FLIR-i1845

Antenna characterization

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Revision History

Date	Rev.	Author	Description
2025-07-09	A	Pär Berglund	Released after internal review

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3 Acronyms, Abbreviations and Definitions

Table 1. Acronyms

Acronym	Description
WSI	Wireless System Integration

4 Introduction

This document presents antenna measurements for the family of Flir thermal cameras *FLIR-i1845*.

The *Flir-i1845* camera have two internal cellular LTE antennas, one of which is for receive only, a dual band Wi-Fi and GNSS antenna.

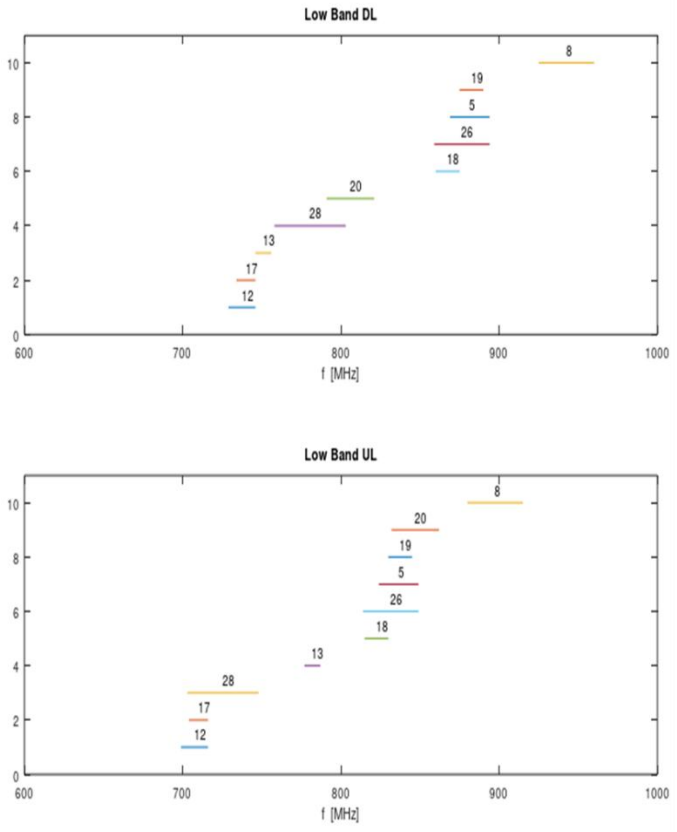
Figure 4-1 FLIR-i1845 (model i65) thermal camera.

5 Antenna measurements

The performance for the antennas within the Flir-i1845 camera is characterized in terms of *Voltage Standing Wave Ratio* (VSWR), *antenna efficiency* and *radiation patterns.*

The two cellular antennas, main and diversity, have an aperture tuner switch connected to the antenna radiator. As a result, the antenna VSWR is depending on switch setting.

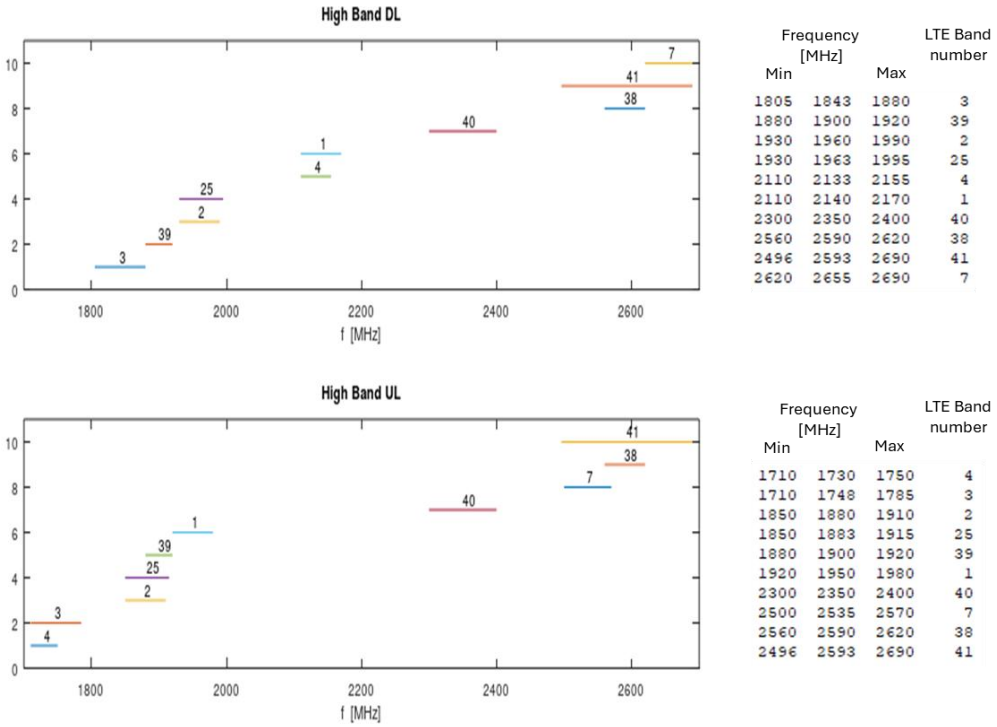
Each LTE band has an assigned switch setting; therefore, the VSWR must be measured with the switch in the appropriate setting for the intended LTE band.



LTE Band number	Frequency [MHz] Min		Max
12	729	738	746
17	734	740	746
13	746	751	756
28	758	781	803
20	791	806	821
18	860	868	875
26	859	877	894
5	869	882	894
19	875	883	890
8	925	943	960

LTE Band number	Frequency [MHz] Min		Max
12	699	708	716
17	704	710	716
28	703	726	748
13	777	782	787
18	815	823	830
26	814	832	849
5	824	837	849
19	830	838	845
20	832	847	862
8	880	898	915

Figure 5-1 Downlink and Uplink frequencies for Low frequency LTE bands.



Frequency [MHz] Min		Max	LTE Band number
1805	1843	1880	3
1880	1900	1920	39
1930	1960	1990	2
1930	1963	1995	25
2110	2133	2155	4
2110	2140	2170	1
2300	2350	2400	40
2560	2590	2620	38
2496	2593	2690	41
2620	2655	2690	7

Frequency [MHz] Min		Max	LTE Band number
1710	1730	1750	4
1710	1748	1785	3
1850	1880	1910	2
1850	1883	1915	25
1880	1900	1920	39
1920	1950	1980	1
2300	2350	2400	40
2500	2535	2570	7
2560	2590	2620	38
2496	2593	2690	41

Figure 5-2 Downlink and Uplink frequencies for High frequency LTE bands.

5.1 Voltage Standing Wave Ratio

Voltage Standing Wave Ratio (VSWR) is a measure of how well an antenna is impedance matched to the system impedance. A VSWR of one means a perfect match where all the available power is delivered to the antenna and an infinite VSWR means a short or an open circuit where all the energy is reflected.

5.1.1 Cellular Main antenna

LTE bands: 12, 13, 28

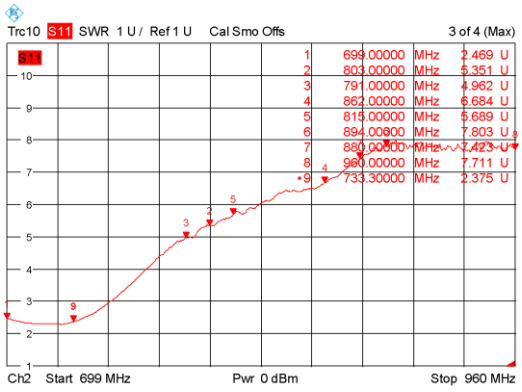


*Figure 5-3 Flir-i1845 cellular main antenna LTE bands 12, 13, 28 (**marker 1-2**).*

LTE band: 20

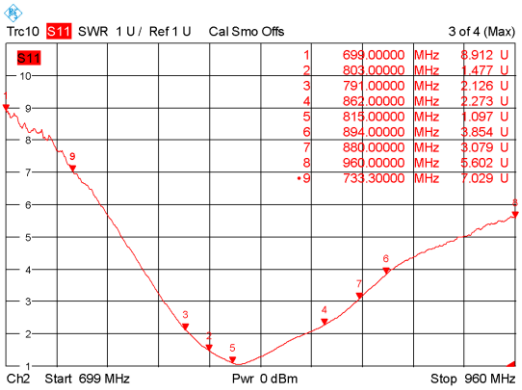


*Figure 5-4 Flir-i1845 cellular main antenna LTE band 20 (**marker 3-4**).*

LTE bands: 5,18,19,26

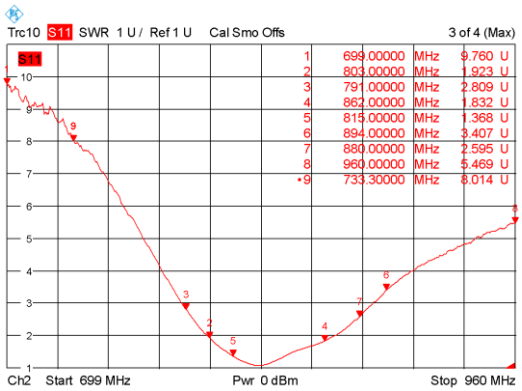


*Figure 5-5 Flir-i1845 cellular main antenna LTE bands 5,18,19,26 (**marker 5-6**).*

LTE bands: 8

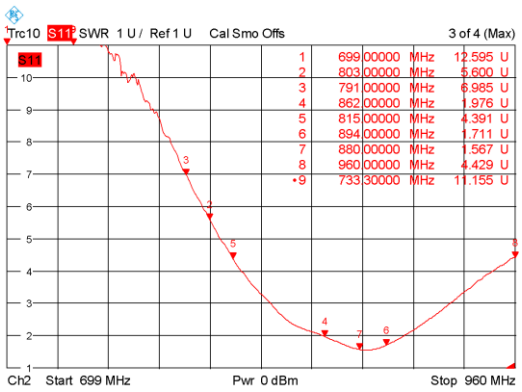


*Figure 5-6 Flir-i1845 cellular main antenna LTE band 8 (**marker 7-8**).*

LTE bands: 1,2,3,4,25,39,40

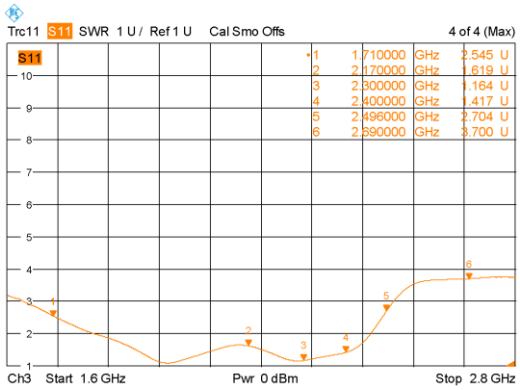


*Figure 5-7 Flir-i1845 cellular main antenna LTE bands 1,2,3,4,25,39,40 (**marker 1-4**).*

LTE bands: 7,38,41

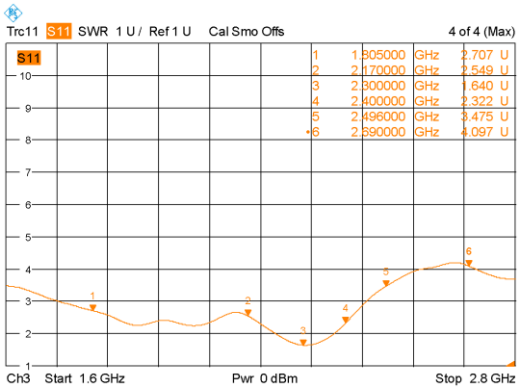


*Figure 5-8 Flir-i1845 cellular main antenna LTE bands 7,38,41 (**marker 5-6**).*

5.1.2 Cellular Diversity antenna

LTE bands: 12, 13, 28

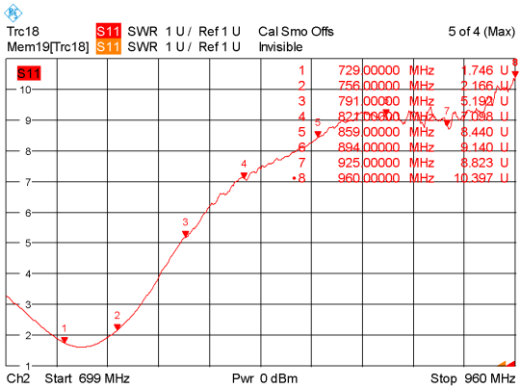


*Figure 5-9 Flir-i1845 cellular diversity antenna LTE bands 12, 13, 28 (**marker 1-2**).*

LTE band: 20

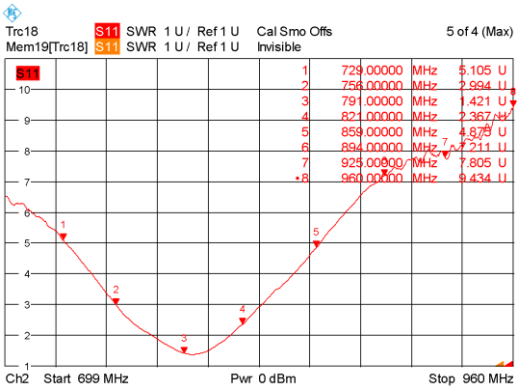


*Figure 5-10 Flir-i1845 cellular diversity antenna LTE band 20 (**marker 3-4**).*

LTE bands: 5,18,19,26

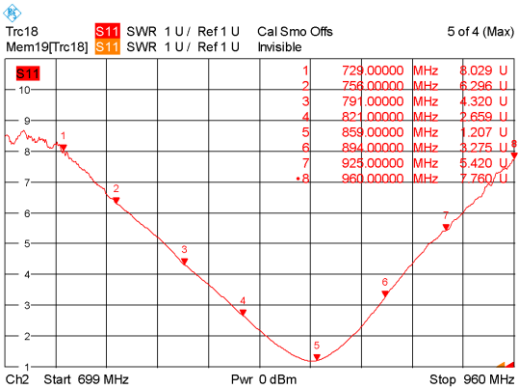


*Figure 5-11 Flir-i1845 cellular diversity antenna LTE bands 5,18,19,26 (**marker 5-6**).*

LTE bands: 8

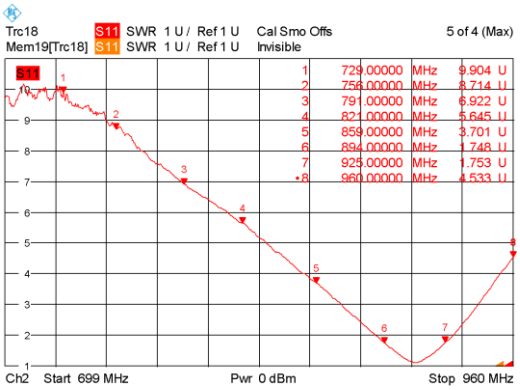


*Figure 5-12 Flir-i1845 cellular diversity antenna LTE band 8 (**marker 7-8**).*

LTE bands: 1,2,3,4,25,39,40

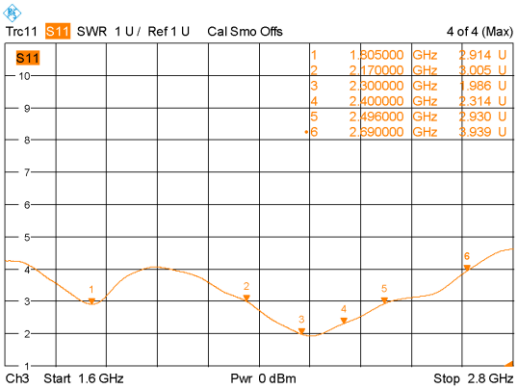


*Figure 5-13 Flir-i1845 cellular diversity antenna LTE bands 1,2,3,4,25,39,40 (**marker 1-4**).*

LTE bands: 7,38,41

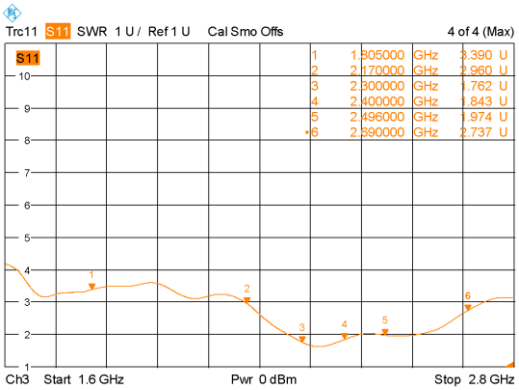


*Figure 5-14 Flir-i1845 cellular diversity antenna LTE bands 7,38,41 (**marker 5-6**).*

5.1.3 Wi-Fi antenna

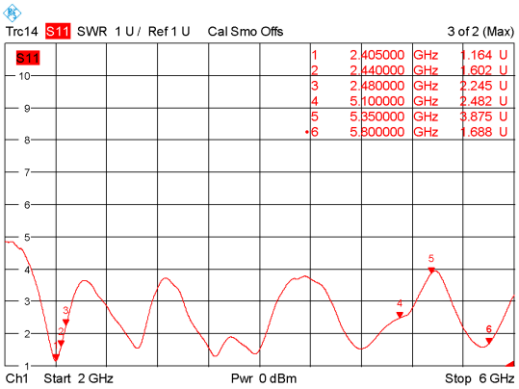


Figure 5-15 Flir-i1845 Wi-Fi antenna

5.1.4 GNSS antenna

The performance of the GNSS antenna is significantly affected by the cellular antenna switch and its associated components. VSWR measurements are performed for all possible switch configurations.

LTE bands setting: 12, 13, 28

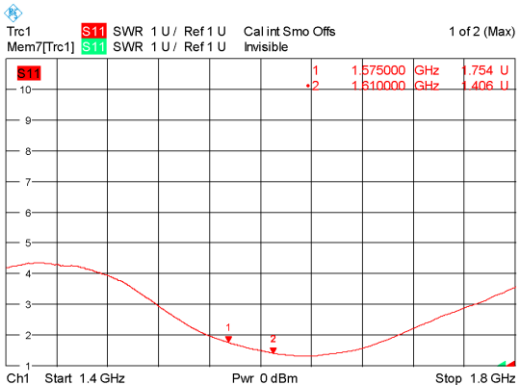


Figure 5-16 Flir-i1845 GNSS antenna. LTE band settings: 12, 13, 28

LTE bands setting: 20

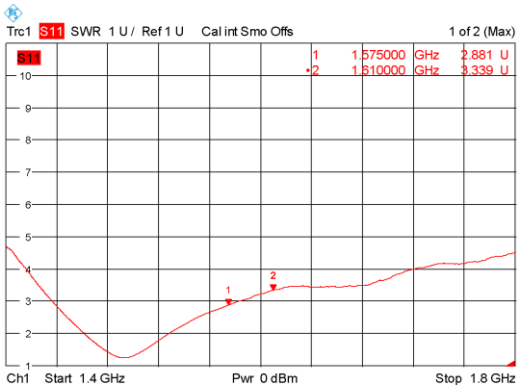


Figure 5-17 Flir-i1845 GNSS antenna. LTE band settings: 20

LTE bands setting: 5,7,18,19,26,38,41

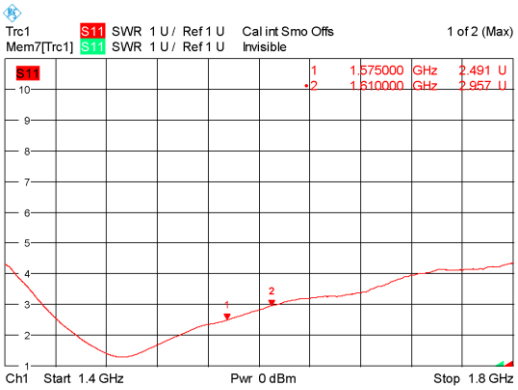


Figure 5-18 Flir-i1845 GNSS antenna. LTE band settings: 5,7,18,19,26,38,41

LTE bands setting: 1,2,3,4,8,25,39,40

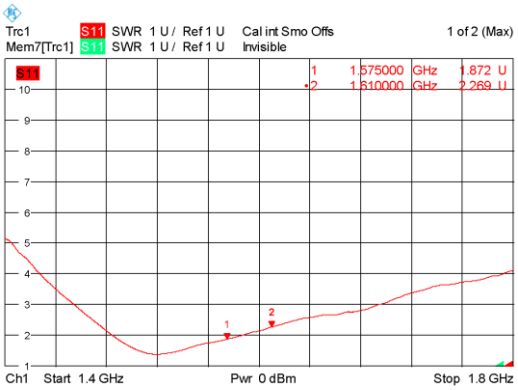


Figure 5-19 Flir-i1845 GNSS antenna. LTE band settings: 1,2,3,4,8,25,39,40

5.2 Antenna efficiency

The antenna efficiency measurements are carried out in a Satimo SG-23 6GHz Antenna Test Chamber. The antenna efficiency, ε_T, is the ratio of the power delivered at the 50Ω antenna interface, P_t, relative to the power radiated from the antenna, $P_{radiated}$.

$$\varepsilon_T = \frac{P_{radiated}}{P_t}$$

5.2.1 Cellular Main antenna

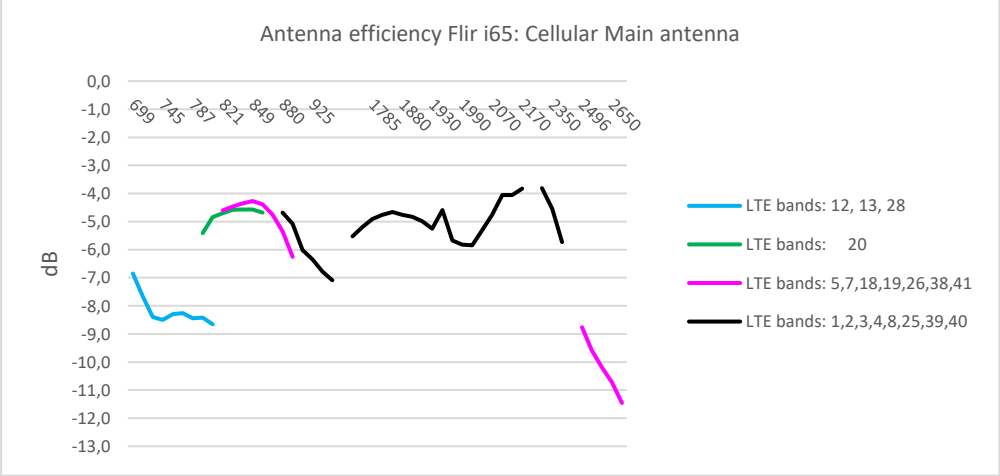


Figure 5-20 Antenna efficiency Flir-i1845; Cellular main antenna.

Table 2 Antenna efficiency Flir-i1845; Cellular main antenna.

	LTE bands: 12, 13, 28	LTE bands: 20	LTE bands: 5,7,18,19,26,38,41	LTE bands: 1,2,3,4,8,25 39,40
Frequency [MHz]	Antenna efficiency [dB]			
699	-6,9			
715	-7,7			
729	-8,4			
745	-8,5			
756	-8,3			
775	-8,3			
787	-8,4			
791	-8,4	-5,4		
803	-8,7	-4,8		
821		-4,7	-4,6	
824		-4,6	-4,5	
835		-4,6	-4,4	
849		-4,6	-4,3	
859		-4,7	-4,4	
869			-4,8	
880			-5,4	-4,7
894			-6,3	-5,1
915				-6,0
925				-6,4
940				-6,8
960				-7,1
1710				-5,5
1745				-5,2
1785				-4,9
1805				-4,8
1850				-4,7
1880				-4,8
1910				-4,8
1920				-5,0
1930				-5,3
1950				-4,6
1980				-5,7
1990				-5,8
1995				-5,9
2040				-5,3
2070				-4,8
2110				-4,1
2140				-4,1
2170				-3,8
2300				-3,8
2350				-4,5
2400				-5,7
2496			-8,8	
2550			-9,6	
2600			-10,2	
2650			-10,7	
2690			-11,5	

5.2.2 Cellular Diversity antenna

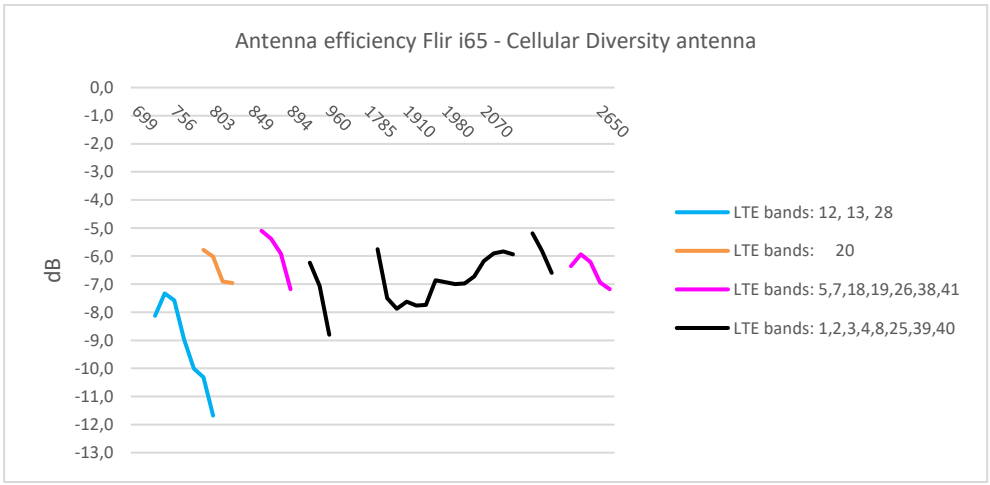


Figure 5-21 Antenna efficiency Flir-i1845; Cellular diversity antenna.

Table 3 Antenna efficiency Flir-i1845; Cellular diversity antenna.

	LTE bands: 12,13, 28	LTE bands: 20	LTE bands: 5,7,18,19, 26,38,41	LTE bands: 1,2,3,4,8,25, 39,40
Frequency [MHz]	Antenna efficiency [dB]			
699				
715				
729	-8,13			
745	-7,33			
756	-7,58			
775	-8,95			
787	-10,01			
791	-10,32	-5,78		
803	-11,68	-6,02		
821		-6,91		
824		-6,96		
835				
849				
859			-5,1	
869			-5,38	
880			-5,92	
894			-7,18	
915				
925				-6,23
940				-7,07
960				-8,8
1710				
1745				
1785				
1805				-5,75
1850				-7,5
1880				-7,87
1910				-7,63
1920				-7,76
1930				-7,74
1950				-6,86
1980				-6,93
1990				-7
1995				-6,98
2040				-6,72
2070				-6,18
2110				-5,9
2140				-5,84
2170				-5,94
2300				-5,19
2350				-5,82
2400				-6,6
2496			-6,36	
2550			-5,94	
2600			-6,21	
2650			-6,94	
2690			-7,18	

5.2.3 Wi-Fi antenna

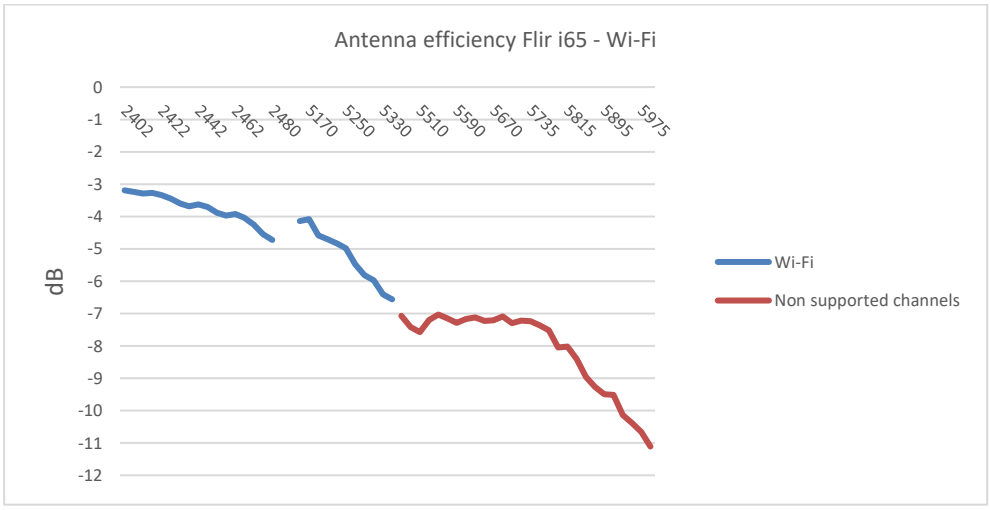


Figure 5-22 Antenna efficiency Flir-i1845; Wi-Fi antenna.

Table 4 Antenna efficiency Flir-i1845; Wi-Fi antenna.

Frequency [MHz]	Efficiency [dB]
2402	-3,2
2407	-3,2
2412	-3,3
2417	-3,3
2422	-3,3
2427	-3,5
2432	-3,6
2437	-3,7
2442	-3,6
2447	-3,7
2452	-3,9
2457	-4,0
2462	-3,9
2467	-4,0
2472	-4,3
2477	-4,6
2480	-4,7
5150	-3,4
5170	-3,4
5190	-3,9
5210	-4,0
5230	-4,1
5250	-4,3
5270	-4,8
5290	-5,1
5310	-5,3
5330	-5,7
5350	-5,9
5470	-6,4
5490	-6,7
5510	-6,9
5530	-6,5
5550	-6,3
5570	-6,5
5590	-6,6
5610	-6,5
5630	-6,4
5650	-6,5
5670	-6,5
5690	-6,4
5710	-6,6
5730	-6,5
5735	-6,5
5755	-6,7
5775	-6,8
5795	-7,4
5815	-7,3
5835	-7,7
5855	-8,3
5875	-8,6
5895	-8,8
5915	-8,8
5935	-9,4
5955	-9,7
5975	-10,0
5985	-10,4

5.2.4 GNSS antenna

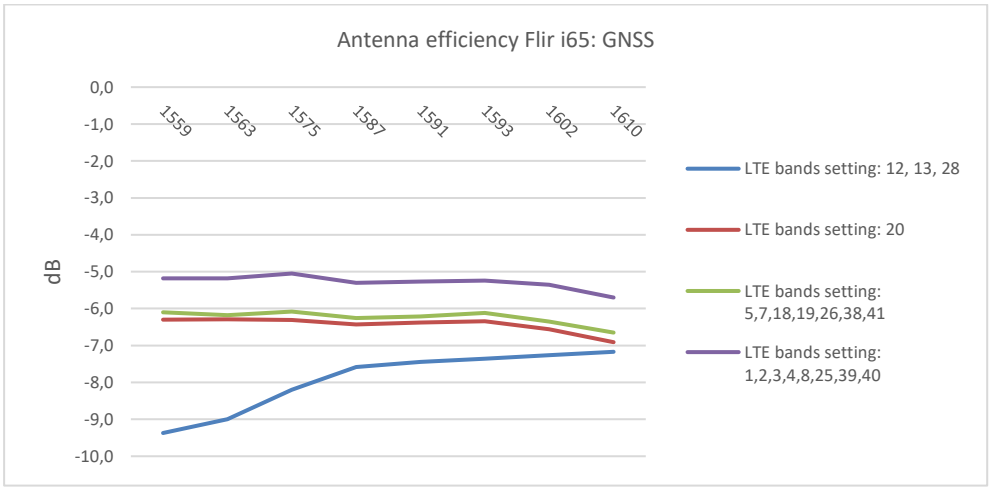


Figure 5-23 Antenna efficiency Flir-i1845; GNSS antenna.

	LTE bands setting: 12, 13, 28	LTE bands setting: 20	LTE bands setting: 5,7,18,19,26, 38,41	LTE bands setting: 1,2,3,4,8,25, 39,40
Frequency [MHz]	Efficiency [dB]			
1559	-9,4	-6,3	-6,1	-5,2
1563	-9,0	-6,3	-6,2	-5,2
1575	-8,2	-6,3	-6,1	-5,1
1587	-7,6	-6,4	-6,3	-5,3
1591	-7,4	-6,4	-6,2	-5,3
1593	-7,4	-6,3	-6,1	-5,2
1602	-7,3	-6,6	-6,4	-5,4
1610	-7,2	-6,9	-6,7	-5,7

Table 5 Antenna efficiency Flir-i1845; GNSS antenna.

5.3 2D Radiation patterns

The antenna radiation pattern measurements are carried out in a Satimo SG-23 6GHz Antenna Test Chamber. Radiation patterns are presented for three measurement planes: XY-, XZ- and YZ-planes.

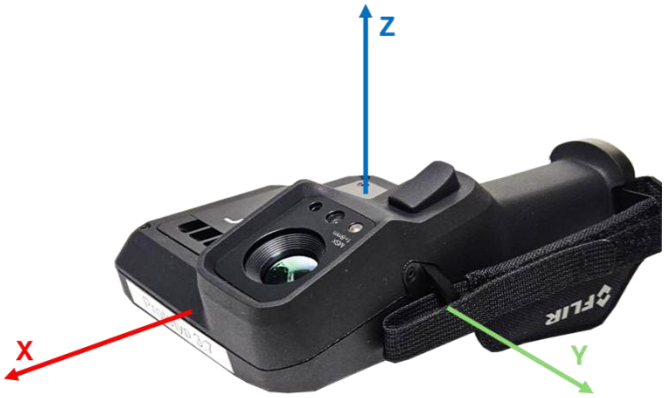


Figure 5-24 Measurement plane definition.

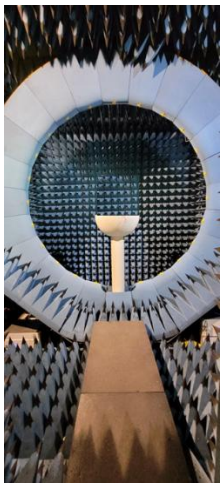


Figure 5-25 Satimo SG-23 6 GHz Stargate Antenna Test Chamber.

5.3.1 Cellular main antenna

LTE bands: 12, 13, 28

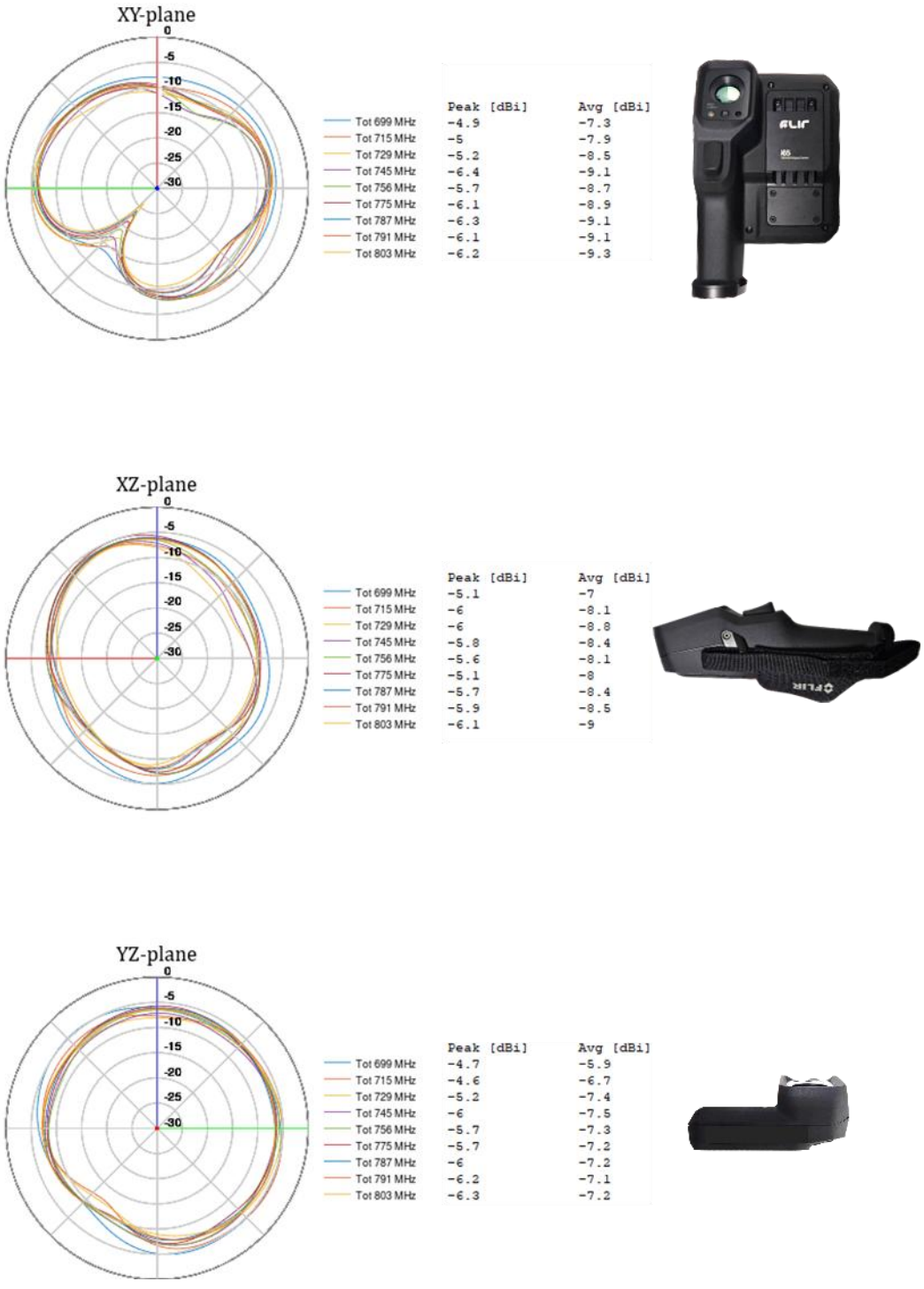


*Figure 5-26 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands **12, 13, 28***

LTE band: 20

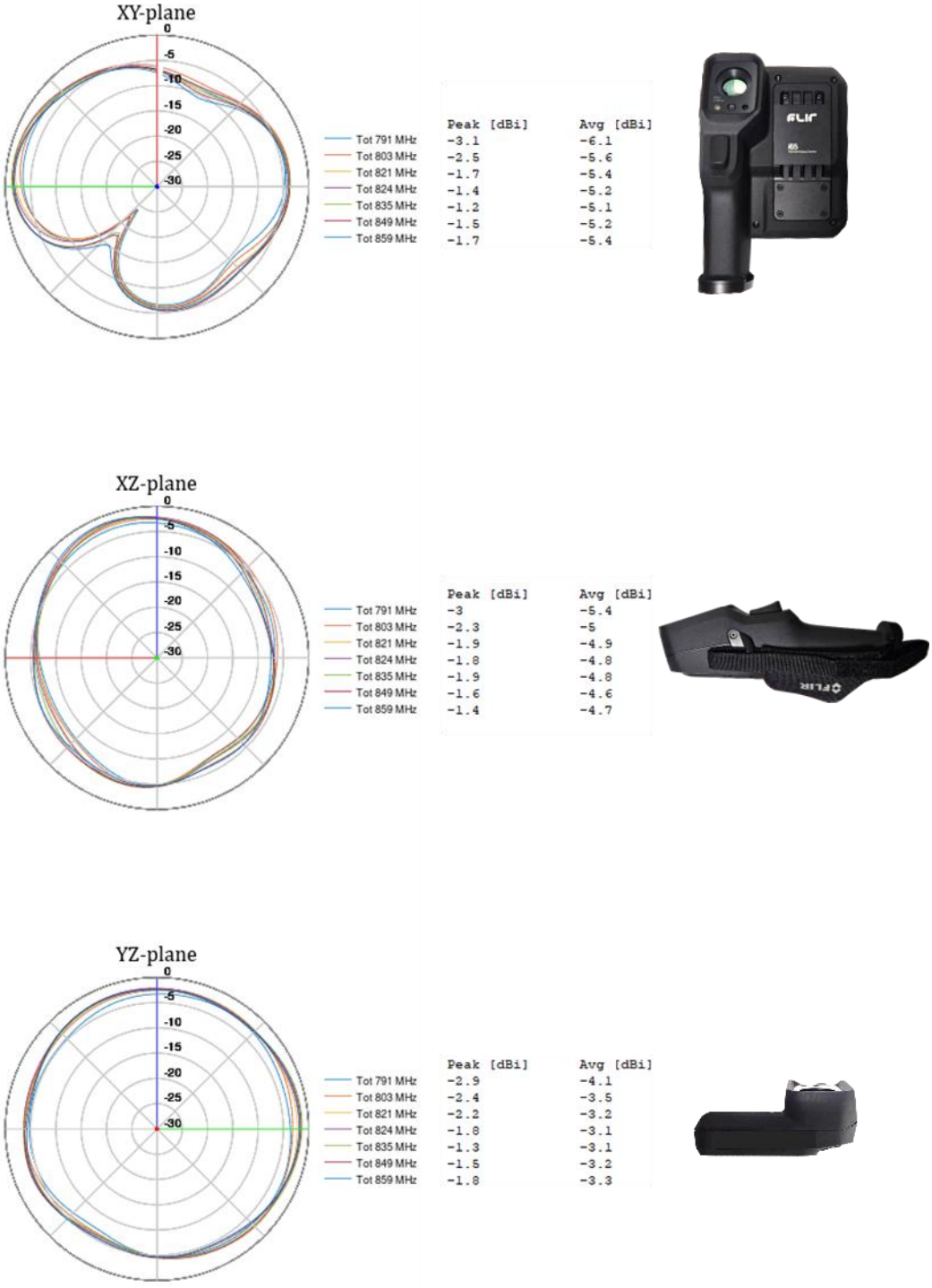


*Figure 5-27 2D radiation patterns Flir-i1845; Cellular main antenna LTE band **20***

LTE bands: 5,18,19,26

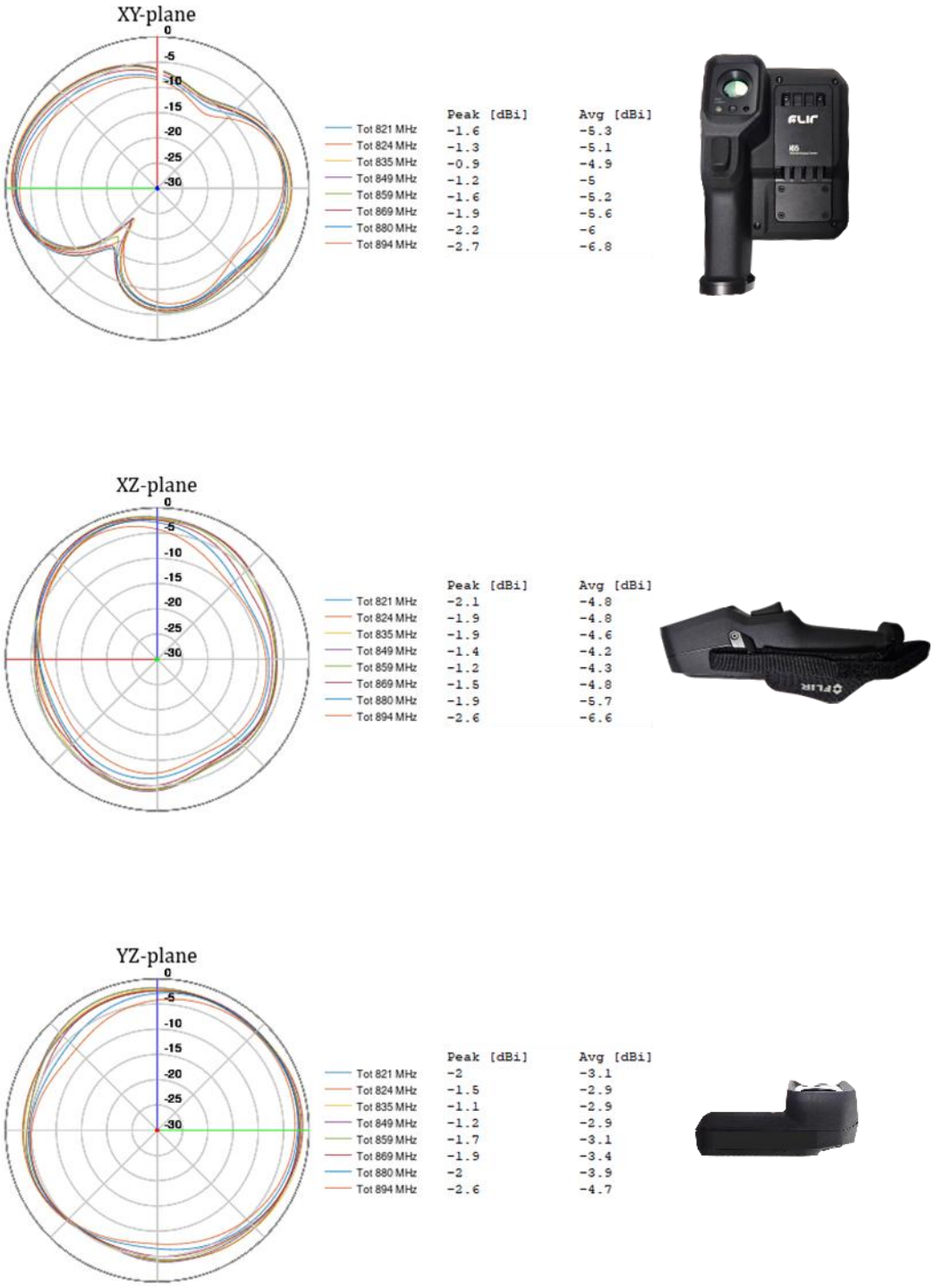


*Figure 5-28 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands **5,18,19,26***

LTE bands: 8

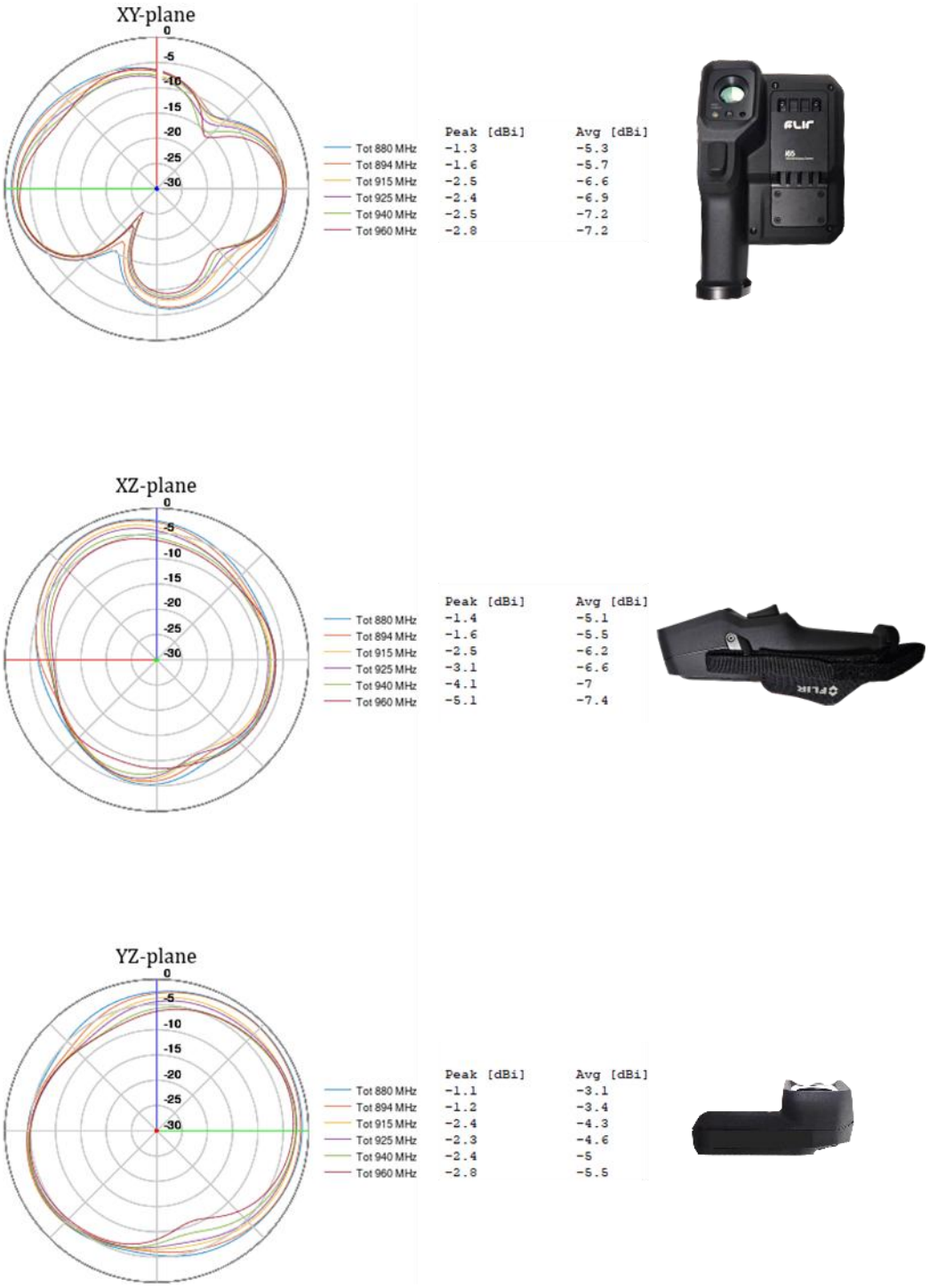


*Figure 5-29 2D radiation patterns Flir-i1845; Cellular main antenna LTE band **8***

LTE bands: 1,2,3,4,25,39,40

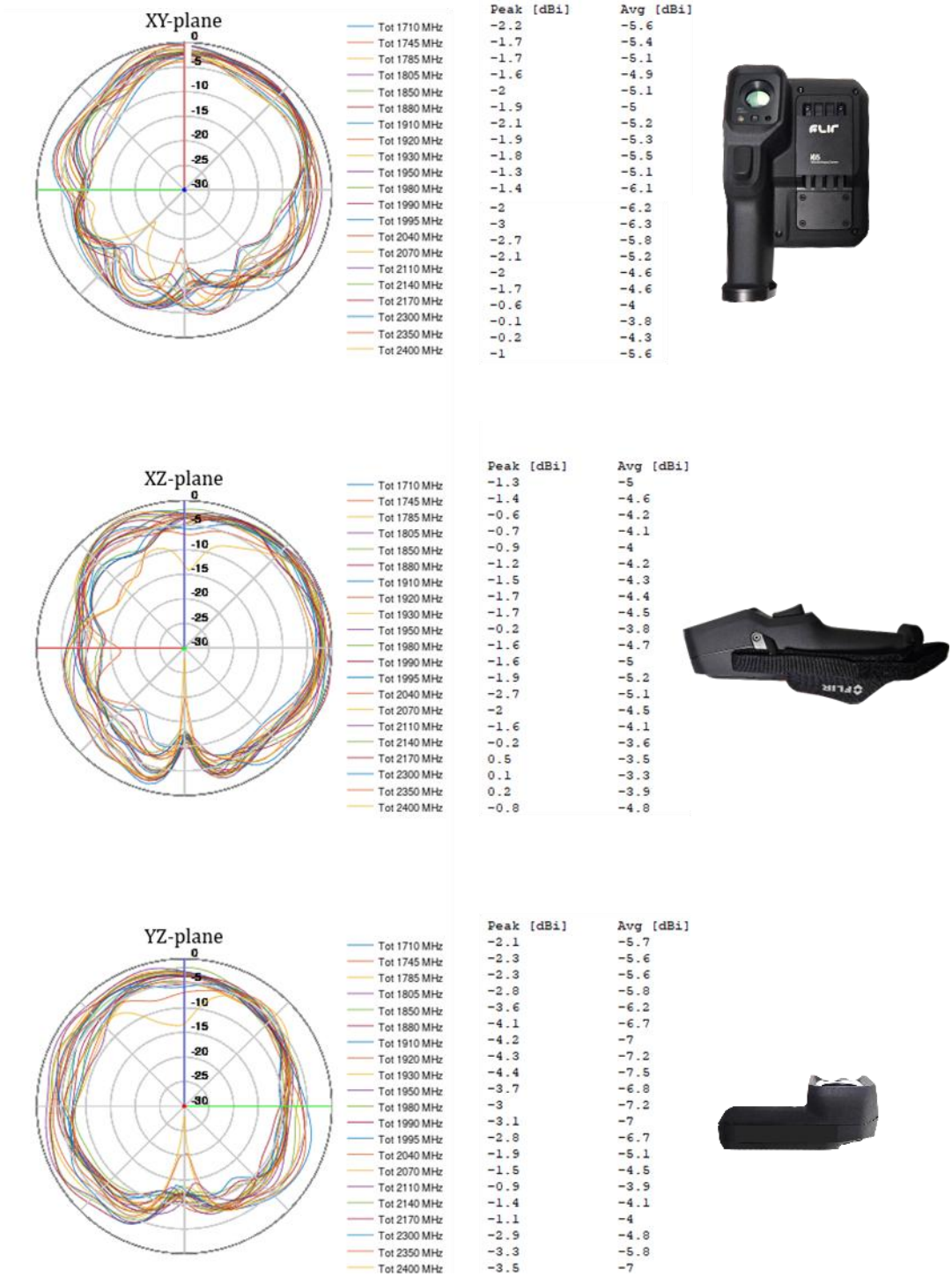


*Figure 5-30 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands **1,2,3,4,25,39,40***

LTE bands: 7,38,41

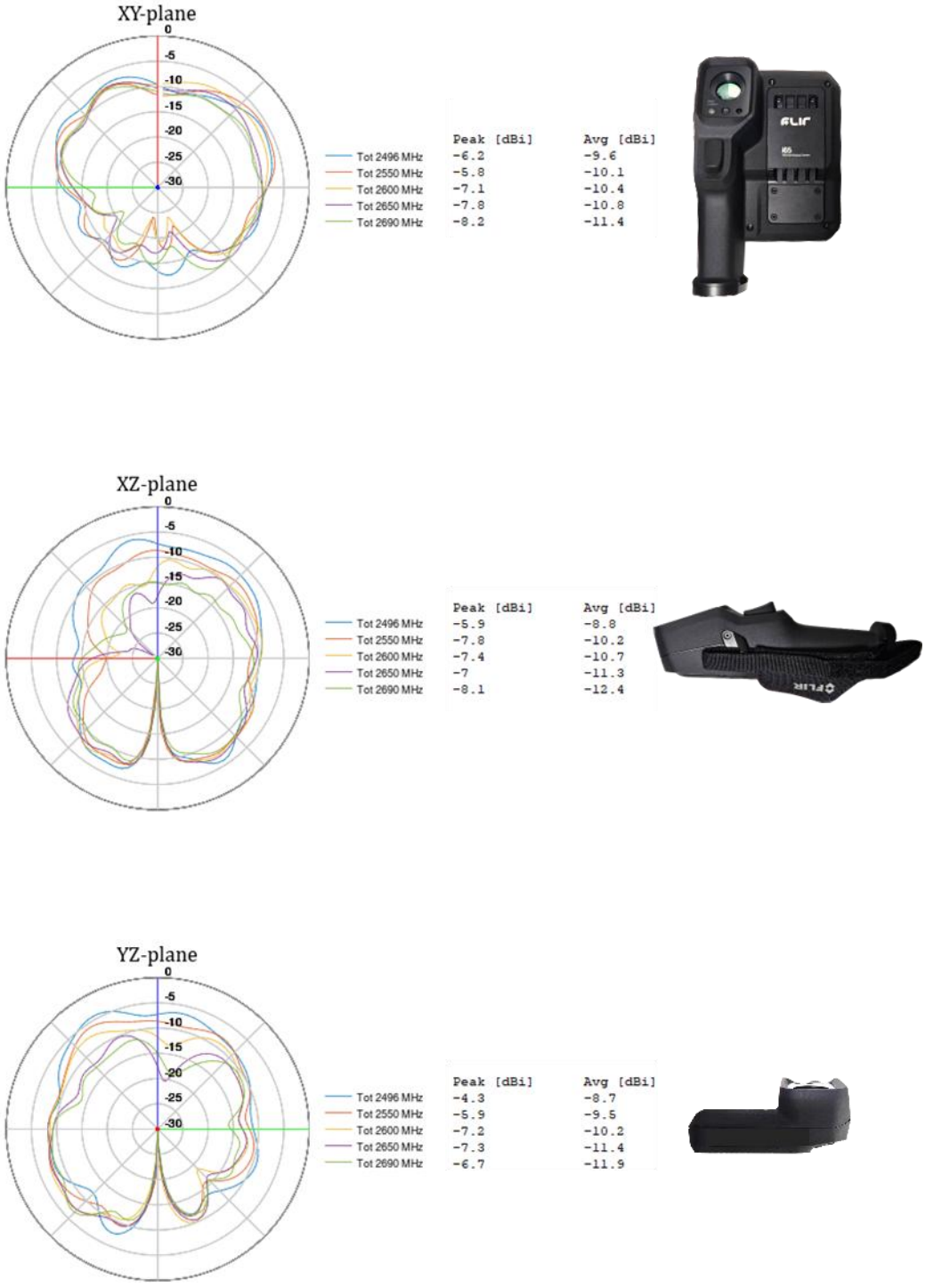


*Figure 5-31 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands **7,38,41***

5.3.2 Cellular diversity antenna

LTE bands: 12, 13, 28

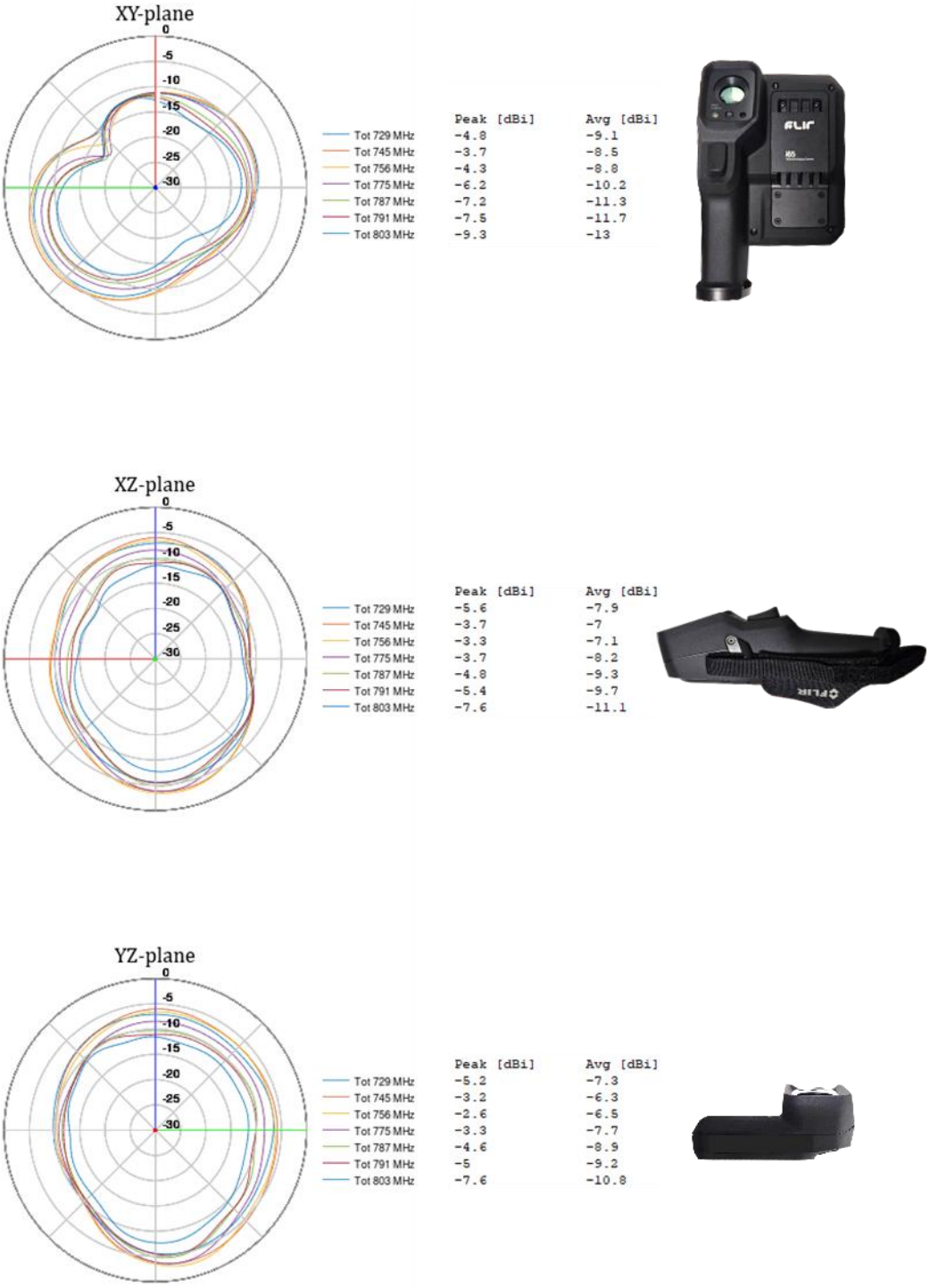


*Figure 5-32 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands **12, 13, 28***

LTE band: 20

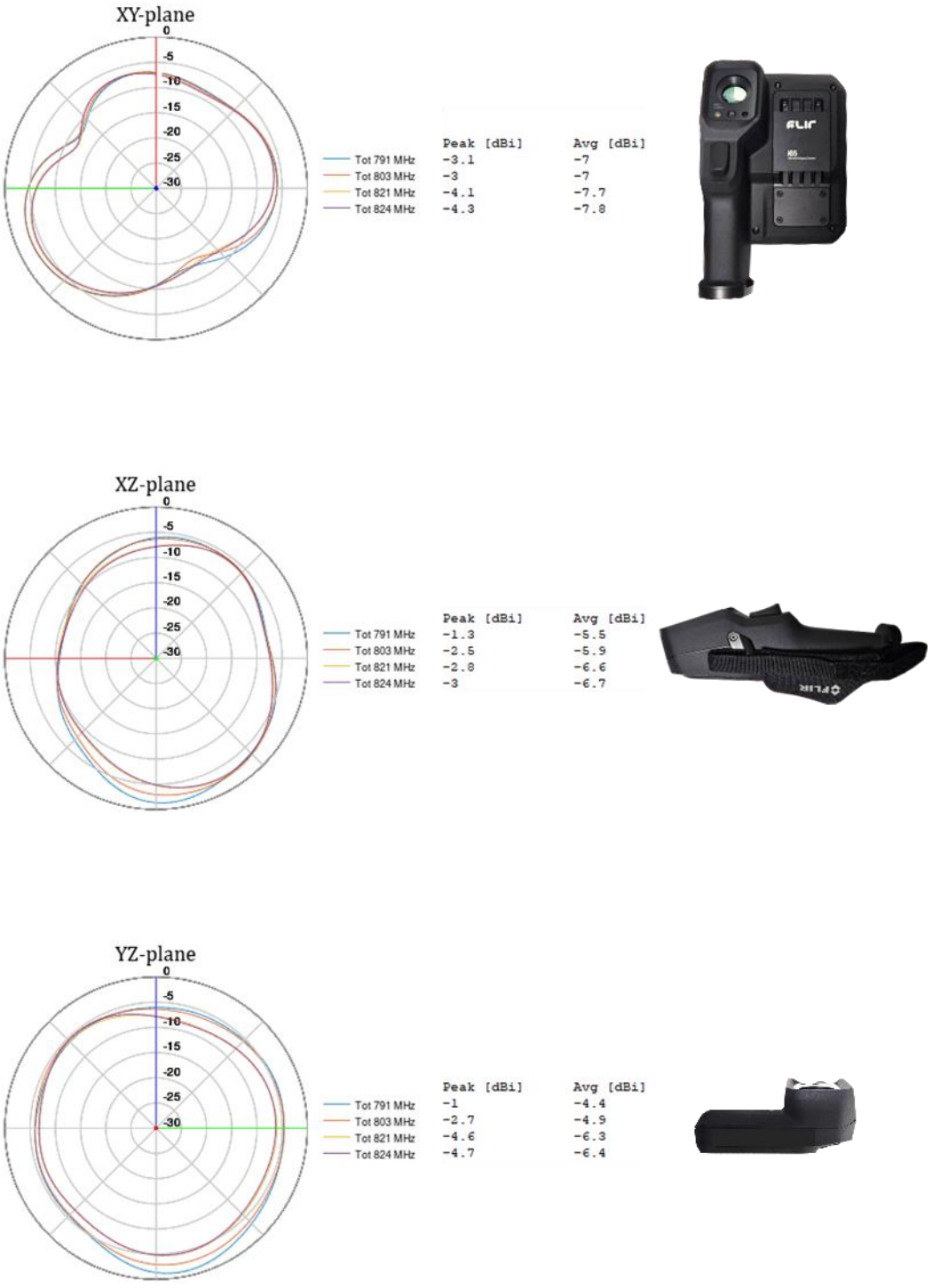


*Figure 5-33 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE band **20***

LTE bands: 5,18,19,26

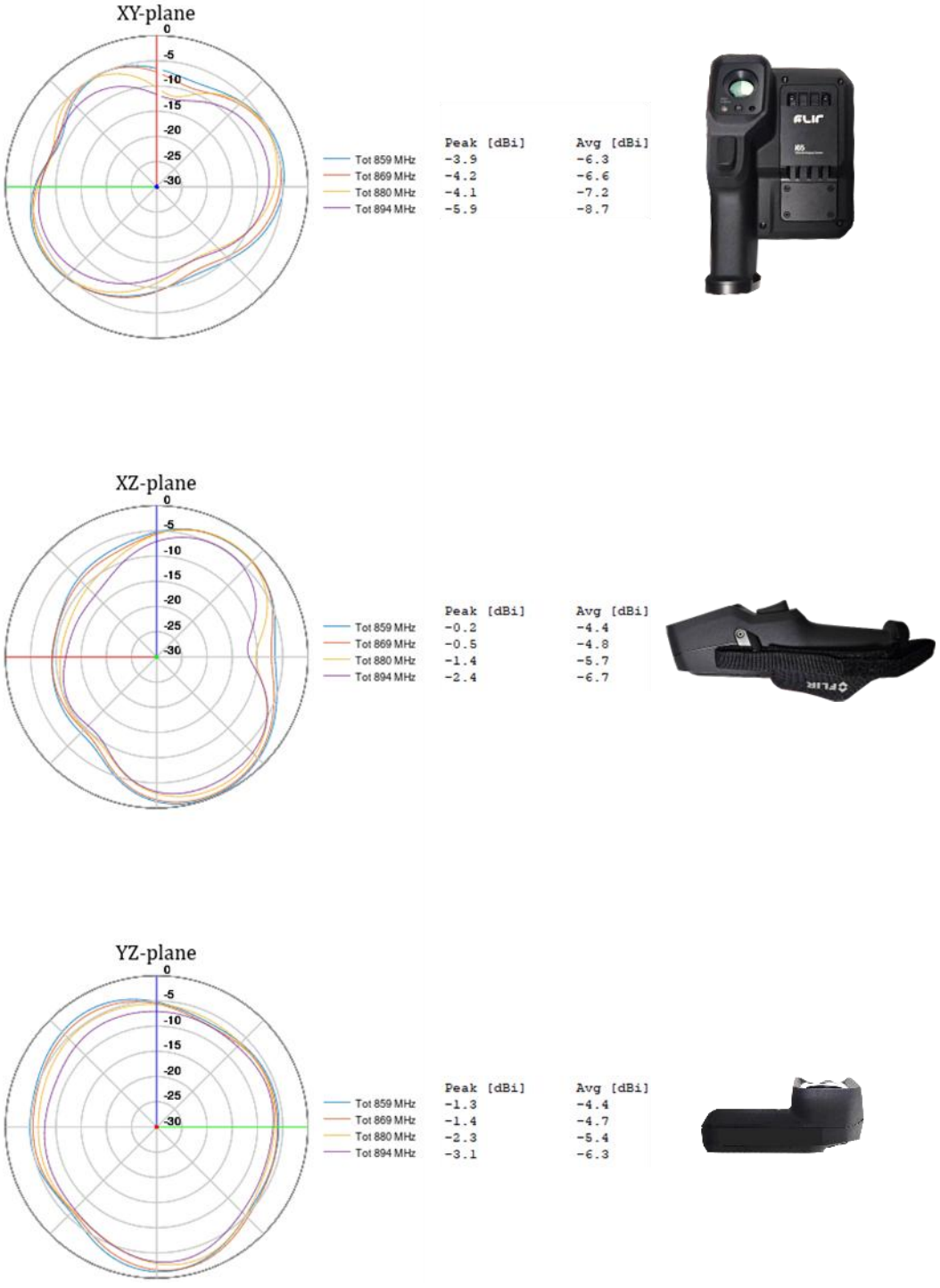


*Figure 5-34 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands **5,18,19,26***

LTE bands: 8

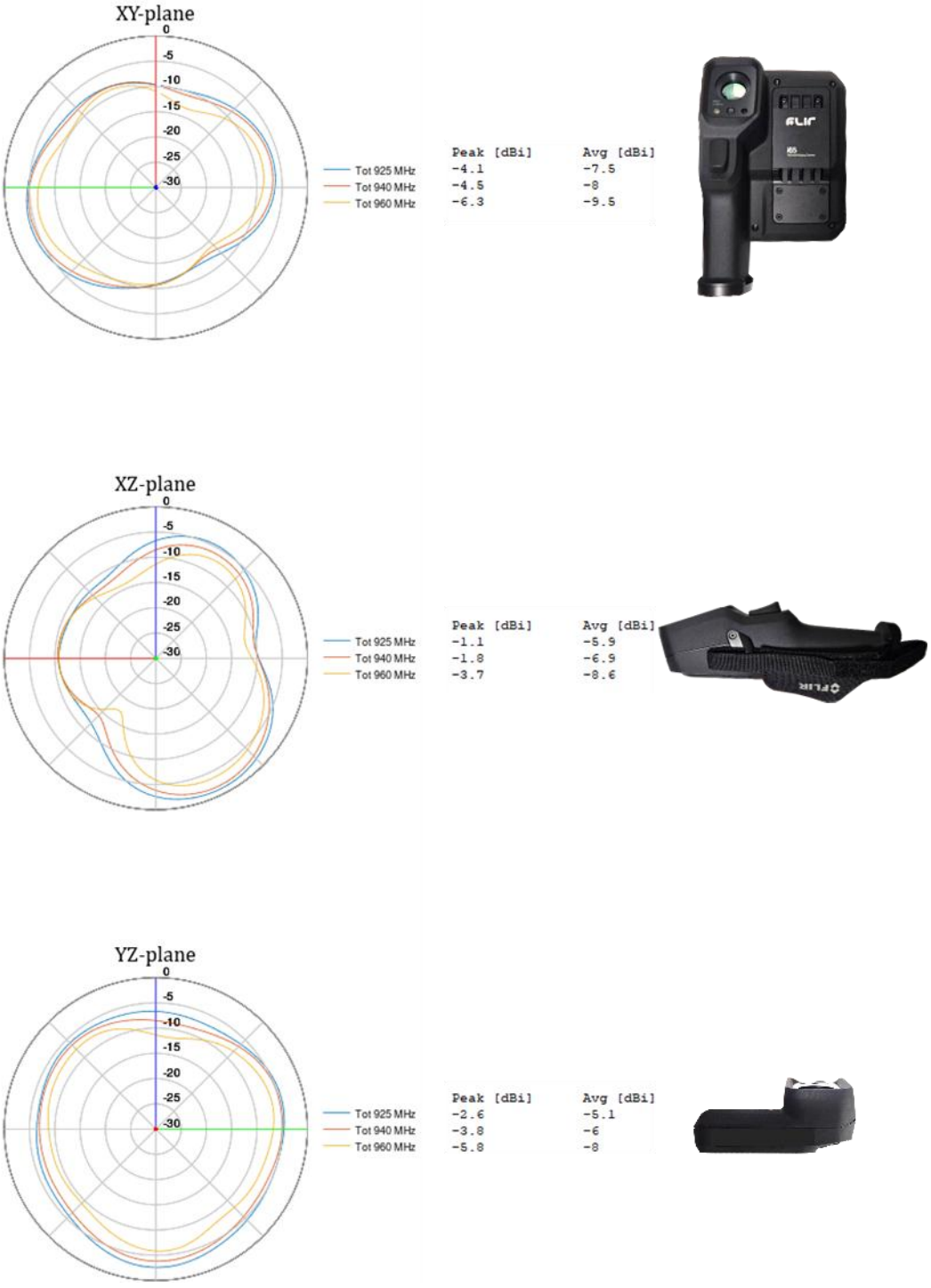


*Figure 5-35 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE band **8***

LTE bands: 1,2,3,4,25,39,40

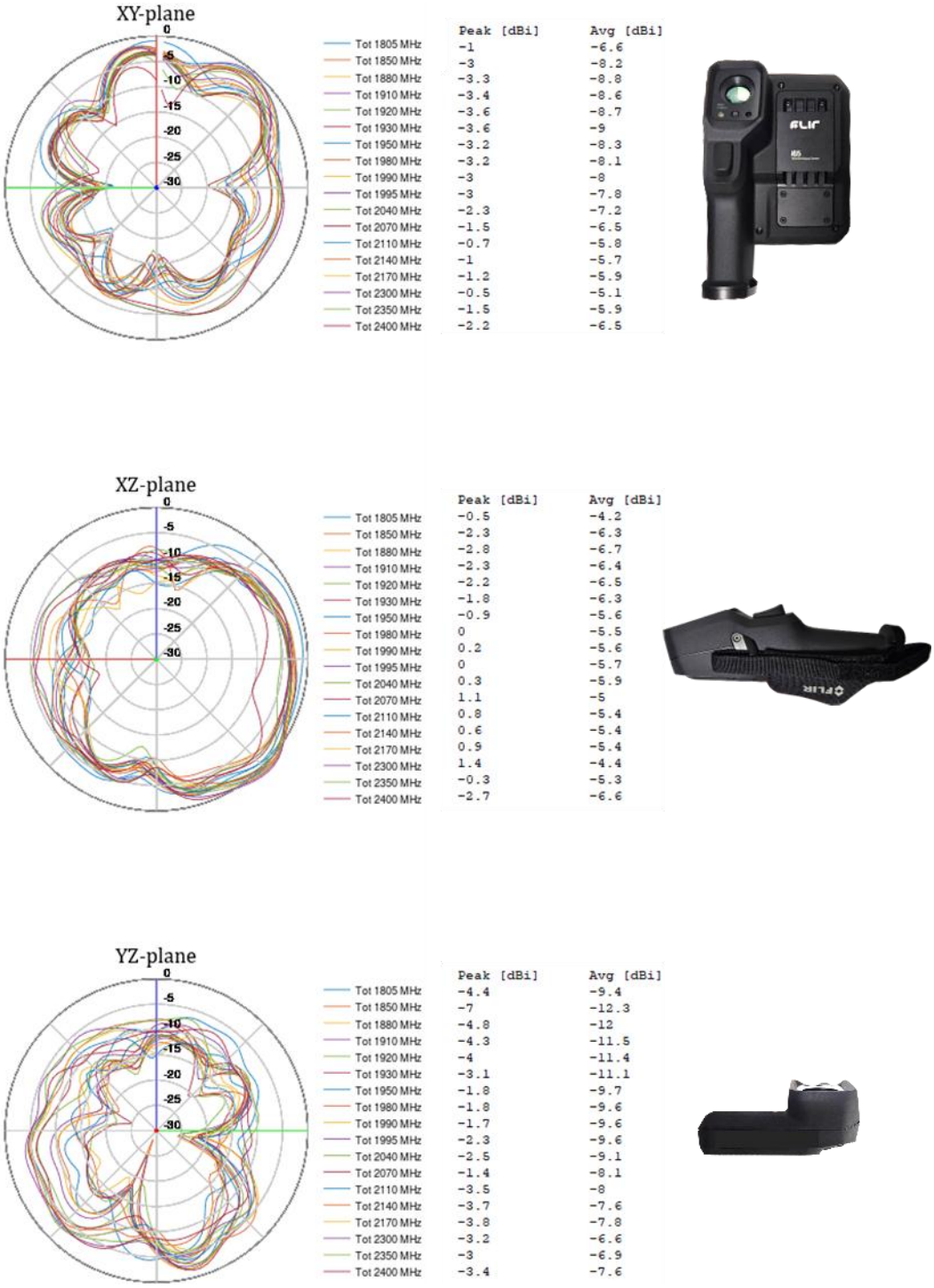


Figure 5-36 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands ***1,2,3,4,25,39,40***

LTE bands: 7,38,41

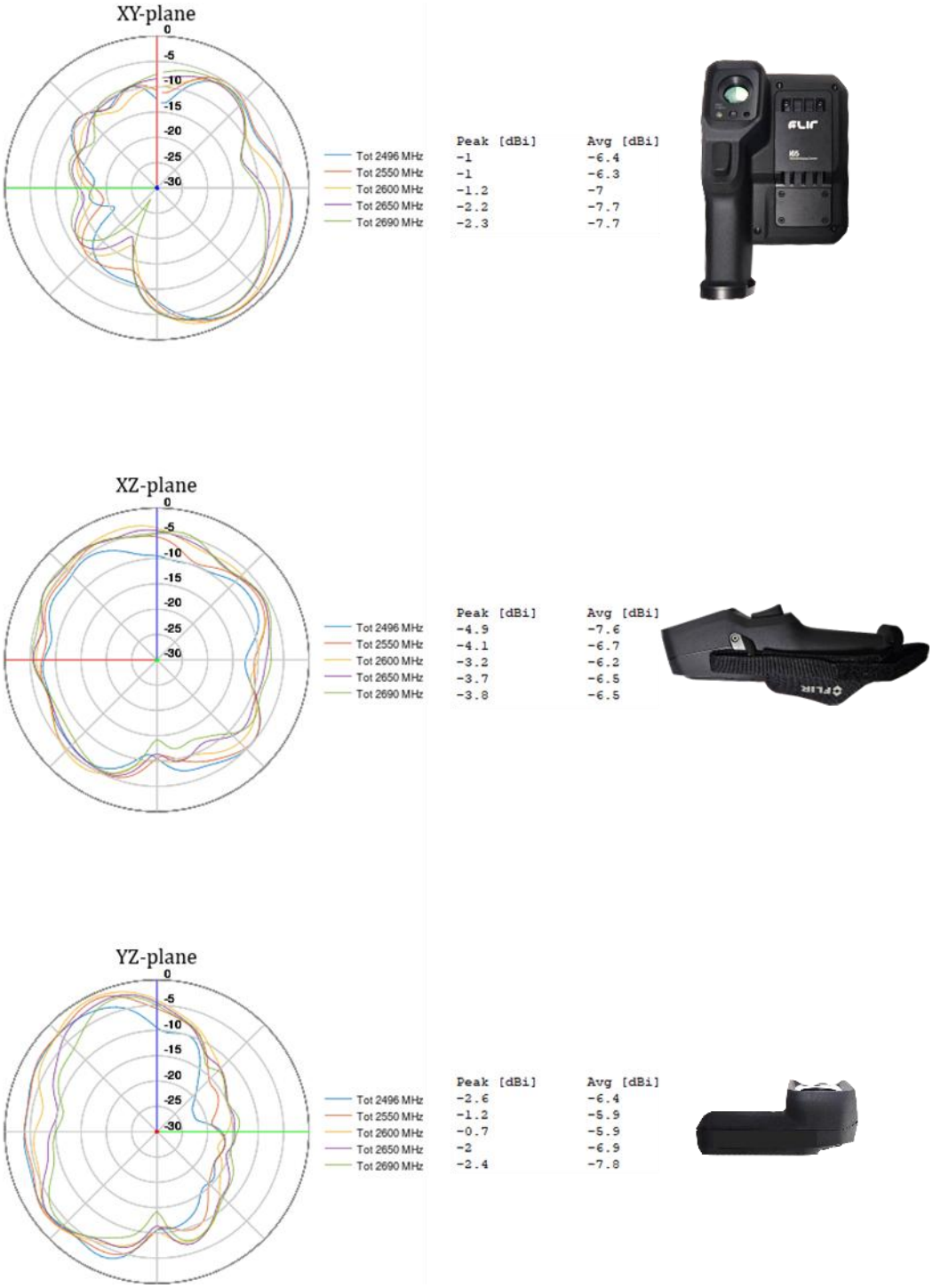


*Figure 5-37 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands **7,38,41***

5.3.3 Wi-Fi antenna

2.4GHz band

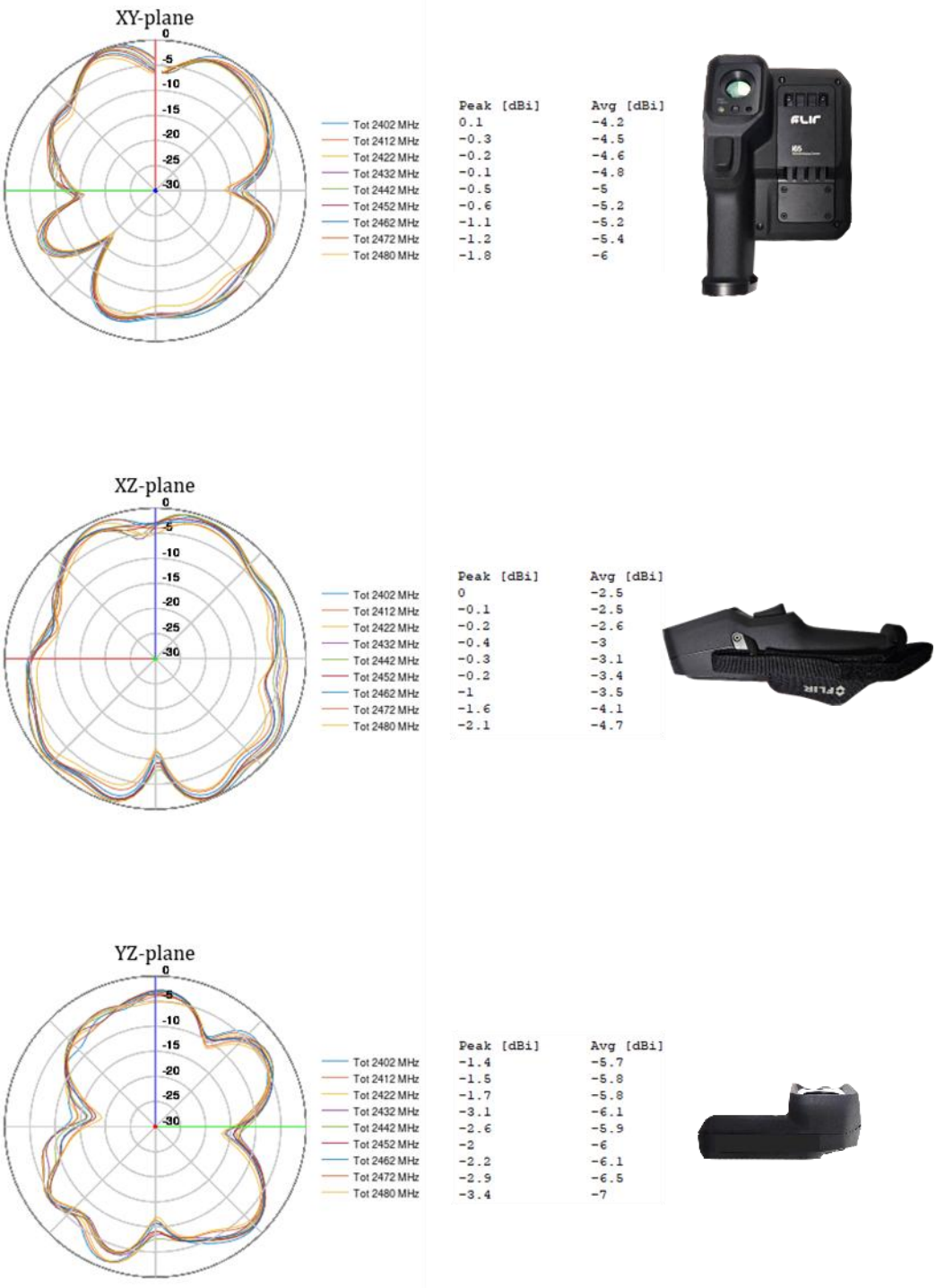


Figure 5-38 2D radiation patterns Flir-i1845; Wi-Fi antenna 2.4GHz band

5GHz band

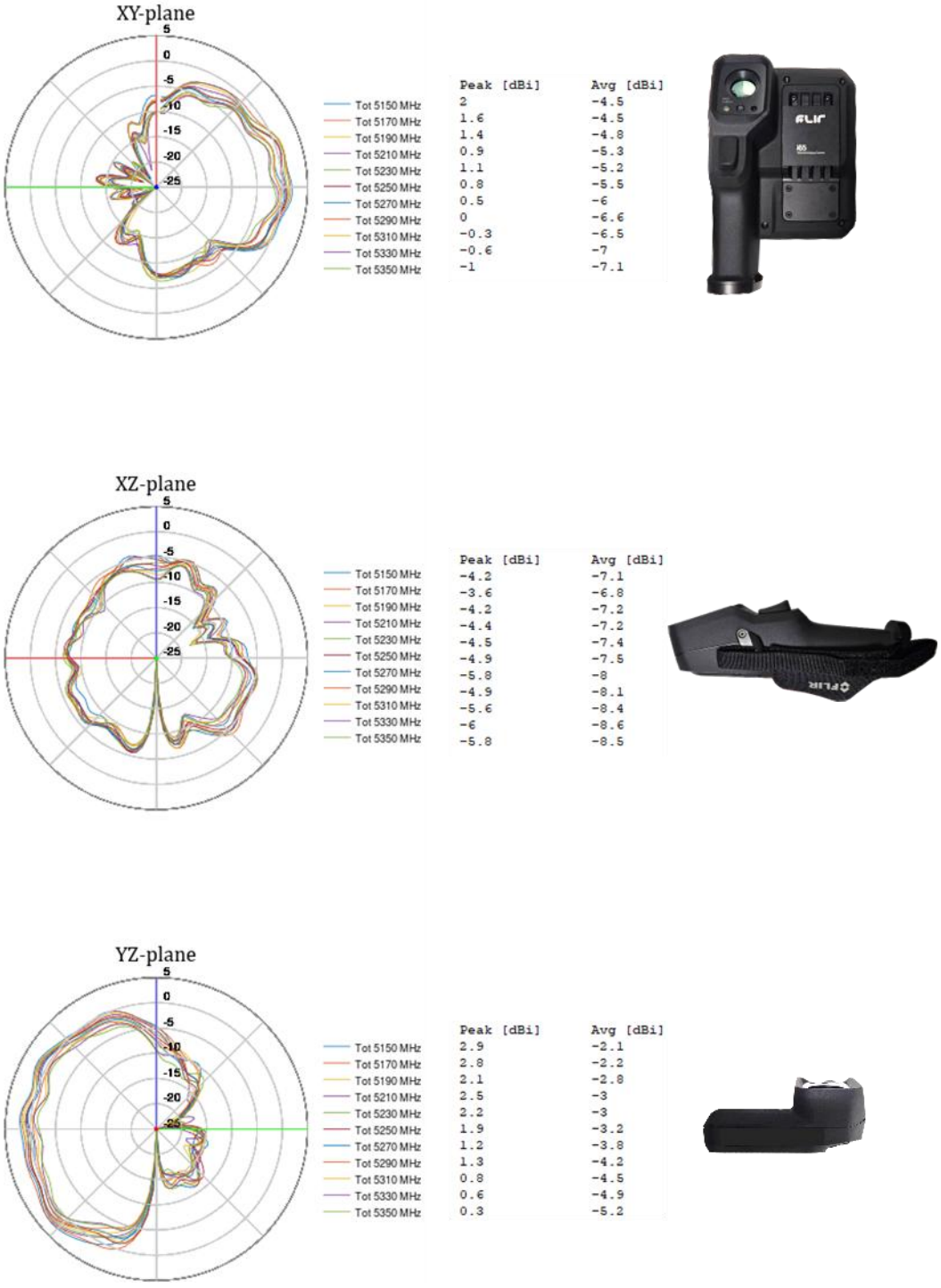


Figure 5-39 2D radiation patterns Flir-i1845; Wi-Fi antenna 5GHz band

5.3.4 GNSS antenna

LTE bands setting 12, 13, 28

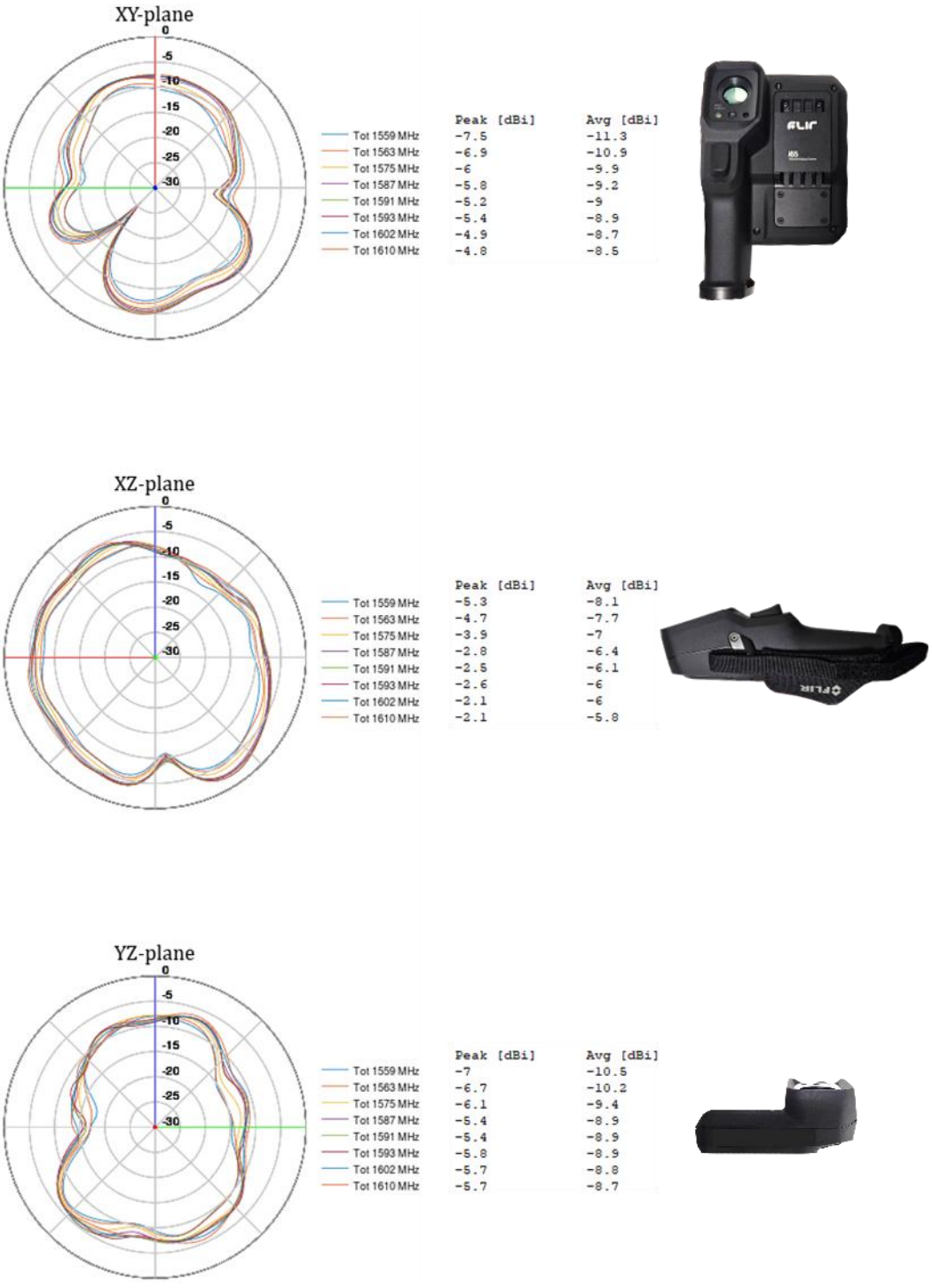


*Figure 5-40 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting **12, 13, 28***

LTE bands setting 20

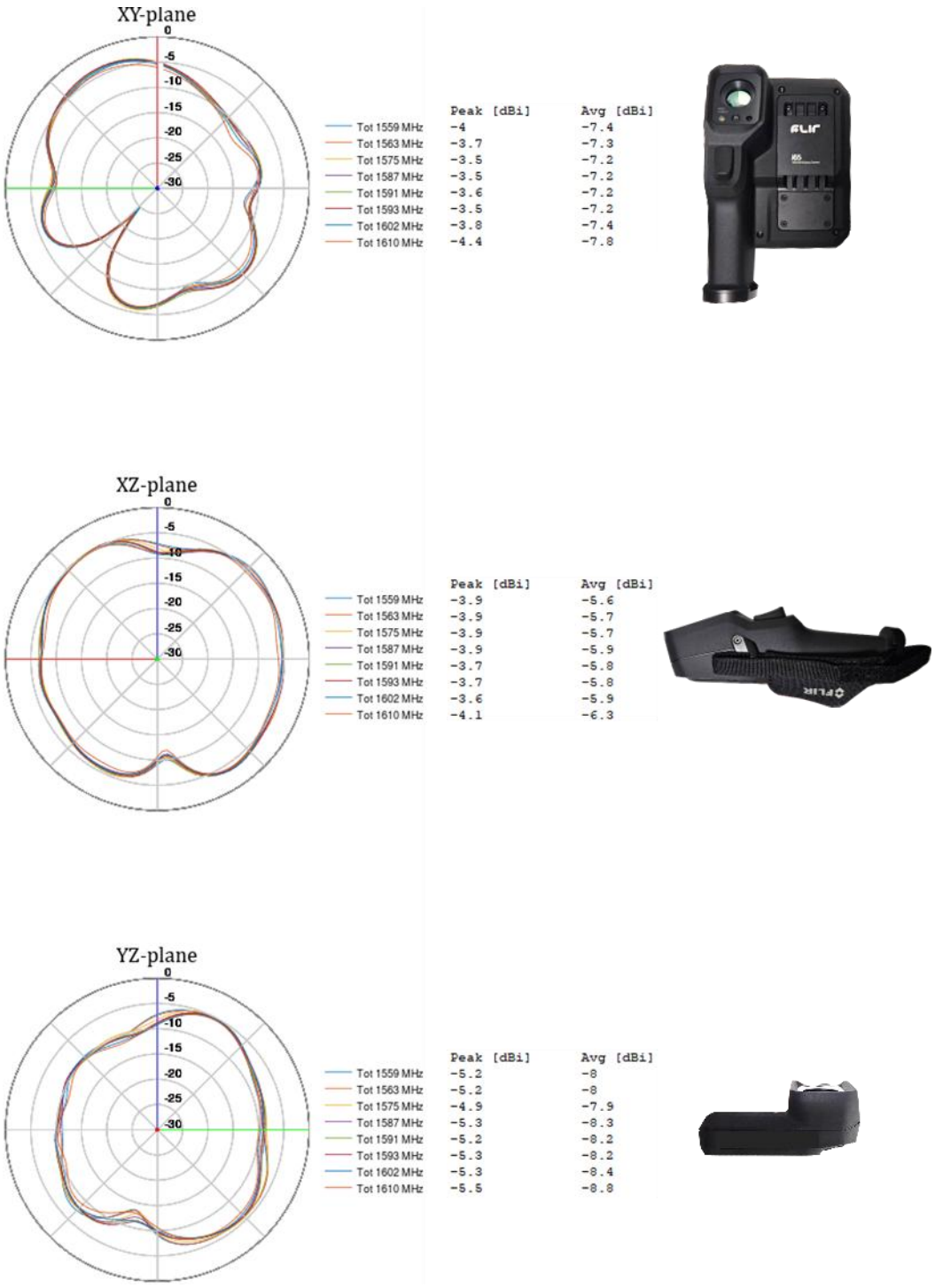


*Figure 5-41 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting **20***

LTE bands setting 5,18,19,26, 7, 38, 41

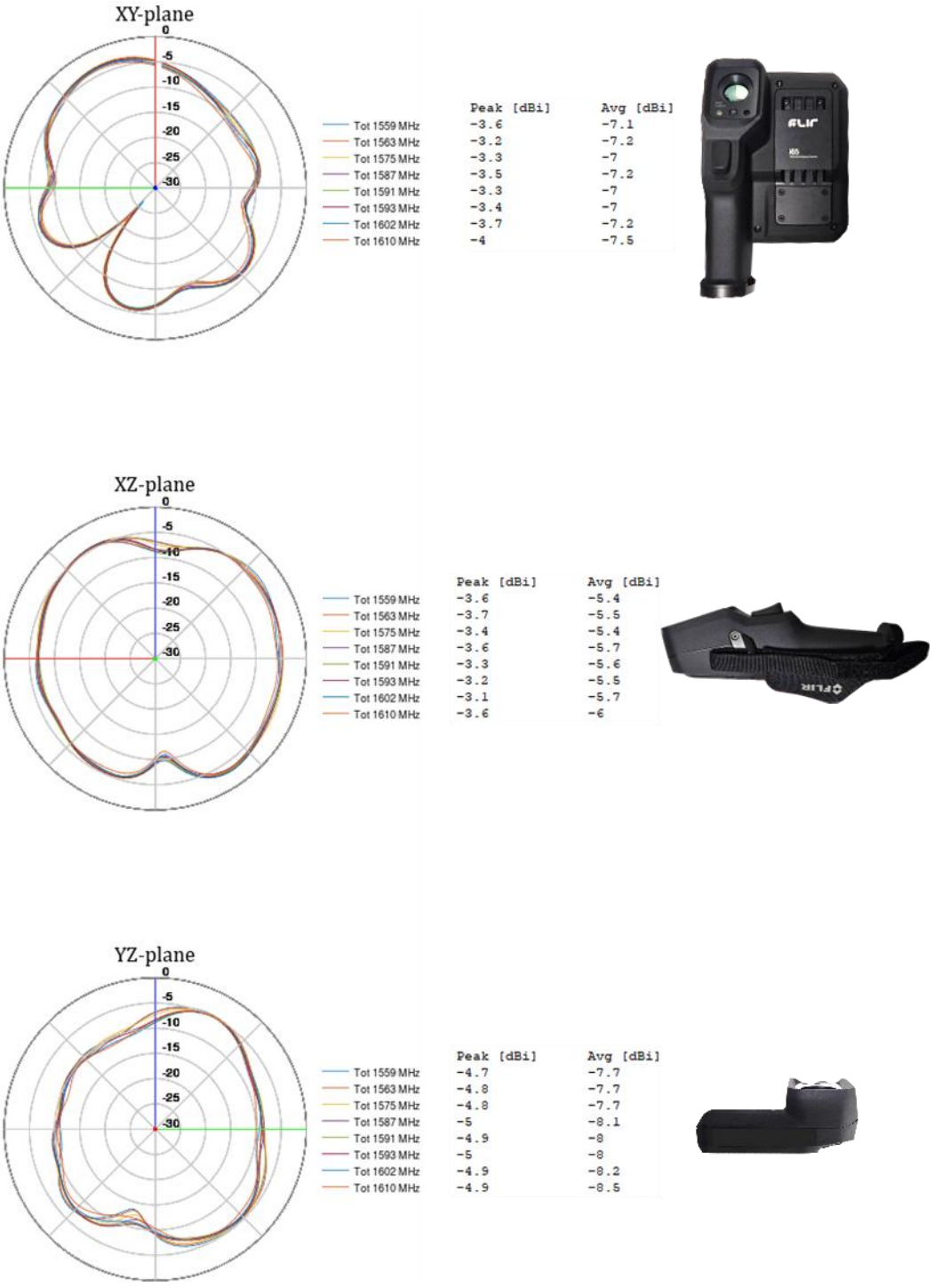


Figure 5-42 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting ***5,18,19,26, 7, 38, 41***

LTE bands setting 1,2,3,4,8,25,39,40

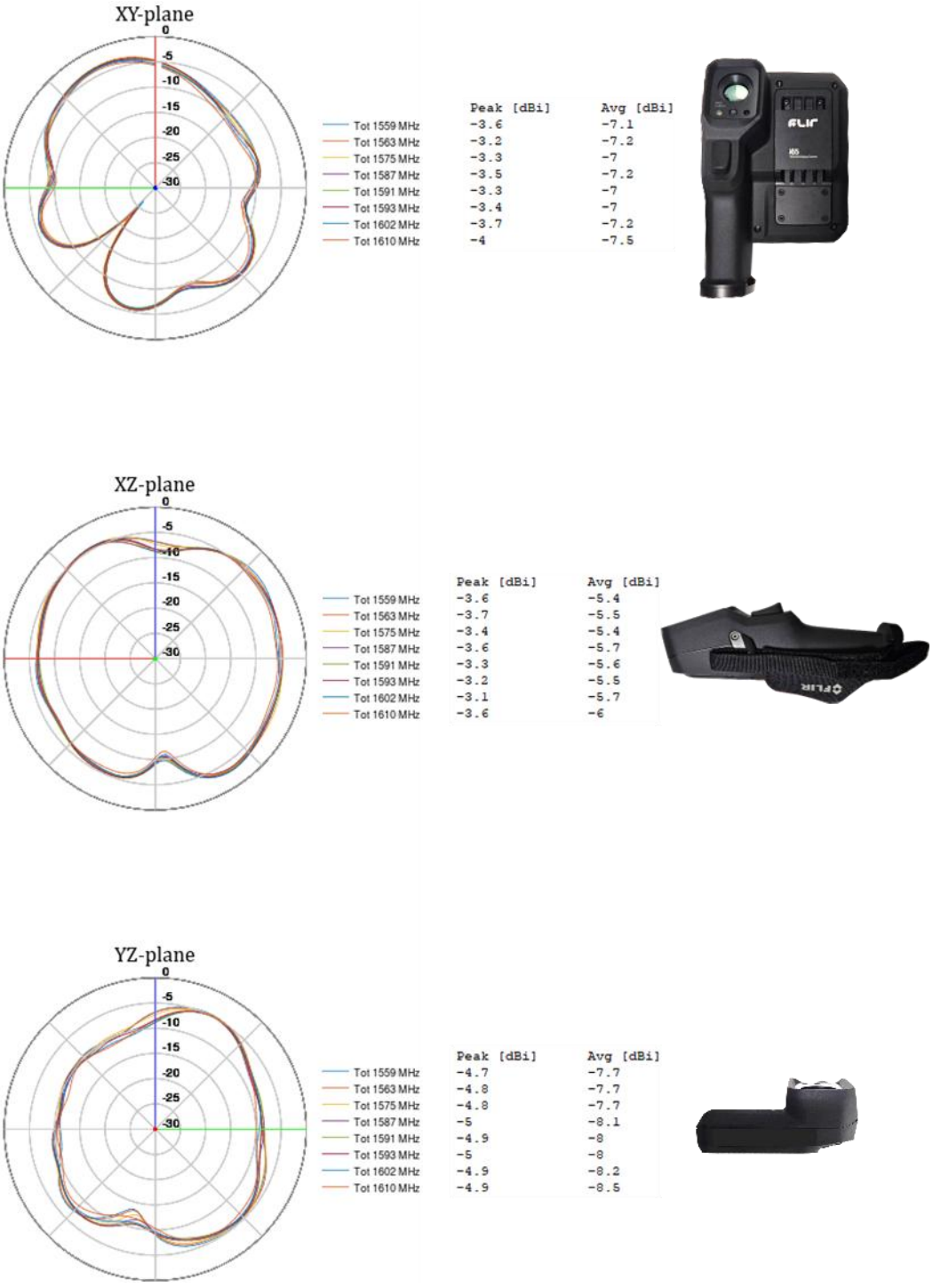


*Figure 5-43 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting **1,2,3,4,8,25,39,40***

5.4 Antenna peak gain

5.4.1 Cellular Main antenna

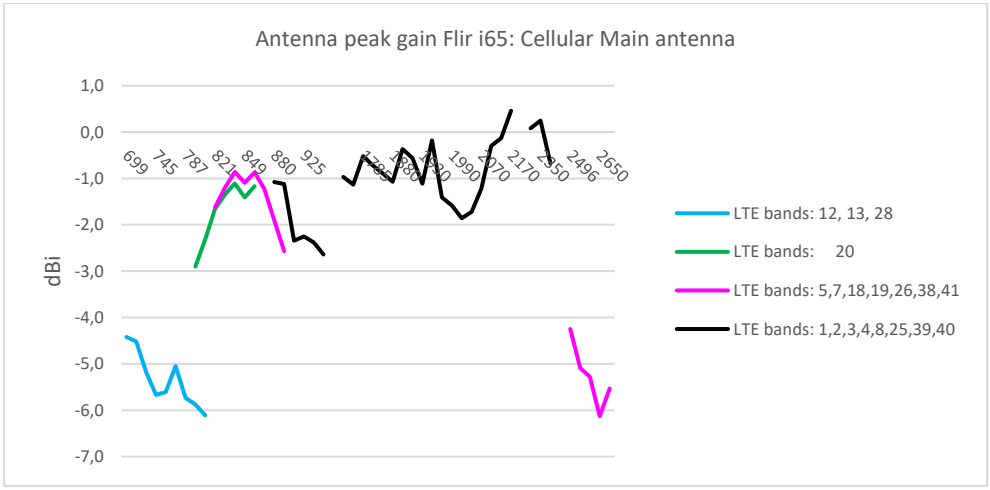


Figure 5-44 Antenna peak gain Flir-i1845; Cellular main antenna.

Table 6 Antenna peak gain Flir-i1845; Cellular main antenna.

Frequency [MHz]	LTE bands: 12, 13, 28	LTE bands: 20	LTE bands: 5,7,18,19,26, 38,41	LTE bands: 1,2,3,4,8,25, 39,40
	Antenna peak gain [dBi]			
699	-4,4			
715	-4,5			
729	-5,2			
745	-5,7			
756	-5,6			
775	-5,1			
787	-5,7			
791	-5,9	-2,9		
803	-6,1	-2,3		
821		-1,7	-1,6	
824		-1,4	-1,2	
835		-1,1	-0,9	
849		-1,4	-1,1	
859		-1,2	-0,9	
869			-1,2	
880			-1,9	-1,1
894			-2,6	-1,1
915				-2,3
925				-2,3
940				-2,4
960				-2,6
1710				-1,0
1745				-1,1
1785				-0,5
1805				-0,7
1850				-0,9
1880				-1,1
1910				-0,4
1920				-0,6
1930				-1,1
1950				-0,2
1980				-1,4
1990				-1,6
1995				-1,9
2040				-1,7
2070				-1,2
2110				-0,3
2140				-0,1
2170				0,5
2300				0,1
2350				0,3
2400				-0,7
2496			-4,3	
2550			-5,1	
2600			-5,3	
2650			-6,1	
2690			-5,5	

5.4.2 Cellular Diversity antenna

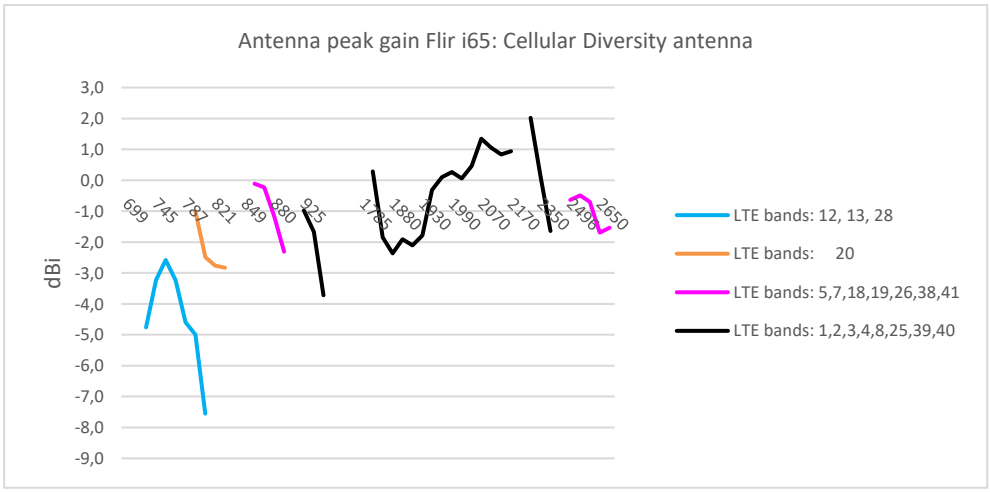


Figure 5-45 Antenna peak gain Flir-i1845; Cellular diversity antenna.

Table 7 Antenna peak gain Flir-i1845; Cellular diversity antenna.

	LTE bands: 12, 13, 28	LTE bands: 20	LTE bands: 5,7,18,19,26, 38,41	LTE bands: 1,2,3,4,8,25, 39,40
Frequency [MHz]	Antenna peak gain [dBi]			
699				
715				
729	-4,76			
745	-3,22			
756	-2,58			
775	-3,24			
787	-4,59			
791	-5	-1		
803	-7,55	-2,49		
821		-2,76		
824		-2,83		
835				
849				
859			-0,11	
869			-0,23	
880			-1,16	
894			-2,31	
915				
925				-0,98
940				-1,67
960				-3,72
1710				
1745				
1785				
1805				0,29
1850				-1,85
1880				-2,36
1910				-1,91
1920				-2,11
1930				-1,79
1950				-0,31
1980				0,1
1990				0,27
1995				0,06
2040				0,46
2070				1,34
2110				1,05
2140				0,84
2170				0,94
2300				2,02
2350				0,13
2400				-1,64
2496			-0,63	
2550			-0,49	
2600			-0,7	
2650			-1,69	
2690			-1,54	

5.4.3 Wi-Fi antenna

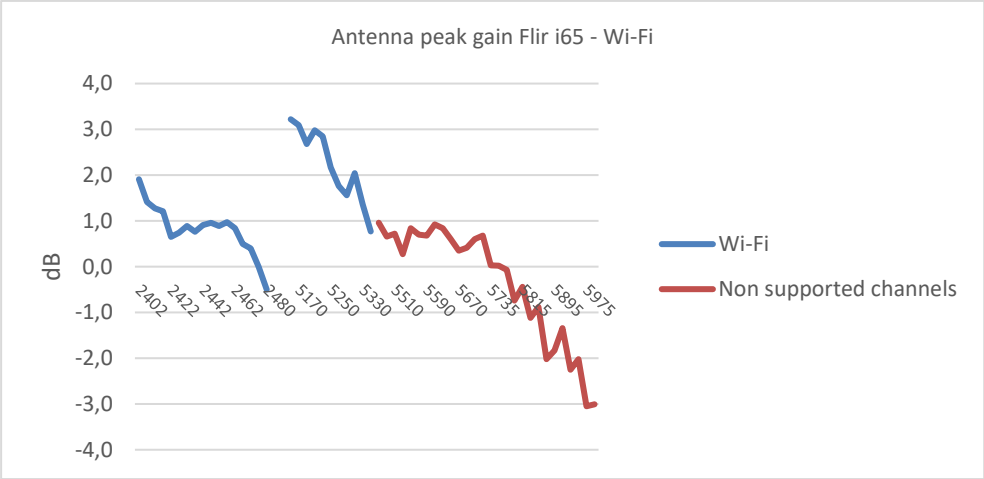


Figure 5-46 Antenna peak gain Flir-i1845; Wi-Fi antenna.

Table 8 Antenna peak gain Flir-i1845; Wi-Fi antenna.

Frequency [MHz]	Antenna peak gain [dBi]
2402	1,9
2407	1,4
2412	1,3
2417	1,2
2422	0,7
2427	0,7
2432	0,9
2437	0,8
2442	0,9
2447	1,0
2452	0,9
2457	1,0
2462	0,8
2467	0,5
2472	0,4
2477	0,0
2480	-0,5
5150	3,2
5170	3,1
5190	2,7
5210	3,0
5230	2,9
5250	2,2
5270	1,8
5290	1,6
5310	2,0
5330	1,4
5350	0,8
5470	1,0
5490	0,7
5510	0,7
5530	0,3
5550	0,8
5570	0,7
5590	0,7
5610	0,9
5630	0,8
5650	0,6
5670	0,4
5690	0,4
5710	0,6
5730	0,7
5735	0,0
5755	0,0
5775	-0,1
5795	-0,7
5815	-0,4
5835	-1,1
5855	-0,9
5875	-2,0
5895	-1,8
5915	-1,3
5935	-2,3
5955	-2,0
5975	-3,1
5985	-3,0

5.4.4 GNSS antenna

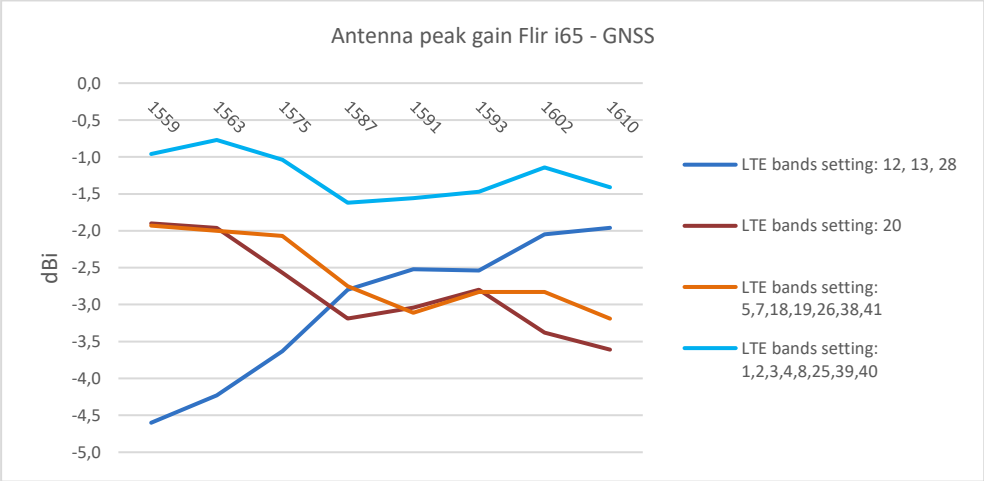


Figure 5-47 Antenna peak gain Flir-i1845; GNSS antenna.

Table 9 Antenna peak gain Flir-i1845; GNSS antenna.

	LTE bands setting: 12, 13, 28	LTE bands setting: 20	LTE bands setting: 5,7,18,19, 26,38,41	LTE bands setting: 1,2,3,4,8,25, 39,40
Frequency [MHz]	Antenna peak gain [dBi]			
1559	-4,6	-1,9	-1,9	-1,0
1563	-4,2	-2,0	-2,0	-0,8
1575	-3,6	-2,6	-2,1	-1,0
1587	-2,8	-3,2	-2,8	-1,6
1591	-2,5	-3,0	-3,1	-1,6
1593	-2,5	-2,8	-2,8	-1,5
1602	-2,1	-3,4	-2,8	-1,1
1610	-2,0	-3,6	-3,2	-1,4

6 Summary

The antenna performances for the Flir-i1845 thermal camera internal antennas have been evaluated. Results for VSWR, antenna efficiency and radiation patterns are presented. Based on the radiation pattern measurements, the maximum antenna peak gain of the transmitting antennas is presented below

LTE bands:	2, 13, 28	-4.4 dBi
LTE band:	20	-1.1 dBi
LTE bands:	5,18,19,26	-0.9 dBi
LTE bands:	8	-1.1 dBi
LTE bands:	1,2,3,4,8,25,39,40	0.3 dBi
LTE band:	7	-4.3 dBi
Wi-Fi band:	2.4GHz	1.9 dBi
Wi-Fi band:	5GHz (5150-5350MHz)	3.2 dBi

7 Antenna measurement system

All radiated measurements were performed using the measurement setup described in this appendix.

Table 7-1 List of equipment in antenna measurement system.

Item	Vendor	Model/Version
3D measurement chamber	Satimo	SG-23
Network Analyzer	Rohde & Schwarz	ZNB-8
Software	MVG	Wave Studio 22.5.6
Last calibration	MVG	2024-09

A. 3D radiation patterns

A.1 Cellular main antenna

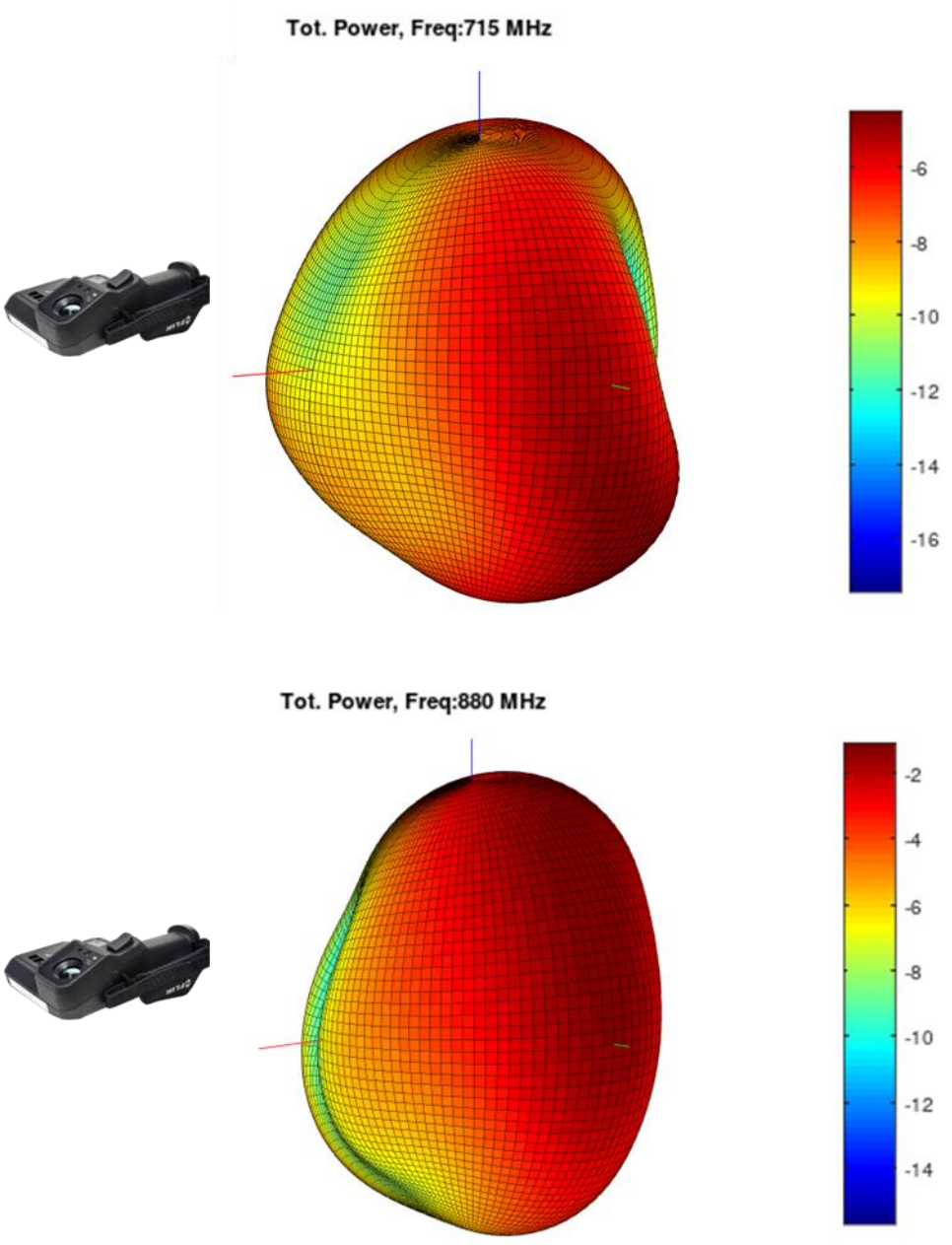


Figure A-1 3D radiation pattern for cellular main antenna, 715 and 880MHz.

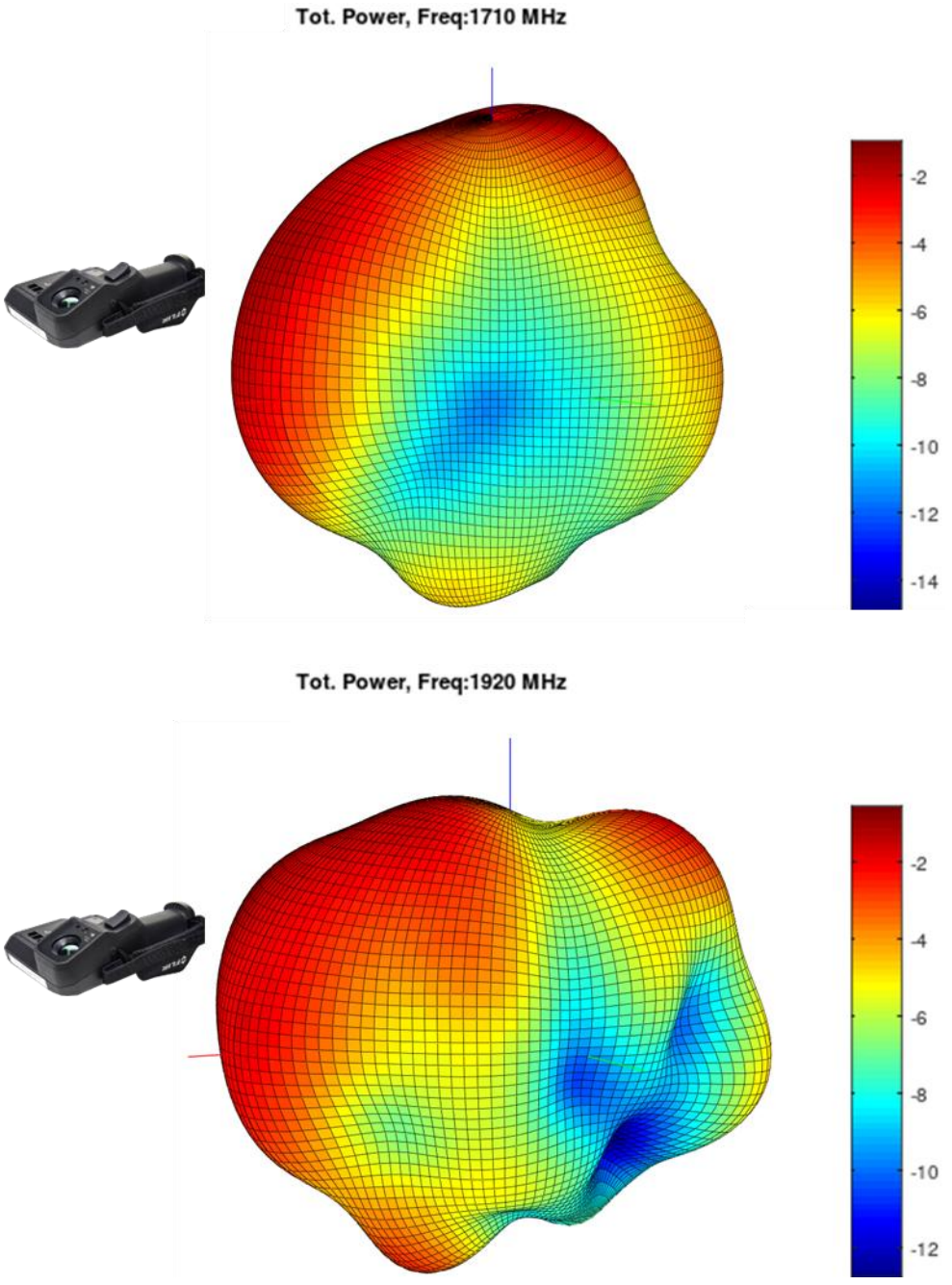


Figure A-2 3D radiation pattern for cellular main antenna, 1710 and 1920MHz.

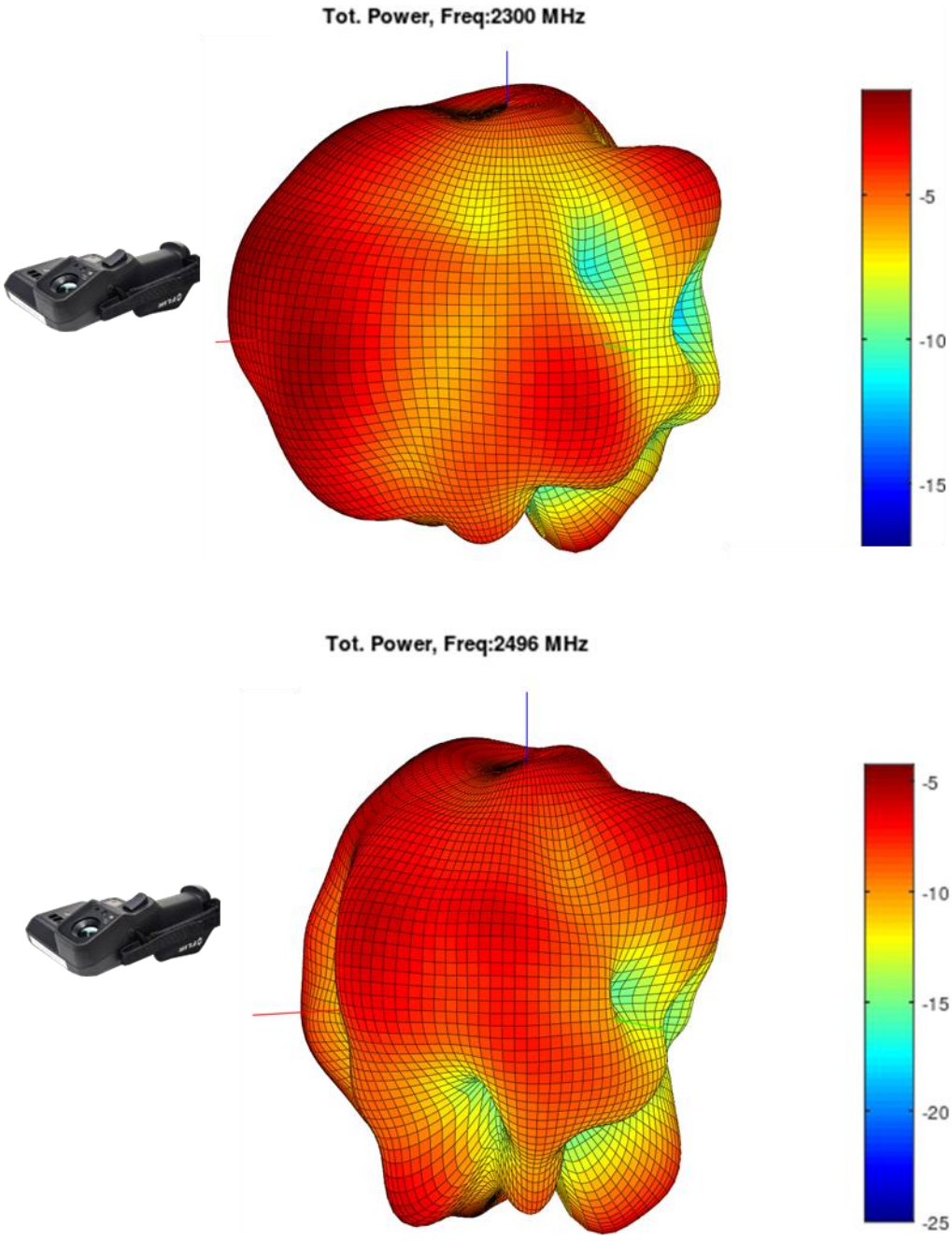


Figure A-3 3D radiation pattern for cellular main antenna, 2300 and 2496MHz.

A.2 Cellular diversity antenna

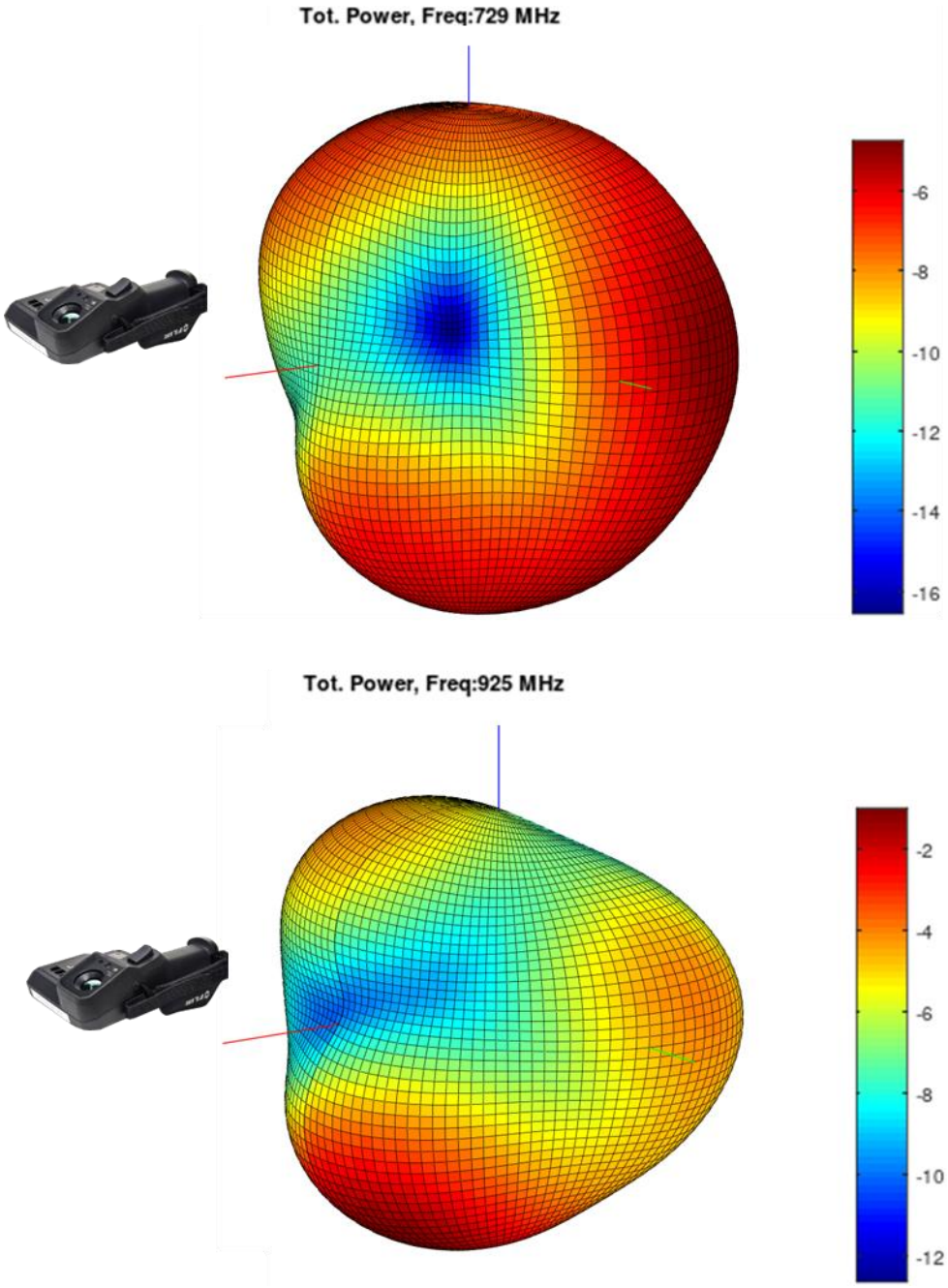


Figure A-4 3D radiation pattern for cellular diversity antenna, 729 and 925MHz.

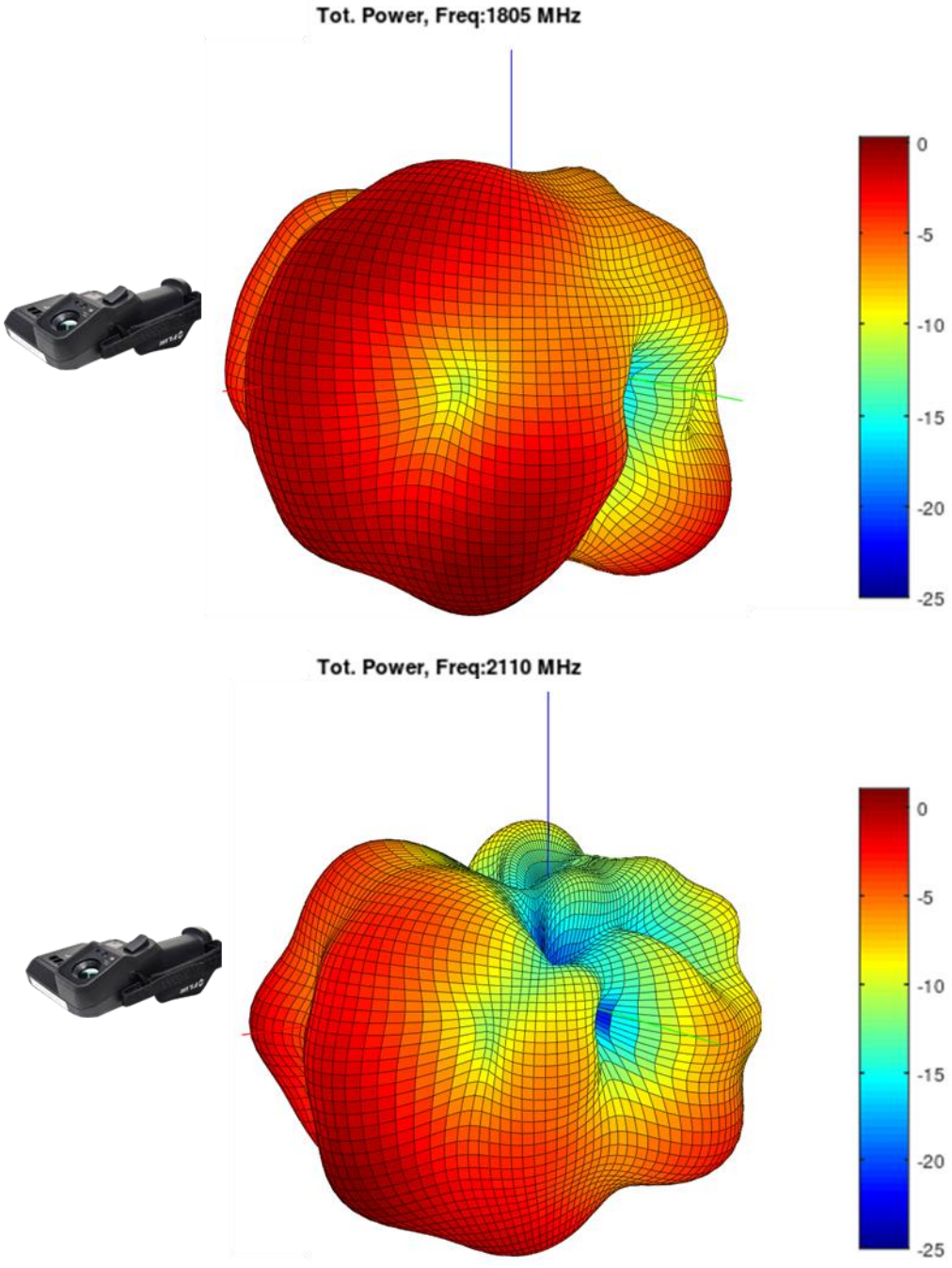


Figure A-5 3D radiation pattern for cellular diversity antenna, 1805 and 2110MHz.

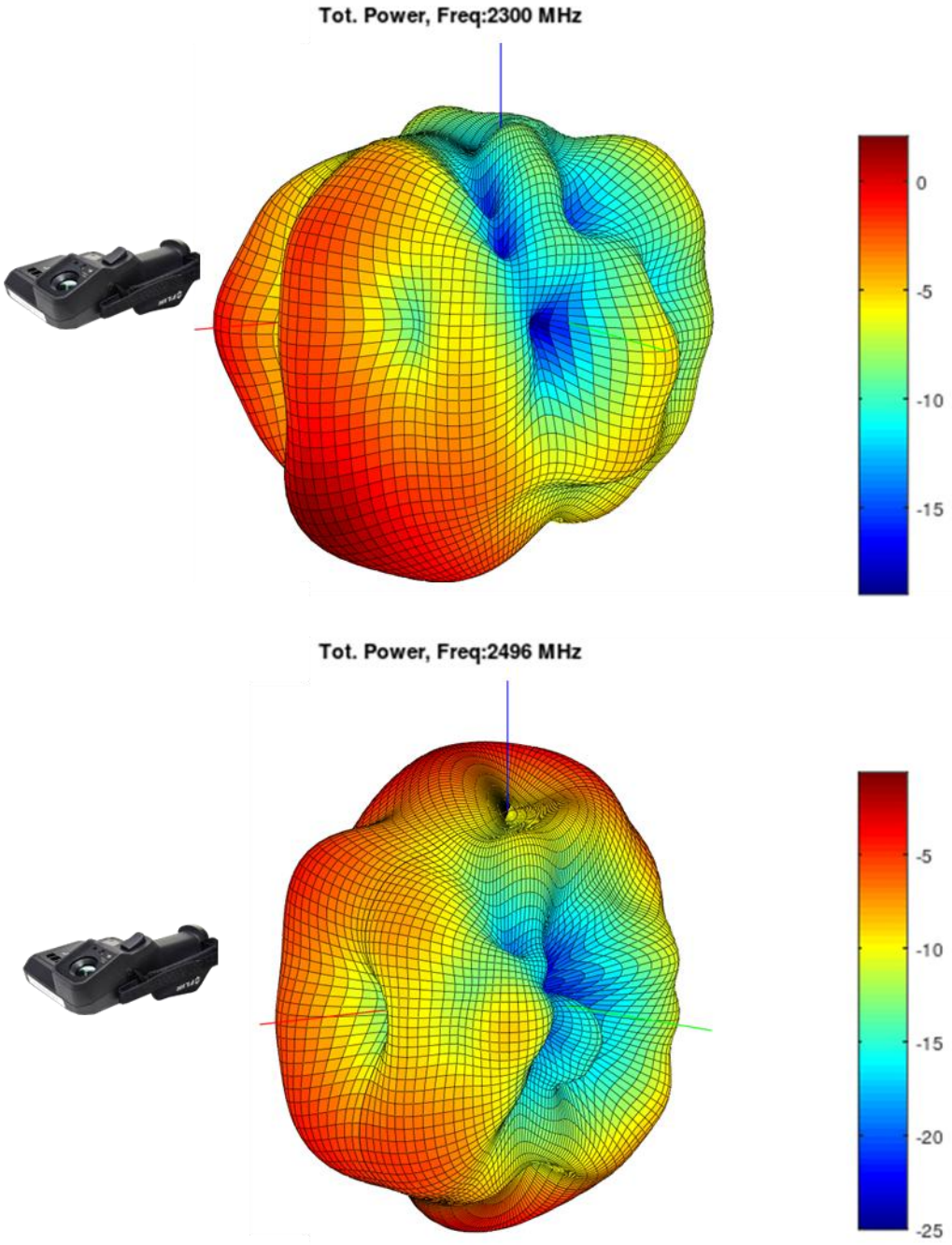


Figure A-6 3D radiation pattern for cellular diversity antenna, 2300 and 2496MHz.

A.3 Wi-Fi antenna

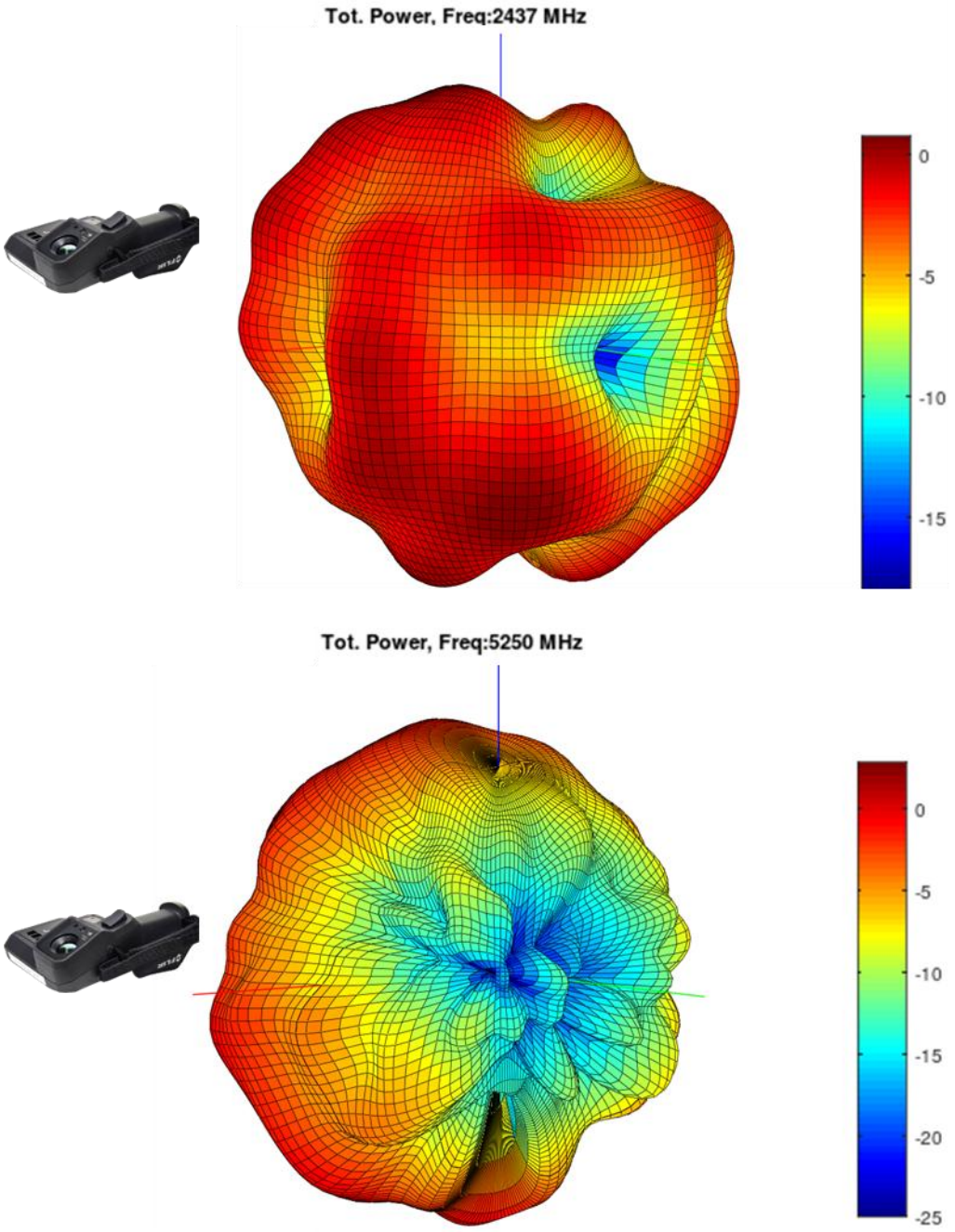


Figure A-7 3D radiation pattern for Wi-Fi antenna, 2437 and 5250MHz.

A.4 GNSS antenna

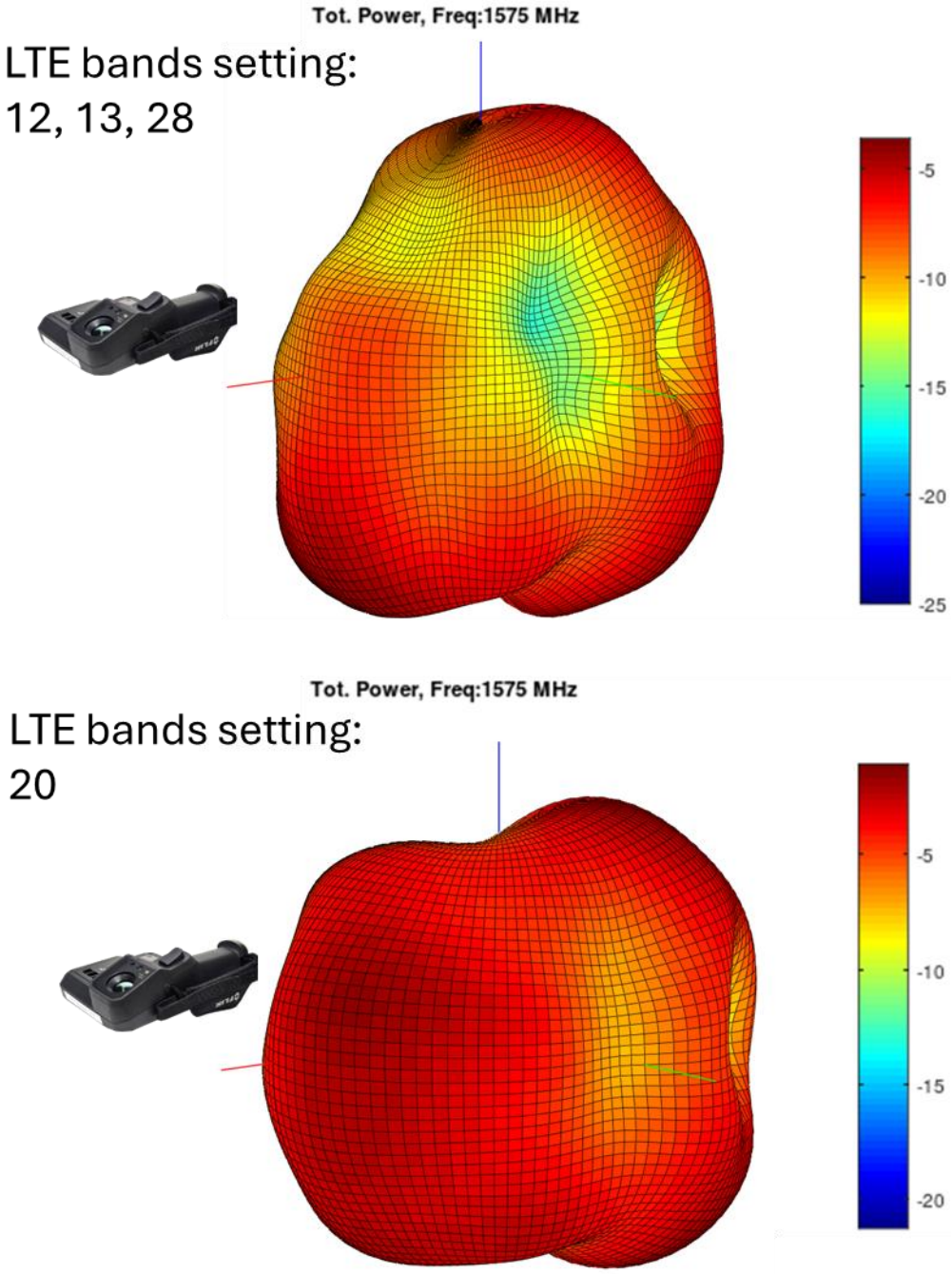


Figure A-8 3D radiation pattern for GNSS antenna, 1575MHz.

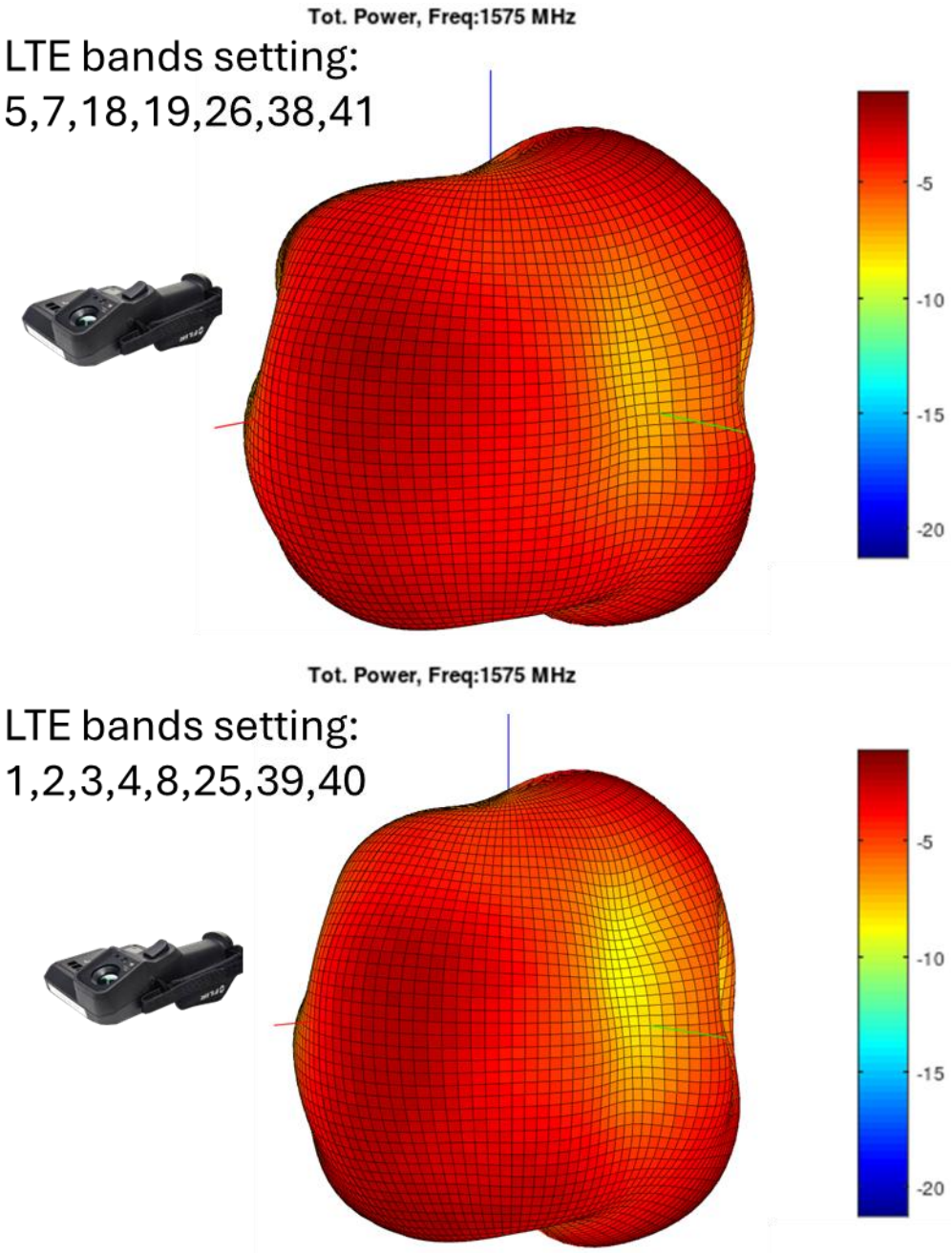


Figure A-9 3D radiation pattern for GNSS antenna, 1575MHz.