



FLIR-i1845

Antenna characterization - Hardware version T300960-B

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Revision History

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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*, hardware version *T300960-B*

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.

The antenna elements are produced by Quectel with part numbers Flir T132364 and Flir T132365.

All measurements are performed by Sigma Connectivity WSI AB in Kista Sweden.



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.

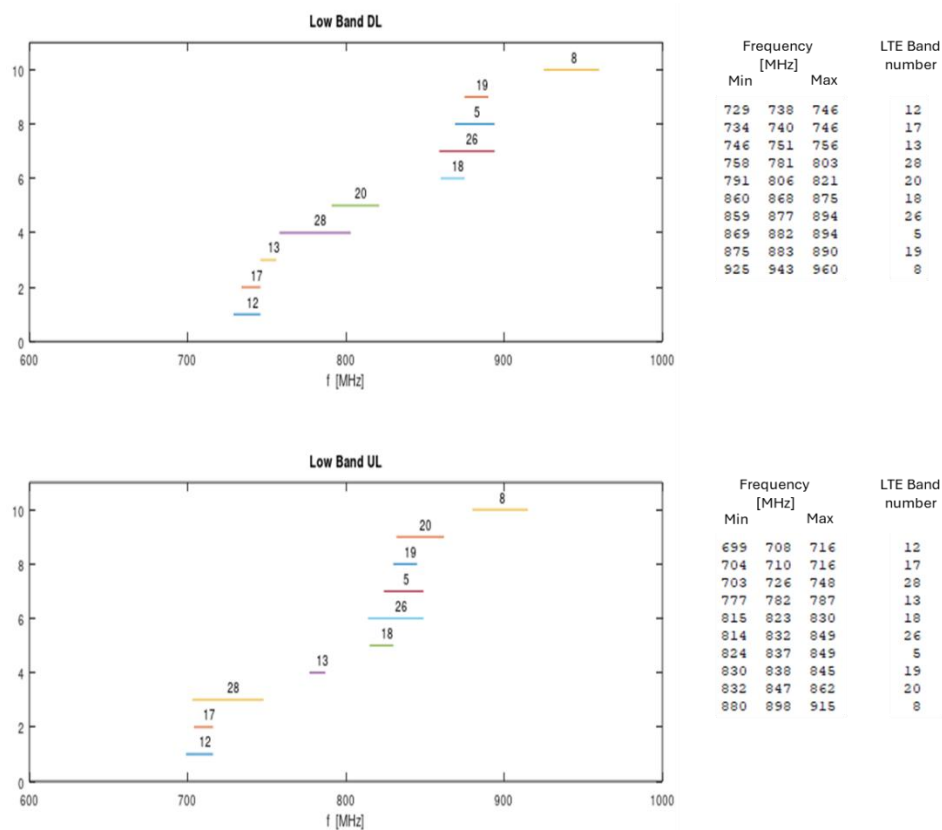


Figure 5-1 Downlink and Uplink frequencies for Low frequency LTE bands.

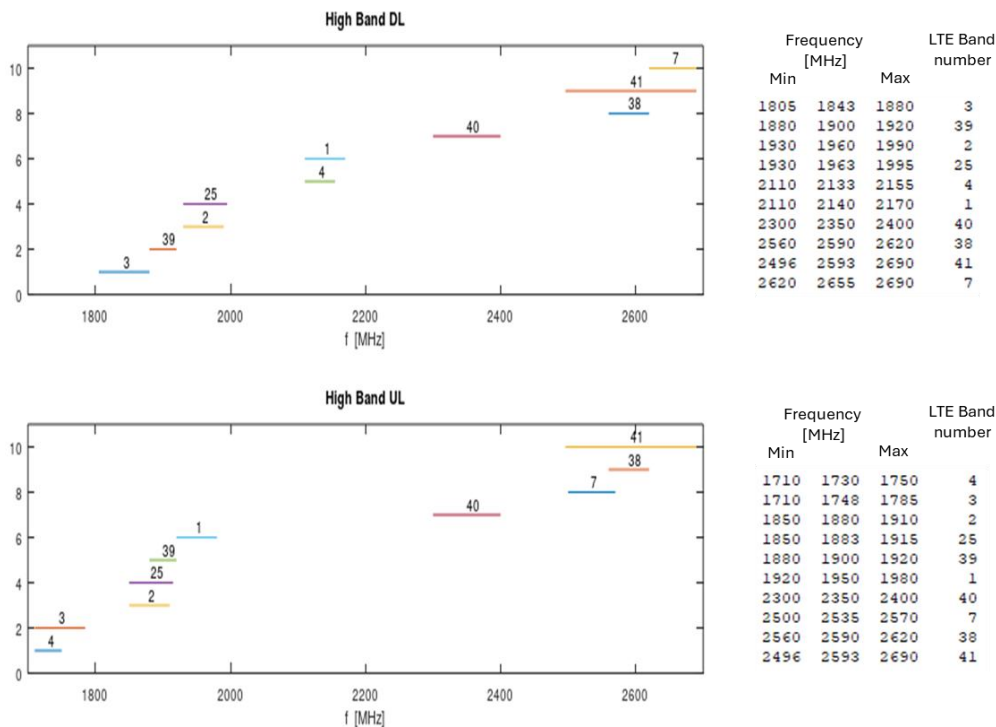


Figure 5-2 Downlink and Uplink frequencies for High frequency LTE bands.

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

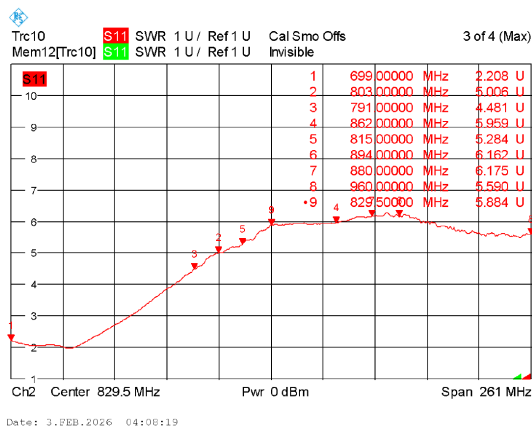


Figure 5-3 Flir-i1845 cellular main antenna LTE bands 12, 13, 28 (marker 1-2).



LTE band: 20

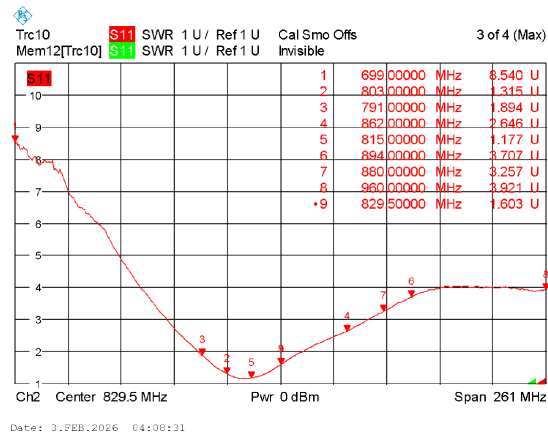


Figure 5-4 Flir-i1845 cellular main antenna LTE band 20 (marker 3-4).

LTE bands: 5,18,19,26

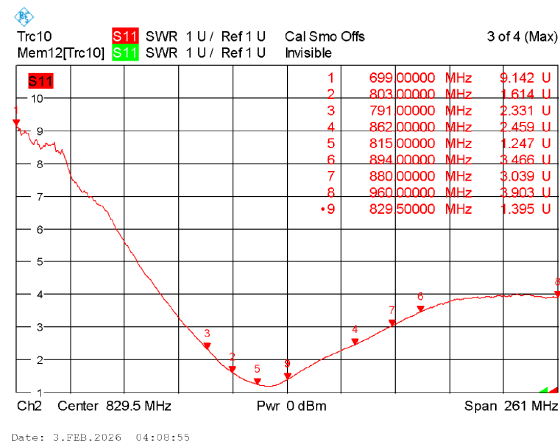
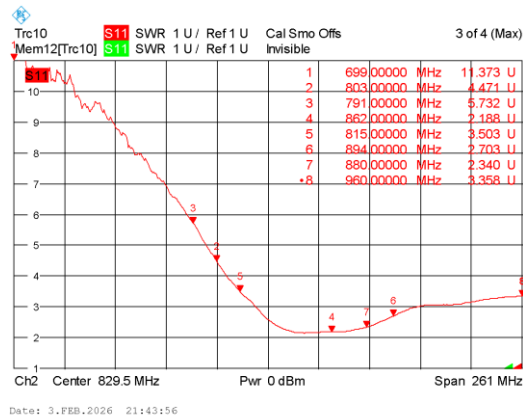


Figure 5-5 Flir-i1845 cellular main antenna LTE bands 5,18,19,26 (marker 5-6).

LTE bands: 8



ö-

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

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

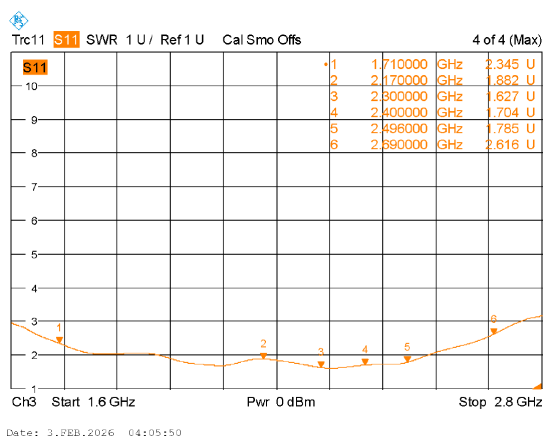


Figure 5-7 Flir-i1845 cellular main antenna LTE bands 1,2,3,4,25,39,40 (marker 1-4).

LTE bands: 7,38,41

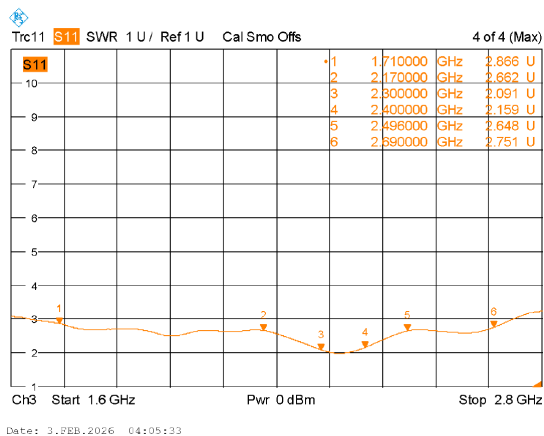


Figure 5-8 Flir-i1845 cellular main antenna LTE bands 7,38,41 (marker 5-6).

5.1.2 Cellular Diversity antenna

LTE bands: 12, 13, 28

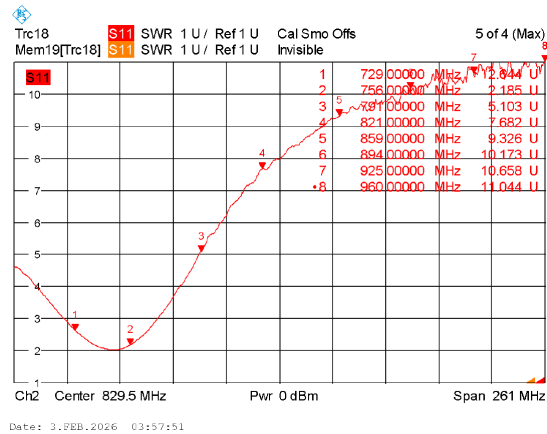


Figure 5-9 Flir-i1845 cellular diversity antenna LTE bands 12, 13, 28 (marker 1-2).

LTE band: 20

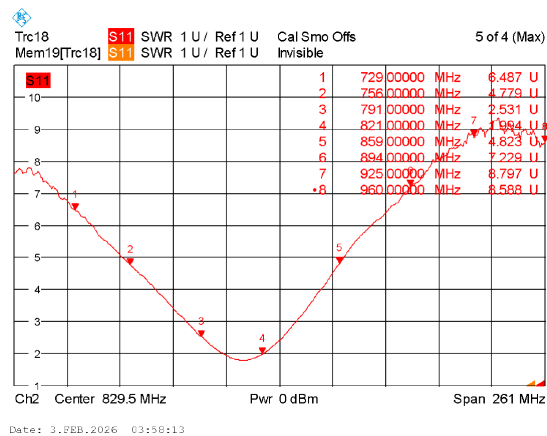


Figure 5-10 Flir-i1845 cellular diversity antenna LTE band 20 (marker 3-4).

LTE bands: 5,18,19,26

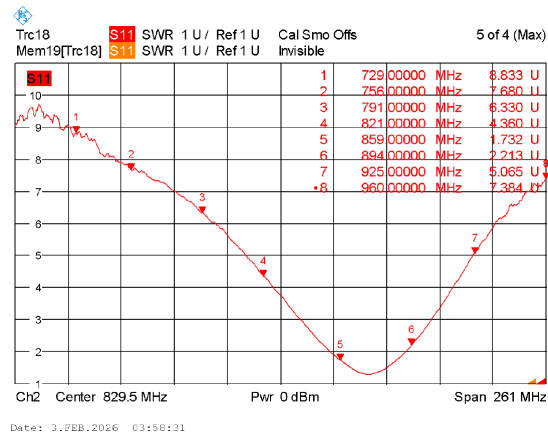


Figure 5-11 Flir-i1845 cellular diversity antenna LTE bands 5,18,19,26 (marker 5-6).

LTE bands: 8

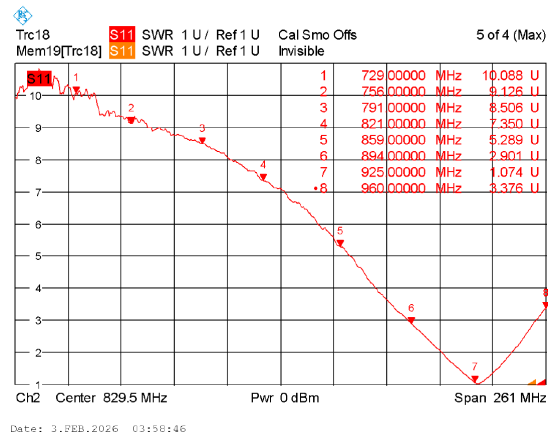


Figure 5-12 Flir-i1845 cellular diversity antenna LTE band 8 (marker 7-8).

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

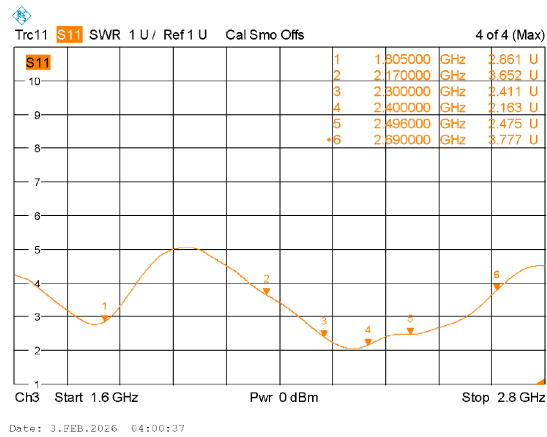


Figure 5-13 Flir-i1845 cellular diversity antenna LTE bands 1,2,3,4,25,39,40 (marker 1-4).

LTE bands: 7,38,41

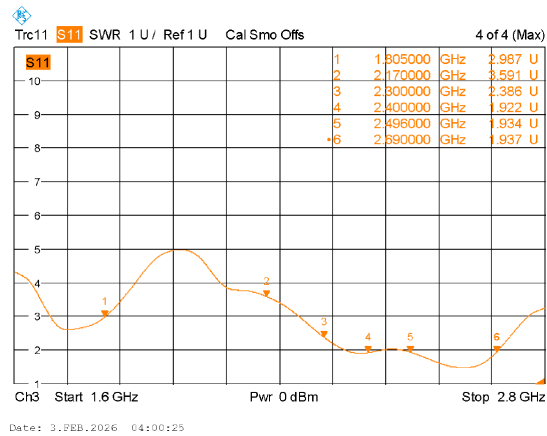


Figure 5-14 Flir-i1845 cellular diversity antenna LTE bands 7,38,41 (marker 5-6).

5.1.3 Wi-Fi antenna

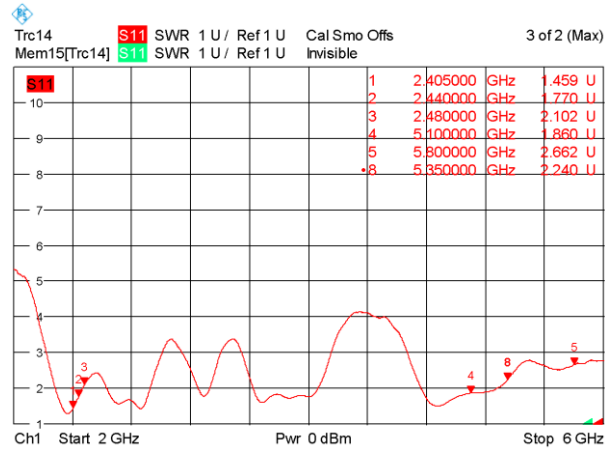


Figure 5-15 Flir-i1845 Wi-Fi antenna

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

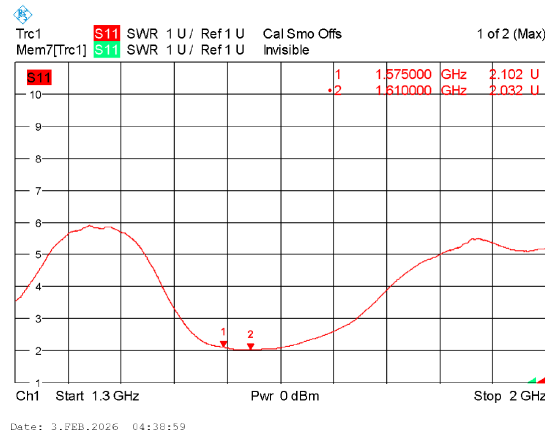


Figure 5-16 Flir-i1845 GNSS antenna. LTE band settings: 12, 13, 28

LTE bands setting: 20

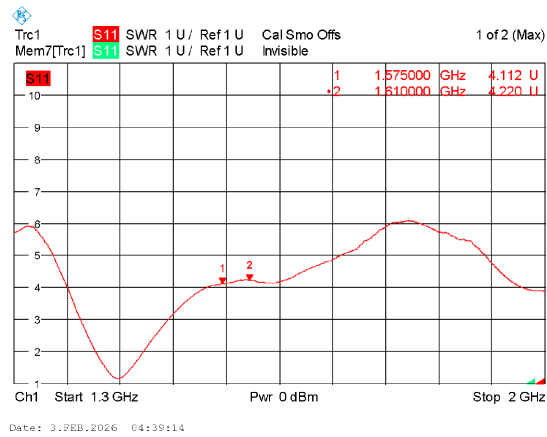


Figure 5-17 Flir-i1845 GNSS antenna. LTE band settings: 20

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

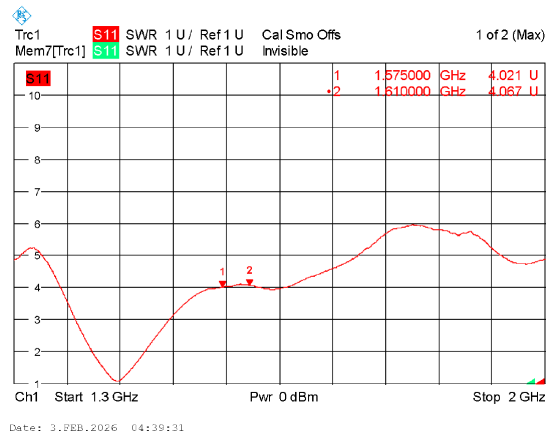


Figure 5-18 Flir-i1845 GNSS antenna. LTE band settings: 5,7,18,19,26,38,41

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

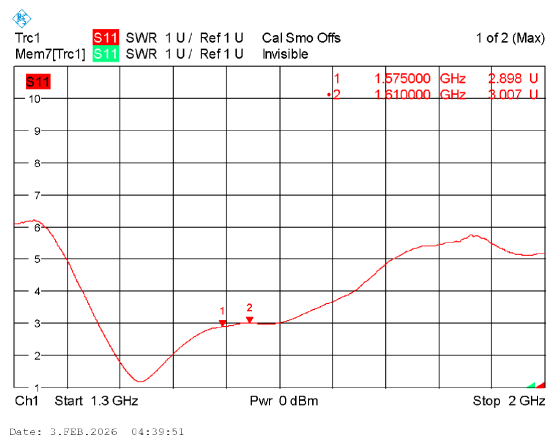


Figure 5-19 Flir-i1845 GNSS antenna. LTE band settings: 1,2,3,4,8,25,39,40

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

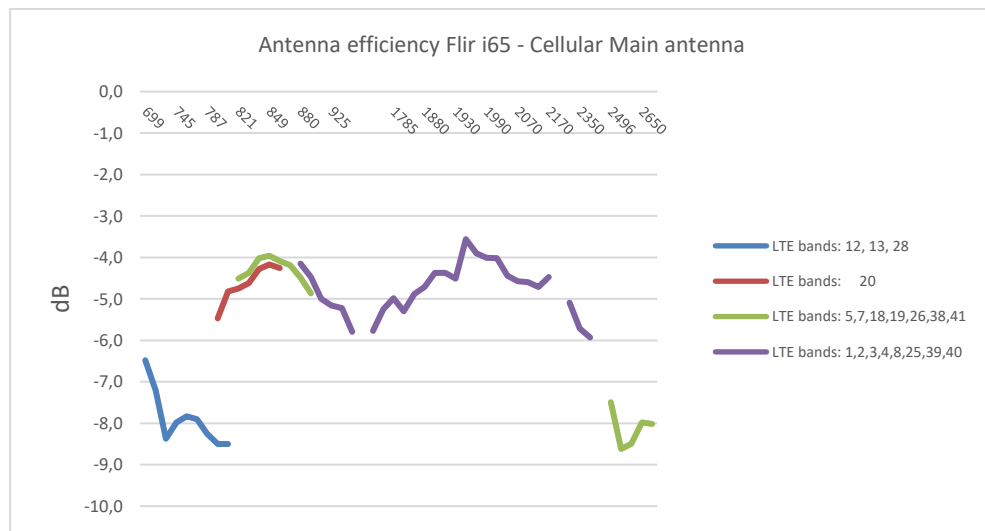


Figure 5-20 Antenna efficiency Flir-i1845; Cellular main antenna.



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

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

5.2.2 Cellular Diversity antenna

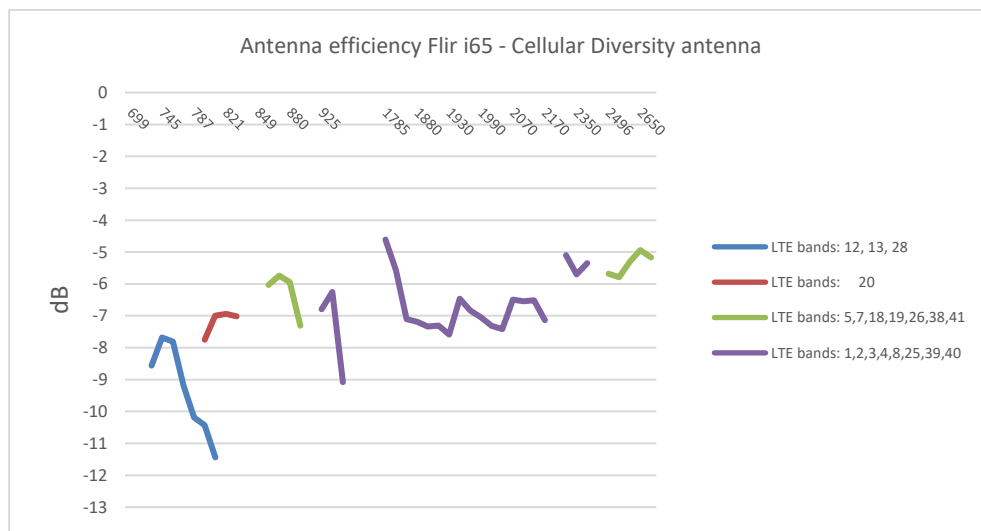


Figure 5-21 Antenna efficiency Flir-i1845; Cellular diversity antenna.



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

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 efficiency [dB]
699					
715					
729	-8,6				
745	-7,7				
756	-7,8				
775	-9,2				
787	-10,2				
791	-10,4	-7,8			
803	-11,4	-7,0			
821		-6,9			
824		-7,0			
835					
849					
859			-6,0		
869			-5,7		
880			-5,9		
894			-7,3		
915					
925				-6,8	
940				-6,3	
960				-9,1	
1710					
1745					
1785				-4,6	
1805				-5,6	
1850				-7,1	
1880				-7,2	
1910				-7,3	
1920				-7,3	
1930				-7,6	
1950				-6,5	
1980				-6,8	
1990				-7,1	
1995				-7,3	
2040				-7,4	
2070				-6,5	
2110				-6,5	
2140				-6,5	
2170				-7,1	
2300				-5,1	
2350				-5,7	
2400				-5,4	
2496			-5,7		
2550			-5,8		
2600			-5,3		
2650			-4,9		
2690			-5,2		

5.2.3 Wi-Fi antenna

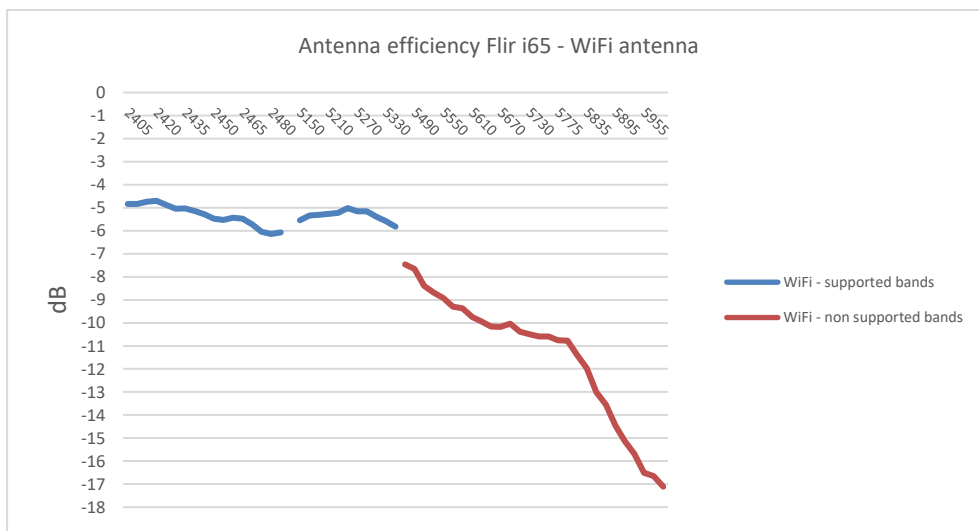


Figure 5-22 Antenna efficiency Flir-i1845; Wi-Fi antenna.



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

Frequency [MHz]	Antenna efficiency [dB]
2405	-4,8
2410	-4,8
2415	-4,7
2420	-4,7
2425	-4,9
2430	-5,1
2435	-5,0
2440	-5,1
2445	-5,3
2450	-5,5
2455	-5,5
2460	-5,4
2465	-5,5
2470	-5,7
2475	-6,1
2480	-6,1
2482	-6,1
5150	-5,6
5170	-5,3
5190	-5,3
5210	-5,3
5230	-5,2
5250	-5,0
5270	-5,2
5290	-5,2
5310	-5,4
5330	-5,6
5350	-5,8
5470	-7,5
5490	-7,7
5510	-8,4
5530	-8,7
5550	-8,9
5570	-9,3
5590	-9,4
5610	-9,7
5630	-9,9
5650	-10,2
5670	-10,2
5690	-10,0
5710	-10,4
5730	-10,5
5735	-10,6
5755	-10,6
5775	-10,8
5795	-10,8
5815	-11,4
5835	-12,0
5855	-13,0
5875	-13,6
5895	-14,5
5915	-15,1
5935	-15,7
5955	-16,5
5975	-16,7
5985	-17,1

5.2.4 GNSS antenna

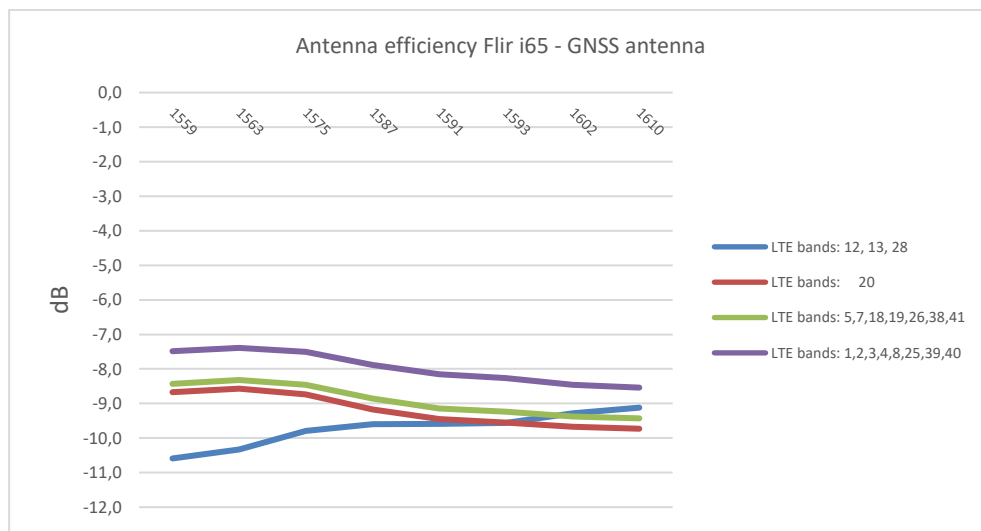


Figure 5-23 Antenna efficiency Flir-i1845; GNSS antenna.

Table 5 Antenna efficiency Flir-i1845; GNSS 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 efficiency [dB]			
1559	-10,6	-8,7	-8,4	-7,5
1563	-10,3	-8,6	-8,3	-7,4
1575	-9,8	-8,7	-8,5	-7,5
1587	-9,6	-9,2	-8,9	-7,9
1591	-9,6	-9,5	-9,1	-8,2
1593	-9,6	-9,6	-9,2	-8,3
1602	-9,3	-9,7	-9,4	-8,5
1610	-9,1	-9,7	-9,4	-8,5

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.

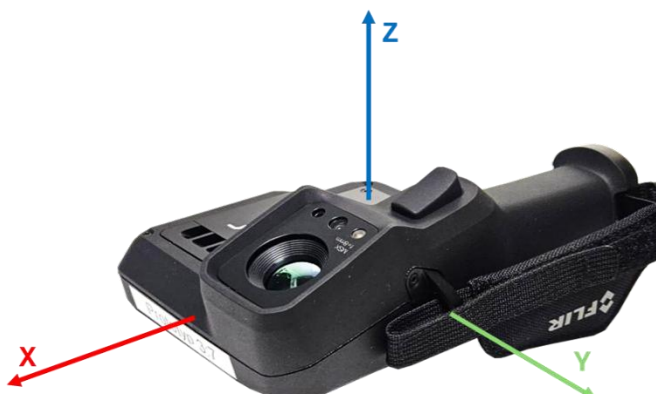


Figure 5-24 Measurement plane definition.



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

5.3.1 Cellular main antenna

LTE bands: 12, 13, 28

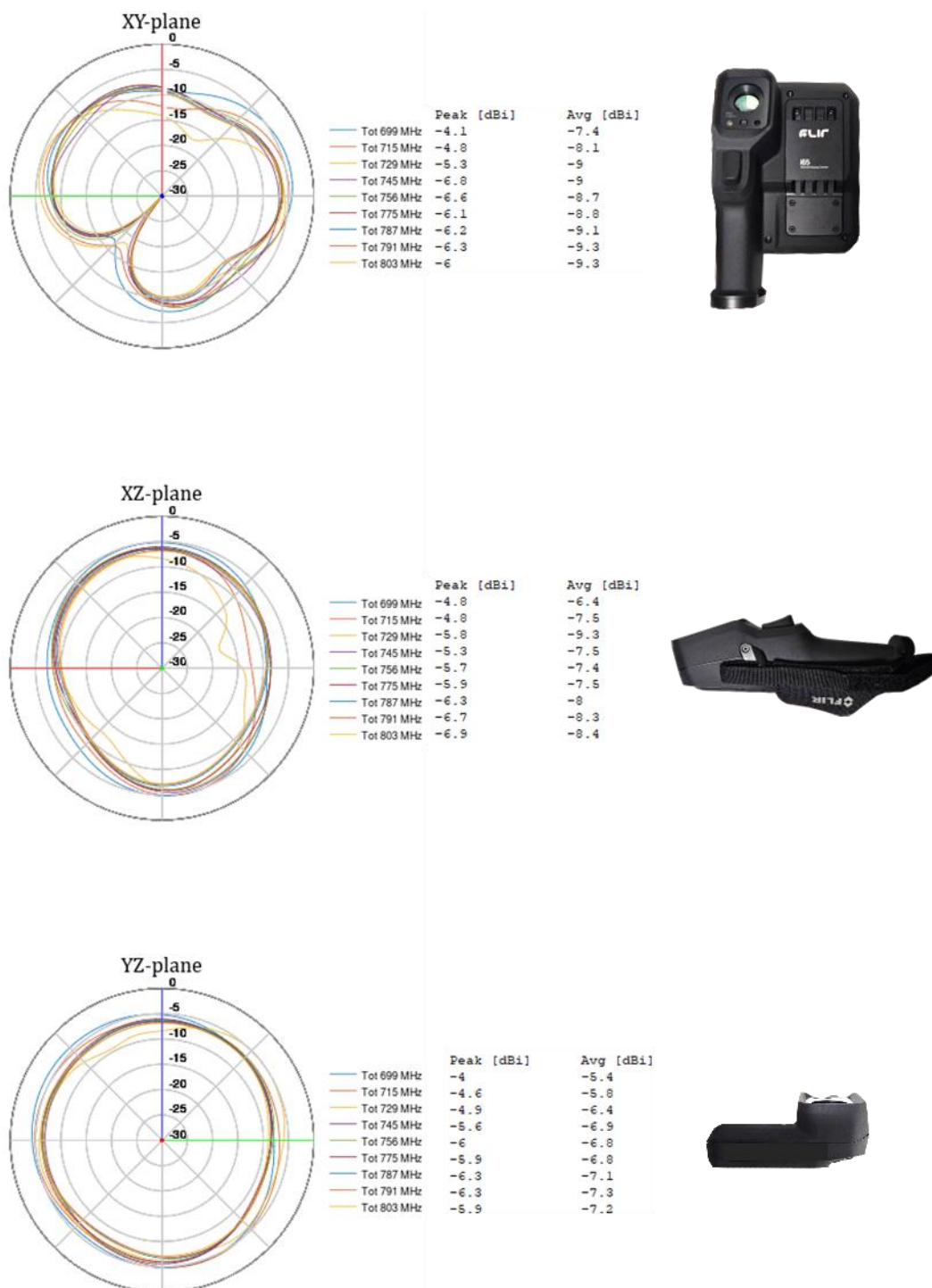


Figure 5-26 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 12, 13, 28

LTE band: 20

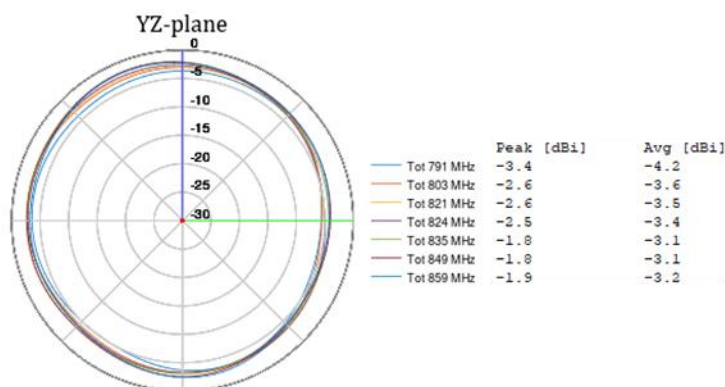
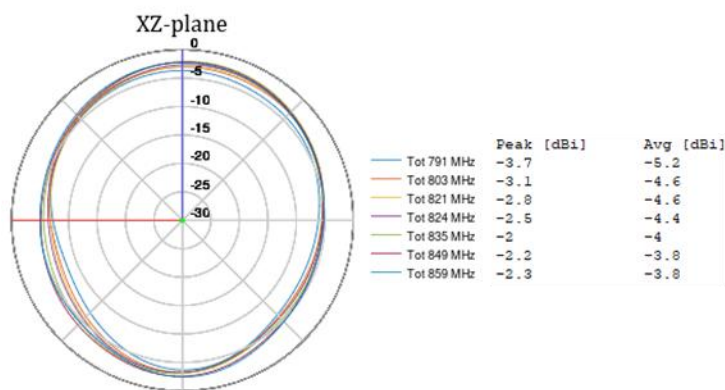
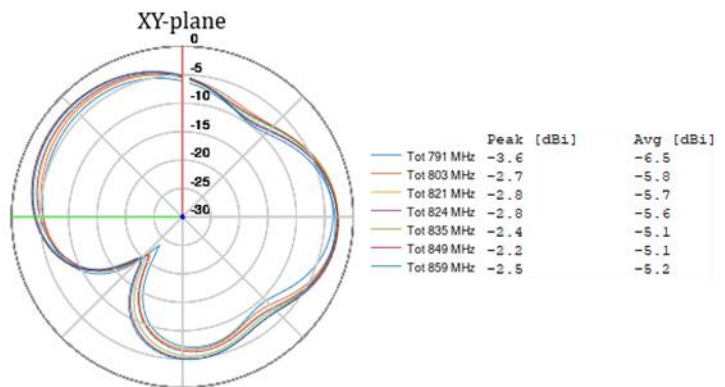


Figure 5-27 2D radiation patterns Flir-i1845; Cellular main antenna LTE band 20

LTE bands: 5,18,19,26

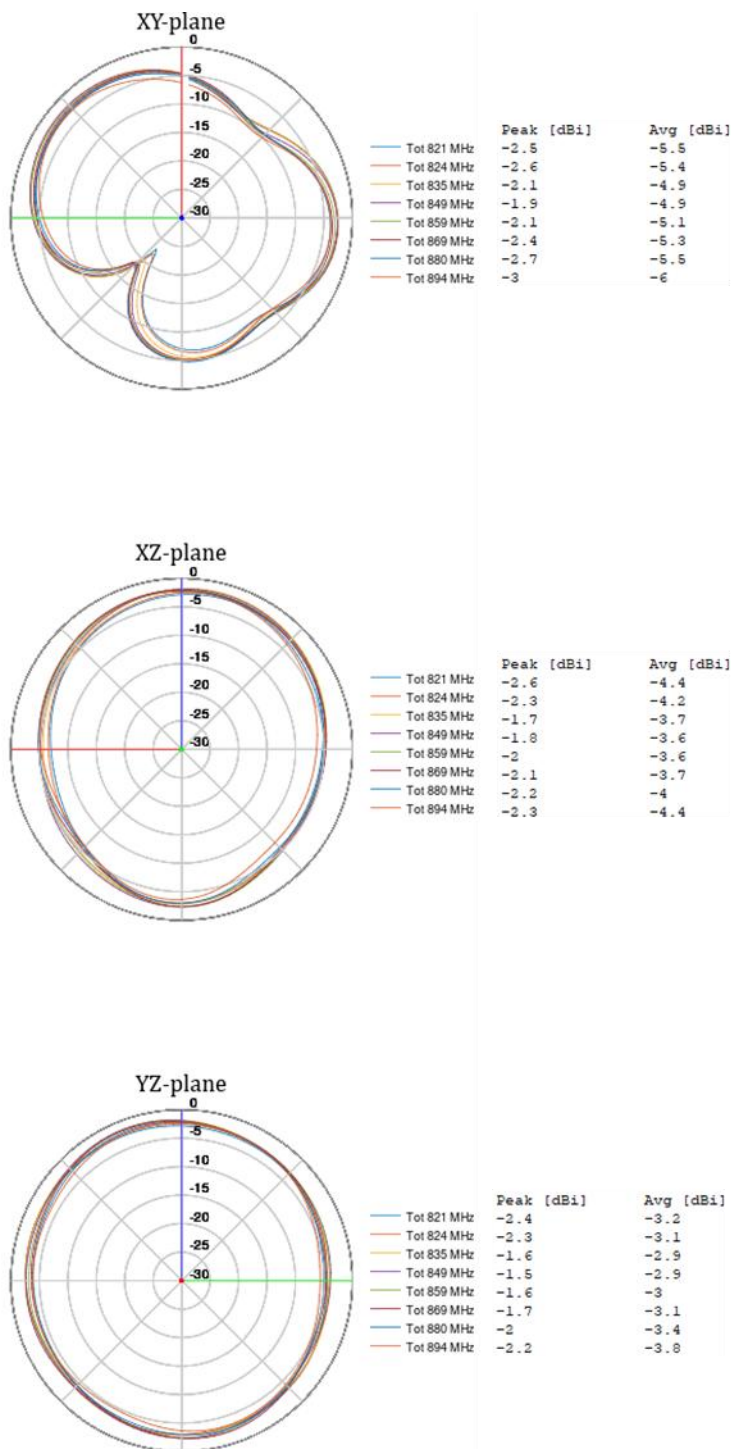


Figure 5-28 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 5,18,19,26

LTE bands: 8

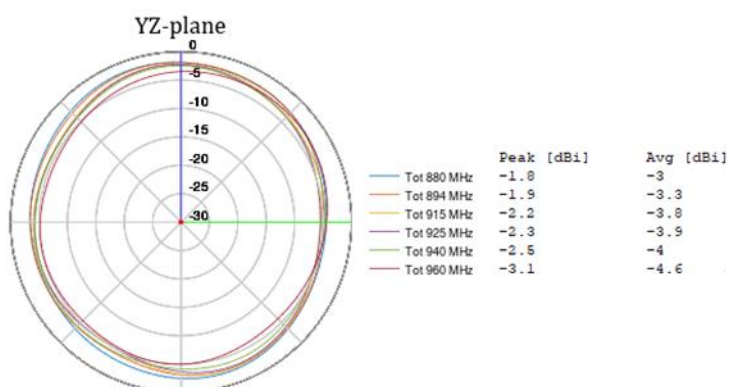
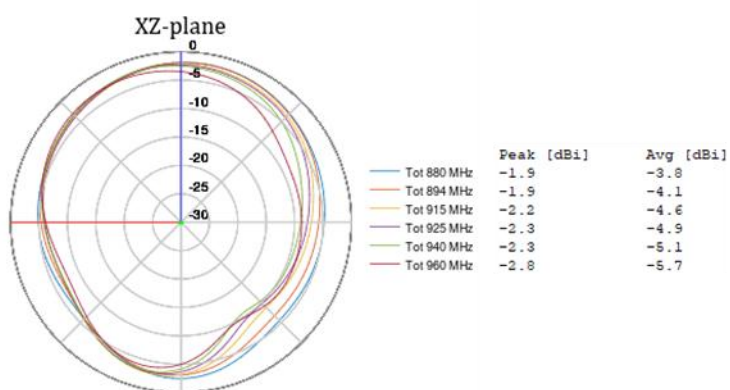
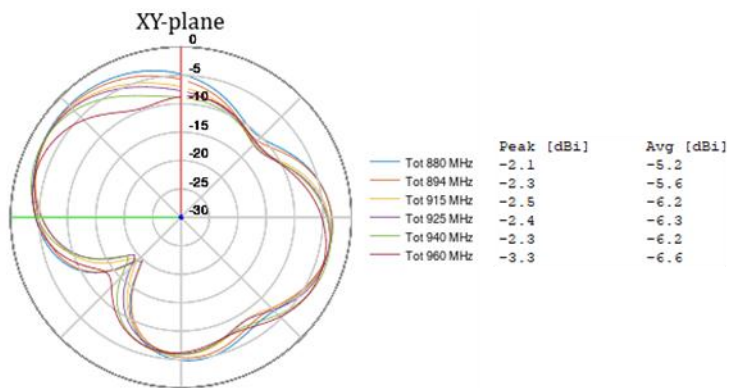


Figure 5-29 2D radiation patterns Flir-i1845; Cellular main antenna LTE band 8

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

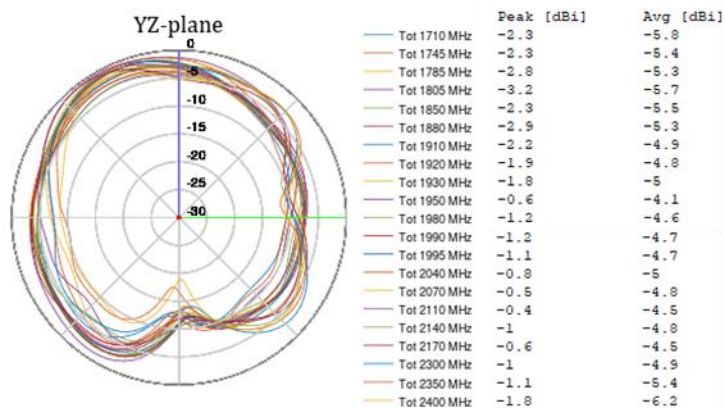
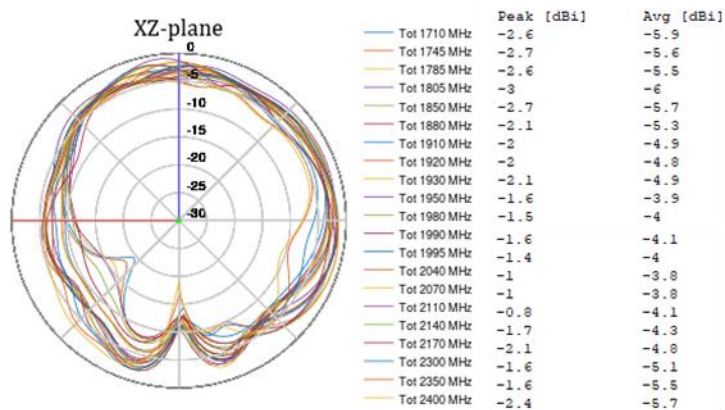
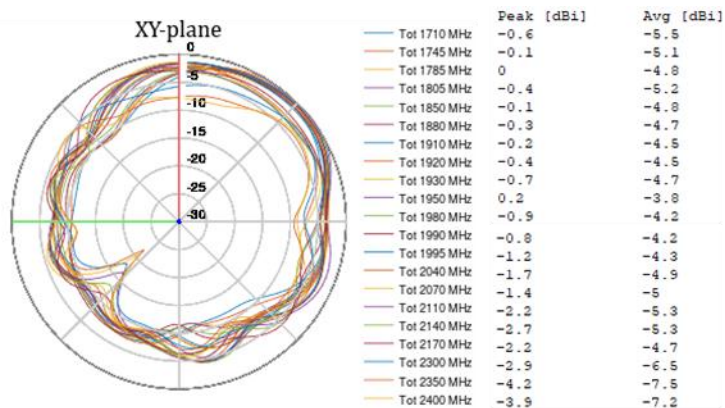


Figure 5-30 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 1,2,3,4,25,39,40

LTE bands: 7,38,41

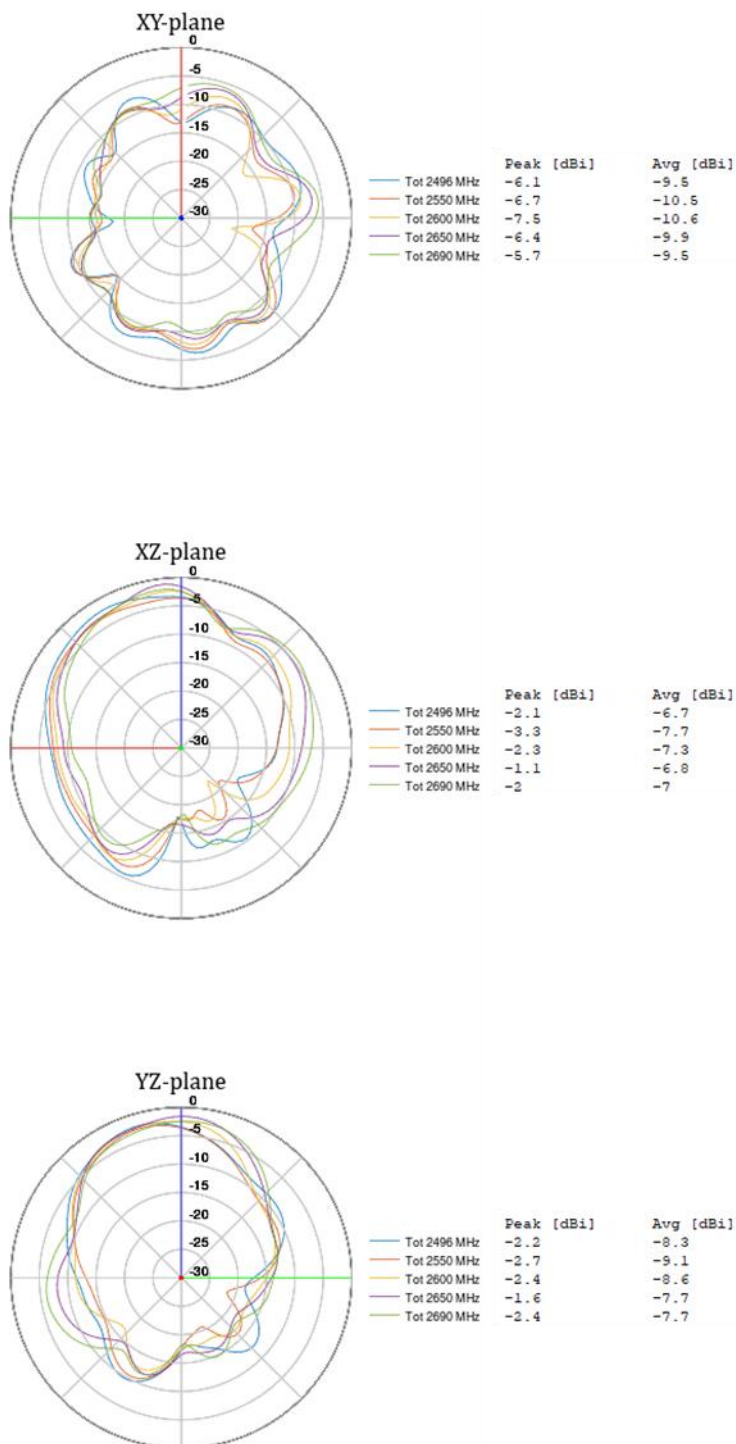


Figure 5-31 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 7,38,41

5.3.2 Cellular diversity antenna

LTE bands: 12, 13, 28

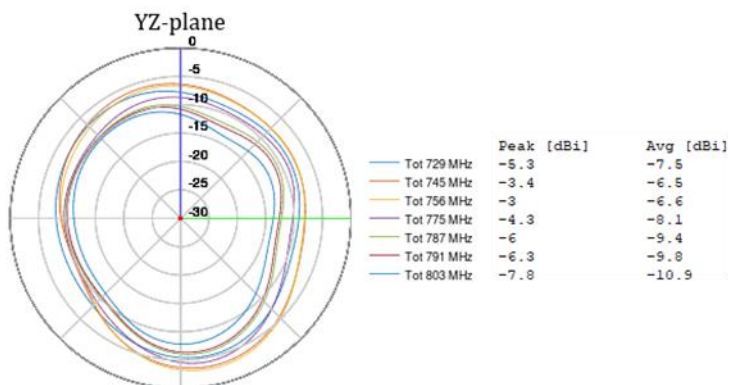
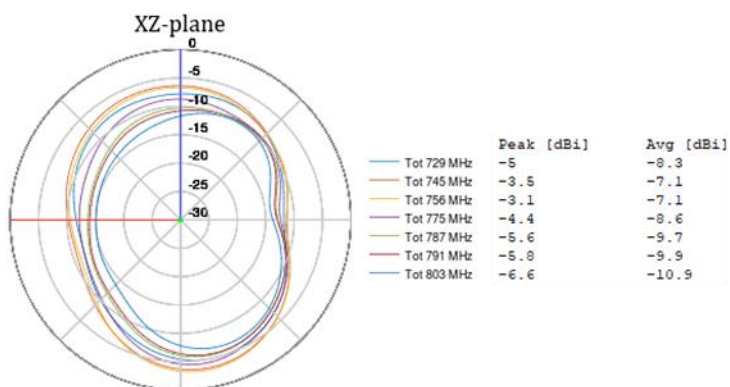
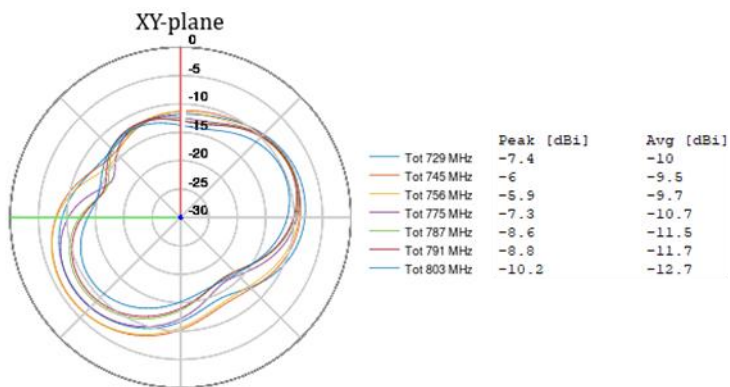


Figure 5-32 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 12, 13, 28

LTE band: 20

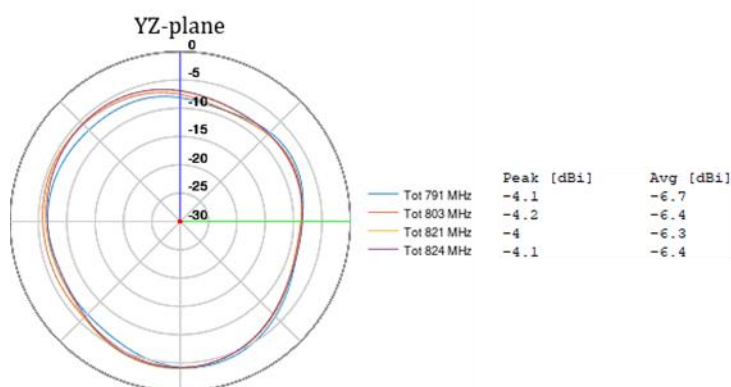
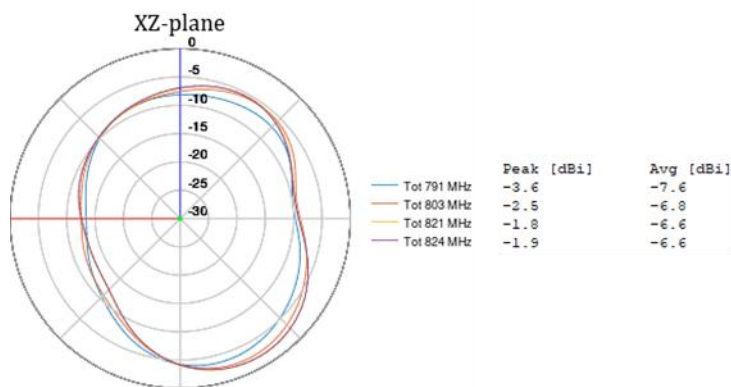
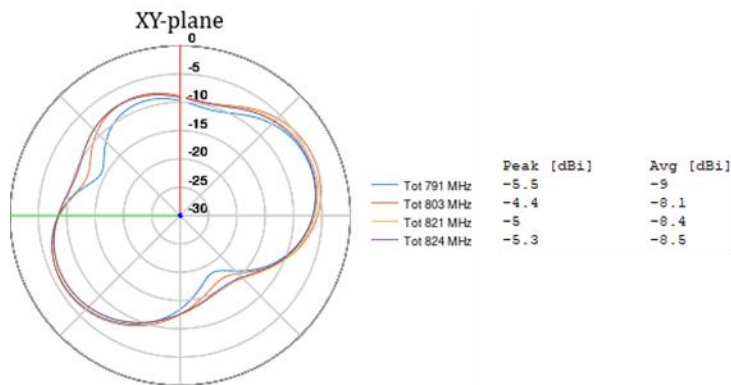


Figure 5-33 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE band 20

LTE bands: 5,18,19,26

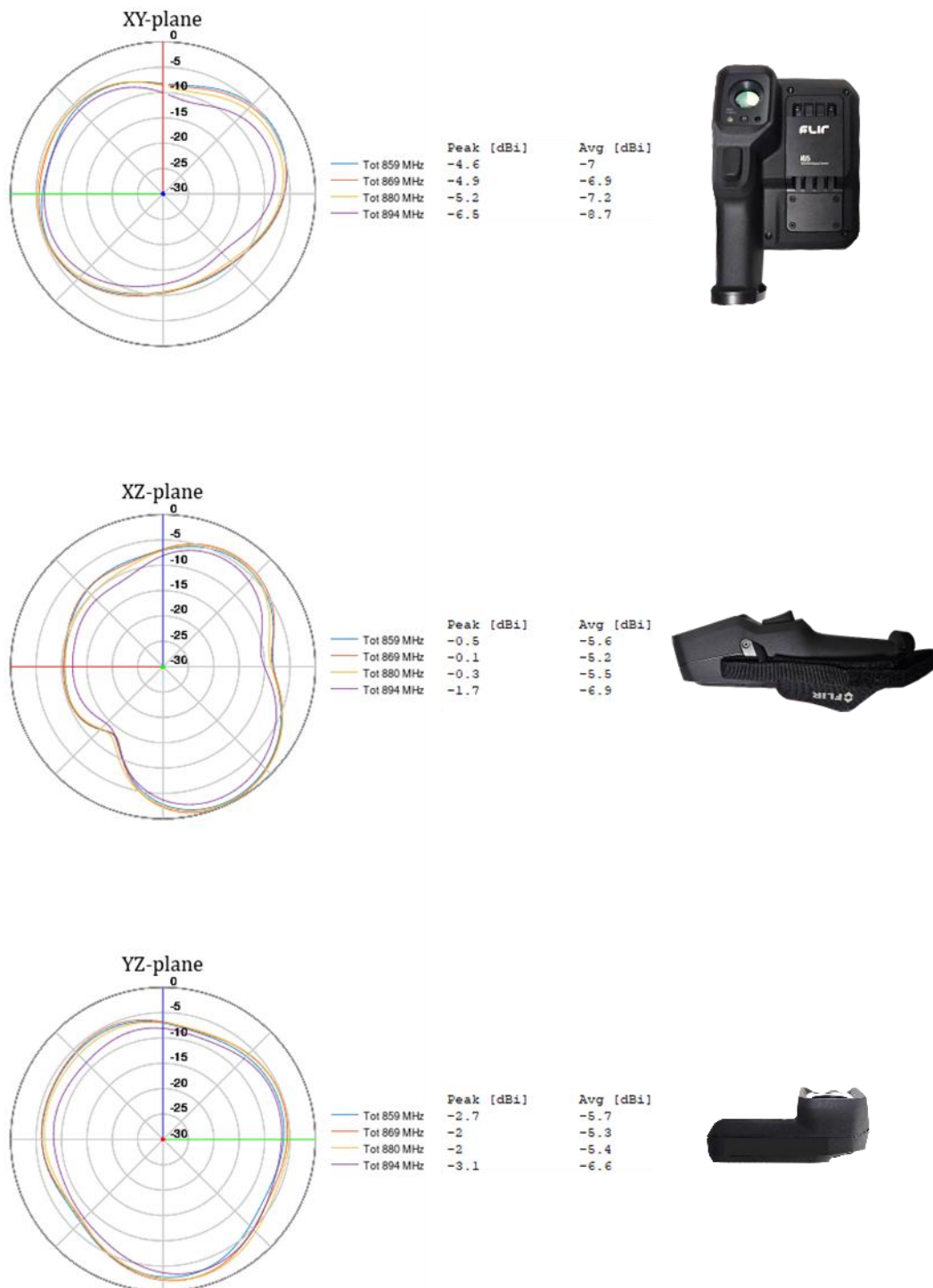


Figure 5-34 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 5,18,19,26

LTE bands: 8

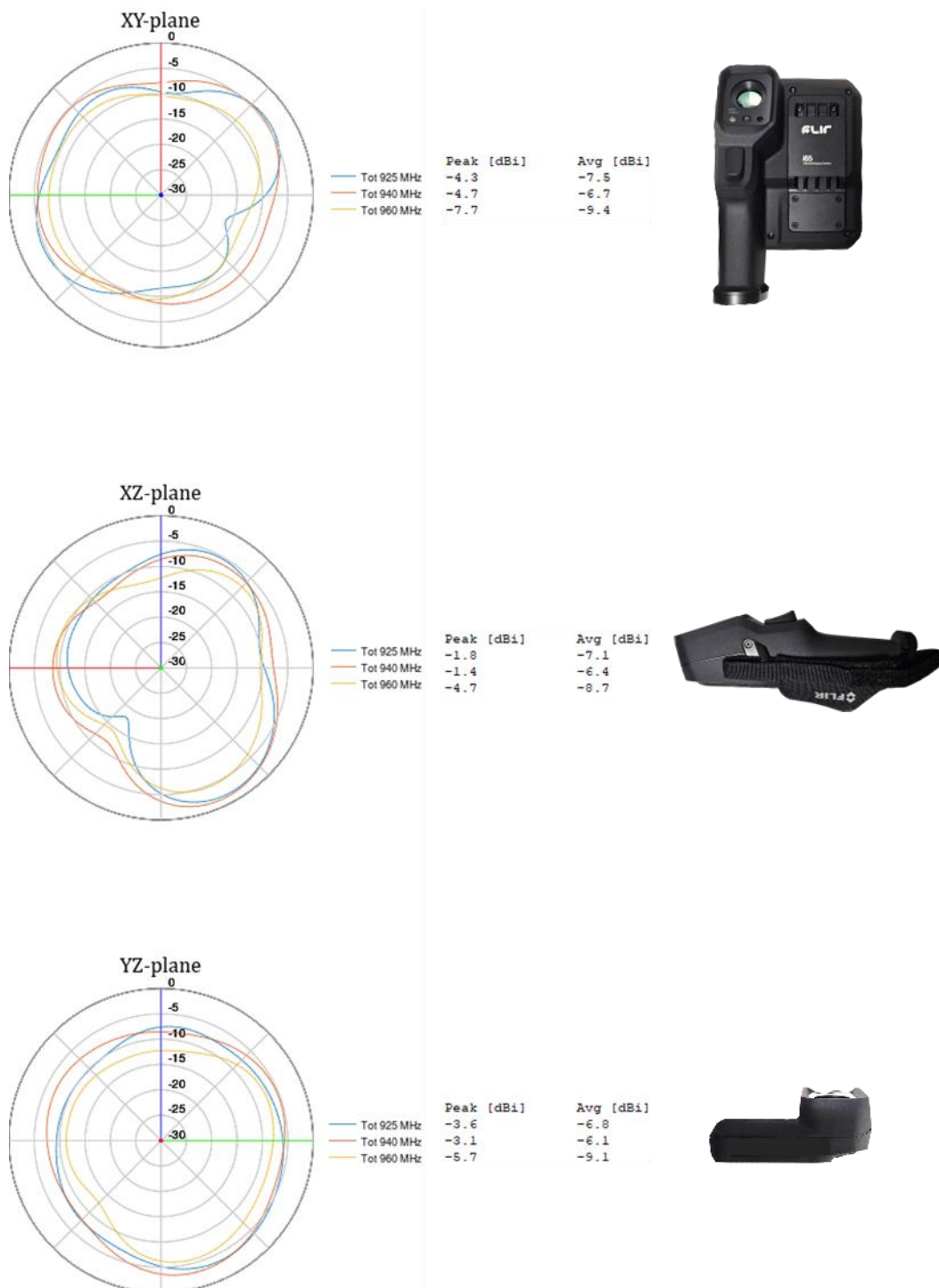


Figure 5-35 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE band 8

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

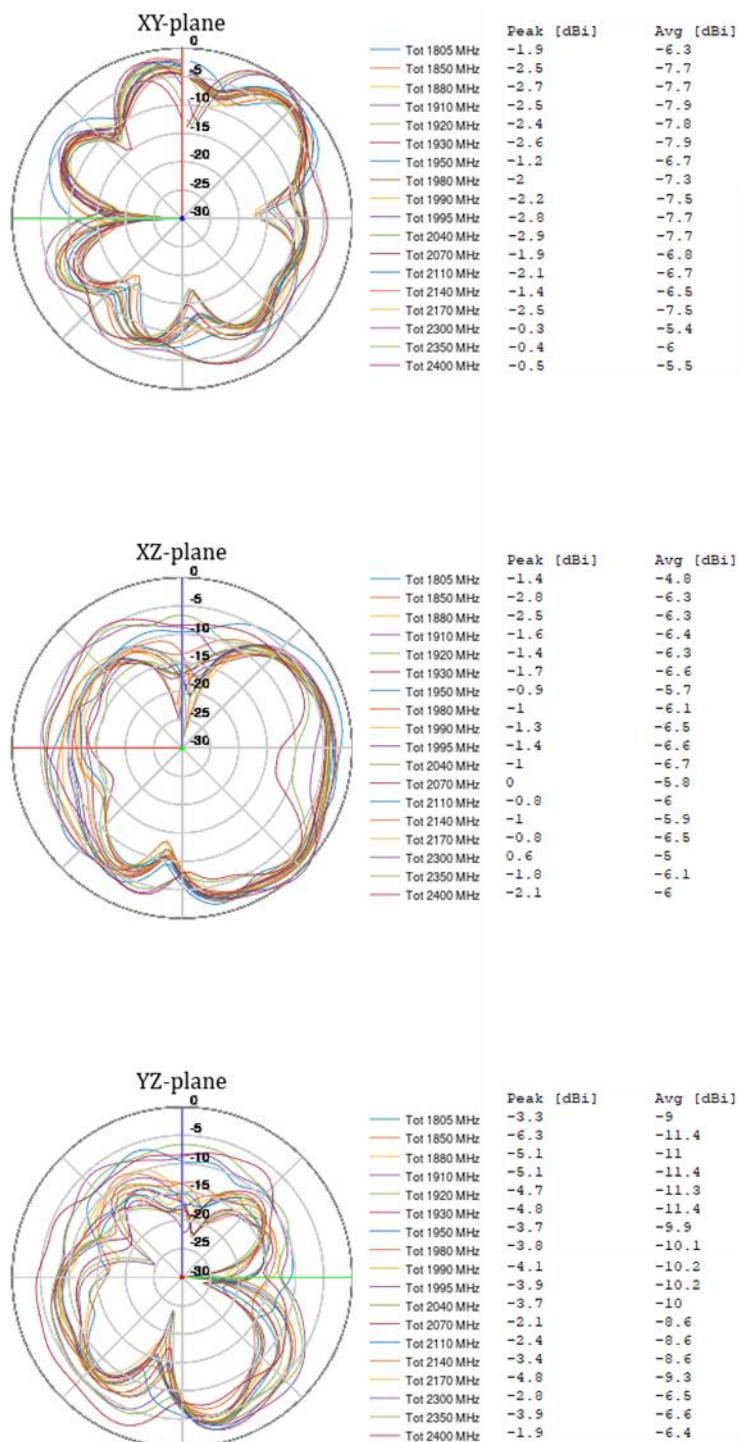


Figure 5-36 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 1,2,3,4,25,39,40

LTE bands: 7,38,41

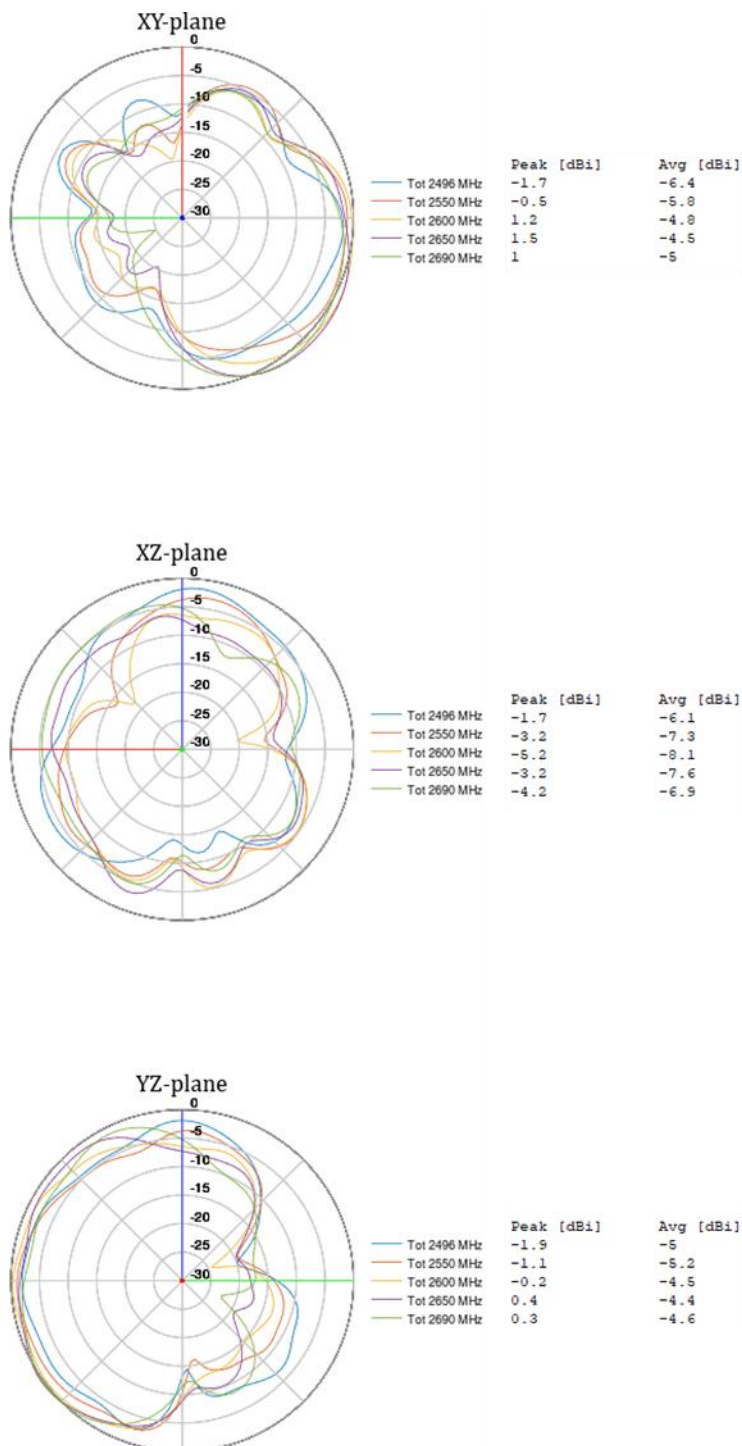


Figure 5-37 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 7,38,41

5.3.3 Wi-Fi antenna

2.4GHz band

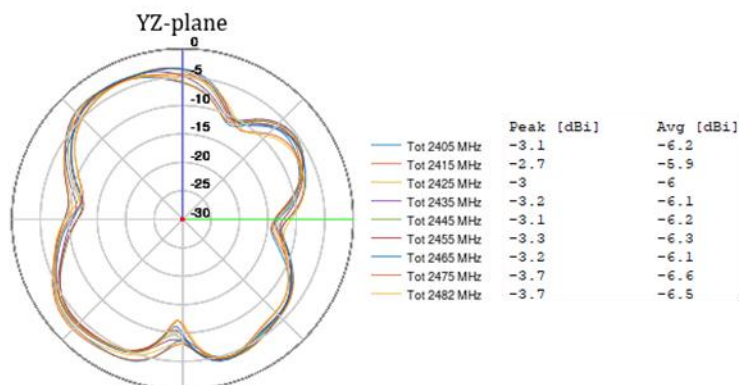
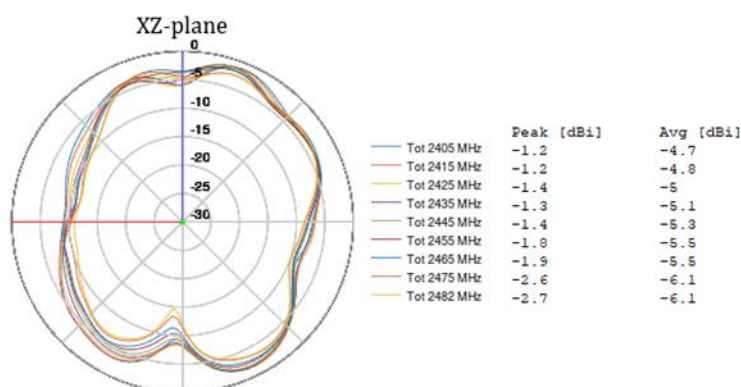
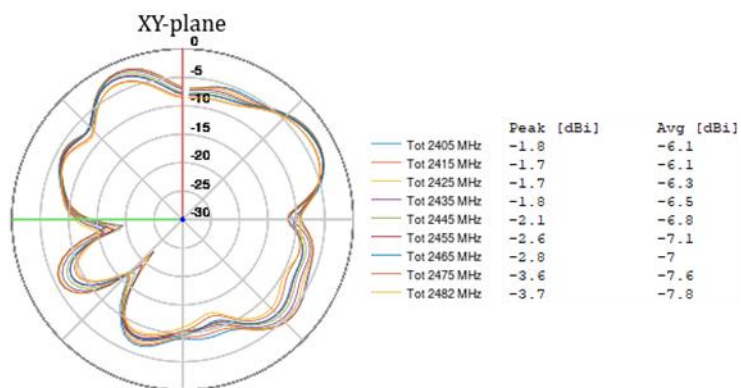


Figure 5-38 2D radiation patterns Flir-i1845; Wi-Fi antenna 2.4GHz band

5GHz band

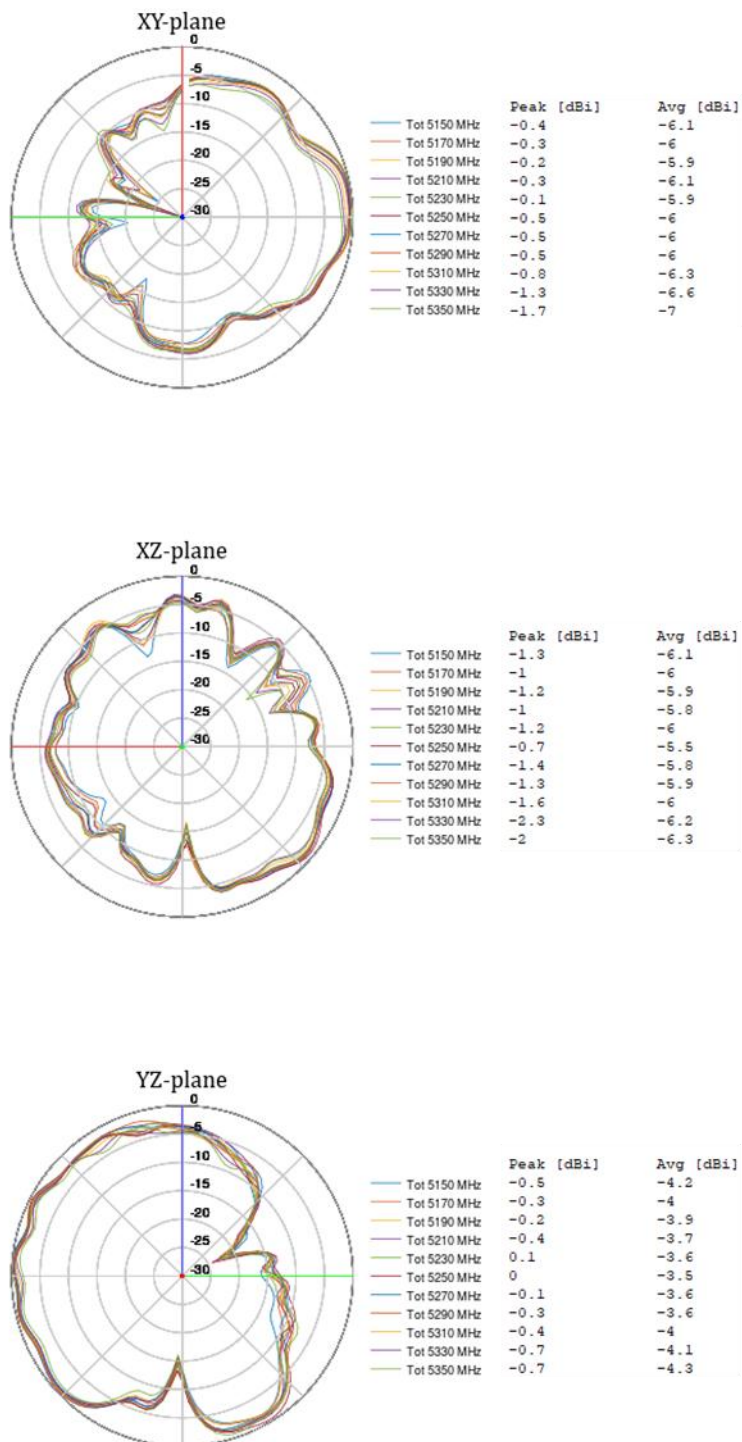


Figure 5-39 2D radiation patterns Flir-i1845; Wi-Fi antenna 5GHz band

5.3.4 GNSS antenna

LTE bands setting 12, 13, 28

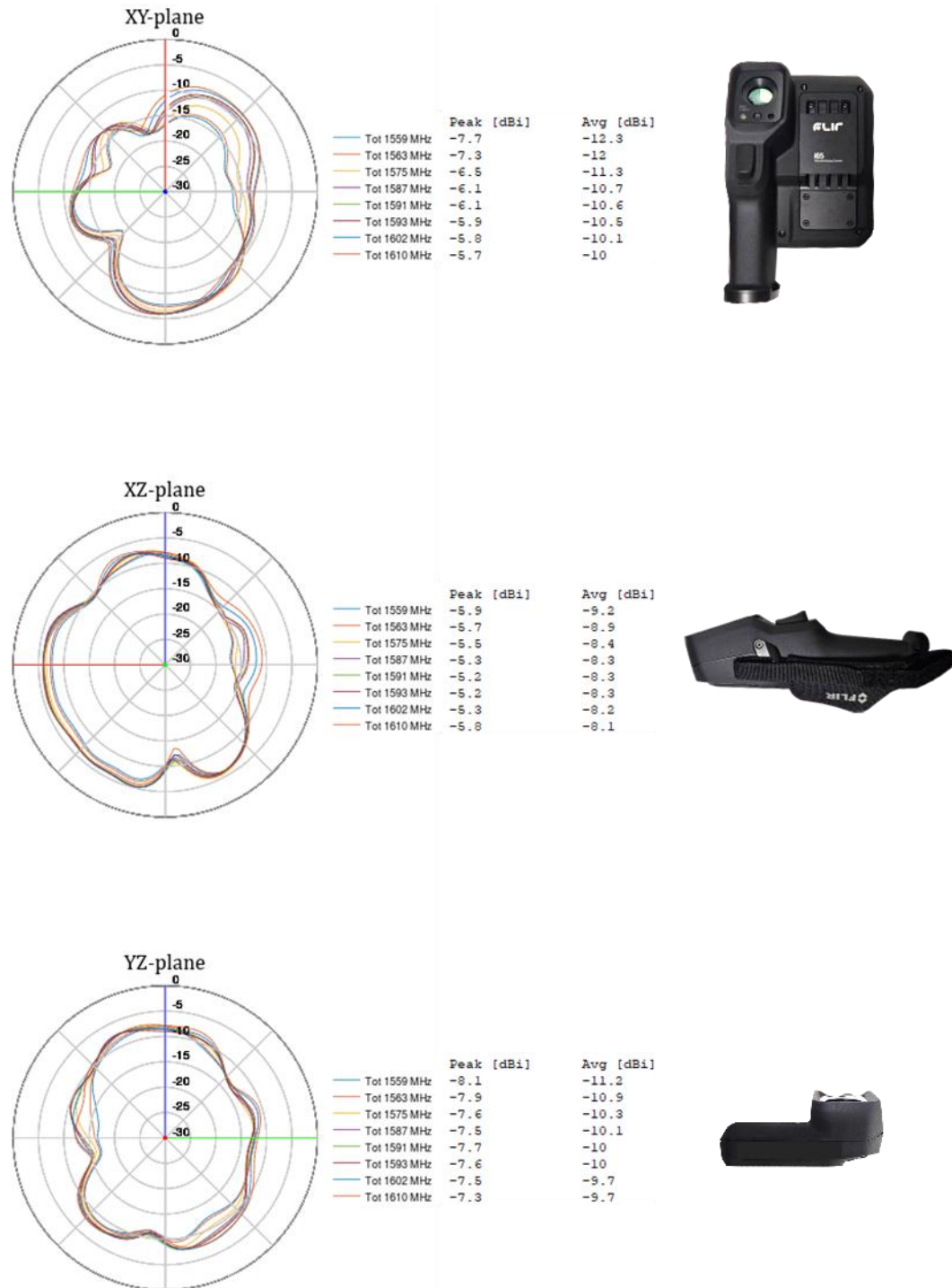


Figure 5-40 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 12, 13, 28

LTE bands setting 20

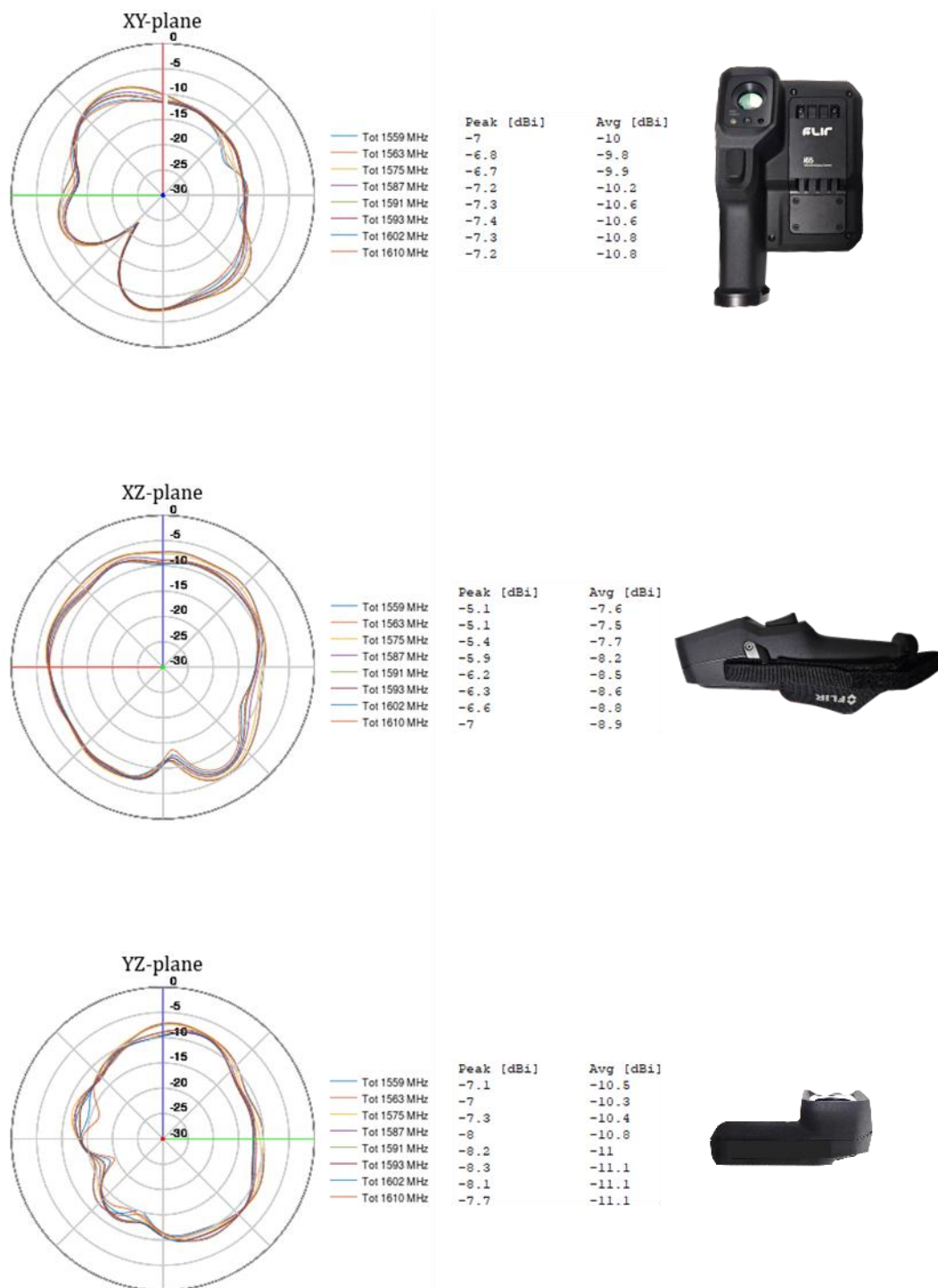


Figure 5-41 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 20

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

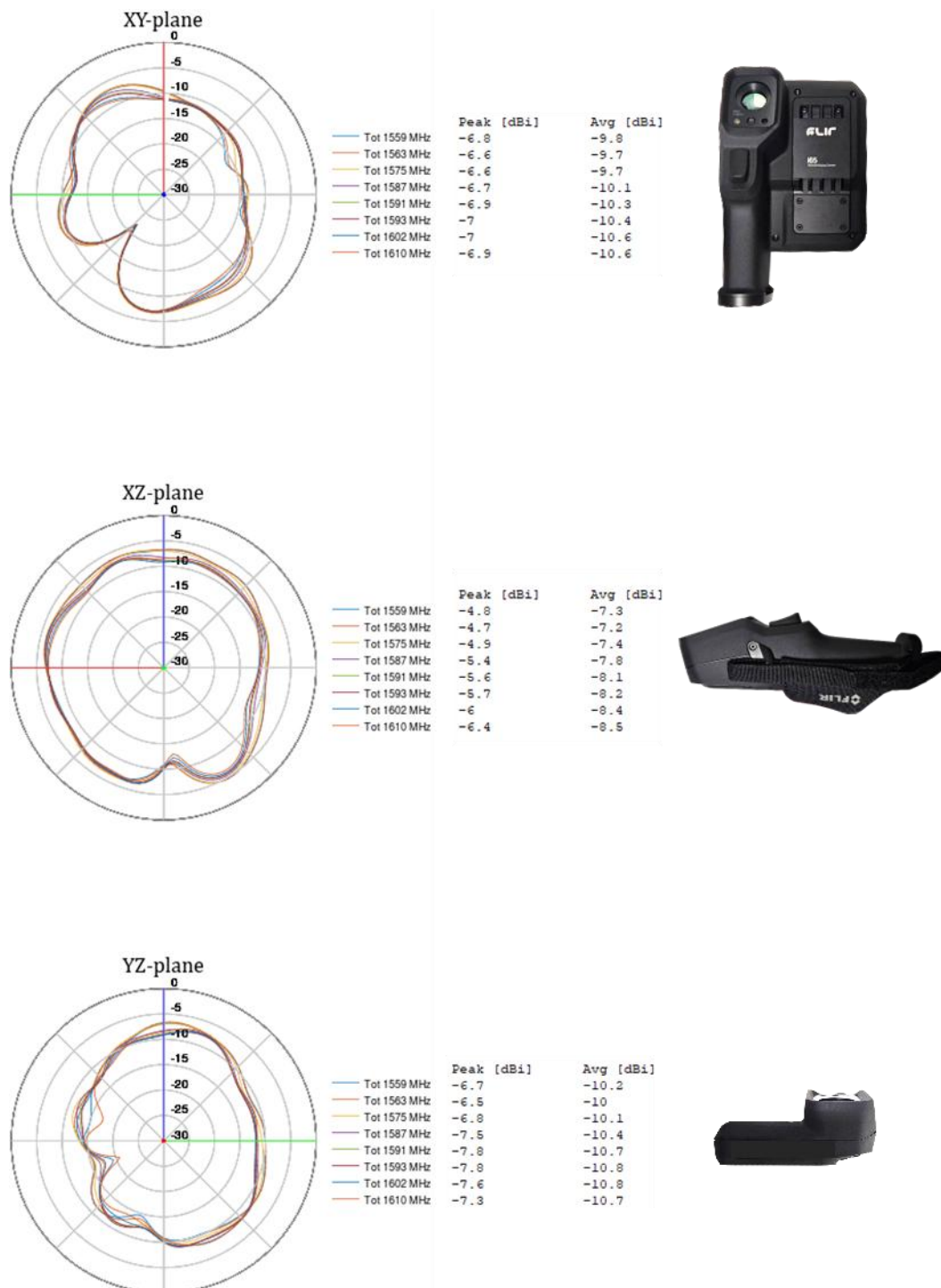


Figure 5-42 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 5,18,19,26, 7, 38, 41

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

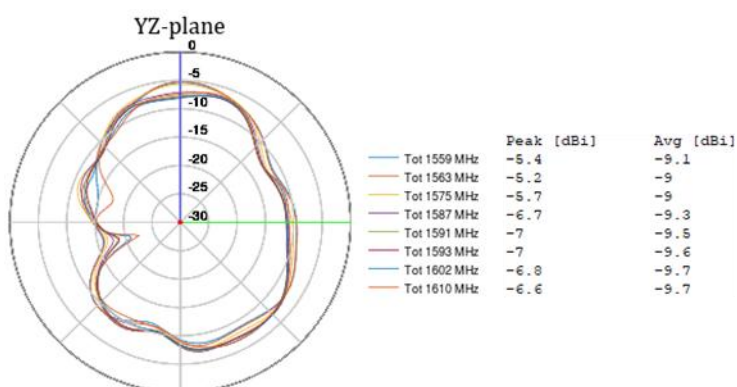
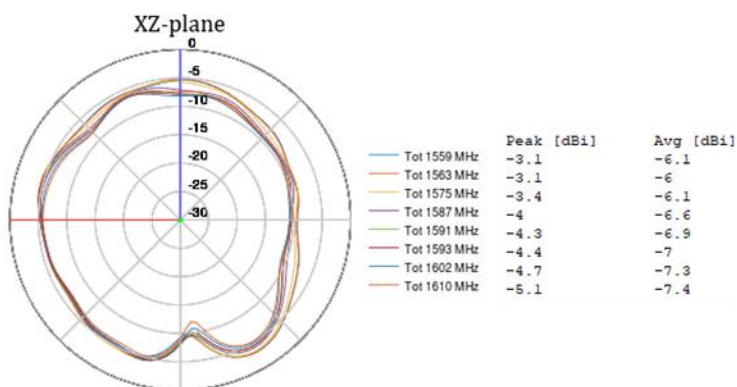
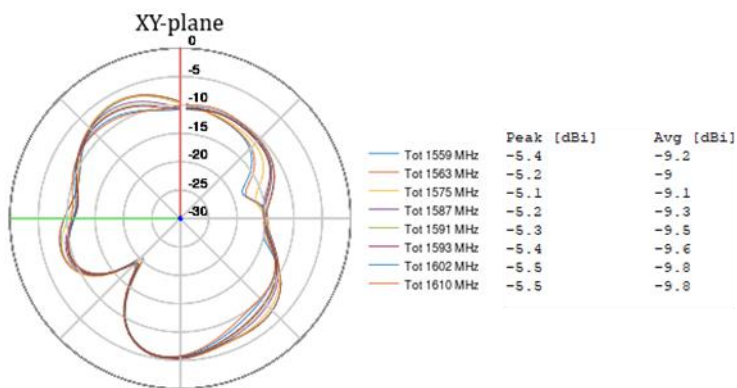


Figure 5-43 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 1,2,3,4,8,25,39,40

5.4 Antenna peak gain

5.4.1 Cellular Main antenna

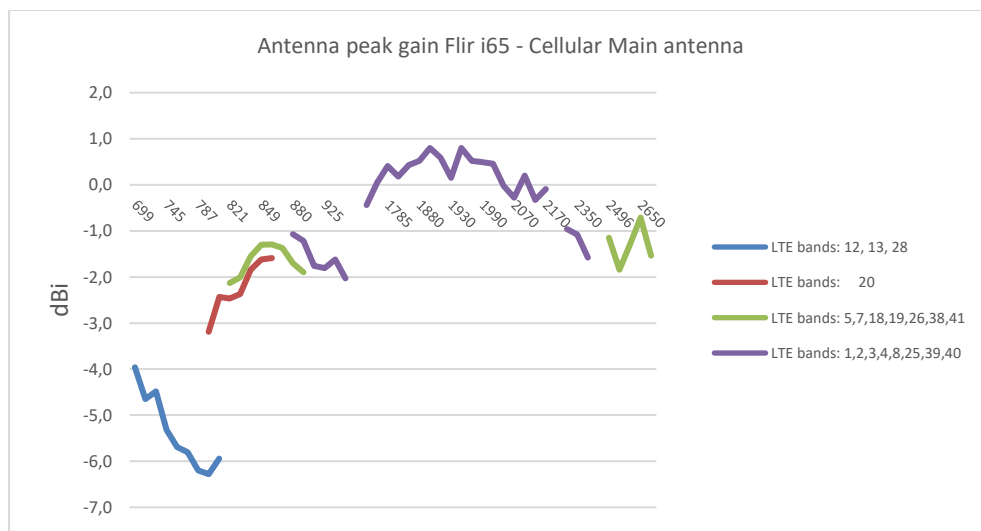


Figure 5-44 Antenna peak gain Flir-i1845; Cellular main antenna.



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	-4,0			
715	-4,7			
729	-4,5			
745	-5,3			
756	-5,7			
775	-5,8			
787	-6,2			
791	-6,3	-3,2		
803	-5,9	-2,4		
821		-2,5	-2,1	
824		-2,4	-2,0	
835		-1,8	-1,6	
849		-1,6	-1,3	
859		-1,6	-1,3	
869			-1,4	
880			-1,7	-1,1
894			-1,9	-1,2
915				-1,8
925				-1,8
940				-1,6
960				-2,0
1710				-0,4
1745				0,1
1785				0,4
1805				0,2
1850				0,4
1880				0,5
1910				0,8
1920				0,6
1930				0,2
1950				0,8
1980				0,5
1990				0,5
1995				0,5
2040				0,0
2070				-0,3
2110				0,2
2140				-0,3
2170				-0,1
2300				-1,0
2350				-1,1
2400				-1,6
2496			-1,2	
2550			-1,8	
2600			-1,3	
2650			-0,7	
2690			-1,5	

5.4.2 Cellular Diversity antenna

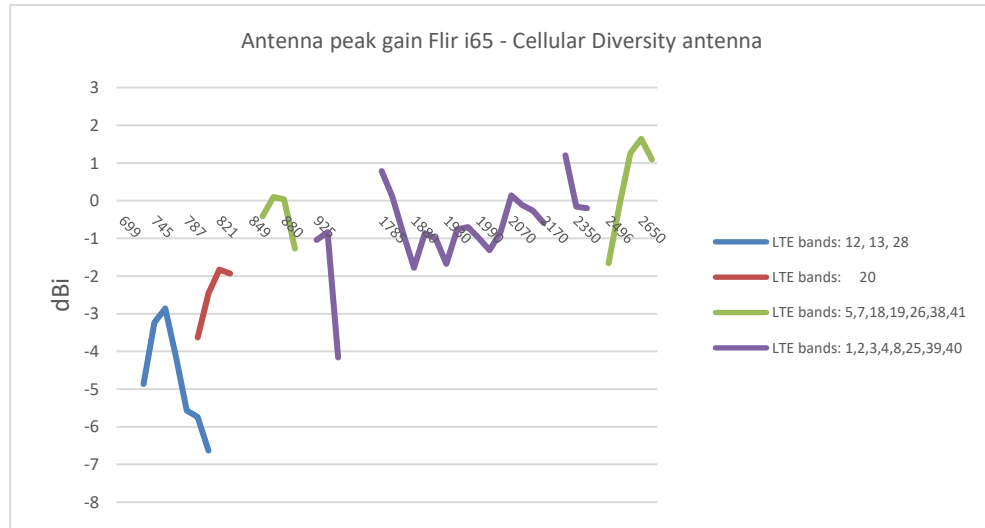


Figure 5-45 Antenna peak gain Flir-i1845; Cellular diversity antenna.



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

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				
715				
729	-4,9			
745	-3,2			
756	-2,9			
775	-4,2			
787	-5,6			
791	-5,7	-3,6		
803	-6,6	-2,5		
821		-1,8		
824		-1,9		
835				
849				
859			-0,4	
869			0,1	
880			0,0	
894			-1,3	
915				
925				-1,0
940				-0,8
960				-4,2
1710				
1745				
1785				0,8
1805				0,1
1850				-0,9
1880				-1,8
1910				-0,9
1920				-1,0
1930				-1,7
1950				-0,8
1980				-0,7
1990				-1,0
1995				-1,3
2040				-0,9
2070				0,1
2110				-0,1
2140				-0,3
2170				-0,6
2300				1,2
2350				-0,2
2400				-0,2
2496			-1,7	
2550			-0,1	
2600			1,3	
2650			1,6	
2690			1,1	

5.4.3 Wi-Fi antenna

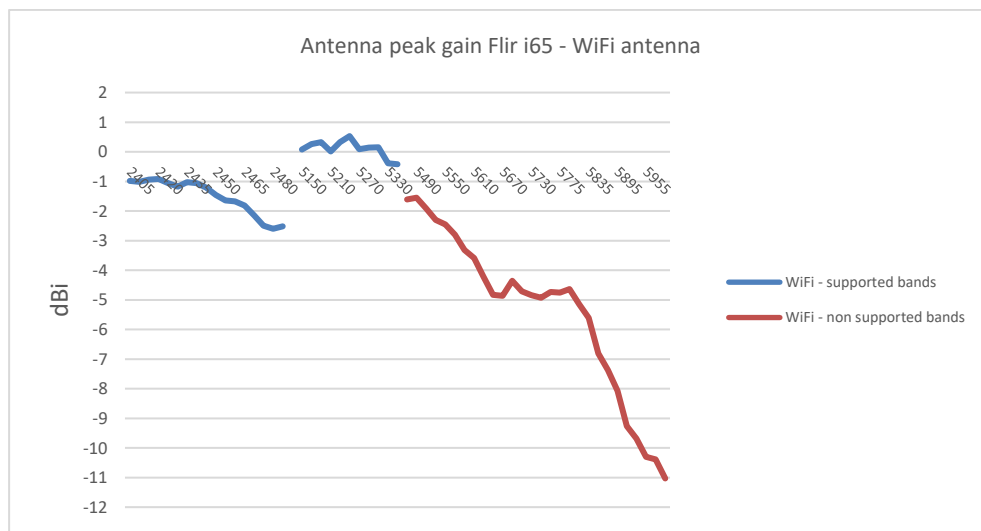


Figure 5-46 Antenna peak gain Flir-i1845; Wi-Fi antenna.



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3-3-TR-587 982-01

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

Frequency [MHz]	Antenna peak gain [dBi]
2405	-1,0
2410	-1,0
2415	-0,9
2420	-0,9
2425	-1,1
2430	-1,2
2435	-1,0
2440	-1,1
2445	-1,2
2450	-1,5
2455	-1,6
2460	-1,7
2465	-1,8
2470	-2,2
2475	-2,5
2480	-2,6
2482	-2,5
5150	0,1
5170	0,3
5190	0,3
5210	0,0
5230	0,3
5250	0,5
5270	0,1
5290	0,1
5310	0,2
5330	-0,4
5350	-0,4
5470	-1,6
5490	-1,6
5510	-1,9
5530	-2,3
5550	-2,5
5570	-2,8
5590	-3,3
5610	-3,6
5630	-4,2
5650	-4,8
5670	-4,9
5690	-4,4
5710	-4,7
5730	-4,8
5735	-4,9
5755	-4,7
5775	-4,8
5795	-4,6
5815	-5,1
5835	-5,6
5855	-6,8
5875	-7,4
5895	-8,1
5915	-9,3
5935	-9,7
5955	-10,3
5975	-10,4
5985	-11,0

5.4.4 GNSS antenna

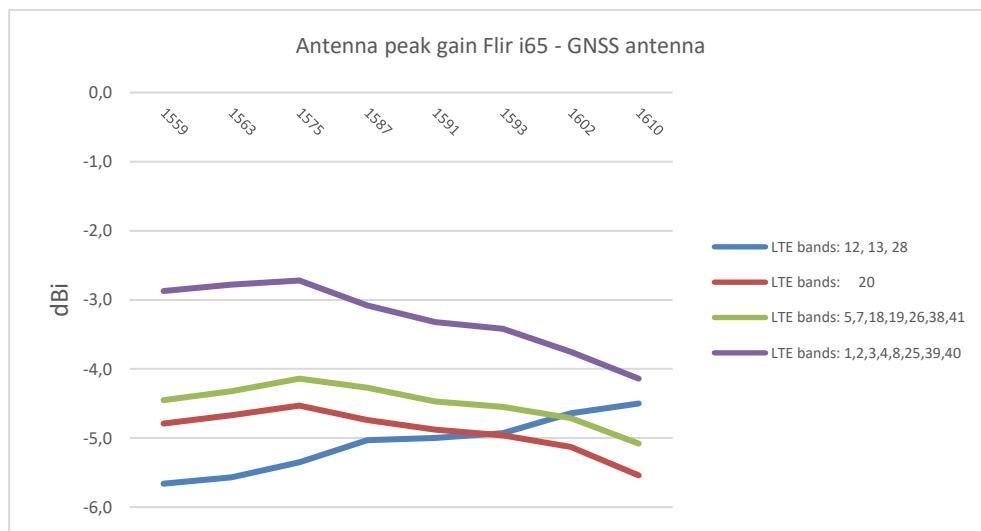


Figure 5-47 Antenna peak gain Flir-i1845; GNSS antenna.

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

Frequency [MHz]	Antenna peak gain [dBi]			
	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
1559	-5,7	-4,8	-4,5	-2,9
1563	-5,6	-4,7	-4,3	-2,8
1575	-5,4	-4,5	-4,1	-2,7
1587	-5,0	-4,7	-4,3	-3,1
1591	-5,0	-4,9	-4,5	-3,3
1593	-4,9	-5,0	-4,6	-3,4
1602	-4,6	-5,1	-4,7	-3,8
1610	-4,5	-5,5	-5,1	-4,1

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 band	Max antenna peak gain
2, 13, 28	-4.0 dBi
20	-1.6 dBi
5,18,19,26	-1.3 dBi
8	-1.1 dBi
1,2,3,4,8,25,39,40	0.8 dBi
7	-0.7 dBi

Wi-Fi band	Max antenna peak gain
2.4GHz	-0.9 dBi
5GHz (5150-5350MHz)	0.5 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	2025-08

A. 3D radiation patterns

A.1 Cellular main antenna

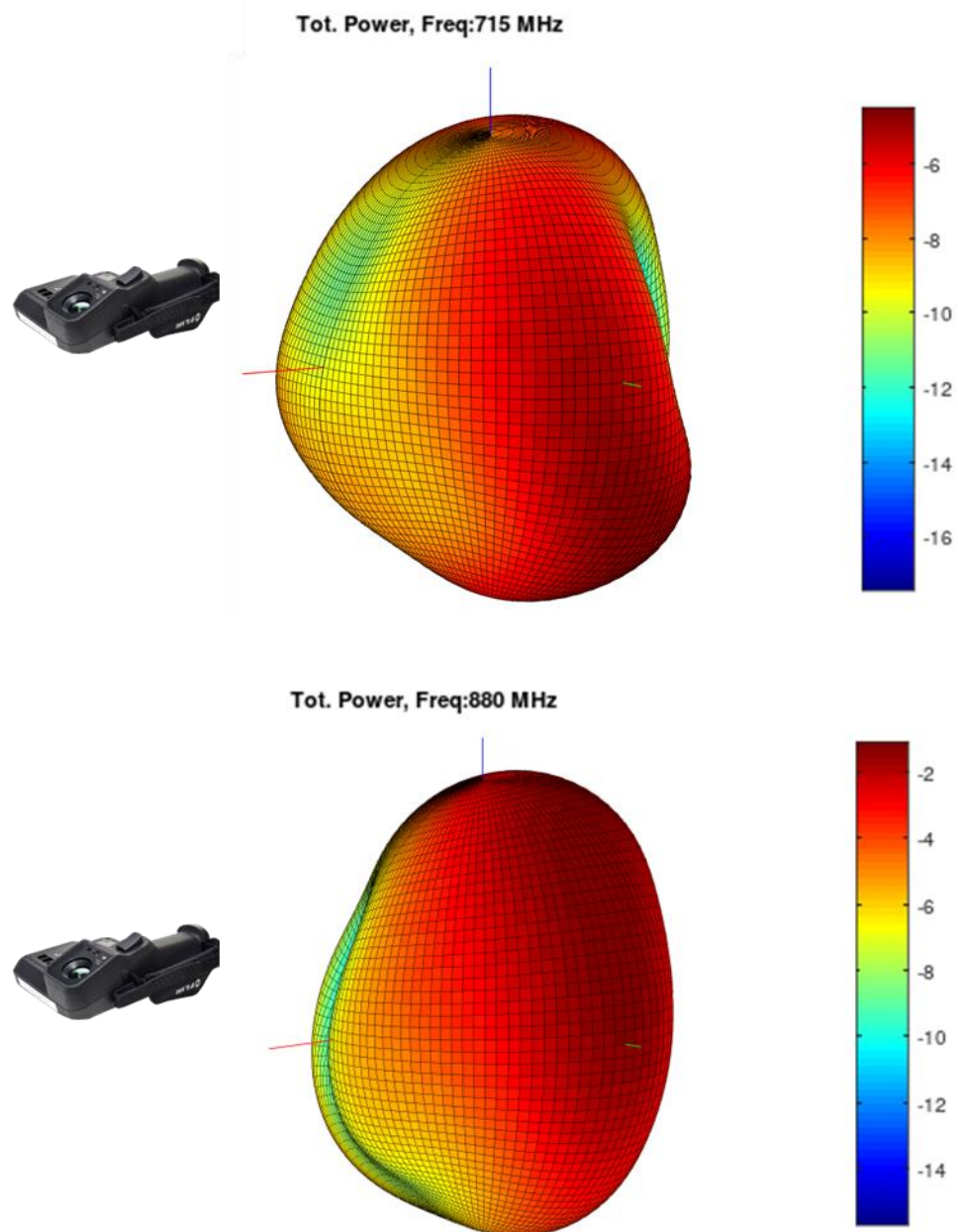


Figure A-1 3D radiation pattern for cellular main antenna, 715 and 880MHz.

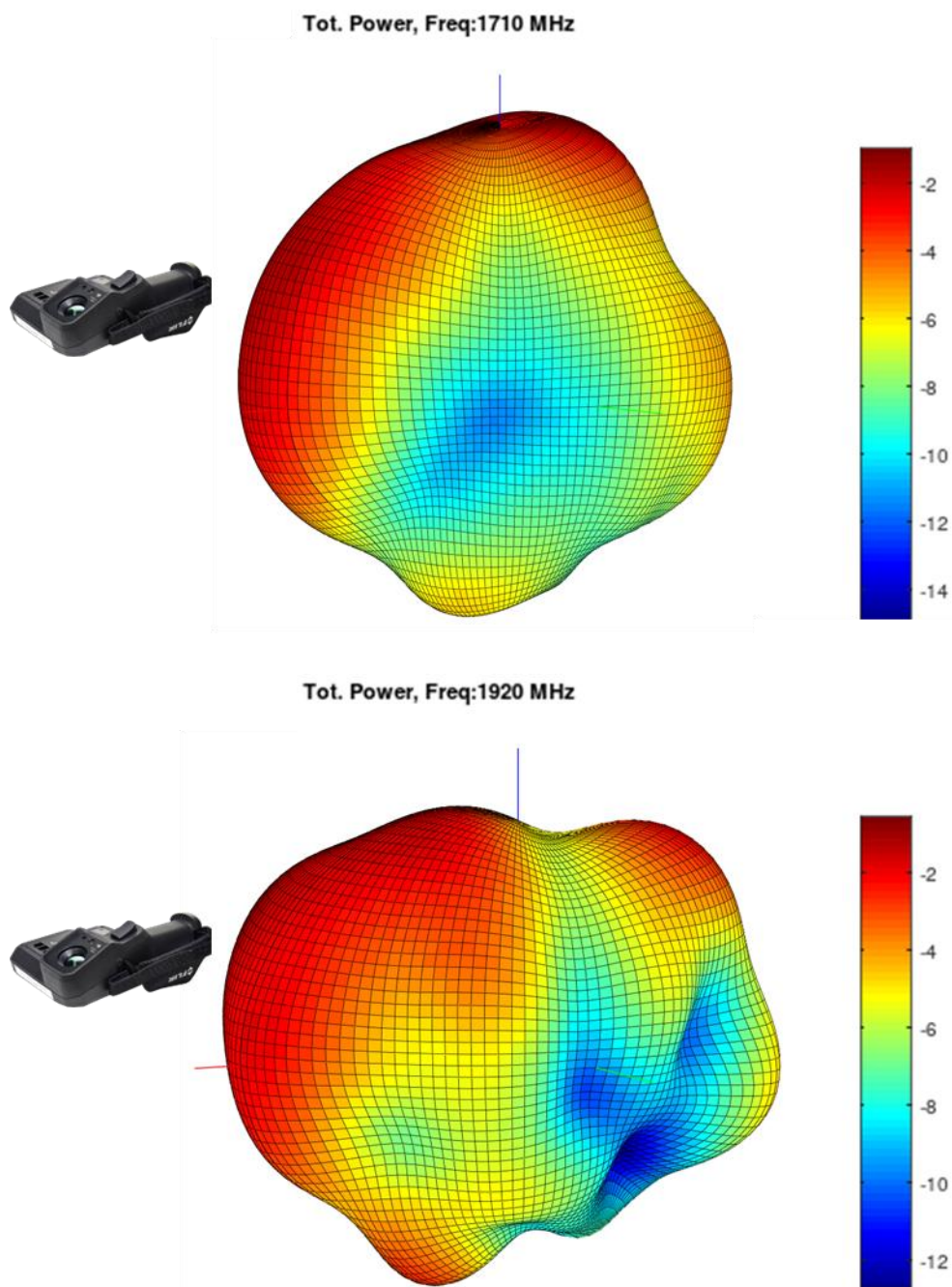


Figure A-2 3D radiation pattern for cellular main antenna, 1710 and 1920MHz.

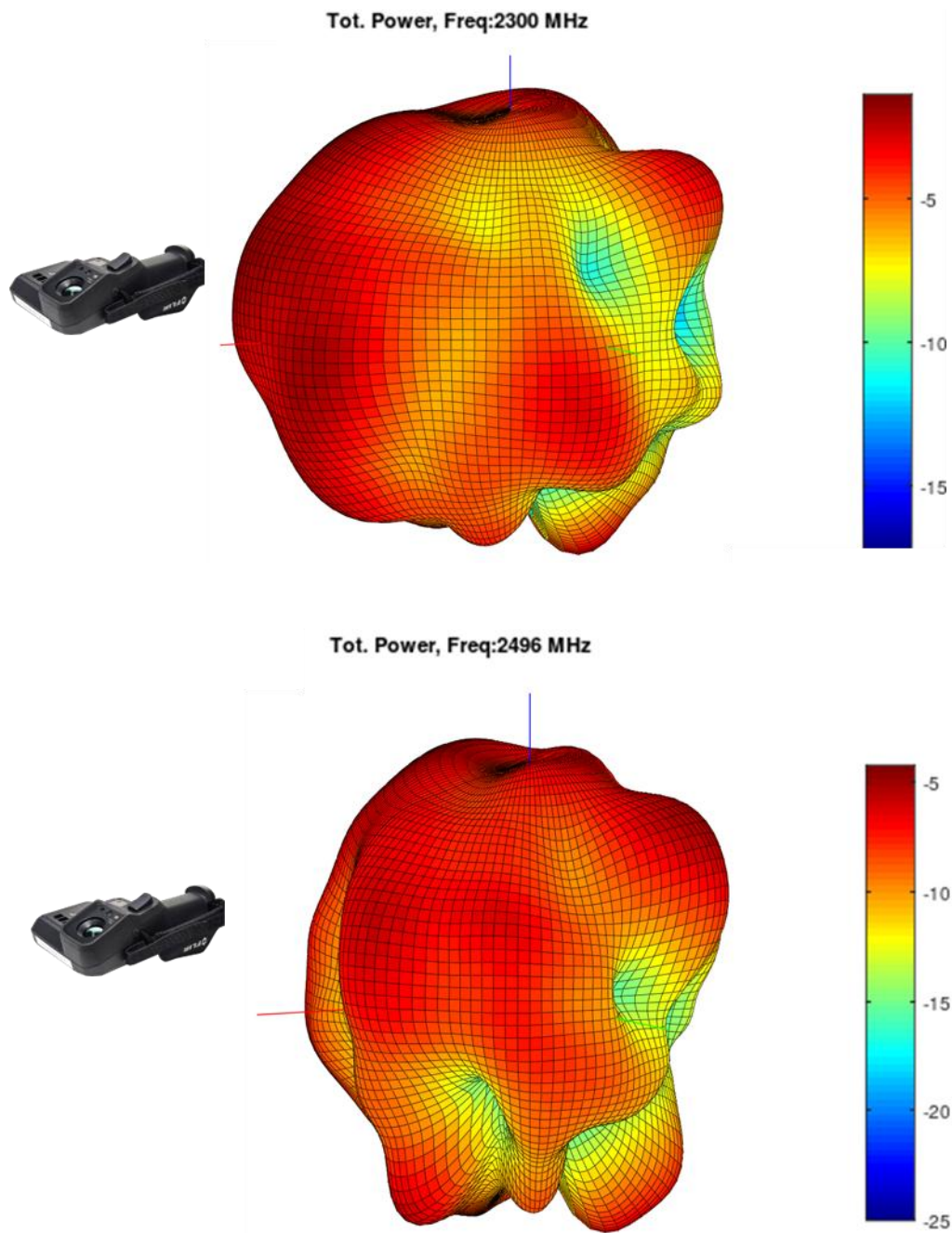


Figure A-3 3D radiation pattern for cellular main antenna, 2300 and 2496MHz.

A.2 Cellular diversity antenna

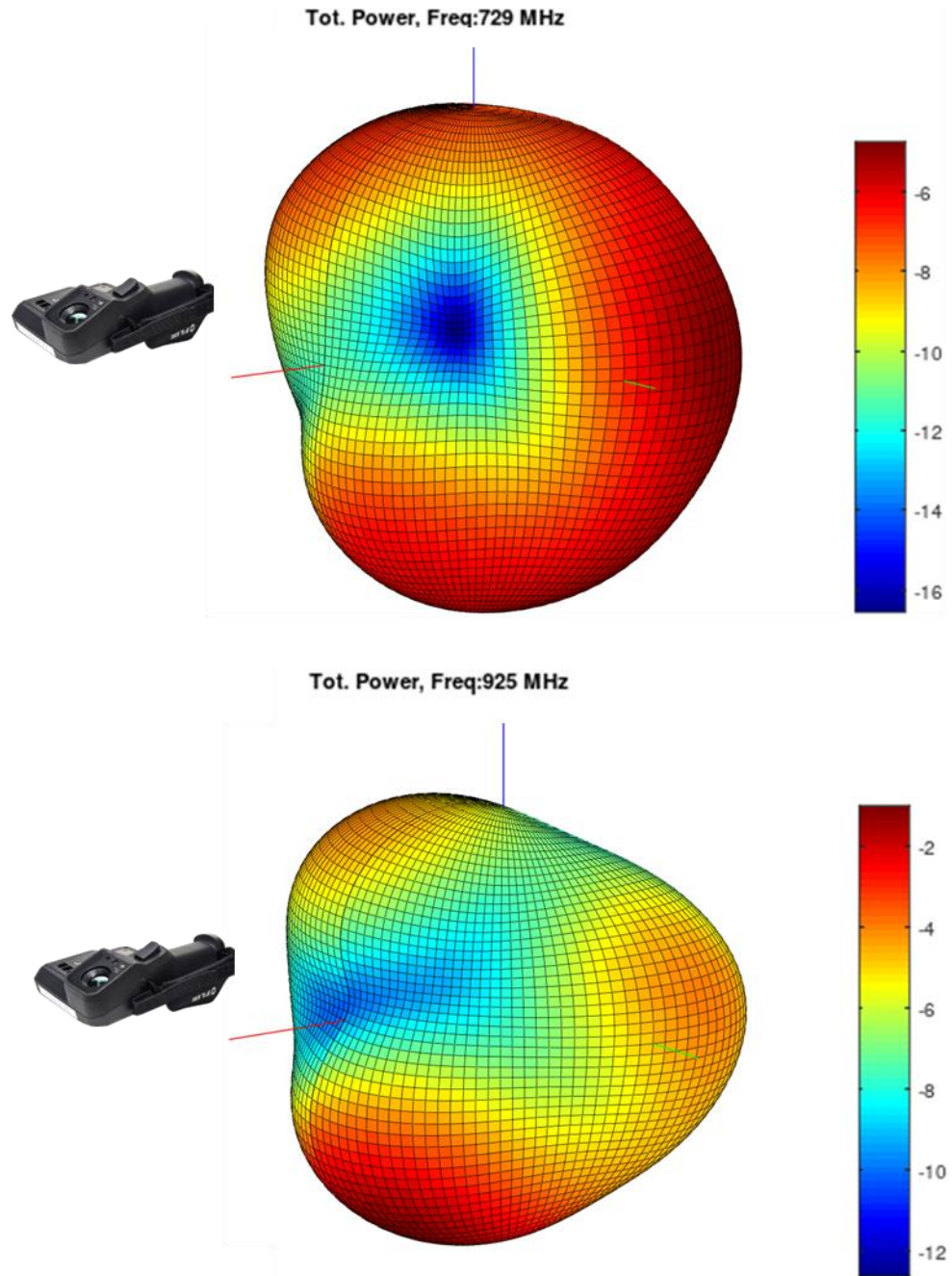


Figure A-4 3D radiation pattern for cellular diversity antenna, 729 and 925MHz.

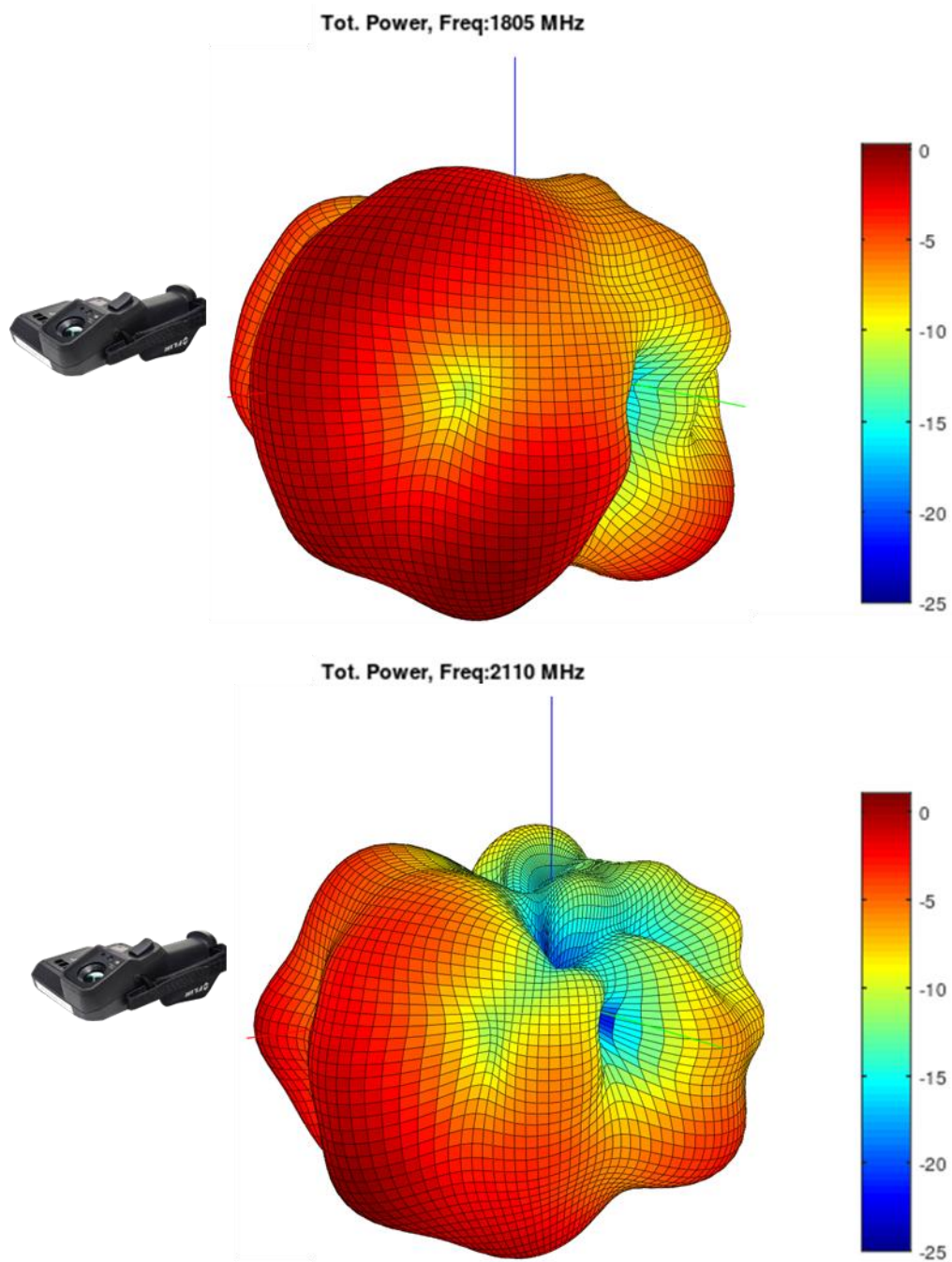


Figure A-5 3D radiation pattern for cellular diversity antenna, 1805 and 2110MHz.

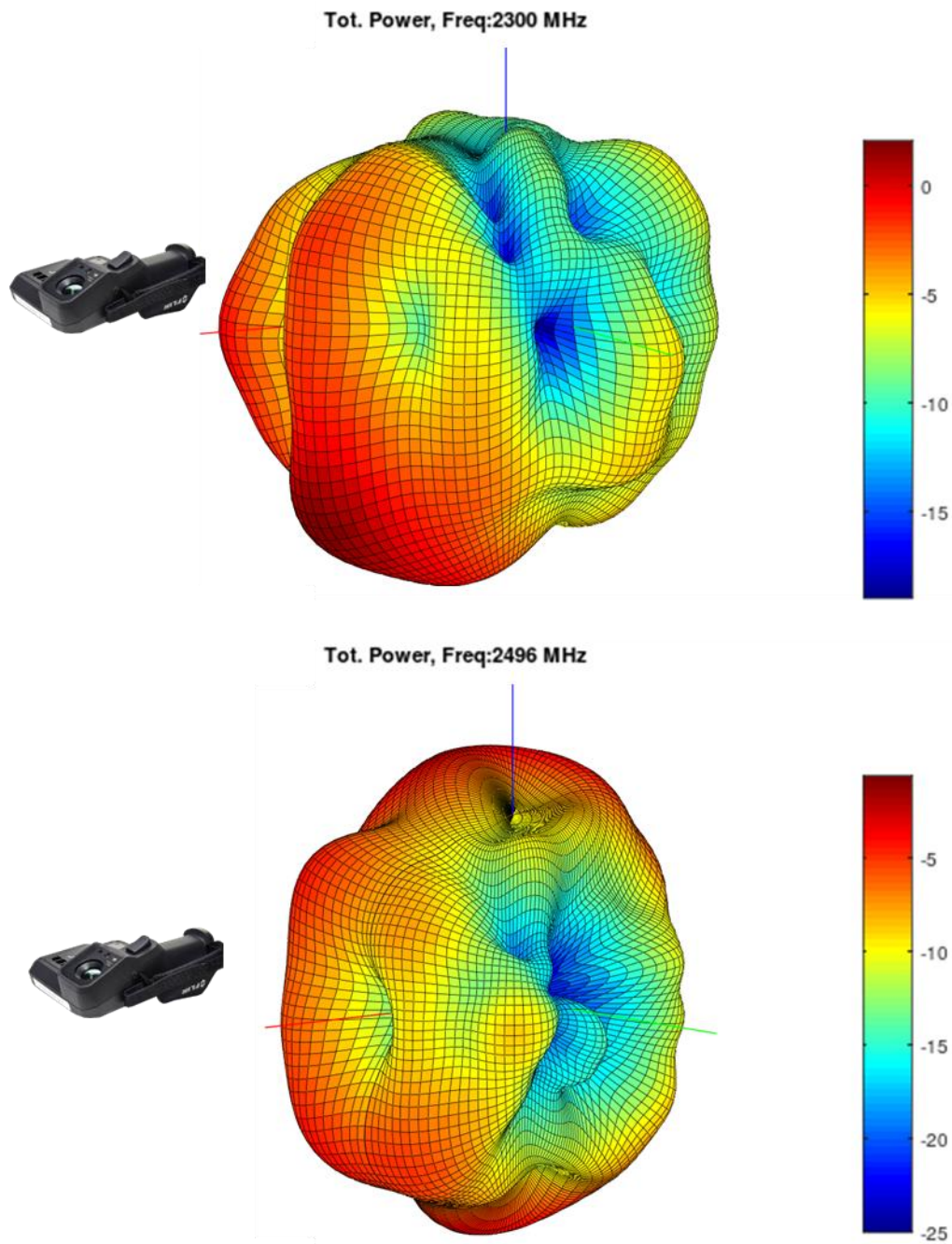


Figure A-6 3D radiation pattern for cellular diversity antenna, 2300 and 2496MHz.

A.3 Wi-Fi antenna

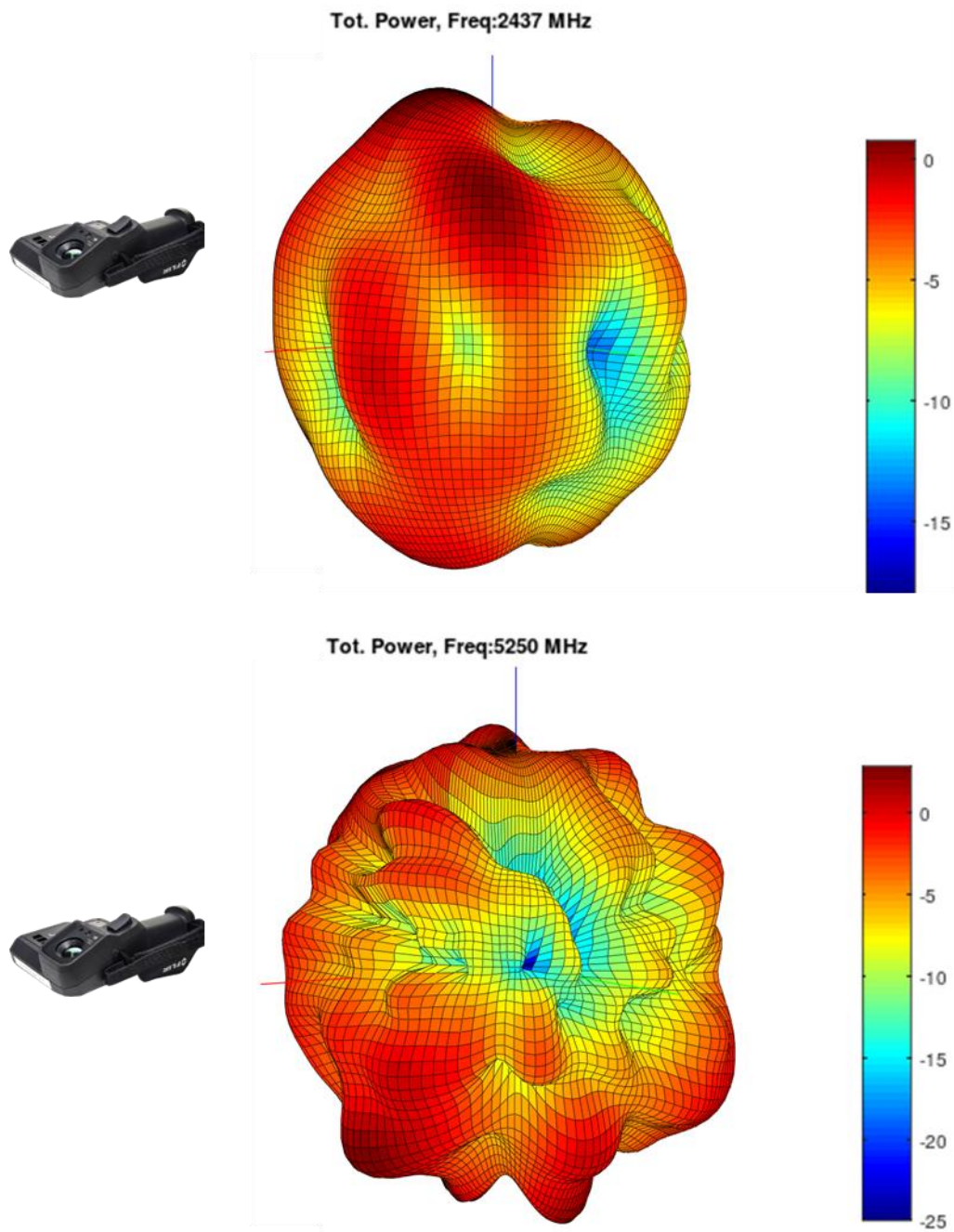


Figure A-7 3D radiation pattern for Wi-Fi antenna, 2437 and 5250MHz.

A.4 GNSS antenna

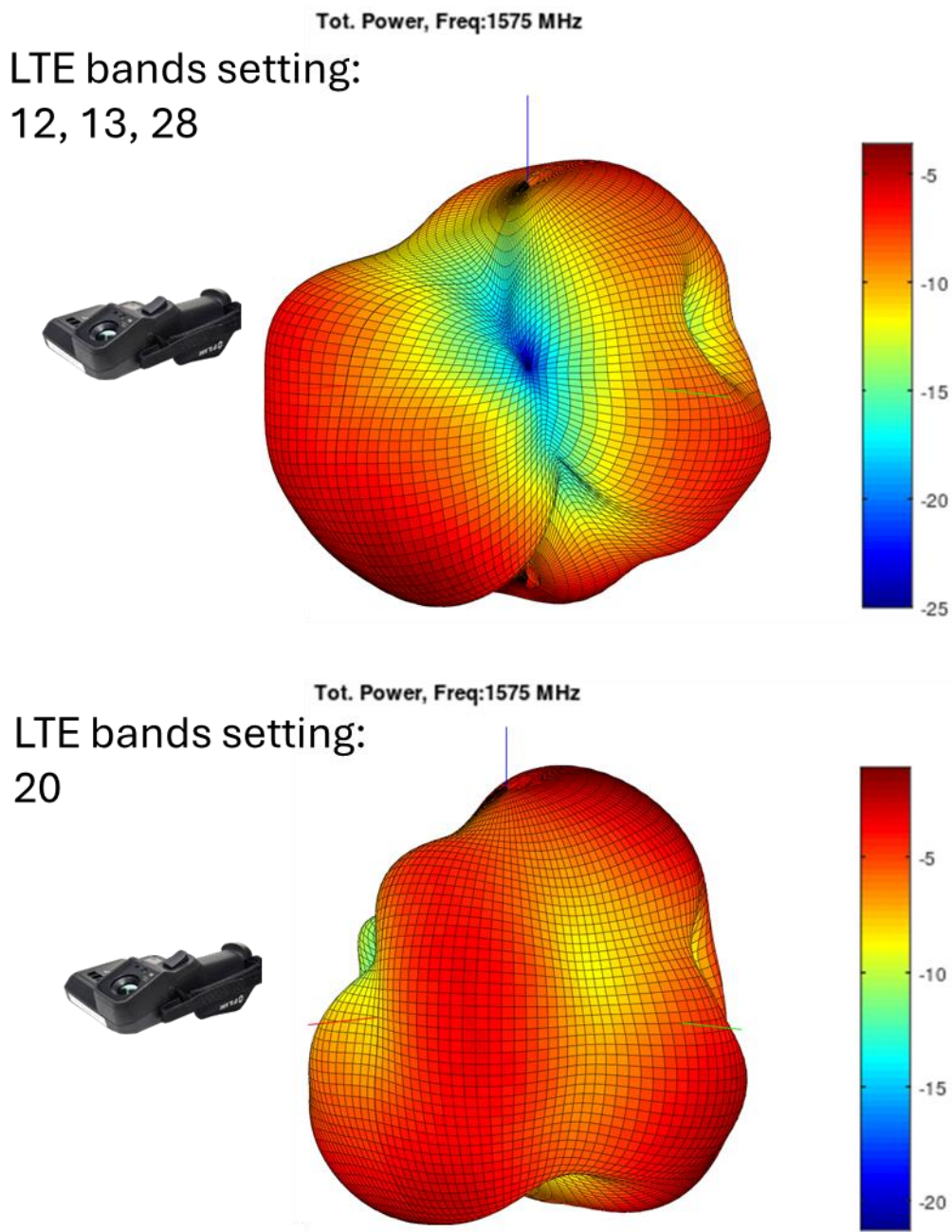


Figure A-8 3D radiation pattern for GNSS antenna, 1575MHz.

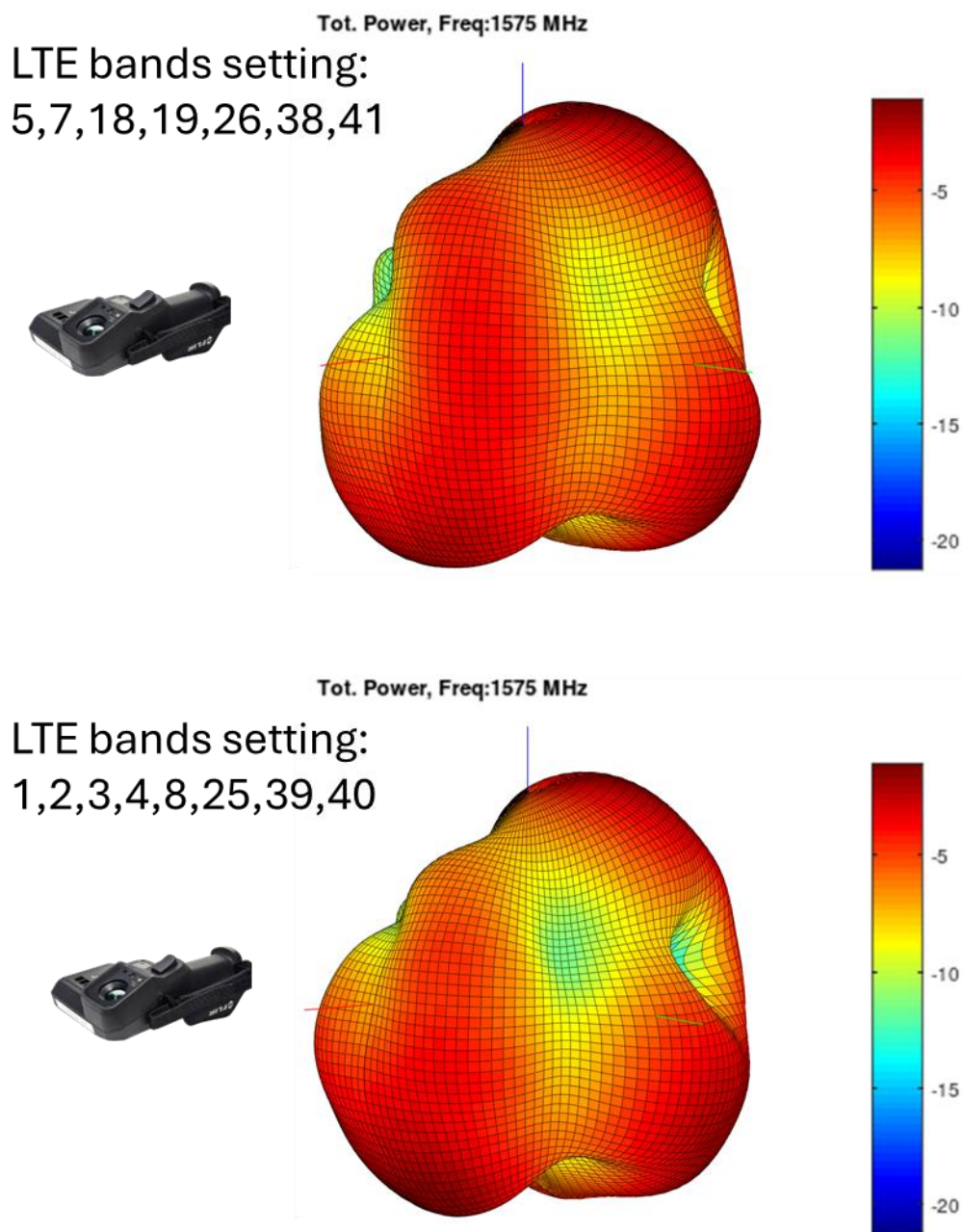


Figure A-9 3D radiation pattern for GNSS antenna, 1575MHz.