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佳邦科技股份有限公司

INPAQ TECHNOLOGY CO., LTD.

PASSIVE SYSTEM ALLIANCE

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东软_C928_海外版 LTE/WIFI Antenna Evaluation Report

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INPAQ Technology Co., Ltd.

Last updated in Jan.20th, 2025

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Revision History

Released Date	Version	Record
Oct.9th,2024	V0.0	初版无源调试数据
Jan.18th,2025	V0.1	C928海外版整机完整测试数据

Requirements of Antenna Design and Measurement

Requirements of Antenna Design

RF Function	Number of ANT	Frequency Band	Remark
WIFI/BT	2	2400-2500MHz,5100-5900MHz	
LTE Main	1	700-960MHz,1710-2690MHz	
LTE DIV	1	1710-2690MHz	

Requirements of Measurement

OTA Test Item	Specification (Free Space)	Remark
WIFI/BT	2400-2500MHz≥50%,5100-5900MHz≥50%	
LTE Main	700-960MHz≥35%,1710-2690MHz≥35%	
LTE DIV	1710-2690MHz≥35%	

Requirements of Antenna Design and Measurement

序号	项目		性能指标要求	备注
1	频率选择性		5G 主/副： 700M∽1000M&1700M∽2700M&3.3G∽5G 5G 分集： 1700M∽2700M&3.3G∽5G 4G 主/副： 700M∽1000M&1700M∽2700M	根据控制器所支持频段作适配
2	阻抗		50Ω	
3	电压驻波比		≤3	
4	天线隔离度	系统内	≥10dB	
		2/3/4/5G -V2X	≥15dB	
		2/3/4/5G –WIFI	≥15dB	
		2/3/4/5G-BT	≥15dB	
		2/3/4/5G -GNSS	≥25dB	
5	天线效率		f<3G 35%以上；3G≤f 40%以上	
6	2D 增益平坦度	θ 取 45°、60°、70°、80°、85°、90°	增益平坦度≤12dB 低于平均增益 10dB 的角度之和＜30°	辐射方向图中截取
7	天线平均增益 (θ 取 60°∽90°)	f＜1GHz	≥-8dBi	
		1≤f＜2.3G	≥-9dBi	
		2.3≤f	≥-10dBi	
8	总全向辐射功率 TRP		f<3G：≥传导实测 Max power-5.5dB 3G≤f：≥传导实测 Max power-4.5dB	5G/4G 频段，需备注测试 BW
9	总全向灵敏度 TIS		≤传导实测 Min sensitivity+6.5dB	

表 9 WiFi 天线标准表

序号	项目		性能指标要求	备注
1	频率选择性		2.4G∽2.5G 5.7G∽5.85G	
2	阻抗		50Ω	
3	电压驻波比		≤2.5	
4	天线隔离度	系统内	≥10dB	
		WiFi-2/3/4/5G	≥15dB	
		WiFi-V2X	≥15dB	
		WiFi-BT	≥15dB	
		WiFi-GNSS	≥25dB	
5	天线效率		≥50%	
6	2D 增益平坦度	θ 取 0°、30°、60°、90°、120°、150°、180°	增益平坦度≤12dB 低于平均增益 10dB 的角度之和＜30°	辐射方向图中截取
7	总全向辐射功率 TRP		≥传导实测 Max power-4.5dB	建议 6M 速率
8	总全向灵敏度 TIS		≤传导实测 Min sensitivity+6.5dB	

终端客户SPEC

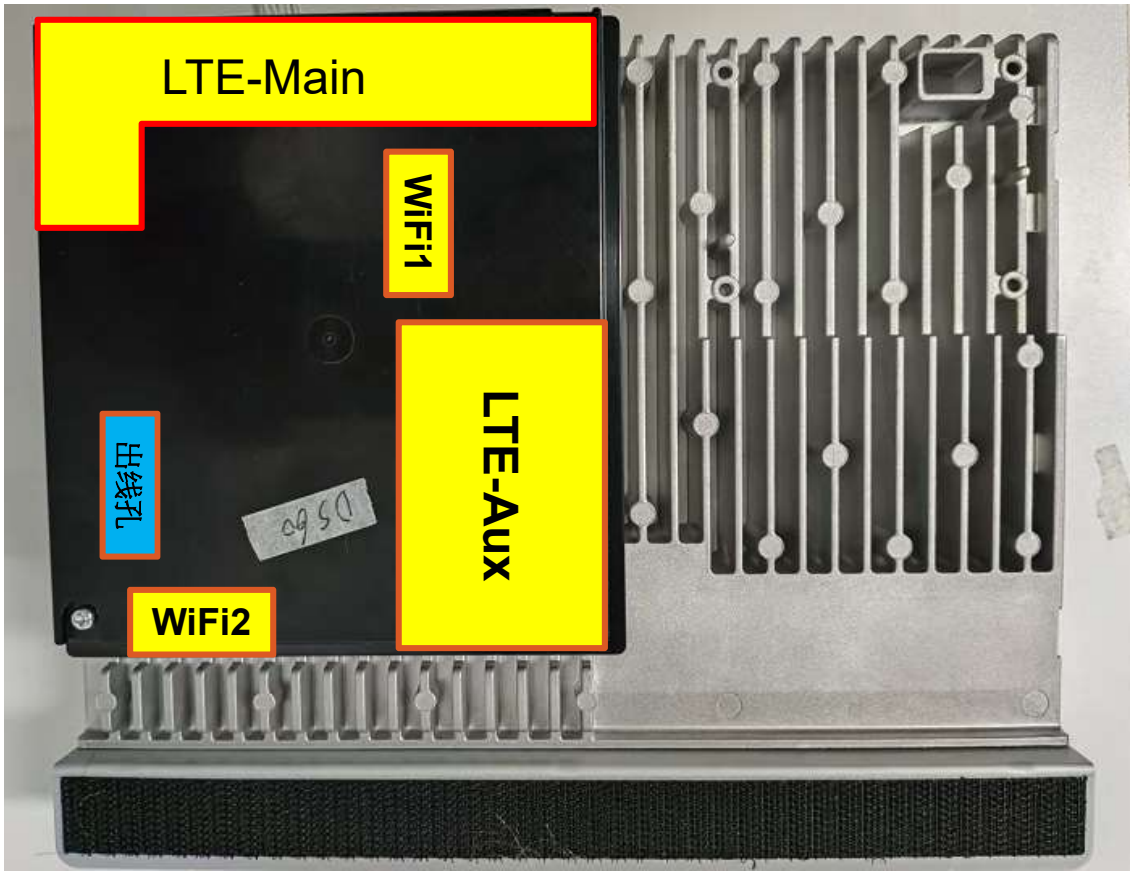
Requirements of Antenna Design and Measurement

BT 天线标准表

序号	项目		性能指标要求	备注
1	频率选择性		2.4G~2.5G	
2	阻抗		50Ω	
3	电压驻波比		≤2.5	
4	天线隔离度	系统内	≥10dB	
		BT-2/3/4/5G	≥15dB	
		BT-V2X	≥15dB	
		BT-WiFi	≥15dB	
		BT-GNSS	≥25dB	
5	天线效率		≥50%	
6	2D 增益平坦度	θ 取 0°、30°、60°、90°、120°、150°、180°	增益平坦度≤12dB 低于平均增益 10dB 的角度之和＜30°	辐射方向图中截取
7	总全向辐射功率 TRP		≥传导实测 Max power-4.5dB	建议 EDR-2DH5
8	总全向灵敏度 TIS		≤传导实测 Min sensitivity+6.5dB	

终端客户SPEC

Antenna Placement & Solution



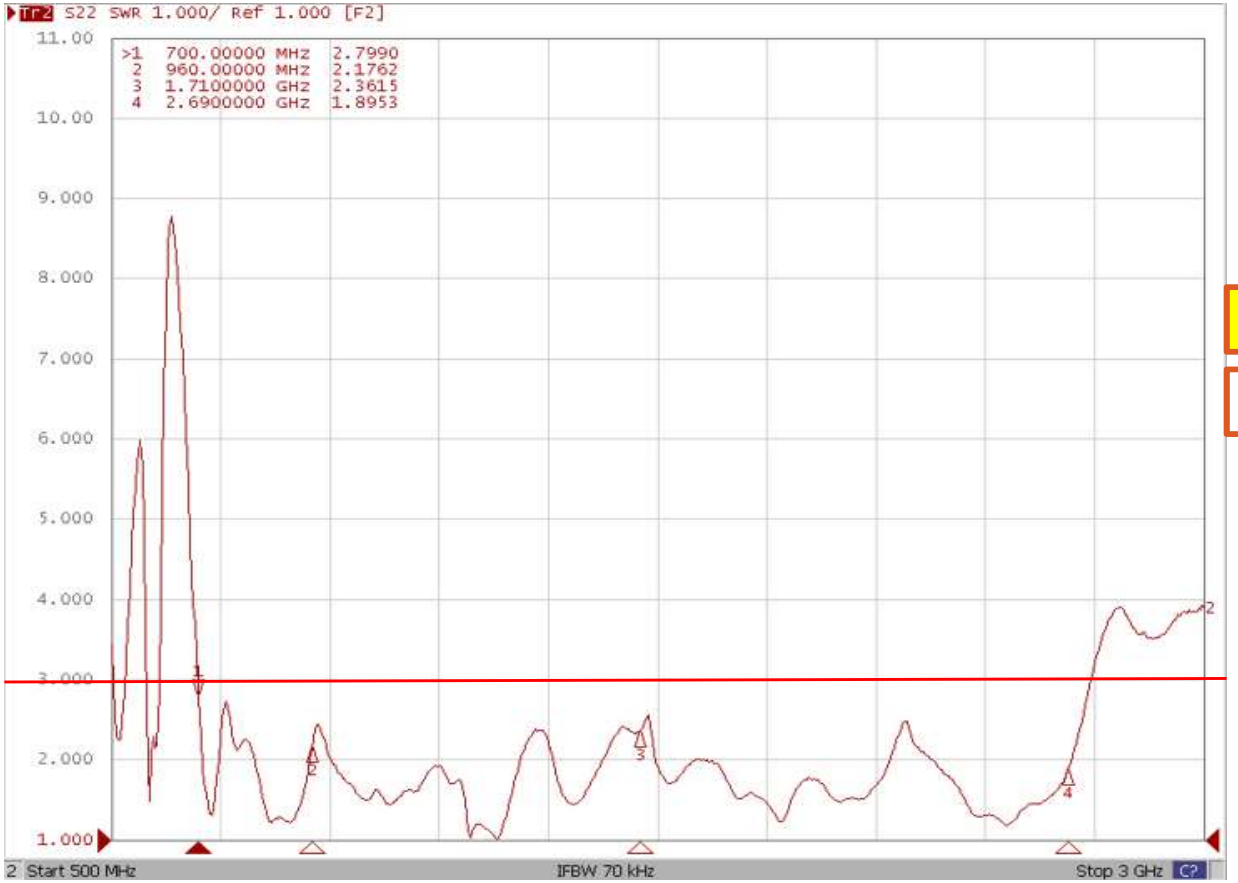
天线布局位置说明

Antenna Placement & Solution

无源测试接线方式

由于无源调试需要将Cable拉出机壳外，因此需要采用更长的线材，同时为了保持最接近整机状态，在等长于生产定义线长的位置中剥并与主板接地。

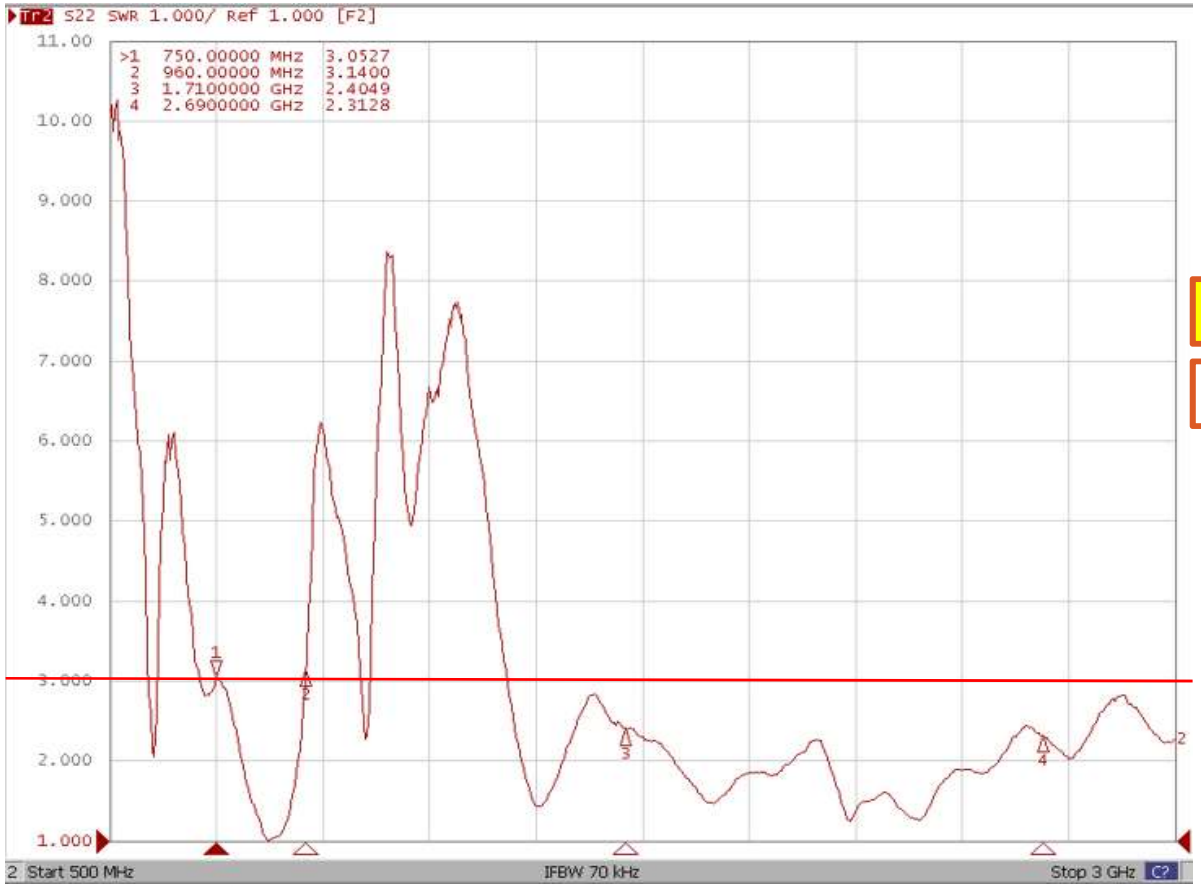
VSWR Results



PASS

LTE-Main Antenna

VSWR Results



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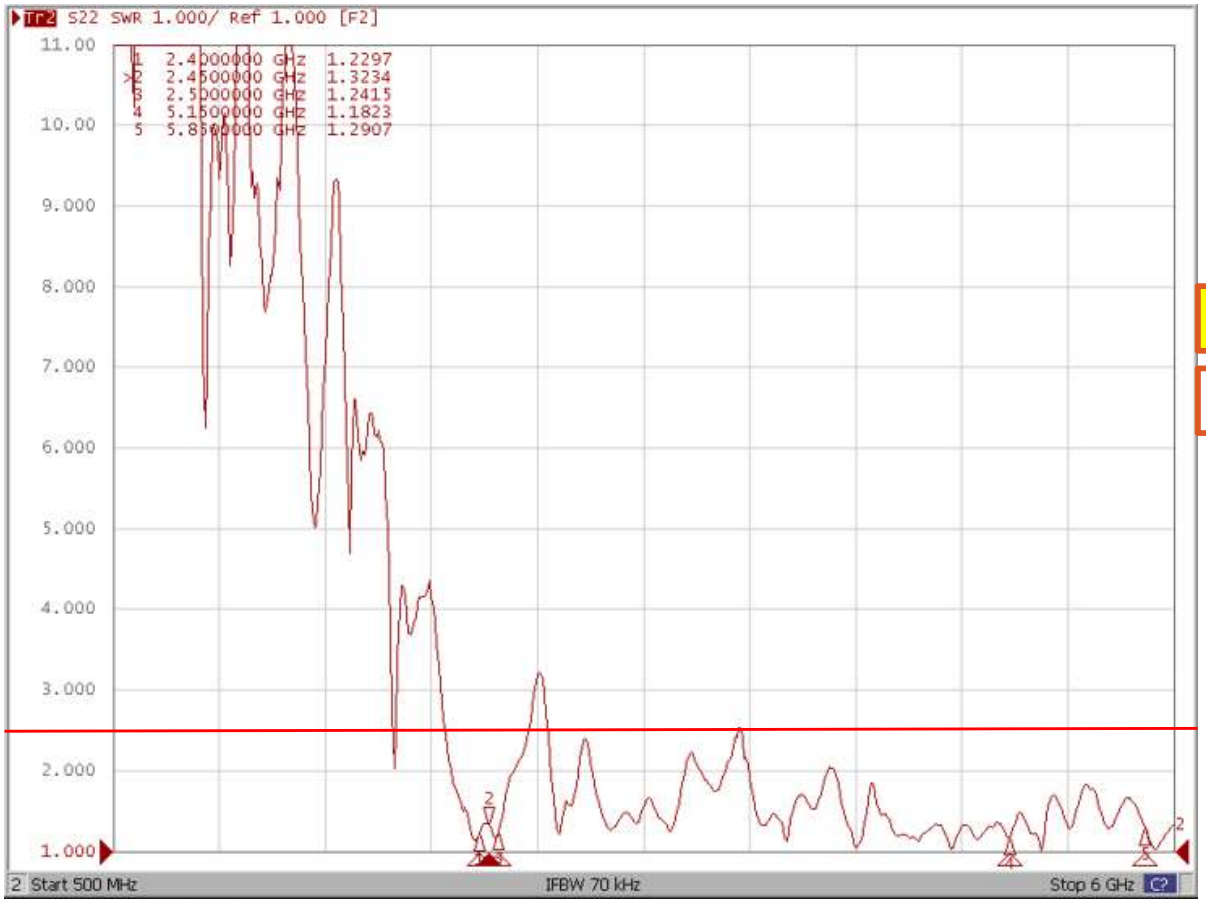
LTE-DIV Antenna

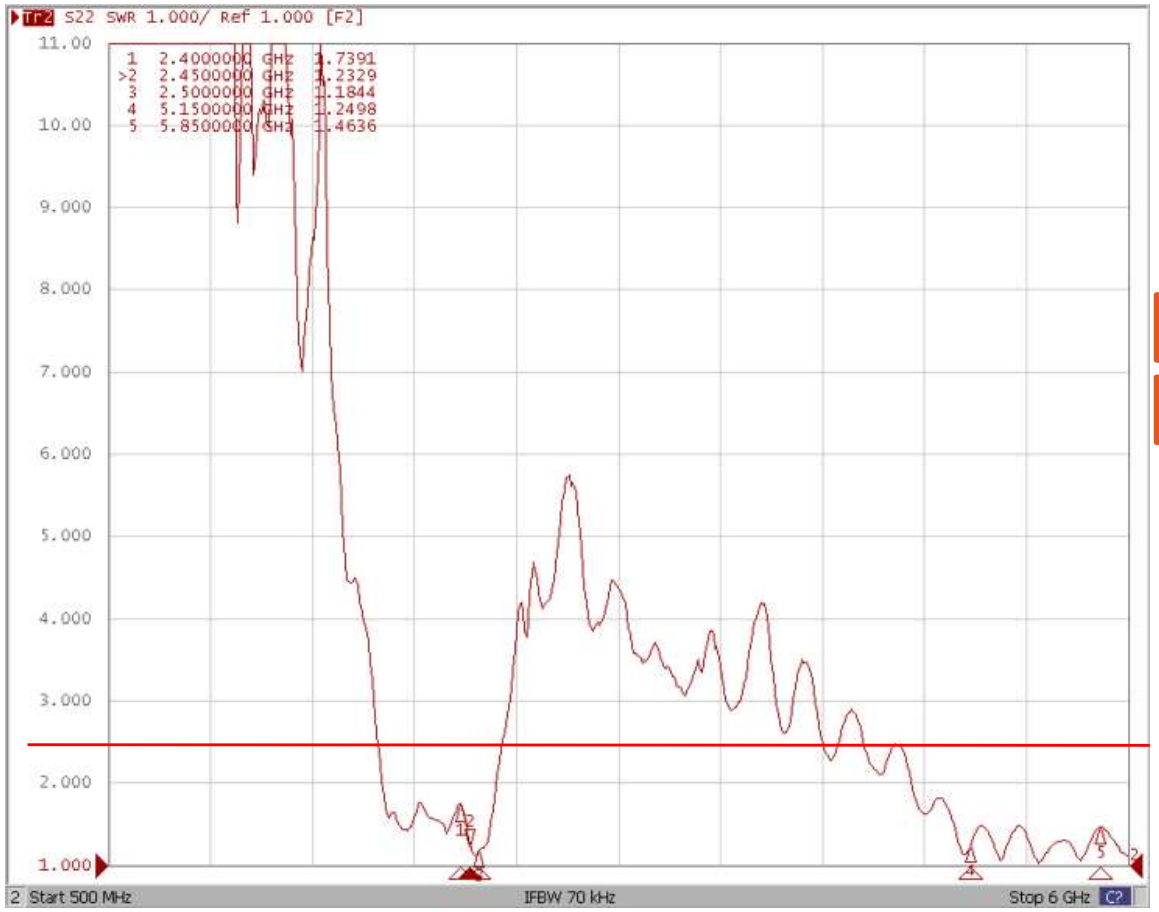
VSWR Results



PASS

WIFI-1 Antenna

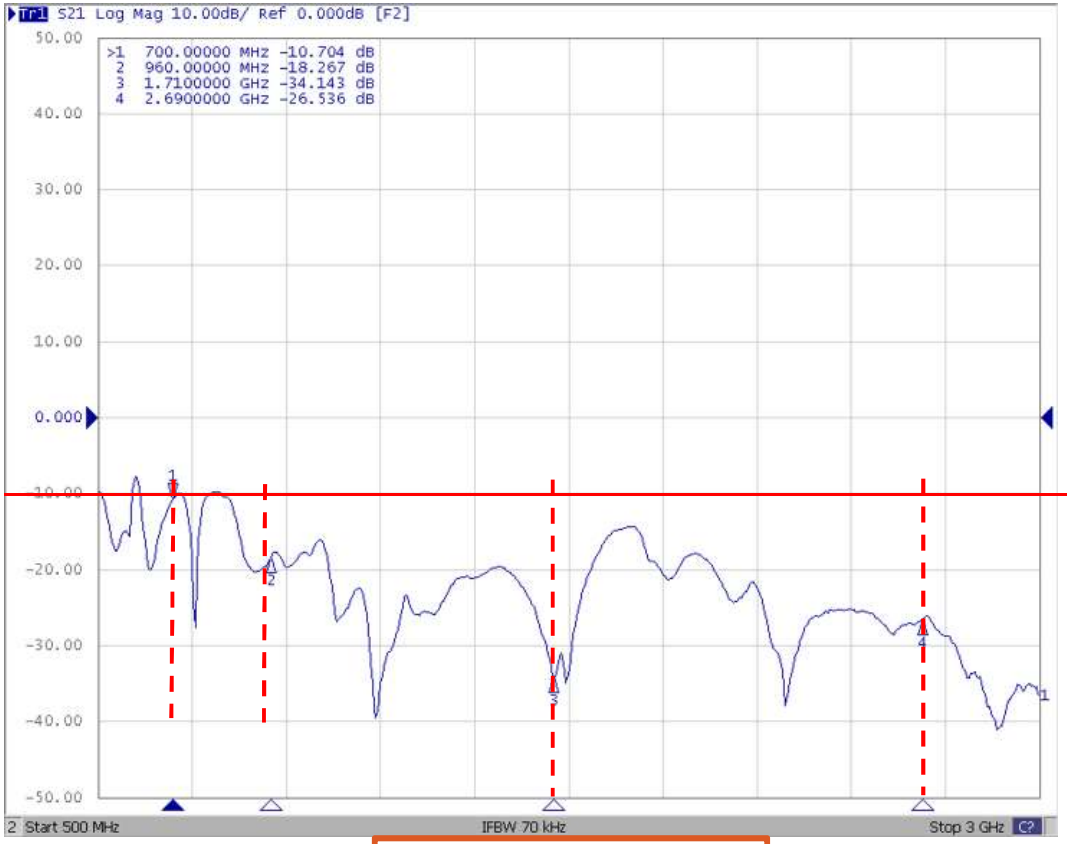
VSWR Results



PASS

WIFI-2 Antenna

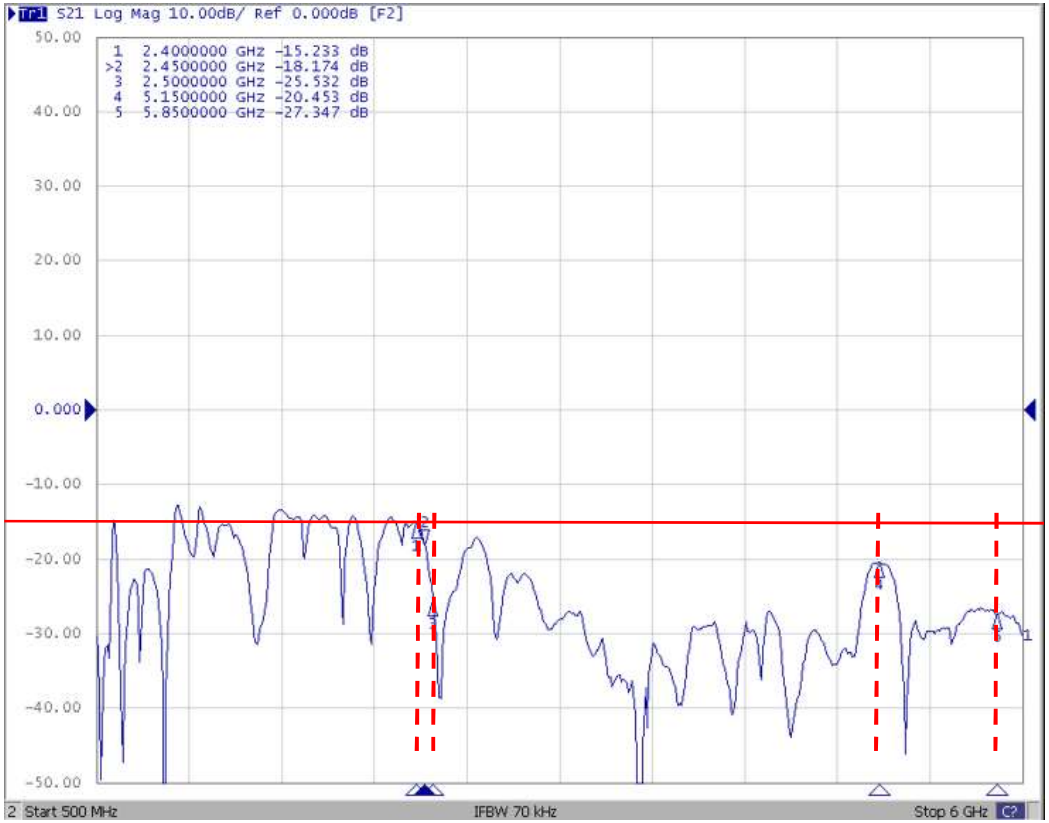
Isolation Results



PASS

LTE-Main & LTE-Div

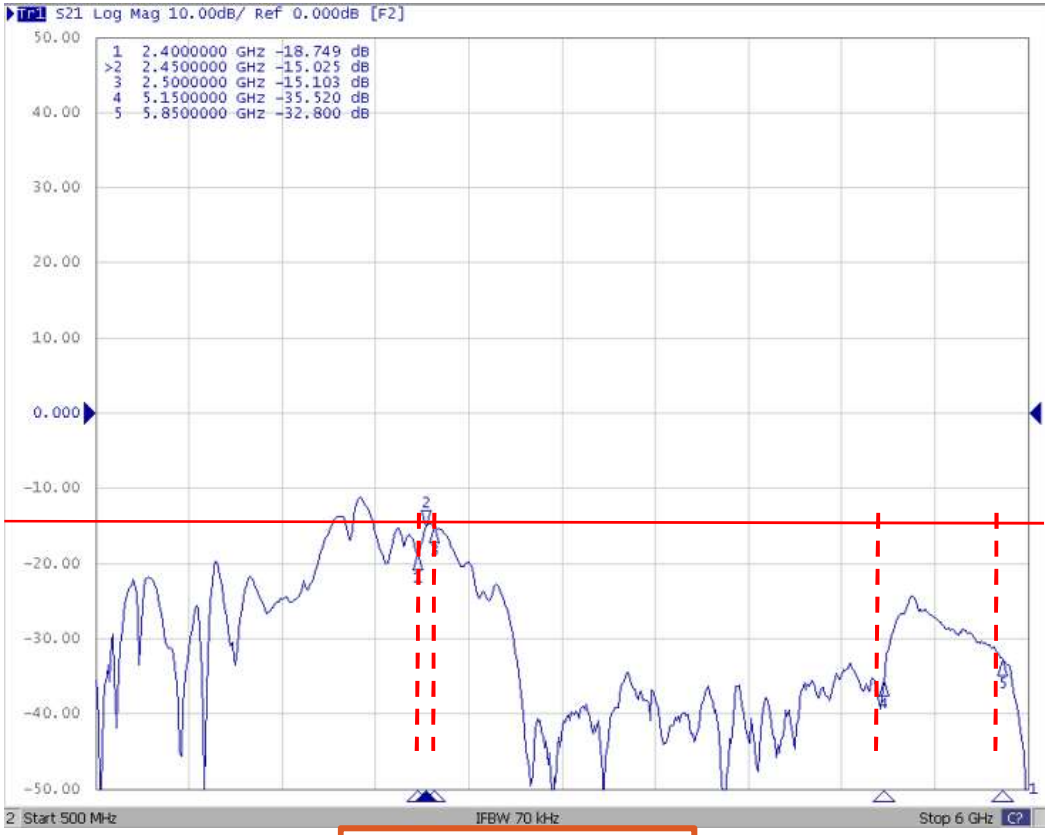
Isolation Results



PASS

LTE-Main & WIFI1

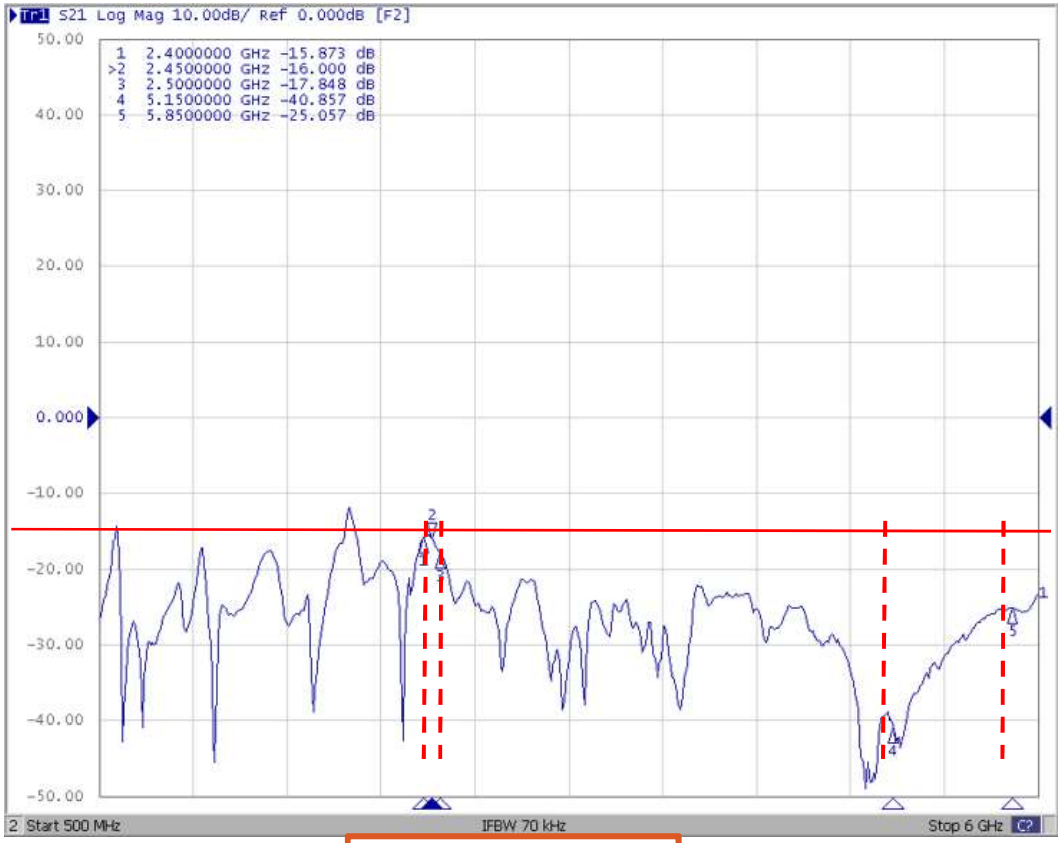
Isolation Results



PASS

LTE-Main & WIFI2

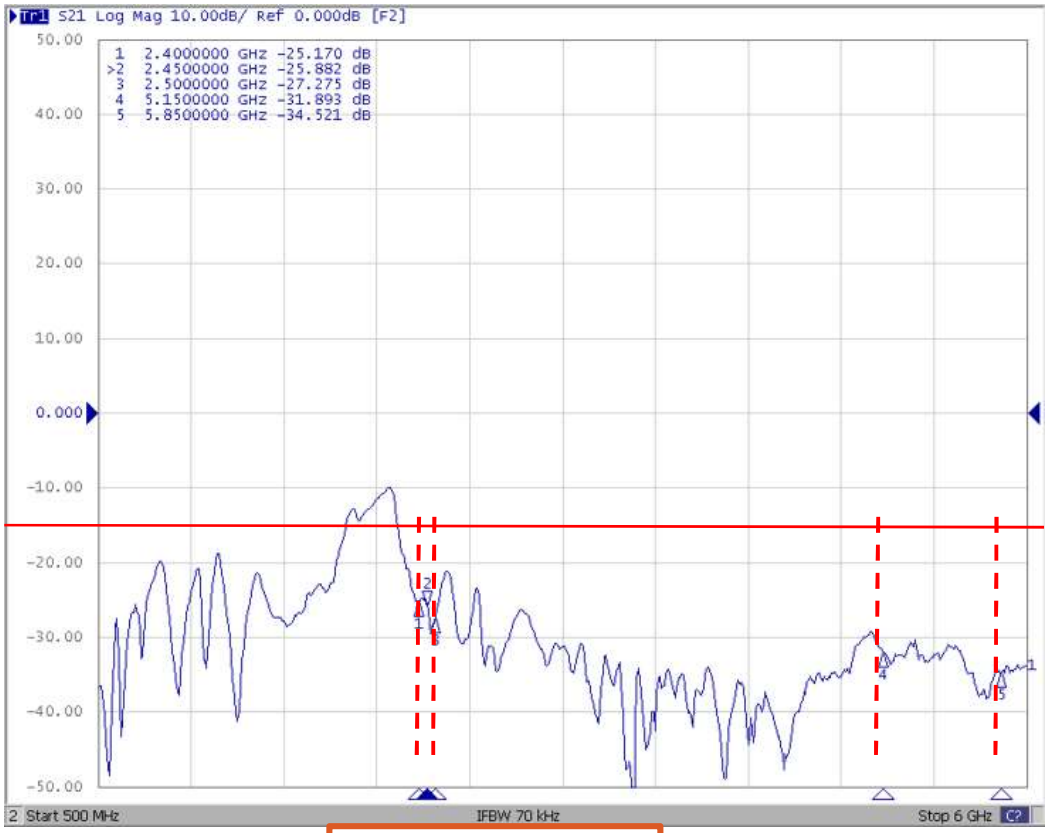
Isolation Results



PASS

LTE-DIV & WIFI1

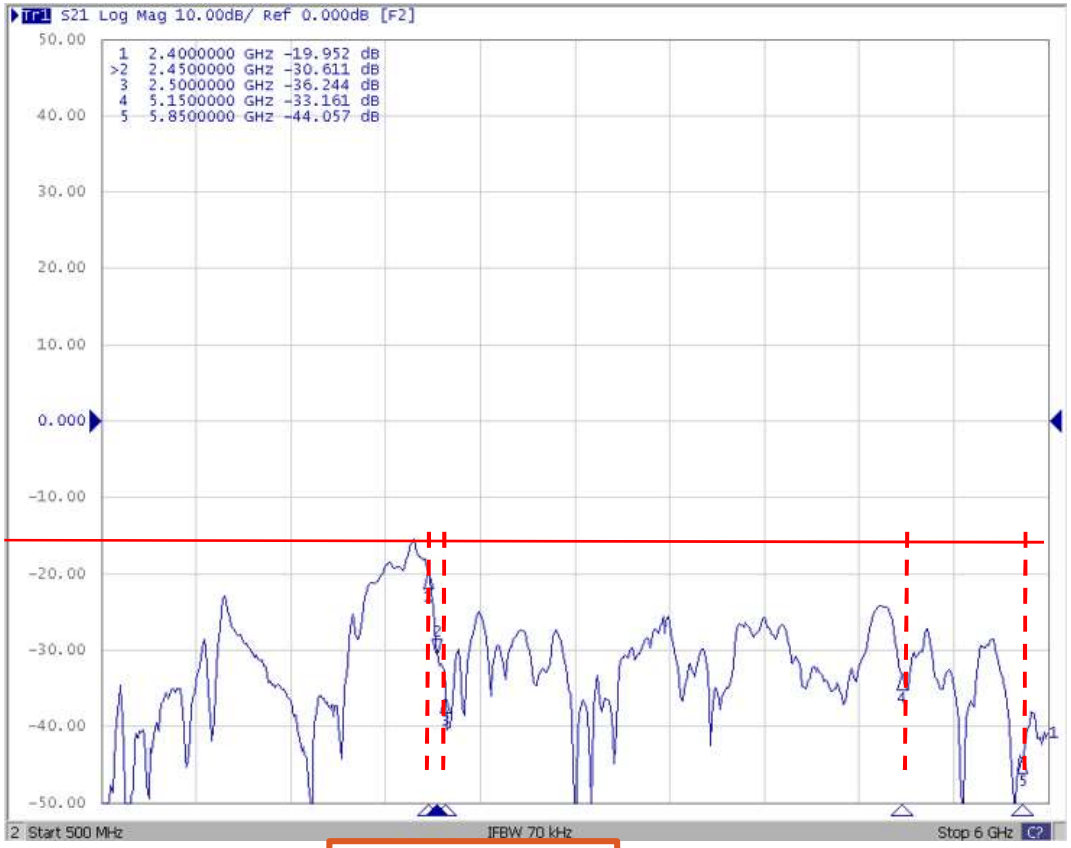
Isolation Results



PASS

LTE-DIV & WIFI2

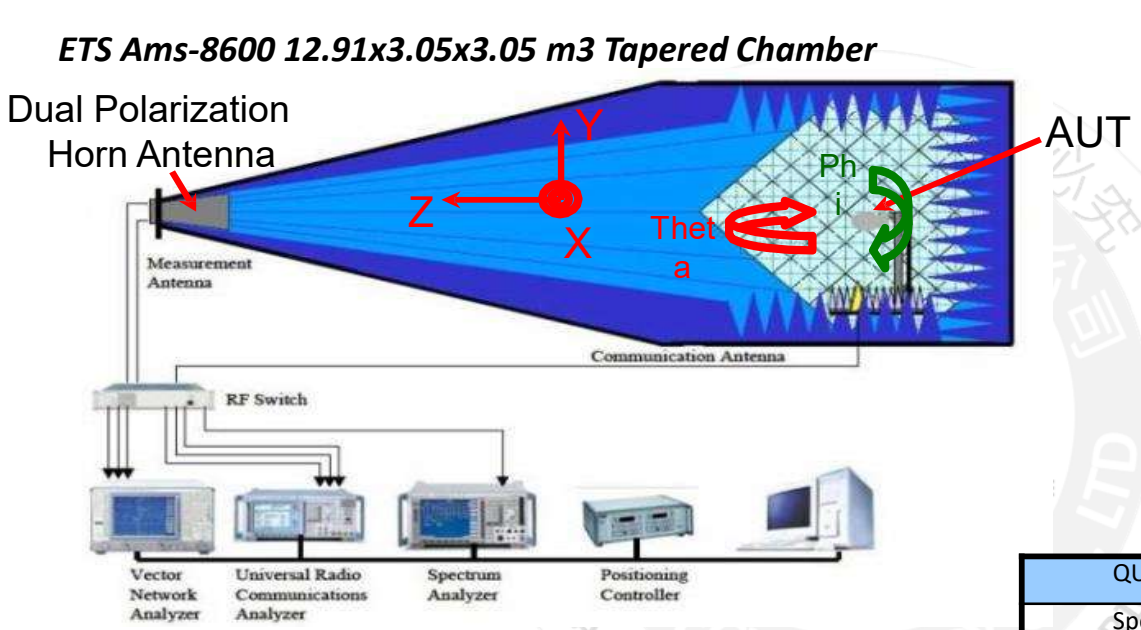
Isolation Results



PASS

WIFI1 & WIFI2

Test Setup for Radiation Pattern Measurement



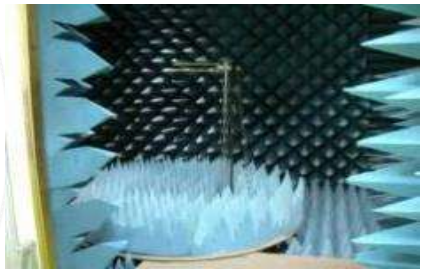
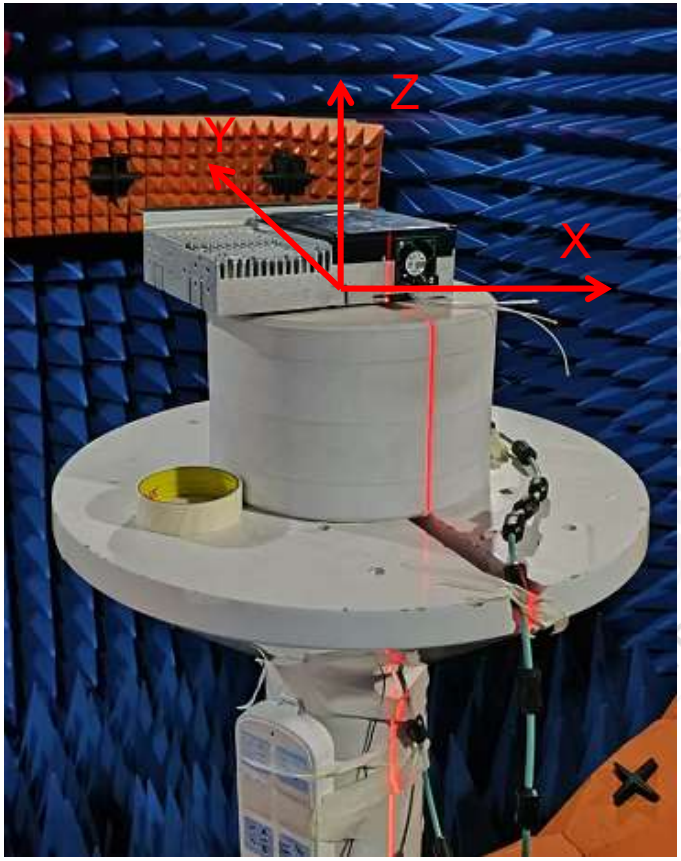


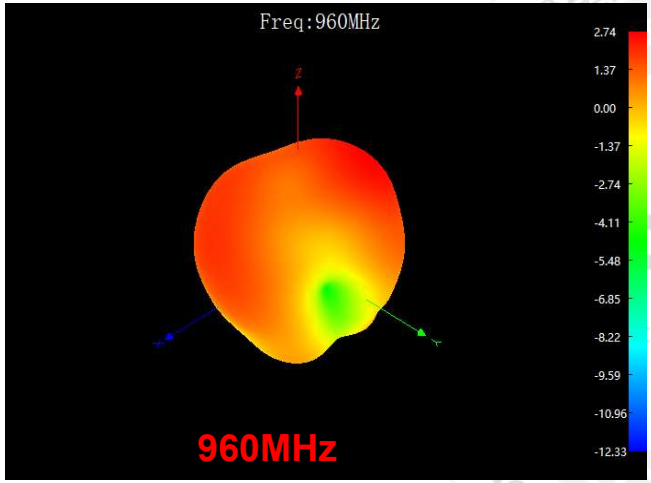
Figure 1: System diagram for test system including compact-size tapered anechoic chamber and optional test instrumentation

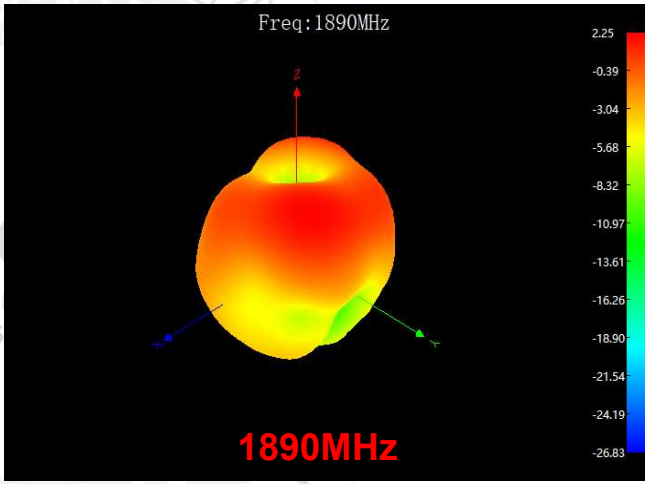
QUIPMENT	BRAND	MODULE TYPE
Spectrum	Agilent	E4402B
Signal Generator	Agilent	8960
Switch	Agilent	3499A
Switch	ETS	2090
Network Analyzer	Agilent	N5230A

3D/2D Radiation Pattern Results



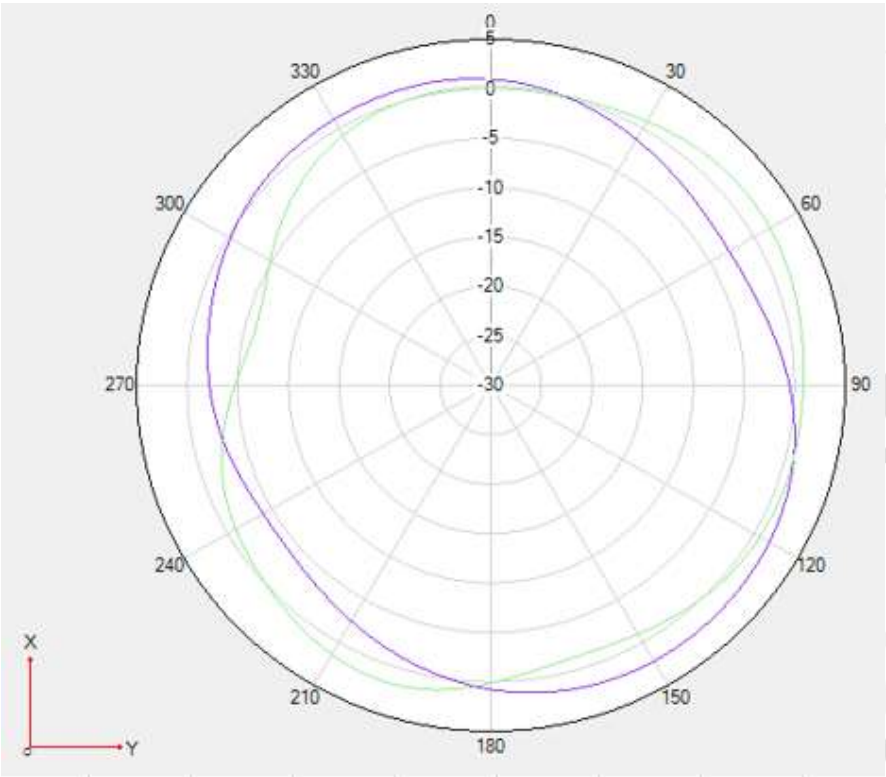
3D/2D Radiation Pattern Results

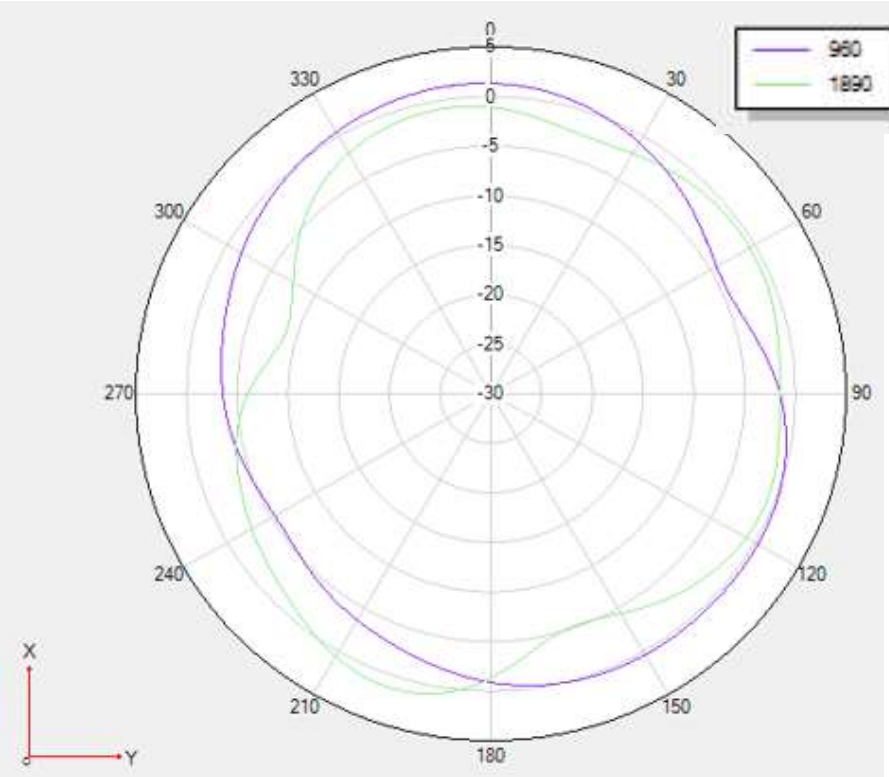




LTE-Main

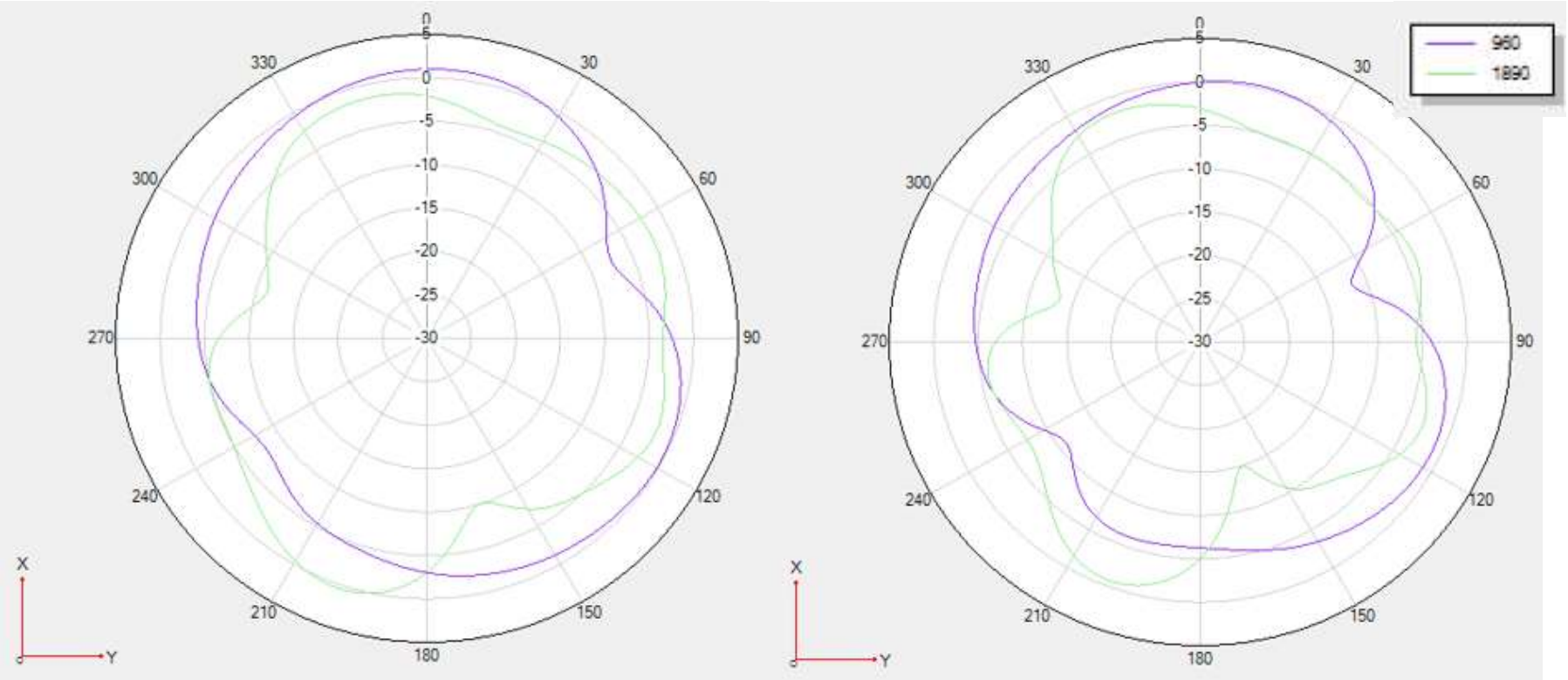
3D/2D Radiation Pattern Results





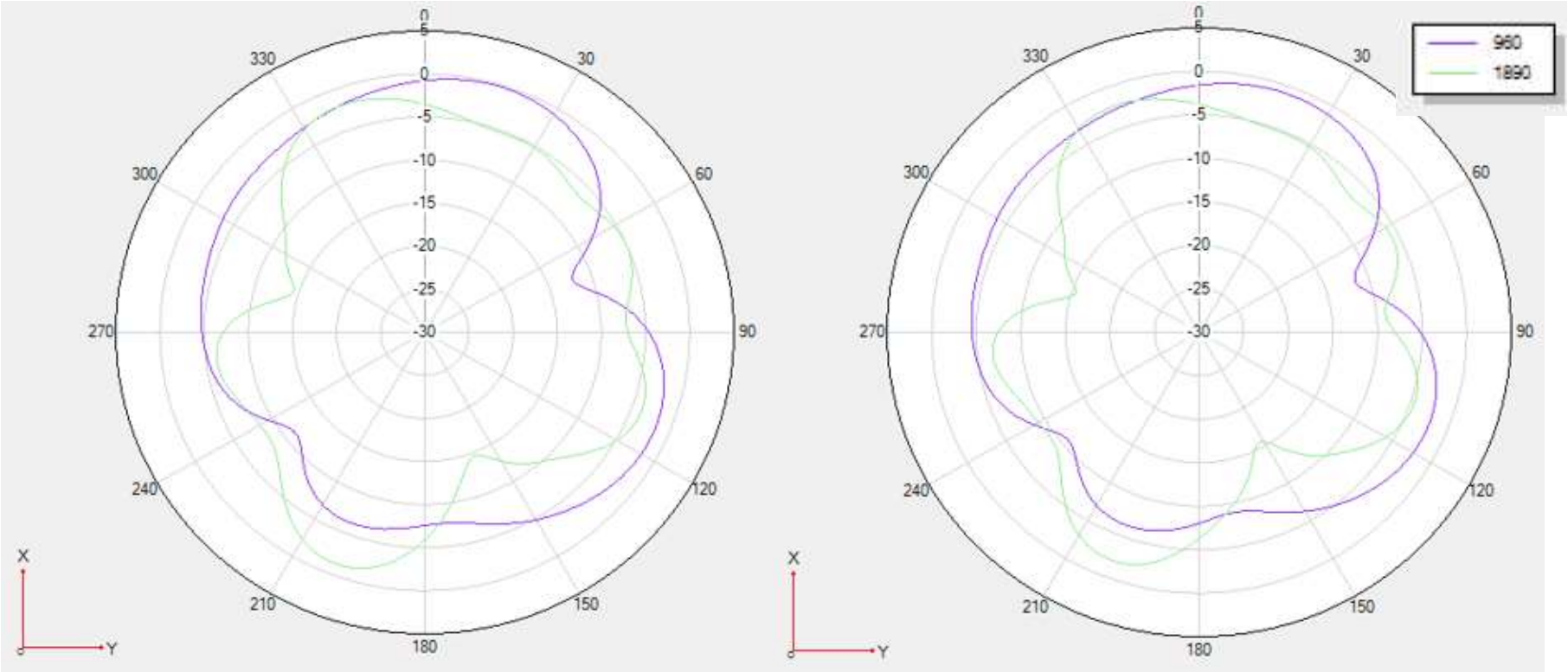
Θ:45° LTE-Main Θ:60°

3D/2D Radiation Pattern Results



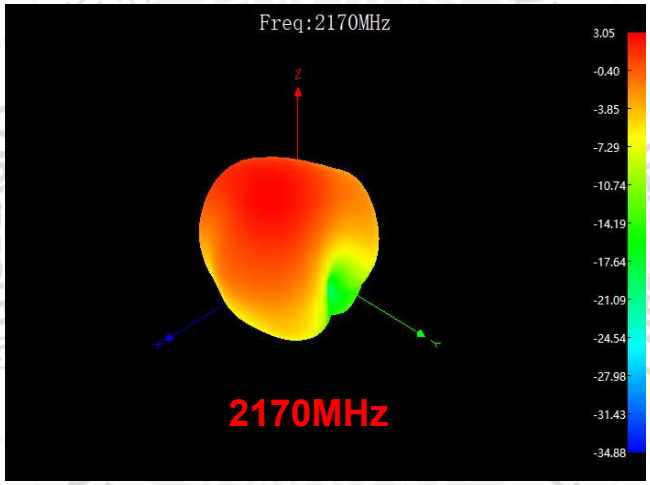
Θ:70˚ **LTE-Main** Θ:80˚

3D/2D Radiation Pattern Results



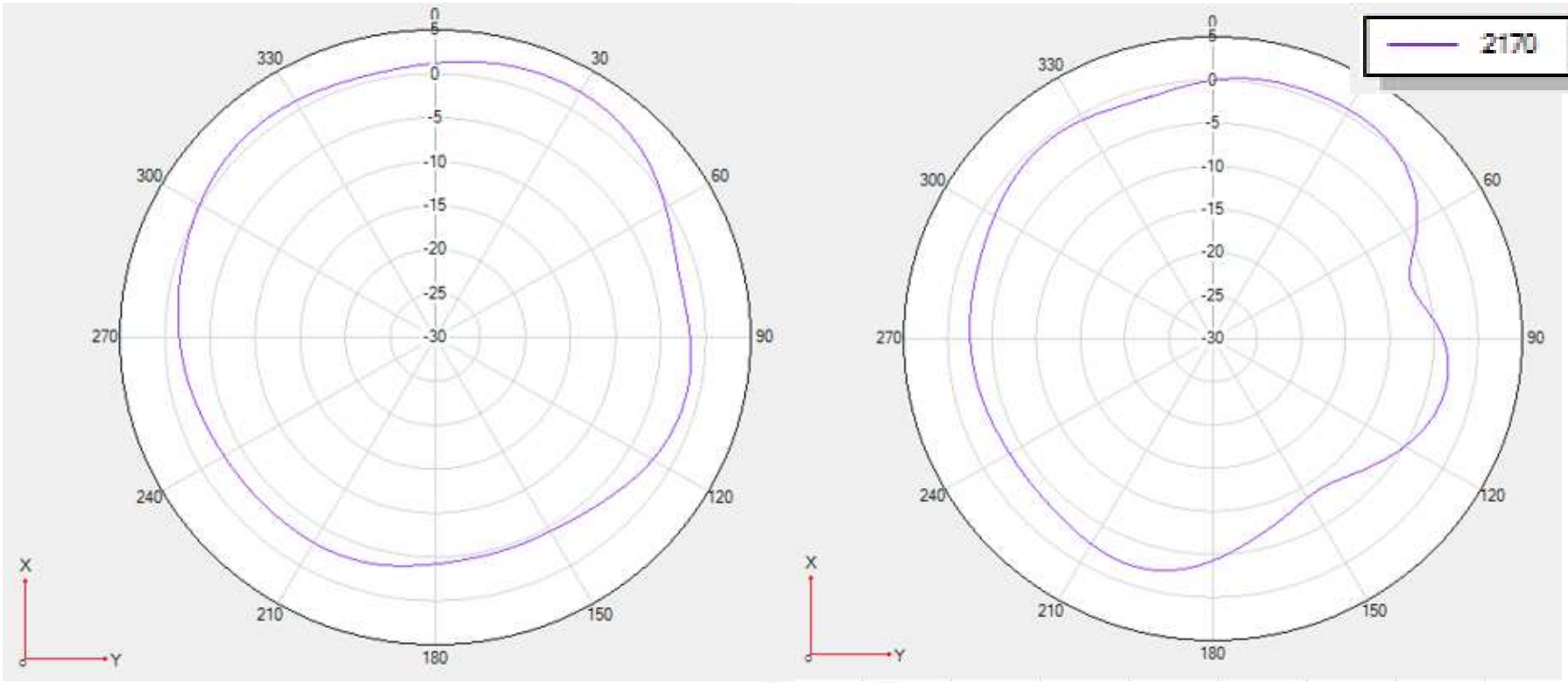
Θ:85˚ LTE-Main Θ:90˚

3D/2D Radiation Pattern Results



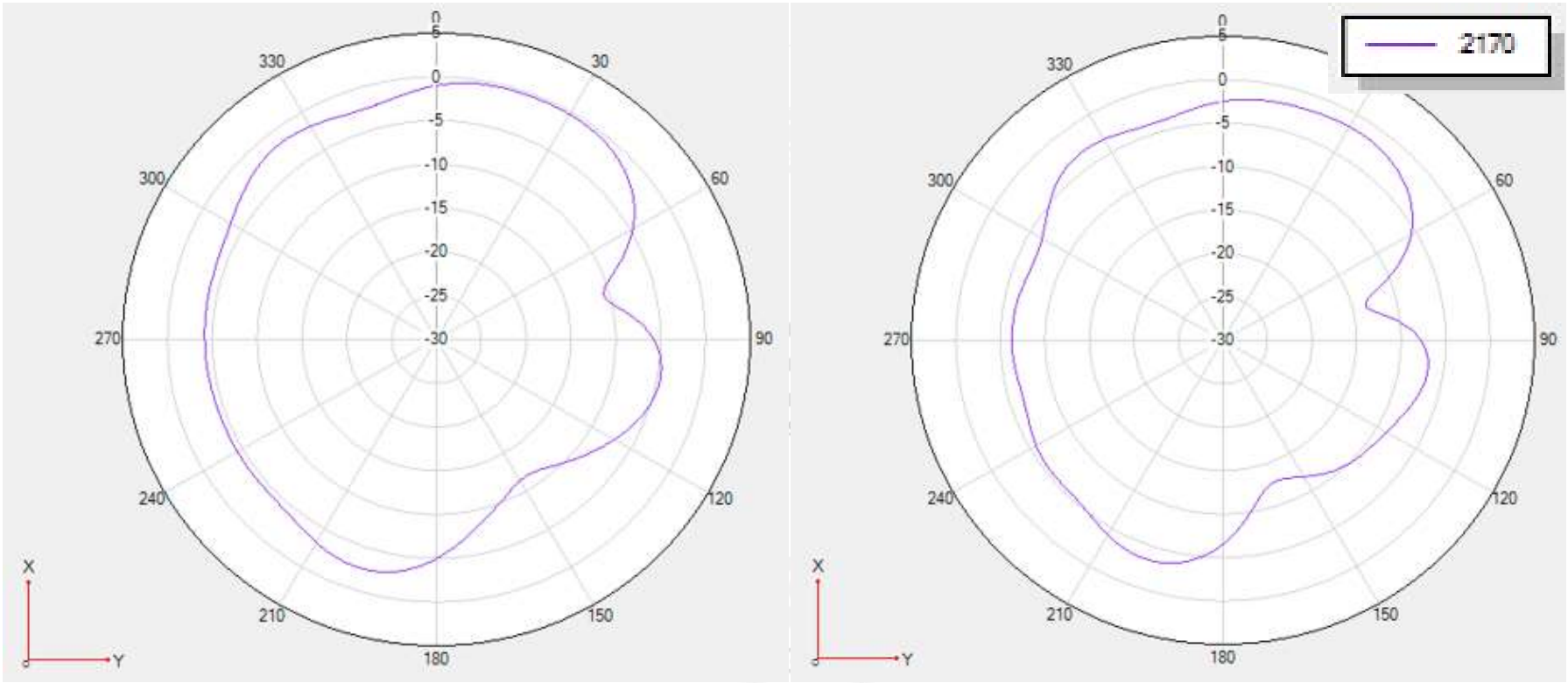
LTE-Div

3D/2D Radiation Pattern Results



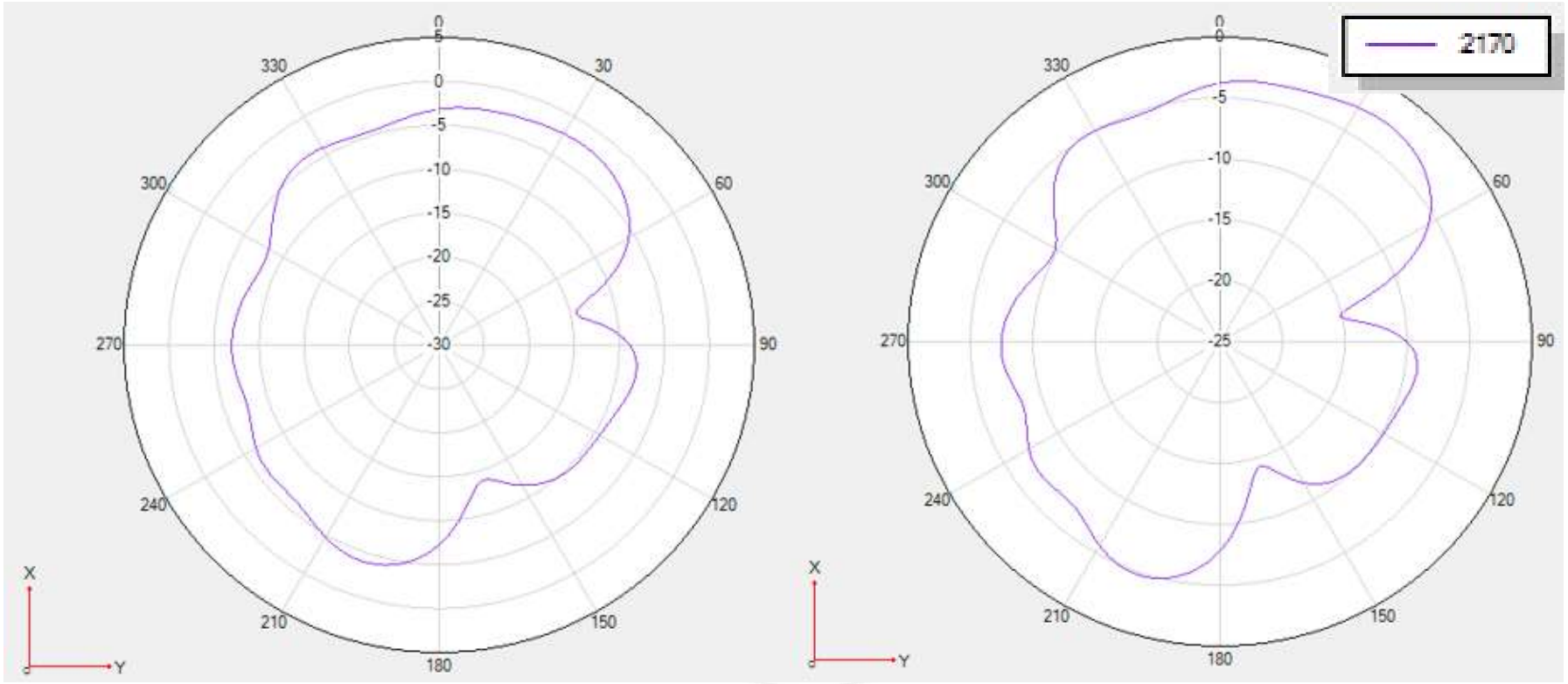
Θ:45˚ LTE-Div Θ:60˚

3D/2D Radiation Pattern Results



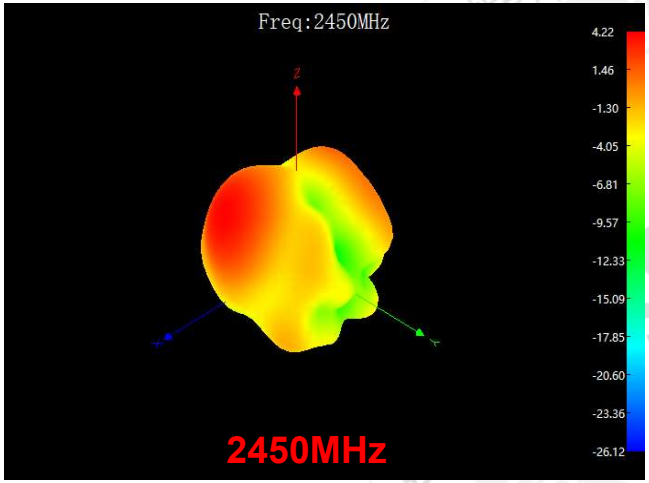
Θ:70˚ LTE-Div Θ:80˚

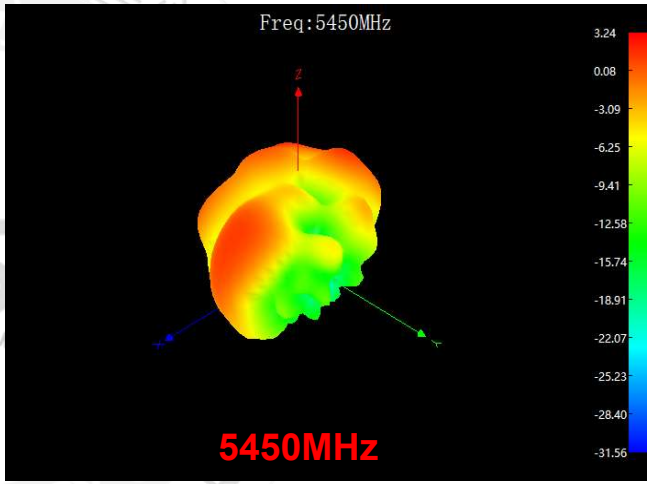
3D/2D Radiation Pattern Results



Θ:85˚ LTE-Div Θ:90˚

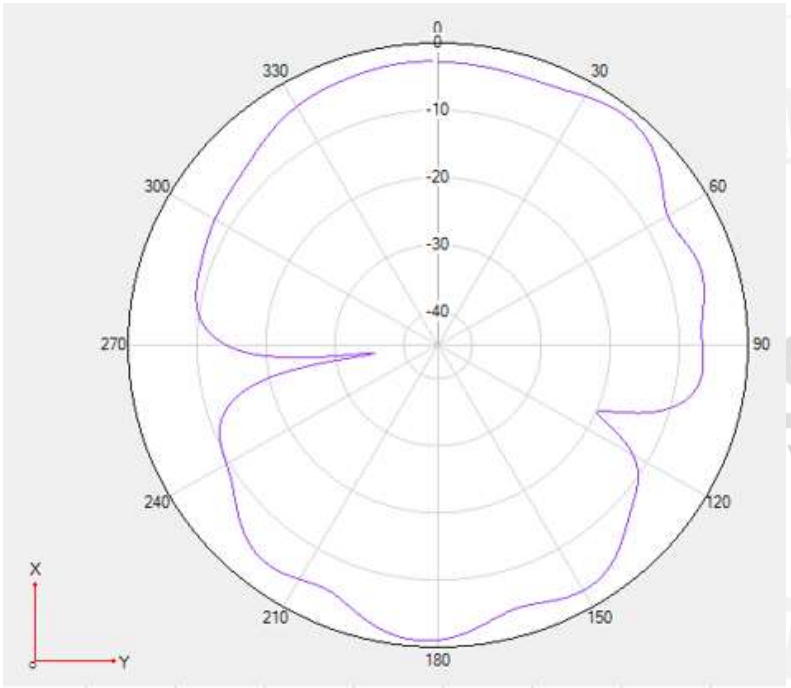
3D/2D Radiation Pattern Results



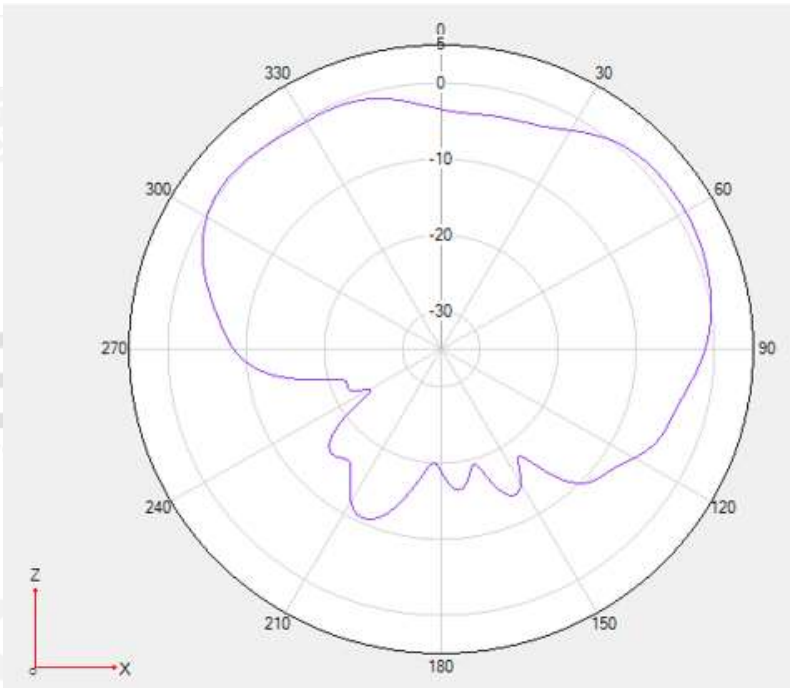


WIFI1

3D/2D Radiation Pattern Results



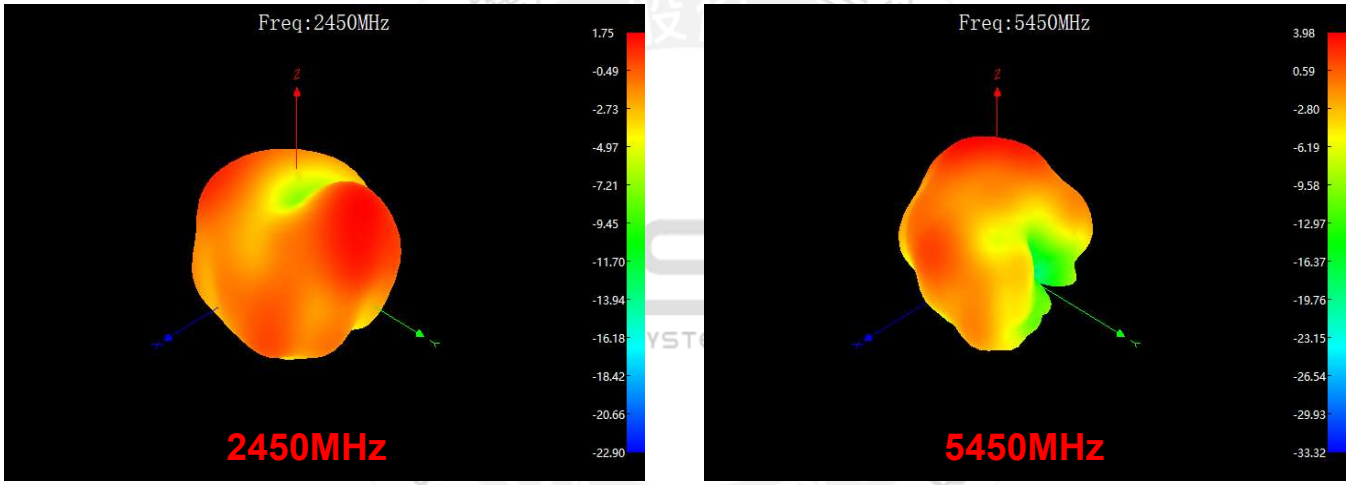
2450MHz @ Θ:90˚



5450MHz @ Θ:90˚

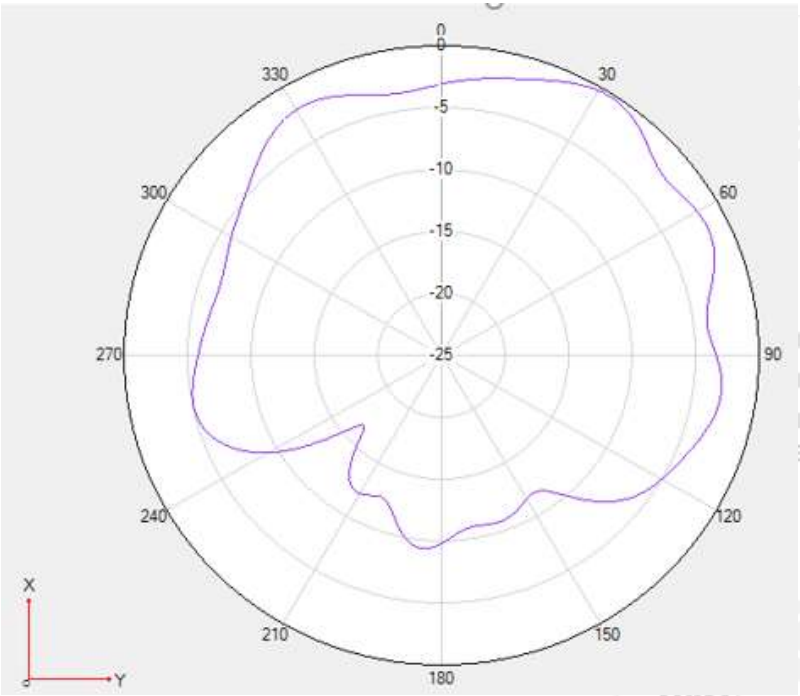
WIFI1

3D/2D Radiation Pattern Results

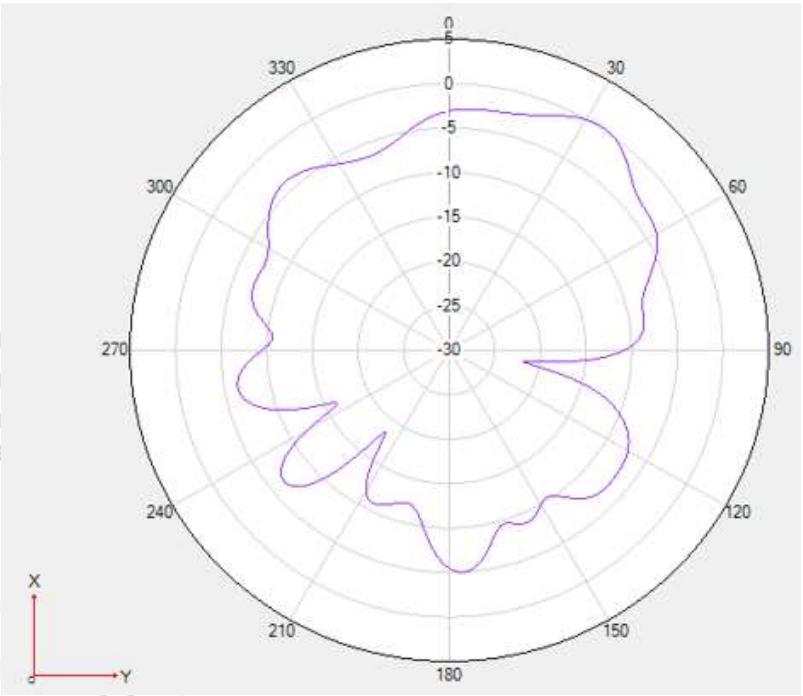


WIFI2

3D/2D Radiation Pattern Results



2450MHz @ Θ:90˚



5450MHz @ Θ:90˚

WIFI2

Results Summary-Peak Gain & Efficiency

LTE-Main Antenna

Frequency/Mhz	Efficiency / dB	Efficiency / %	Maxgain /dBi
700	-4.57	34.9	-0.91
710	-3.89	40.84	-0.37
720	-3.48	44.87	0.82
730	-3.45	45.19	1.01
740	-3.90	40.73	0.38
750	-4.57	34.94	-1.2
770	-5.52	28.07	-1.9
780	-4.44	35.96	0.61
790	-3.43	45.39	1.96
800	-3.27	47.1	2.14
820	-4.02	39.63	1.62
830	-4.08	39.08	1.25
840	-4.18	38.19	1.25
850	-4.27	37.41	1.66
860	-3.95	40.27	1.63
880	-3.09	49.09	1.76
890	-2.72	53.46	2.28
910	-2.70	53.68	2.28
920	-2.94	50.79	2.8
930	-3.08	49.18	3.21
940	-2.76	52.92	3.22
950	-2.69	53.82	2.97
960	-2.73	53.34	2.74
AVG	-3.64	43.86	1.28

Frequency/Mhz	Efficiency / dB	Efficiency / %	MaxGain/ dBi
1710	-3.59	43.75	3.91
1730	-4.04	39.43	2.68
1750	-3.29	46.88	3.79
1770	-2.70	53.7	4.07
1790	-2.78	52.72	3.97
1810	-2.85	51.88	3.92
1830	-3.16	48.31	3.42
1850	-3.54	44.26	3.33
1870	-3.85	41.21	2.99
1890	-4.19	38.11	2.25
1910	-4.55	35.08	2.45
1930	-4.24	37.65	2.58
1950	-4.04	39.42	1.88
1970	-3.77	41.98	2.06
1990	-3.51	44.57	1.92
2010	-3.62	43.45	2.54
2030	-4.05	39.36	3.27
2050	-4.62	34.51	2.64
2070	-4.35	36.76	1.62
2090	-4.19	38.12	1.11
2110	-3.78	41.92	0.63
2130	-3.67	42.91	-0.04
2150	-3.74	42.27	0.53
2170	-3.11	48.87	1.67

Frequency/Mhz	Efficiency / dB	Efficiency / %	MaxGain/ dBi
2290	-3.31	46.67	2.27
2310	-3.77	41.98	0.67
2330	-3.73	42.36	1.58
2350	-3.34	46.34	1.94
2370	-3.54	44.26	2.18
2390	-3.3	46.77	2.7
2510	-3.18	48.08	1.96
2530	-3.14	48.53	2.07
2550	-3.04	49.66	2.39
2570	-3.12	48.75	3.01
2590	-3.3	46.77	2.99
2610	-3.33	46.45	2.22
2630	-2.87	51.64	2.66
2650	-2.52	55.98	3.16
2670	-2.55	55.59	3.34
2690	-2.63	54.58	3.97
AVG	-3.50	45.04	2.46

PASS

Results Summary-Peak Gain & Efficiency

LTE-DIV Antenna

Frequency/Mhz	Efficiency / dB	Efficiency / %	MaxGain/ dBi		Frequency/Mhz	Efficiency / dB	Efficiency / %	MaxGain/ dBi
1710	-3.12	48.75	3.9		2290	-2.45	56.89	5.65
1730	-2.93	50.93	4.34		2310	-2.33	58.48	5.16
1750	-2.57	55.34	4.2		2330	-2.11	61.52	4.99
1770	-2.15	60.95	4.52		2350	-1.9	64.57	5.19
1790	-2.14	61.09	4.54		2370	-2.22	59.98	5.42
1810	-2.17	60.67	4.42		2390	-2.14	61.09	6.18
1830	-2.34	58.34	4.5					
1850	-2.56	55.46	4.43		2510	-2.96	50.58	5.75
1870	-2.71	53.58	4.07		2530	-3	50.12	5.73
1890	-2.89	51.4	3.73		2550	-2.97	50.47	5.98
1910	-3.18	48.08	2.69		2570	-2.98	50.35	6.22
1930	-3.42	45.5	2.54		2590	-3.1	48.98	5.85
1950	-3.49	44.77	2.89		2610	-3.16	48.31	5.18
1970	-3.63	43.35	2.87		2630	-3.05	49.55	4.68
1990	-3.47	44.98	3.27		2650	-2.92	51.05	4.41
2010	-3.48	44.87	3.83		2670	-2.96	50.58	4.32
2030	-3.53	44.36	4.17		2690	-2.99	50.23	4.97
2050	-3.57	43.95	3.51					
2070	-3.74	42.27	2.75					
2090	-3.67	42.95	2.98					
2110	-3.71	42.56	3.3					
2130	-3.99	39.9	3.41					
2150	-3.96	40.18	3.38					
2170	-3.84	41.3	3.05		AVG	-2.99	50.71	4.32

PASS

Results Summary-Peak Gain & Efficiency

WIFI1 Antenna

Frequency /Mhz	Efficiency / dB	Efficiency / %	MaxGain /dBi
2400	-2.7	53.7	4.3
2410	-2.88	51.52	4.86
2420	-2.95	50.7	4.64
2430	-3.14	48.53	4.62
2440	-2.97	50.47	4.58
2450	-3.12	48.75	4.22
2460	-2.79	52.6	4.58
2470	-2.82	52.24	4.1
2480	-2.66	54.2	4.22
2490	-2.69	53.83	3.6
2500	-2.64	54.45	3.65
AVG	-2.85	51.91	4.31

Frequency/ Mhz	Efficiency / dB	Efficiency / %	MaxGain/dBi
5150	-2.91	51.19	4.55
5200	-3.01	50.06	5.2
5250	-2.74	53.21	5.29
5300	-2.90	51.29	5.06
5350	-2.96	50.57	4.46
5400	-2.88	51.5	4.18
5450	-3.00	50.07	3.24
5500	-3.02	49.85	2.68
5550	-3.07	49.27	2.97
5600	-3.24	47.45	2.61
5650	-3.16	48.36	2.21
5700	-3.01	49.98	2.15
5750	-2.99	50.25	3.79
5800	-3.11	48.88	4.46
5850	-2.82	52.24	4.22
AVG	-2.99	50.23	3.80

PASS

Results Summary-Peak Gain & Efficiency

WIFI2 Antenna

Frequency /Mhz	Efficiency / dB	Efficiency / %	MaxGain /dBi
2400	-2.32	52.57	0.84
2410	-2.45	50.95	1.29
2420	-2.45	50.95	1.07
2430	-2.55	49.59	1.22
2440	-2.46	50.76	1.62
2450	-2.59	49.02	1.75
2460	-3.00	51.25	2.72
2470	-2.46	50.76	2.76
2480	-3.07	51.65	3.49
2490	-3.24	51.35	3.49
2500	-2.39	51.65	3.94
AVG	-2.64	50.95	2.20

Frequency/ Mhz	Efficiency / dB	Efficiency / %	MaxGain/dBi
5150	-2.69	53.82	5.34
5200	-2.87	51.64	5.37
5250	-2.71	53.58	4.73
5300	-2.97	50.42	4.21
5350	-2.94	50.86	4.36
5400	-2.78	52.77	3.96
5450	-3.02	49.88	3.98
5500	-2.80	52.43	3.27
5550	-2.79	52.66	3.66
5600	-2.86	51.75	3.71
5650	-2.80	52.43	3.19
5700	-3.07	49.34	3.26
5750	-2.90	51.31	4.05
5800	-3.07	49.34	4.61
5850	-2.92	51.08	3.85
AVG	-2.88	51.55	4.10

PASS

Results Summary-OTA

LTE

Band	Measurement	Channel	Frequency(MHz)	传导(dB)	OTA(dB)	OTA-传导(dB)	Spec(dB)
FDD_B1(10MHz)	TRP	18050	1925	22.93	21.07	-1.86	≥-5.5
		18300	1950	22.94	21.02	-1.92	
		18550	1975	22.98	20.91	-2.07	
	TIS(RSSI)	50	2115	-98.5	-93.85	4.65	≤6.5
		300	2140	-98	-92.28	5.72	
		550	2165	-99	-92.83	6.17	
FDD_B2(10MHz)	TRP	18650	1855	22.87	20.88	-1.99	≥-5.5
		18900	1880	22.76	21.05	-1.71	
		19150	1905	22.76	20.9	-1.86	
	TIS(RSSI)	650	1935	-97.2	-94.9	2.3	≤6.5
		900	1960	-98.2	-96.25	1.95	
		1150	1985	-97.7	-95.56	2.14	
FDD_B3(10MHz)	TRP	19250	1715	21.96	20.45	-1.51	≥-5.5
		19575	1747.5	21.92	20.05	-1.87	
		19900	1780	21.86	20.46	-1.4	
	TIS(RSSI)	1250	1810	-97.5	-95.42	2.08	≤6.5
		1575	1842.5	-97.7	-95.39	2.31	
		1900	1875	-95.7	-94.36	1.34	

PASS

Results Summary-OTA

LTE

Band	Measurement	Channel	Frequency(MHz)	传导(dB)	OTA(dB)	OTA-传导(dB)	Spec(dB)
FDD_B4(10MHz)	TRP	20000	1715	22.38	20.85	-1.53	≥-5.5
		20175	1732.5	22.26	20.42	-1.84	
		20350	1750	22.22	20.54	-1.68	
	TIS(RSSI)	2000	2115	-98.4	-94.44	3.96	≤6.5
		2175	2132.5	-98.5	-93.16	5.34	
		2350	2150	-98	-95.43	2.57	
FDD_B5(10MHz)	TRP	20450	829	23.36	20.52	-2.84	≥-5.5
		20525	836.5	23.35	21.02	-2.33	
		20600	844	23.06	21.06	-2	
	TIS(RSSI)	2450	874	-99	-95.58	3.42	≤6.5
		2525	881.5	-98.7	-95.63	3.07	
		2600	889	-98.7	-94.58	4.12	
FDD_B7(10MHz)	TRP	20800	2505	22.48	20.8	-1.68	≥-5.5
		21100	2535	22.75	21.09	-1.66	
		21400	2565	22.2	21.02	-1.18	
	TIS(RSSI)	2800	2625	-98	-98.67	-0.67	≤6.5
		3100	2655	-97.2	-99.4	-2.2	
		3400	2685	-96.7	-99.09	-2.39	

PASS

Results Summary-OTA

LTE

Band	Measurement	Channel	Frequency(MHz)	传导(dB)	OTA(dB)	OTA-传导(dB)	Spec(dB)
FDD_B8(10MHz)	TRP	21500	885	22.32	20.11	-2.21	≥-5.5
		21625	897.5	22.23	20.38	-1.85	
		21750	910	22.5	19.78	-2.72	
	TIS(RSSI)	3500	930	-99.4	-97.08	2.32	≤6.5
		3625	942.5	-99.2	-96.46	2.74	
		3750	955	-99.5	-93.81	5.69	
FDD_B20(10MHz)	TRP	24200	837	22.89	20.26	-2.83	≥-5.5
		24300	847	22.91	20.75	-2.16	
		24400	857	22.84	20.41	-2.43	
	TIS(RSSI)	6200	796	-98.9	-92.38	6.52	≤6.5
		6300	806	-99	-90.58	8.42	
		6400	816	-98.7	-93.03	5.67	
FDD_B28(10MHz)	TRP	27260	708	22.31	17.84	-4.47	≥-5.5
		27435	725.5	22.36	18.65	-3.71	
		27610	743	22.22	17.72	-4.5	
	TIS(RSSI)	9260	763	-98.5	-92.23	6.27	≤6.5
		9435	780.5	-99	-92.9	6.1	
		9610	798	-98.5	-93.01	5.49	

PASS

Results Summary-OTA

LTE

Band	Measurement	Channel	Frequency(MHz)	传导(dB)	OTA(dB)	OTA-传导(dB)	Spec(dB)
TDD_B38(20MHz)	TRP	37850	2580	22.2	20.67	-1.53	≥-5.5
		38000	2595	22	20.45	-1.55	
		38150	2610	22.18	20.2	-1.98	
	TIS(RSSI)	37850	2580	-92	-96.07	-4.07	≤6.5
		38000	2595	-91.7	-96.63	-4.93	
		38150	2610	-91.5	-95.91	-4.41	
TDD_B40(20MHz)	TRP	38750	2310	21.74	18.84	-2.9	≥-5.5
		39150	2350	21.58	19.24	-2.34	
		39550	2390	21.51	19.23	-2.28	
	TIS(RSSI)	38750	2310	-92	-91.41	0.59	≤6.5
		39150	2350	-92.7	-93.97	-1.27	
		39550	2390	-92.4	-94.44	-2.04	
TDD_B41(20MHz)	TRP	40340	2565	22.55	20.83	-1.72	≥-5.5
		40620	2593	22.72	21	-1.72	
		41140	2645	22	19.9	-2.1	
	TIS(RSSI)	40340	2565	-92	-95.67	-3.67	≤6.5
		40620	2593	-91.7	-96.33	-4.63	
		41140	2645	-91	-94.61	-3.61	

PASS

Results Summary-OTA

WIFI

Measurement	Band	Channel	Frequency(MHz)	传导(dB)	OTA(dB)	OTA-传导 (dB)	Spec(dB)
TRP	WIFI_N (6.5M)	1	2412	16.21	14.29	-1.92	≥-4.5
		6	2437	16.65	15.11	-1.54	
		11	2462	16.85	15.55	-1.3	
TIS(EIRP)	WIFI_N (6.5M)	1	2412	-89	-85.51	3.49	≤6.5
		6	2437	-89.2	-83.93	5.27	
		11	2462	-88.5	-83.11	5.39	
TRP	WIFI_A (6M)	36	5180	12.75	12.16	-0.59	≥-4.5
		149	5745	12.78	12.26	-0.52	
		165	5825	12.92	12.26	-0.66	
TIS(EIRP)	WIFI_A (54M)	36	5180	-76.5	-75.26	1.24	≤6.5
		149	5745	-76	-75.81	0.19	
		165	5825	-76	-74.41	1.59	

PASS

Results Summary-OTA

BT

Measurement	Channel	Frequency(MHz)	传导(dB)	OTA(dB)	OTA-传导(dB)	Spec(dB)	
TRP	0	2402	16.68	15.04	-1.64	≥-4.5	PASS
	39	2441	17.17	16.01	-1.16		
	78	2480	16.31	15.14	-1.17		
TIS	0	2402	-93.5	-87.24	6.26	≤6.5dB	
	39	2441	-94	-88.35	5.65		
	78	2480	-93.5	-87.66	5.84		

Conclusion

1. 本次测试硬件状态为**C928**海外版主机连接车载屏幕同时工作；
2. 经本次测试验证，天线各性能指标经暗室环境测试可以满足客户既定标准。

以上请知悉，感谢！

Thank you