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Parque Tecnológico de Andalucía,
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C.I.F. A29 507 456

Test report No:
NIE: 63161RAN.001

Test report

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

(*) Identification of item tested	Smart Ultrasonic Water Meter, with LoRa-WAN connectivity
(*) Trademark	Sonata
(*) Model and /or type reference	Sonata LoRa
(*) Other identification of the product	HW: 2.0 SW : 1.0.4
(*) Features	LoRa-WAN connectivity as end-device/sensor on LoRa-WAN physical channel EU863-870
Manufacturer	WaterTECH S.p.A. Passaggio Duomo, 2, 20123 Milano, Italy
Test method requested, standard	[1] LoRa Alliance End-Device Certification Radiated RF Performance for EU 868 MHz ISM Band Devices
Approved by (name / position & signature)	Miguel Lacave Antennas Lab. Manager
Date of issue	2019-11-11
Report template No	FDT08_22 (*) "Data provided by the client"

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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 Testing and Certification S.A.U. has a calibration and maintenance program for its measurement equipment.

DEKRA Testing and Certification S.A.U. 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 Testing and Certification S.A.U. at the time of performance of the test.

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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 Testing and Certification S.A.U.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. 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. April 2019. Revision 3.8.2.
2. FAN06 - OTA SISO CTIA - AMS-8700 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").

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.

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 v1.12
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	S/N	Date of reception
63161B/004	Water Meter	Sonata LoRa	70B3D5A9F00233C5	2019-11-06

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

Test sample description

The Sonata is an advanced and highly accurate ultrasonic water meter and data end-point for residential applications.

The Sonata’s robust design ensures reliable and long-lasting precision.

The Sonata is a data rich end-point. By exploiting the performances of LoRa-WAN connectivity, it allows a reliable communication with the MDM system and it’s ready to meet the challenges of tomorrow’s smart water networks.

Identification of the client

Company name: WATERTECH S.P.A.

Postal Address: Passaggio Duomo, 2, 20123 Milano, Italy

Contact Person: Umberto Manzoli

Telephone/e-mail: +39 335 594 7766 / umbertomanzoli@wtmeters.it

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2019-11-06
Date (finish)	2019-11-07

Document history

Report number	Date	Description
63161RAN.001	2019-11-11	First release

Environmental conditions

Date	Max. Temp. ºC	Min. Temp. ºC	Max. Hum. %	Min. Hum. %
From 2019-11-06 to 2019-11-07	26.7	19.3	53.9	38.0

Remarks and comments

Testing has been performed by Manuel García.

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 = 3.5 V_{DC} supplied by its own internal batteries.

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 "TX Power" parameter was set to 0 (maximum EIRP), 3 and 6 for TRP tests and 0 for TIS 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.

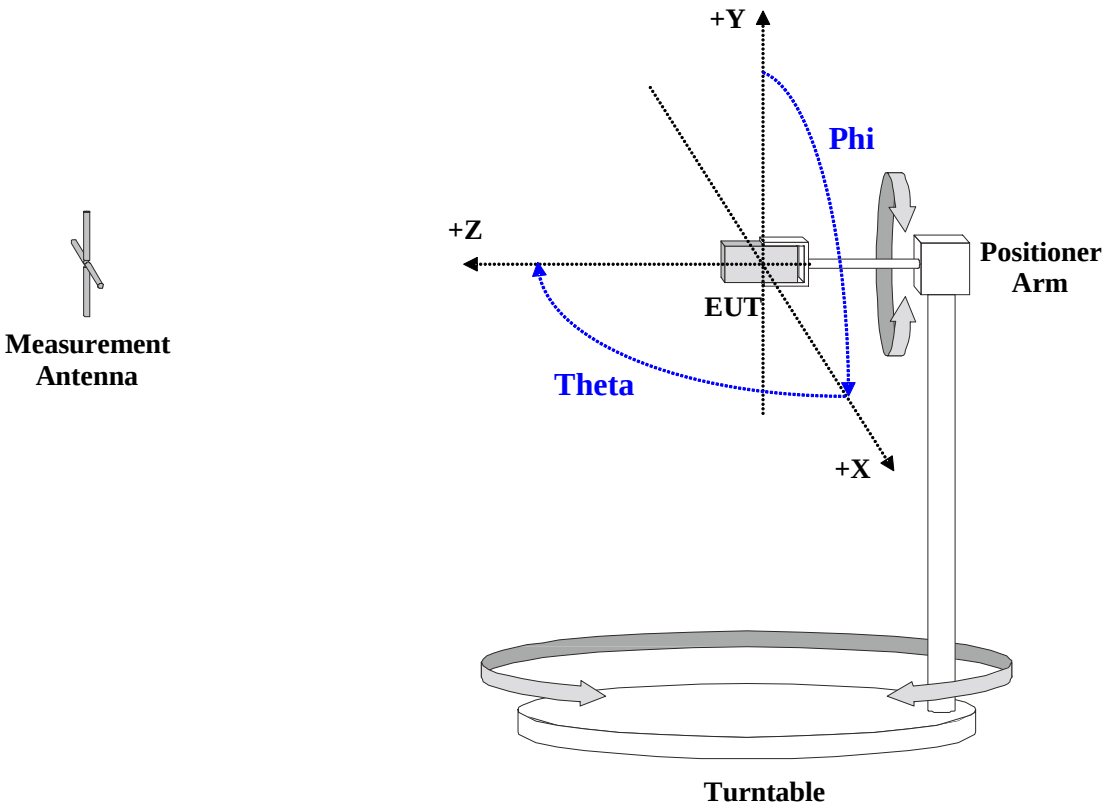

Fig. 1. Coordinate system.

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

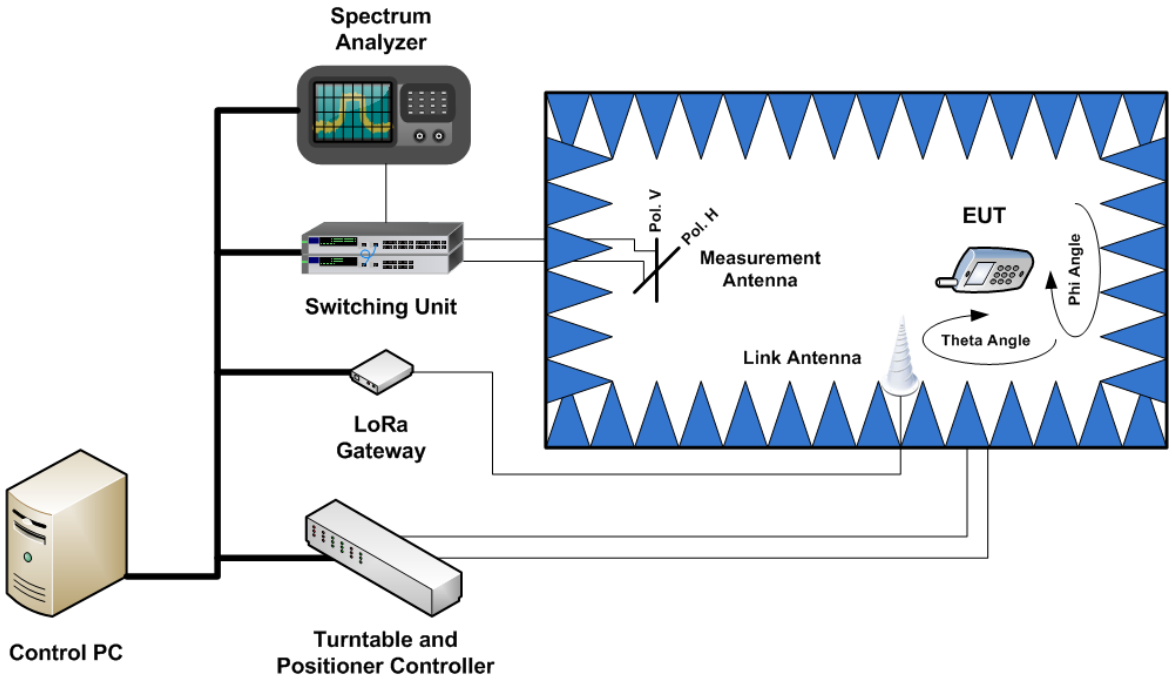

Fig. 2. Transmitter performance test connection diagram.

End-device receiver performance

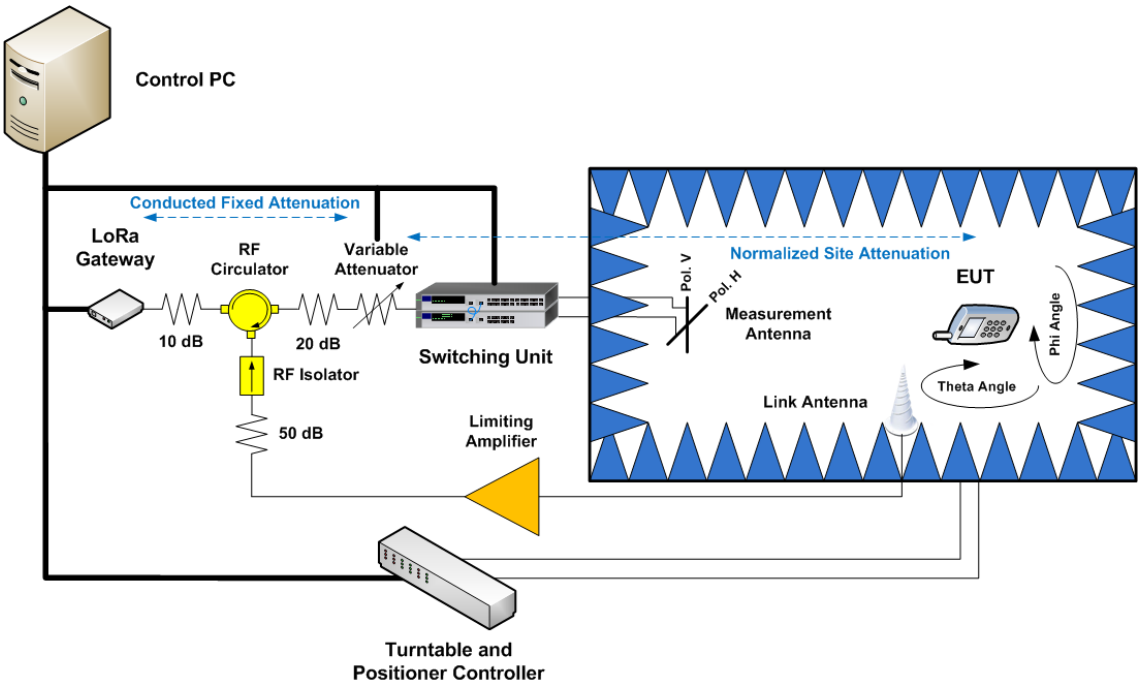

Fig. 3. Receiver performance test connection diagram.

2. TEST RESULTS

2.1 Transmitter performance

Frequency (MHz)	TX Power parameter	TRP (dBm)	Maximum EIRP				
			Horizontal EIRP (dBm)	Vertical EIRP (dBm)	Total EIRP (dBm)	Theta (º)	Phi (º)
863.1	0	10.77	14.70	-3.54	14.76	130	30
	3	N/A	11.55	-1.21	11.77	130	30
	6	N/A	5.53	-7.60	5.73	130	30
865.1	0	11.04	15.06	-2.68	15.13	130	30
	3	N/A	11.47	-1.35	11.69	130	30
	6	N/A	5.25	-7.76	5.46	130	30
868.3	0	11.48	15.08	-1.08	15.18	120	40
	3	N/A	10.79	-2.83	10.98	120	40
	6	N/A	4.19	-9.24	4.38	120	40
869.525	0	11.05	14.94	-3.10	15.00	130	30

2.2 Receiver performance

Frequency (MHz)		863.1	865.1	868.3	869.525	
Spreading Factor		SF12 (DR0)	SF12 (DR0)	SF12 (DR0)	SF12 (DR0)	SF7 (DR5)
TIS (dBm)		-128.02	-131.30	-132.00	-130.85	-118.25
Measured EIS	EIS (dBm)	-135.52	-135.81	-134.94	-122.34	-117.46
	PER (%)	5.00	3.33	1.67	5.00	3.331
	Polarization	Horizontal	Horizontal	Horizontal	Horizontal	Theta
	Theta (º)	130	120	130	130	70
	Phi (º)	30	40	30	30	190
GW Tx Power (dBm)		9.16	11.61	12.80	13.20	13.20
Forward path attenuation (dB)		-141.31	-147.13	-148.61	-148.14	-135.54
Normalized Site Attenuation (NSA) (dB)[1]		-48.99	-49.04	-49.02	-49.07	-49.07
Conducted fixed attenuation (dB)[2]		-92.32	-98.09	-99.59	-99.07	-86.47
RF Path attenuation step size (dB)		0.50	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. April 2019. Revision 3.8.2.

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

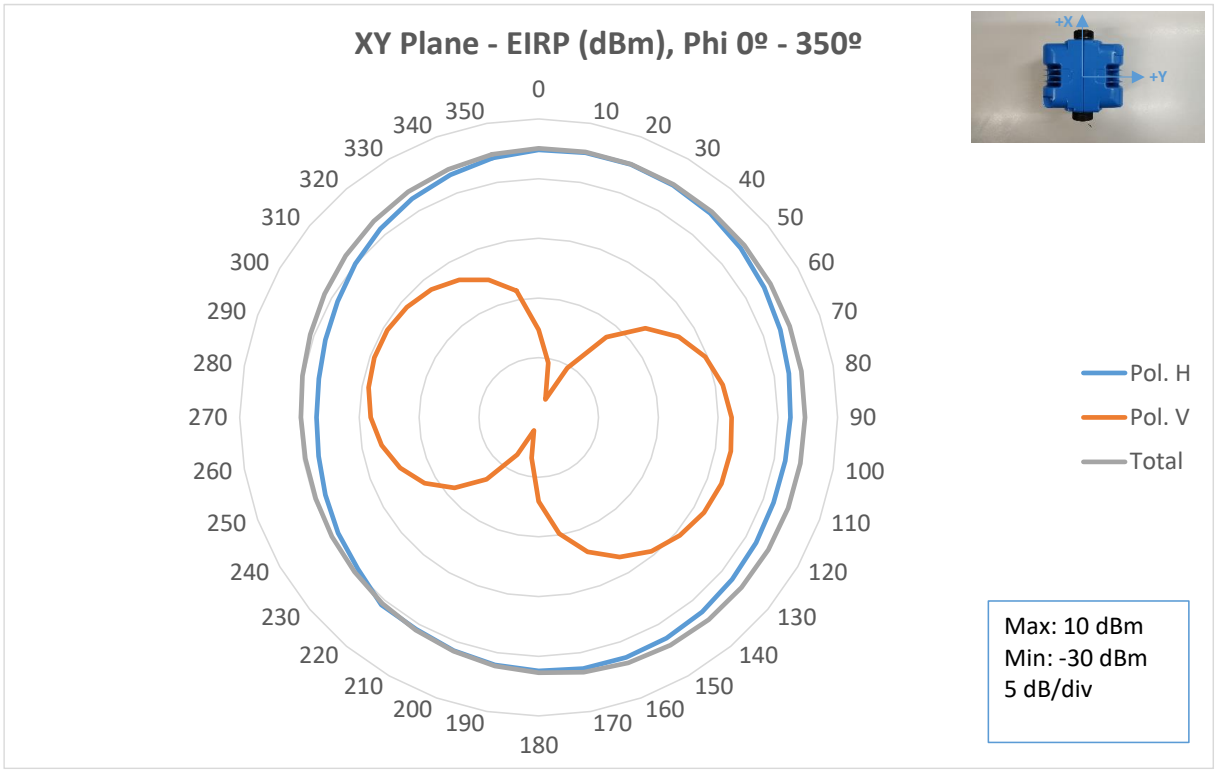

Fig. 4. XY Plane EIRP, Free Space, 863.1 MHz.

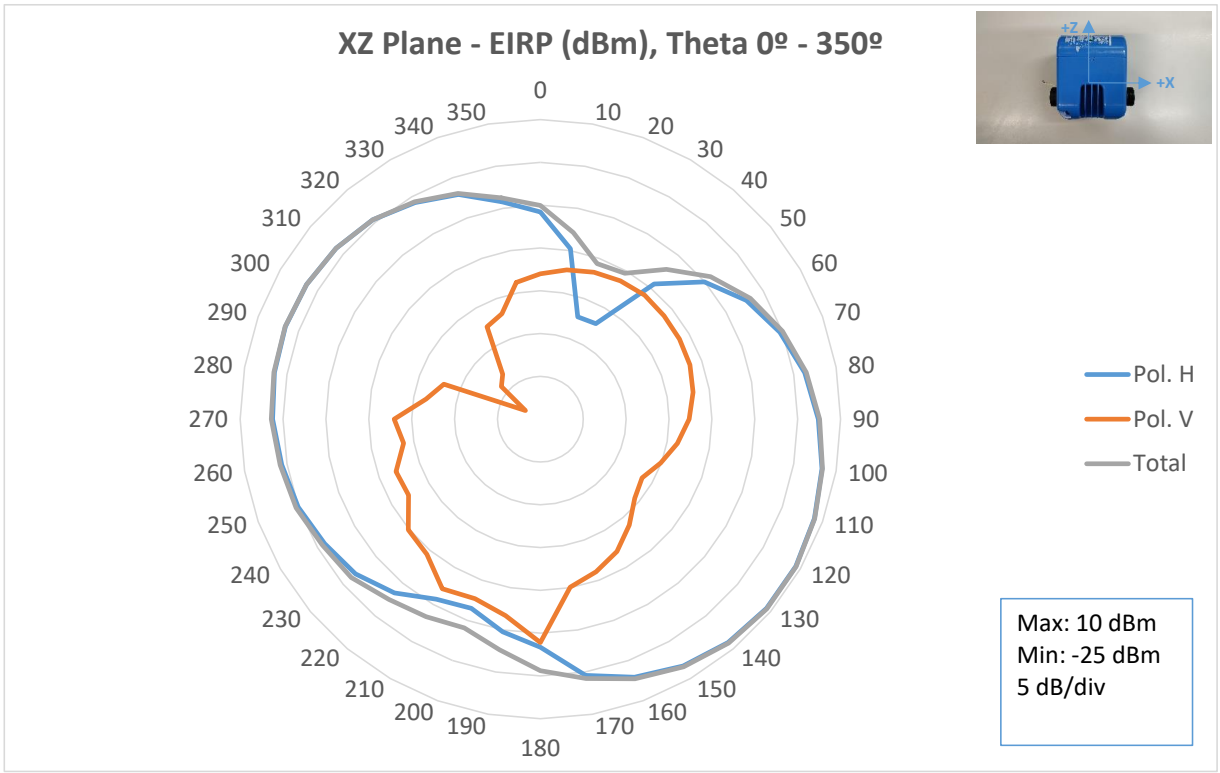

Fig. 5. XZ Plane EIRP, Free Space, 863.1 MHz.

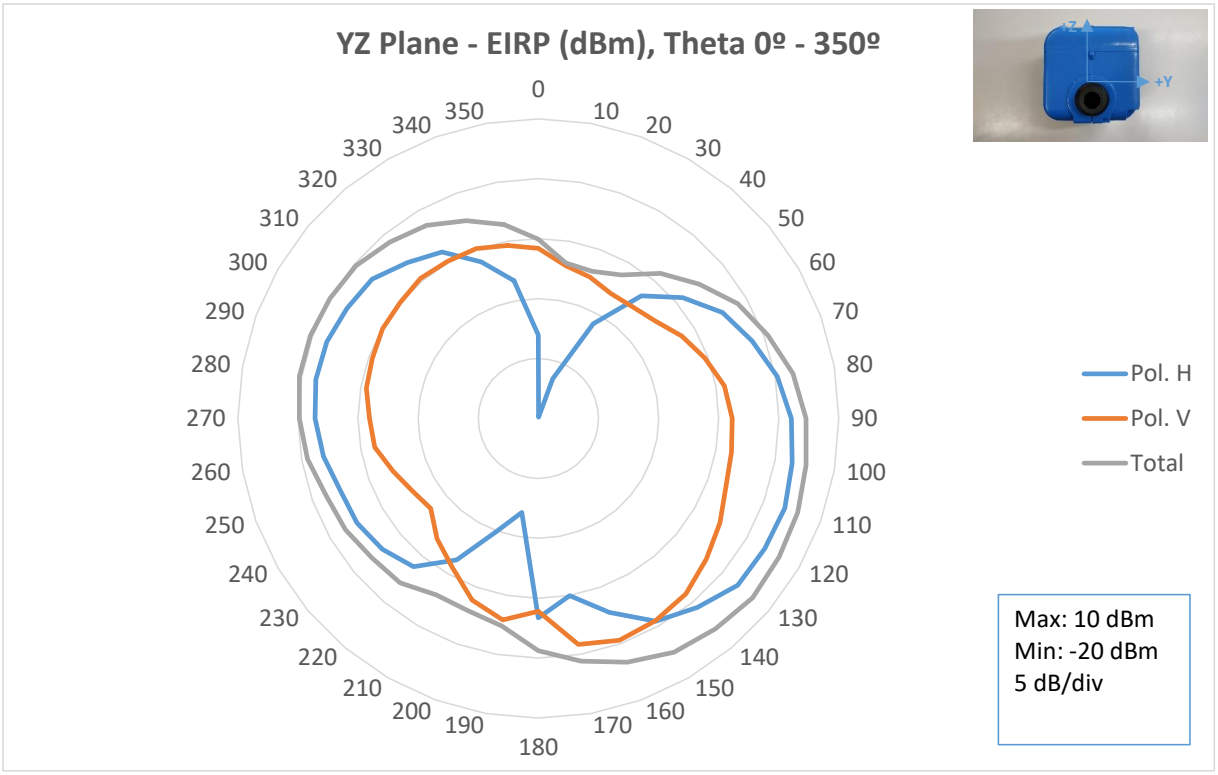

Fig. 6. YZ Plane EIRP, Free Space, 863.1 MHz.

4.2 EIRP Pattern 865.1 MHz – Free Space

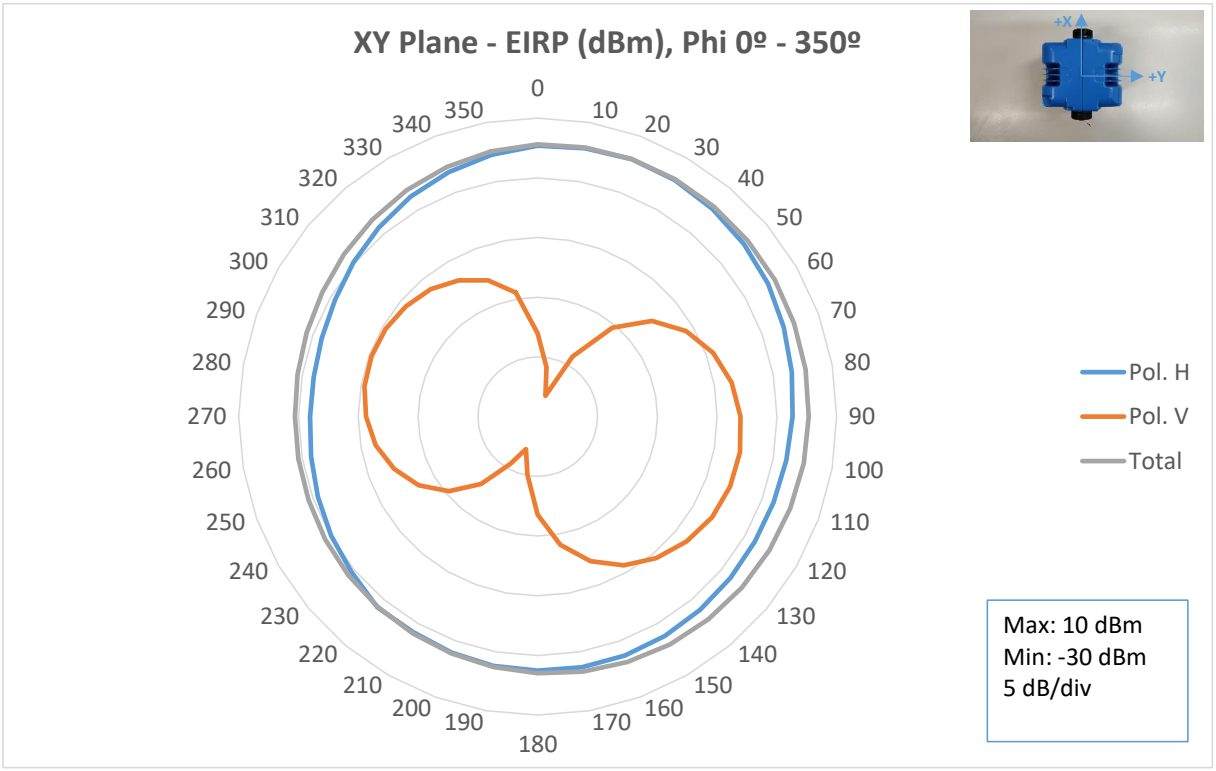

Fig. 7. XY Plane EIRP, Free Space, 865.1 MHz.

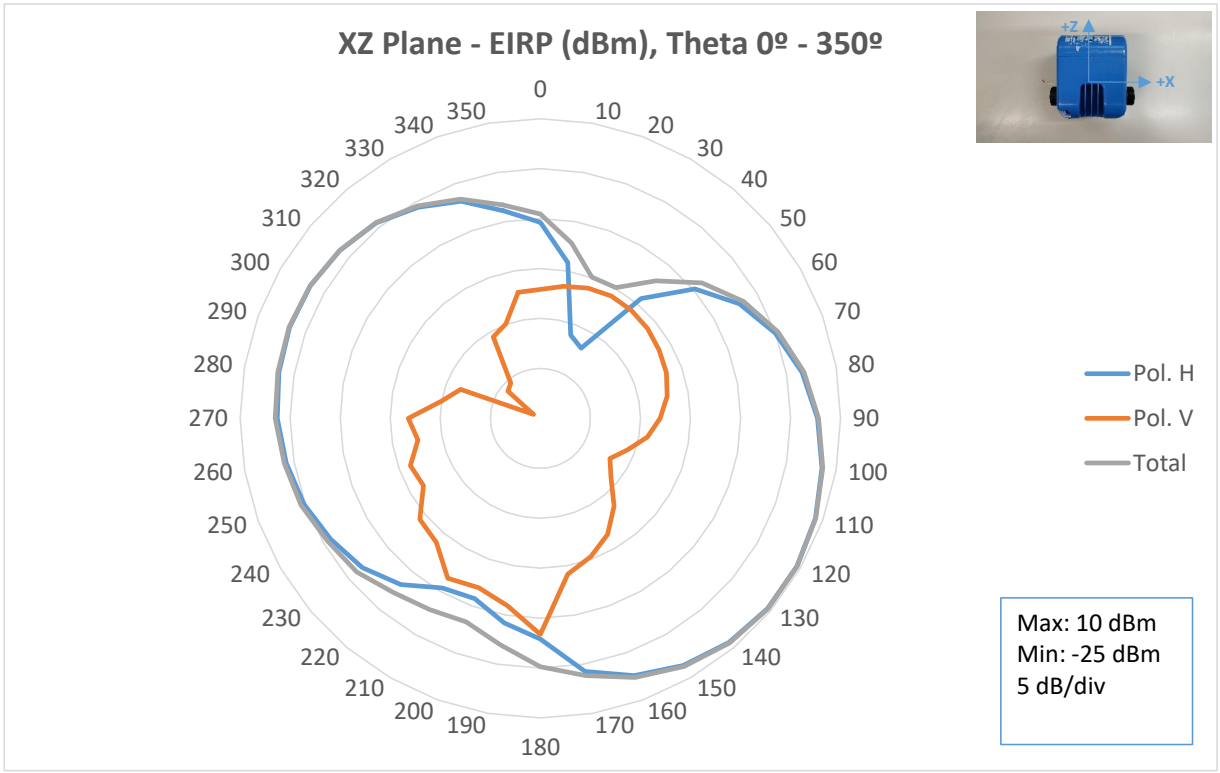

Fig. 8. XZ Plane EIRP, Free Space, 865.1 MHz.

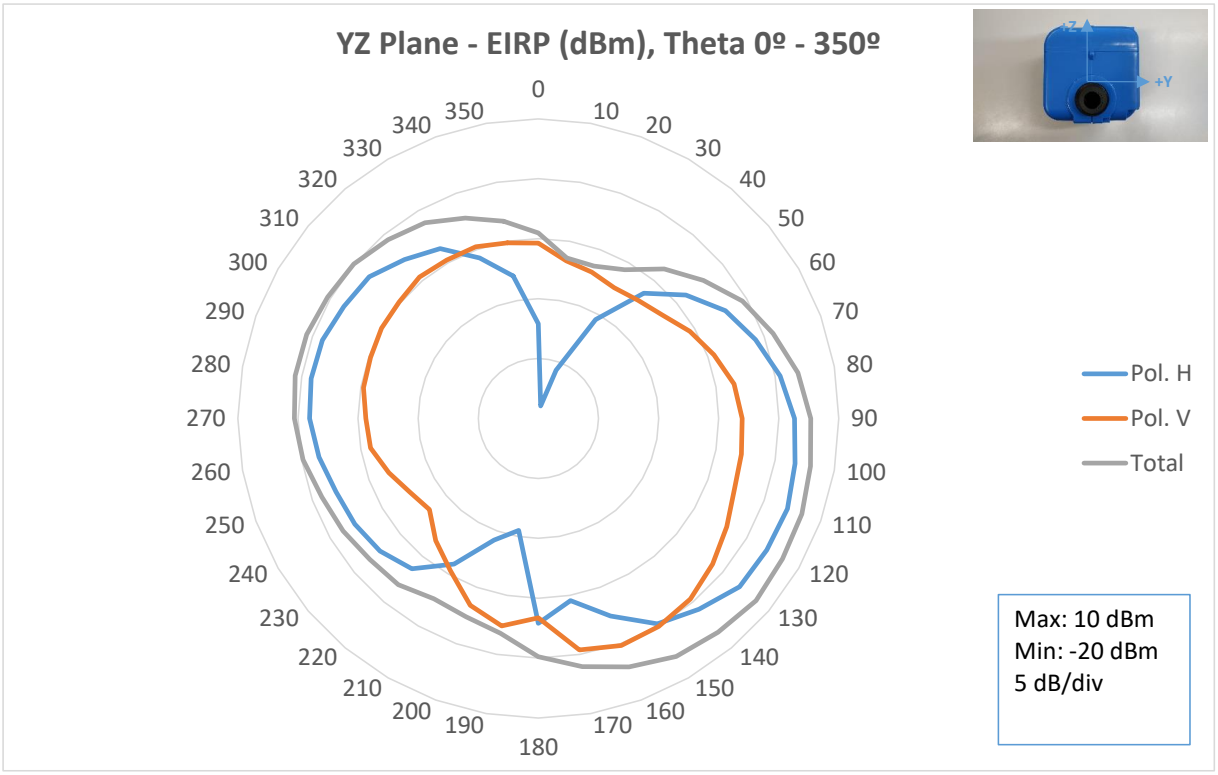

Fig. 9. YZ Plane EIRP, Free Space, 865.1 MHz.

4.3 EIRP Pattern 868.3 MHz – Free Space

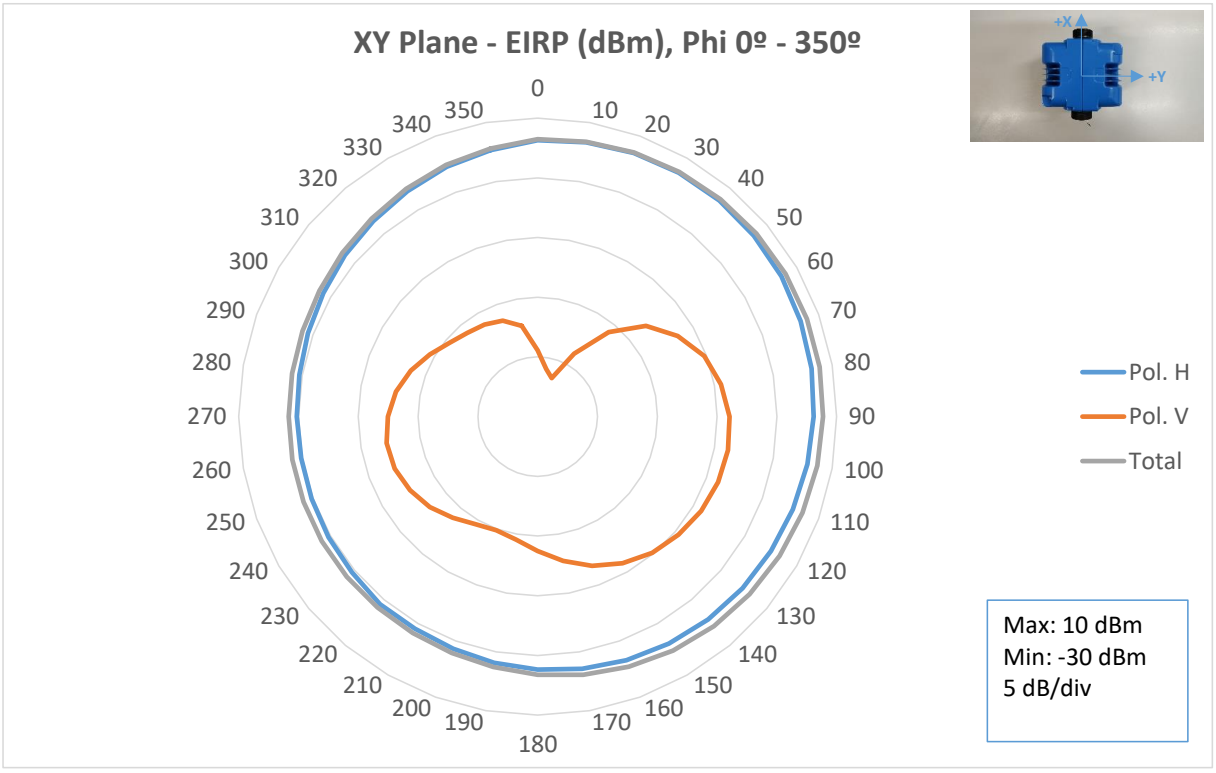

Fig. 10. XY Plane EIRP, Free Space, 868.3 MHz.

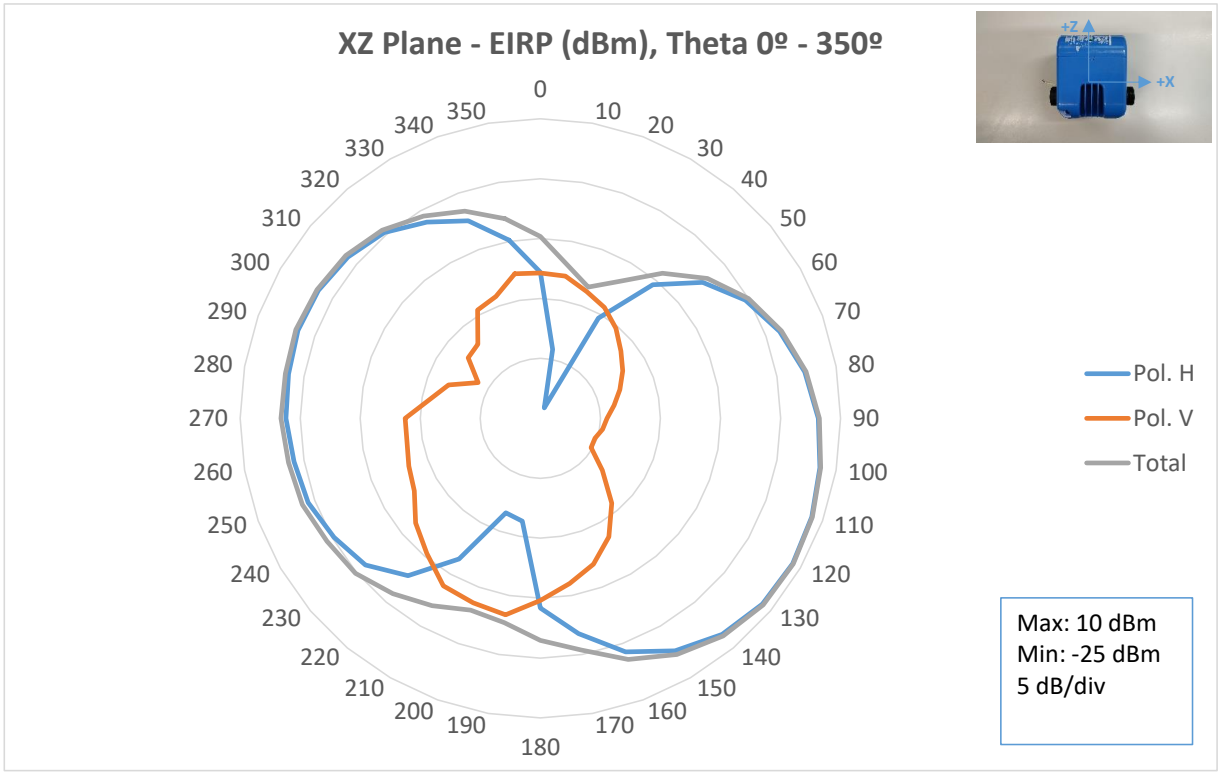

Fig. 11. XZ Plane EIRP, Free Space, 868.3 MHz.

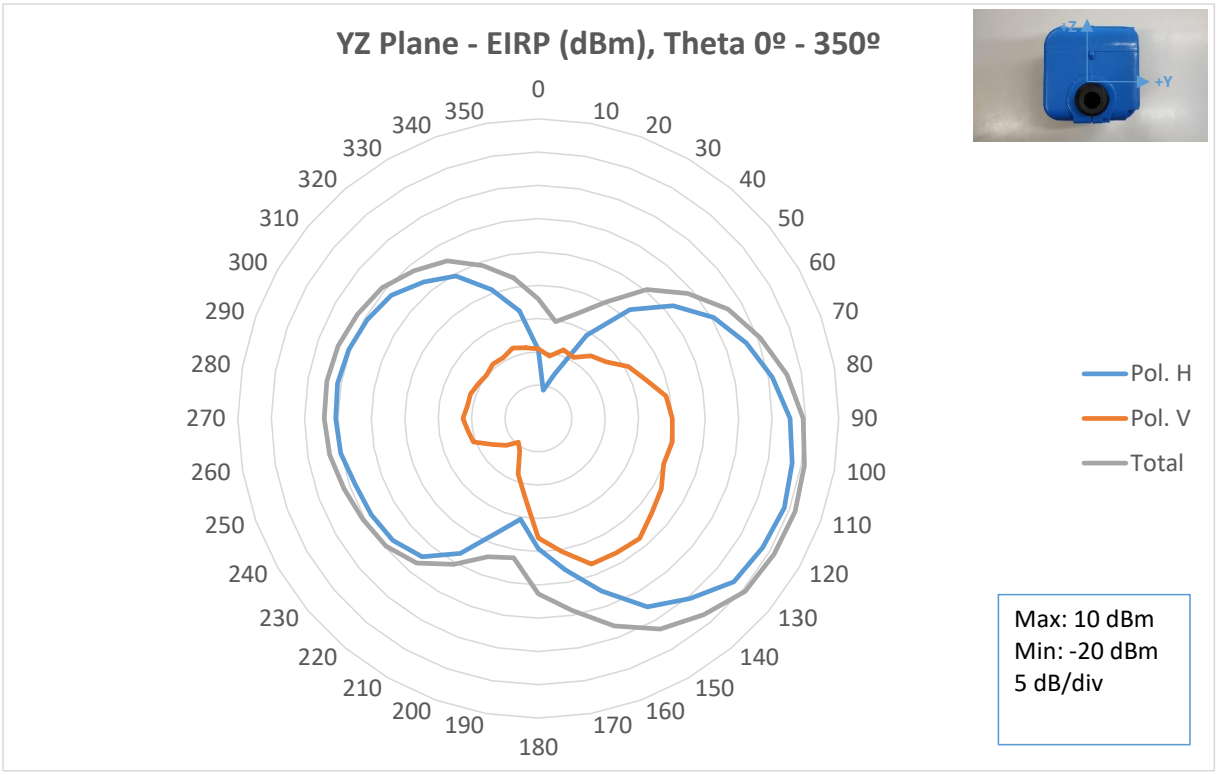

Fig. 12. YZ Plane EIRP, Free Space, 868.3 MHz.

4.4 EIRP Pattern 869.525 MHz – Free Space

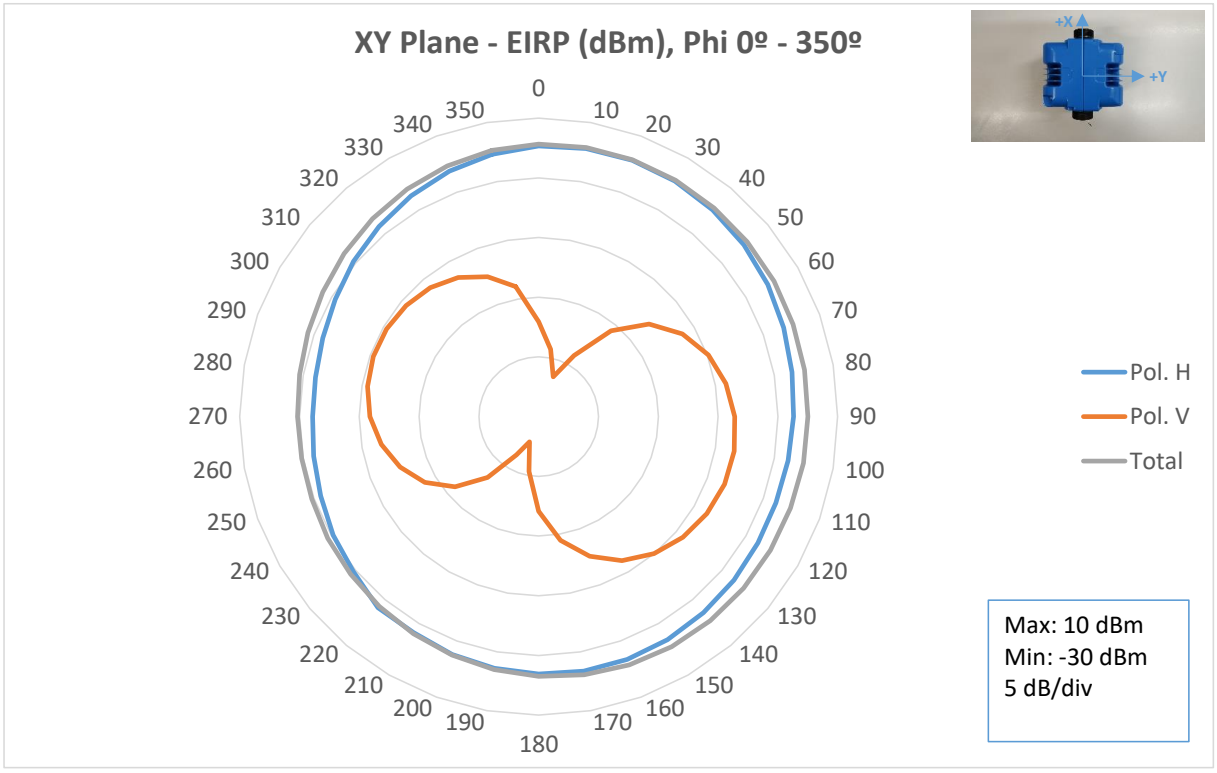

Fig. 13. XY Plane EIRP, Free Space, 869.525 MHz.

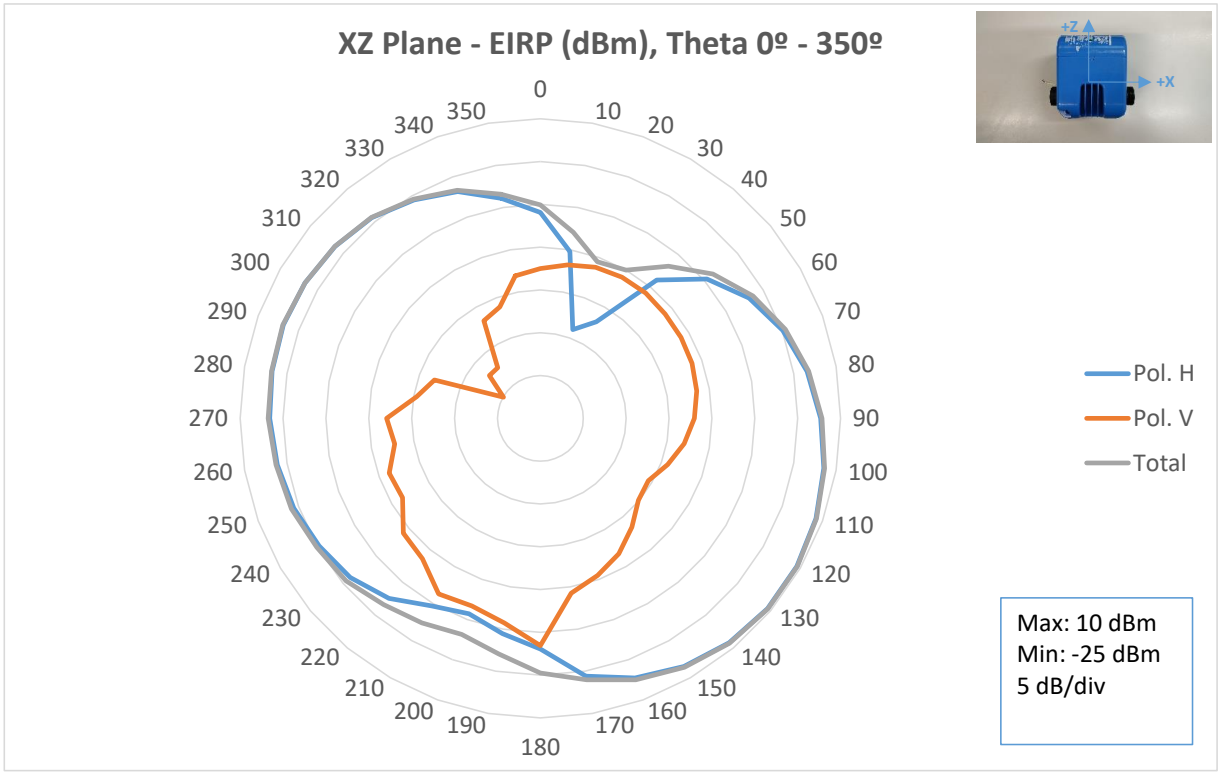

Fig. 14. XZ Plane EIRP, Free Space, 869.525 MHz.

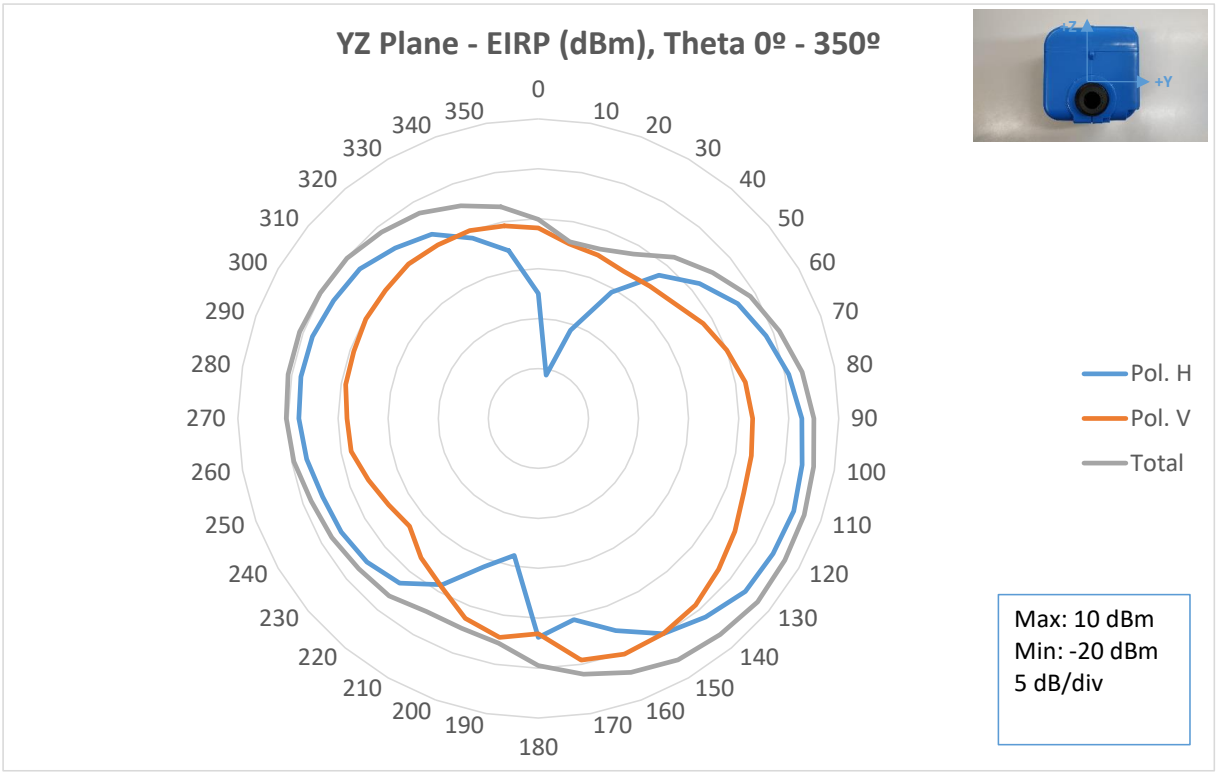

Fig. 15. YZ Plane EIRP, Free Space, 869.525 MHz.

5. RF TEST RESULT ON 3D

5.1 TRP 863.1 MHz – Free Space

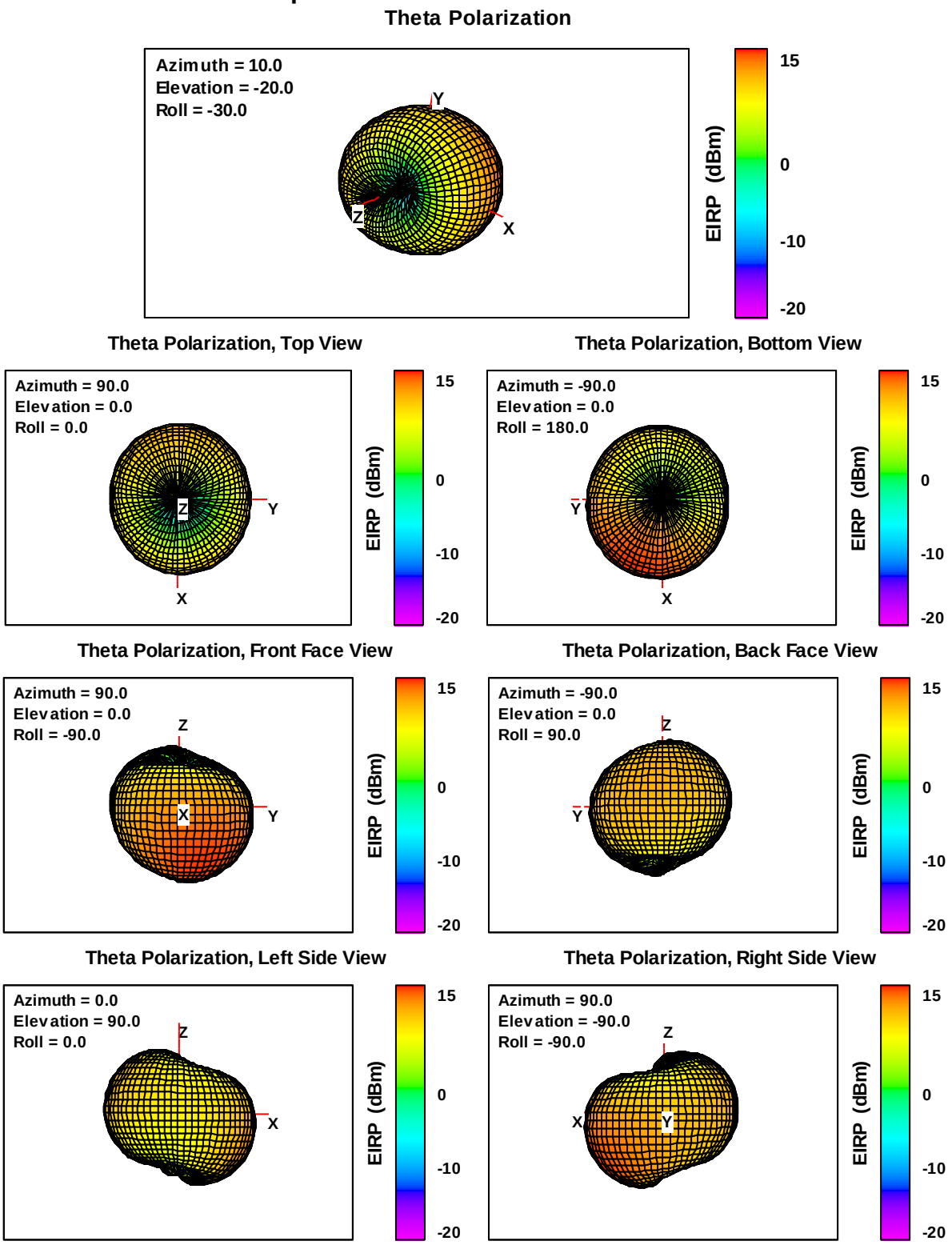

Fig. 16. Theta Polarization (Horizontal) EIRP, Free Space, 863.1 MHz.

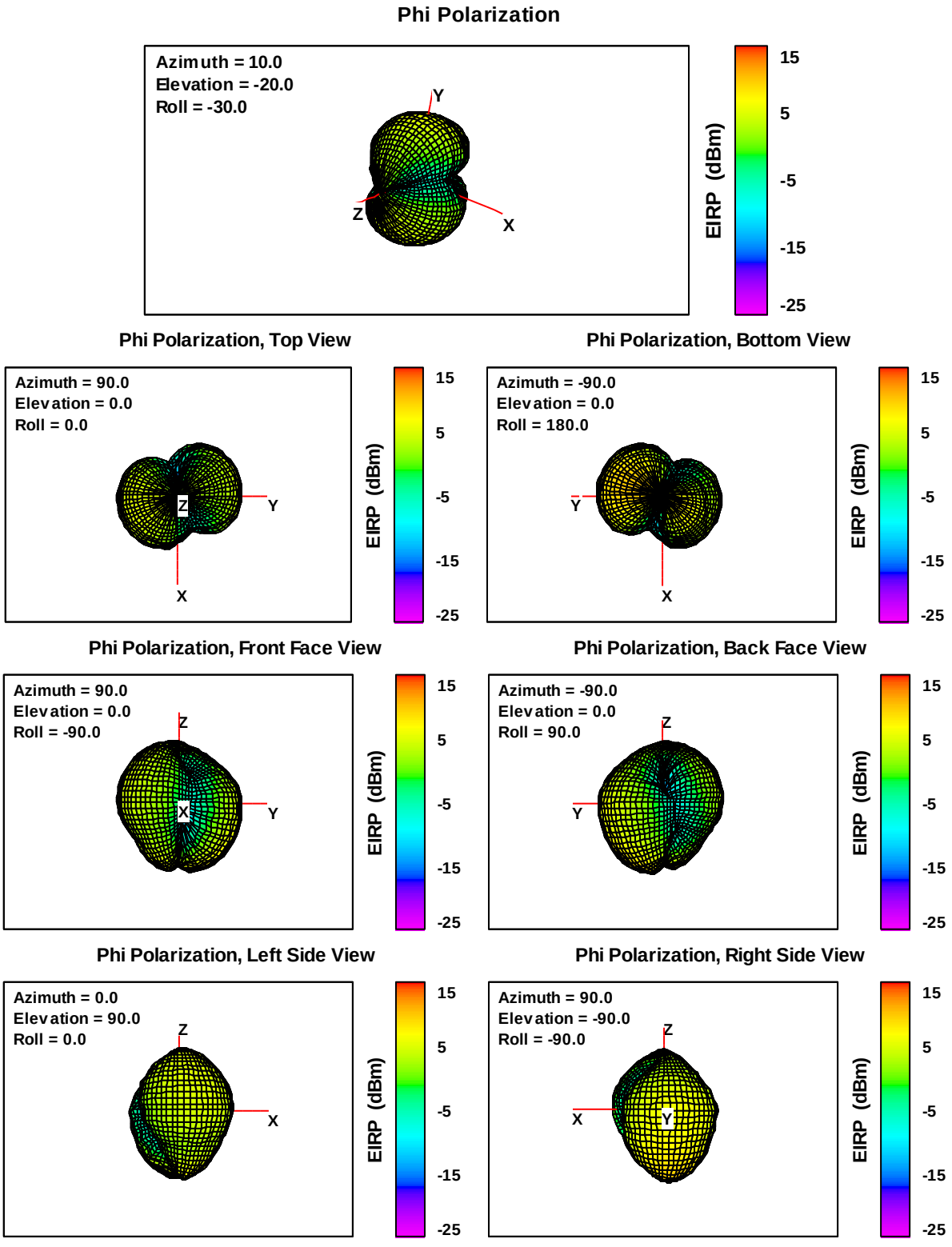

Fig. 17. Phi Polarization (Vertical) EIRP, Free Space, 863.1 MHz.

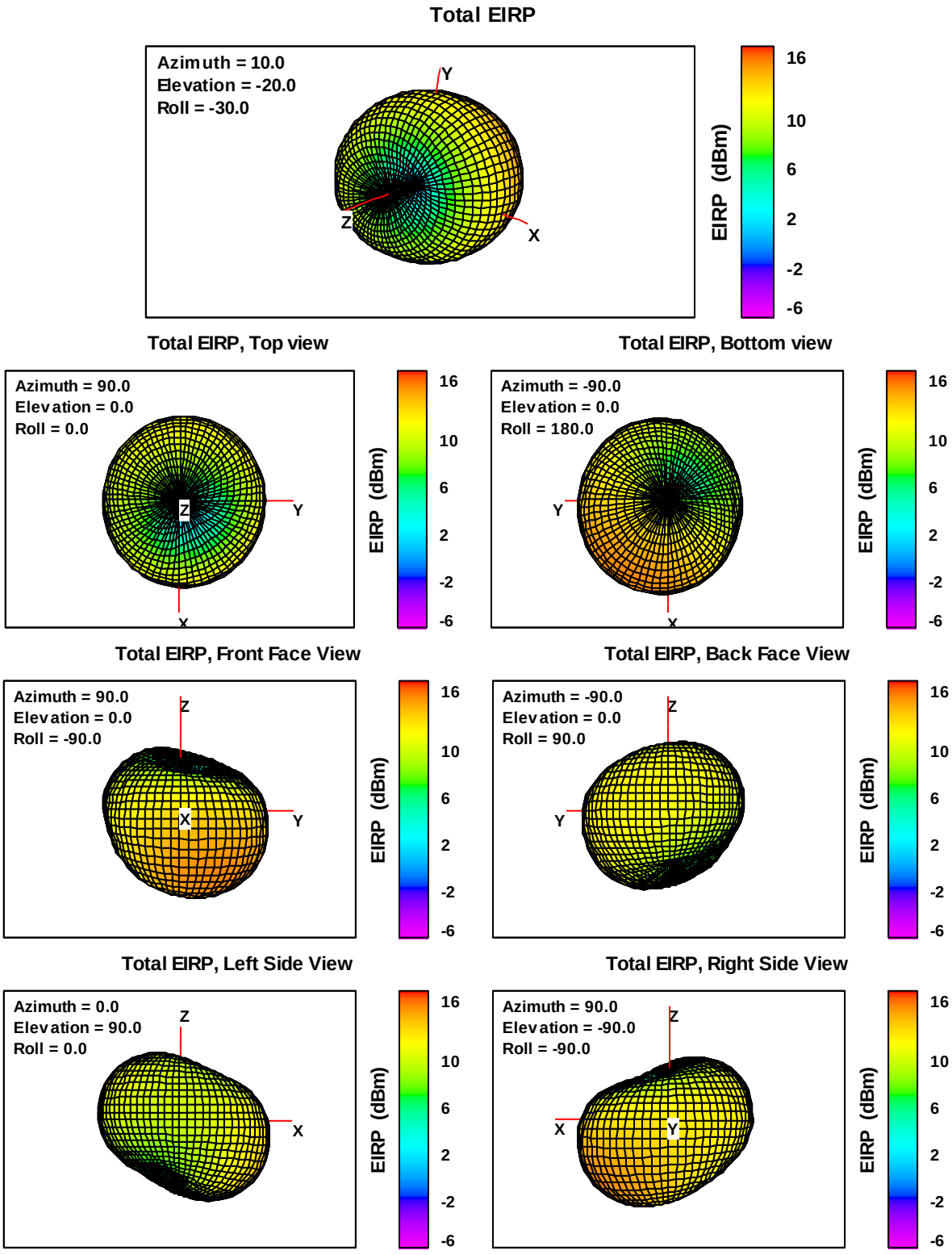

Fig. 18. Total EIRP, Free Space, 863.1 MHz.

5.2 TRP 865.1 MHz – Free Space

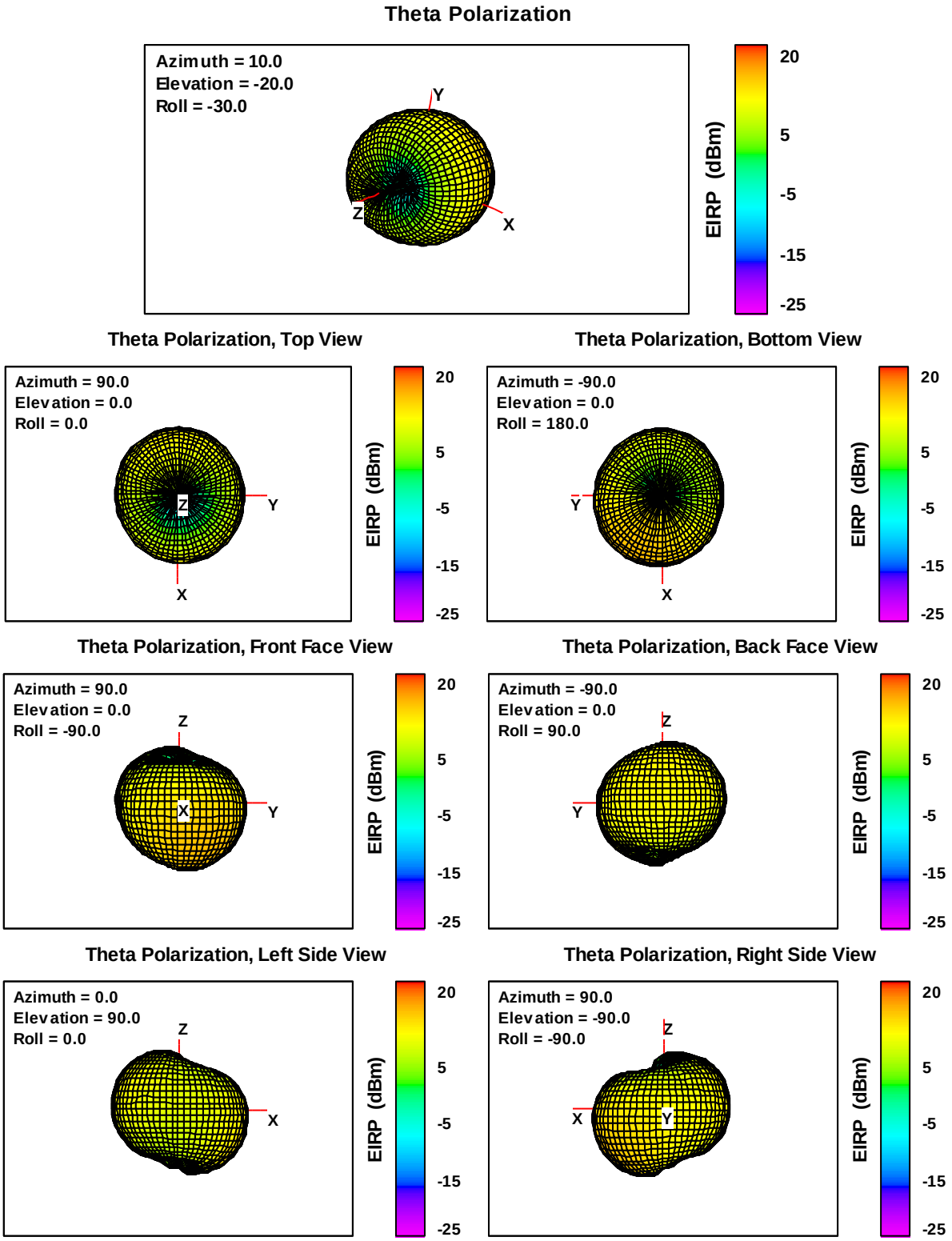

Fig. 19. Theta Polarization (Horizontal) EIRP, Free Space, 865.1 MHz.

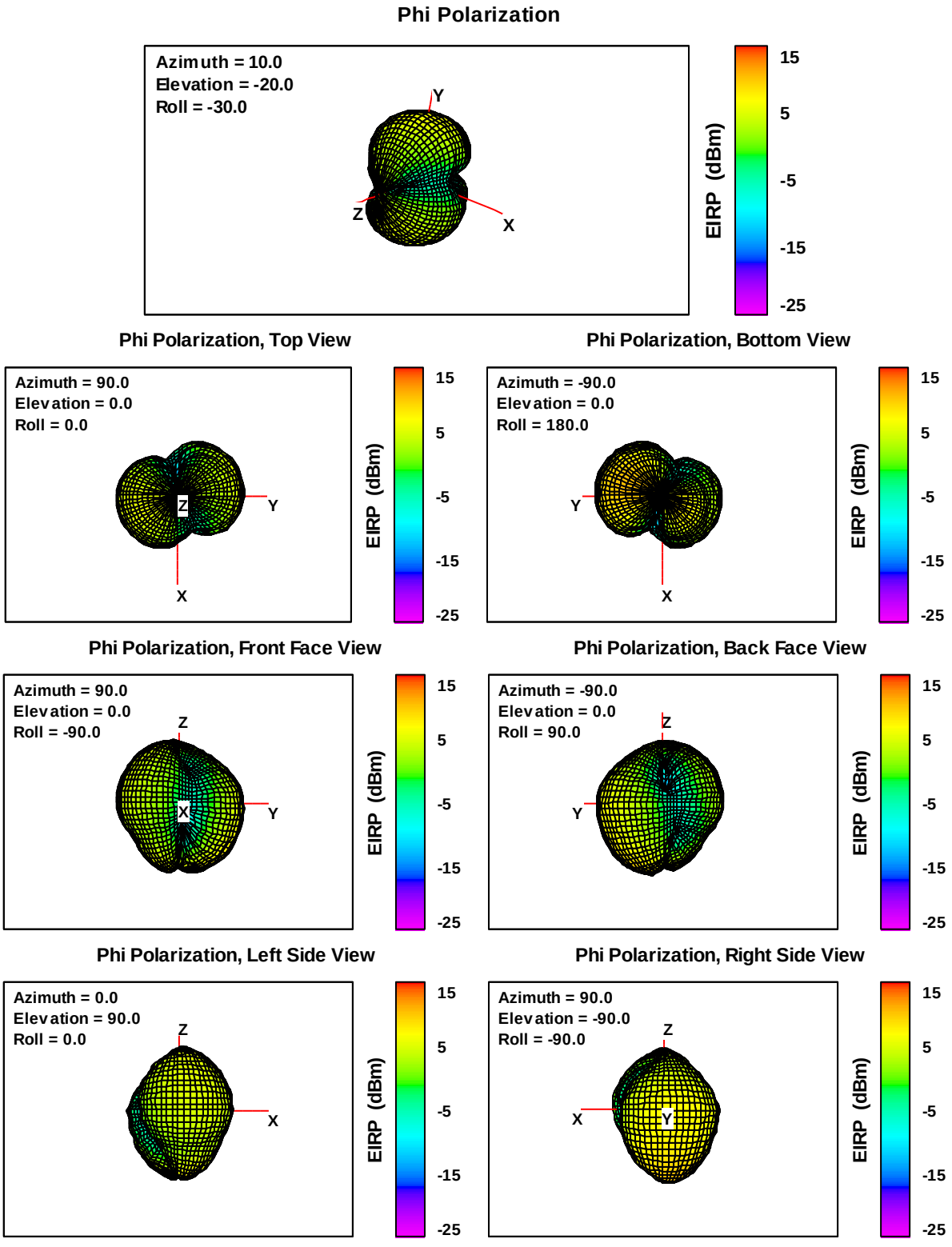

Fig. 20. Phi Polarization (Vertical) EIRP, Free Space, 865.1 MHz.

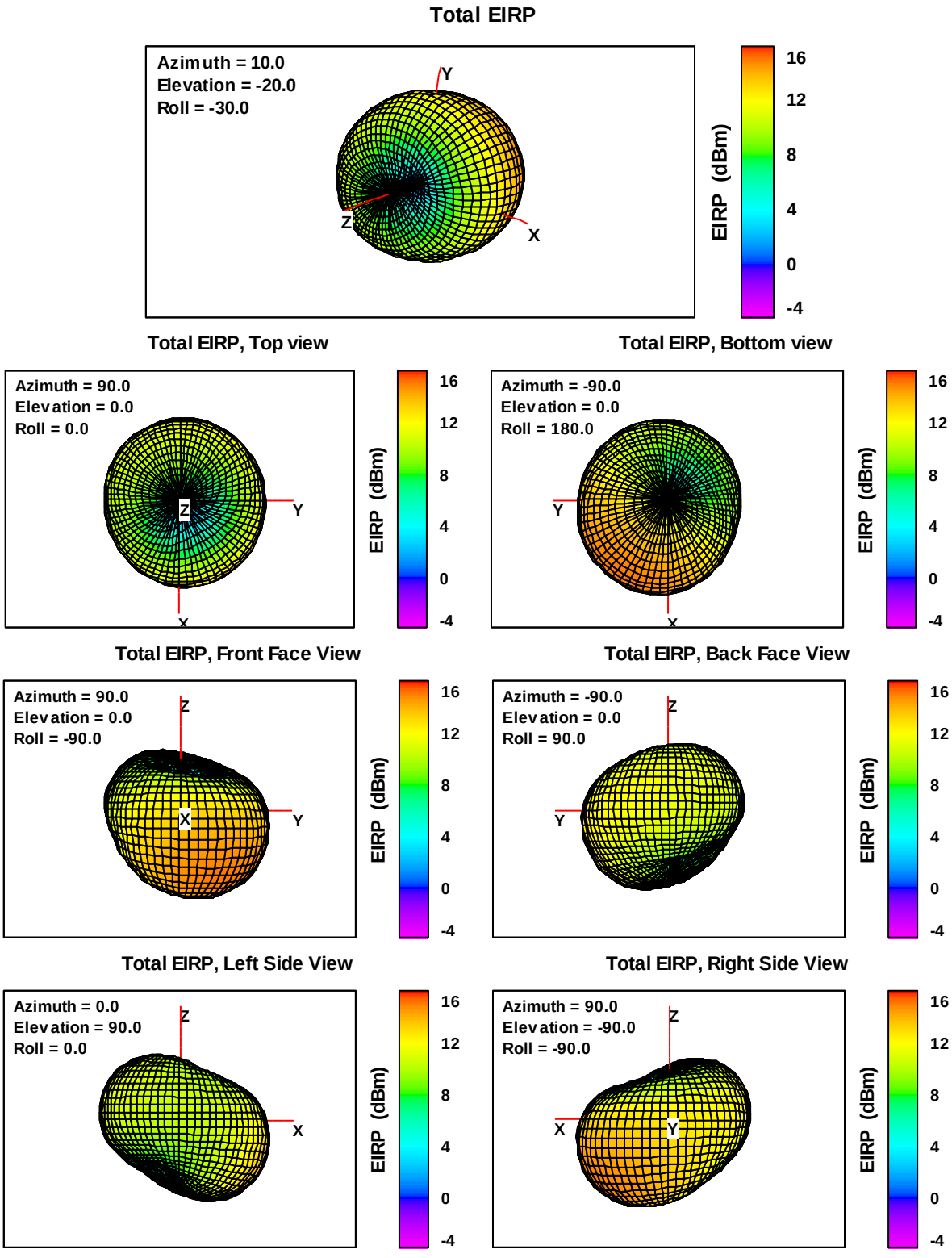

Fig. 21. Total EIRP, Free Space, 865.1 MHz.

5.3 TRP 868.3 MHz – Free Space

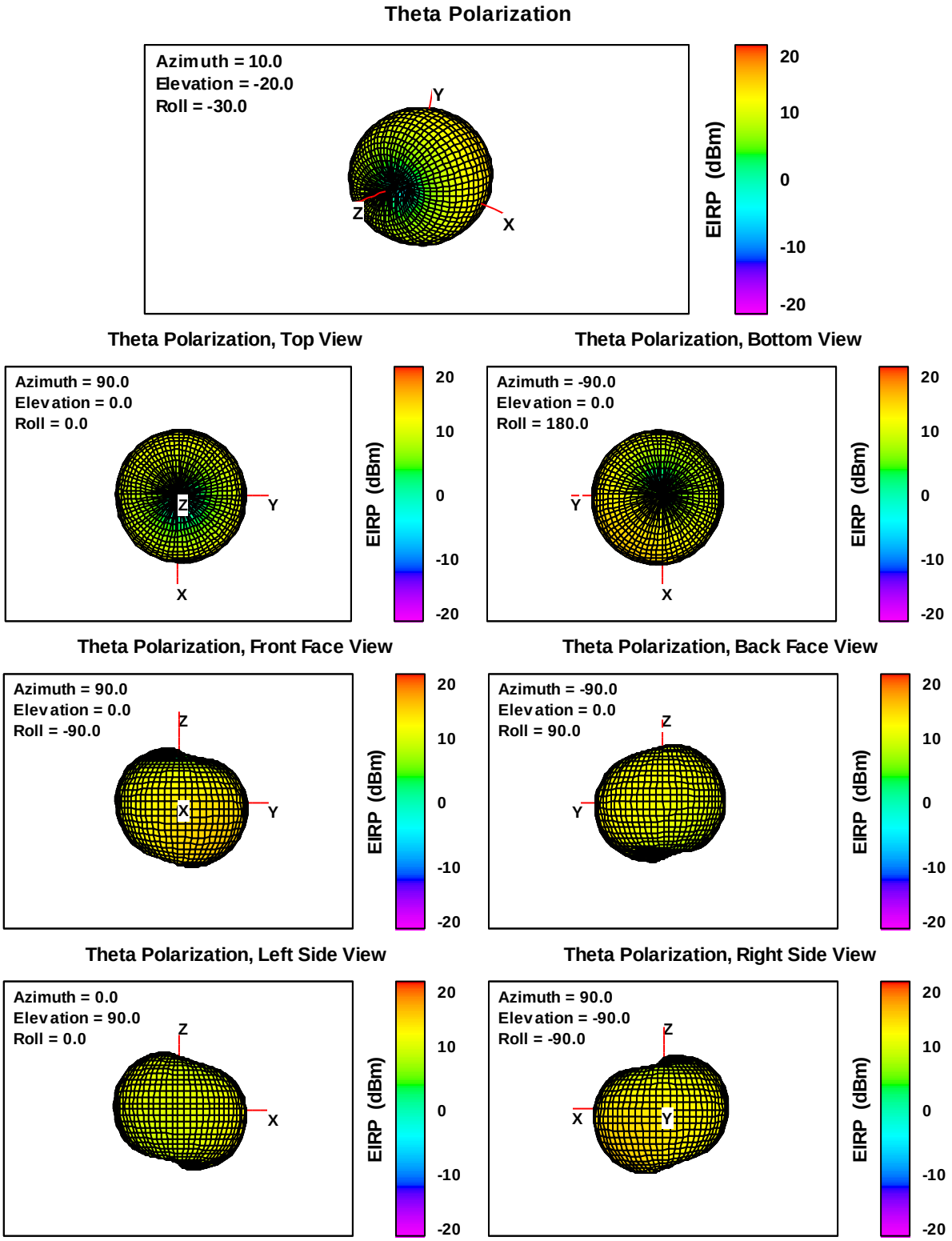

Fig. 22. Theta Polarization (Horizontal) EIRP, Free Space, 868.3 MHz.

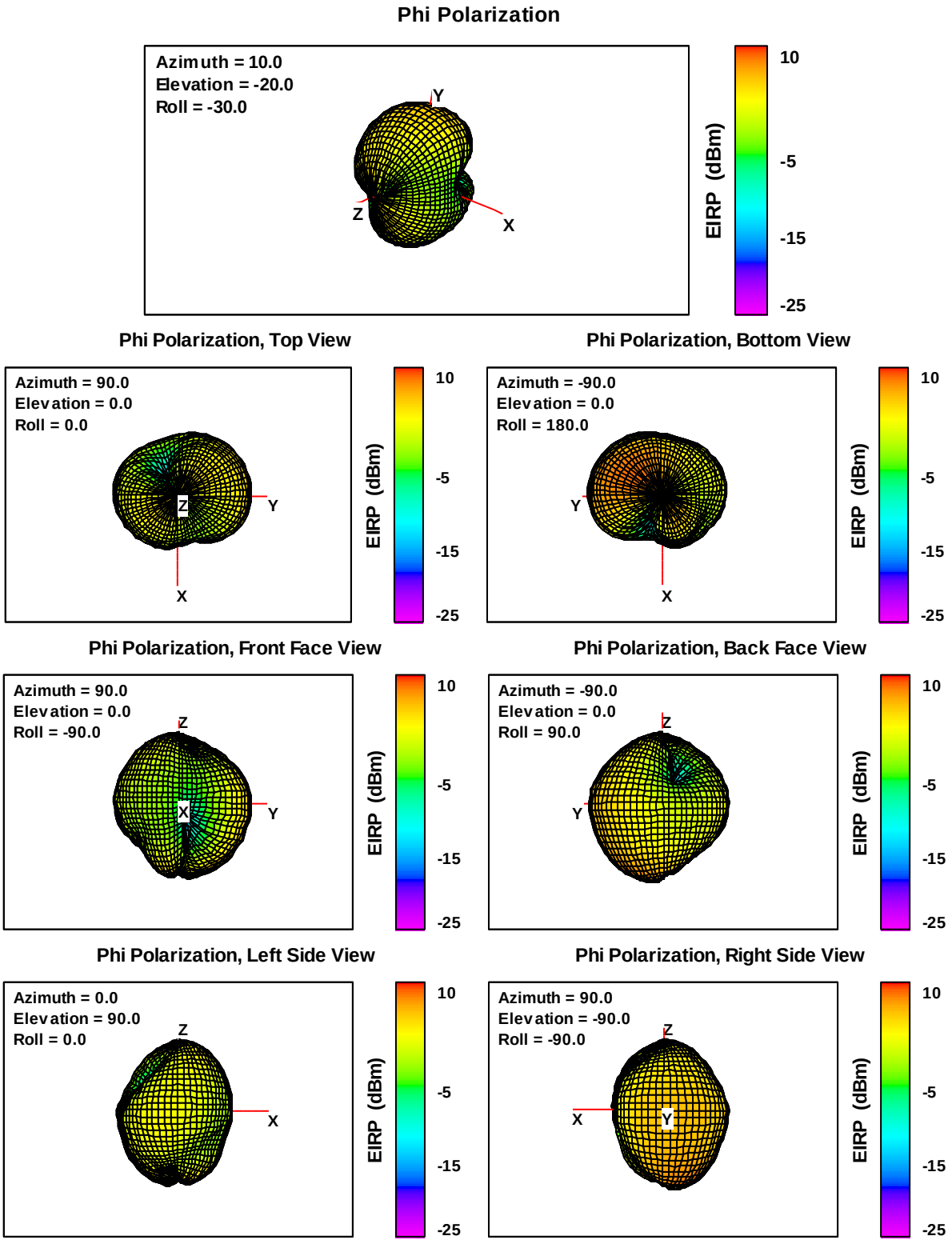

Fig. 23. Phi Polarization (Vertical) EIRP, Free Space, 868.3 MHz.

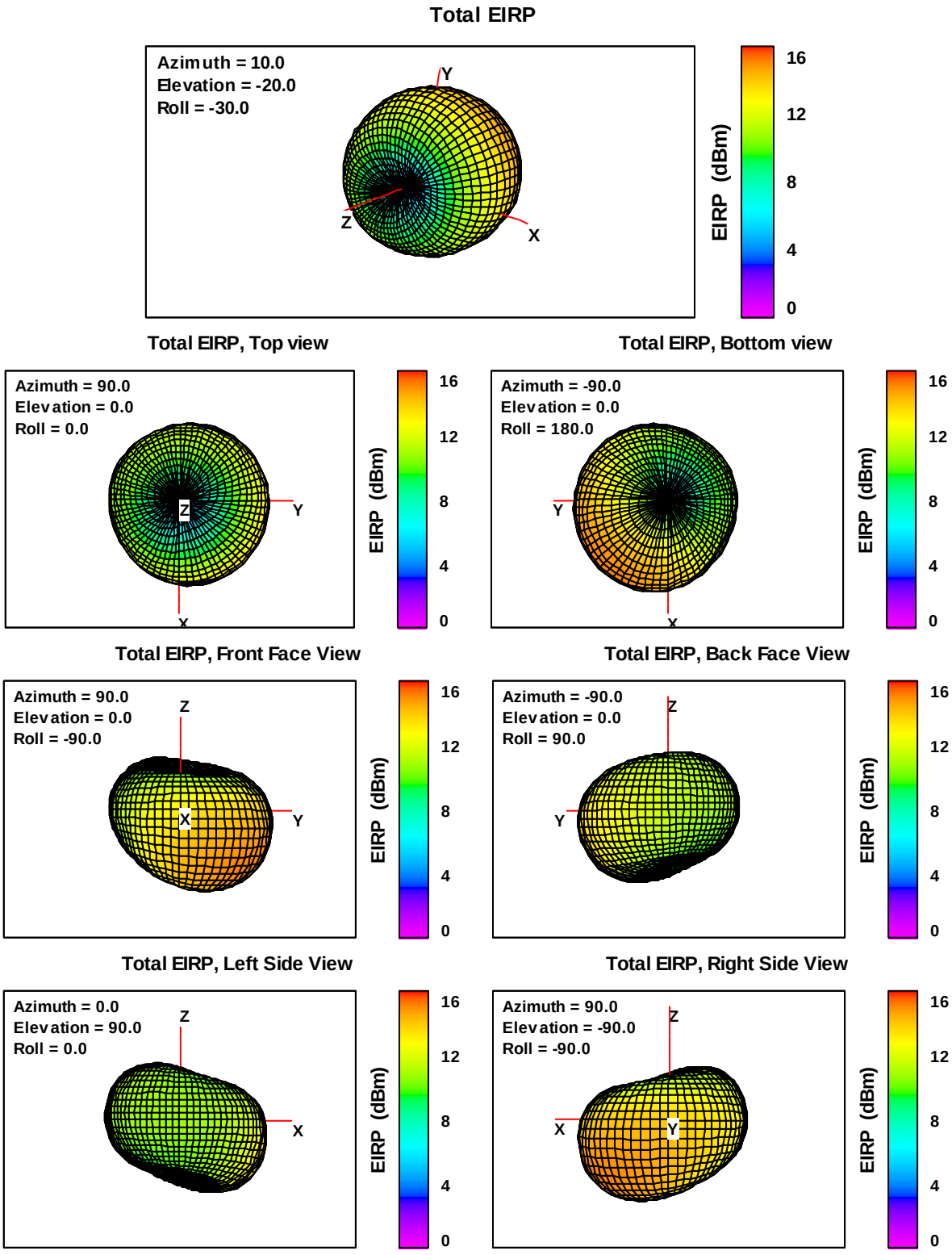

Fig. 24. Total EIRP, Free Space, 868.3 MHz.

5.4 TRP 869.525 MHz – Free Space

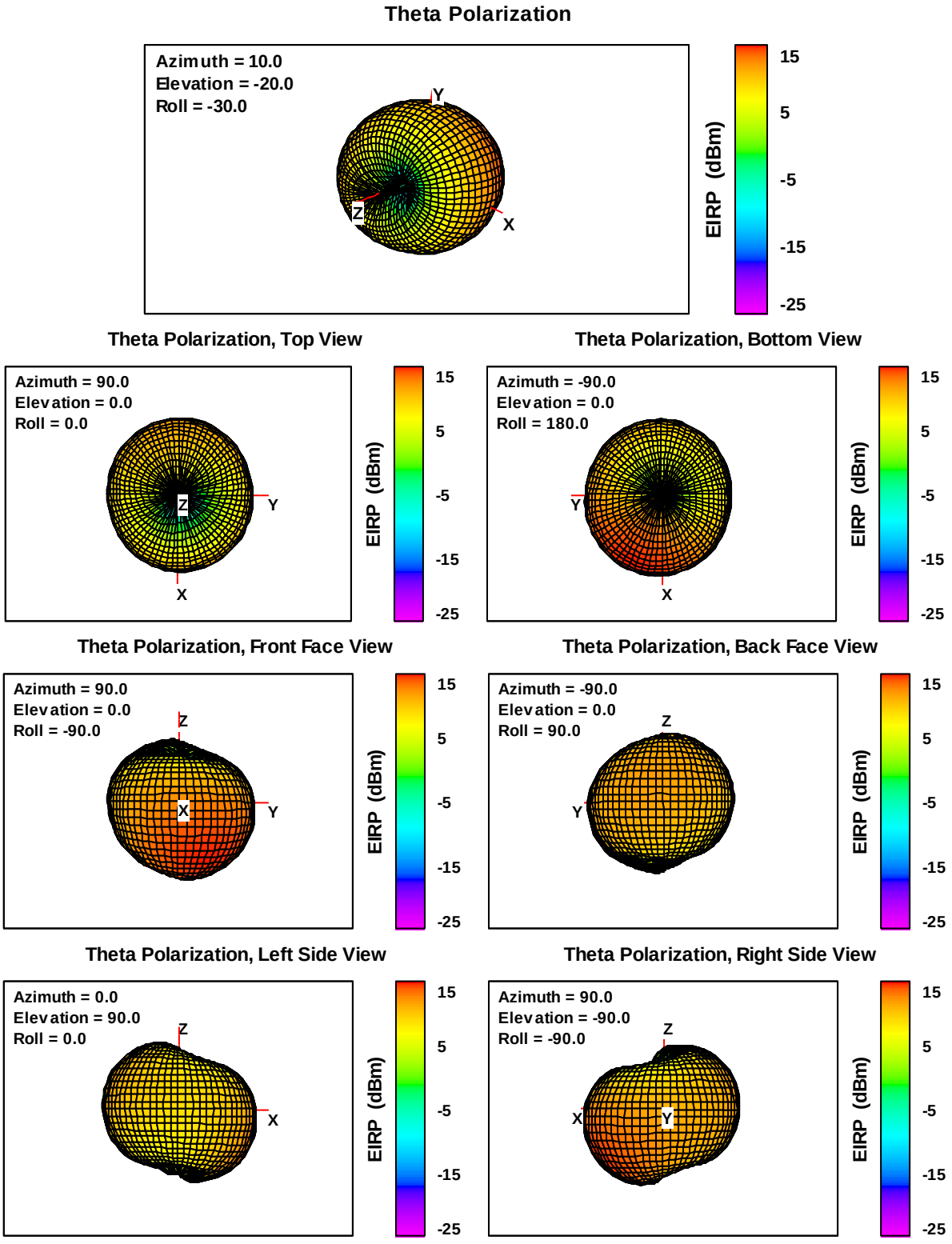

Fig. 25. Theta Polarization (Horizontal) EIRP, Free Space, 869.525 MHz.

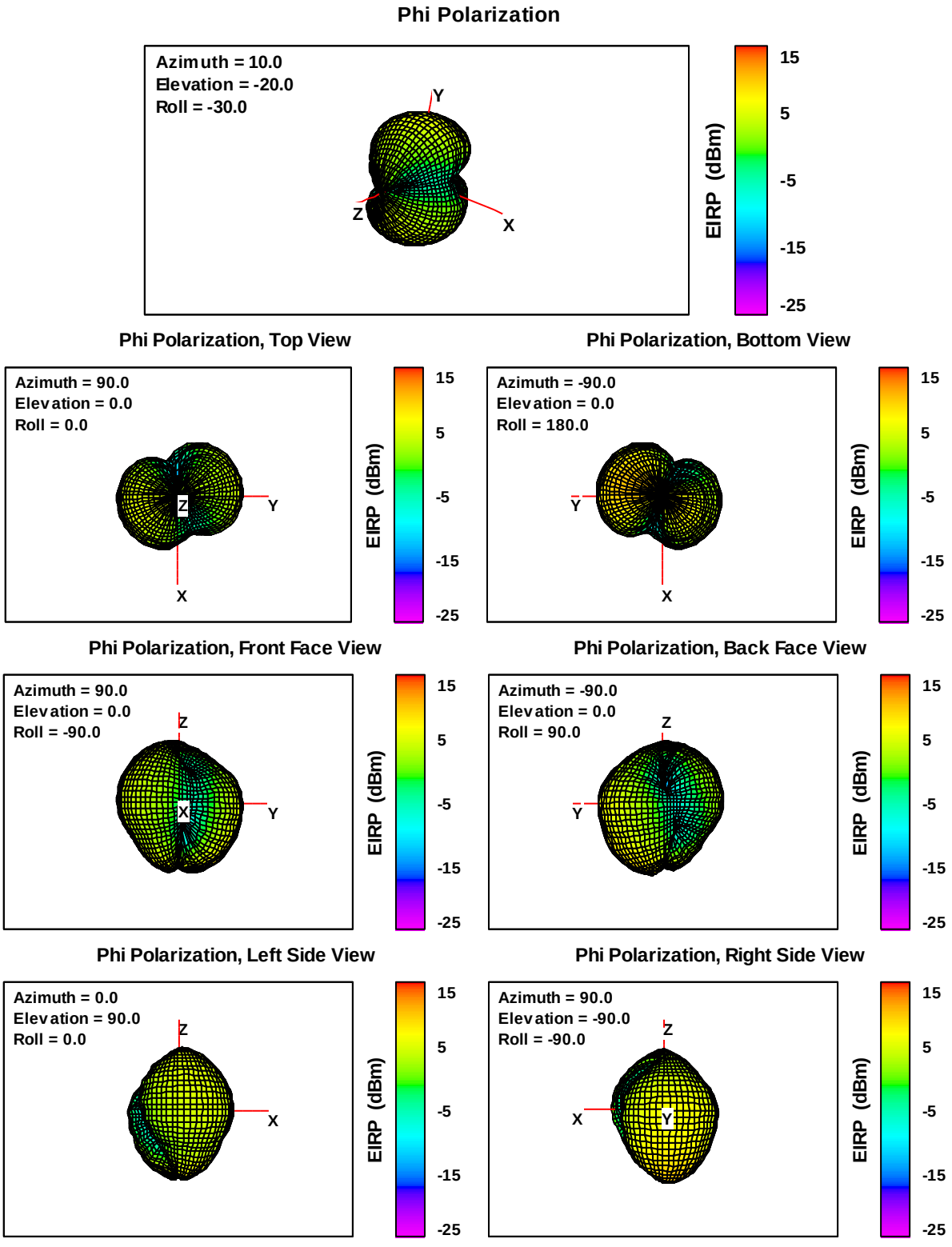

Fig. 26. Phi Polarization (Vertical) EIRP, Free Space, 869.525 MHz.

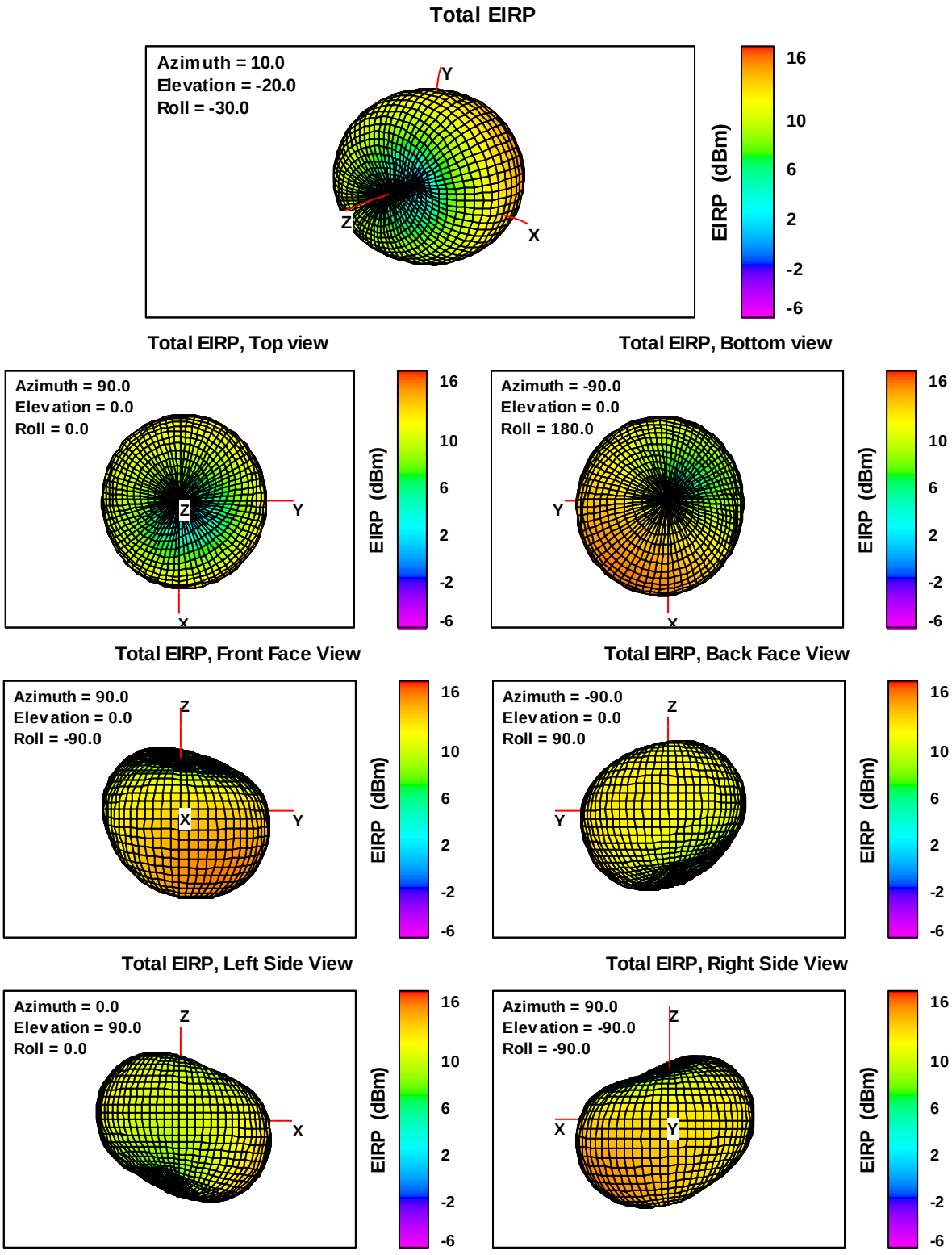

Fig. 27. Total EIRP, Free Space, 869.525 MHz.

6. RANGE REFERENCE MEASUREMENT DATA

Measurement Date:	2019-01-23
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. (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	863.1	-	-	-	46.78	-	1.68	48.46
EU 868 MHz	865.1	-	-	-	46.83	-	1.68	48.51
EU 868 MHz	868.3	-	-	-	46.80	-	1.68	48.48
EU 868 MHz	869.5	-	-	-	46.85	-	1.68	48.53

Measurement Date:	2019-01-24
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. (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	863.1	-	-	-	49.43	-	1.68	51.11
EU 868 MHz	865.1	-	-	-	49.46	-	1.68	51.14
EU 868 MHz	868.3	-	-	-	49.56	-	1.68	51.24
EU 868 MHz	869.5	-	-	-	49.66	-	1.68	51.34

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

Measurement Date:	2019-01-23
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. (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	863.1	-	-	-	47.32	-	1.68	49.00
EU 868 MHz	865.1	-	-	-	47.36	-	1.68	49.04
EU 868 MHz	868.3	-	-	-	47.34	-	1.68	49.02
EU 868 MHz	869.525	-	-	-	47.39	-	1.68	49.07

Measurement Date:	2019-01-24
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. (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	863.1	-	-	-	49.93	-	1.68	51.61
EU 868 MHz	865.1	-	-	-	50.01	-	1.68	51.69
EU 868 MHz	868.3	-	-	-	50.12	-	1.68	51.80
EU 868 MHz	869.525	-	-	-	50.19	-	1.68	51.87

Appendix B: Photographs

Equipment under test:

- **EUT front view:**

Fig 28. EUT front view.

- **EUT back view:**

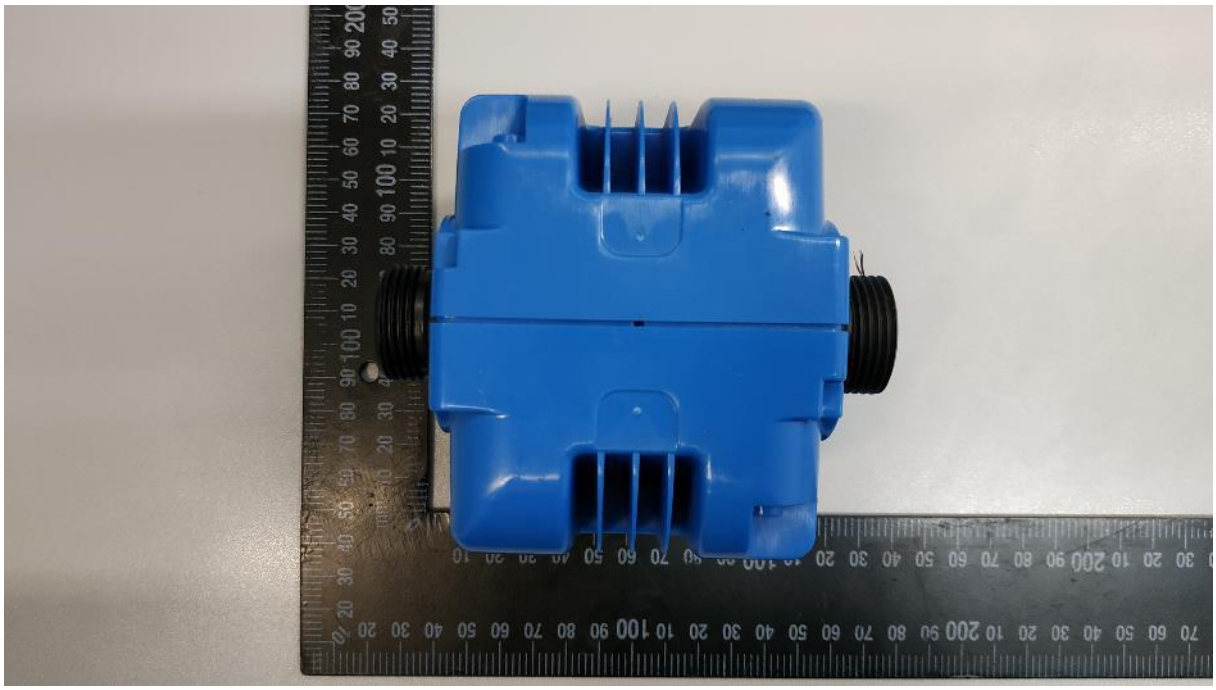

Fig 29. EUT back view.

Test set:

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

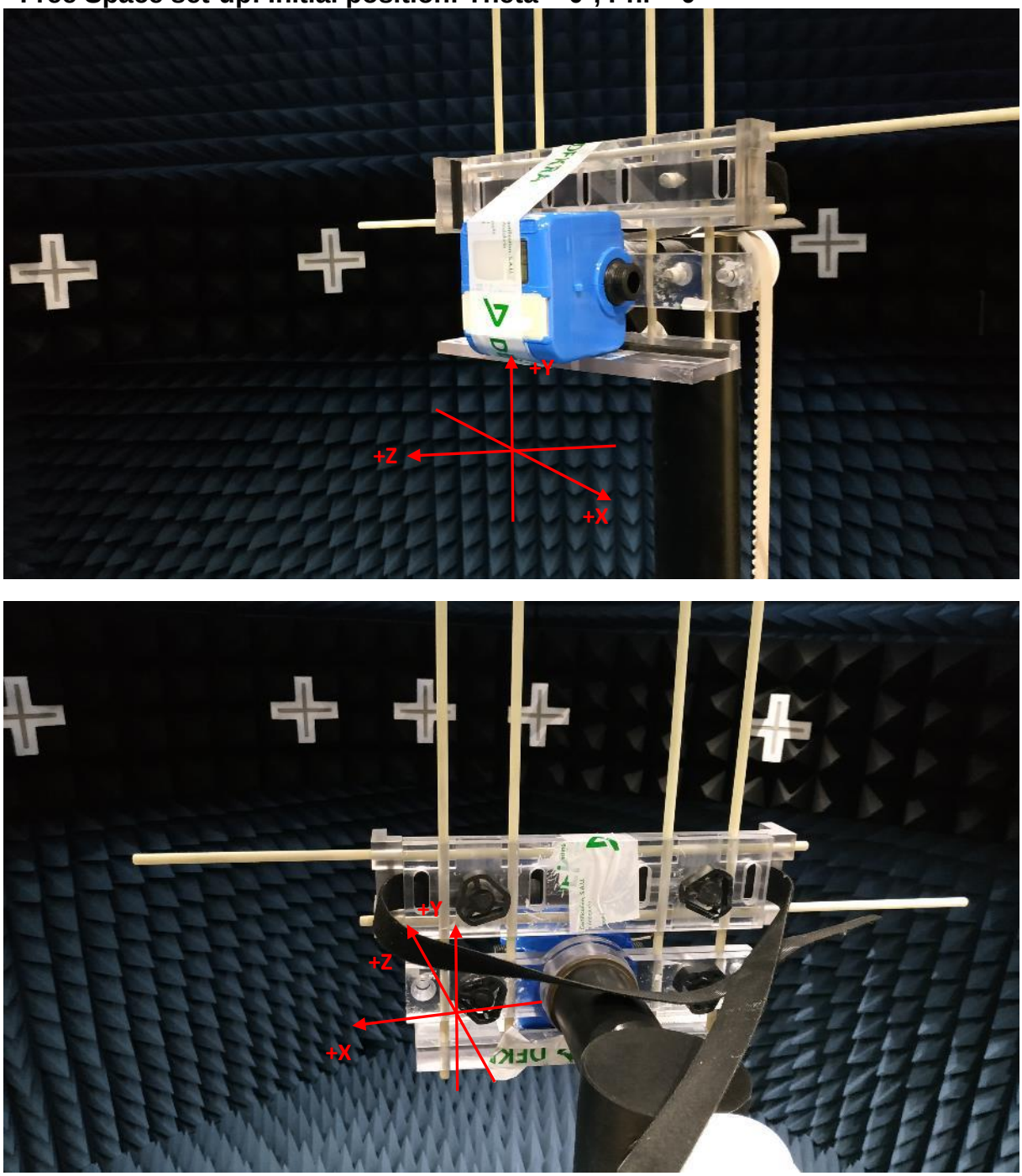

Fig 30. Free Space configuration set-up view.