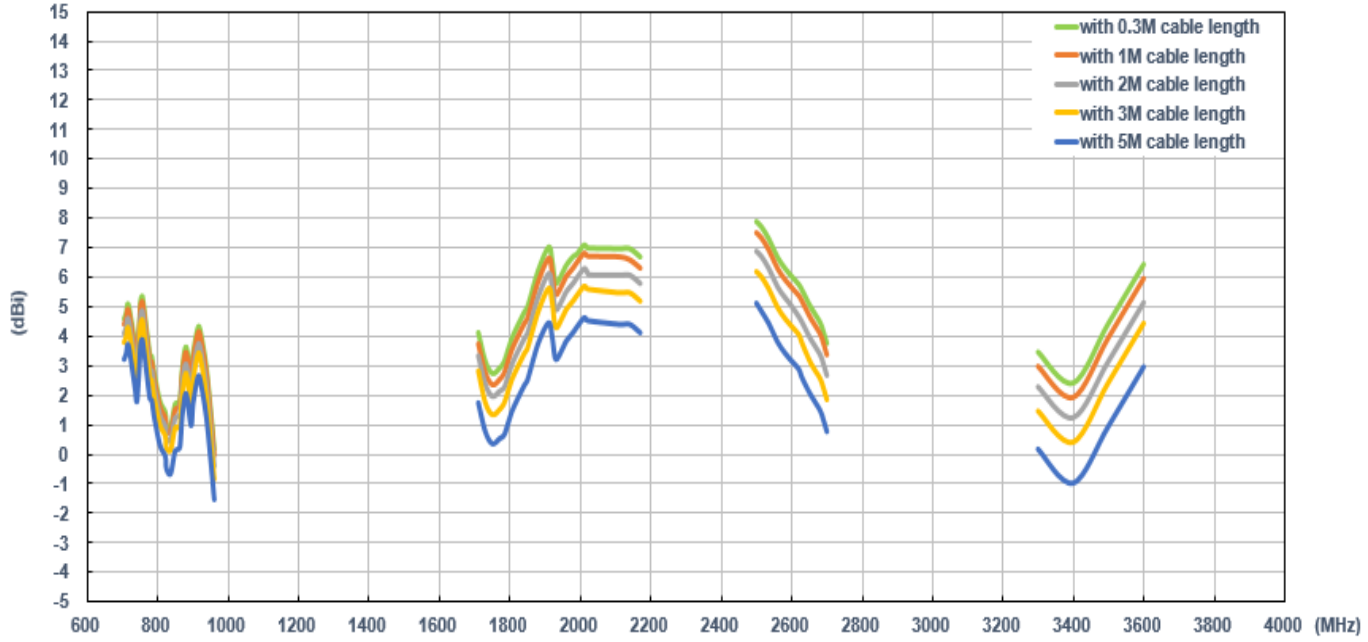
7.1.6 Average Gain (MIMO_1 on the 50*50cm ground plane)



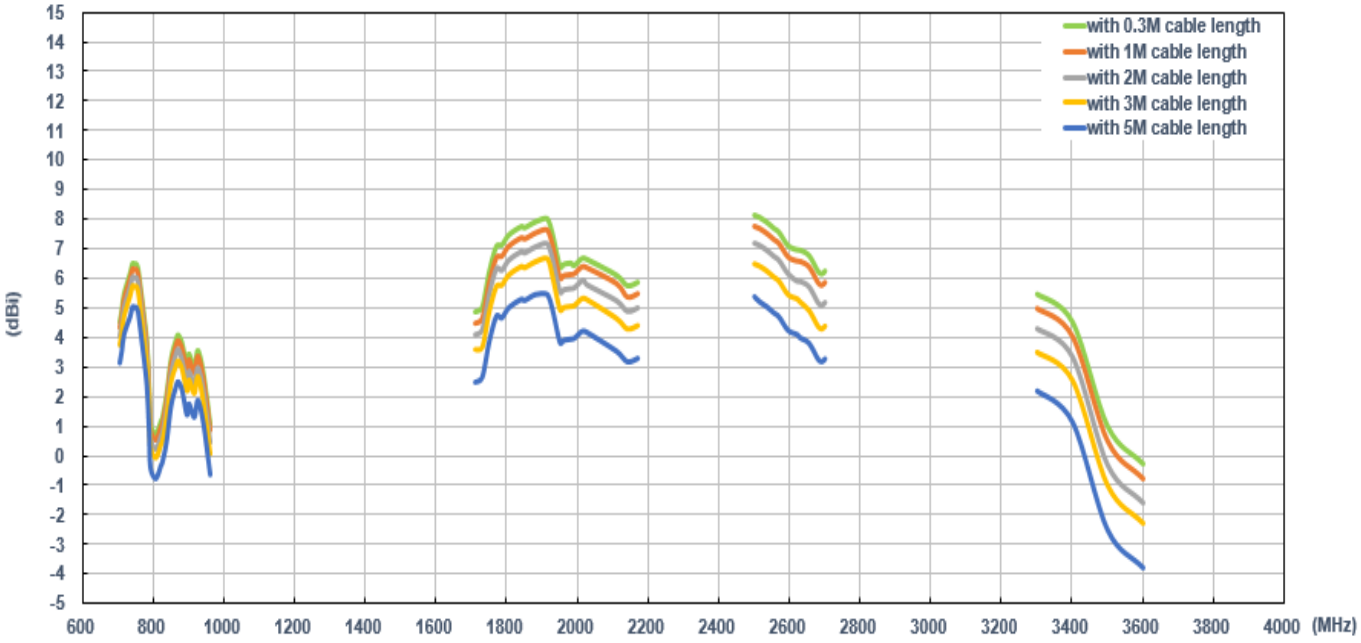
7.1.7 Average Gain (MIMO_2 on the 50*50cm ground plane)



7.1.8 Peak Gain (MIMO_1 on the 50*50cm ground plane)

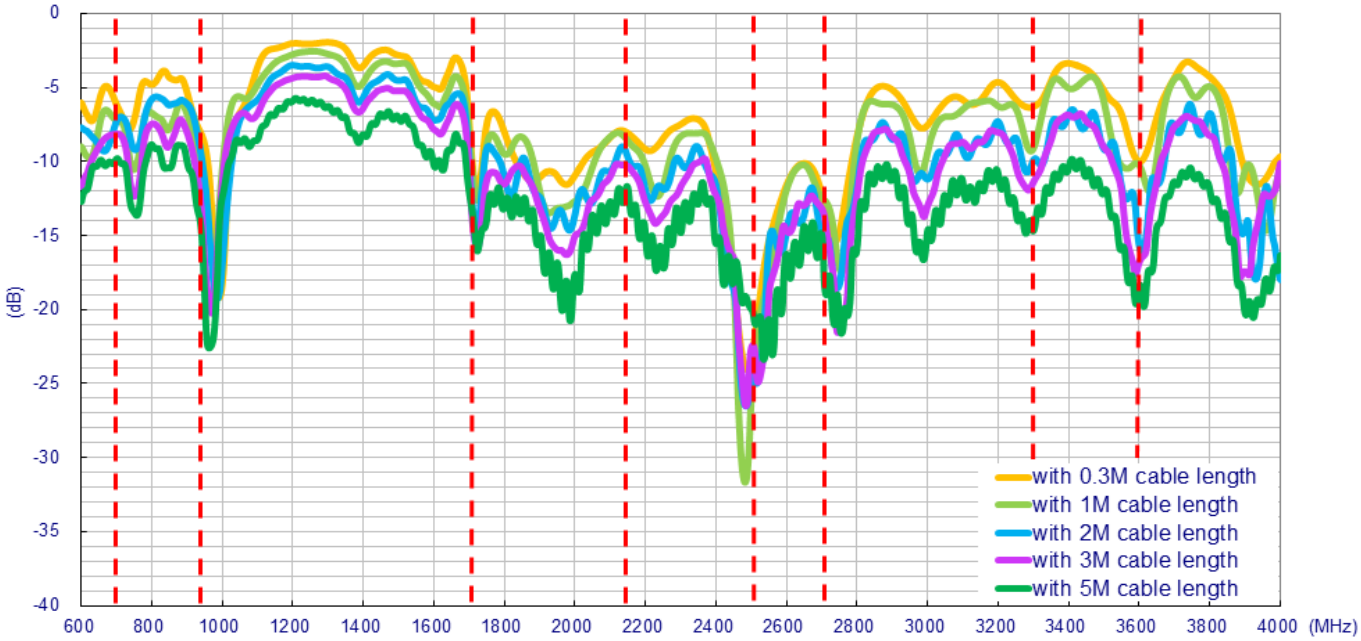


7.1.9 Peak Gain (MIMO_2 on the 50*50cm ground plane)

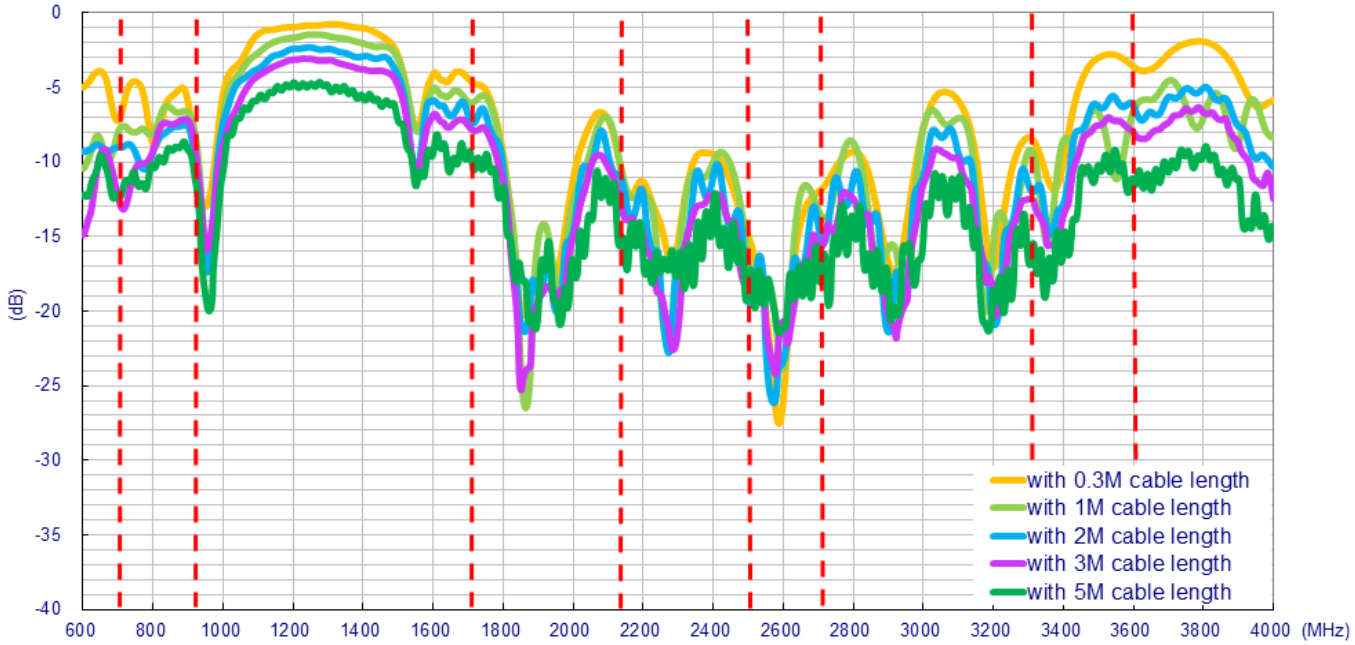


7.2 In free space

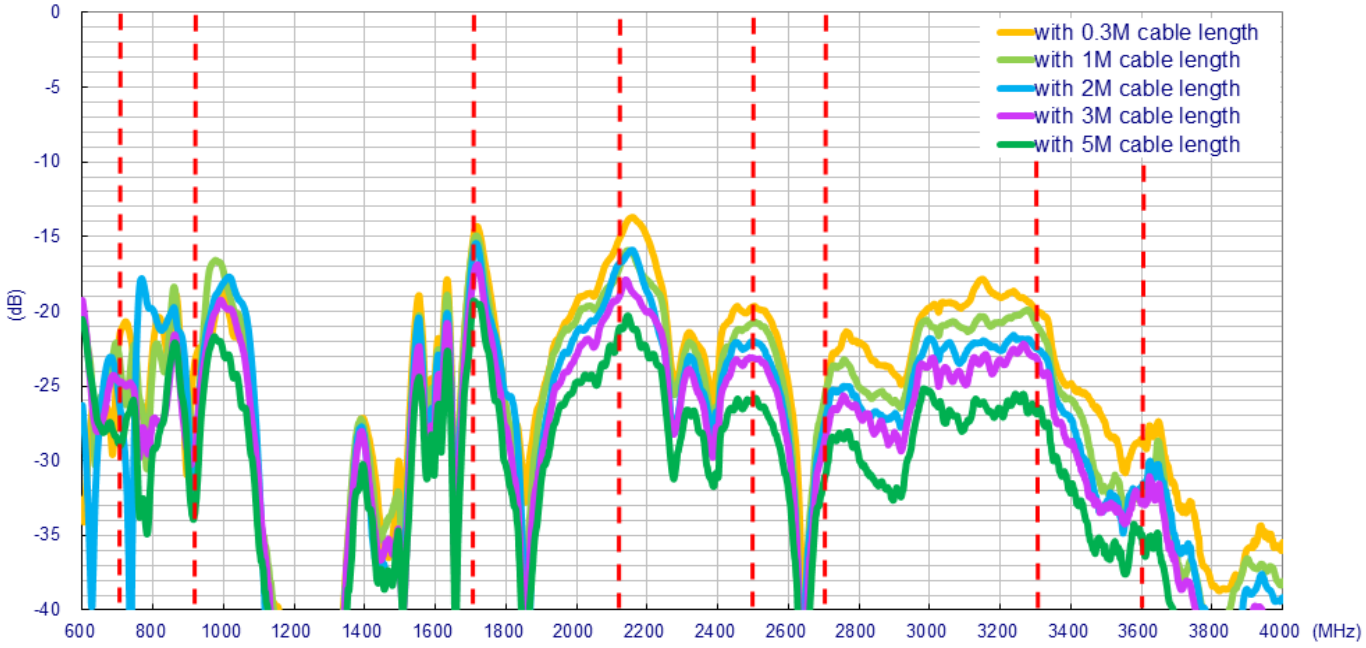
7.2.1 Return Loss (MIMO_1 in free space)



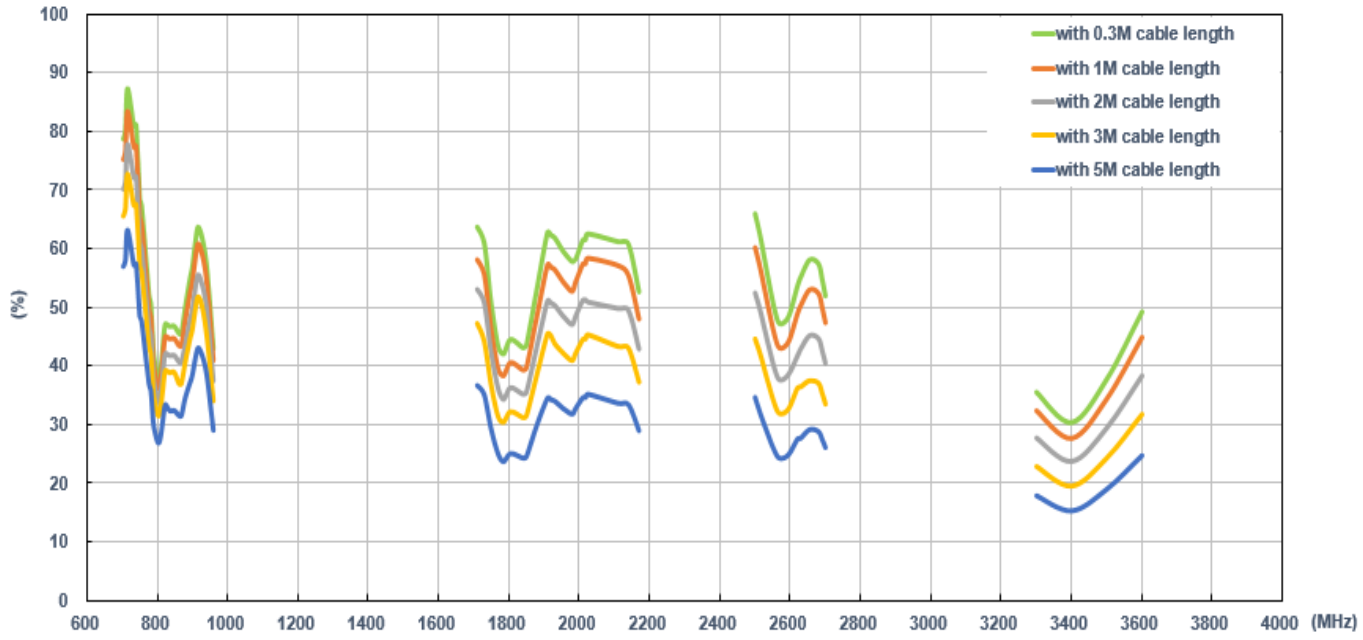
7.2.2 Return Loss (MIMO_2 in free space)



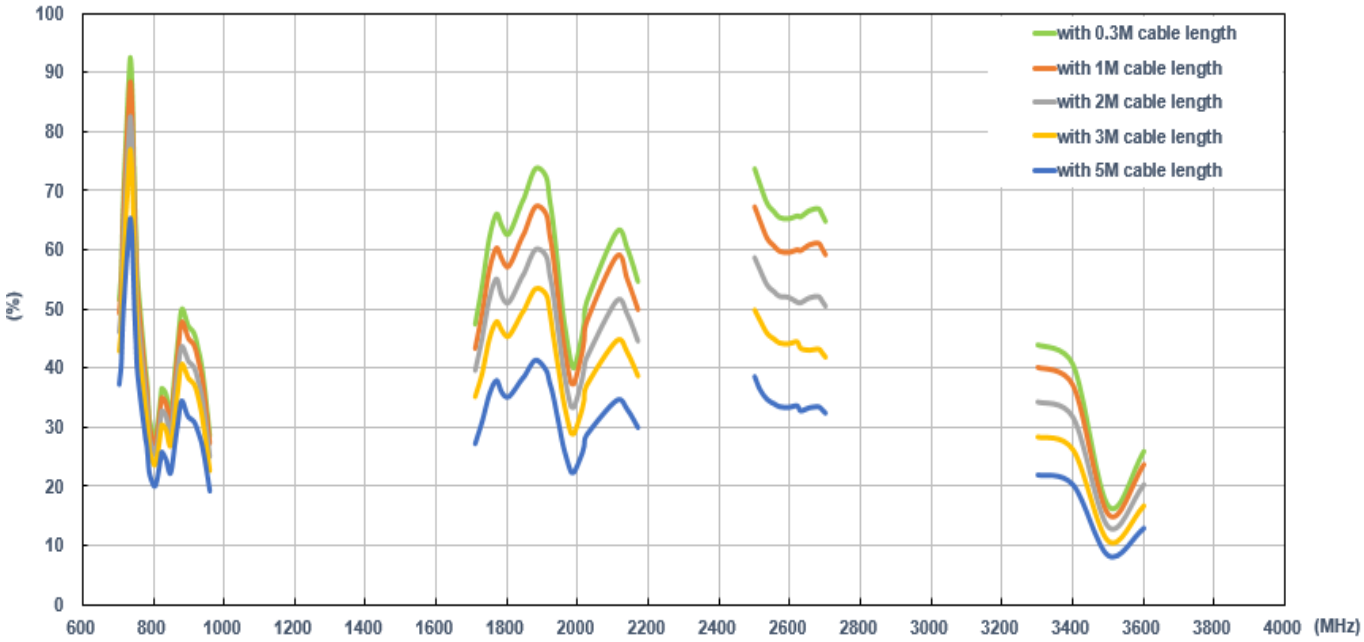
7.2.3 Insertion Loss (in free space)



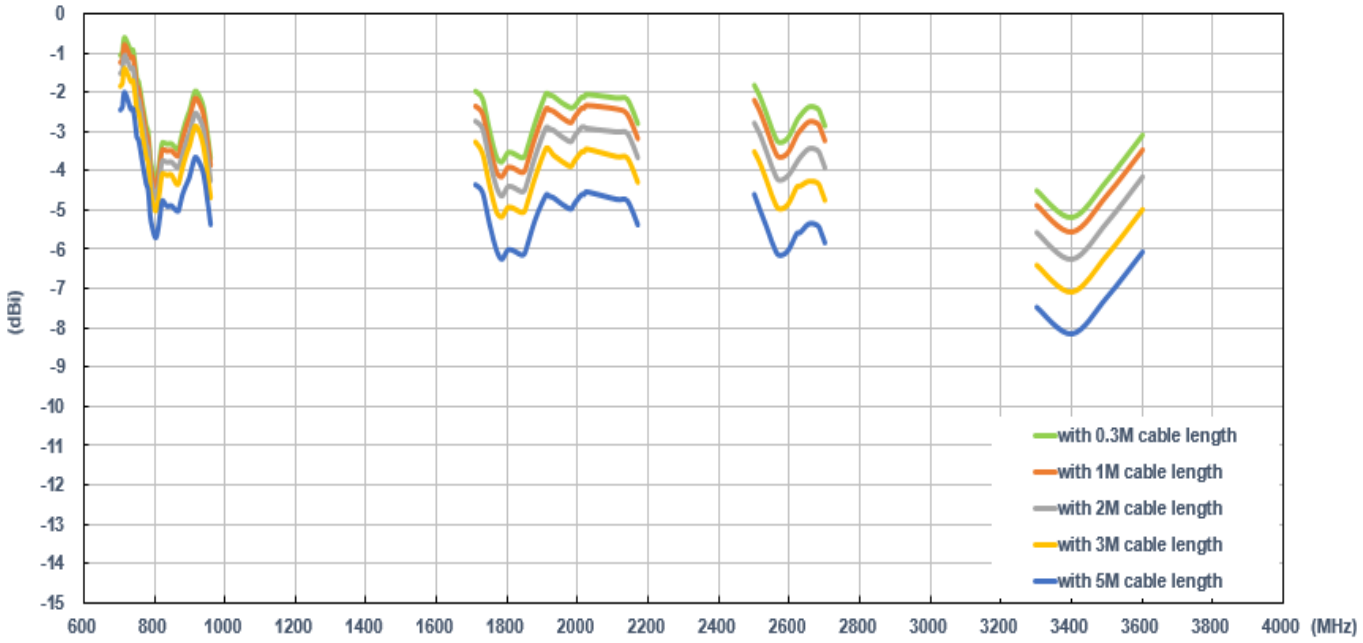
7.2.4 Efficiency (MIMO_1 in free space)



7.2.5 Efficiency (MIMO_2 in free space)

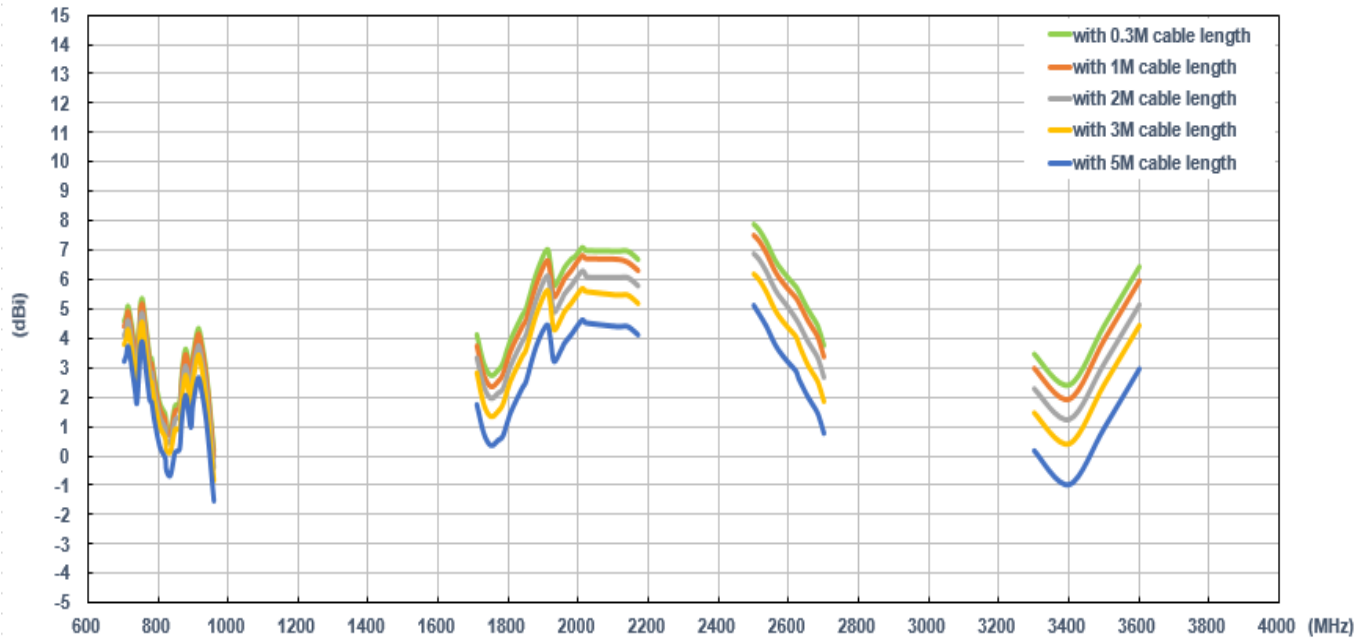


7.2.6 Average Gain (MIMO_1 in free space)



7.2.7 Average Gain (MIMO_2 in free space)

7.2.8 Peak Gain (MIMO_1 in free space)



7.2.9 Peak Gain (MIMO_2 in free space)