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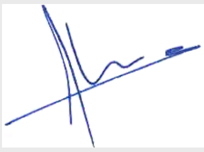
DEKRA

Test report No:
NIE: 78769RAN.001

Test report
Antenna Gain and Radiation Pattern Tests

(*) Identification of Item tested	Device that provides accurate and real-time position data about devices using the Angle of Arrival (AoA) method and the 2.4 GHz ISM band.
(*) Trademark	Nokia
(*) Model and /or type reference tested	LD-7L
(*) Other identification of the product	HW version: 1.5 SW version: 6.1
(*) Features	Bluetooth LE
(*) Manufacturer	Scanfil Malmö AB Bronsyxegatan 6B, 213 75 Malmö, Sweden
Test methodology according to	[1] 3GPP TS 34.114: "User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) antenna performance; Conformance testing", V 12.2.0, (2016-10-05).
Approved by (name / position & signature)	Miguel Lacave Antennas Lab Manager  2024.05.17 14:26:51 +02'00'
Date of issue	2024-05-15
Report template No	FAN41_01 (*) "Data provided by the client"

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Competences and guarantees

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Uncertainty

Uncertainty (factor k=2) was calculated according to the following documents:

1. FAN02 - OTA SISO CTIA - AMS-8500 Uncertainty report

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested", “Other identification of the product”, “Features”, “Manufacturer” and “Test sample description”).

DEKRA Testing and Certification, S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by the client.

Sample M/01 is composed of the following elements:

Control Nº	Description	Model	S/N	Date of reception
76558B/003	Nokia Locator Unit	LD-7L	-	2023-11-30

1. Sample M/01 has undergone the test(s) specified in subclause "Test method requested".

Test sample description

The device under test consist of a part of the Nokia HAIP (High Accuracy Indoor Positioning) system that is used to locate HAIP tags. LD-7L uses 2.4 GHz RF transceiver for locating and configuring HAIP tags and Ethernet to connect to the HAIP network. In addition to locating HAIP tags, LD-7L can be configured as Bluetooth Low Energy broadcaster to provide signals that Bluetooth low energy compatible devices can use for positioning.

LD-7L can be powered using POE (Power Over Ethernet) or 12 V DC power supply. LD-7L is compatible with HAIP Tag LD-6T.

Identification of the client

Company name: Nokia Solutions and Networks Ltd.

Postal address: Budapest, Bókay János u. 36-42, 1083 Hungary

Contact person: Szabolcs Jakits

Telephone / E-mail: +36 70 525 0680 / szabolcs.jakits@nokia.com

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2024-03-18
Date (finish)	2024-03-18

Document history

Report number	Date	Description
78769RAN.001	2024-05-15	First release

Remarks and comments

The instrumentation utilized to perform the tests covered in this test report is listed in the following table.

	Equipment	S/N	DEKRA Control Number
1.	Anechoic chamber ETS LINDGREN AMS-8500	3954	2729
2.	Positioning system controller and RF switch Agilent Technologies 3499A	MY42003363	2831
3.	OTA measurement software ETS LINDGREN EMQuest v1.14	1095	4428
4.	Vector Network Analyzer Keysight Technologies E5071C	MY46104904	3267
5.	Temperature and Pico Tehcnology, model Humidityprobe	ZNR30/064	3574

Testing has been performed by Francisco José Alcaide.

Appendix A: Test results

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1. TEST CONDITIONS

1.1 Test frequencies and output power

3D radiation pattern and antenna gain measurements were performed at 2.4 GHz frequency band. The frequency spectrum at which the test has been performed ranges from 2400 MHz to 2500 MHz test frequencies.

Test frequencies were selected according with demanded by the customer.

1.2 Antenna orientation and setup requirements

For the 3D radiation pattern measurements the EUT is rotated along two different spherical axes: theta (θ) and phi (Φ). The relationship between the 3D Cartesian coordinate system (X, Y, Z) and the theta and phi axes is illustrated in the following figure. This coordinate system should be used as reference in all 3D radiation pattern graphs in section 3 as well as test setup photographs in Appendix B.

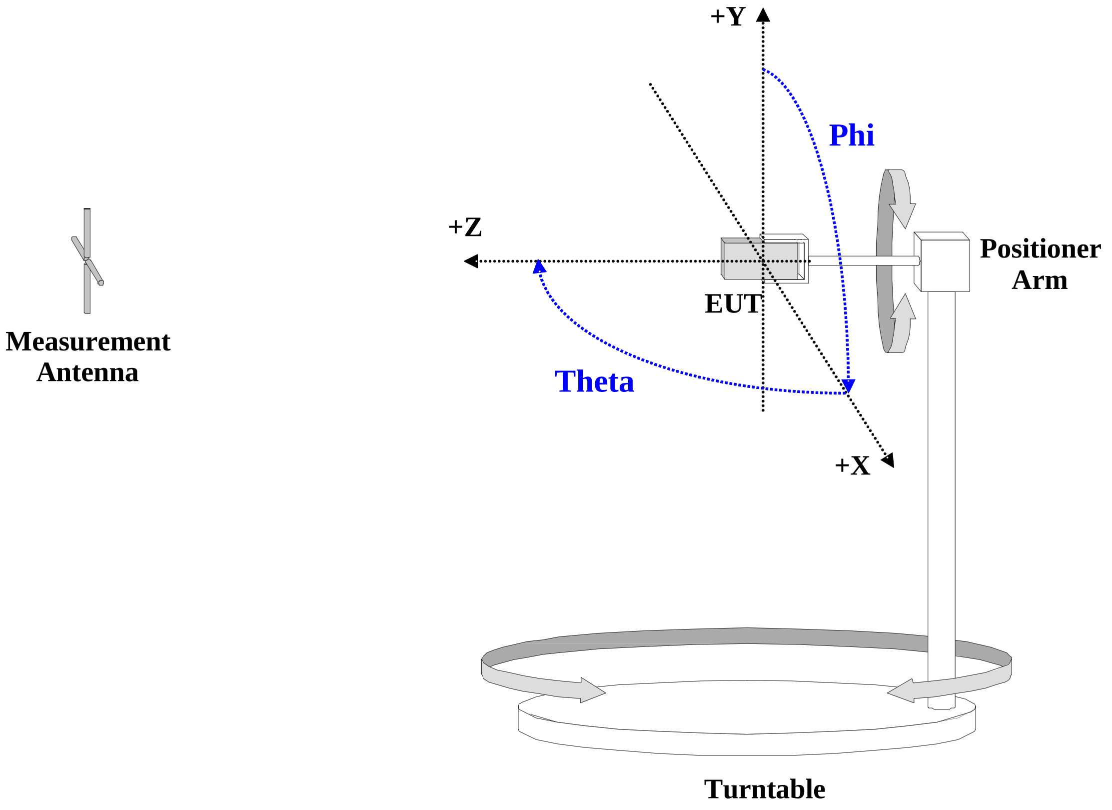

Fig. 1. Coordinate system.

Theta is the spherical axis that rotates along the Cartesian Y axis while Phi is the spherical axis that rotates along the Cartesian Z axis. The initial measurement position (Theta = 0º and Phi = 0º) is illustrated in each of the test setup photographs in Appendix B. The EUT has only one mechanical configuration and it was tested in the "Free-space" placed 5 meters away from the measurement antenna.

2. TEST RESULTS

2.1 Peak antenna gain

The test setup used to derive test results in this clause is illustrated below.

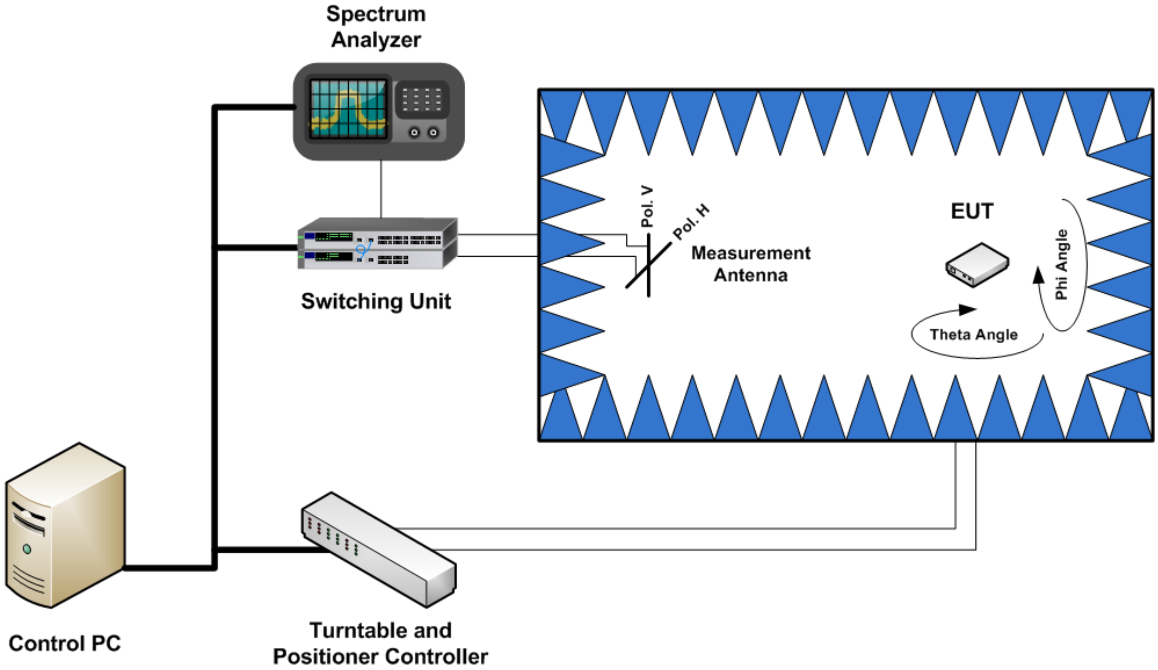

Fig. 2. Equipment and connections for peak antenna gain measurements.

The EUT was placed inside a fully anechoic test system and hold on a multi-axis positioning system (see Figure 16). The EUT was never switched on, all signal excitations were generated by a Vector Network Analyzer (VNA) set to operate on the different test frequencies.

The antenna input port was directly fed with the excitation signals created by the VNA Port 1. Power radiated by the antenna was captured by the measurement antenna (see figure above) and then read by the VNA Port 2. Antenna gain was determined as an S21 parameter in the VNA after applying path corrections (both conducted and radiated path losses).

Antenna gain measurements were performed at intervals of 15 degrees along the theta and phi axes and at both horizontal and vertical polarizations.

Peak antenna gain and efficiency values are presented below:

Frequency (MHz)	Peak Gain (dBi)	Efficiency (%)
2400	3.38	60.24
2401	3.84	59.82
2402	3.63	61.59
2403	3.90	60.51
2404	3.84	60.74
2405	3.64	61.98
2406	3.89	61.47
2407	3.64	60.50
2408	4.01	61.90
2409	3.69	62.10
2410	3.71	62.49
2411	3.86	61.55
2412	3.90	61.94
2413	3.64	61.20
2414	3.67	61.74
2415	3.76	61.38
2416	3.73	61.51
2417	3.62	60.55
2418	3.54	61.34
2419	3.68	61.12
2420	3.59	60.01
2421	3.76	60.90
2422	3.54	60.62
2423	3.62	59.73
2424	3.60	60.49
2425	3.60	59.66
2426	3.42	58.76
2427	3.61	58.53
2428	3.41	58.47
2429	3.68	57.60
2430	3.48	56.71
2431	3.35	58.03
2432	3.46	56.56
2433	3.48	56.70
2434	3.53	56.32
2435	3.39	55.38
2436	3.27	55.78
2437	3.32	55.20
2438	3.14	55.40
2439	3.25	55.21
2440	3.80	55.74
2441	3.41	54.90
2442	3.13	54.40
2443	3.02	53.93
2444	3.05	53.42
2445	3.34	55.08
2446	3.16	54.27
2447	3.14	53.77
2448	3.11	54.09
2449	3.14	54.55
2450	3.31	55.17
2451	3.15	54.55
2452	3.26	53.28
2453	3.07	54.66
2454	3.05	53.91
2455	3.09	53.73
2456	2.83	53.61
2457	2.95	54.00
2458	2.84	53.04
2459	2.90	52.34
2460	3.06	52.50
2461	3.22	52.41
2462	2.82	51.24
2463	2.63	51.55
2464	2.63	51.36
2465	3.00	51.11
2466	2.69	50.86
2467	2.99	50.41
2468	2.55	52.22
2469	2.66	52.30
2470	2.78	51.67
2471	2.58	50.97
2472	2.76	50.58
2473	2.93	50.60
2474	2.51	50.91
2475	2.67	50.49
2476	2.66	49.27
2477	2.47	48.28
2478	2.28	48.48
2479	2.65	49.34
2480	2.29	48.94
2481	2.31	47.81
2482	2.37	48.27
2483	2.26	47.79

2484	2.20	48.12
2485	2.24	47.25
2486	2.76	47.92
2487	2.20	47.67
2488	2.34	47.61
2489	2.17	47.43
2490	2.07	46.63
2491	2.21	46.34
2492	2.30	46.88
2493	1.93	45.71
2494	2.31	45.71
2495	2.22	44.75
2496	2.11	45.19
2497	2.01	44.67
2498	1.77	43.39
2499	1.67	42.52
2500	1.59	42.76

Peak antenna gain vs frequency:

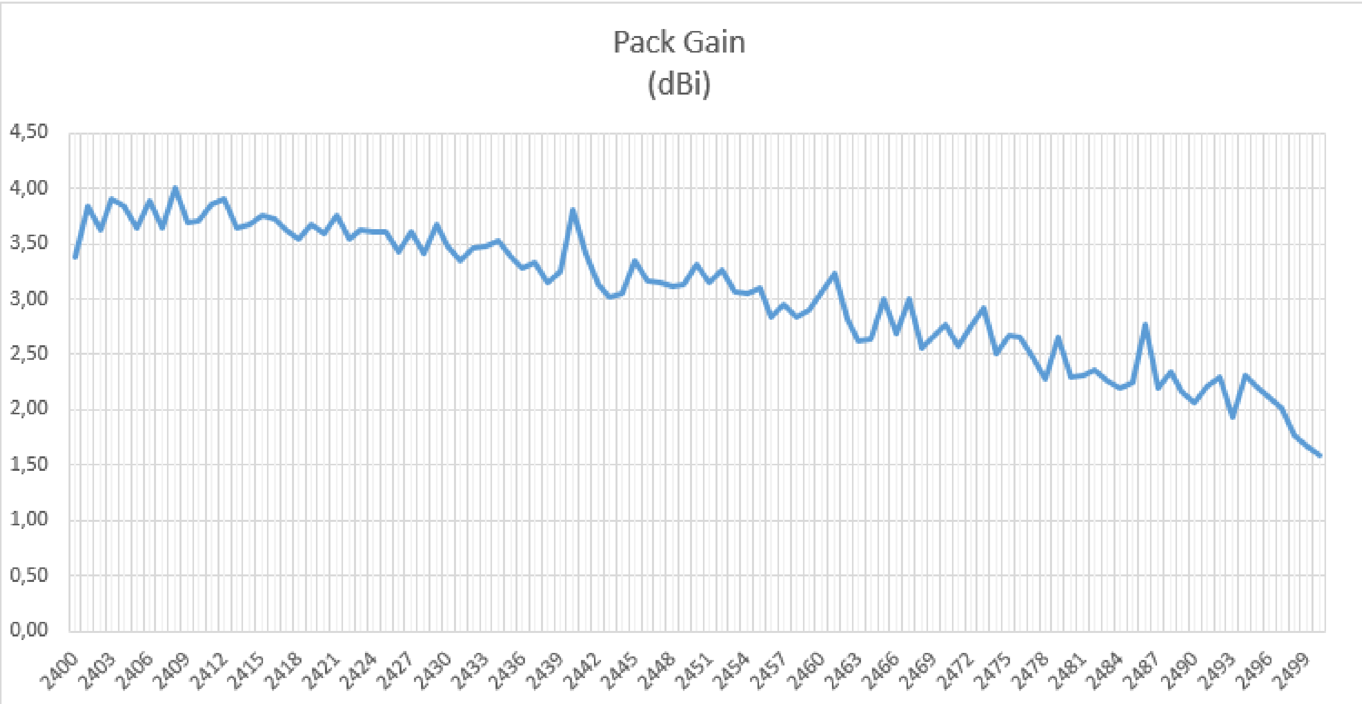

Fig. 3. Peak antenna gain between 2400 MHz and 2500 MHz.

Antenna efficincy vs frequency:

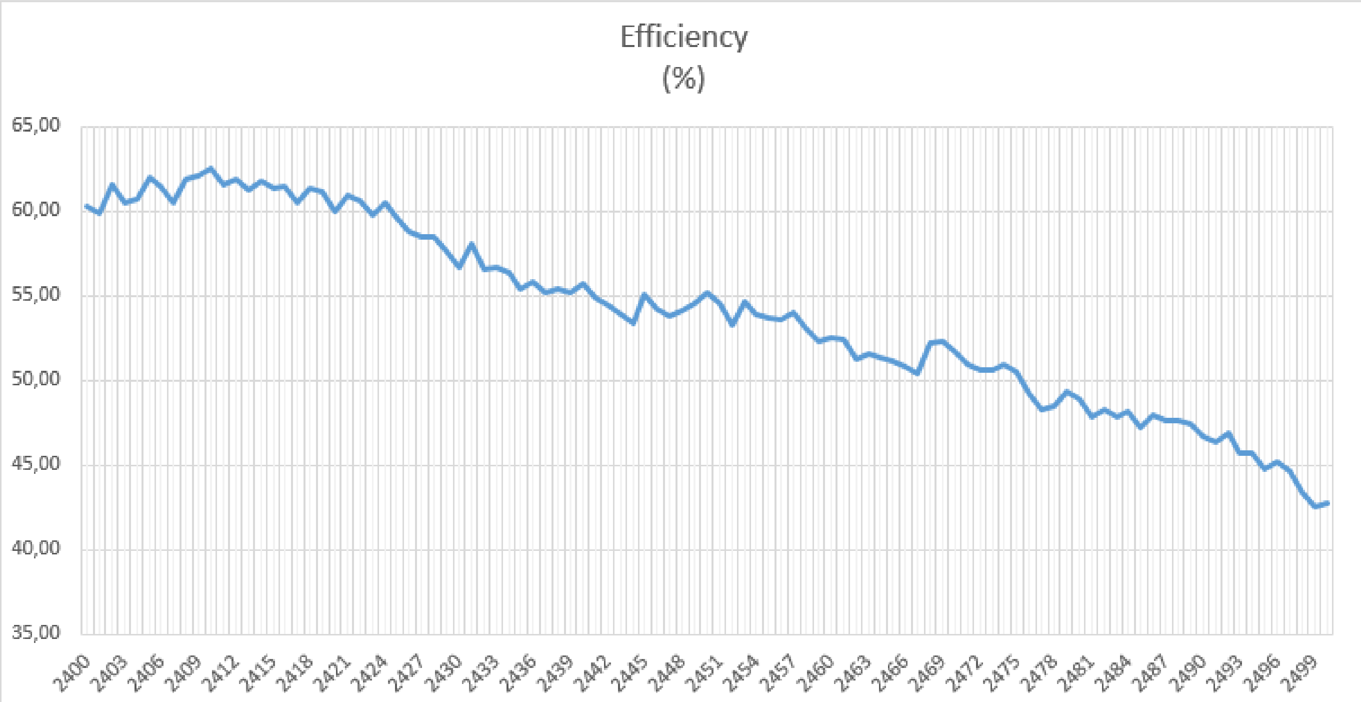

Fig. 4. Antenna efficiency between 2400 MHz and 2500 MHz.

3. 3D RADIATION PATTERNS

3.1 Free Space - Radiation Pattern – 2402 MHz

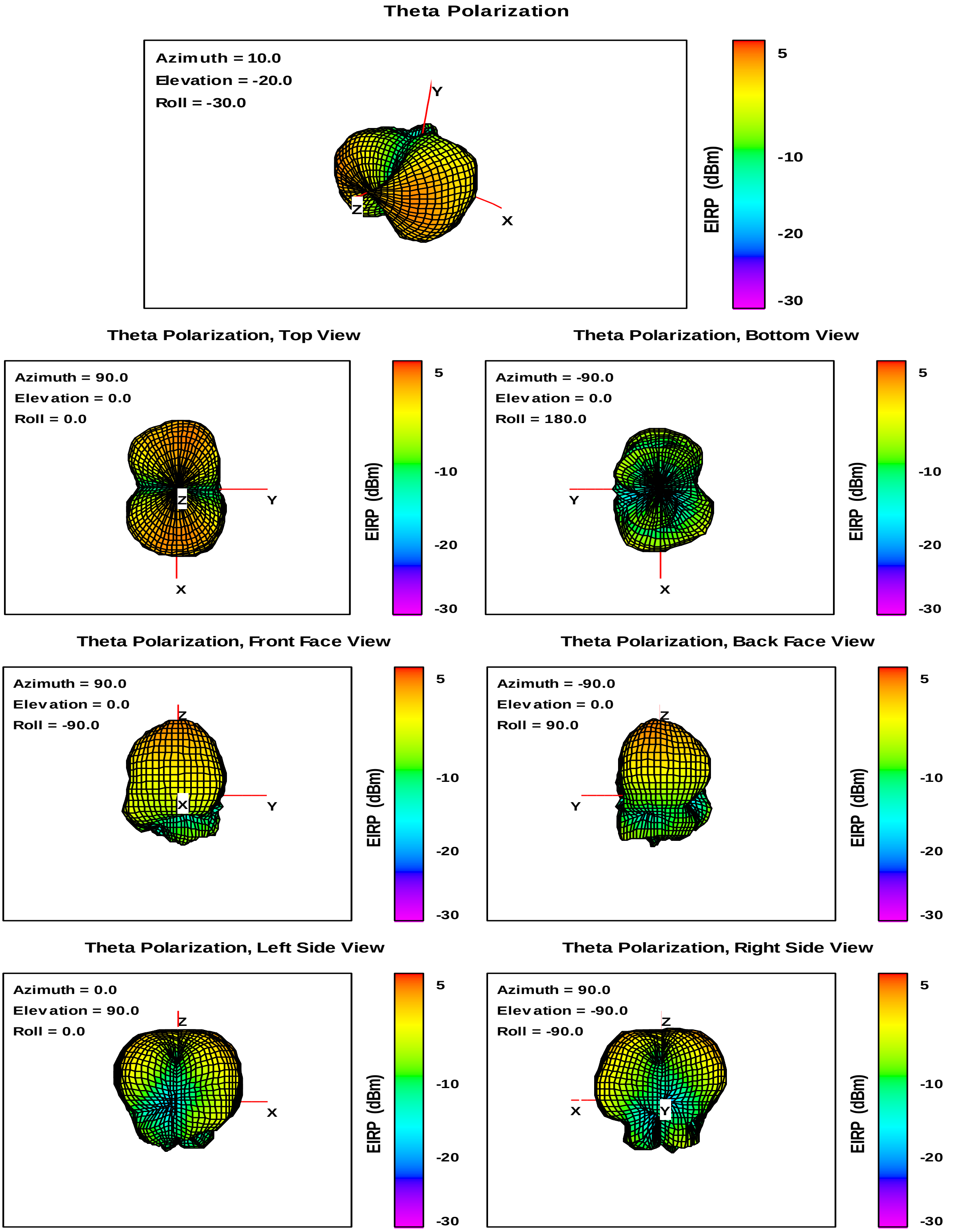

Fig. 5. Theta Polarization EIRP, Free Space, 2402 MHz.

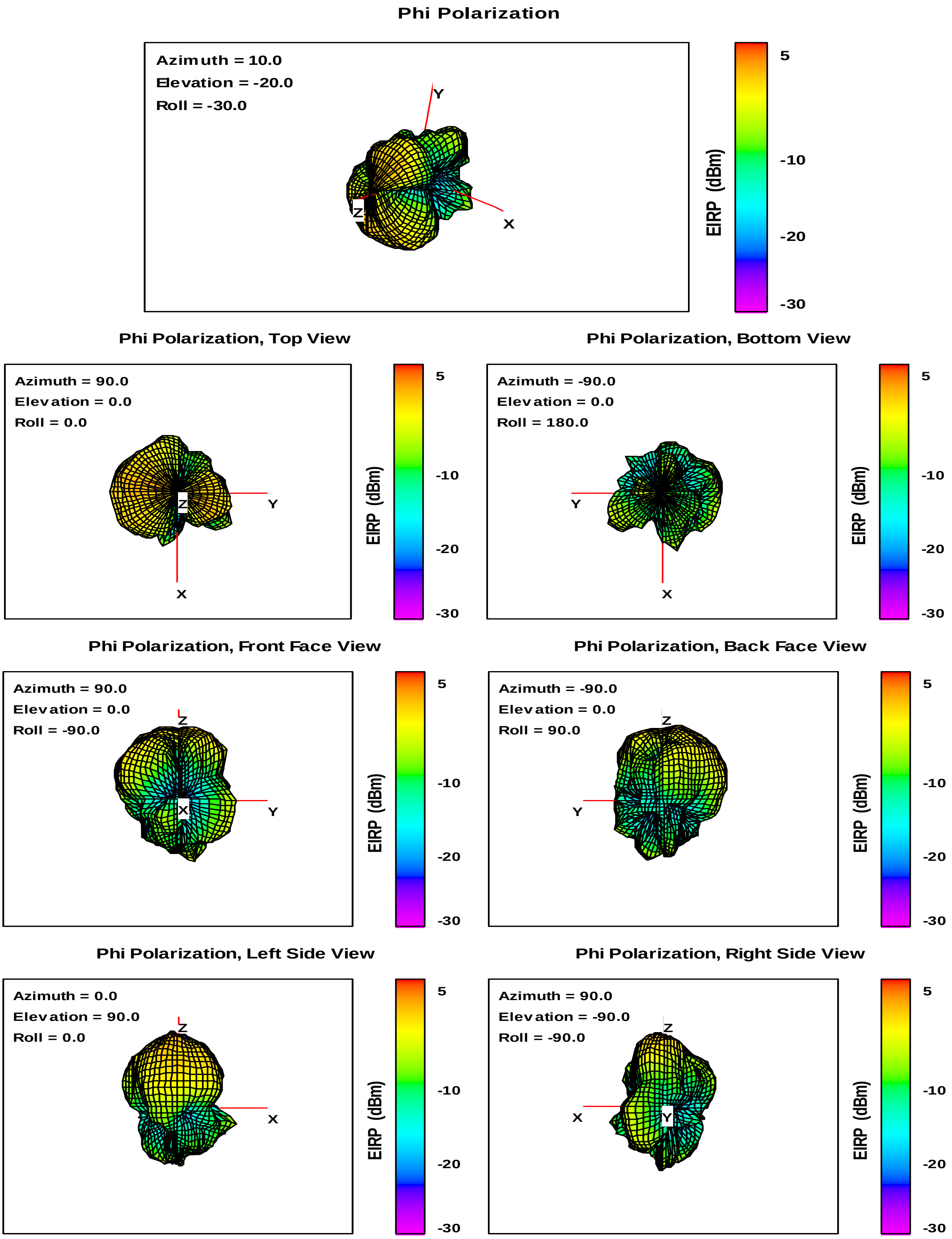

Fig. 6. Phi Polarization EIRP, Free Space, 2402 MHz.

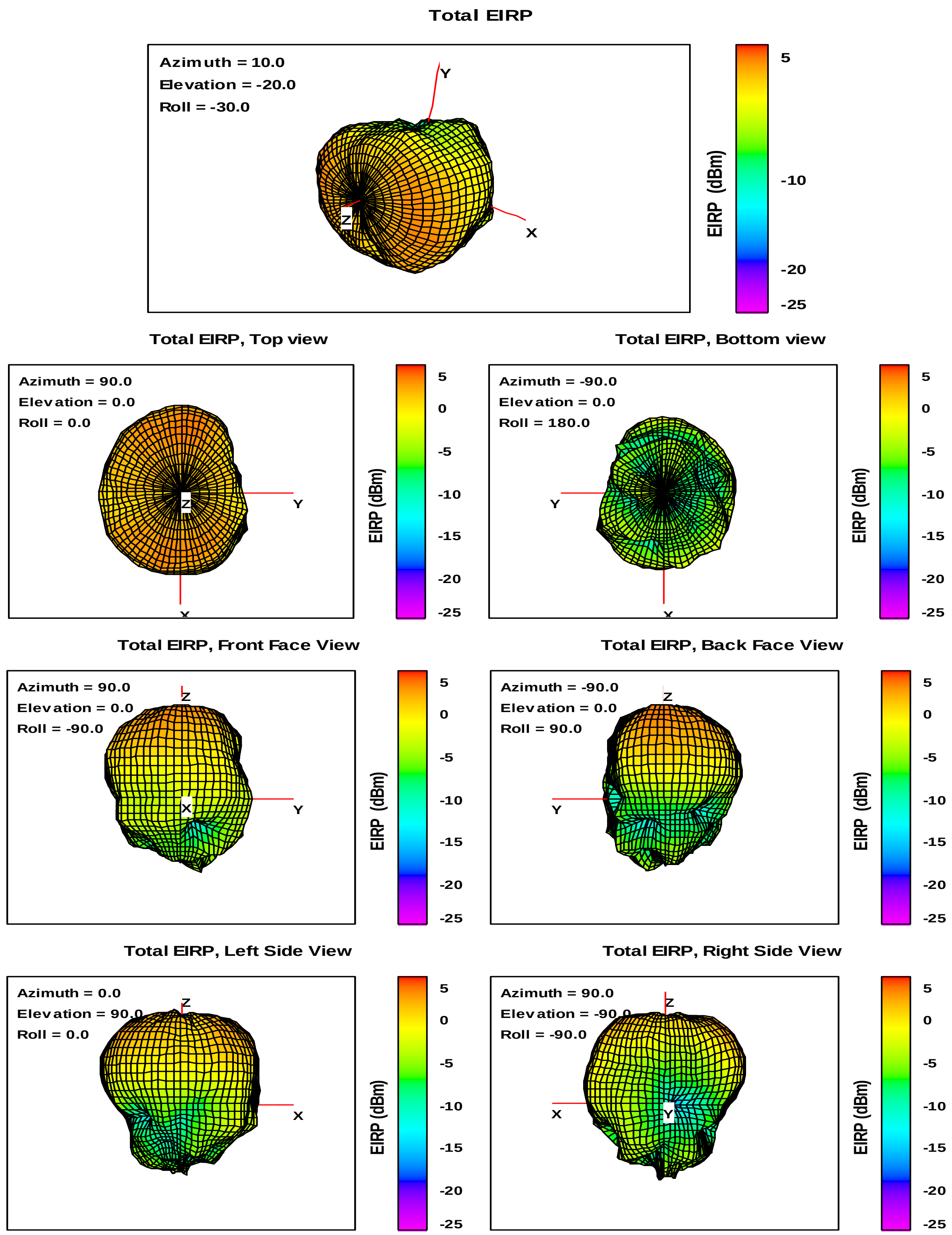

Fig. 7. Total EIRP, Free Space, 2402 MHz.

3.2 Free Space - Radiation Pattern – 2440 MHz

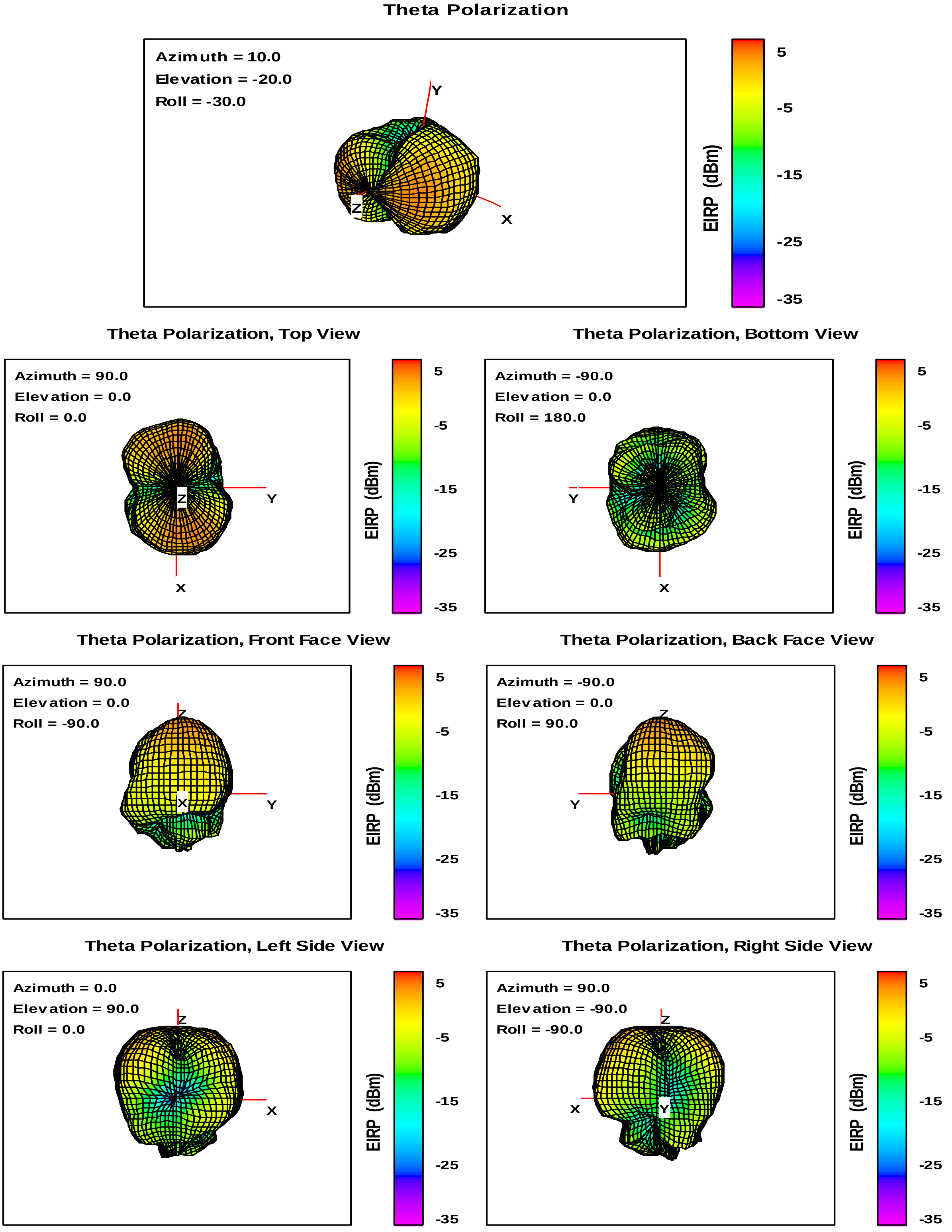

Fig. 8. Theta Polarization EIRP, Free Space, 2440 MHz.

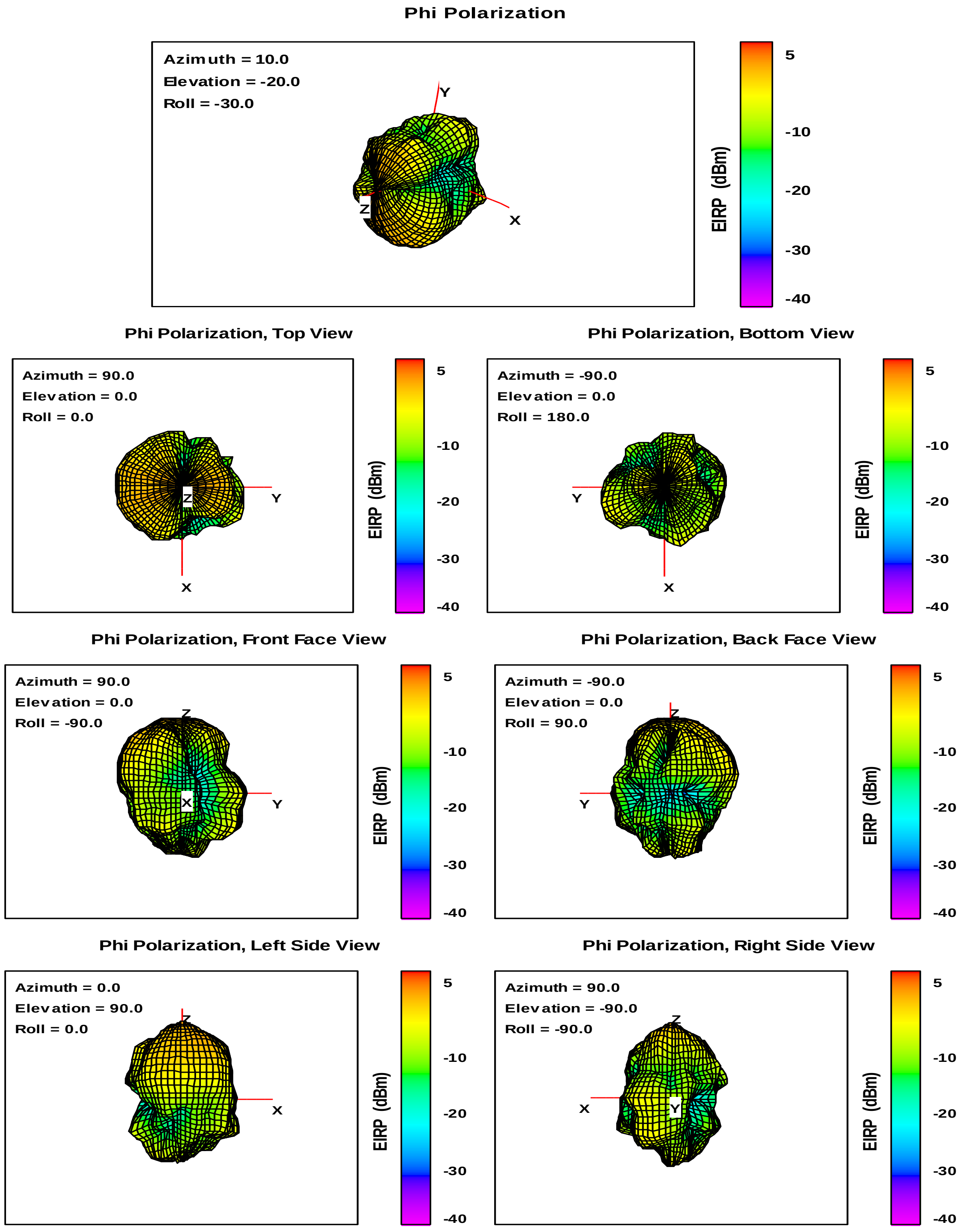

Fig. 9. Phi Polarization EIRP, Free Space, 2440 MHz.

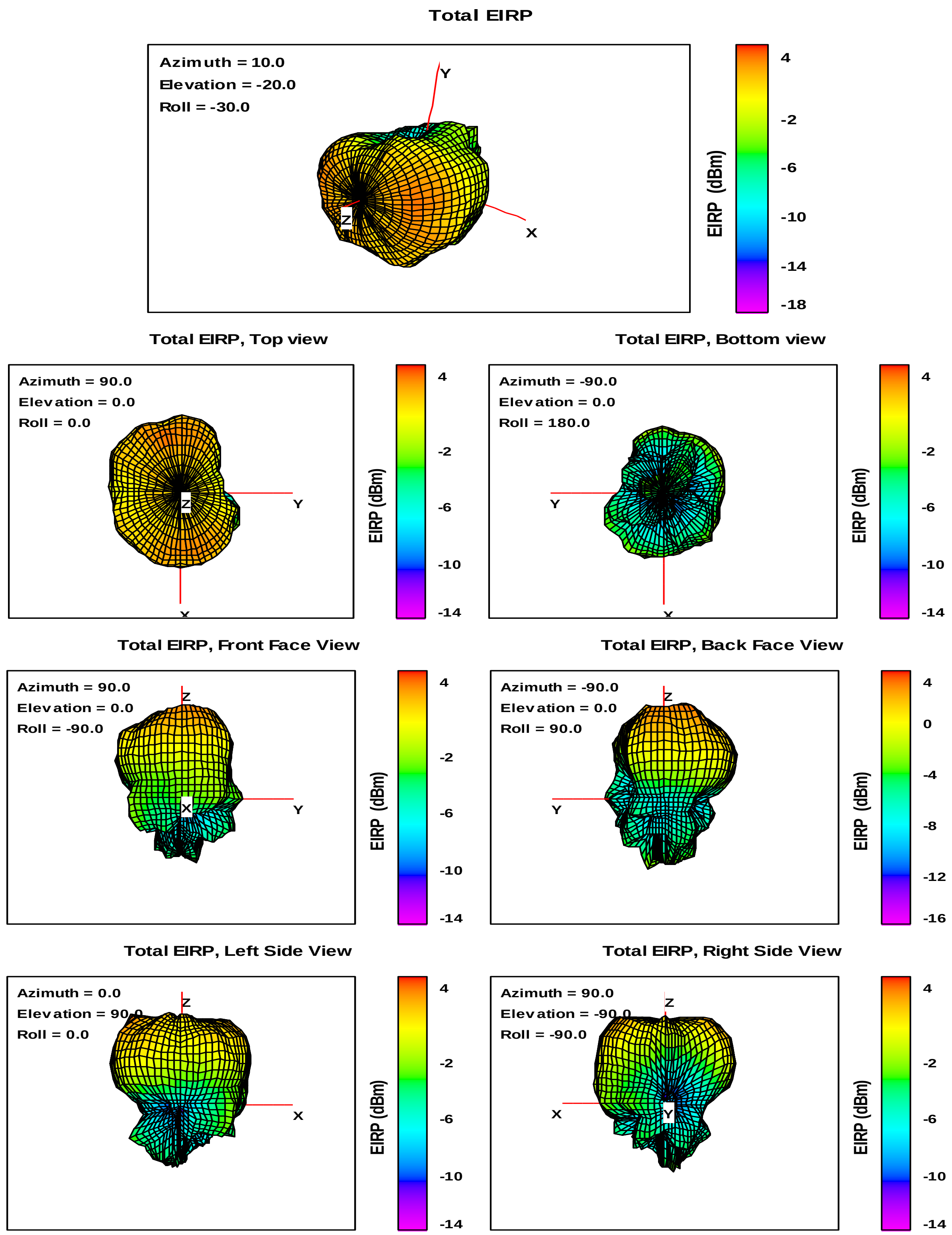

Fig. 10. Total EIRP, Free Space, 2440 MHz.

3.3 Free Space - Radiation Pattern – 2480 MHz

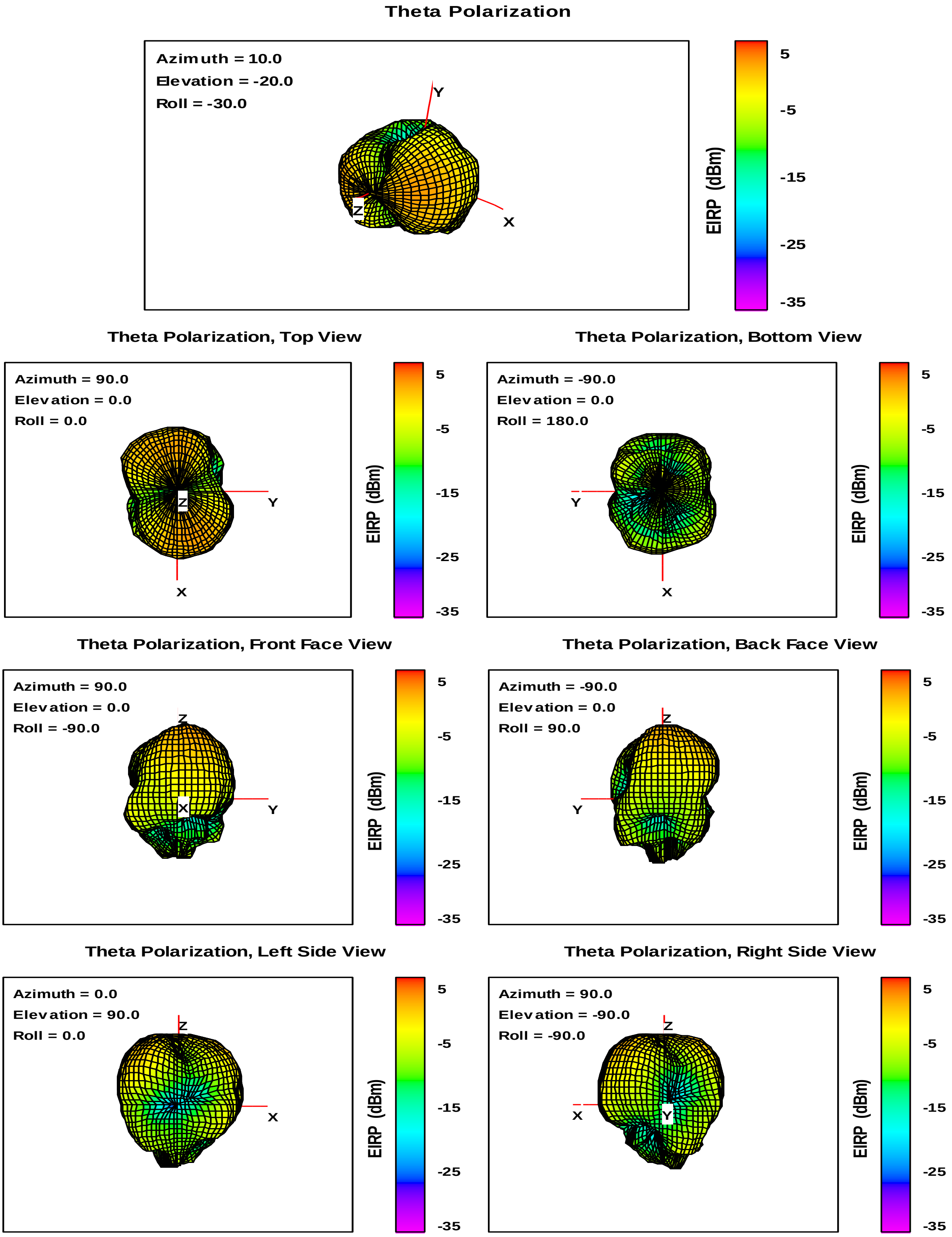

Fig. 11. Theta Polarization EIRP, Free Space, 2480 MHz.

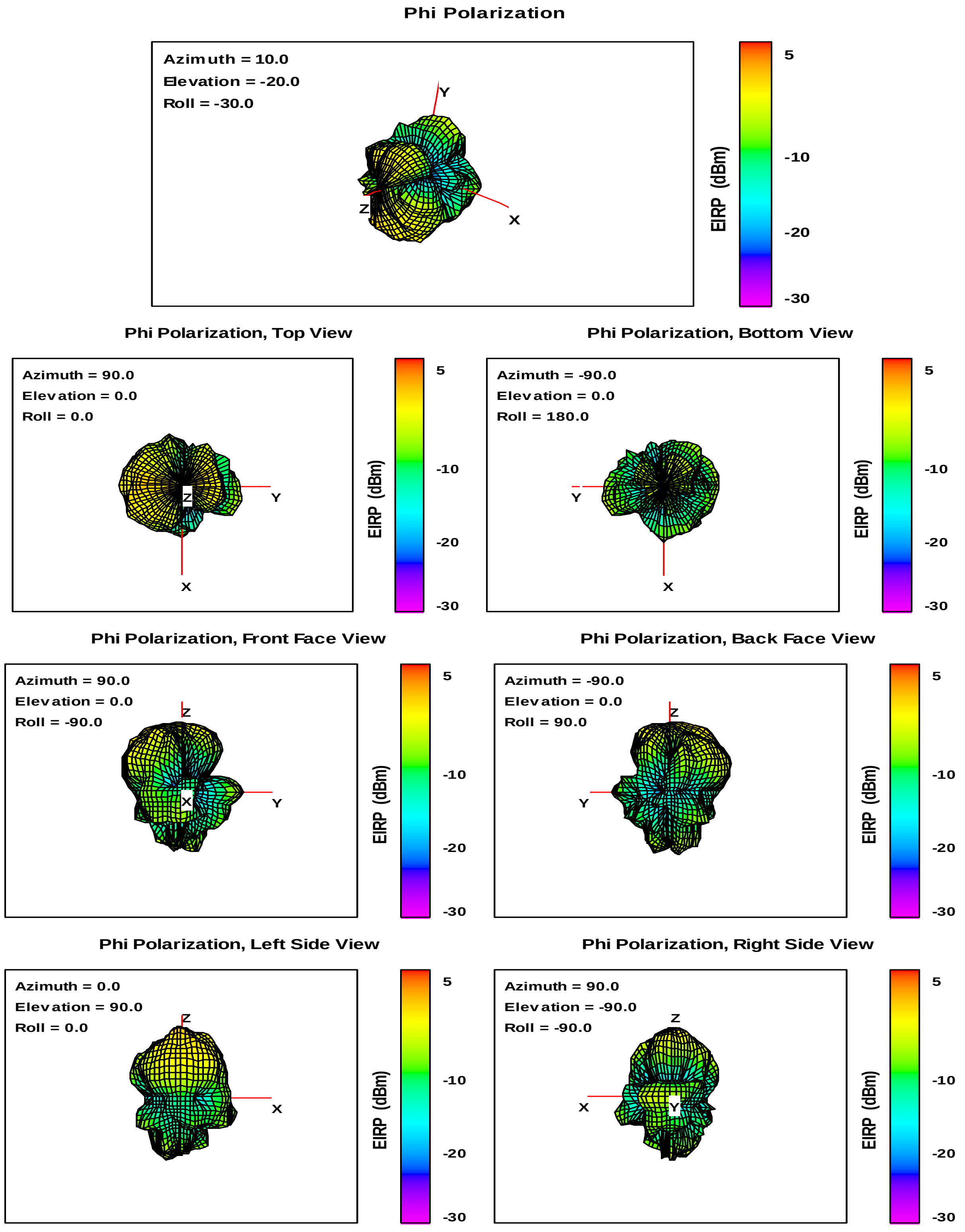

Fig. 12. Phi Polarization EIRP, Free Space, 2480 MHz.

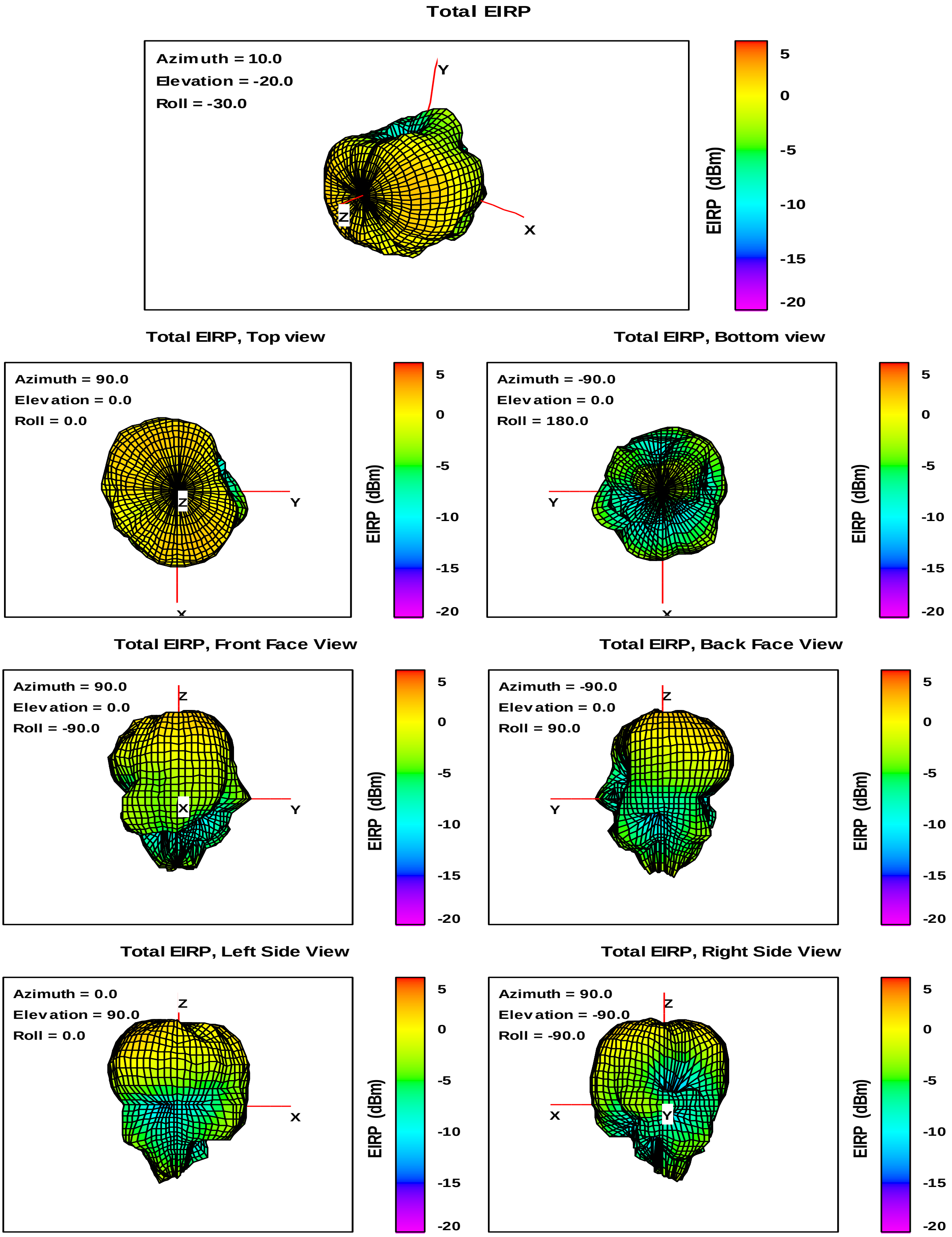

Fig. 13. Total EIRP, Free Space, 2480 MHz.