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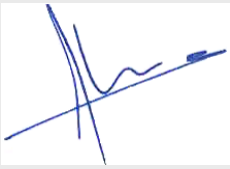
C.I.F. A29 507 456

Test report No:
NIE: 58727RAN.001

Test report

LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices

Identification of item tested	NetOP LoRa Connectivity Board
Trademark	LoRa Connectivity Board
Model and /or type reference	LRBS4001
Other identification of the product	S/N: 10000063
Features	Full LoRaWAN protocol (Class A) compatibility
Manufacturer	Company name: NETOP IoT Network Operator Euro B.V. Postal address: Westerstraat 2A 1156 AB, Marken. The Netherlands
Test method requested, standard	[1] LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices
Test Operator	Manuel Garcia Fuertes
Approved by (name / position & signature)	Miguel Lacave Antennas Lab Manager  MIGUEL LACAVE GARCÍA 2018.10.26 10:15:28 +02'00'
Date of issue	2018-10-25
Report template No	FDT08_21

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Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory competent to carry out the tests described in this report.

In order to assure the traceability to other national and international laboratories, DEKRA has a calibration and maintenance program for its measurement equipment.

DEKRA guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at DEKRA at the time of performance of the test.

DEKRA is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA and the Accreditation Bodies.

Uncertainty

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

1. CTIA Test plan for mobile station over the air performance. Method of measurement for radiated RF power and receiver performance. February 2018. Revision 3.7.1.
2. FAN06 - OTA SISO CTIA - AMS-8700 Uncertainty report

Instrumentation

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

Equipment
1. Anechoic chamber ETS LINDGREN AMS-8700
2. Positioning system controller and RF switch ETS LINDGREN EMCENTER 7000-001
3. OTA measurement software ETS LINDGREN EMQuest v1.10
4. Spectrum analyzer Keysight Technologies PSA E4445A
5. LoRa Gateway Semtech IOT868TKLM1 HAL v3.2.0
6. Step attenuator Vaunix Technology Corporation Lab BrickDigital Attenuator
7. RF Circulator Channel Microwave Corporation, Model BUL330
8. RF Isolator Channel Microwave Corporation, Model AUL330
9. Temperature and Humidity probe, model HWg-STE

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	Device EUI	Date of reception
58727B/002	LoRa Connectivity Board	LRBS4001	58727B/004	2018-10-15

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

Test sample description

The test sample is a long range wireless connectivity board which can be used with many sensor options. This connectivity board is fully compatible with LPWAN technology by using LoRaWAN protocol (Class A).

Identification of the client

Company name: NETOP IoT Network Operator Euro B.V.

Postal Address: Westerstraat 2A 1156 AB, Marken. The Netherlands

Contact Person: Sinan Tuzun

Telephone/e-mail: +90 506 490 90 90 / connect@netop.io

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2018-10-15
Date (finish)	2018-10-19

Document history

Report number	Date	Description
58727RAN.001	2018-10-25	First release

Environmental conditions

Date	Max. Temp. ºC	Min. Temp. ºC	Max. Hum. %	Min. Hum. %
From 2018-10-15 to 2018-10-19	26.1	19.7	64.0	40.1

Remarks and comments

None.

Testing verdicts

Not applicable ..... :	N/A
Pass..... :	P
Fail..... :	F
Measured ..... :	M
Not measured ..... :	N/M

Transmitter Performance:

LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices, PARAGRAPH	Verdict				
	N/A	P	F	M	N/M
2 : End-device transmitter performance				X	

Receiver Performance:

LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices, PARAGRAPH	Verdict				
	N/A	P	F	M	N/M
3 : End-device receiver performance				X	

Appendix A: Test results

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1. TEST CONDITIONS

1.1 Power supply (V)

Power supply (V) under test:

Vn = 3.6 V_{DC} supplied by a fully charged Li-$SOCl_2$ AA battery.

1.2 Test frequencies and output power

In all required operating bands the measurements for Total Radiated Power (TRP) measurements are to be performed on lowest, default and highest channels and Total Isotropic Sensitivity (TIS) measurements are to be performed on default and highest channels defined by the standard [1].

The output power of the EUT was set to maximum for all tests.

1.3 EUT orientation and setup requirements

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 4 as well as test setup photographs in Appendix B.

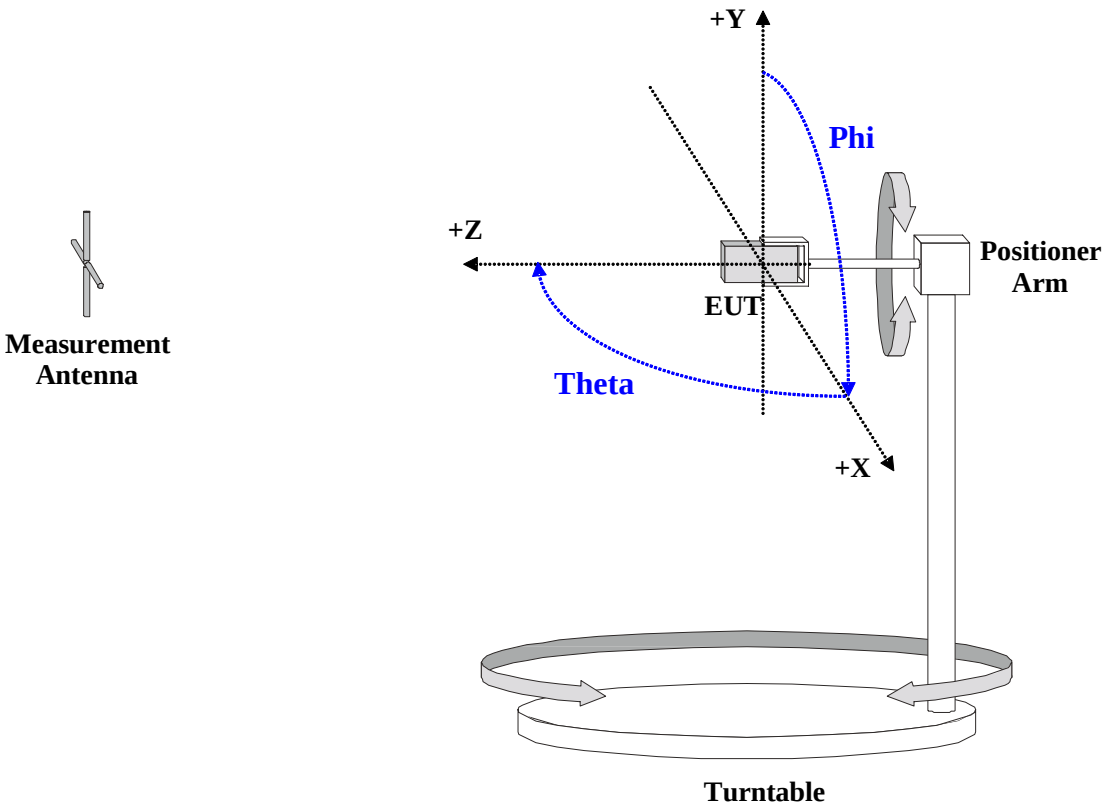

Fig. 1. Coordinate system.

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 each and they were tested in the "Free-space" configuration, whereby EUT has been placed directly on a support placed 2 meters away from the measurement antenna.

End-device transmitter performance

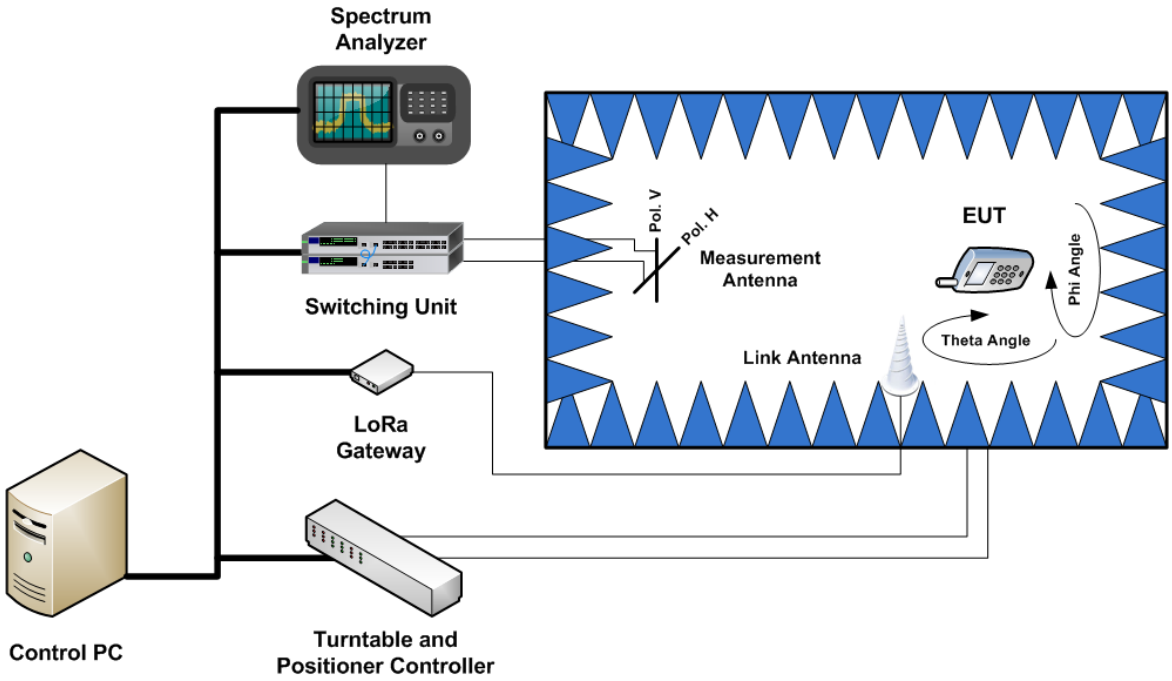

Fig. 2. Transmitter performance test connection diagram.

End-device receiver performance

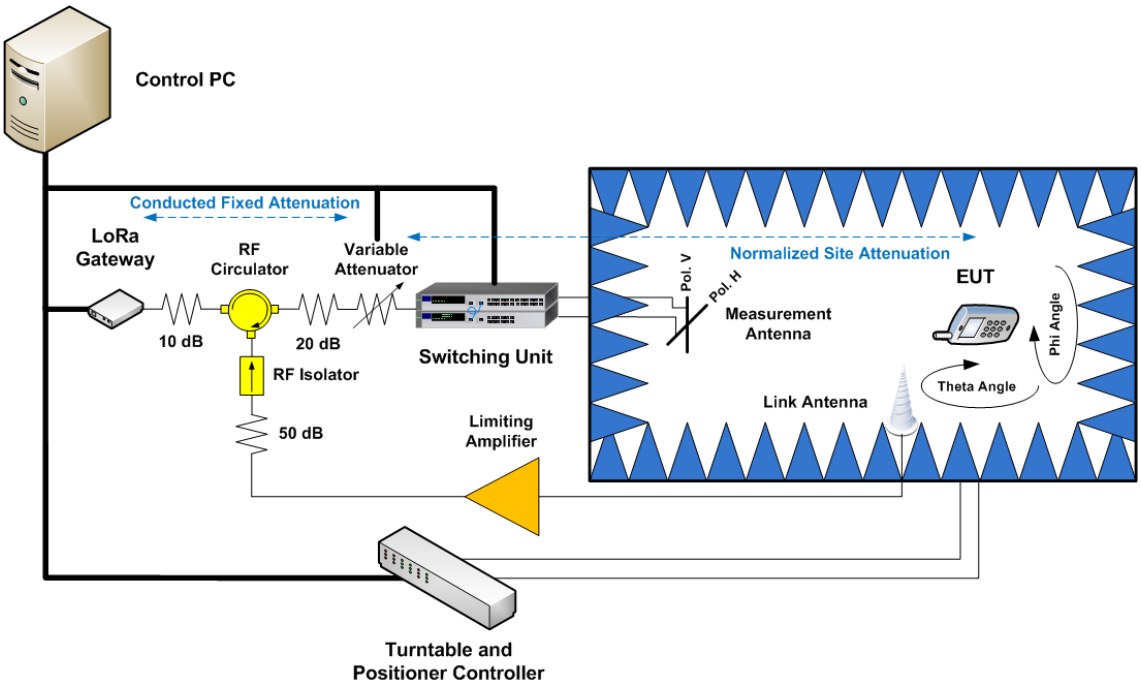

Fig. 3. Receiver performance test connection diagram.

2. TEST RESULTS

2.1 Transmitter performance

Frequency (MHz)	TRP (dBm)	Maximum EIRP				
		Horizontal EIRP (dBm)	Vertical EIRP (dBm)	Total EIRP (dBm)	Theta (º)	Phi (º)
863.1	3.52	5.52	-13.69	5.57	100	350
868.3	2.90	5.05	-15.41	5.09	100	350
869.525	3.76	5.79	-9.82	5.91	90	210

2.2 Receiver performance

Frequency (MHz)		868.3		869.525	
Spreading Factor		SF12 (DR0)	SF7 (DR5)	SF12 (DR0)	SF7 (DR5)
TIS (dBm)		-99.89	-86.03	-100.08	-86.18
Measured EIS	EIS (dBm)	-102.26	-88.40	-102.34	-88.44
	PER (%)	1.67	8.33	3.33	1.67
	Polarization	Theta	Theta	Theta	Theta
	Theta (º)	100	100	90	90
	Phi (º)	350	350	210	210
GW Tx Power (dBm)		12.97	12.97	13.40	13.40
Forward path attenuation (dB)		-115.23	-101.37	-115.74	-101.84
Normalized Site Attenuation (NSA) (dB)[1]		-49.28	-49.28	-49.29	-49.29
Conducted fixed attenuation (dB)[1]		-65.95	-52.09	-66.45	-52.55
RF Path attenuation step size (dB)		0.50	0.50	0.50	0.50

[1] See Figure 3

3. EXPANDED MEASUREMENT UNCERTAINTIES

The expanded measurement uncertainties are listed below for the different frequency bands. These uncertainties refer to a coverage factor of 2, corresponding to 95% confidence level.

The expanded measurement uncertainties listed below were derived following the methodology described in the CTIA Test plan for mobile station over the air performance. Method of measurement for radiated RF power and receiver performance. February 2018. Revision 3.7.1.

Table 1. ***TRP and TIS Measurement Uncertainty results***

Test	**Test Configuration**	**Expanded Uncertainty** (k=2, 95 % confidence level) [dB]	
		Value (dB)	**LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices Uncertainty Limit (dB)**
TRP	**FREE SPACE**	1.60	3.0
TIS	**FREE SPACE**	1.77	3.5

4. RF TEST RESULT ON 2D

4.1 EIRP Pattern 863.1 MHz – Free Space

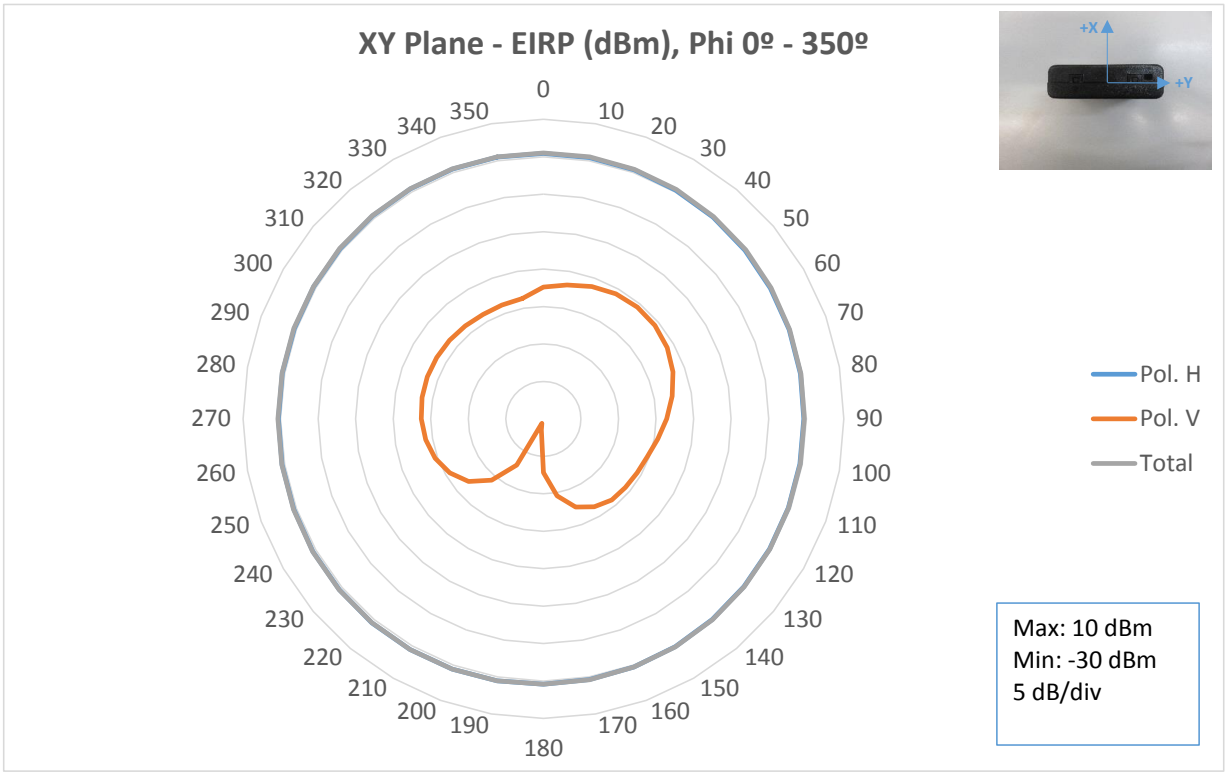

Fig. 4. XY Plane EIRP, Free Space, 863.1 MHz.

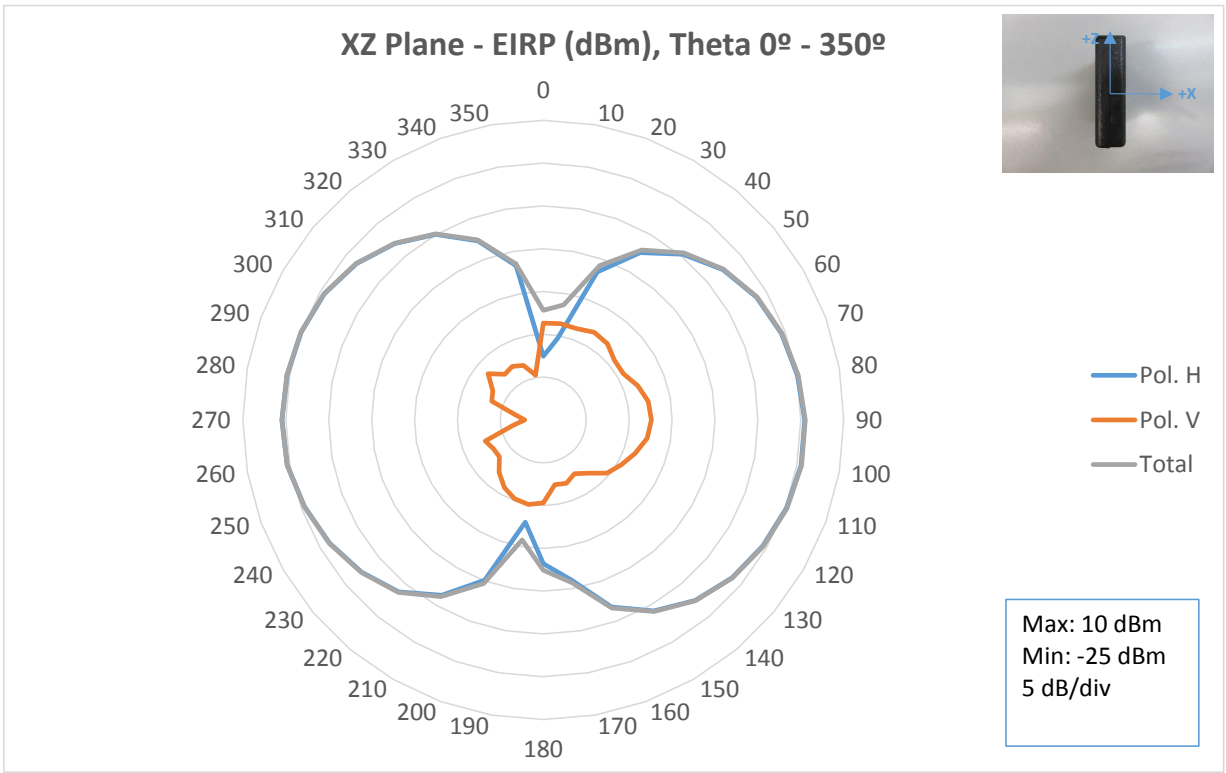

Fig. 5. XZ Plane EIRP, Free Space, 863.1 MHz.

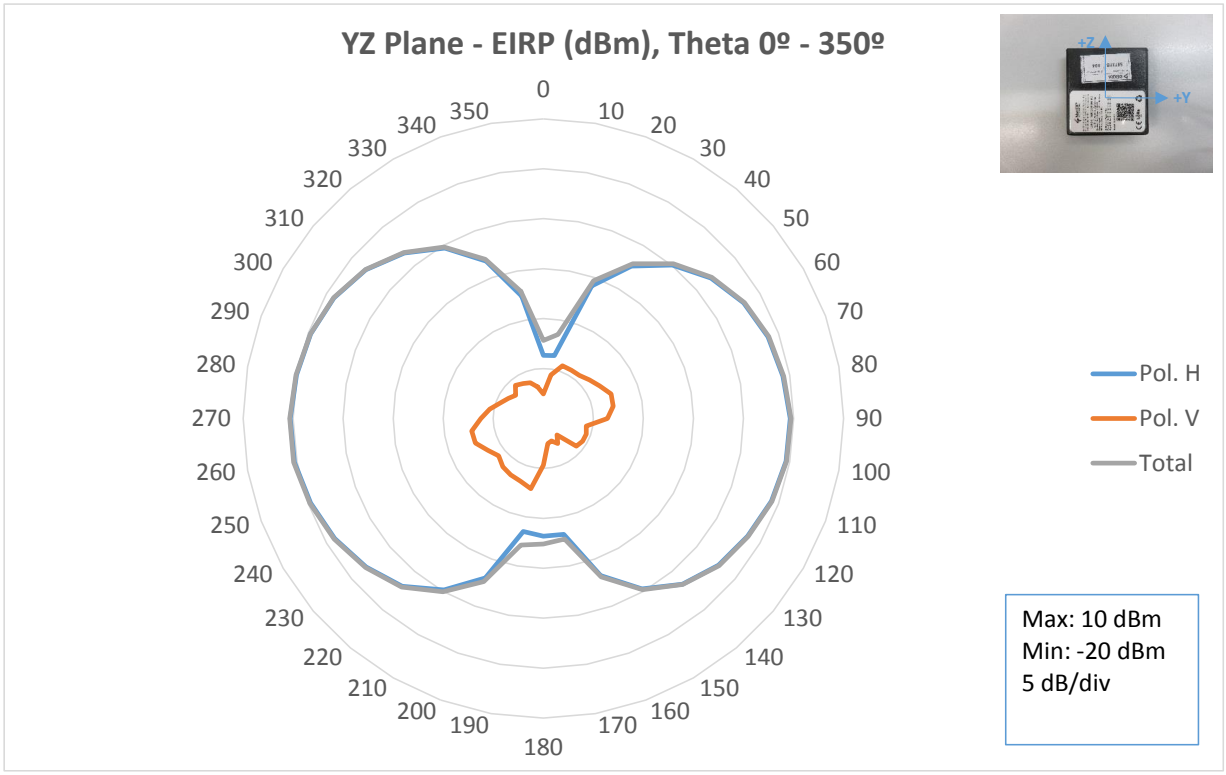

Fig. 6. YZ Plane EIRP, Free Space, 863.1 MHz.

4.2 EIRP Pattern 868.3 MHz – Free Space

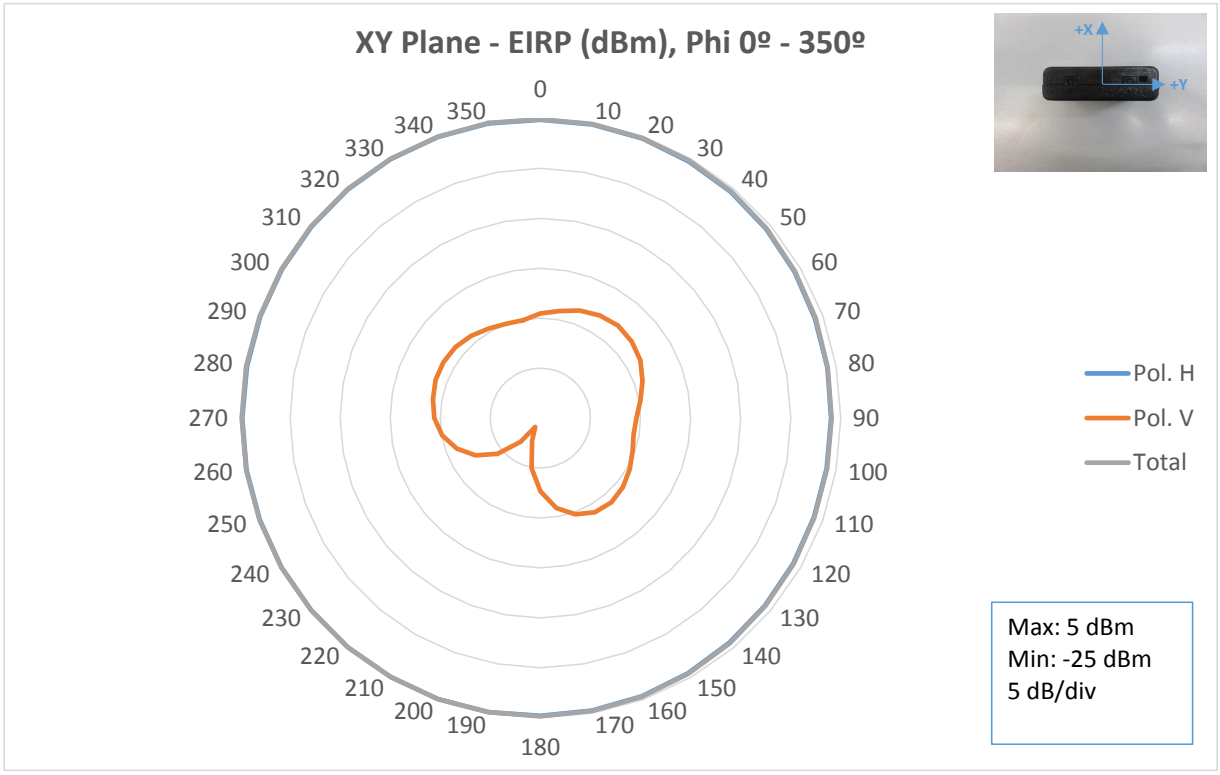

Fig. 7. XY Plane EIRP, Free Space, 868.3 MHz.

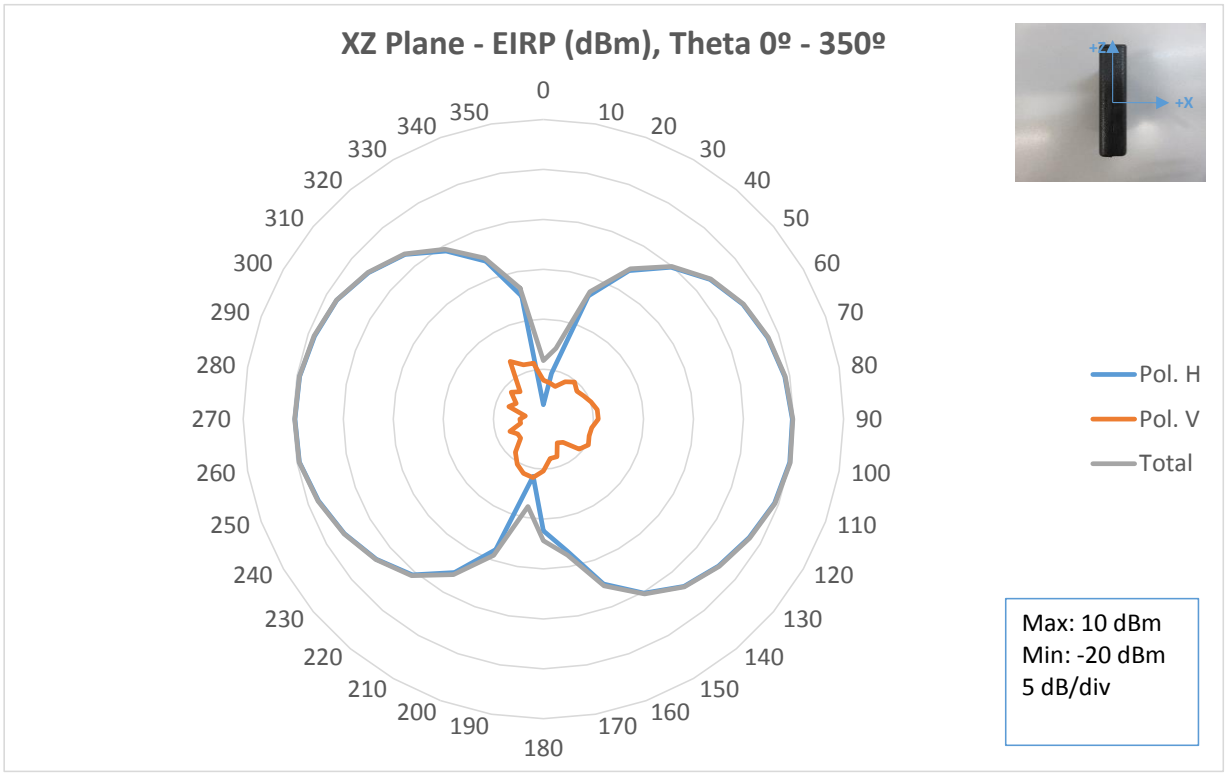

Fig. 8. XZ Plane EIRP, Free Space, 868.3 MHz.

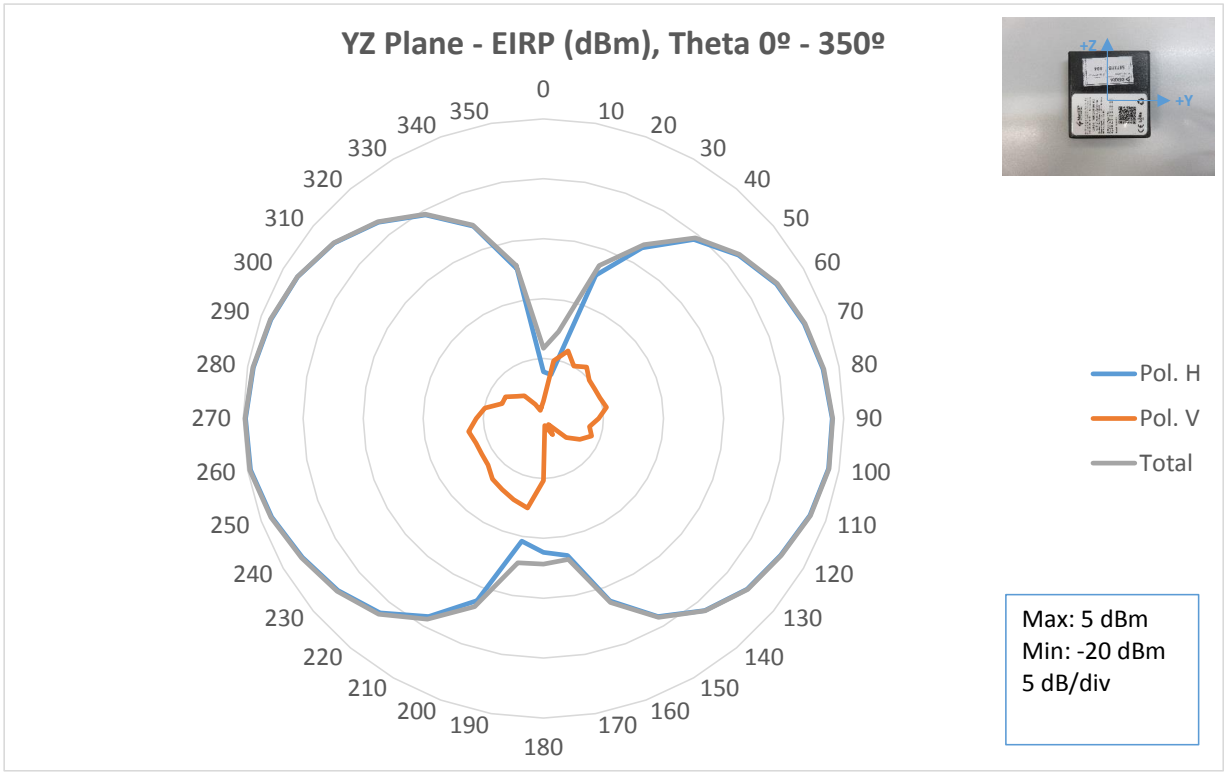

Fig. 9. YZ Plane EIRP, Free Space, 868.3 MHz.

4.3 EIRP Pattern 869.525 MHz – Free Space

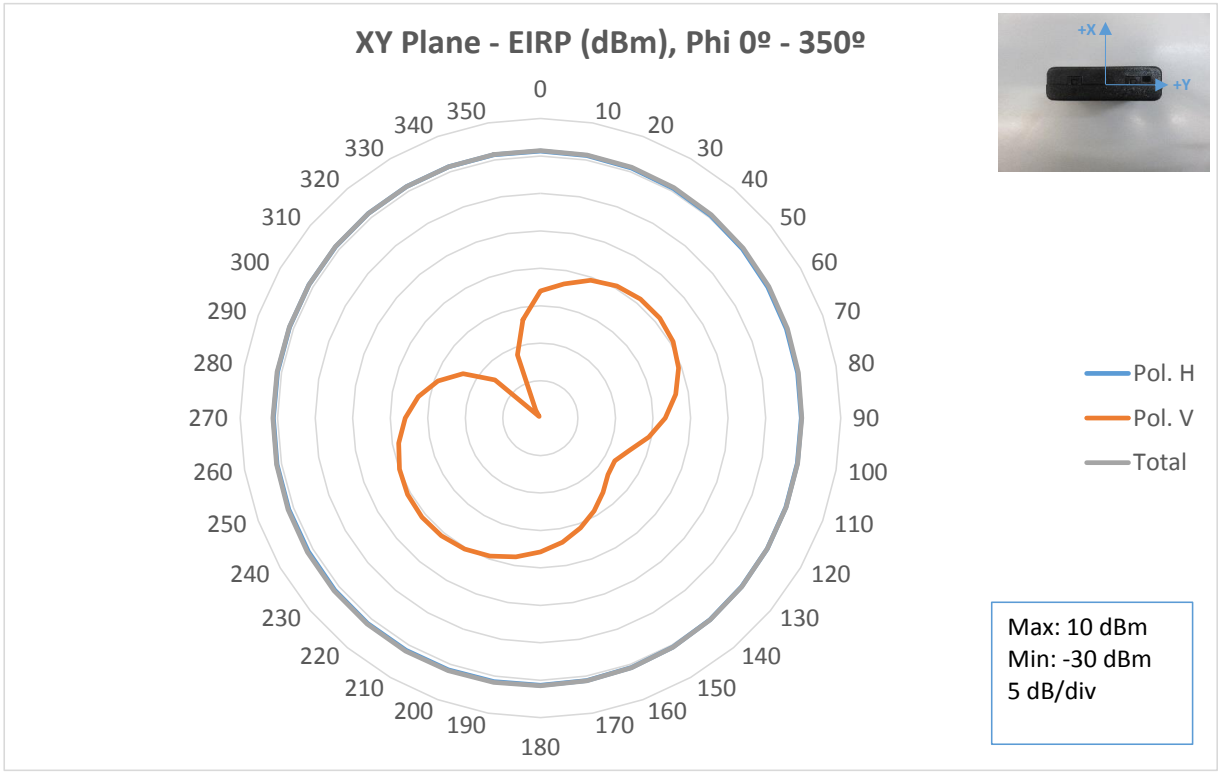

Fig. 10. XY Plane EIRP, Free Space, 869.525 MHz.

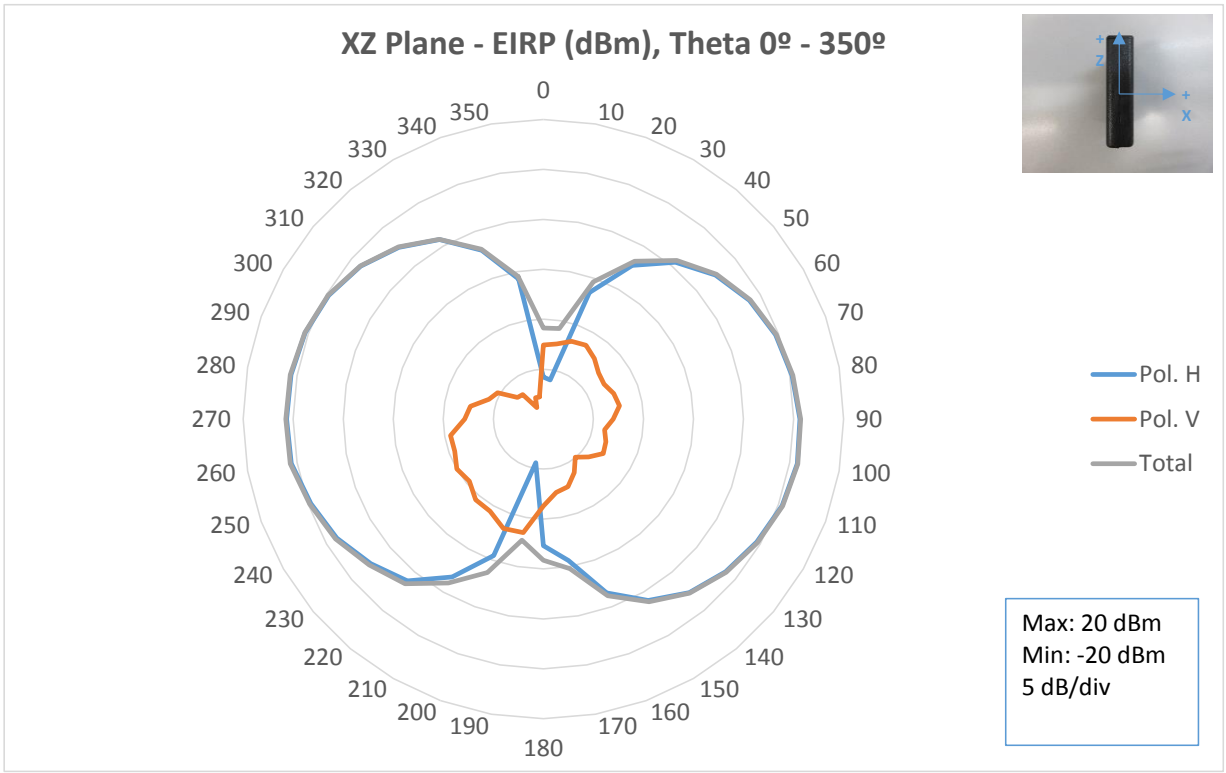

Fig. 11. XZ Plane EIRP, Free Space, 869.525 MHz.

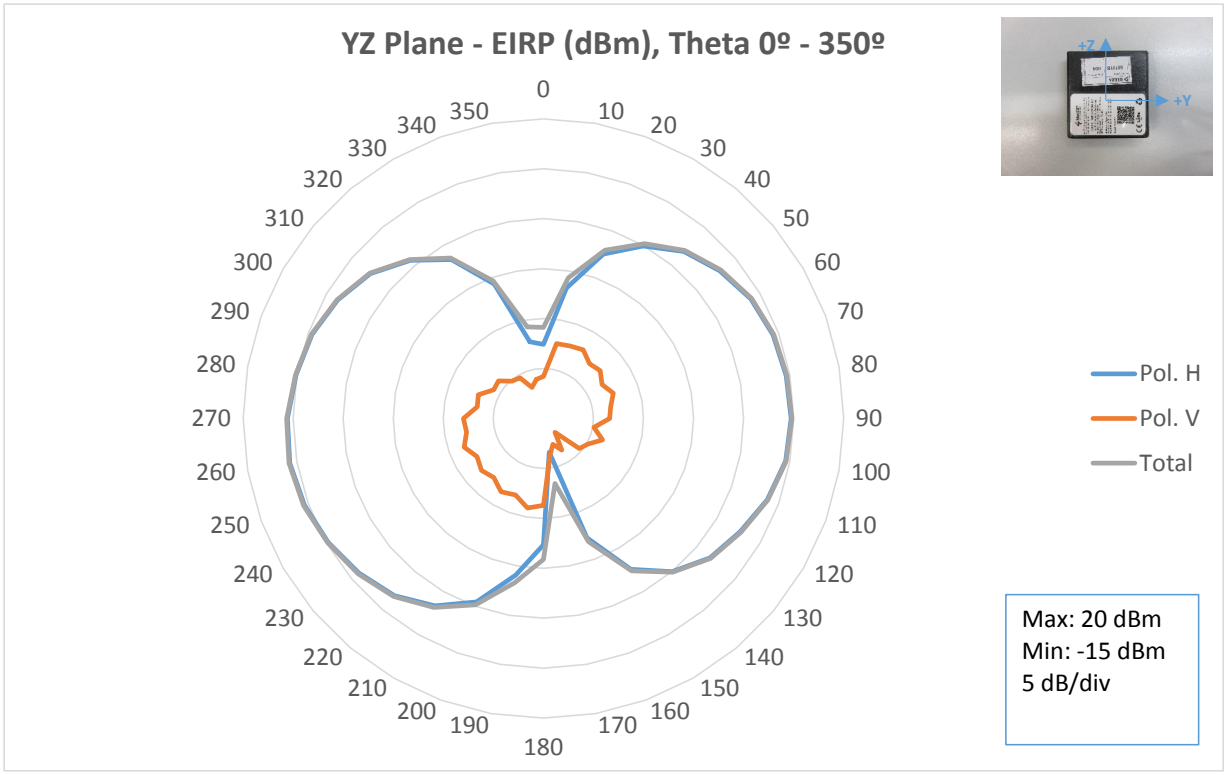

Fig. 12. YZ Plane EIRP, Free Space, 869.525 MHz.

5. RF TEST RESULT ON 3D
5.1 TRP 863.1 MHz – Free Space

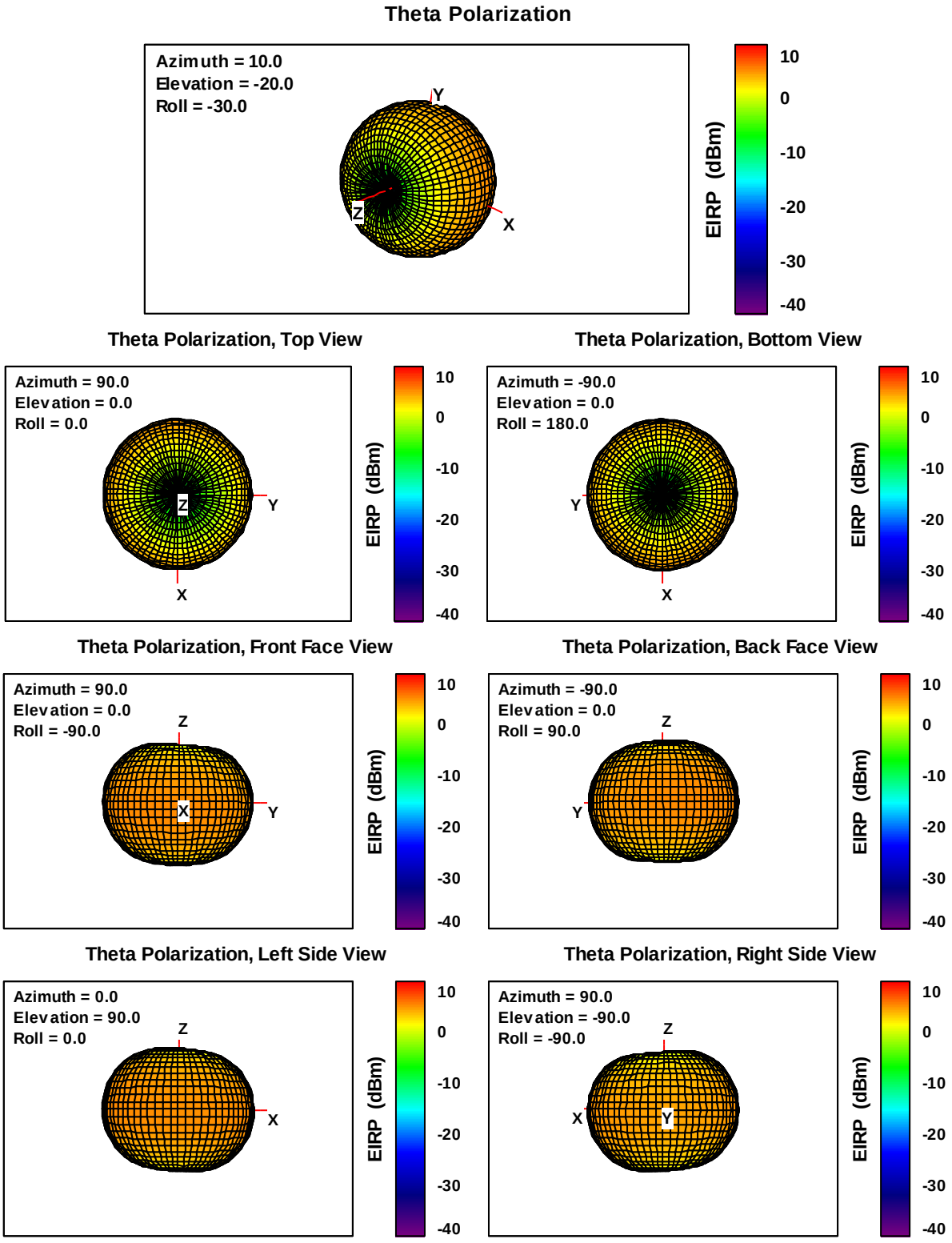

Fig. 13. Theta Polarization (Horizontal) EIRP, Free Space, 863.1 MHz.

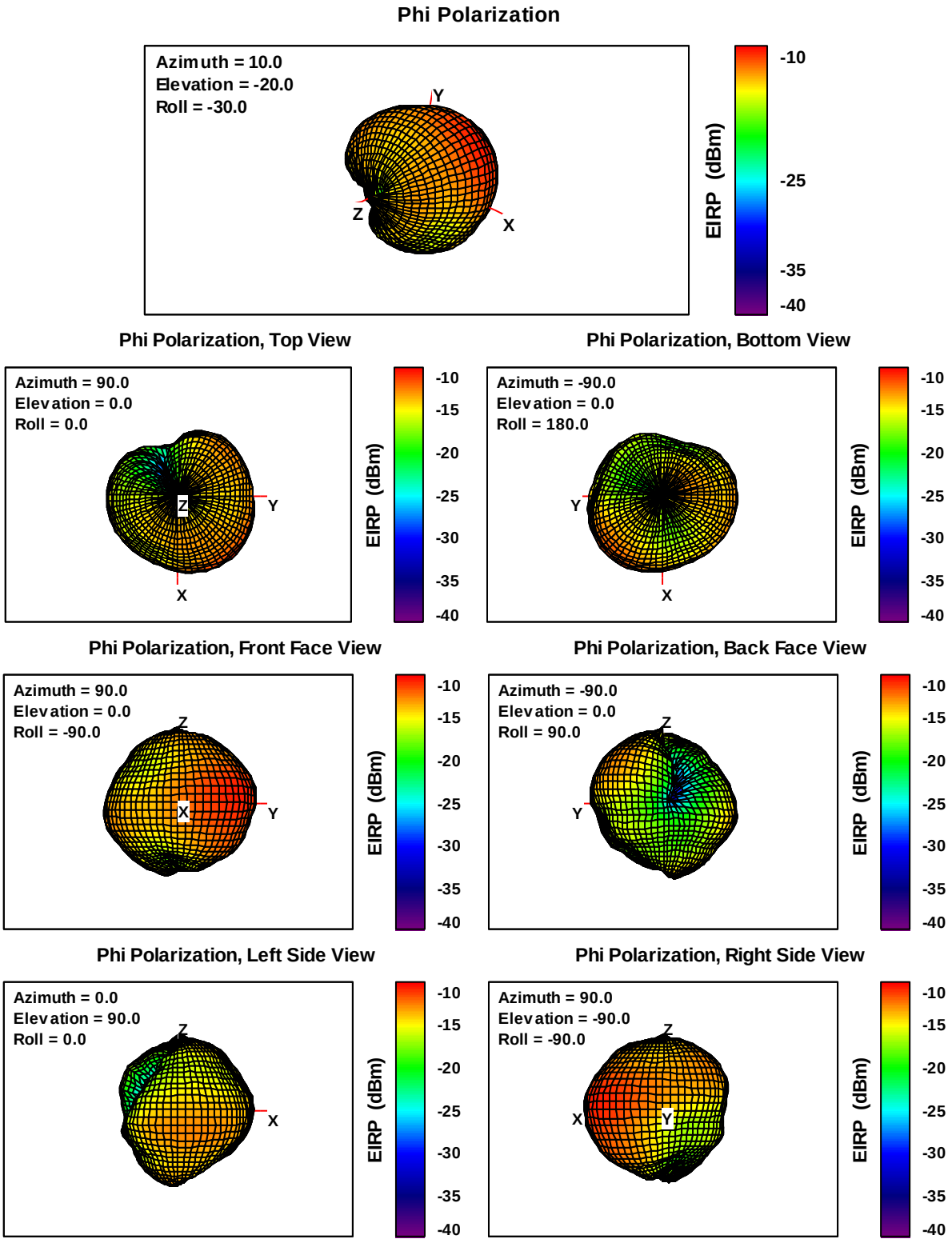

Fig. 14. Phi Polarization (Vertical) EIRP, Free Space, 863.1 MHz.

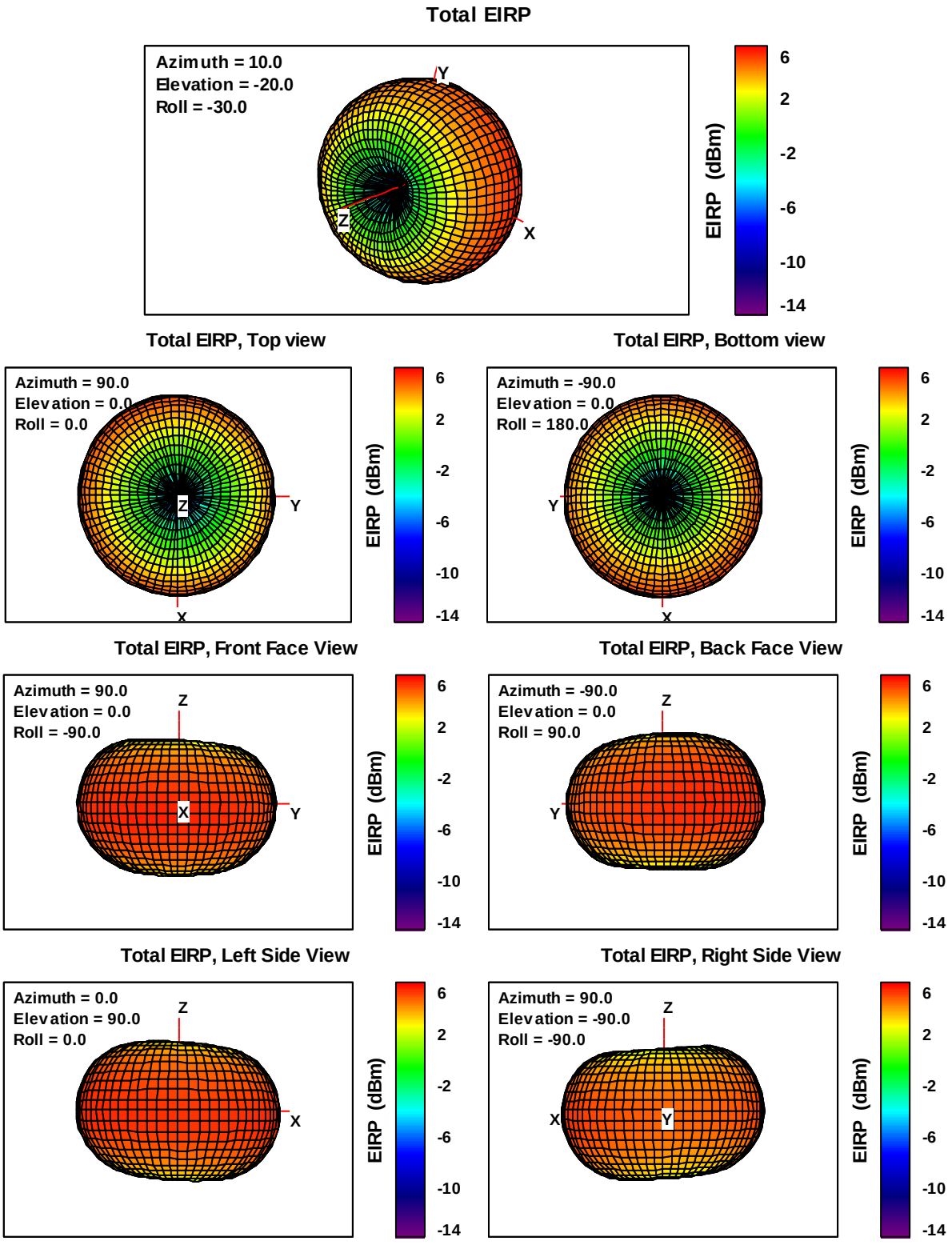

Fig. 15. Total EIRP, Free Space, 863.1 MHz.

5.2 TRP 868.3 MHz – Free Space

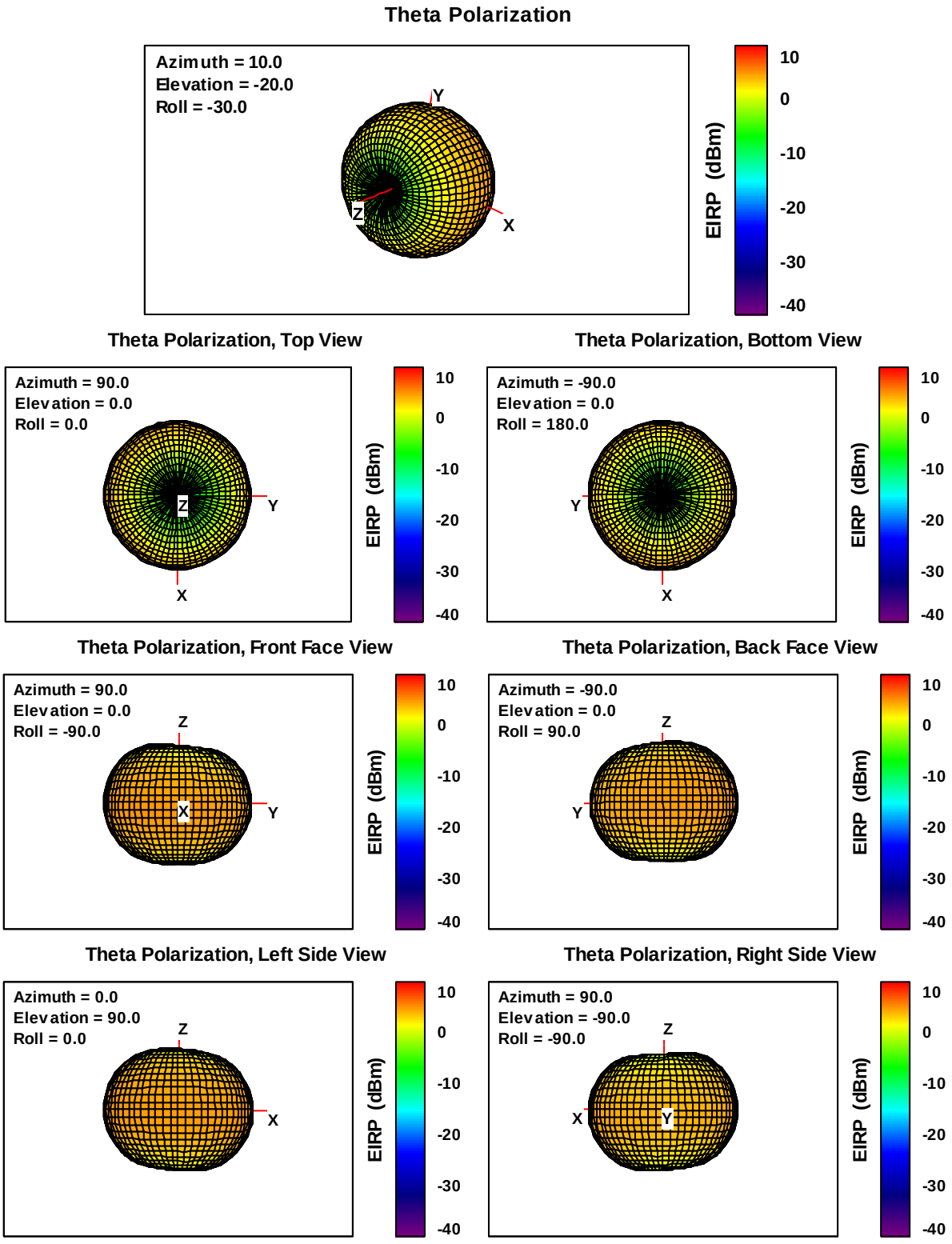

Fig. 16. Theta Polarization (Horizontal) EIRP, Free Space, 868.3 MHz.

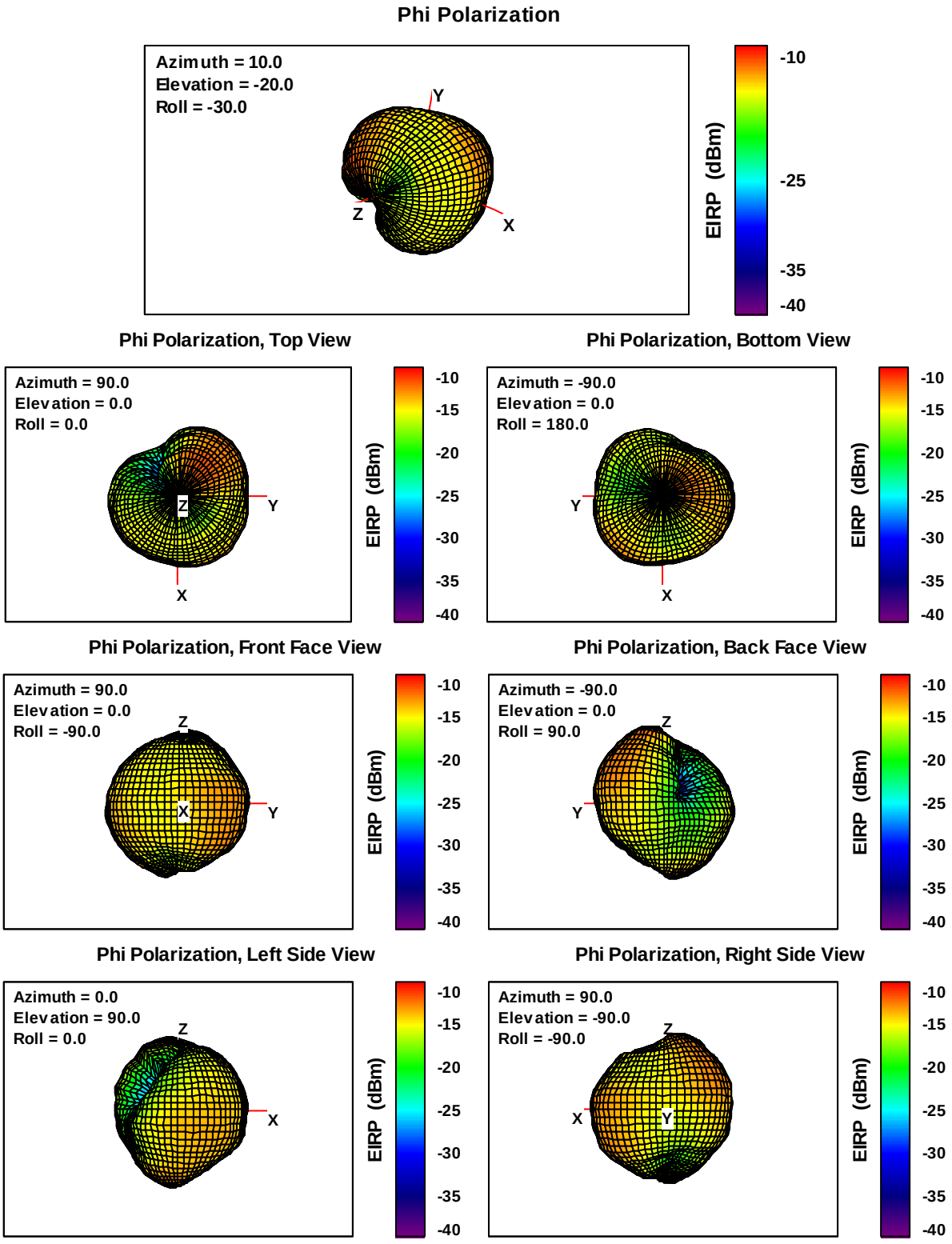

Fig. 17. Phi Polarization (Vertical) EIRP, Free Space, 868.3 MHz.

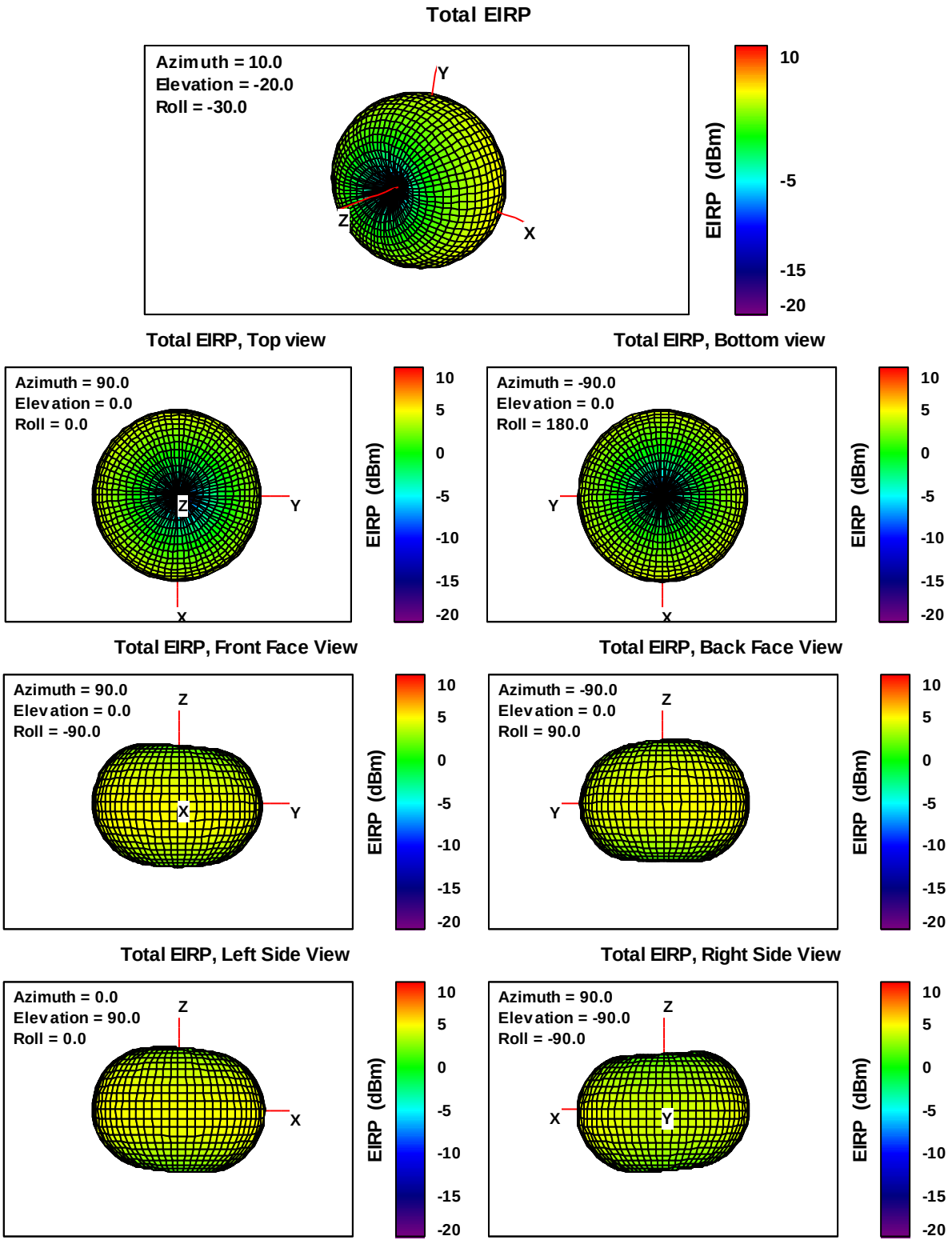

Fig. 18. Total EIRP, Free Space, 868.3 MHz.

5.3 TRP 869.525 MHz – Free Space

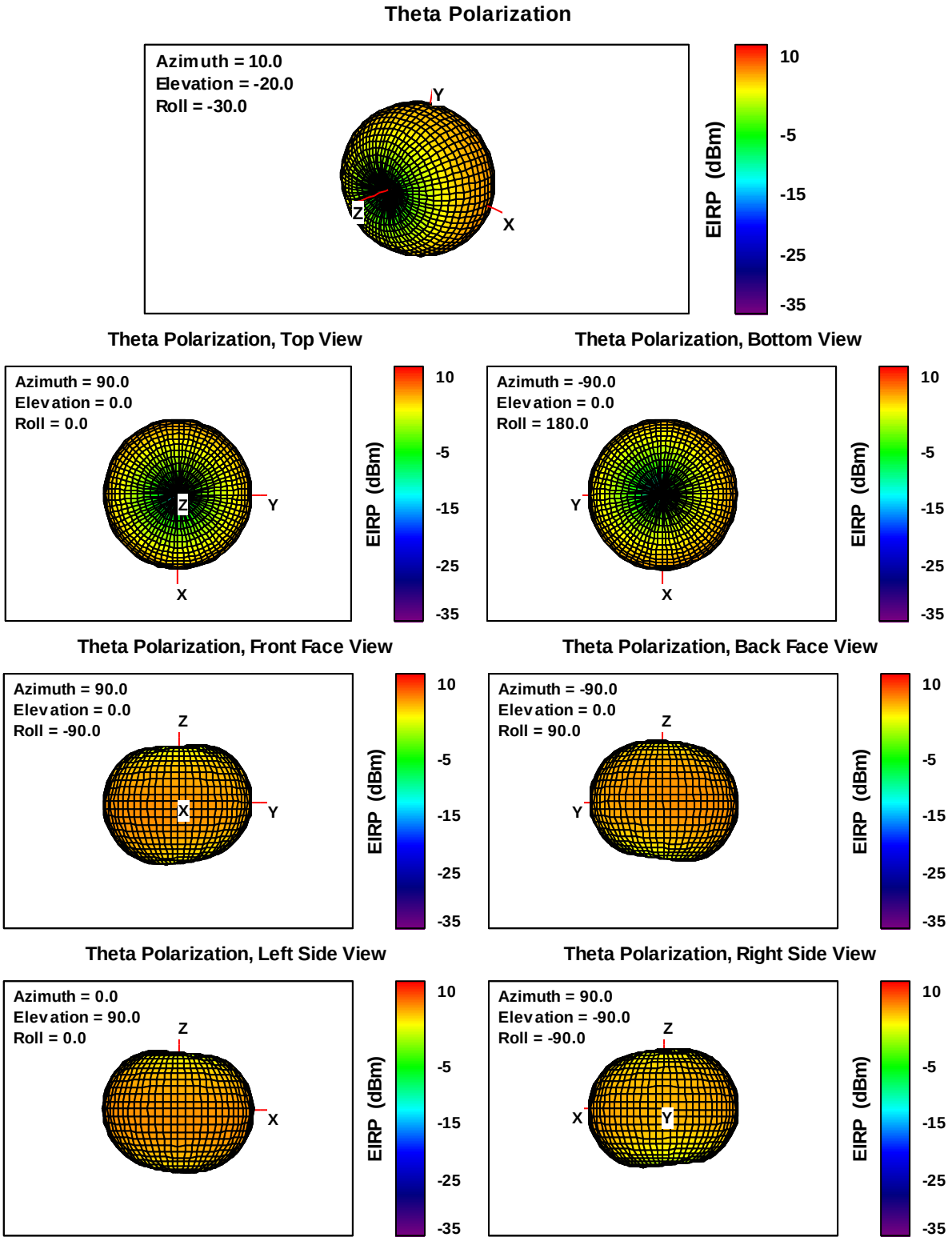

Fig. 19. Theta Polarization (Horizontal) EIRP, Free Space, 869.525 MHz.

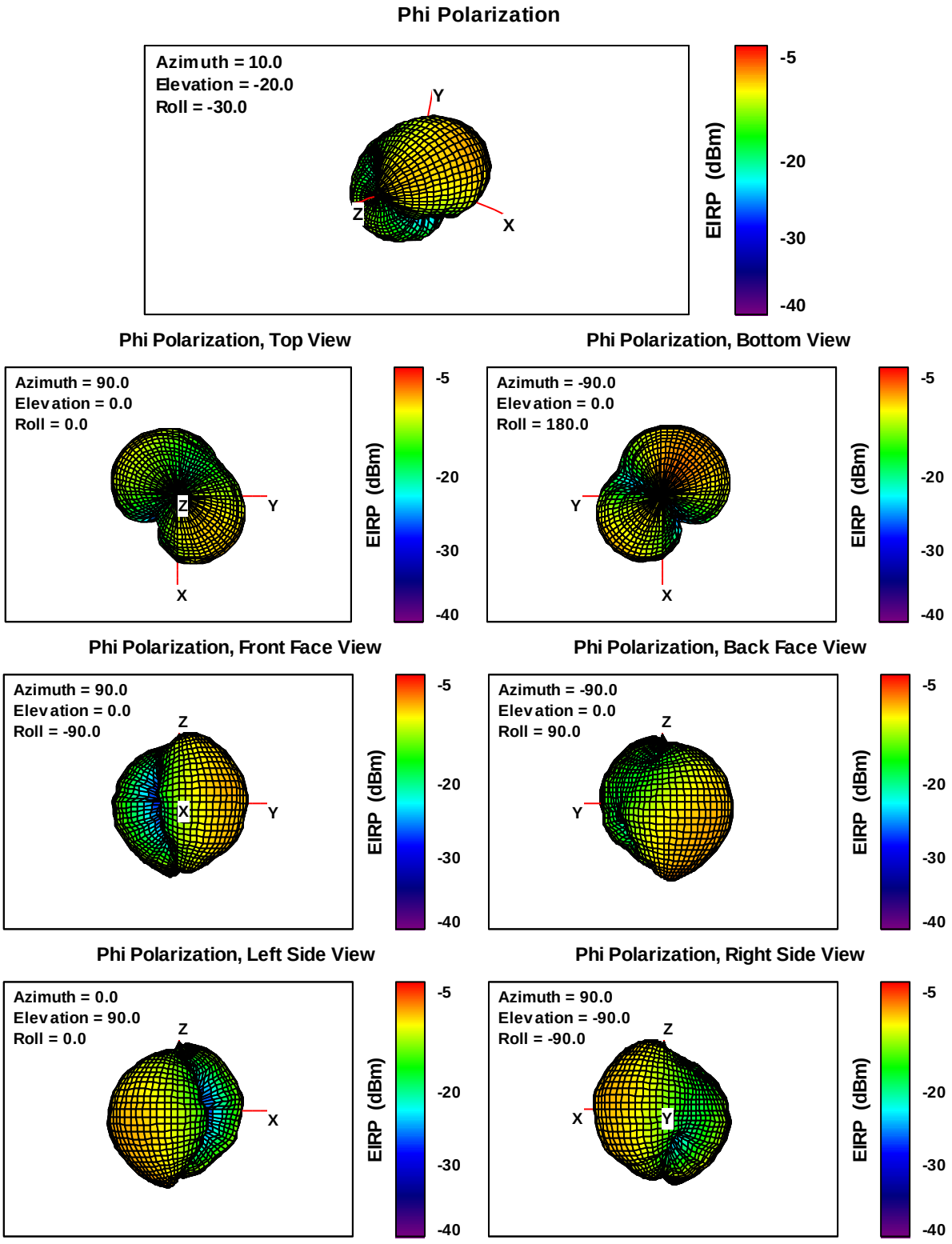

Fig. 20. Phi Polarization (Vertical) EIRP, Free Space, 869.525 MHz.

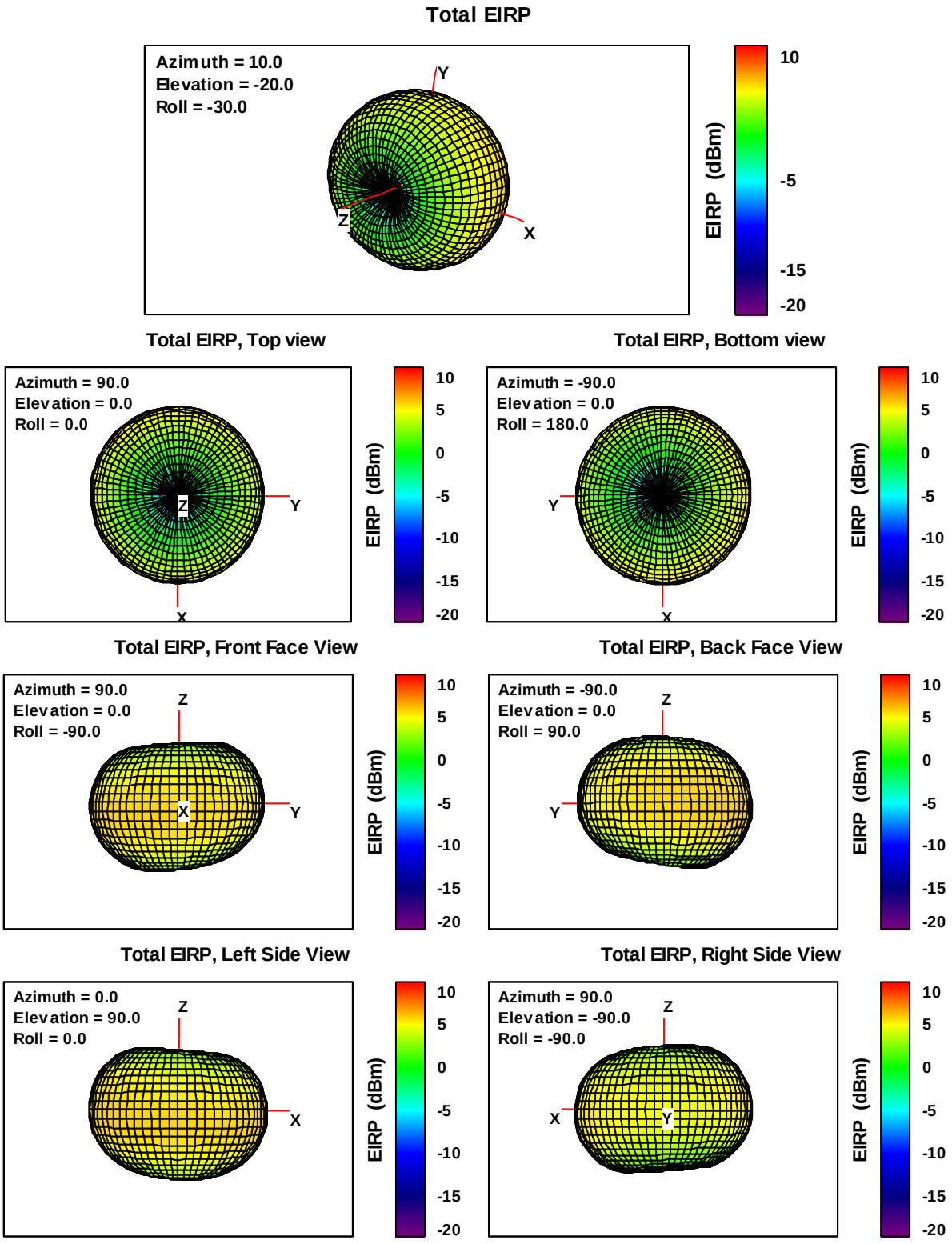

Fig. 21. Total EIRP, Free Space, 869.525 MHz.

6. RANGE REFERENCE MEASUREMENT DATA

Measurement Date:			2017-08-31						
Reference Antenna(s):			ETS Lindgren Dipole antenna 880 MHz, model 3126-880 (Cellular Band)						
Polarization:			Theta (Horizontal)						
Signal Path:			Theta Polarization to Spectrum Analyzer (TRP)						
Band	**Freq. Design.**	**Freq. (MHz)**	**Cable Ref. (dBm)**	**Test Port (dBm)**	**Noise Floor (dBm)**	**Test Port - Cable (dB)**	**Test Port - Noise (dB)**	**Ref. Ant. Gain (dBi)**	**Path Loss (dB)**
EU 868 MHz	LOW-TX	863.1	-	-	-	46.92	-	1.71	48.63
EU 868 MHz	DEFAULT-TX	868.3	-	-	-	47.02	-	1.72	48.74
EU 868 MHz	HIGH-TX	869.5	-	-	-	47.04	-	1.71	48.75

Measurement Date:			2017-08-31						
Reference Antenna(s):			ETS Lindgren Dipole antenna 880 MHz, model 3126-880 (Cellular Band)						
Polarization:			Phi (Vertical)						
Signal Path:			Phi Polarization to Spectrum Analyzer (TRP)						
Band	**Freq. Design.**	**Freq. (MHz)**	**Cable Ref. (dBm)**	**Test Port (dBm)**	**Noise Floor (dBm)**	**Test Port - Cable (dB)**	**Test Port - Noise (dB)**	**Ref. Ant. Gain (dBi)**	**Path Loss (dB)**
EU 868 MHz	LOW-TX	863.1	-	-	-	49.70	-	1.71	51.41
EU 868 MHz	DEFAULT-TX	868.3	-	-	-	49.91	-	1.72	51.64
EU 868 MHz	HIGH-TX	869.5	-	-	-	49.97	-	1.71	51.68

The path loss referenced in the following tables corresponds to the NSA value used in section 2 to determine the EIS level.

Measurement Date:			2017-08-31						
Reference Antenna(s):			ETS Lindgren Dipole antenna 880 MHz, model 3126-880 (Cellular Band)						
Polarization:			Theta (Horizontal)						
Signal Path:			Theta Polarization to Variable Attenuator (TIS)						
Band	**Freq. Design.**	**Freq. (MHz)**	**Cable Ref. (dBm)**	**Test Port (dBm)**	**Noise Floor (dBm)**	**Test Port - Cable (dB)**	**Test Port - Noise (dB)**	**Ref. Ant. Gain (dBi)**	**Path Loss (dB)**
EU 868 MHz	DEFAULT-TX	868.3	-	-	-	47.56	-	1.72	49.28
EU 868 MHz	HIGH-TX	869.5	-	-	-	47.58	-	1.71	49.29

Measurement Date:			2017-08-31						
Reference Antenna(s):			ETS Lindgren Dipole antenna 880 MHz, model 3126-880 (Cellular Band)						
Polarization:			Phi (Vertical)						
Signal Path:			Phi Polarization to Variable Attenuator (TIS)						
Band	**Freq. Design.**	**Freq. (MHz)**	**Cable Ref. (dBm)**	**Test Port (dBm)**	**Noise Floor (dBm)**	**Test Port - Cable (dB)**	**Test Port - Noise (dB)**	**Ref. Ant. Gain (dBi)**	**Path Loss (dB)**
EU 868 MHz	DEFAULT-TX	868.3	-	-	-	50.48	-	1.72	52.20
EU 868 MHz	HIGH-TX	869.5	-	-	-	50.52	-	1.71	52.23

Appendix B: Photographs

Equipment under test:

- **EUT front view:**

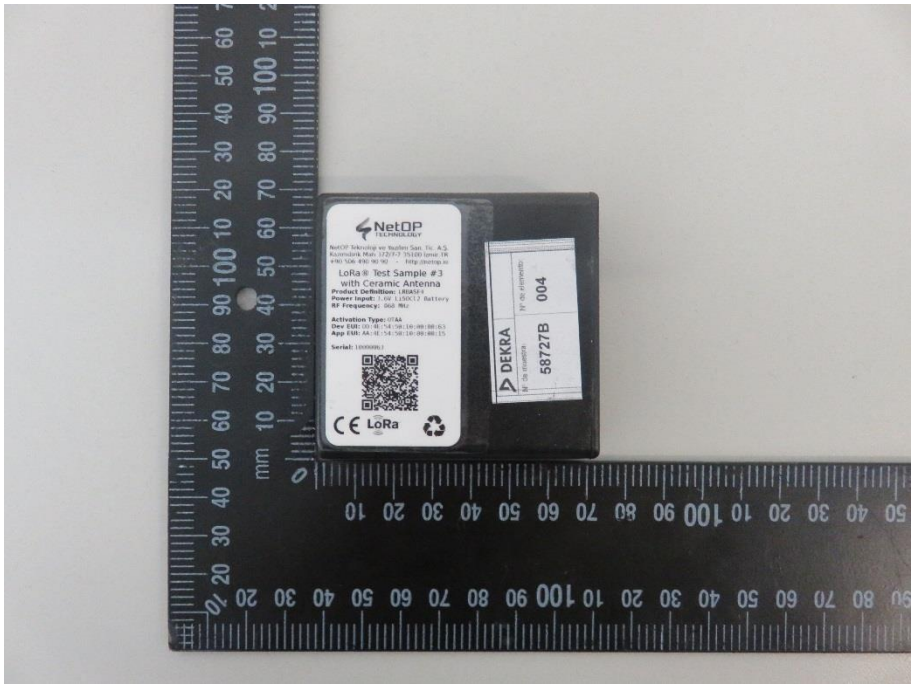

Fig 22. EUT front view.

Test set:

- **Free Space set-up: Initial position: Theta = 0º, Phi = 0º**

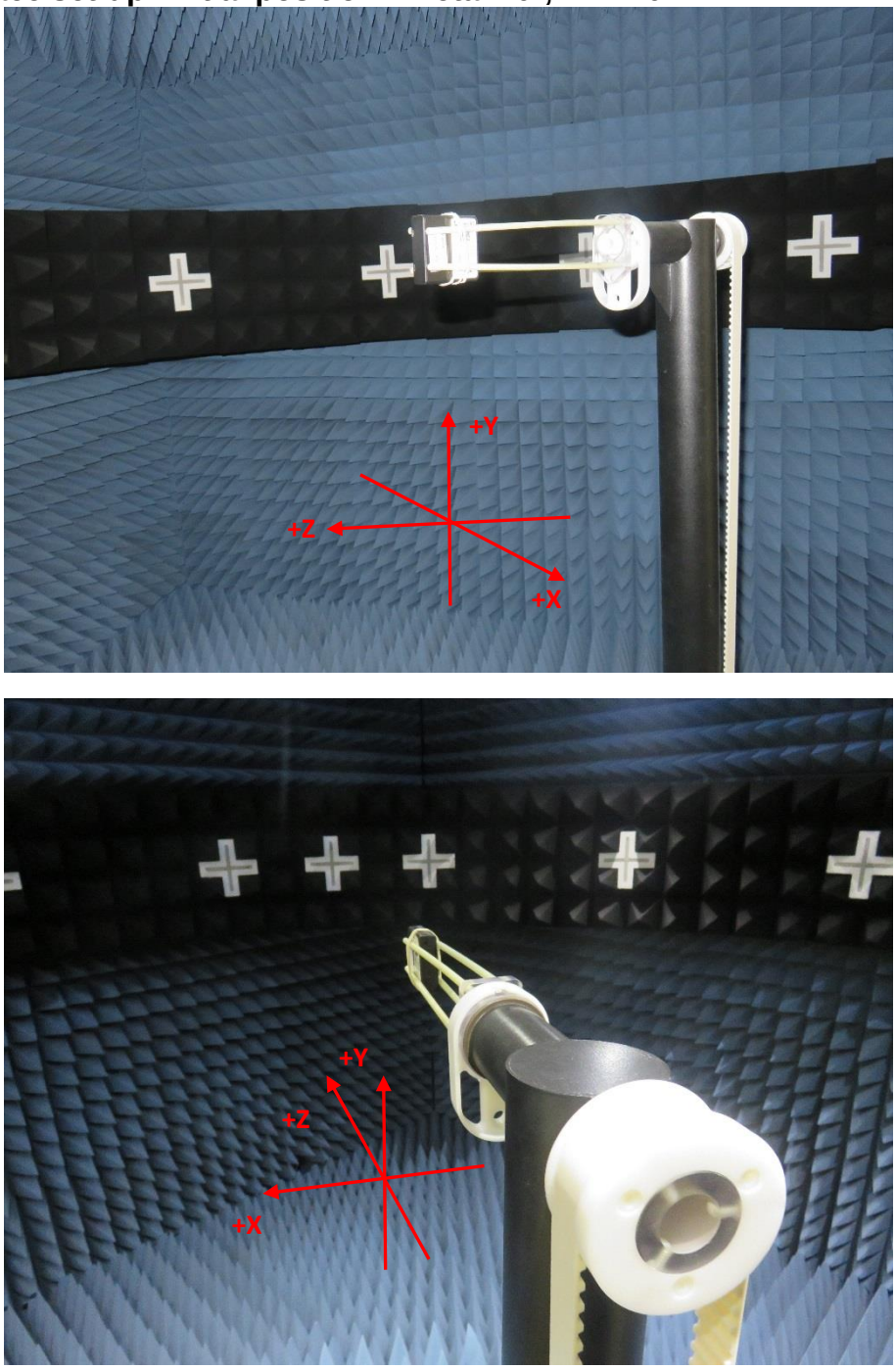

Fig 23. Free Space configuration set-up view.