



FLIR-i1845

Antenna characterization

Doc.no: 3-3-TR-587 982-01

Revision History

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



Table of Contents

1	TABLE OF FIGURES.....	3
2	TABLE OF TABLES	5
3	ACRONYMS, ABBREVIATIONS AND DEFINITIONS	6
4	INTRODUCTION	7
5	ANTENNA MEASUREMENTS.....	8
5.1	VOLTAGE STANDING WAVE RATIO.....	9
5.1.1	CELLULAR MAIN ANTENNA.....	9
5.1.2	CELLULAR DIVERSITY ANTENNA.....	11
5.1.3	WI-FI ANTENNA	13
5.1.4	GNSS ANTENNA.....	14
5.2	ANTENNA EFFICIENCY.....	16
5.2.1	CELLULAR MAIN ANTENNA.....	16
5.2.2	CELLULAR DIVERSITY ANTENNA.....	18
5.2.3	WI-FI ANTENNA	20
5.2.4	GNSS ANTENNA.....	22
5.3	2D RADIATION PATTERNS.....	22
5.3.1	CELLULAR MAIN ANTENNA.....	24
5.3.2	CELLULAR DIVERSITY ANTENNA	30
5.3.3	WI-FI ANTENNA	36
5.3.4	GNSS ANTENNA.....	38
5.4	ANTENNA PEAK GAIN	42
5.4.1	CELLULAR MAIN ANTENNA.....	42
5.4.2	CELLULAR DIVERSITY ANTENNA.....	44
5.4.3	WI-FI ANTENNA	46
5.4.4	GNSS ANTENNA.....	48
6	SUMMARY.....	49
7	ANTENNA MEASUREMENT SYSTEM.....	50
A.	3D RADIATION PATTERNS.....	51
A.1	CELLULAR MAIN ANTENNA.....	51
A.2	CELLULAR DIVERSITY ANTENNA.....	54
A.3	WI-FI ANTENNA.....	57
A.4	GNSS ANTENNA.....	58



1 Table of Figures

Figure 4-1 Flir-i1845 thermal camera.	7
Figure 5-1 Downlink and Uplink frequencies for Low frequency LTE bands.....	8
Figure 5-2 Downlink and Uplink frequencies for High frequency LTE bands....	9
Figure 5-3 Flir-i1845 cellular main antenna LTE bands 12, 13, 28 (marker 1-2).....	9
Figure 5-4 Flir-i1845 cellular main antenna LTE band 20 (marker 3-4).	10
Figure 5-5 Flir-i1845 cellular main antenna LTE bands 5,18,19,26 (marker 5-6).....	10
Figure 5-6 Flir-i1845 cellular main antenna LTE band 8 (marker 7-8).....	10
Figure 5-7 Flir-i1845 cellular main antenna LTE bands 1,2,3,4,25,39,40 (marker 1-4).....	11
Figure 5-8 Flir-i1845 cellular main antenna LTE bands 7,38,41 (marker 5-6).	11
Figure 5-9 Flir-i1845 cellular diversity antenna LTE bands 12, 13, 28 (marker 1-2).	11
Figure 5-10 Flir-i1845 cellular diversity antenna LTE band 20 (marker 3-4).	12
Figure 5-11 Flir-i1845 cellular diversity antenna LTE bands 5,18,19,26 (marker 5-6).....	12
Figure 5-12 Flir-i1845 cellular diversity antenna LTE band 8 (marker 7-8).	12
Figure 5-13 Flir-i1845 cellular diversity antenna LTE bands 1,2,3,4,25,39,40 (marker 1-4).....	13
Figure 5-14 Flir-i1845 cellular diversity antenna LTE bands 7,38,41 (marker 5-6).	13
Figure 5-15 Flir-i1845 Wi-Fi antenna	13
Figure 5-16 Flir-i1845 GNSS antenna. LTE band settings: 12, 13, 28.....	14
Figure 5-17 Flir-i1845 GNSS antenna. LTE band settings: 20.....	14
Figure 5-18 Flir-i1845 GNSS antenna. LTE band settings: 5,7,18,19,26,38,41	15
Figure 5-19 Flir-i1845 GNSS antenna. LTE band settings: 1,2,3,4,8,25,39,40..	15
Figure 5-20 Antenna efficiency Flir-i1845; Cellular main antenna.....	16
Figure 5-21 Antenna efficiency Flir-i1845; Cellular diversity antenna.....	18
Figure 5-22 Antenna efficiency Flir-i1845; Wi-Fi antenna.....	20
Figure 5-23 Antenna efficiency Flir-i1845; GNSS antenna.....	22
Figure 5-28 Measurement plane definition.	23
Figure 5-29 Satimo SG-23 6 GHz Stargate Antenna Test Chamber.....	23
Figure 5-30 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 12, 13, 28	24
Figure 5-31 2D radiation patterns Flir-i1845; Cellular main antenna LTE band 20	25
Figure 5-32 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 5,18,19,26	26



Figure 5-33 2D radiation patterns Flir-i1845; Cellular main antenna LTE band 8	27
Figure 5-34 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 1,2,3,4,25,39,40	28
Figure 5-35 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 7,38,41	29
Figure 5-36 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 12, 13, 28	30
Figure 5-37 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE band 20	31
Figure 5-38 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 5,18,19,26	32
Figure 5-39 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE band 8	33
Figure 5-40 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 1,2,3,4,25,39,40	34
Figure 5-41 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 7,38,41	35
Figure 5-42 2D radiation patterns Flir-i1845; Wi-Fi antenna 2.4GHz band	36
Figure 5-43 2D radiation patterns Flir-i1845; Wi-Fi antenna 5GHz band.....	37
Figure 5-44 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 12, 13, 28	38
Figure 5-45 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 20	39
Figure 5-46 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 5,18,19,26, 7, 38, 41	40
Figure 5-47 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 1,2,3,4,8,25,39,40	41
Figure 5-24 Antenna peak gain Flir-i1845; Cellular main antenna.....	42
Figure 5-25 Antenna peak gain Flir-i1845; Cellular diversity antenna.....	44
Figure 5-26 Antenna peak gain Flir-i1845; Wi-Fi antenna.....	46
Figure 5-27 Antenna peak gain Flir-i1845; GNSS antenna.....	48



2 Table of Tables

Table 1. Acronyms	6
Table 2 Antenna efficiency Flir-i1845; Cellular main antenna.	17
Table 3 Antenna efficiency Flir-i1845; Cellular diversity antenna.	19
Table 4 Antenna efficiency Flir-i1845; Wi-Fi antenna.	21
Table 5 Antenna efficiency Flir-i1845; GNSS antenna.....	22
Table 6 Antenna peak gain Flir-i1845; Cellular main antenna.	43
Table 7 Antenna peak gain Flir-i1845; Cellular diversity antenna.	45
Table 8 Antenna peak gain Flir-i1845; Wi-Fi antenna.	47
Table 9 Antenna peak gain Flir-i1845; GNSS antenna.....	48
Table 7-1 List of equipment in antenna measurement system.	50



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.

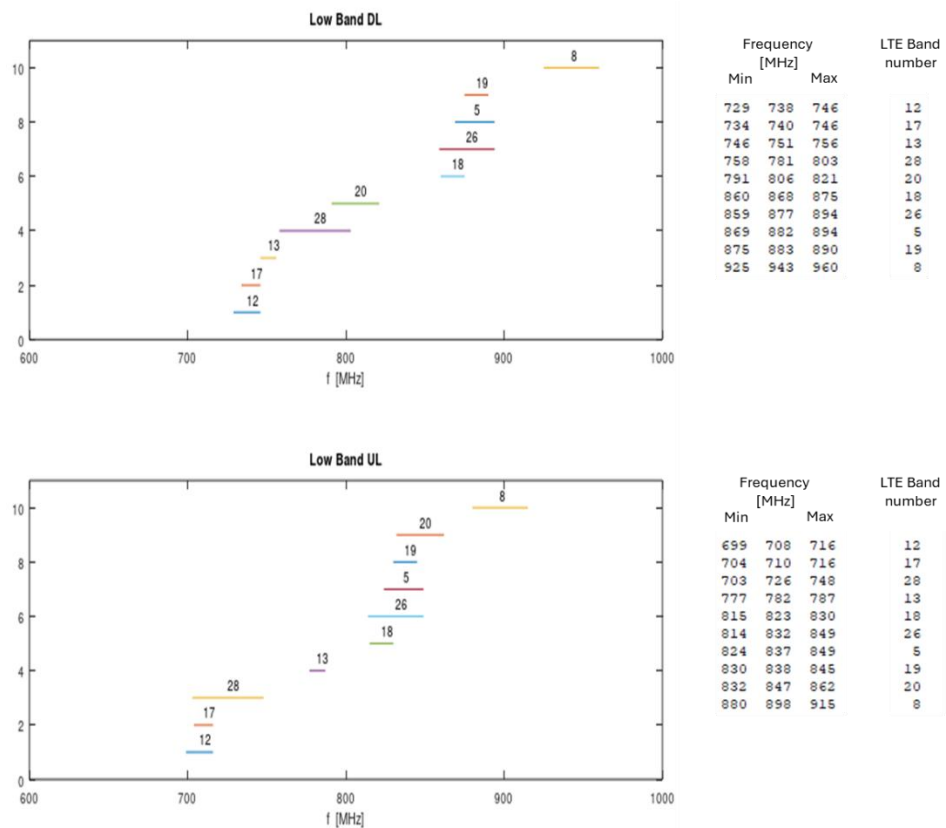


Figure 5-1 Downlink and Uplink frequencies for Low frequency LTE bands.

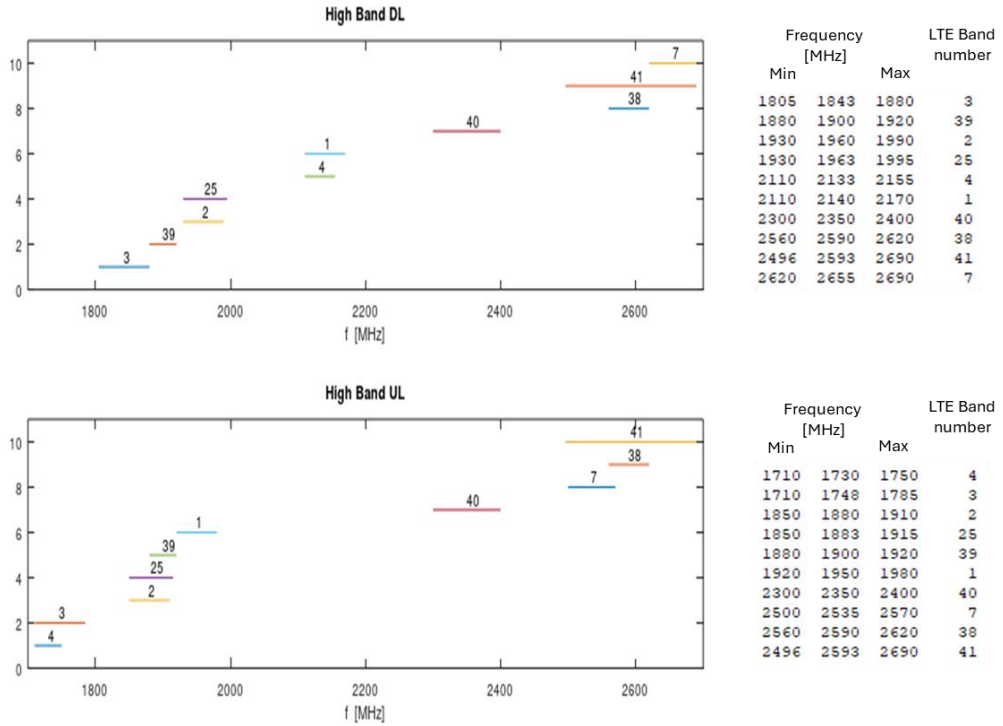


Figure 5-2 Downlink and Uplink frequencies for High frequency LTE bands.

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

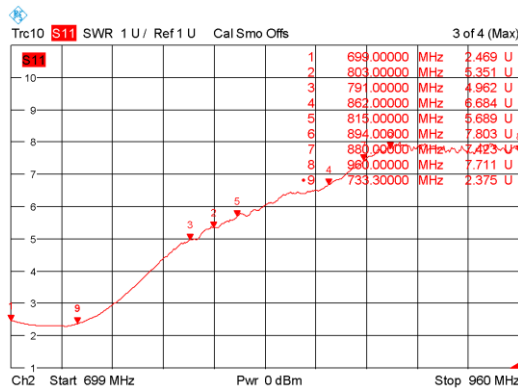


Figure 5-3 Flir-i1845 cellular main antenna LTE bands 12, 13, 28 (marker 1-2).



LTE band: 20

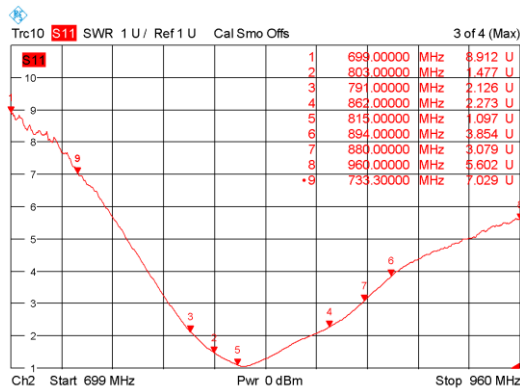


Figure 5-4 Flir-i1845 cellular main antenna LTE band 20 (marker 3-4).

LTE bands: 5,18,19,26

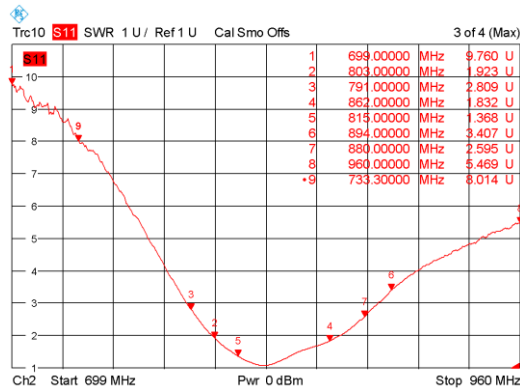


Figure 5-5 Flir-i1845 cellular main antenna LTE bands 5,18,19,26 (marker 5-6).

LTE bands: 8

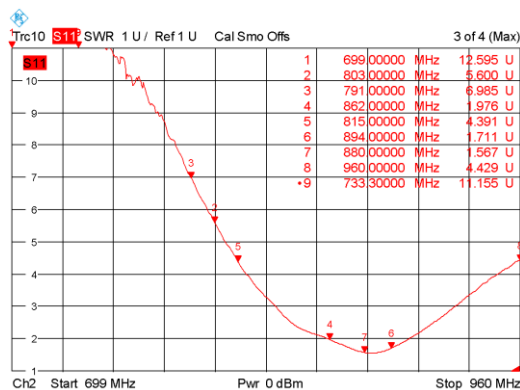


Figure 5-6 Flir-i1845 cellular main antenna LTE band 8 (marker 7-8).



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

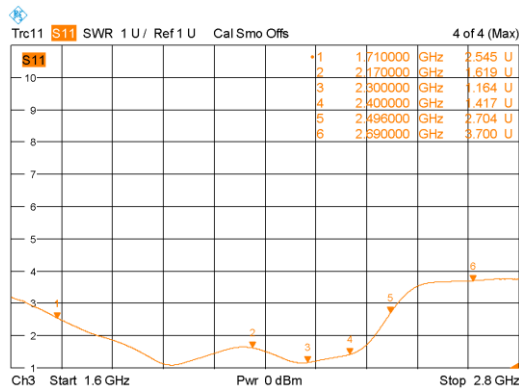


Figure 5-7 Flir-i1845 cellular main antenna LTE bands 1,2,3,4,25,39,40 (marker 1-4).

LTE bands: 7,38,41

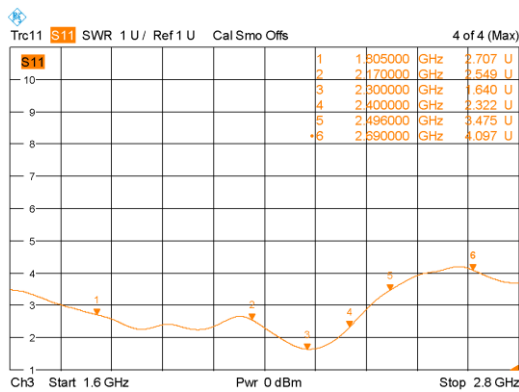


Figure 5-8 Flir-i1845 cellular main antenna LTE bands 7,38,41 (marker 5-6).

5.1.2 Cellular Diversity antenna

LTE bands: 12, 13, 28

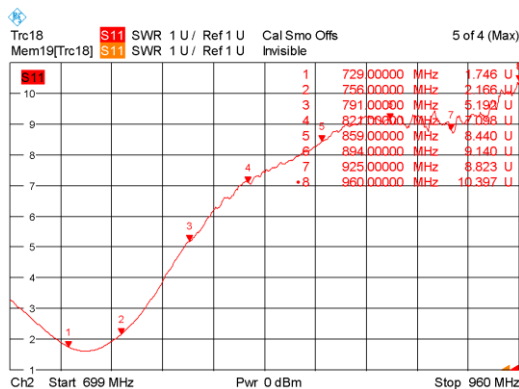


Figure 5-9 Flir-i1845 cellular diversity antenna LTE bands 12, 13, 28 (marker 1-2).



LTE band: 20

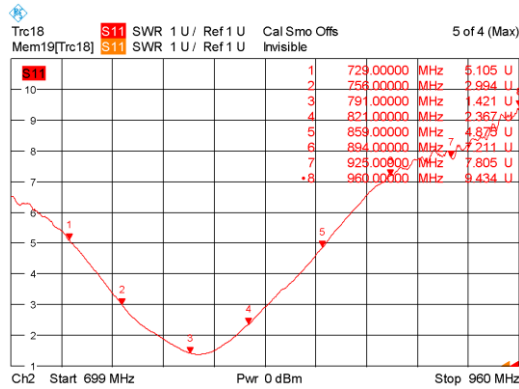


Figure 5-10 Flir-i1845 cellular diversity antenna LTE band 20 (marker 3-4).

LTE bands: 5,18,19,26

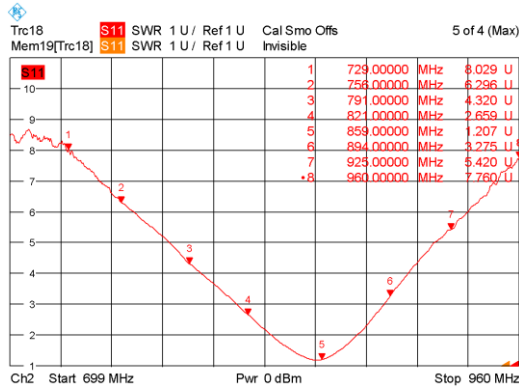


Figure 5-11 Flir-i1845 cellular diversity antenna LTE bands 5,18,19,26 (marker 5-6).

LTE bands: 8

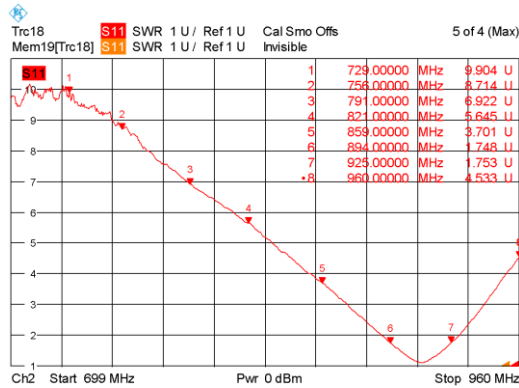


Figure 5-12 Flir-i1845 cellular diversity antenna LTE band 8 (marker 7-8).



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

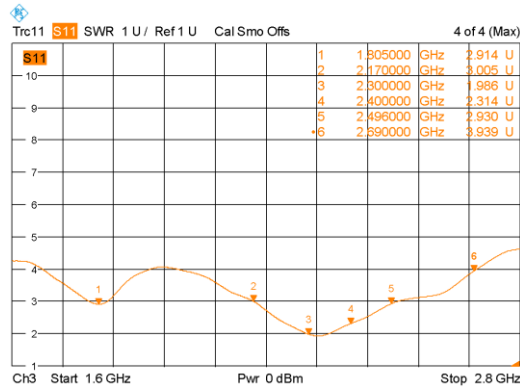


Figure 5-13 Flir-i1845 cellular diversity antenna LTE bands 1,2,3,4,25,39,40 (marker 1-4).

LTE bands: 7,38,41

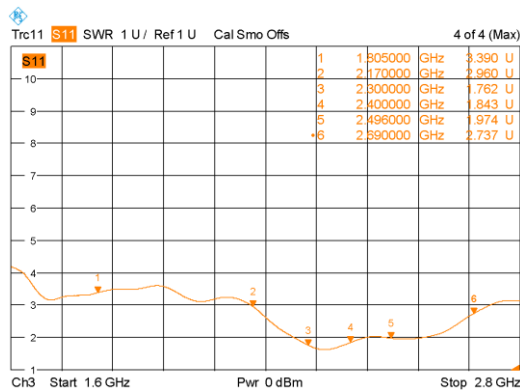


Figure 5-14 Flir-i1845 cellular diversity antenna LTE bands 7,38,41 (marker 5-6).

5.1.3 Wi-Fi antenna

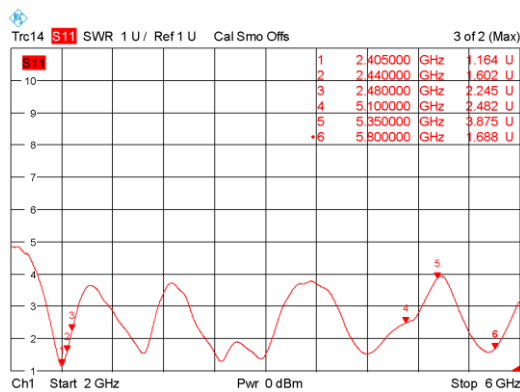


Figure 5-15 Flir-i1845 Wi-Fi antenna

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

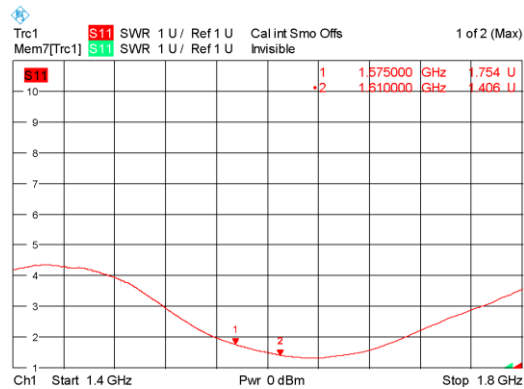


Figure 5-16 Flir-i1845 GNSS antenna. LTE band settings: 12, 13, 28

LTE bands setting: 20

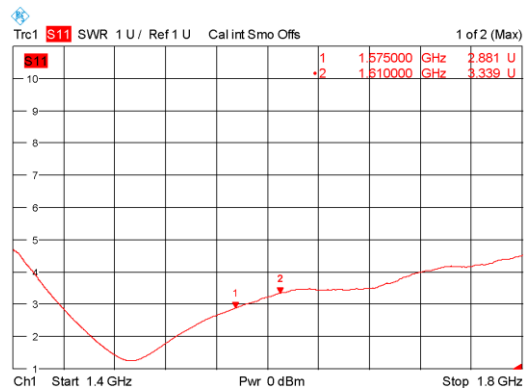


Figure 5-17 Flir-i1845 GNSS antenna. LTE band settings: 20



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

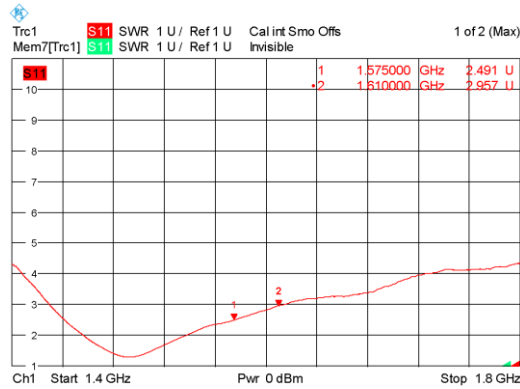


Figure 5-18 Flir-i1845 GNSS antenna. LTE band settings: 5,7,18,19,26,38,41

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

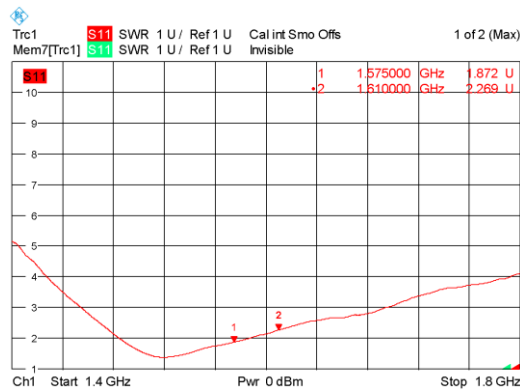


Figure 5-19 Flir-i1845 GNSS antenna. LTE band settings: 1,2,3,4,8,25,39,40

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, $P_{radiated}$.

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

5.2.1 Cellular Main antenna

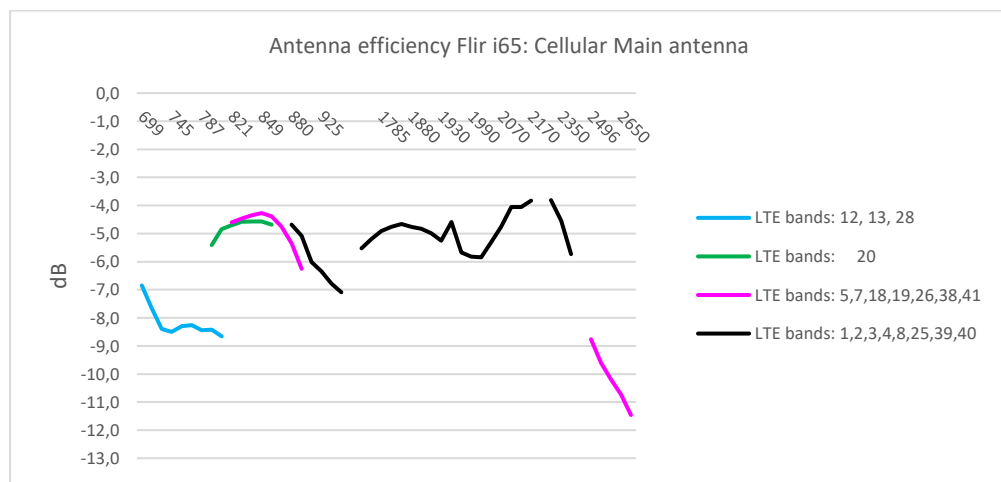


Figure 5-20 Antenna efficiency Flir-i1845; Cellular main antenna.



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

Frequency [MHz]	Antenna efficiency [dB]		
	LTE bands: 12, 13, 28	LTE bands: 20	LTE bands: 5,7,18,19,2 6,38,41
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
894			-6,3
915			-5,1
925			-6,0
940			-6,4
960			-6,8
1710			-7,1
1745			-5,5
1785			-5,2
1805			-4,9
1850			-4,8
1880			-4,7
1910			-4,8
1920			-4,8
1930			-5,0
1950			-5,3
1980			-4,6
1990			-5,7
1995			-5,9
2040			-5,8
2070			-5,9
2110			-5,3
2140			-4,8
2170			-4,1
2300			-4,1
2350			-3,8
2400			-3,8
2496		-8,8	
2550		-9,6	
2600		-10,2	
2650		-10,7	
2690		-11,5	

5.2.2 Cellular Diversity antenna

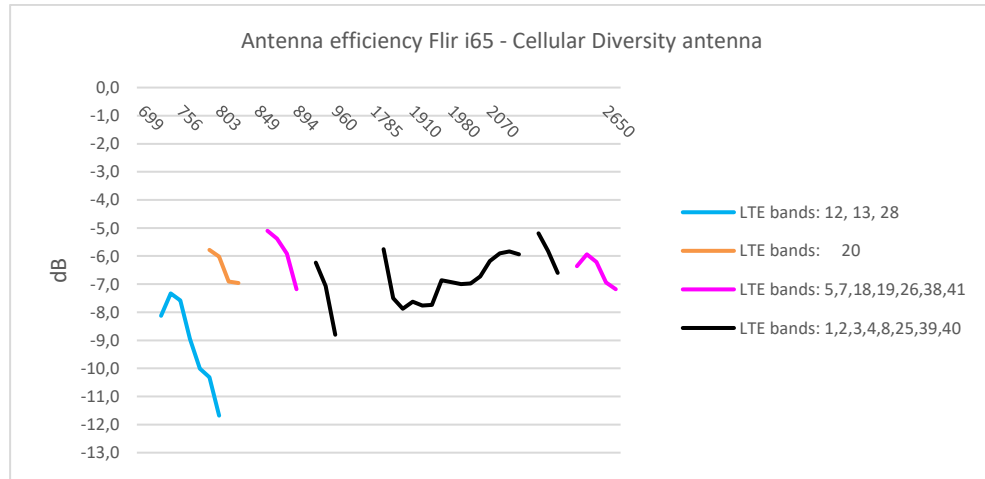


Figure 5-21 Antenna efficiency Flir-i1845; Cellular diversity antenna.



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

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
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

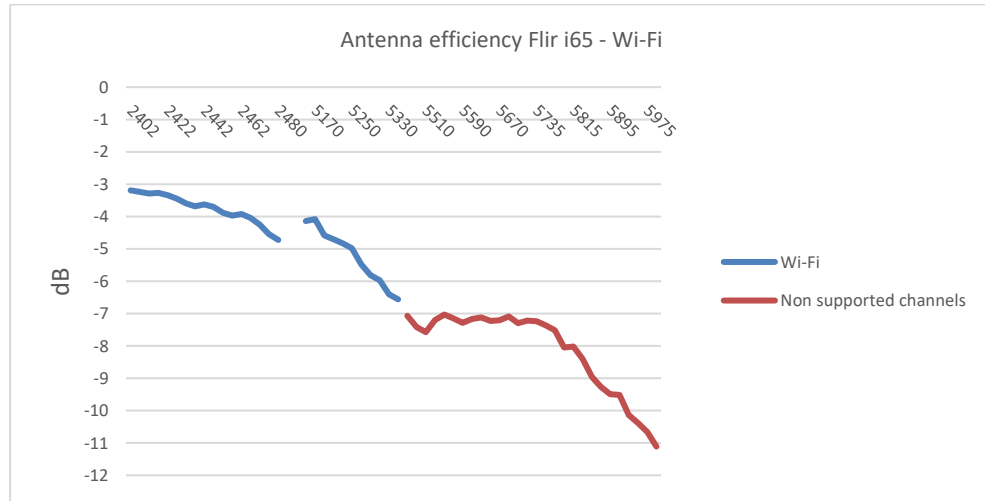


Figure 5-22 Antenna efficiency Flir-i1845; Wi-Fi antenna.



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

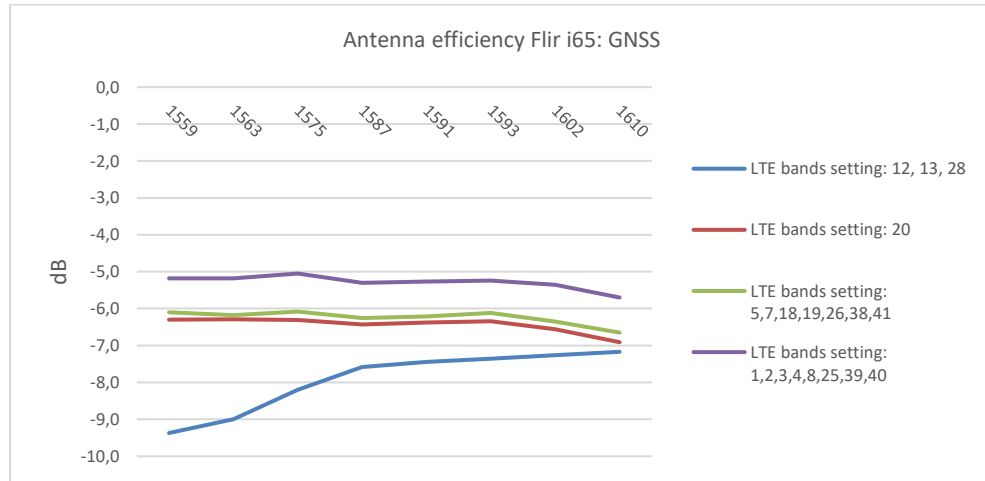


Figure 5-23 Antenna efficiency Flir-i1845; GNSS antenna.

Frequency [MHz]	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
	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

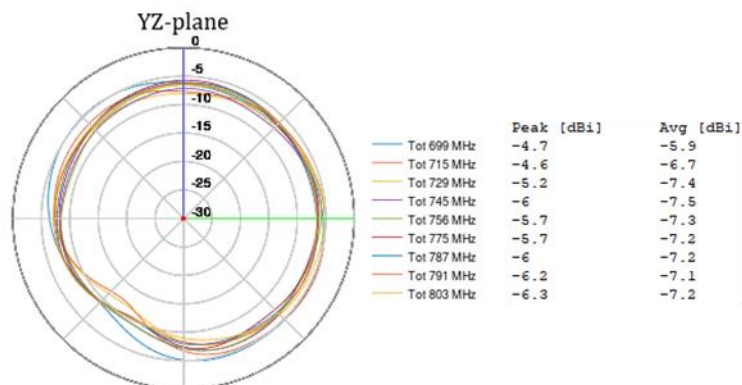
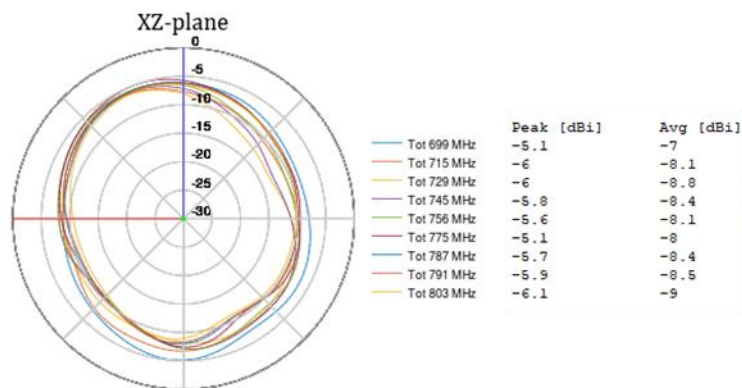
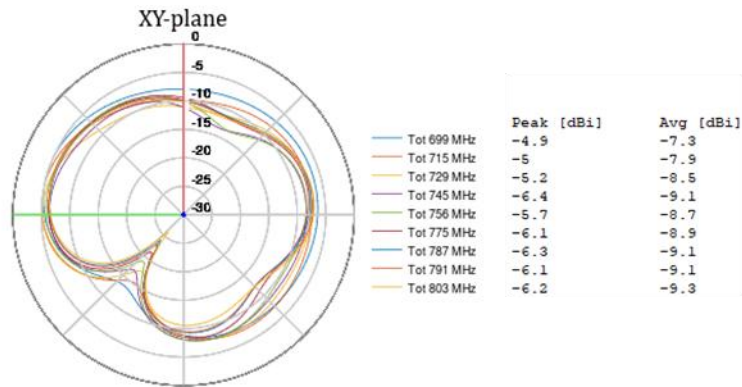


Figure 5-26 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 12, 13, 28

LTE band: 20

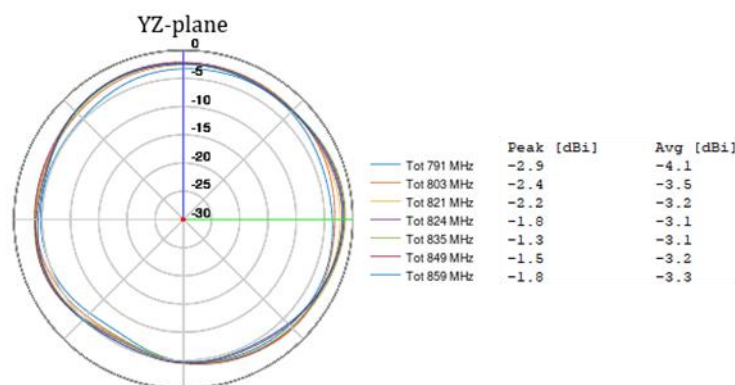
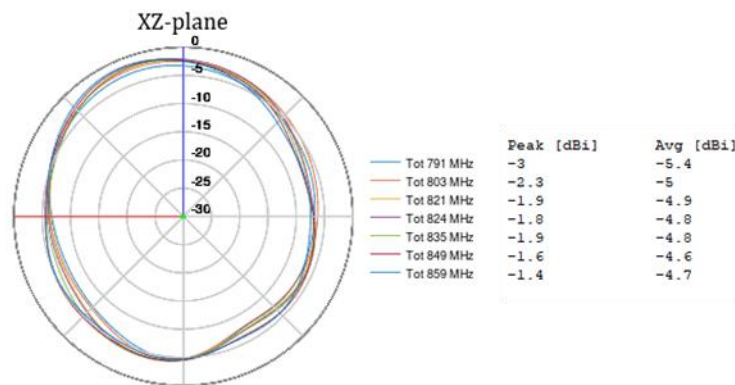
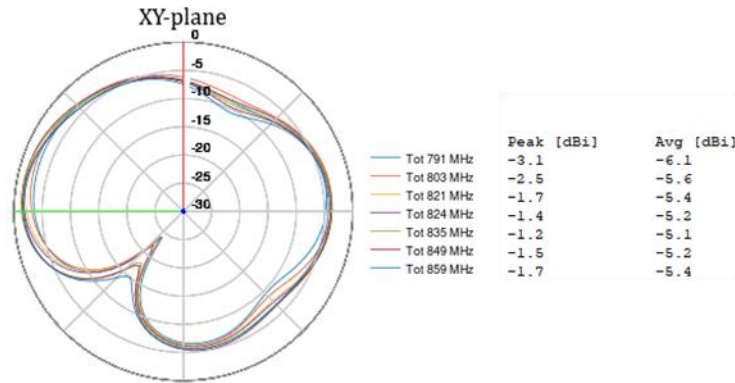


Figure 5-27 2D radiation patterns Flir-i1845; Cellular main antenna LTE band 20

LTE bands: 5,18,19,26

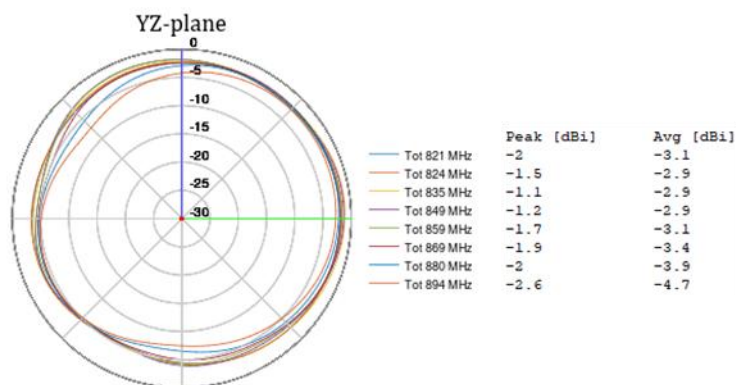
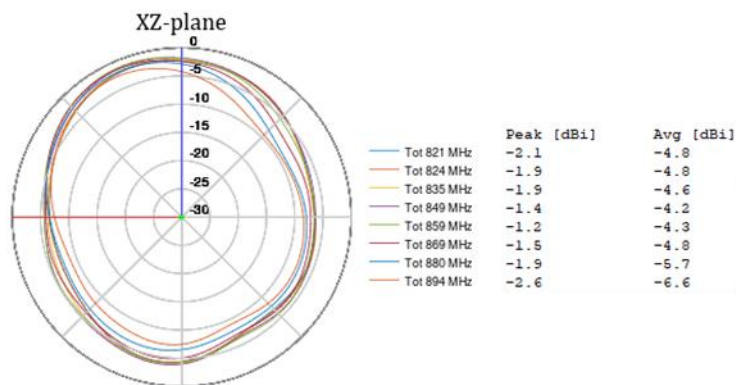
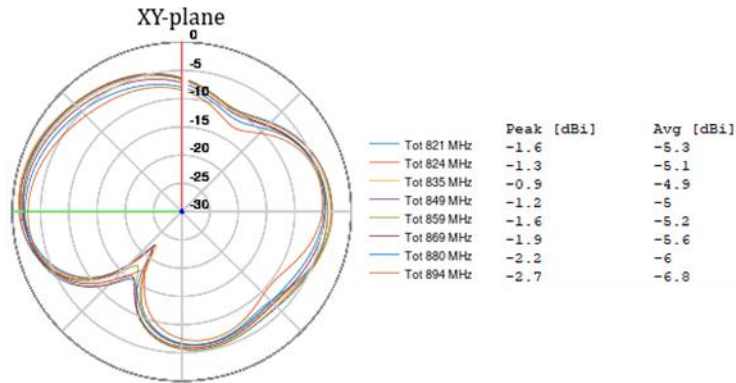


Figure 5-28 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 5,18,19,26

LTE bands: 8

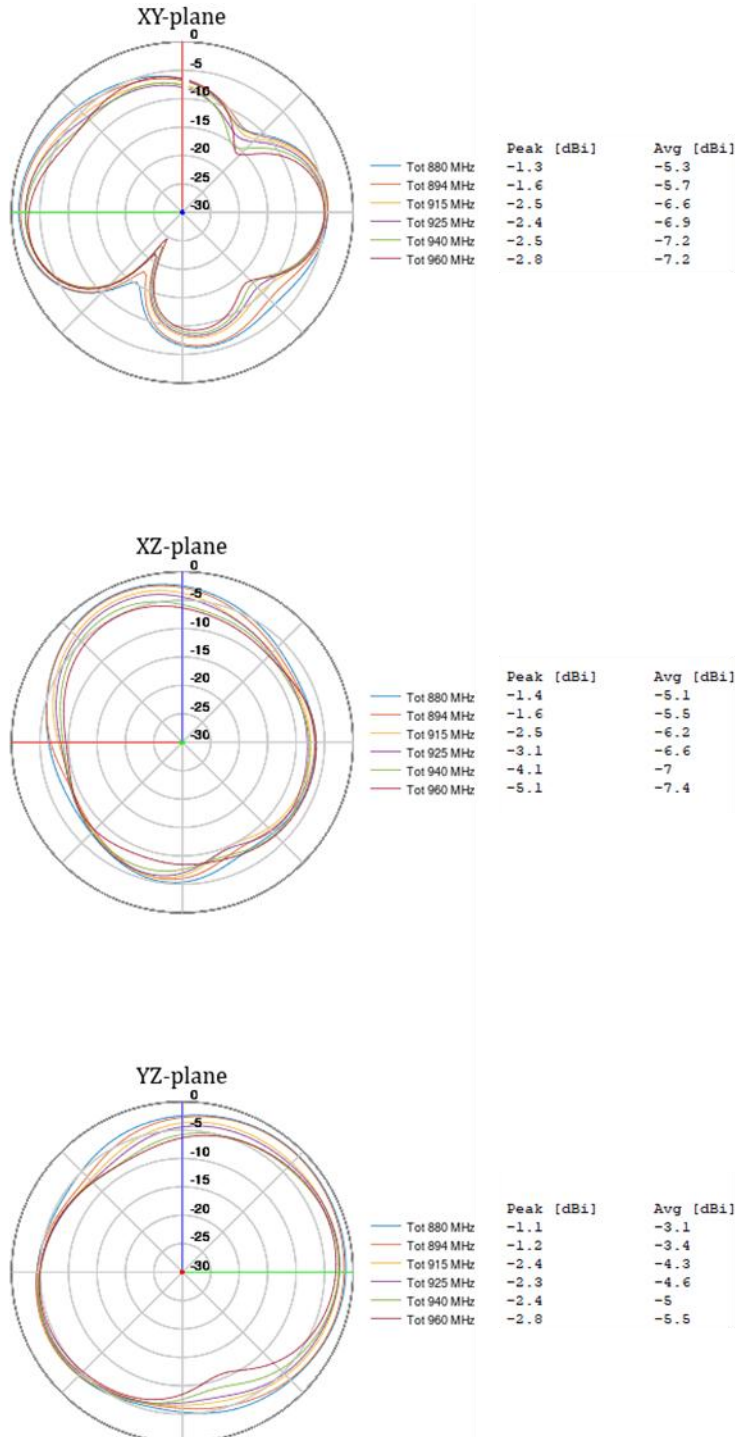
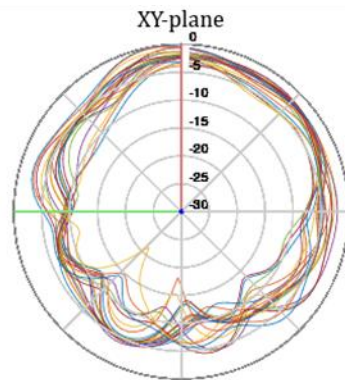


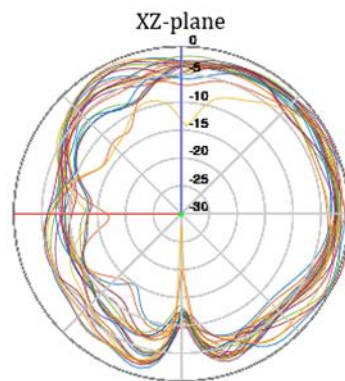
Figure 5-29 2D radiation patterns Flir-i1845; Cellular main antenna LTE band 8

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



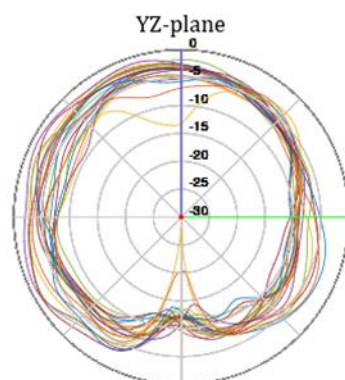
Tot 1710 MHz	-2.2
Tot 1745 MHz	-1.7
Tot 1785 MHz	-1.7
Tot 1805 MHz	-1.6
Tot 1850 MHz	-2
Tot 1880 MHz	-1.9
Tot 1910 MHz	-2.1
Tot 1920 MHz	-1.9
Tot 1930 MHz	-1.8
Tot 1950 MHz	-1.3
Tot 1980 MHz	-1.4
Tot 1990 MHz	-2
Tot 1995 MHz	-3
Tot 2040 MHz	-2.7
Tot 2070 MHz	-2.1
Tot 2110 MHz	-2
Tot 2140 MHz	-1.7
Tot 2170 MHz	-0.6
Tot 2300 MHz	-0.1
Tot 2350 MHz	-0.2
Tot 2400 MHz	-1

Peak [dBi]	Avg [dBi]
-2.2	-5.6
-1.7	-5.4
-1.7	-5.1
-1.6	-4.9
-2	-5.1
-1.9	-5
-2.1	-5.2
-1.9	-5.3
-1.8	-5.5
-1.3	-5.1
-1.4	-6.1
-2	-6.2
-3	-6.3
-2.7	-5.8
-2.1	-5.2
-2	-4.6
-1.7	-4.6
-0.6	-4
-0.1	-3.8
-0.2	-4.3
-1	-5.6



Tot 1710 MHz	-1.3
Tot 1745 MHz	-1.4
Tot 1785 MHz	-0.6
Tot 1805 MHz	-0.7
Tot 1850 MHz	-0.9
Tot 1880 MHz	-1.2
Tot 1910 MHz	-1.5
Tot 1920 MHz	-1.7
Tot 1930 MHz	-1.7
Tot 1950 MHz	-0.2
Tot 1980 MHz	-1.6
Tot 1990 MHz	-1.6
Tot 1995 MHz	-1.9
Tot 2040 MHz	-2.7
Tot 2070 MHz	-2
Tot 2110 MHz	-1.6
Tot 2140 MHz	-0.2
Tot 2170 MHz	0.5
Tot 2300 MHz	0.1
Tot 2350 MHz	0.2
Tot 2400 MHz	-0.8

Peak [dBi]	Avg [dBi]
-1.3	-5
-1.4	-4.6
-0.6	-4.2
-0.7	-4.1
-0.9	-4
-1.2	-4.2
-1.5	-4.3
-1.7	-4.4
-1.7	-4.5
-0.2	-3.8
-1.6	-4.7
-1.6	-5
-1.9	-5.2
-2.7	-5.1
-2	-4.5
-1.6	-4.1
-0.2	-3.6
0.5	-3.5
0.1	-3.3
0.2	-3.9
-0.8	-4.8



Tot 1710 MHz	-2.1
Tot 1745 MHz	-2.3
Tot 1785 MHz	-2.3
Tot 1805 MHz	-2.8
Tot 1850 MHz	-3.6
Tot 1880 MHz	-4.1
Tot 1910 MHz	-4.2
Tot 1920 MHz	-4.3
Tot 1930 MHz	-4.4
Tot 1950 MHz	-3.7
Tot 1980 MHz	-3
Tot 1990 MHz	-3.1
Tot 1995 MHz	-2.8
Tot 2040 MHz	-1.9
Tot 2070 MHz	-1.5
Tot 2110 MHz	-0.9
Tot 2140 MHz	-1.4
Tot 2170 MHz	-1.1
Tot 2300 MHz	-2.9
Tot 2350 MHz	-3.3
Tot 2400 MHz	-3.5

Peak [dBi]	Avg [dBi]
-2.1	-5.7
-2.3	-5.6
-2.3	-5.6
-2.8	-5.8
-3.6	-6.2
-4.1	-6.7
-4.2	-7
-4.3	-7.2
-4.4	-7.5
-3.7	-6.8
-3	-7.2
-3.1	-7
-2.8	-6.7
-1.9	-5.1
-1.5	-4.5
-0.9	-3.9
-1.4	-4.1
-1.1	-4
-2.9	-4.8
-3.3	-5.8
-3.5	-7



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

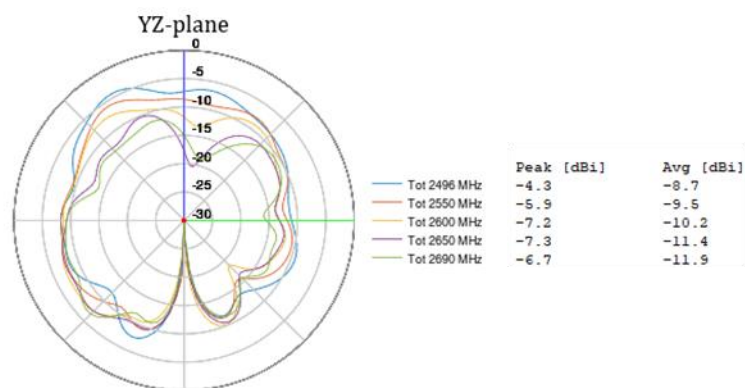
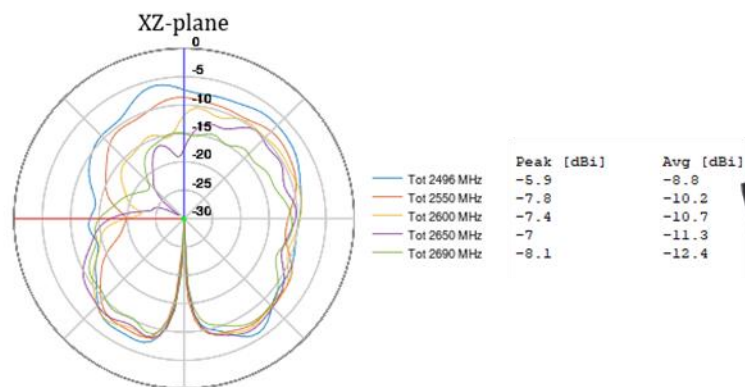
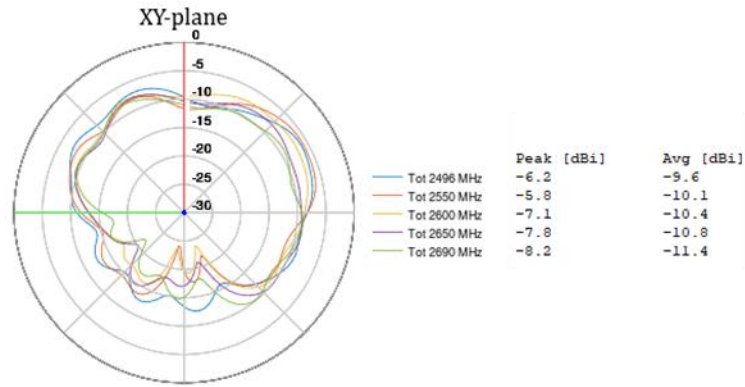
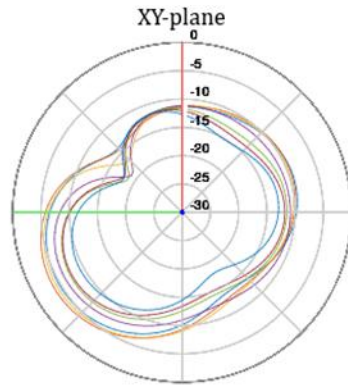


Figure 5-31 2D radiation patterns Flir-i1845; Cellular main antenna LTE bands 7,38,41

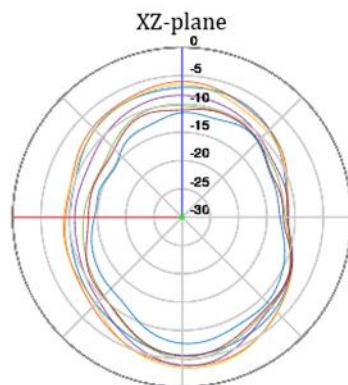
5.3.2 Cellular diversity antenna

LTE bands: 12, 13, 28



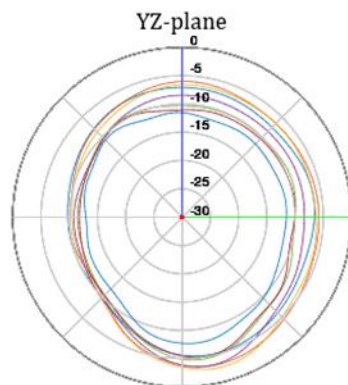
Band	Peak [dBi]	Avg [dBi]
Tot 729 MHz	-4.8	-9.1
Tot 745 MHz	-3.7	-8.5
Tot 756 MHz	-4.3	-8.8
Tot 775 MHz	-6.2	-10.2
Tot 787 MHz	-7.2	-11.3
Tot 791 MHz	-7.5	-11.7
Tot 803 MHz	-9.3	-13

Band	Peak [dBi]	Avg [dBi]
Tot 729 MHz	-4.8	-9.1
Tot 745 MHz	-3.7	-8.5
Tot 756 MHz	-4.3	-8.8
Tot 775 MHz	-6.2	-10.2
Tot 787 MHz	-7.2	-11.3
Tot 791 MHz	-7.5	-11.7
Tot 803 MHz	-9.3	-13



Band	Peak [dBi]	Avg [dBi]
Tot 729 MHz	-5.6	-7.9
Tot 745 MHz	-3.7	-7
Tot 756 MHz	-3.3	-7.1
Tot 775 MHz	-3.7	-8.2
Tot 787 MHz	-4.8	-9.3
Tot 791 MHz	-5.4	-9.7
Tot 803 MHz	-7.6	-11.1

Band	Peak [dBi]	Avg [dBi]
Tot 729 MHz	-5.6	-7.9
Tot 745 MHz	-3.7	-7
Tot 756 MHz	-3.3	-7.1
Tot 775 MHz	-3.7	-8.2
Tot 787 MHz	-4.8	-9.3
Tot 791 MHz	-5.4	-9.7
Tot 803 MHz	-7.6	-11.1



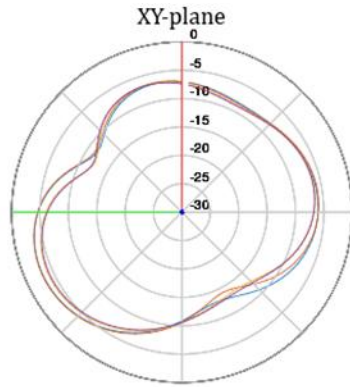
Band	Peak [dBi]	Avg [dBi]
Tot 729 MHz	-5.2	-7.3
Tot 745 MHz	-3.2	-6.3
Tot 756 MHz	-2.6	-6.5
Tot 775 MHz	-3.3	-7.7
Tot 787 MHz	-4.6	-8.9
Tot 791 MHz	-5	-9.2
Tot 803 MHz	-7.6	-10.8

Band	Peak [dBi]	Avg [dBi]
Tot 729 MHz	-5.2	-7.3
Tot 745 MHz	-3.2	-6.3
Tot 756 MHz	-2.6	-6.5
Tot 775 MHz	-3.3	-7.7
Tot 787 MHz	-4.6	-8.9
Tot 791 MHz	-5	-9.2
Tot 803 MHz	-7.6	-10.8

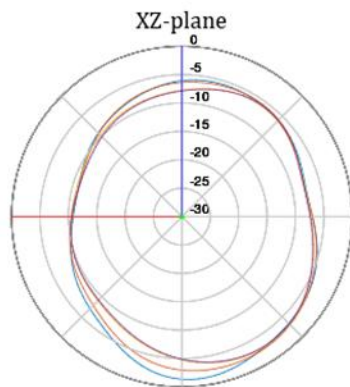


Figure 5-32 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 12, 13, 28

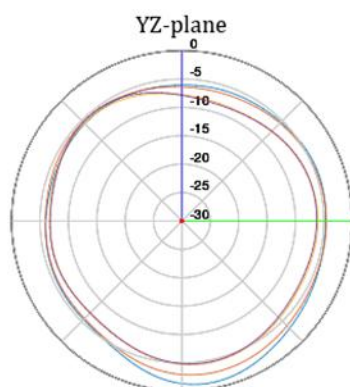
LTE band: 20



	Peak [dBi]	Avg [dBi]
Tot 791 MHz	-3.1	-7
Tot 803 MHz	-3	-7
Tot 821 MHz	-4.1	-7.7
Tot 824 MHz	-4.3	-7.8



	Peak [dBi]	Avg [dBi]
Tot 791 MHz	-1.3	-5.5
Tot 803 MHz	-2.5	-5.9
Tot 821 MHz	-2.8	-6.6
Tot 824 MHz	-3	-6.7



	Peak [dBi]	Avg [dBi]
Tot 791 MHz	-1	-4.4
Tot 803 MHz	-2.7	-4.9
Tot 821 MHz	-4.6	-6.3
Tot 824 MHz	-4.7	-6.4



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

LTE bands: 5,18,19,26

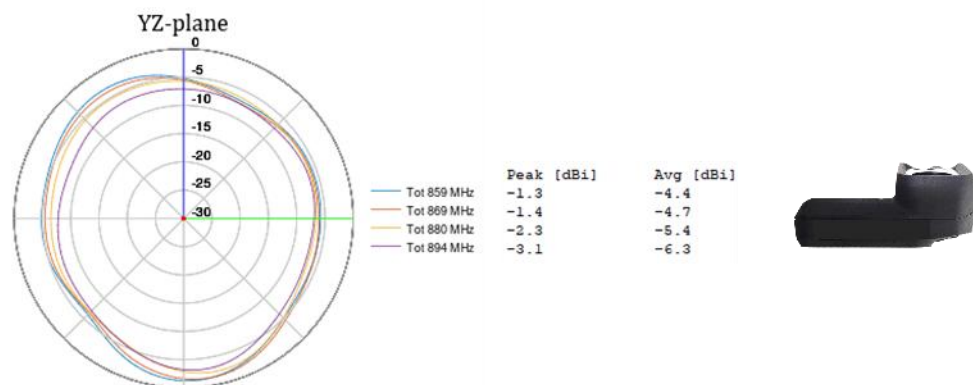
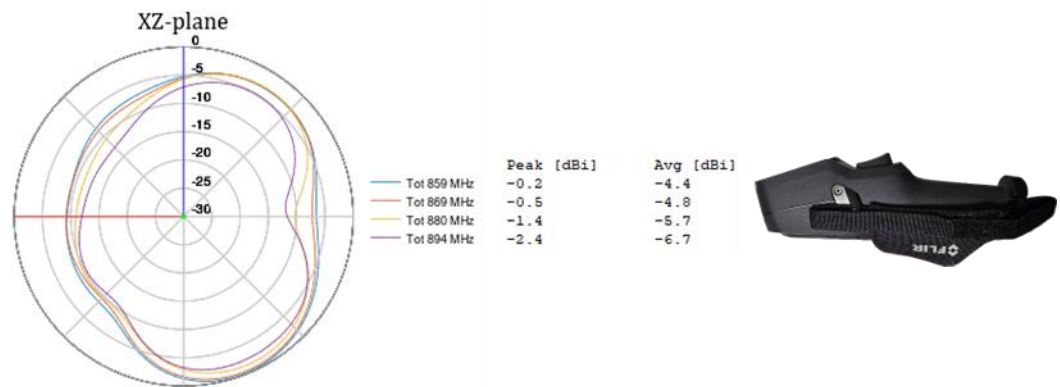
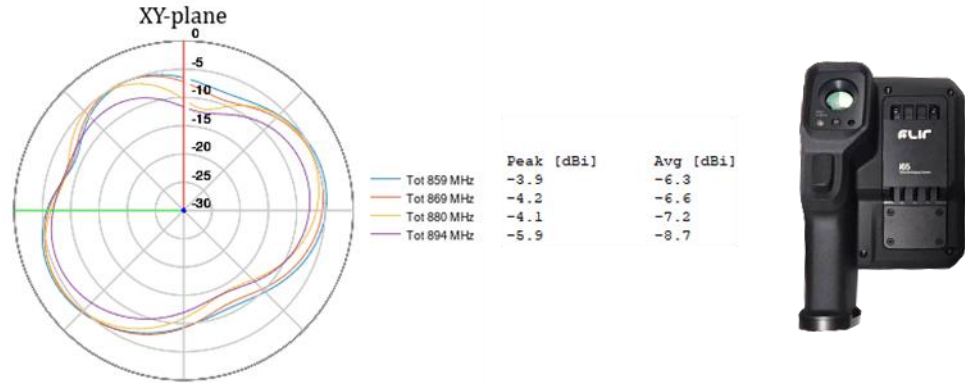


Figure 5-34 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 5,18,19,26

LTE bands: 8

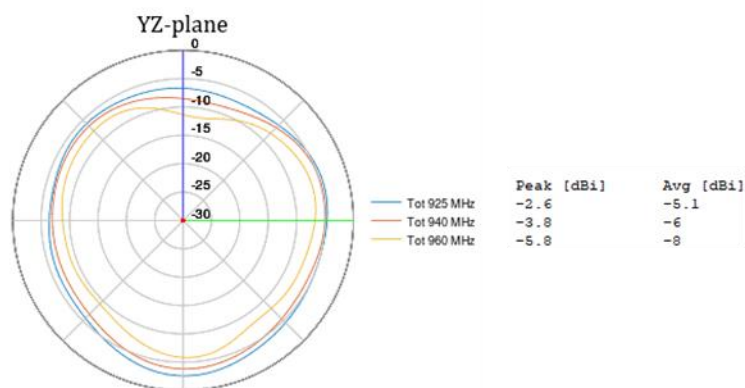
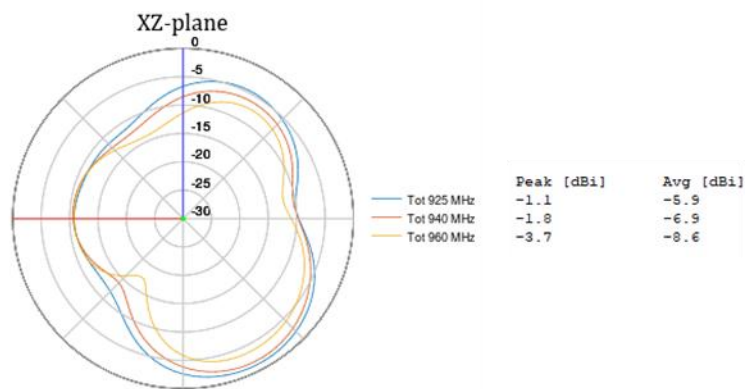
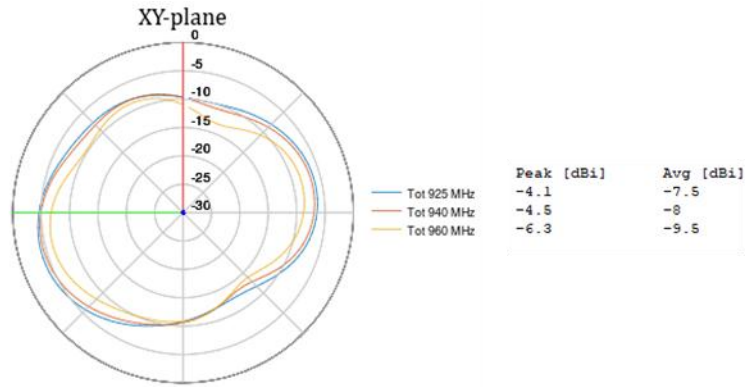


Figure 5-35 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE band 8

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

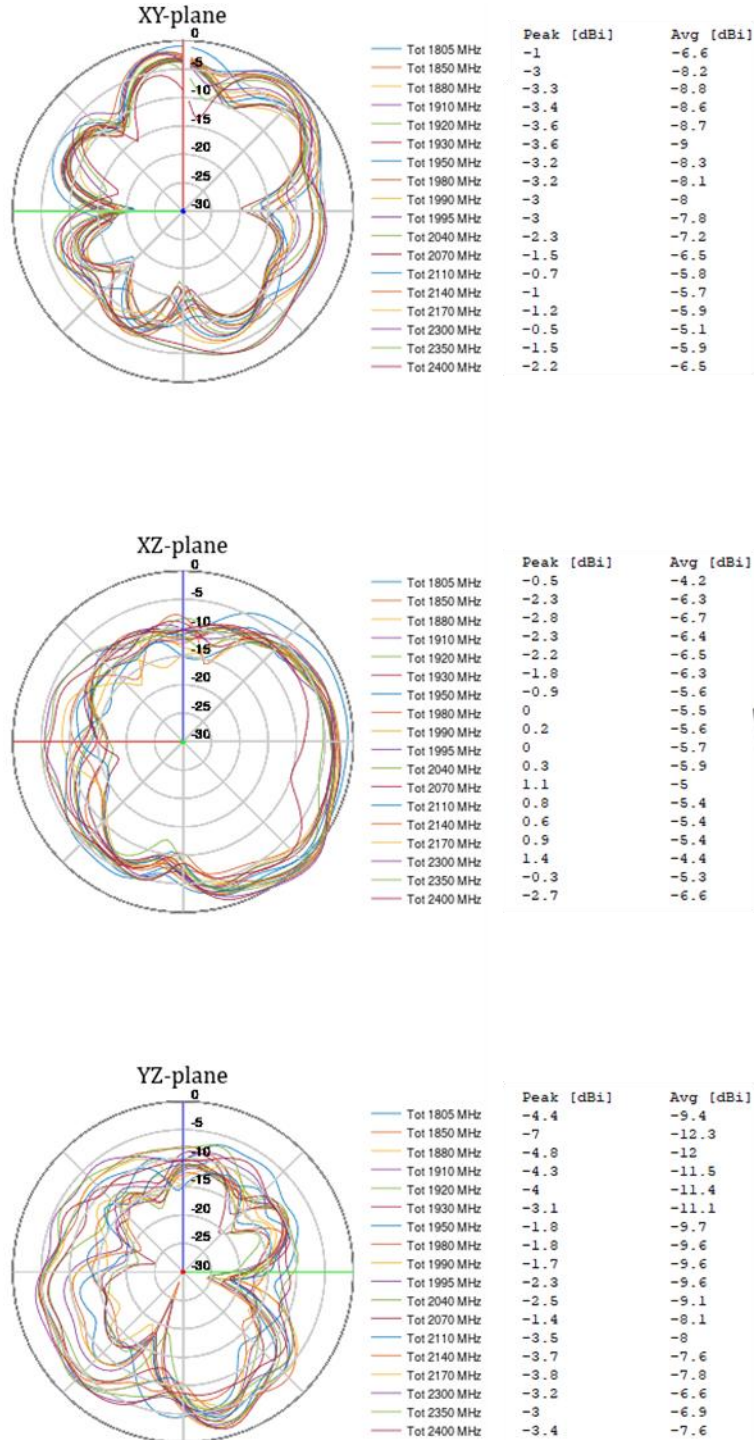


Figure 5-36 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 1,2,3,4,25,39,40

LTE bands: 7,38,41

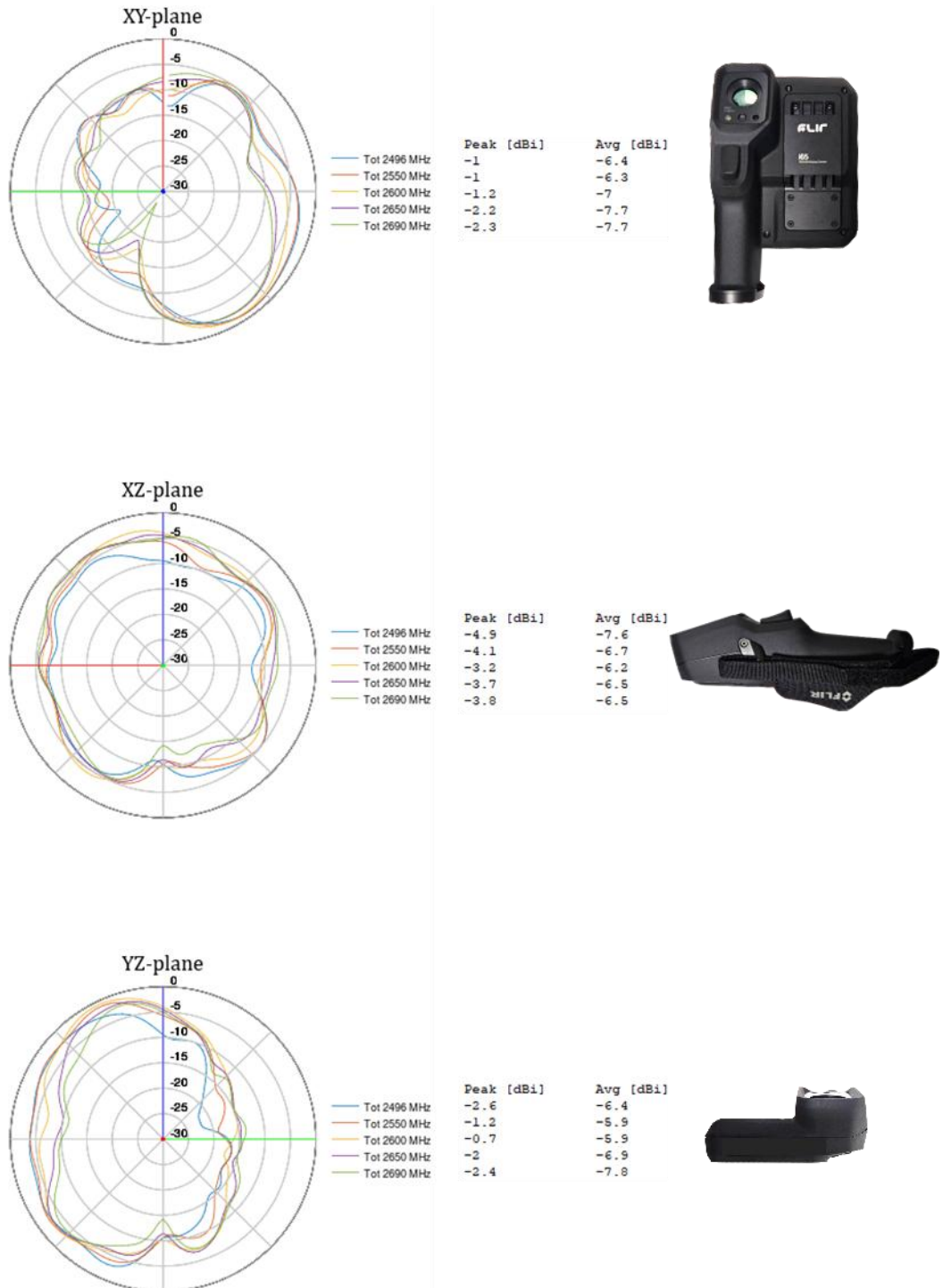


Figure 5-37 2D radiation patterns Flir-i1845; Cellular diversity antenna LTE bands 7,38,41

5.3.3 Wi-Fi antenna

2.4GHz band

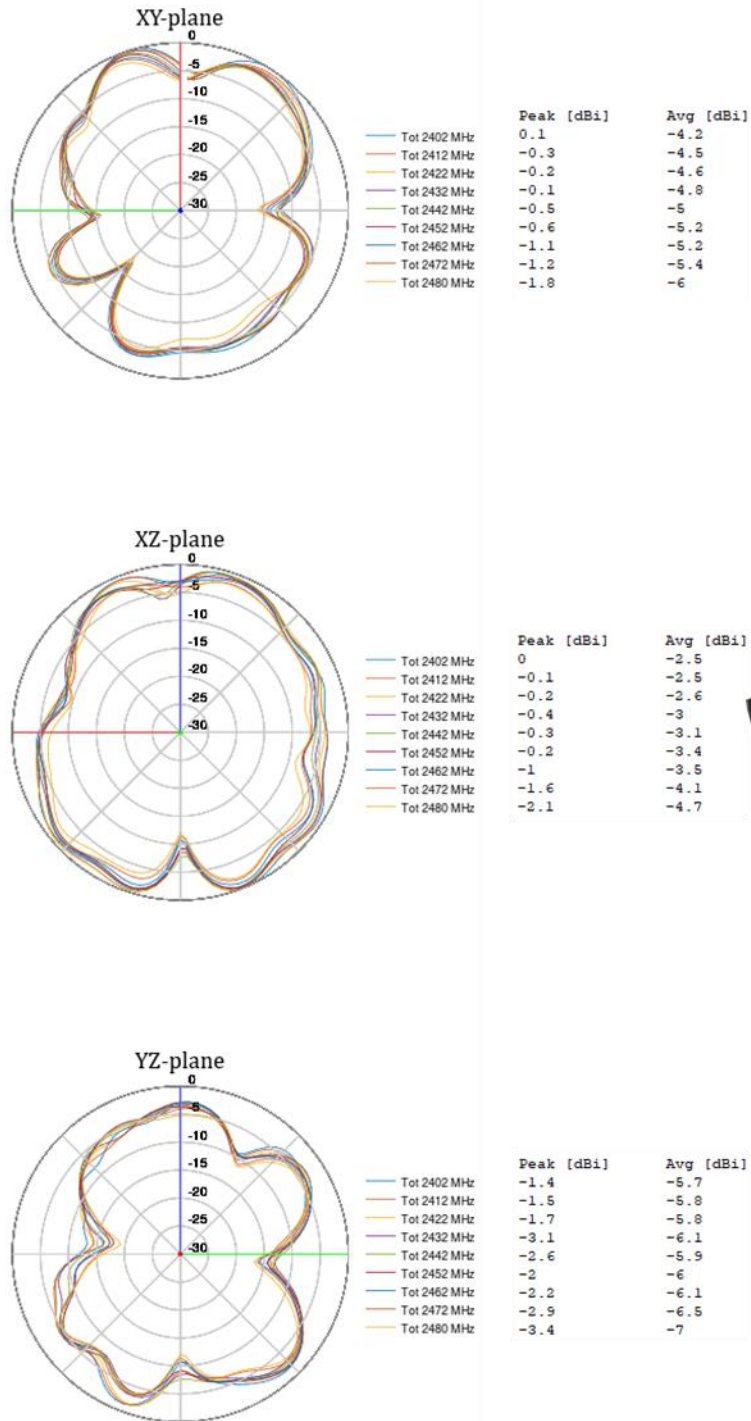


Figure 5-38 2D radiation patterns Flir-i1845; Wi-Fi antenna 2.4GHz band

5GHz band

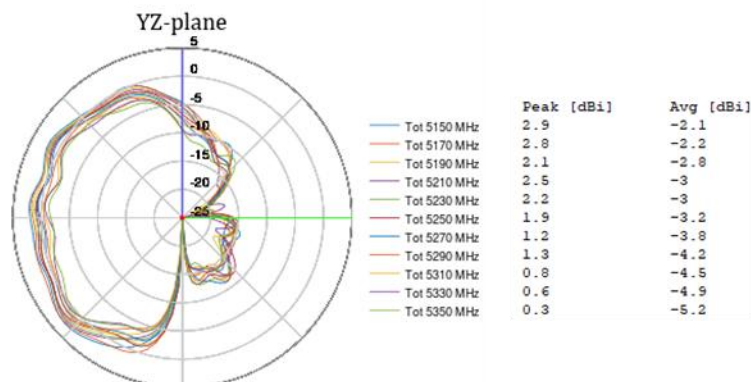
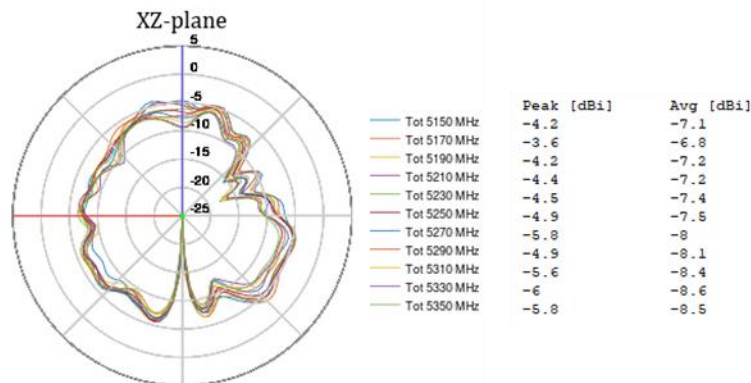
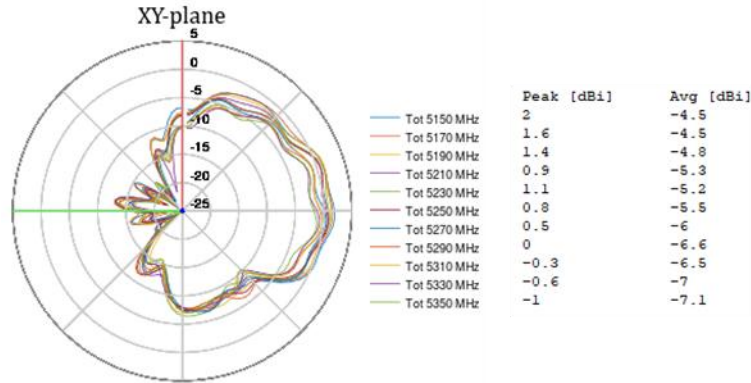


Figure 5-39 2D radiation patterns Flir-i1845; Wi-Fi antenna 5GHz band

5.3.4 GNSS antenna

LTE bands setting 12, 13, 28

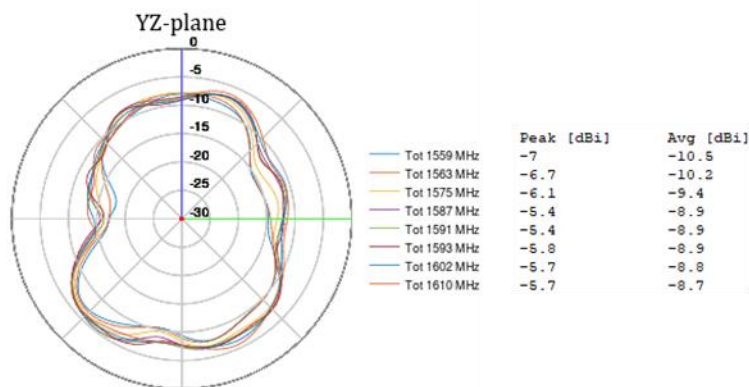
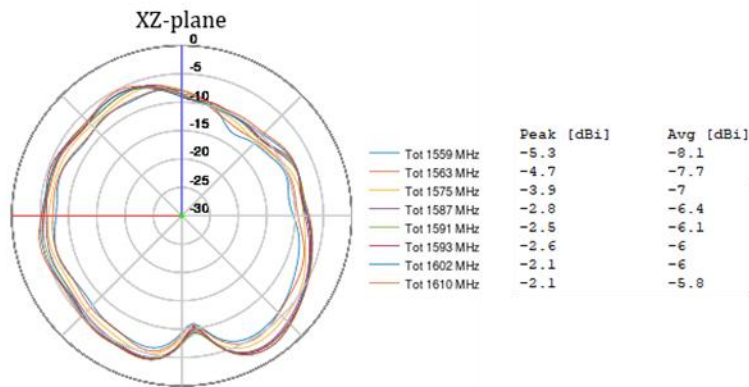
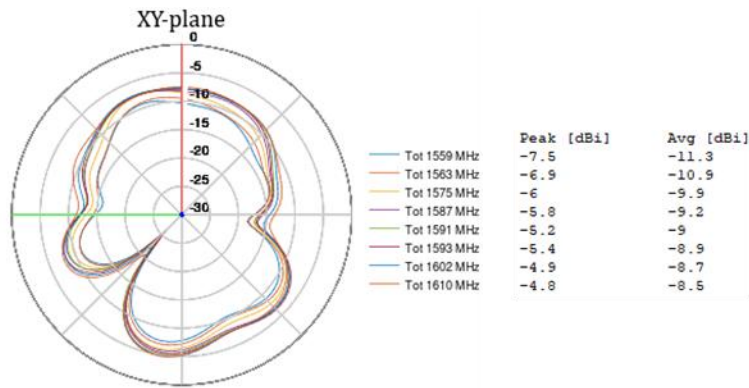


Figure 5-40 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 12, 13, 28

LTE bands setting 20

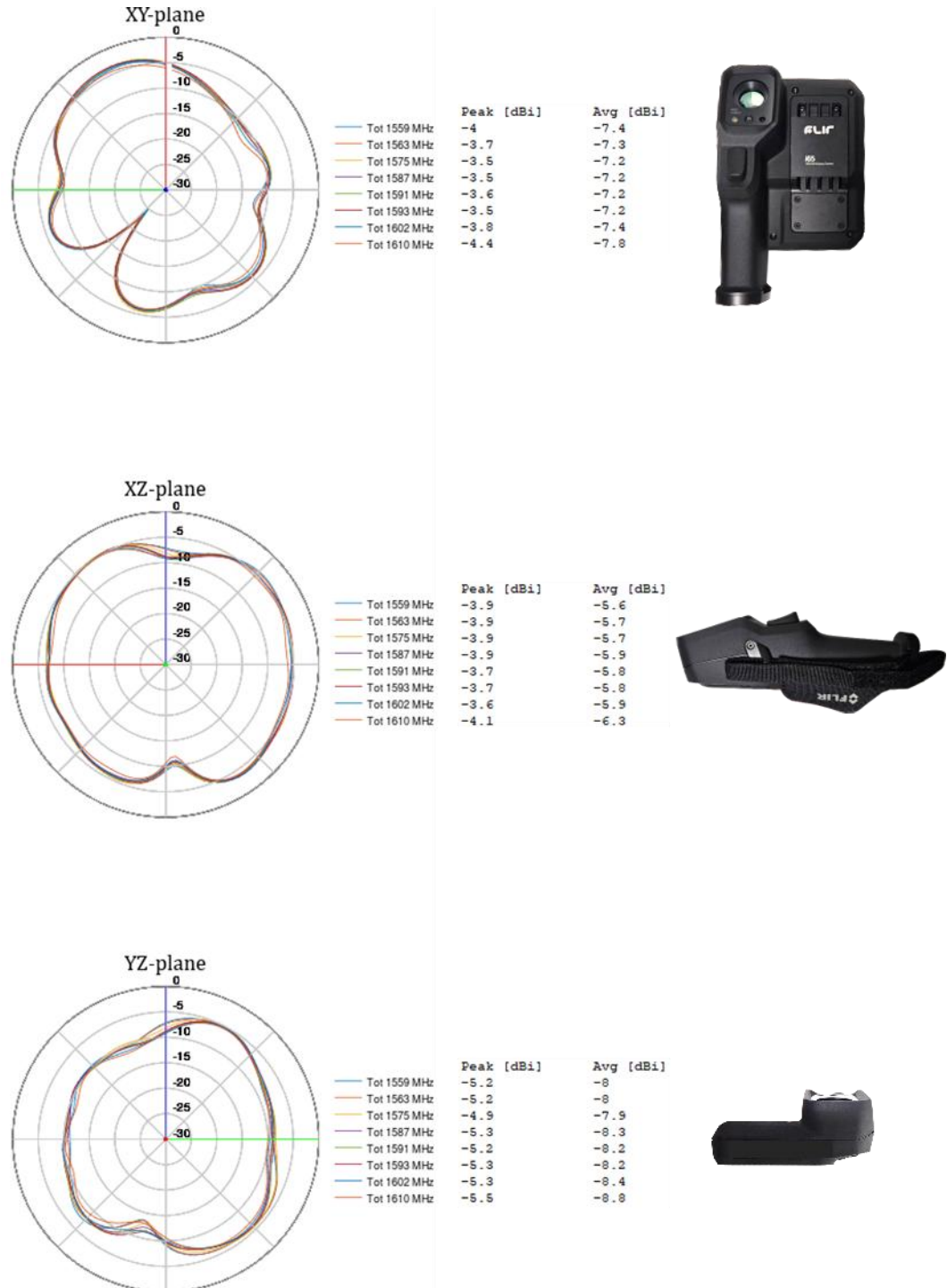
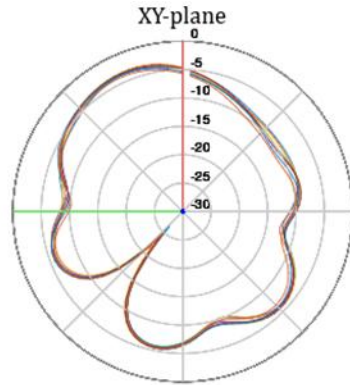
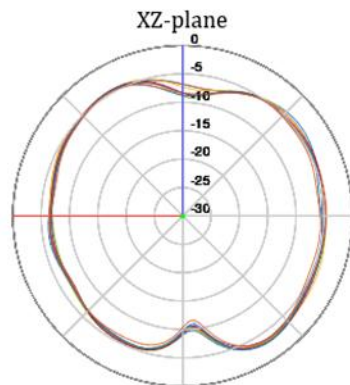


Figure 5-41 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 20

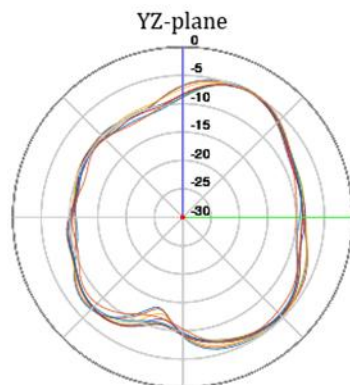
LTE bands setting 5,18,19,26, 7, 38, 41



	Peak [dBi]	Avg [dBi]
Tot 1559 MHz	-3.6	-7.1
Tot 1563 MHz	-3.2	-7.2
Tot 1575 MHz	-3.3	-7
Tot 1587 MHz	-3.5	-7.2
Tot 1591 MHz	-3.3	-7
Tot 1593 MHz	-3.4	-7
Tot 1602 MHz	-3.7	-7.2
Tot 1610 MHz	-4	-7.5



	Peak [dBi]	Avg [dBi]
Tot 1559 MHz	-3.6	-5.4
Tot 1563 MHz	-3.7	-5.5
Tot 1575 MHz	-3.4	-5.4
Tot 1587 MHz	-3.6	-5.7
Tot 1591 MHz	-3.3	-5.6
Tot 1593 MHz	-3.2	-5.5
Tot 1602 MHz	-3.1	-5.7
Tot 1610 MHz	-3.6	-6

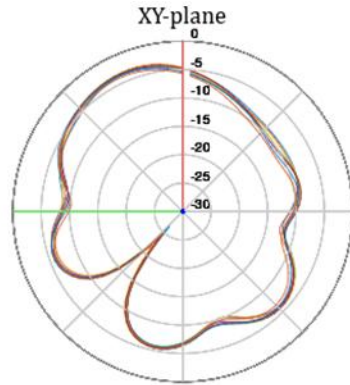


	Peak [dBi]	Avg [dBi]
Tot 1559 MHz	-4.7	-7.7
Tot 1563 MHz	-4.8	-7.7
Tot 1575 MHz	-4.8	-7.7
Tot 1587 MHz	-5	-8.1
Tot 1591 MHz	-4.9	-8
Tot 1593 MHz	-5	-8
Tot 1602 MHz	-4.9	-8.2
Tot 1610 MHz	-4.9	-8.5



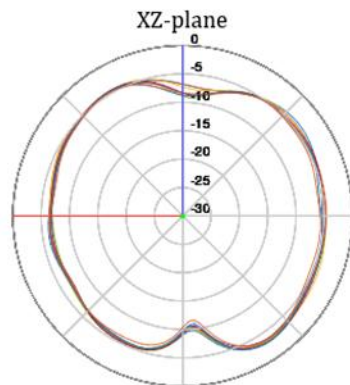
Figure 5-42 2D radiation patterns Flir-i1845; GNSS antenna LTE bands setting 5,18,19,26, 7, 38, 41

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



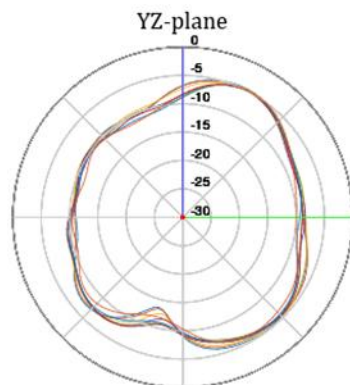
Tot 1559 MHz
Tot 1563 MHz
Tot 1575 MHz
Tot 1587 MHz
Tot 1591 MHz
Tot 1593 MHz
Tot 1602 MHz
Tot 1610 MHz

Peak [dBi]	Avg [dBi]
-3.6	-7.1
-3.2	-7.2
-3.3	-7
-3.5	-7.2
-3.3	-7
-3.4	-7
-3.7	-7.2
-4	-7.5



Tot 1559 MHz
Tot 1563 MHz
Tot 1575 MHz
Tot 1587 MHz
Tot 1591 MHz
Tot 1593 MHz
Tot 1602 MHz
Tot 1610 MHz

Peak [dBi]	Avg [dBi]
-3.6	-5.4
-3.7	-5.5
-3.4	-5.4
-3.6	-5.7
-3.3	-5.6
-3.2	-5.5
-3.1	-5.7
-3.6	-6



Tot 1559 MHz
Tot 1563 MHz
Tot 1575 MHz
Tot 1587 MHz
Tot 1591 MHz
Tot 1593 MHz
Tot 1602 MHz
Tot 1610 MHz

Peak [dBi]	Avg [dBi]
-4.7	-7.7
-4.8	-7.7
-4.8	-7.7
-5	-8.1
-4.9	-8
-5	-8
-4.9	-8.2
-4.9	-8.5



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

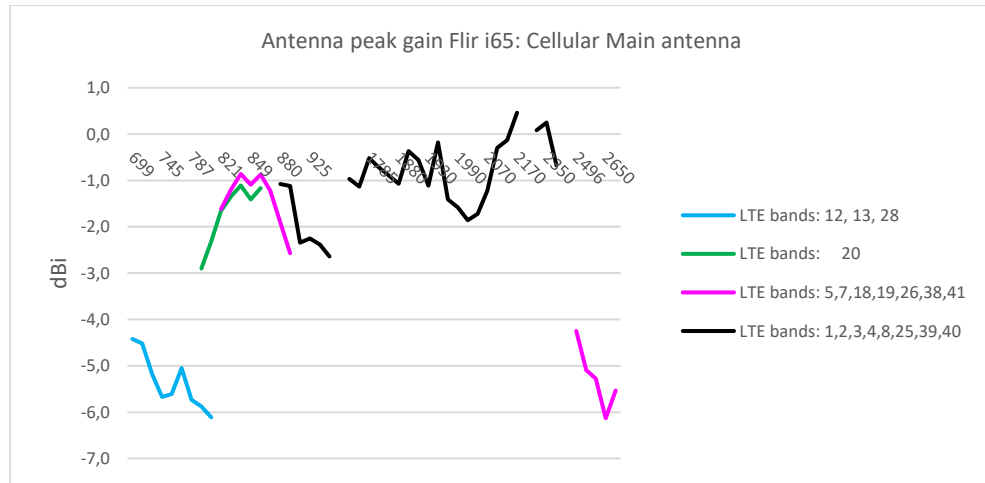


Figure 5-44 Antenna peak gain Flir-i1845; Cellular main antenna.



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

Frequency [MHz]	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
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

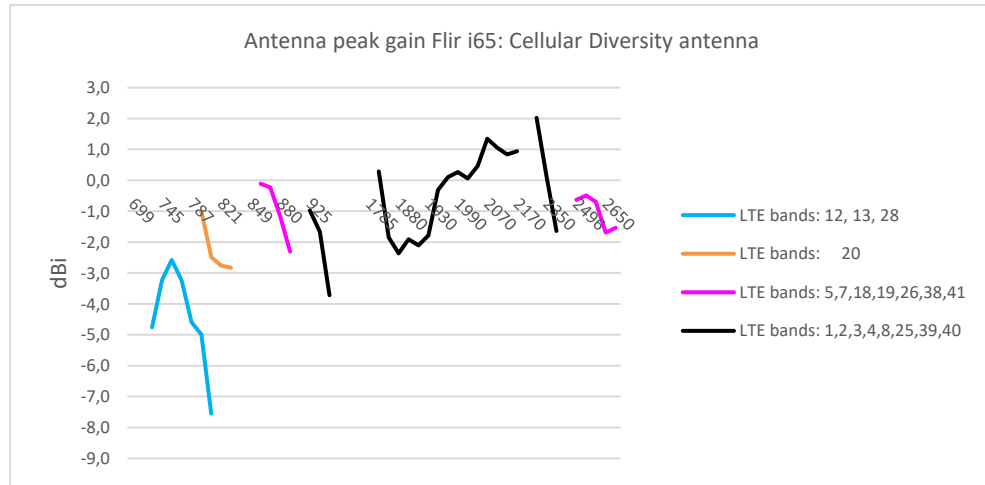


Figure 5-45 Antenna peak gain Flir-i1845; Cellular diversity antenna.



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

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	-4,76				
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

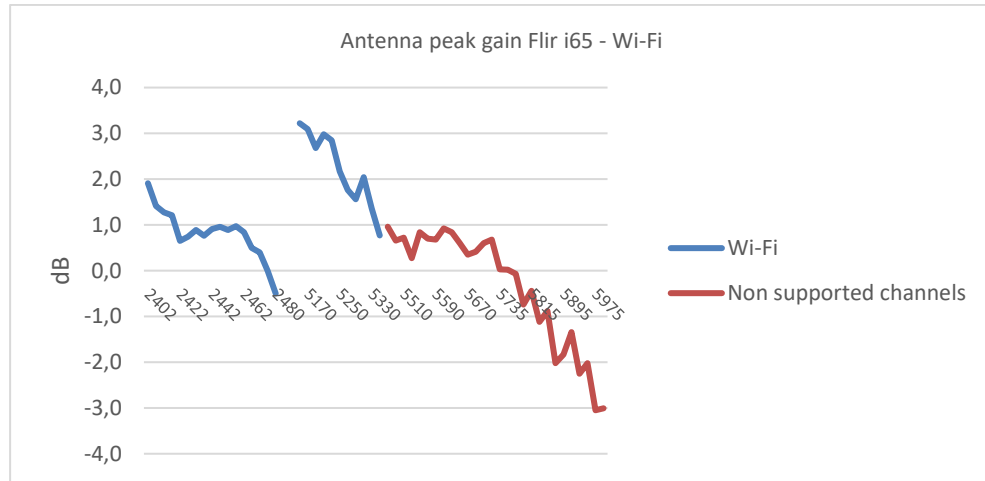


Figure 5-46 Antenna peak gain Flir-i1845; Wi-Fi antenna.



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

Frequency	Antenna peak gain
[MHz]	[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

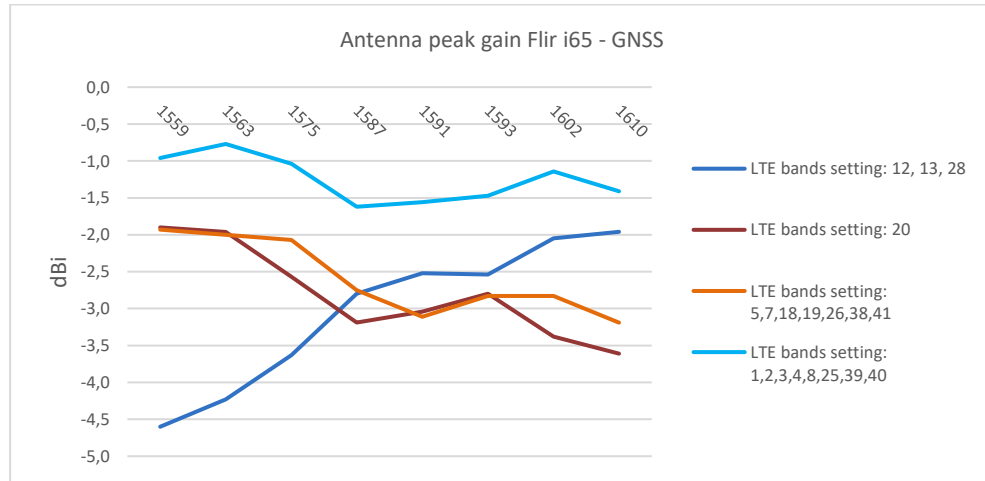


Figure 5-47 Antenna peak gain Flir-i1845; GNSS antenna.

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

Frequency [MHz]	Antenna peak gain [dBi]			
	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
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

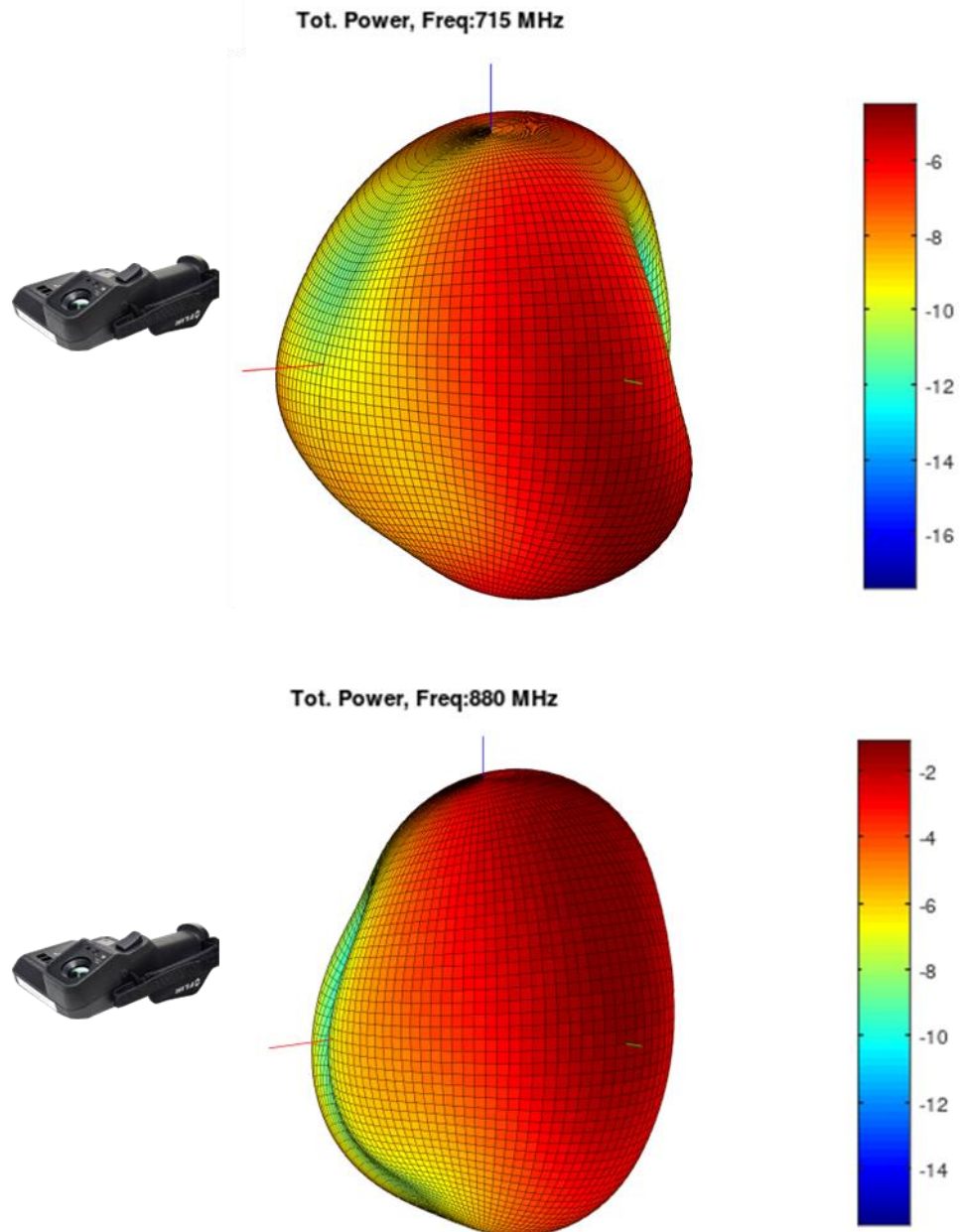


Figure A-1 3D radiation pattern for cellular main antenna, 715 and 880MHz.

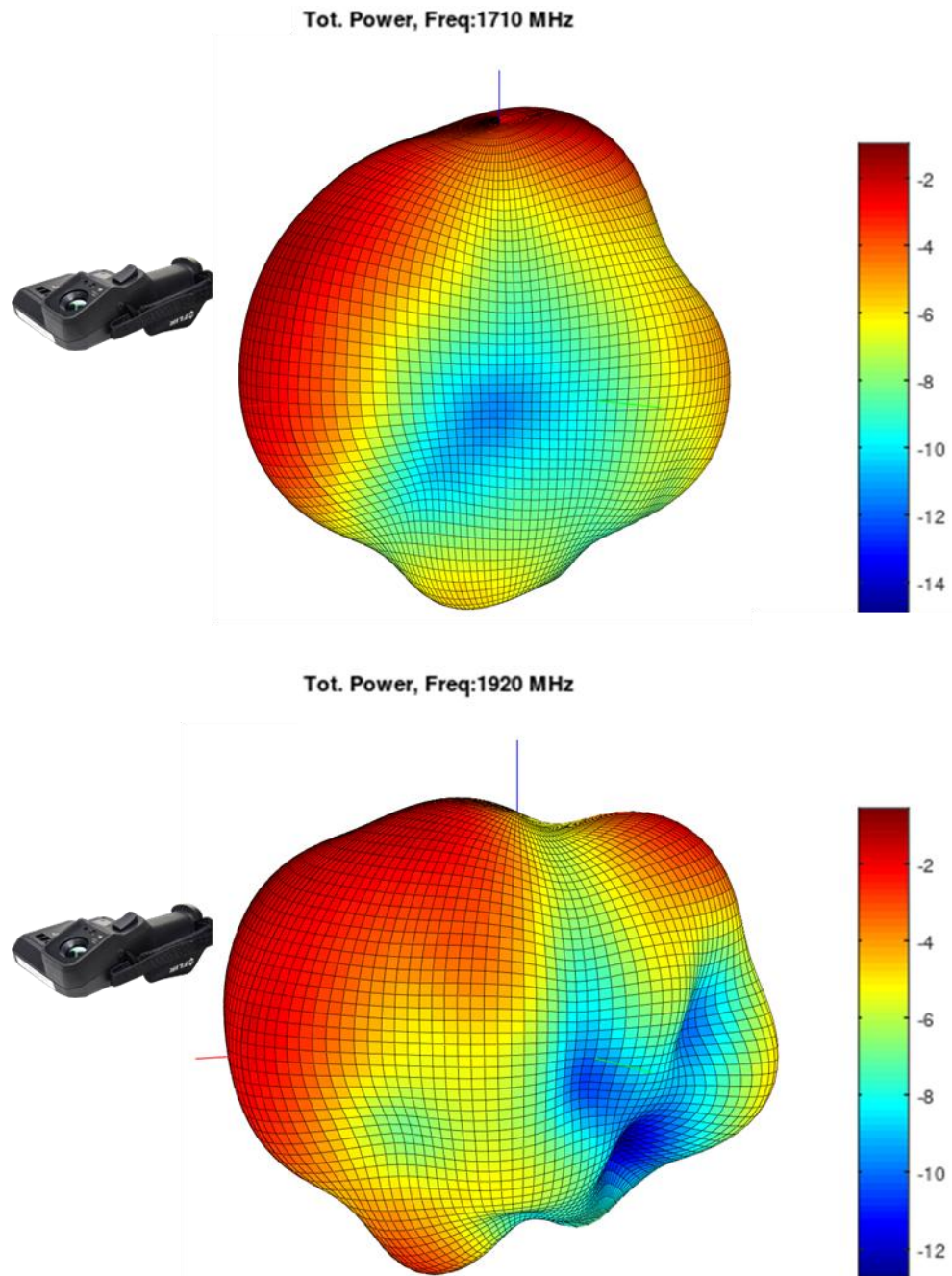


Figure A-2 3D radiation pattern for cellular main antenna, 1710 and 1920MHz.

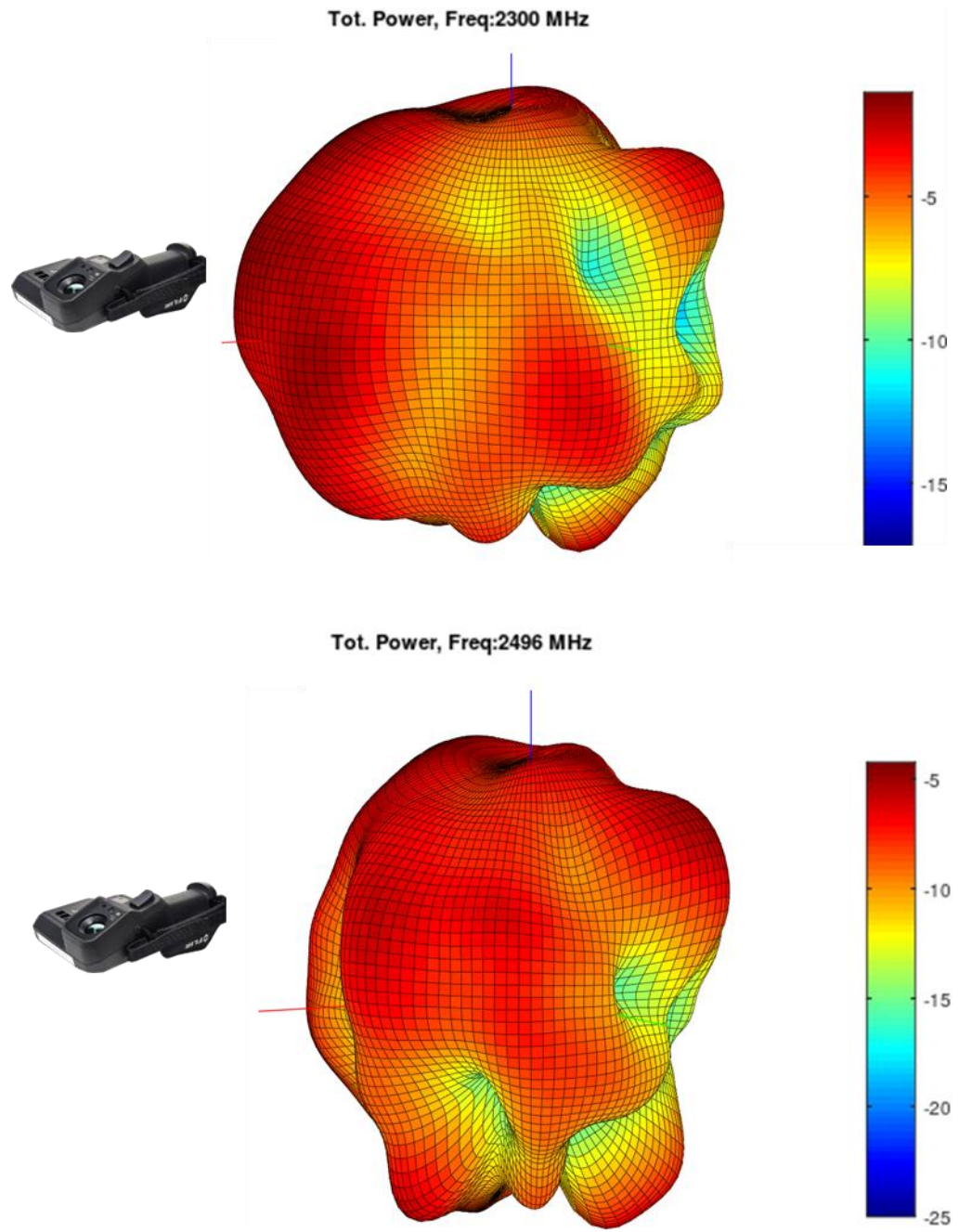


Figure A-3 3D radiation pattern for cellular main antenna, 2300 and 2496MHz.

A.2 Cellular diversity antenna

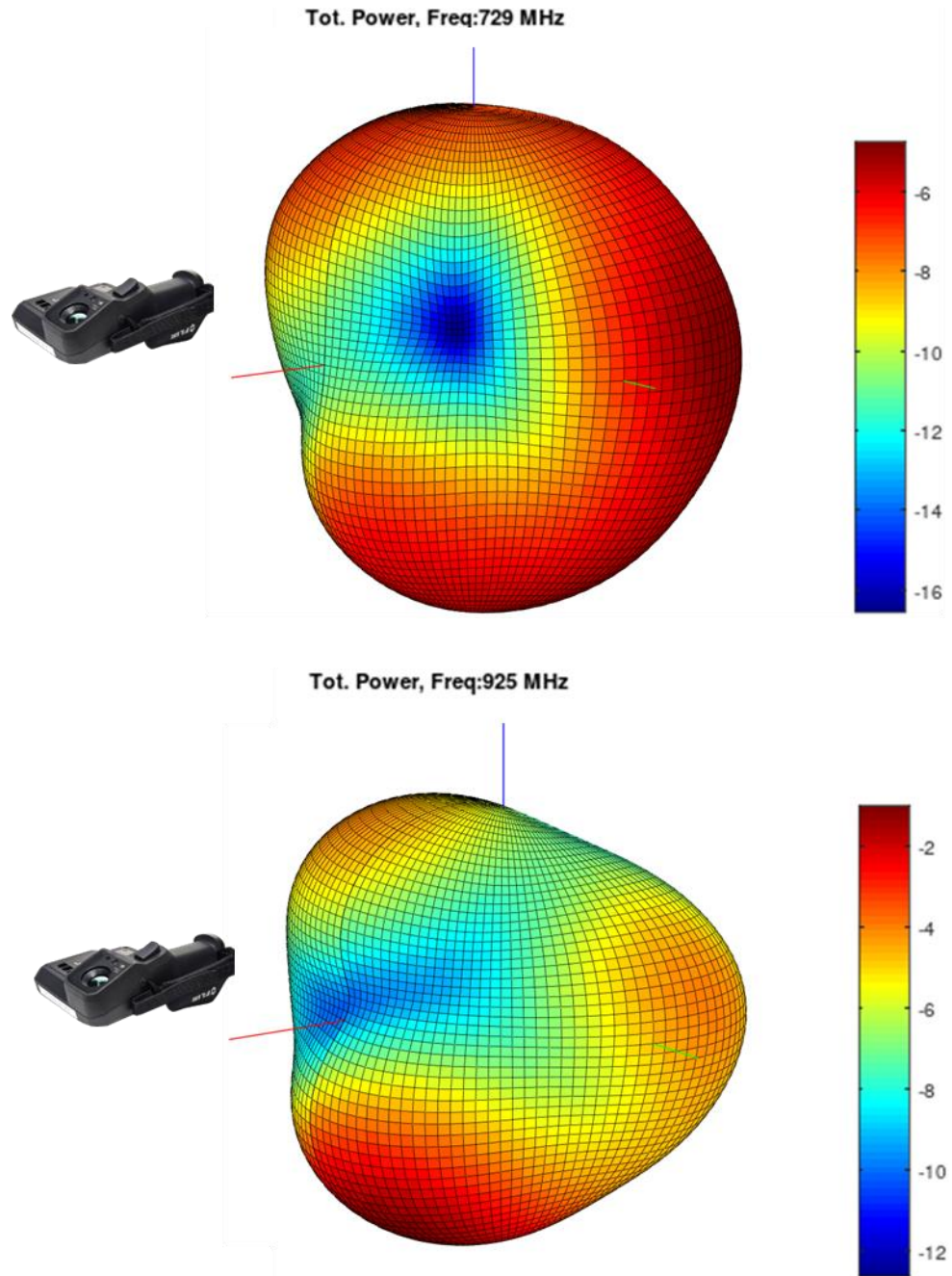


Figure A-4 3D radiation pattern for cellular diversity antenna, 729 and 925MHz.

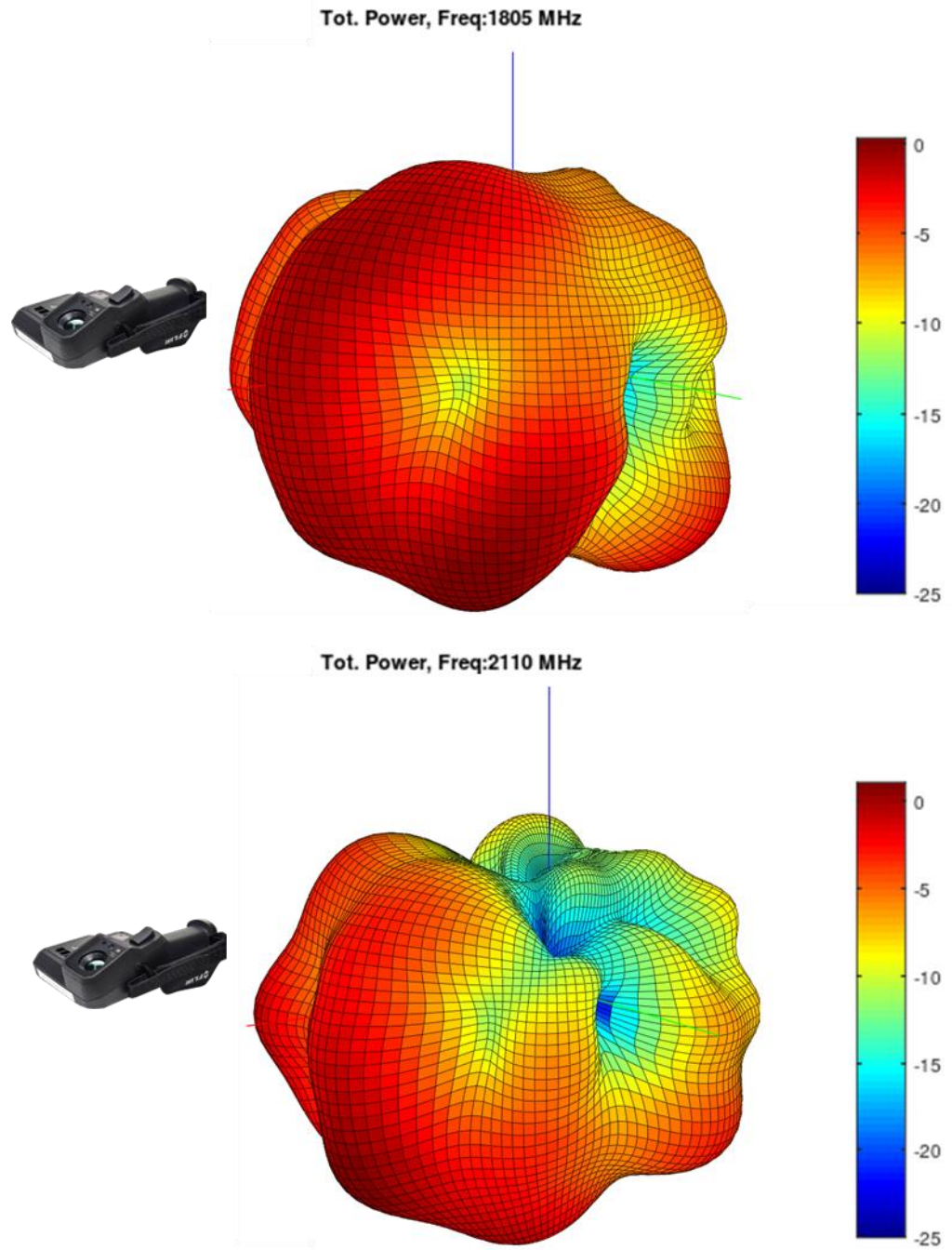


Figure A-5 3D radiation pattern for cellular diversity antenna, 1805 and 2110MHz.

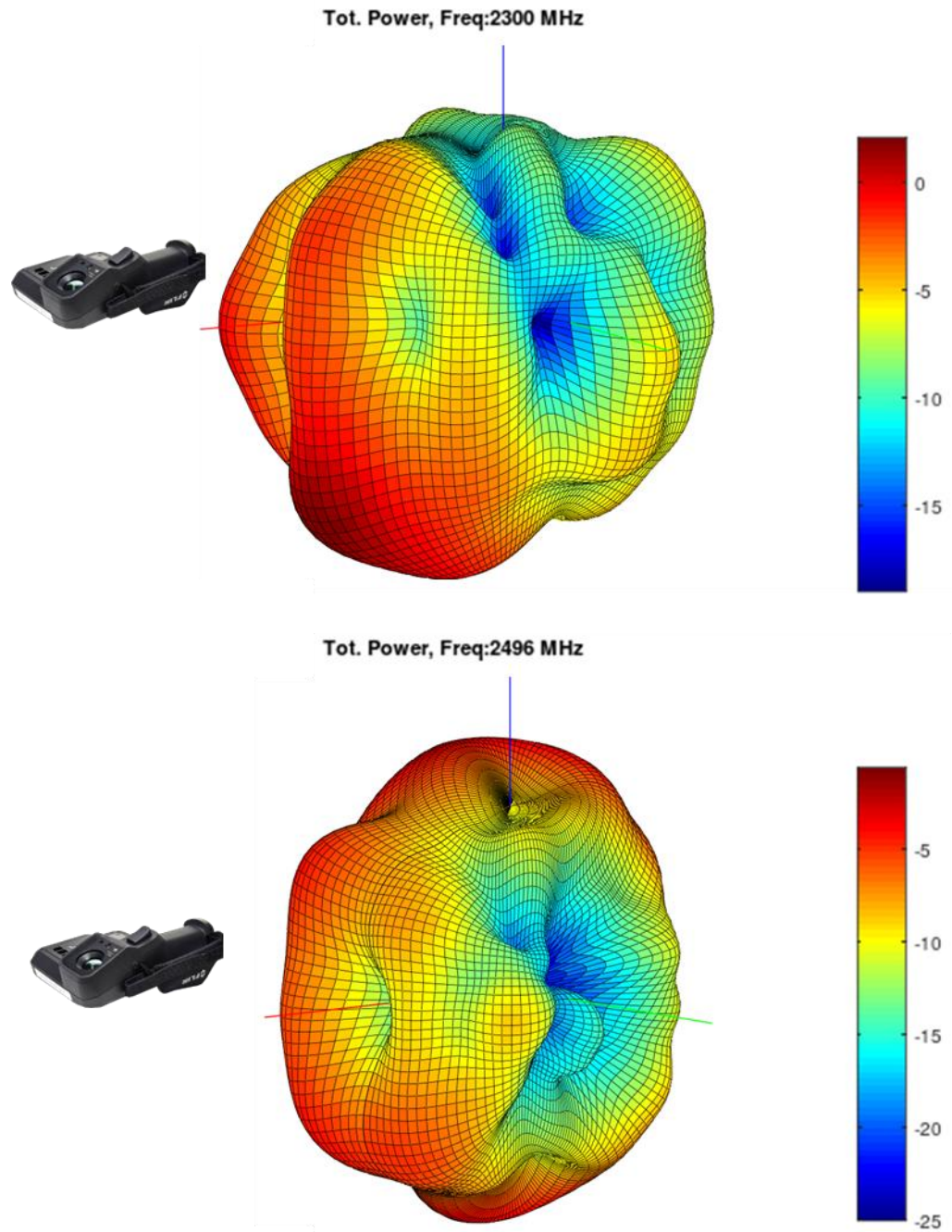


Figure A-6 3D radiation pattern for cellular diversity antenna, 2300 and 2496MHz.

A.3 Wi-Fi antenna

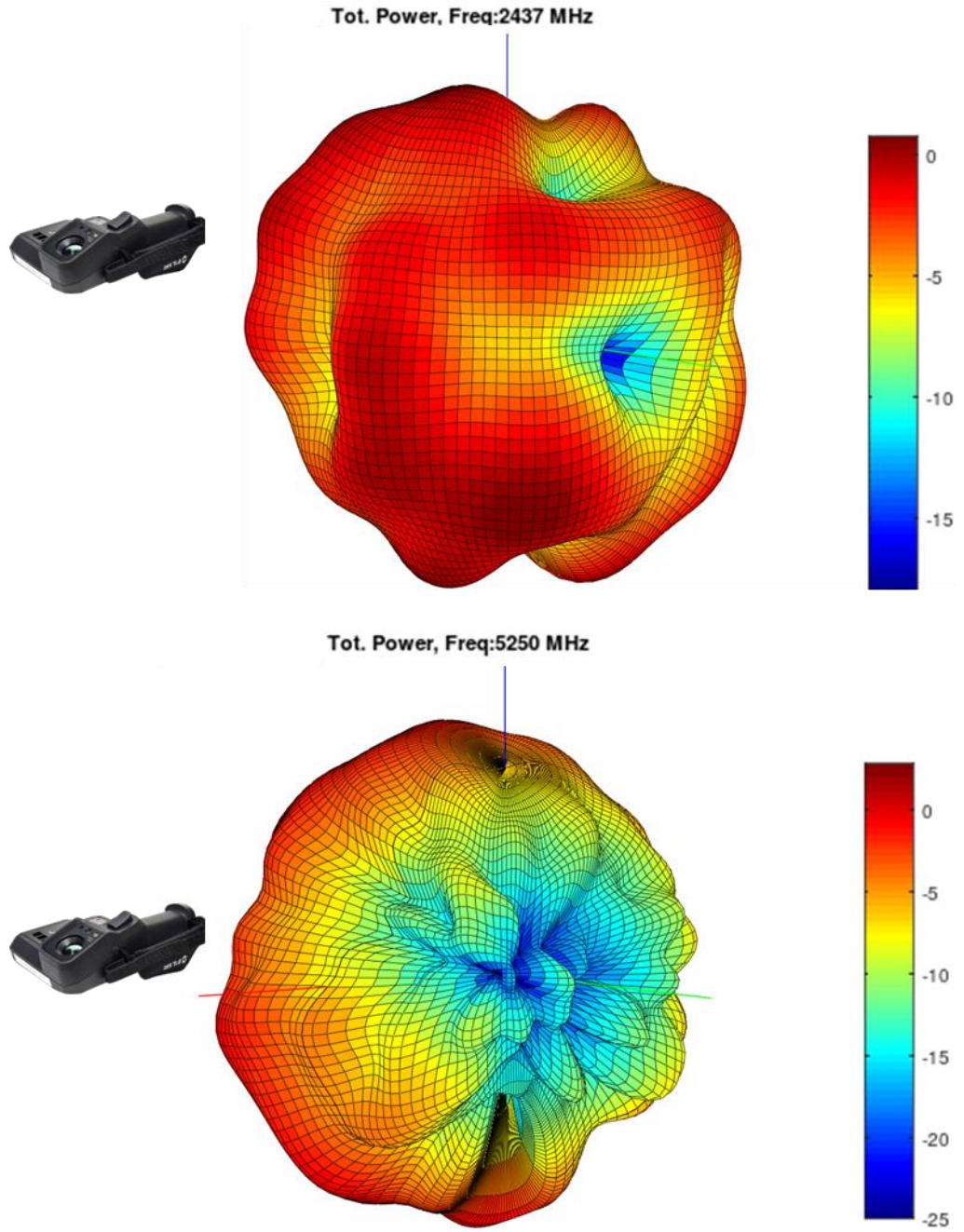


Figure A-7 3D radiation pattern for Wi-Fi antenna, 2437 and 5250MHz.

A.4 GNSS antenna

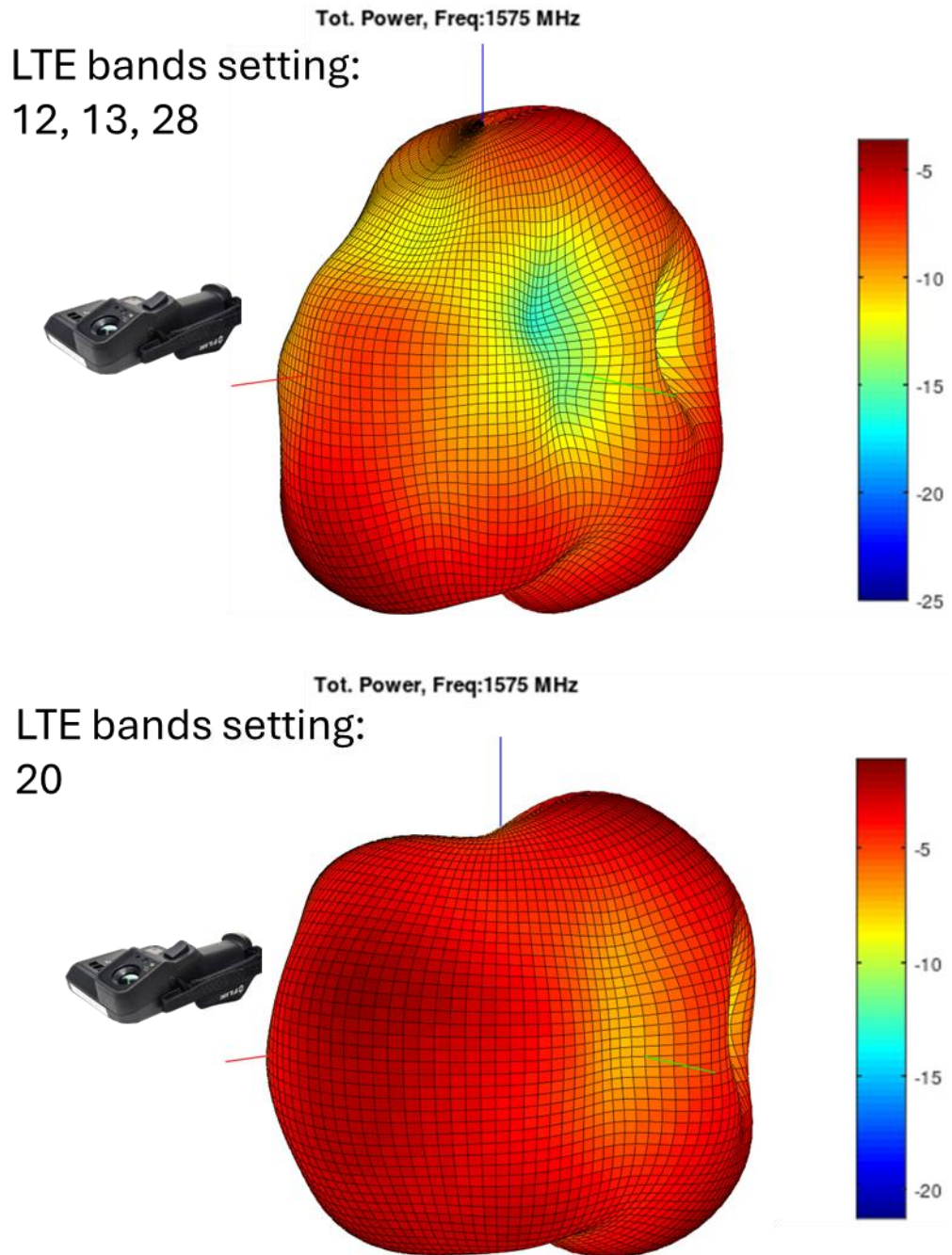


Figure A-8 3D radiation pattern for GNSS antenna, 1575MHz.

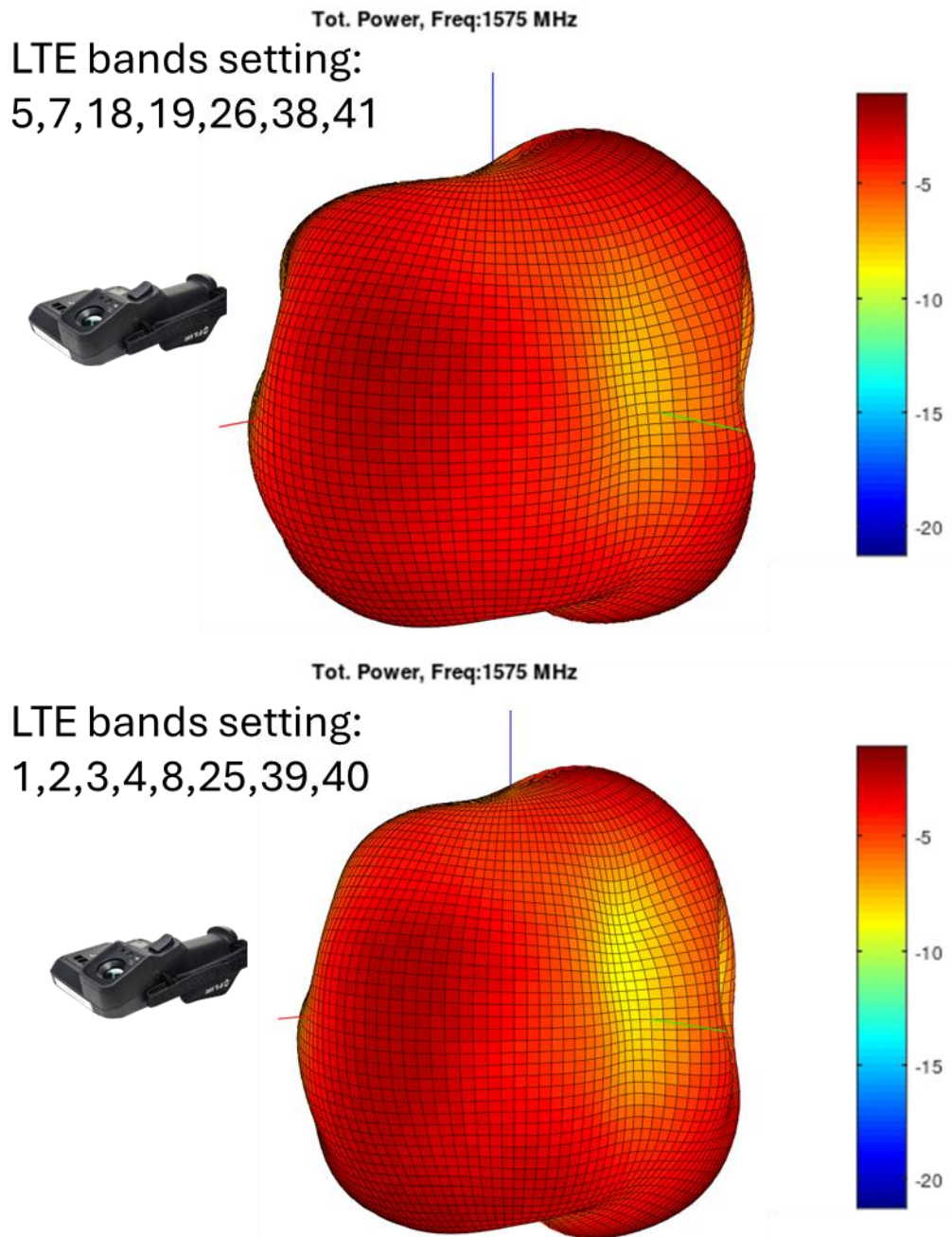


Figure A-9 3D radiation pattern for GNSS antenna, 1575MHz.