



ANTENNA GAIN AND PATTERN MEASUREMENT REPORT
For Gain value reference

FOR

WLAN ANTENNA

PART/MODEL NUMBER: TMR2400/ZFR18

DATE ISSUED: DECEMBER 21, 2021

REPORT NUMBER: 13988148-O1V1

Prepared for
Johnson Controls Inc.
507 E Michigan St
Milwaukee, WI, 53202-5202
U.S.A.

Prepared by
UL VERIFICATION SERVICES INC.
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Revision History

<u>Rev.</u>	<u>Issue Date</u>	<u>Revisions</u>	<u>Revised By</u>
V1	12/21/2021	Initial Issue	

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1 ATTESTATION OF TEST RESULTS

Company Name and Address	Johnson Controls Inc.
	507 E Michigan St
	Milwaukee, WI, 53202-5202
	U.S.A.
EUT Description	WLAN Antenna
Part/Model	TMR2400/ZFR18
Date Tested	9/07/2021 – 9/25/2021

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
Non-standard Test Method*	Information Only
*as agreed upon the quote for order # 13988148	

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP/A2LA, NIST, or any agency of the U.S. Government.

This report contains data provided by the customer which can impact the validity of results. UL Verification Services Inc. is only responsible for the validity of results after the integration of the data provided by the customer.

Approved & Released For
 UL Verification Services Inc. By:



Ekta Budhbhatti
 OTA SUPERVISOR
 UL Verification Services Inc.

Tested and Prepared By:



Casey Dial
 TEST ENGINEER
 UL Verification Services Inc.

2 TEST FACILITY

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA. The test was performed in OTA A.

- Test operator and Report writer: Casey Dial
- Report reviewed by: Ekta Budhbhatti

3 TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST					
Description	Manufacturer	Model	Asset	Cal Date	Cal Due
PNA-L Network Analyzer	Agilent	N5230C	MY49001404	22 January 2021	22 January 2022

4 DEVICE UNDER TEST INFORMATION

Antenna	
Manufacturer	Johnson Controls Inc.
Part/Model Number	TMR2400/ZFR18
Frequency range (GHz)	2.405, 2.440, 2.480
Device/Antenna type	WLAN Antenna

5 RESULT SUMMARY

5.1 Passive Antenna Pattern

Measurement	Frequency (MHz)		
	2405	2440	2480
3D Peak Gain (dBi)	-8.26	-7.90	-7.58
2D/Peak Gain (dBi)	-8.20	-7.65	-7.38
VSWR	-12.60	-13.75	-12.28

5.2 Active Antenna Pattern

Active Antenna Pattern @ 15V DC			
Measurements	2405	2440	2480
3D Gain (dBi)	1.56	1.16	3.33
2D Gain (dBi) @ 135 Theta	1.80	1.33	3.11

Active Antenna Pattern @ 15V DC [Pigtail loss accounted for]			
Measurements	2405	2440	2480
3D Gain (dBi)	1.06	0.66	2.83
2D Gain (dBi) @ 135 Theta	1.30	0.83	2.61

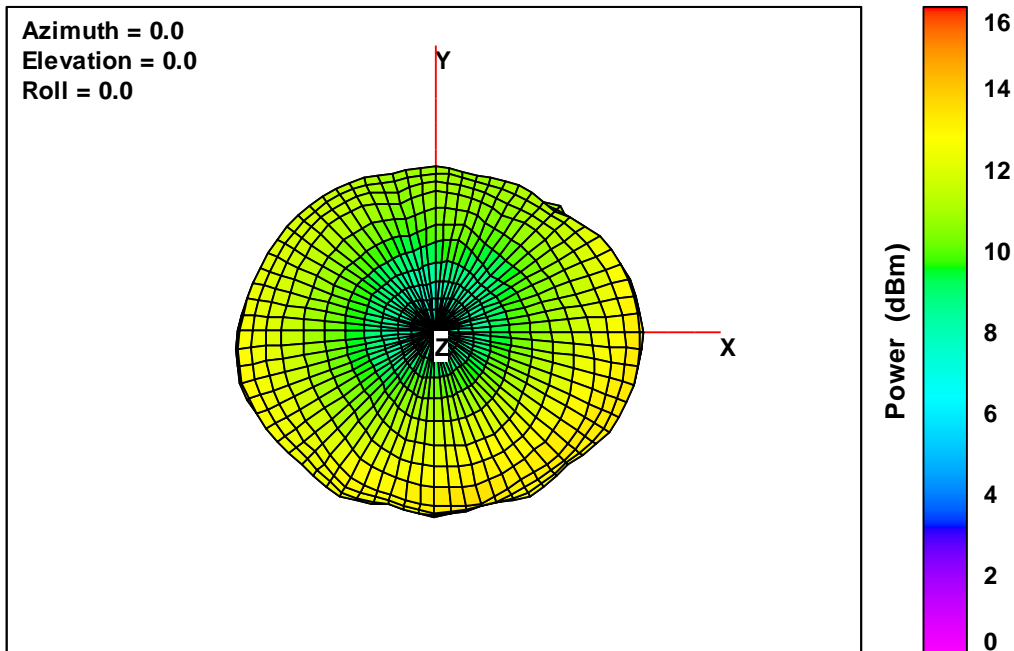
Measurements	2405	2440	2480
Conducted power (dBm)*	13.0	13.4	13.1

*The antenna port input power level was provided by the Johnson control system which was entered in the parameter file to calculate final Gain/Power value.

6 PLOTS

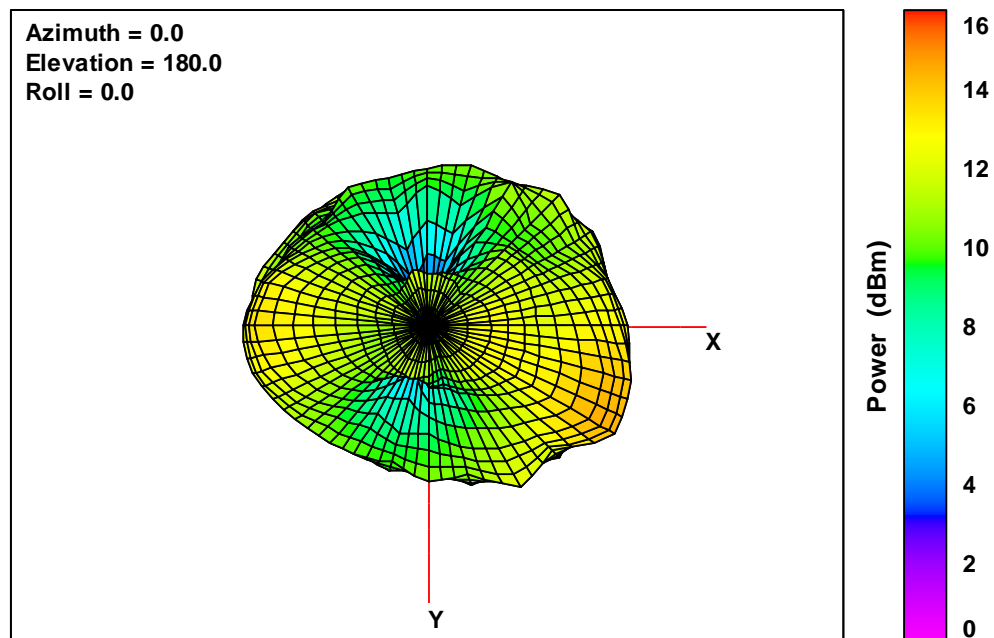
6.1 3D ACTIVE- 2405 MHz

Total EIS, Top View



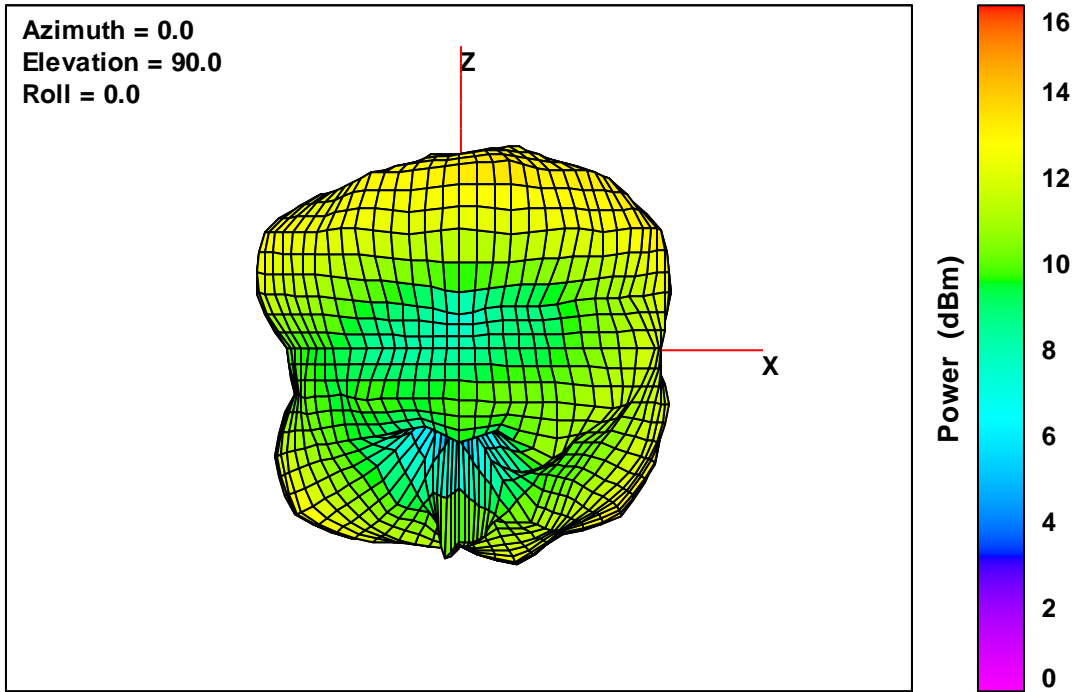
Free-Space Total EIS, Top View, 2405.0 MHz

Total EIS, Bottom View



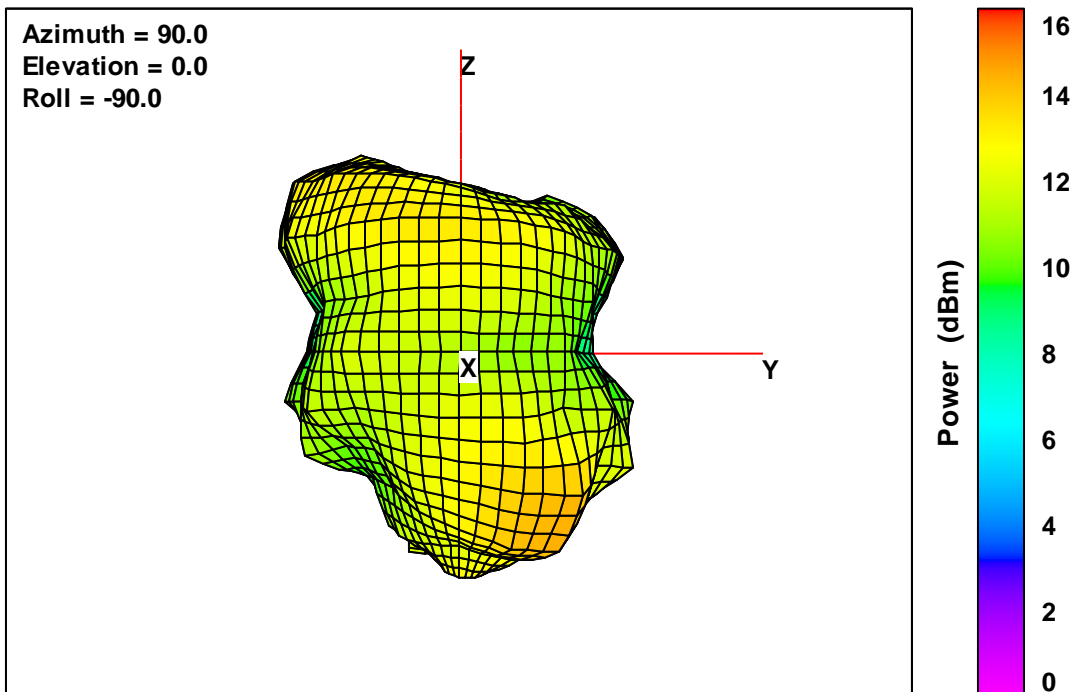
Free-Space Total EIS, Bottom View, 2405.0 MHz

Total EIS, Left Side View



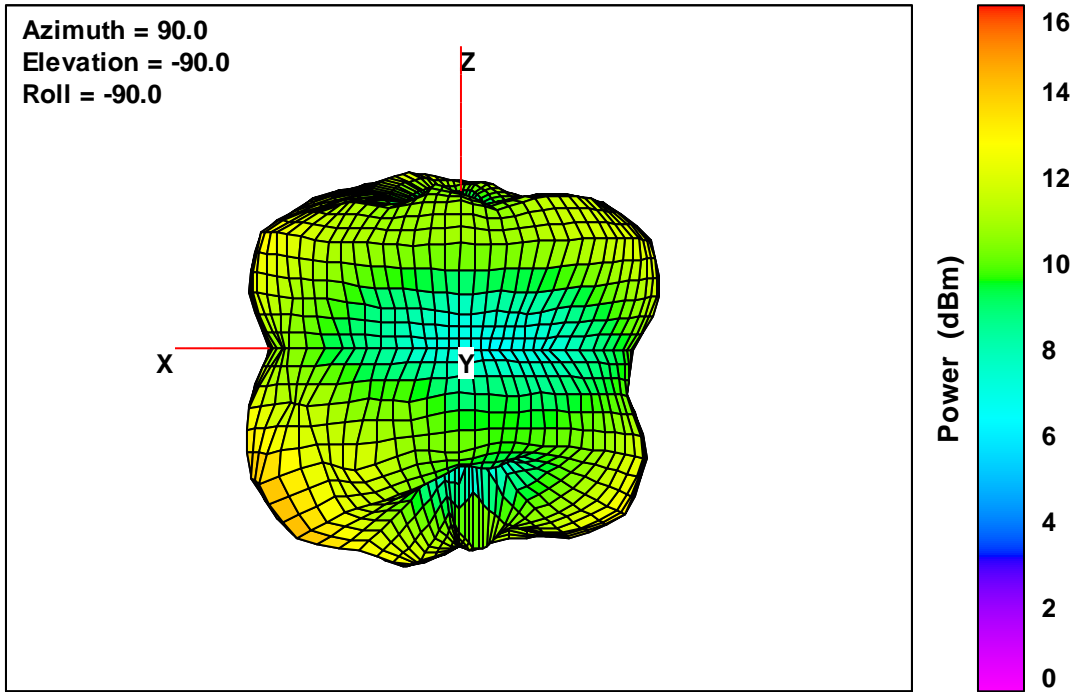
Free-Space Total EIS, Left Side View, 2405.0 MHz

Total EIS, Front Face View



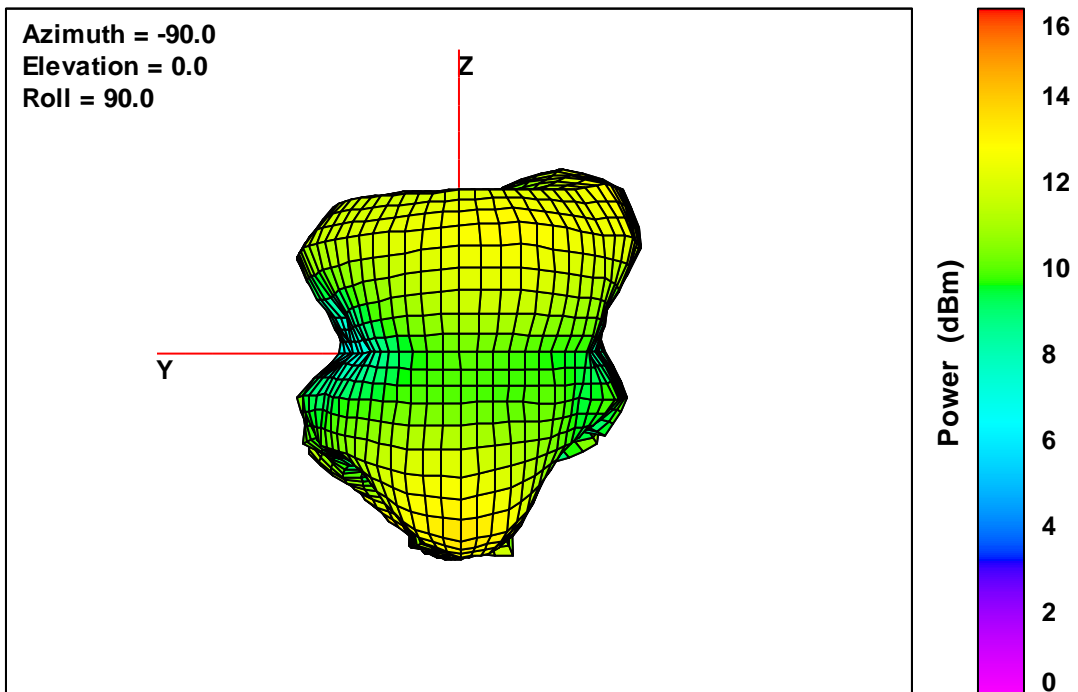
Free-Space Total EIS, Front Face View, 2405.0 MHz

Total EIS, Right Side View



Free-Space Total EIS, Right Side View, 2405.0 MHz

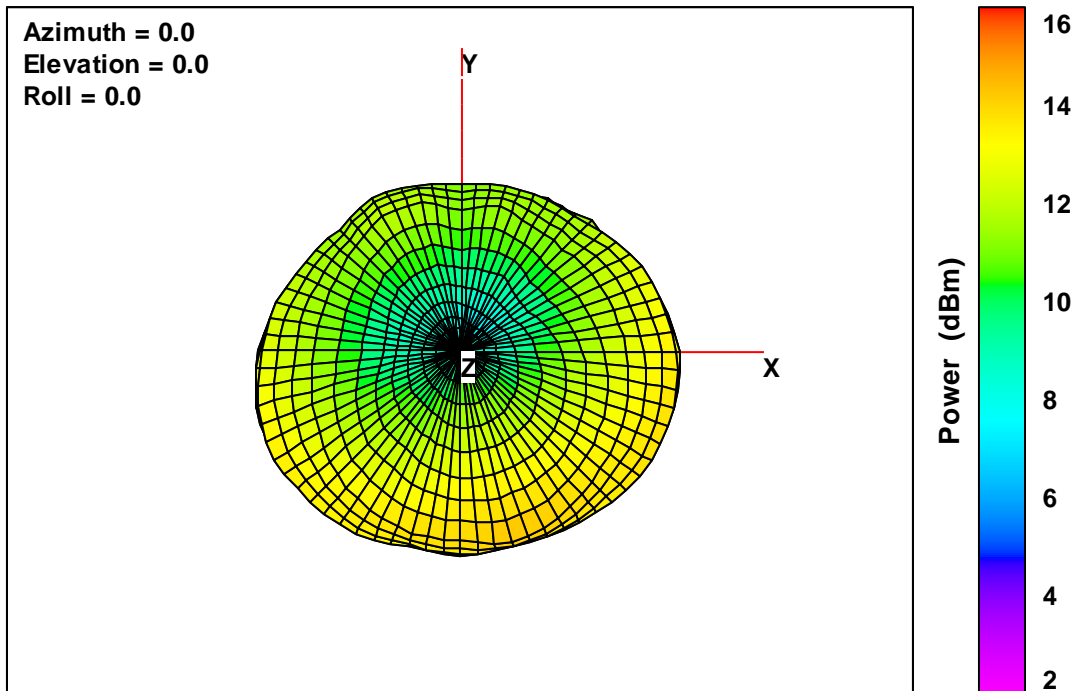
Total EIS, Back Face View



Free-Space Total EIS, Back Face View, 2405.0 MHz

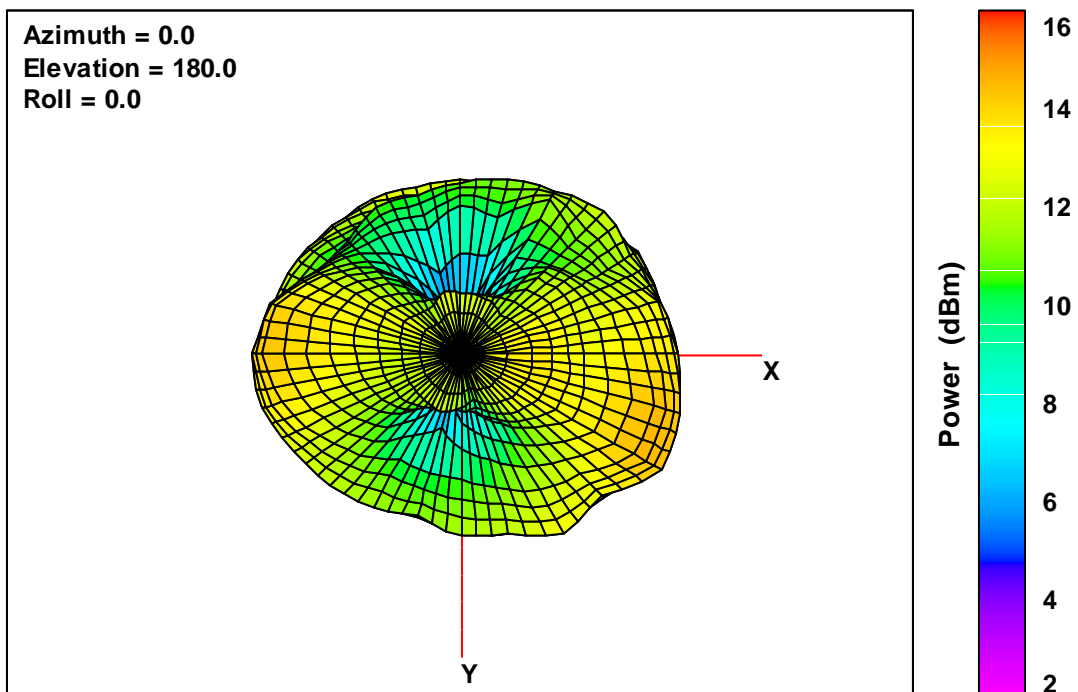
6.2 3D ACTIVE- 2440 MHz

Total EIS, Top View



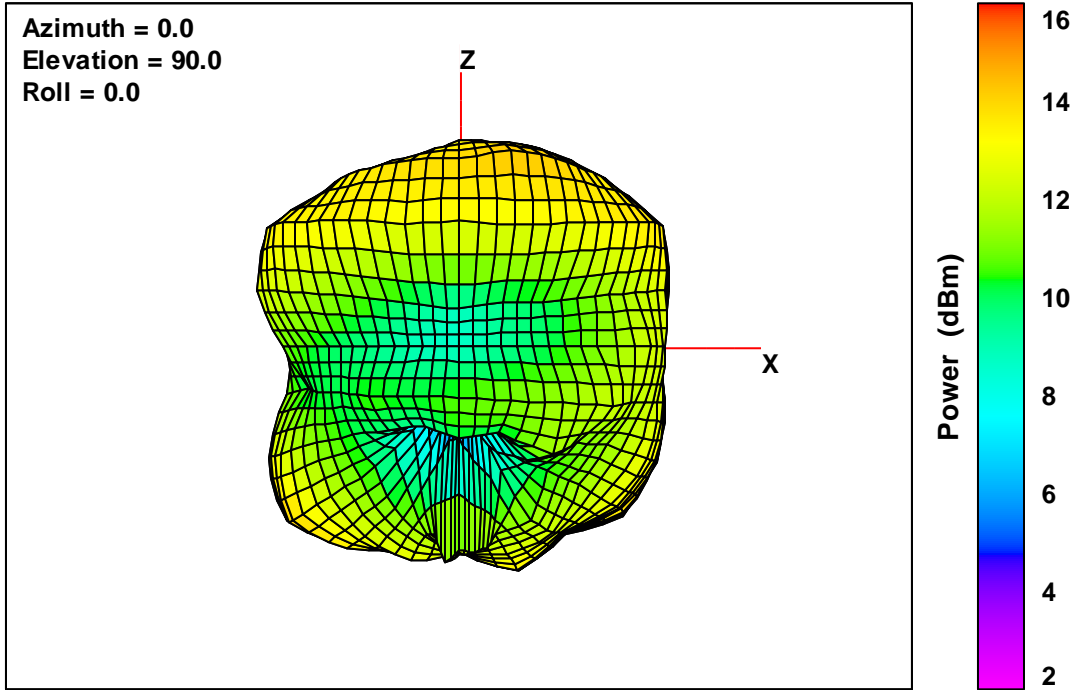
Free-Space Total EIS, Top View, 2440.0 MHz

Total EIS, Bottom View



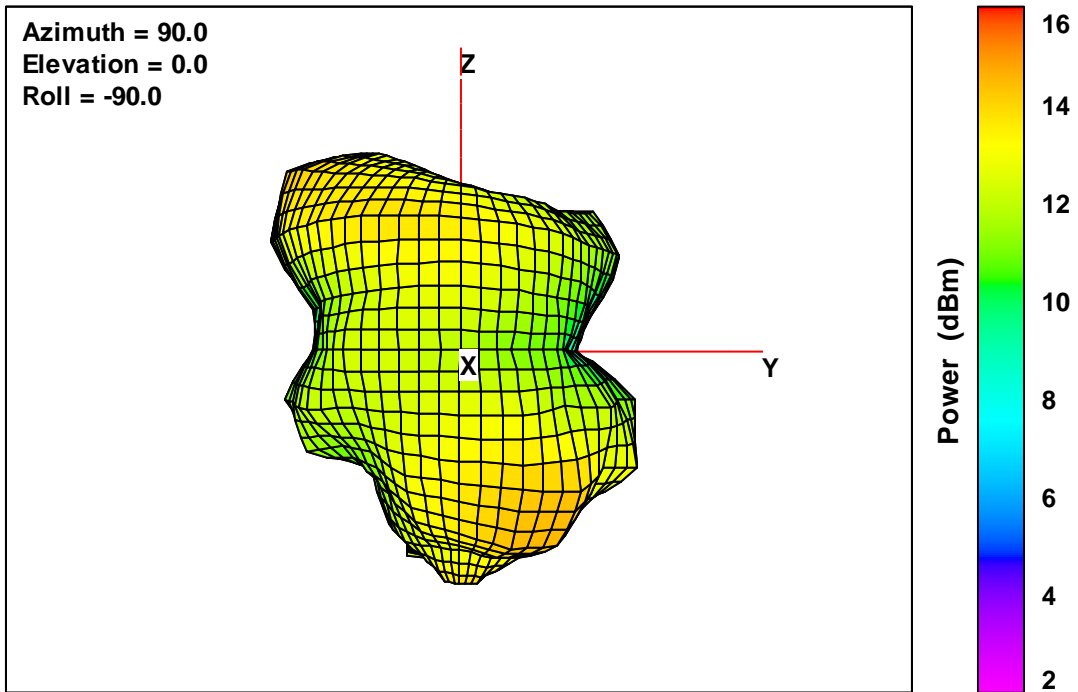
Free-Space Total EIS, Bottom View, 2440.0 MHz

Total EIS, Left Side View



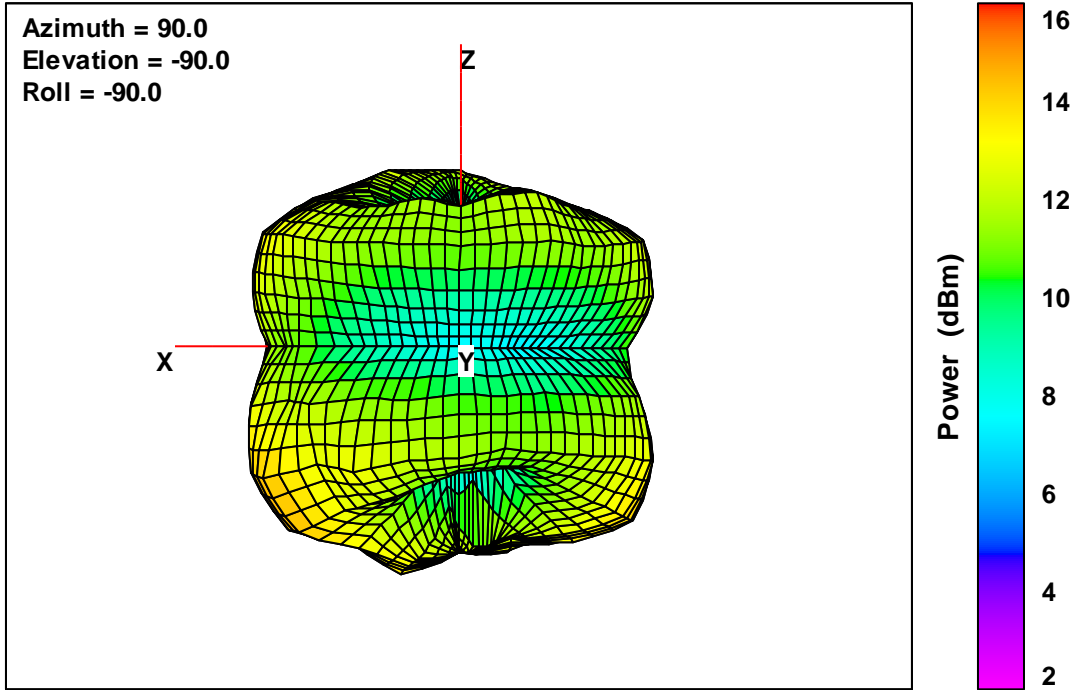
Free-Space Total EIS, Left Side View, 2440.0 MHz

Total EIS, Front Face View



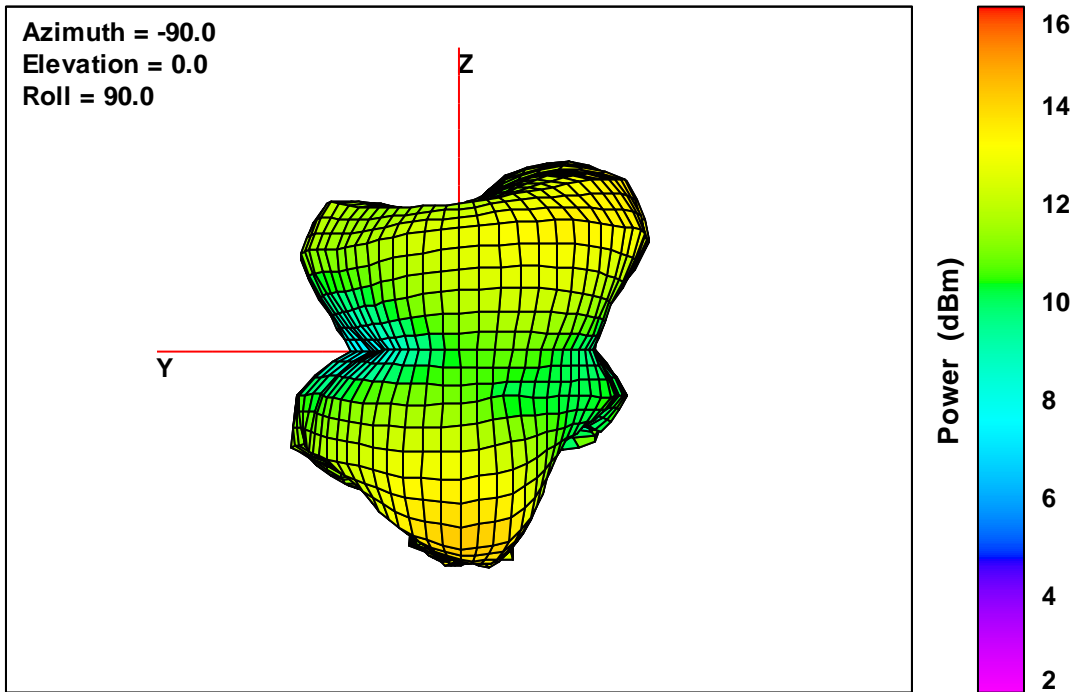
Free-Space Total EIS, Front Face View, 2440.0 MHz

Total EIS, Right Side View



Free-Space Total EIS, Right Side View, 2440.0 MHz

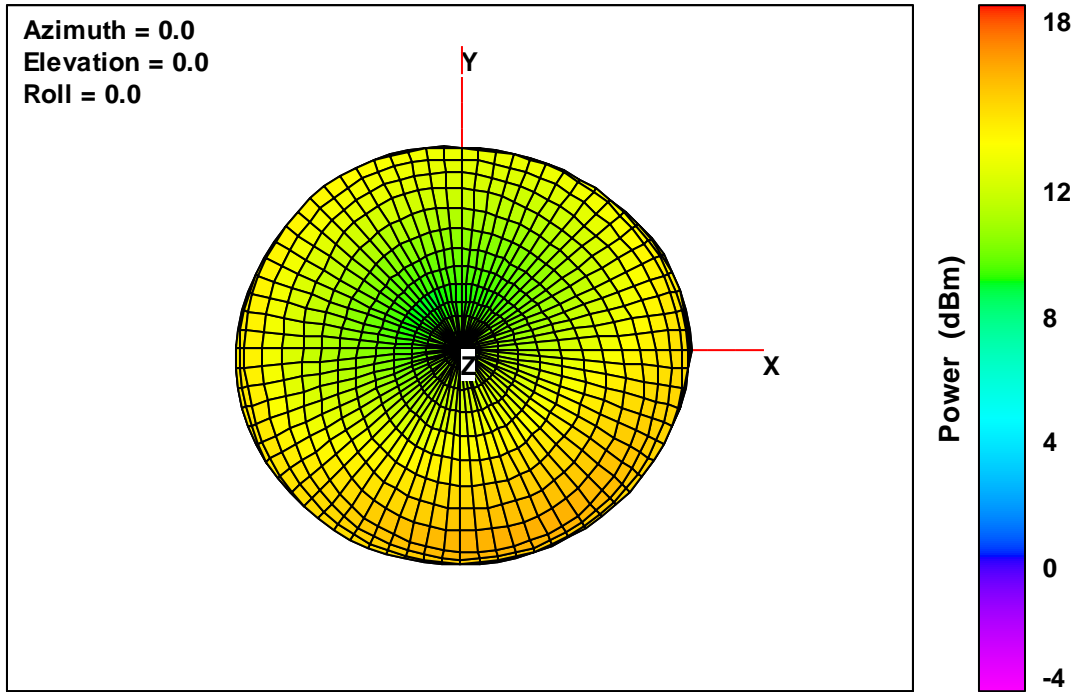
Total EIS, Back Face View



Free-Space Total EIS, Back Face View, 2440.0 MHz

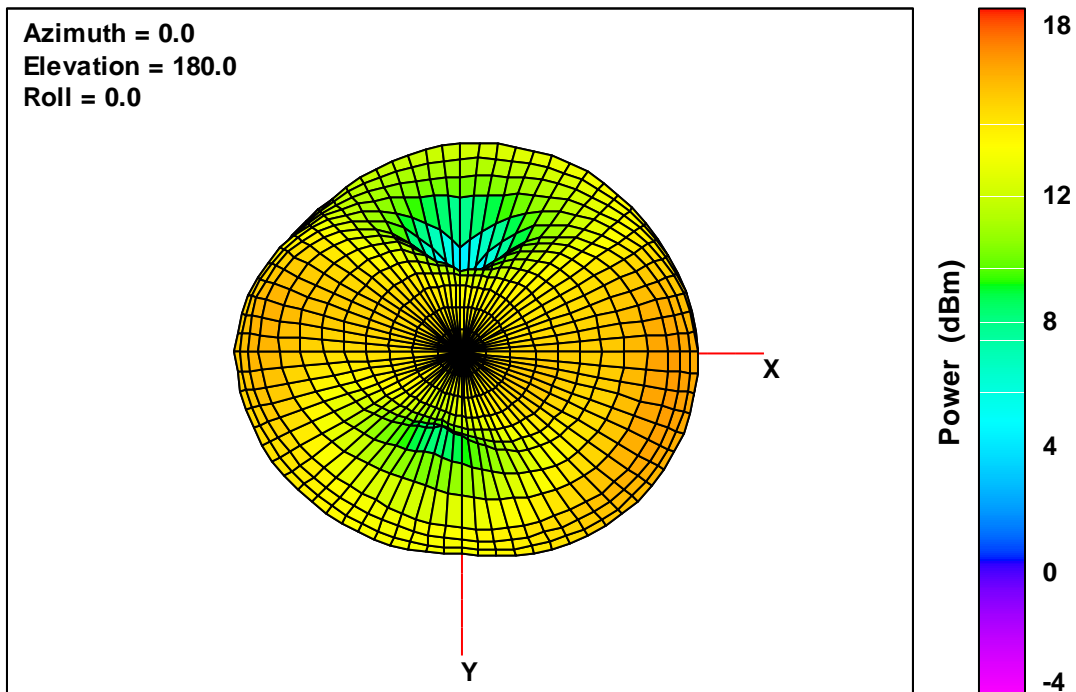
6.3 3D ACTIVE- 2480 MHz

Total EIS, Top View



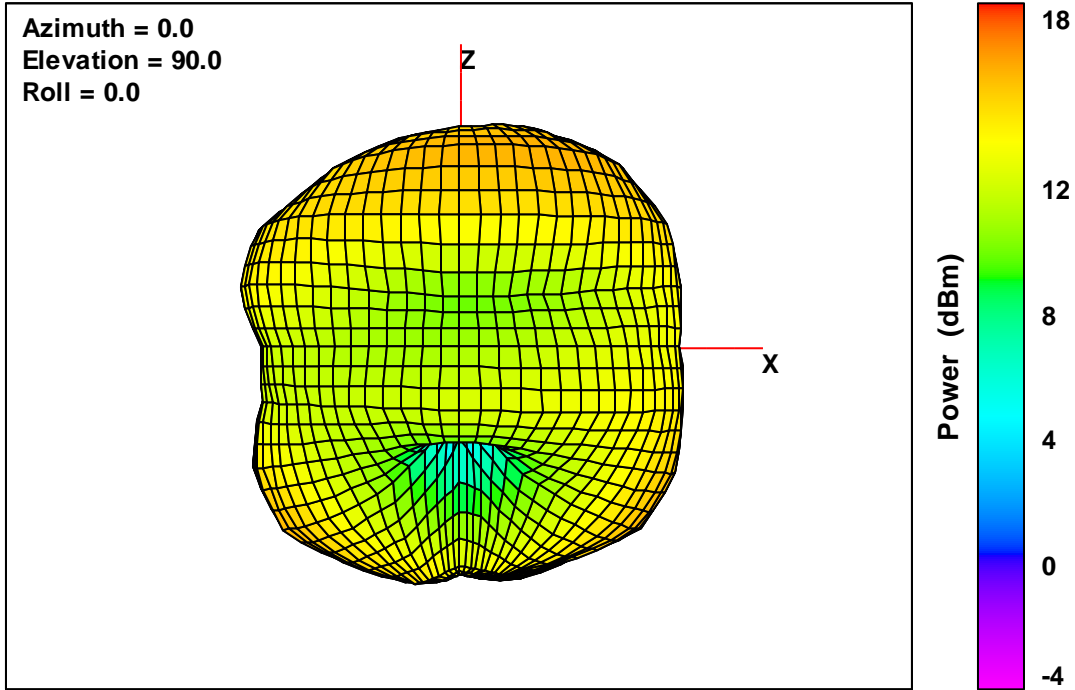
Free-Space Total EIS, Top View, 2480.0 MHz

Total EIS, Bottom View



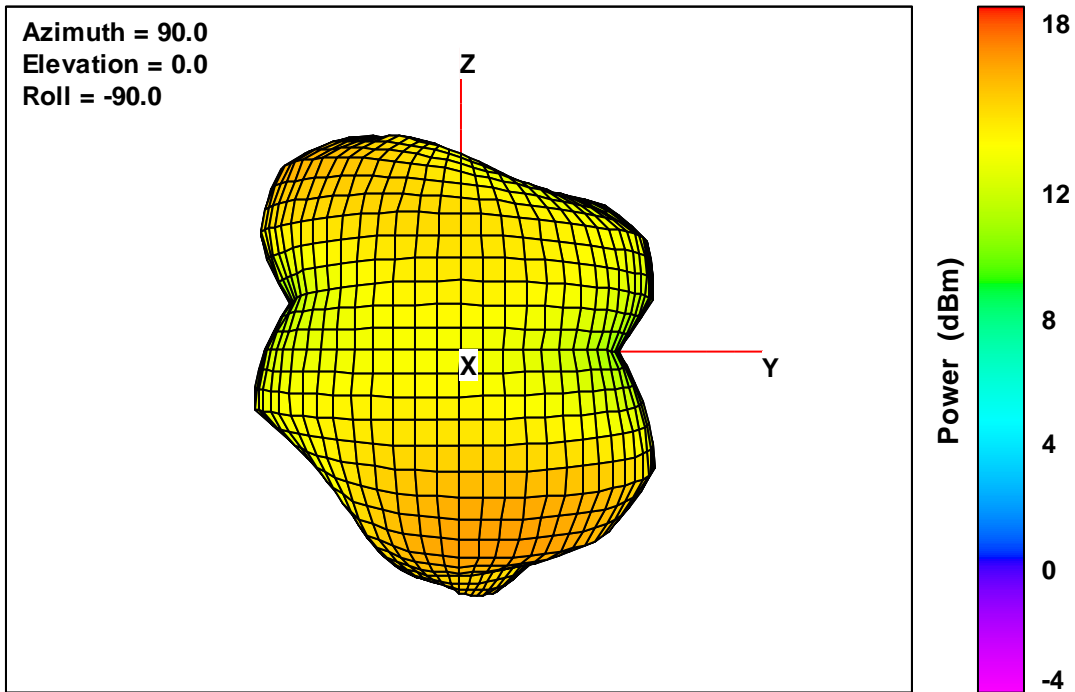
Free-Space Total EIS, Bottom View, 2480.0 MHz

Total EIS, Left Side View



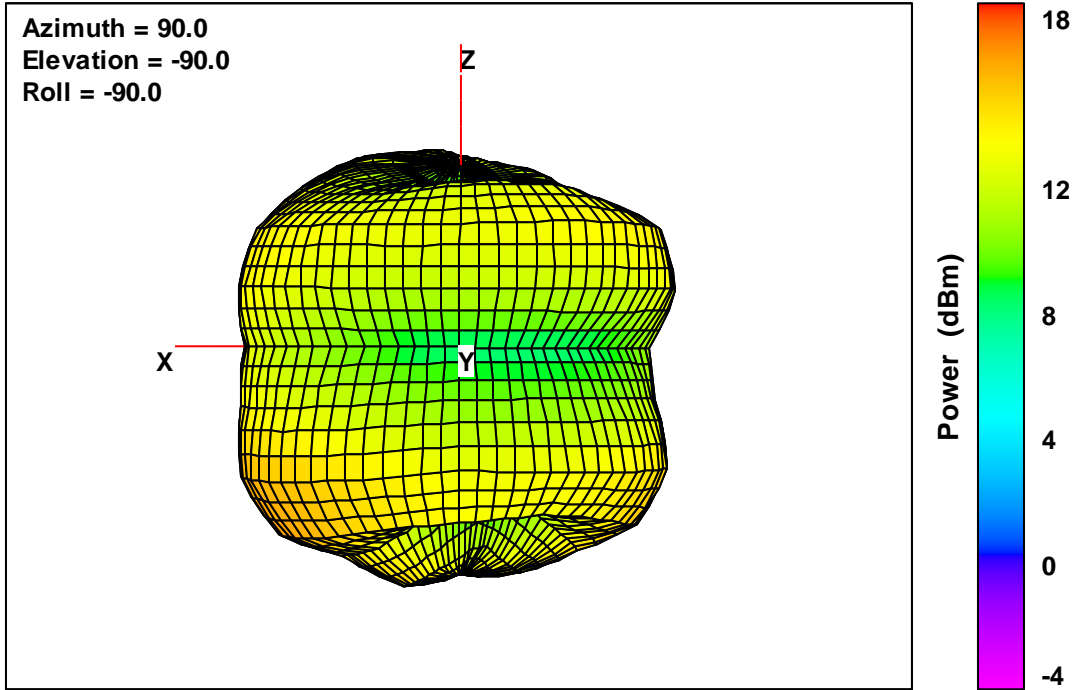
Free-Space Total EIS, Left Side View, 2480.0 MHz

Total EIS, Front Face View



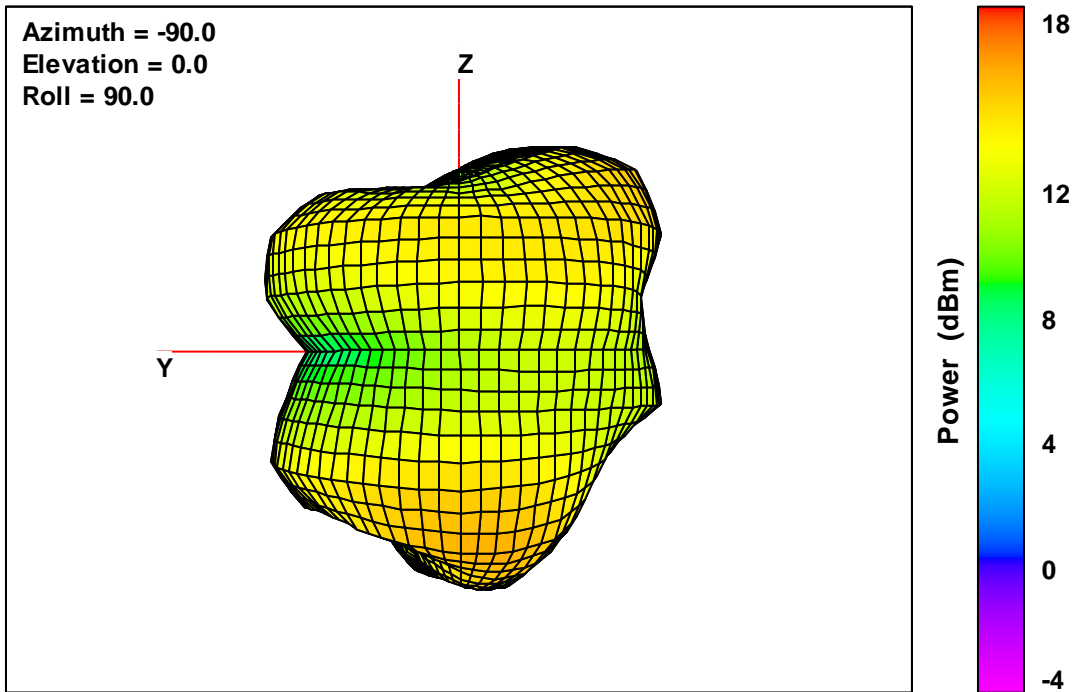
Free-Space Total EIS, Front Face View, 2480.0 MHz

Total EIS, Right Side View



Free-Space Total EIS, Right Side View, 2480.0 MHz

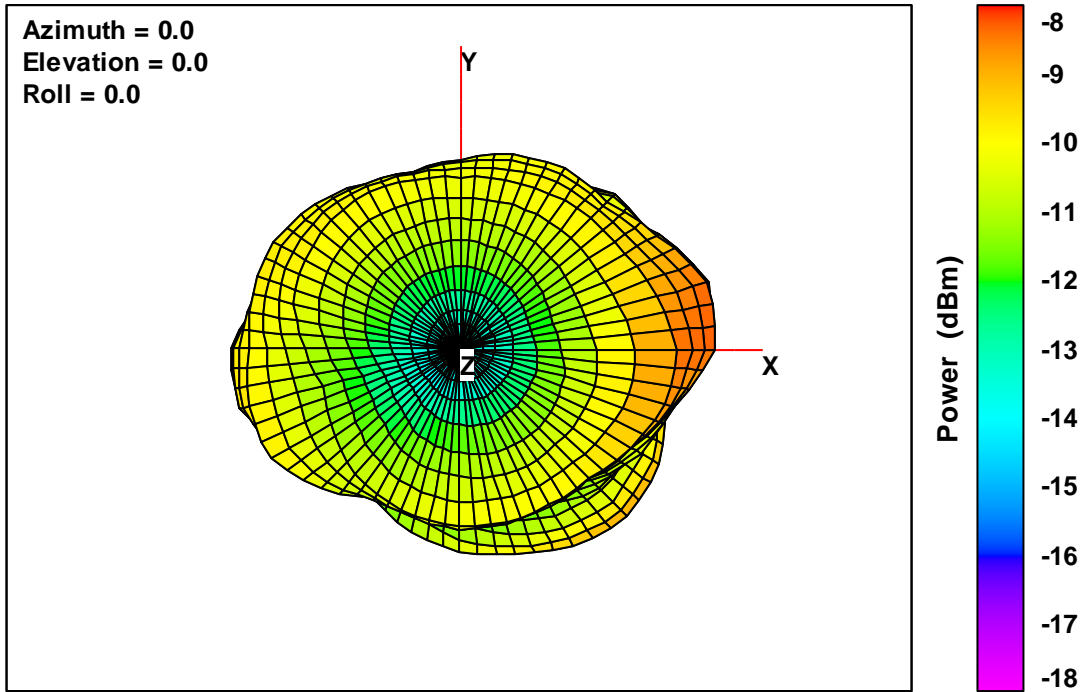
Total EIS, Back Face View



Free-Space Total EIS, Back Face View, 2480.0 MHz

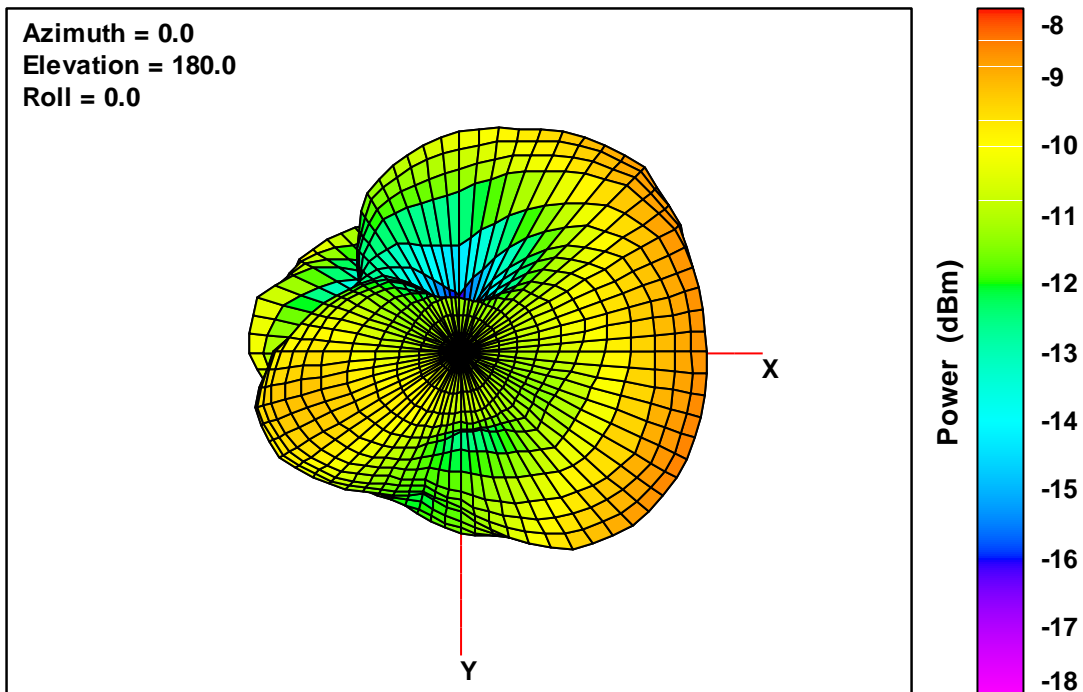
6.4 3D PASSIVE- 2405 MHz

Total EIRP, Top View



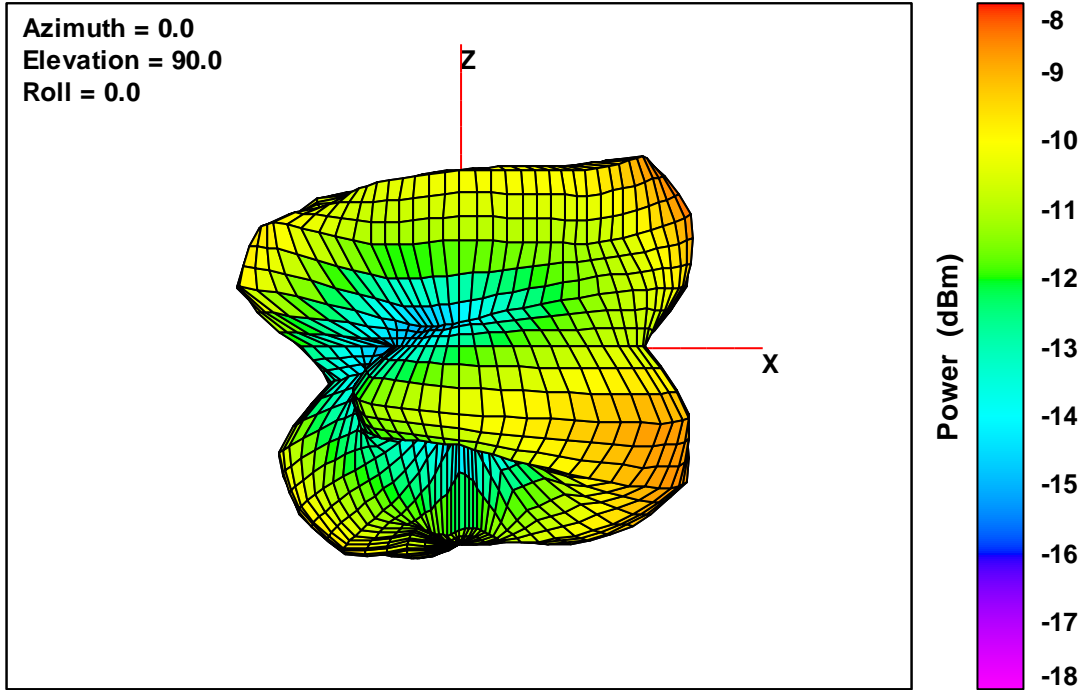
Free-Space Total EIRP, Top View , 2405 MHz

Total EIRP, Bottom View



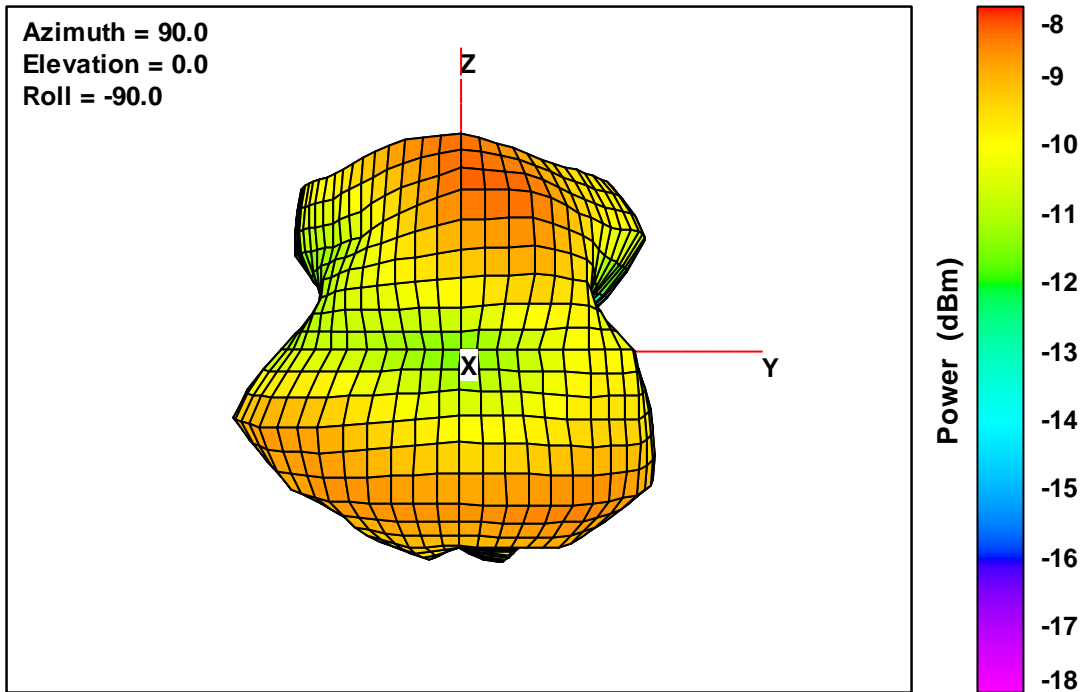
Free-Space Total EIRP, Bottom View , 2405 MHz

Total EIRP, Left Side View



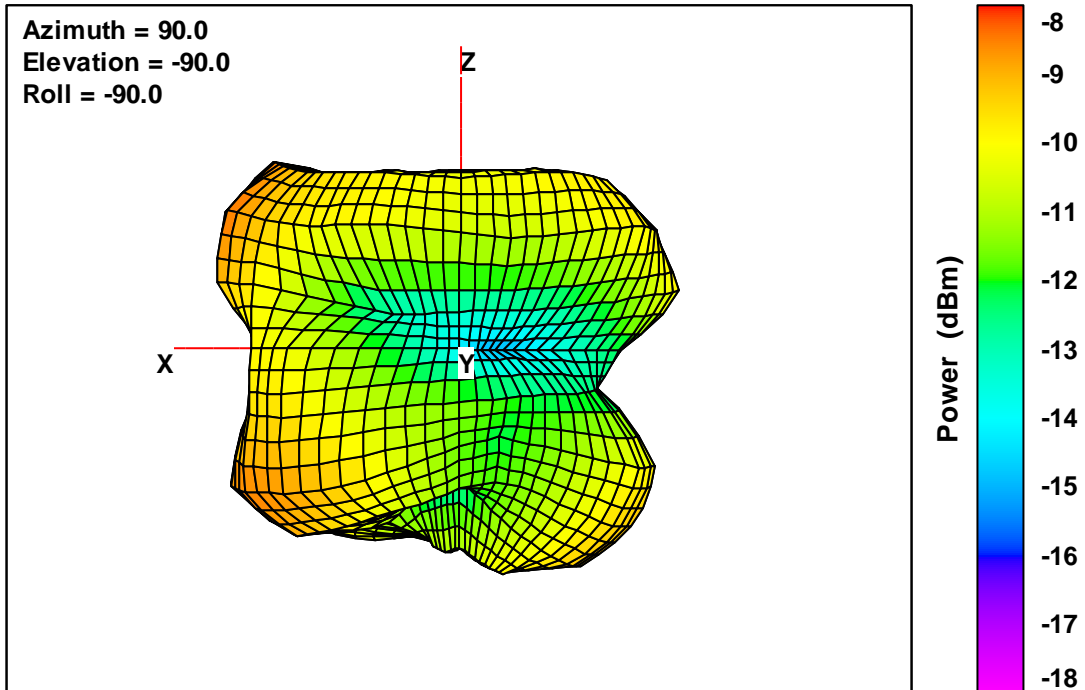
Free-Space Total EIRP, Left Side View , 2405 MHz

Total EIRP, Front Face View



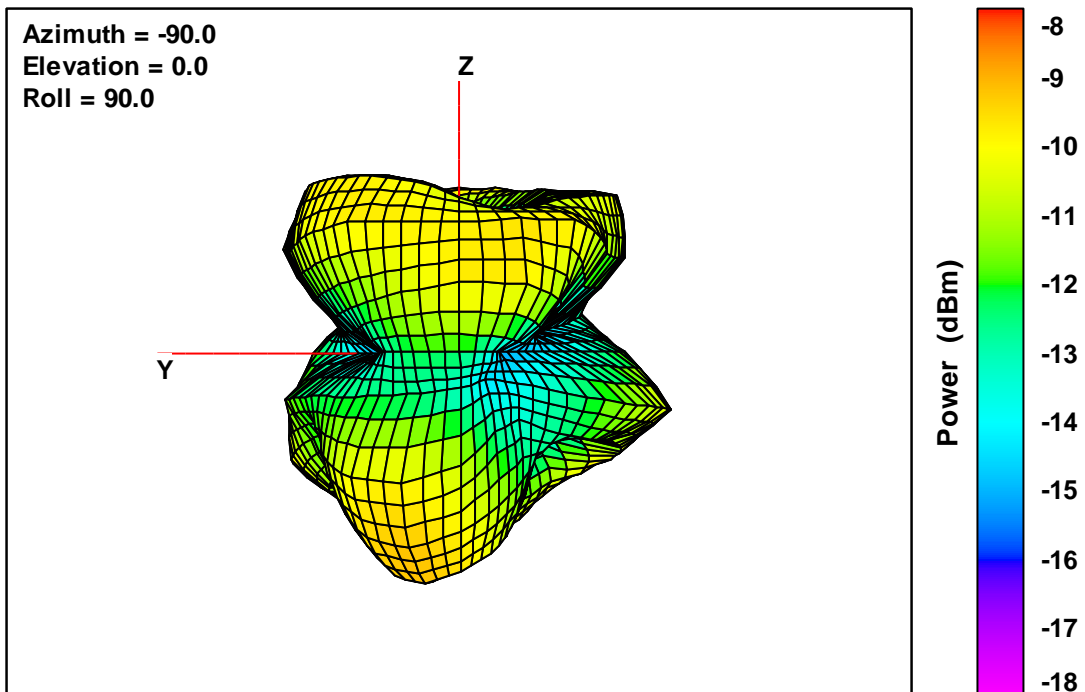
Free-Space Total EIRP, Front Face View , 2405 MHz

Total EIRP, Right Side View



Free-Space Total EIRP, Right Side View , 2405 MHz

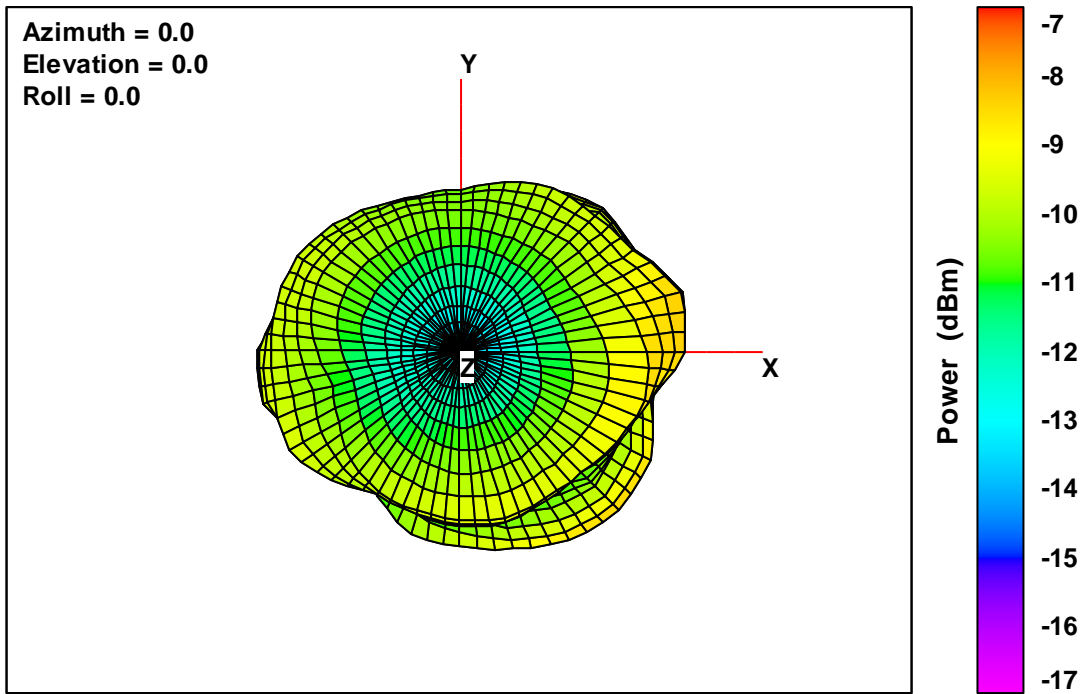
Total EIRP, Back Face View



Free-Space Total EIRP, Back Face View , 2405 MHz

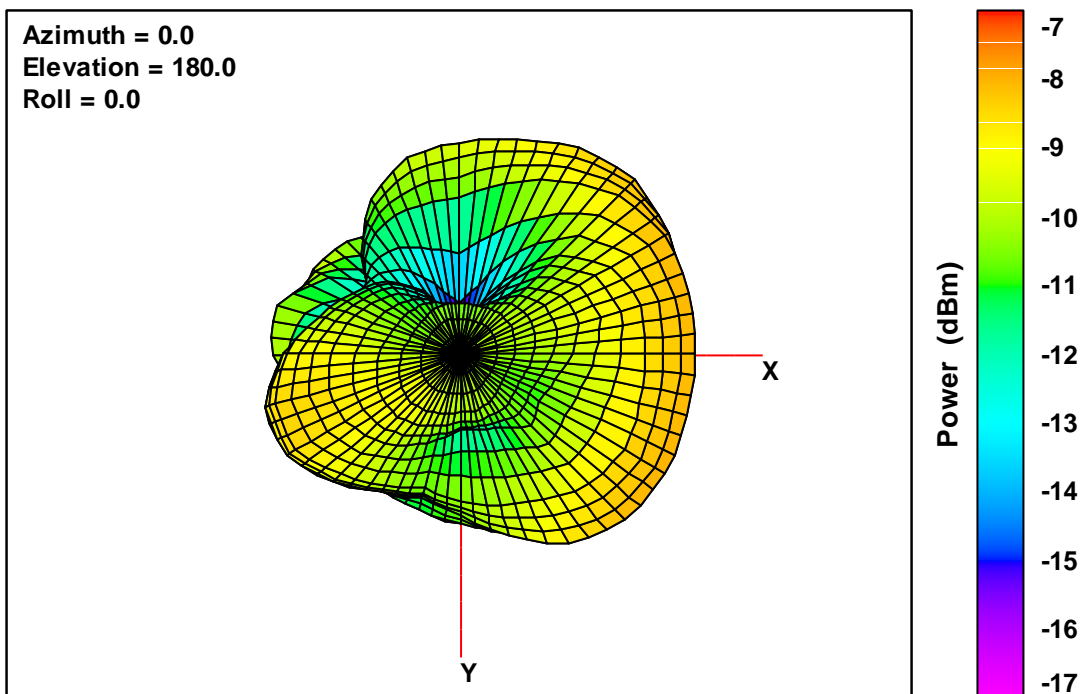
6.5 3D PASSIVE- 2440 MHz

Total EIRP, Top View



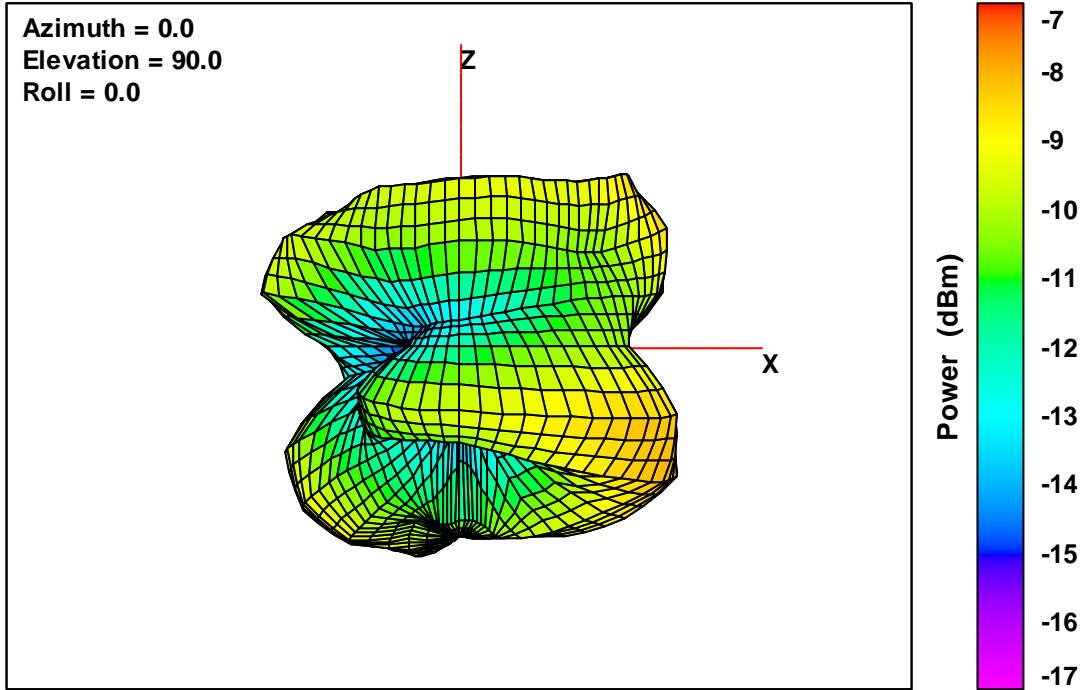
Free-Space Total EIRP, Top View , 2440 MHz

Total EIRP, Bottom View



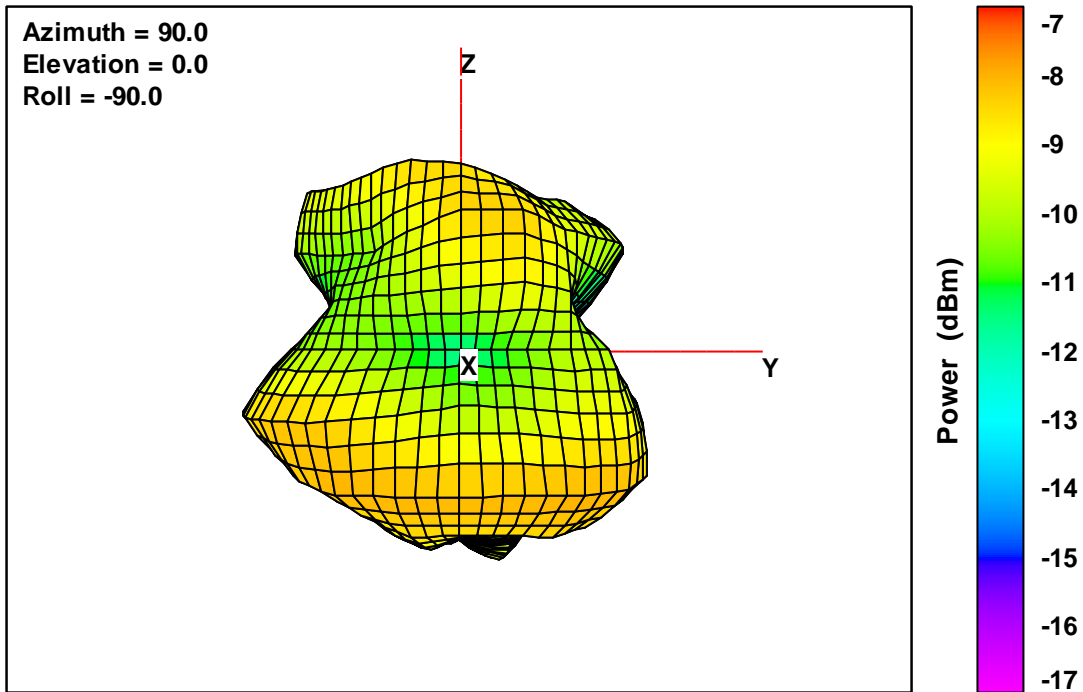
Free-Space Total EIRP, Bottom View , 2440 MHz

Total EIRP, Left Side View



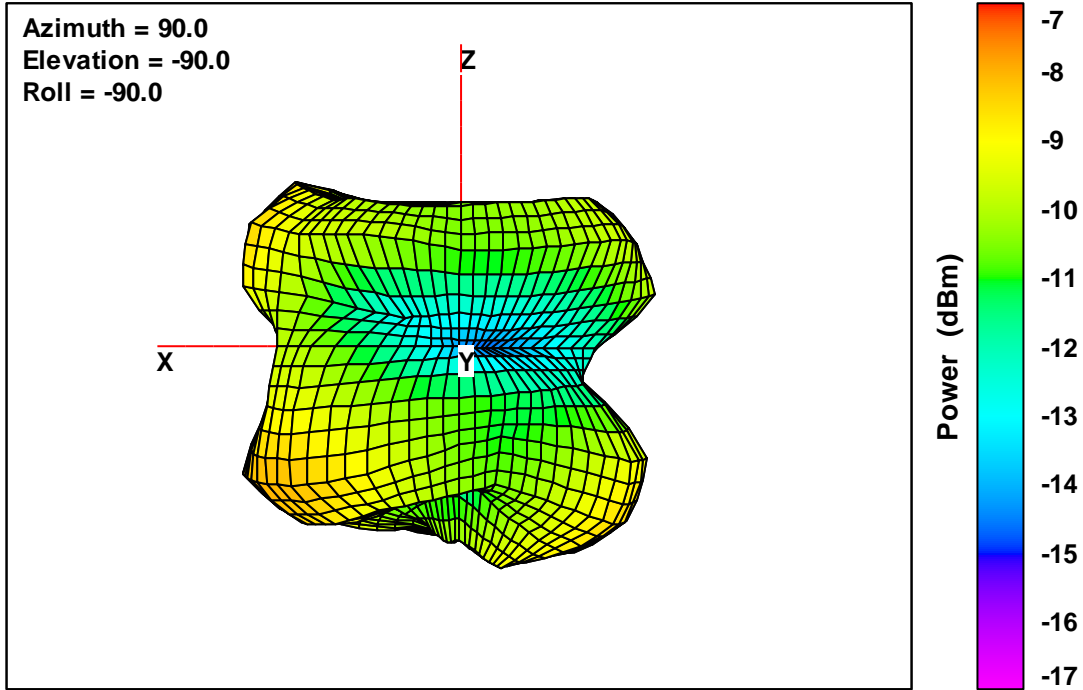
Free-Space Total EIRP, Left Side View , 2440 MHz

Total EIRP, Front Face View



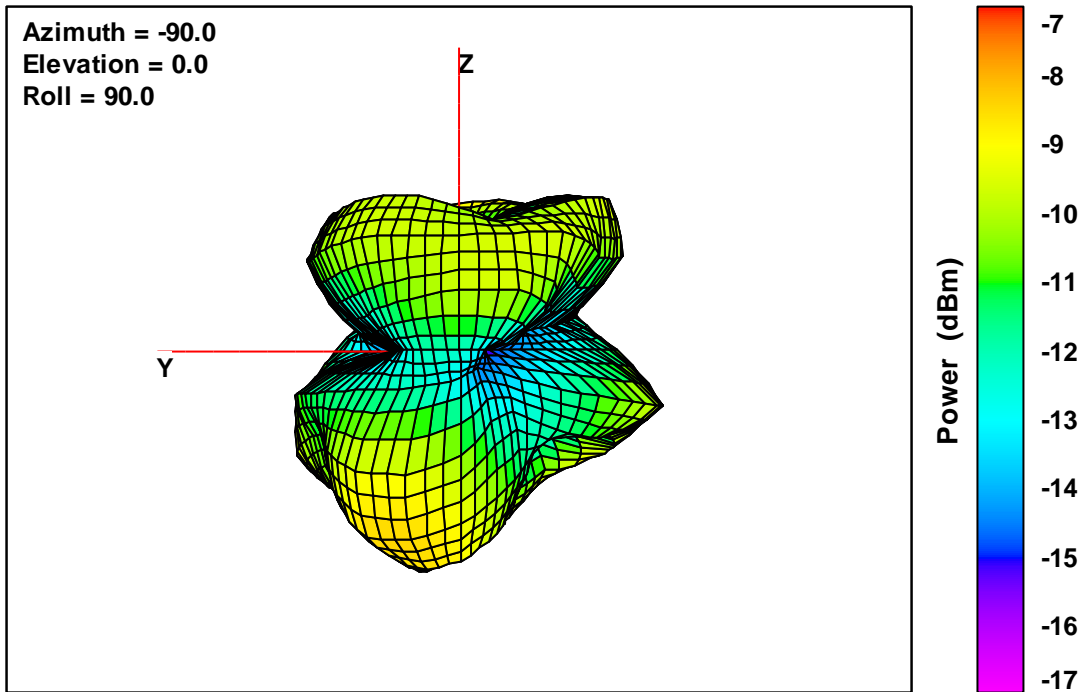
Free-Space Total EIRP, Front Face View , 2440 MHz

Total EIRP, Right Side View



Free-Space Total EIRP, Right Side View , 2440 MHz

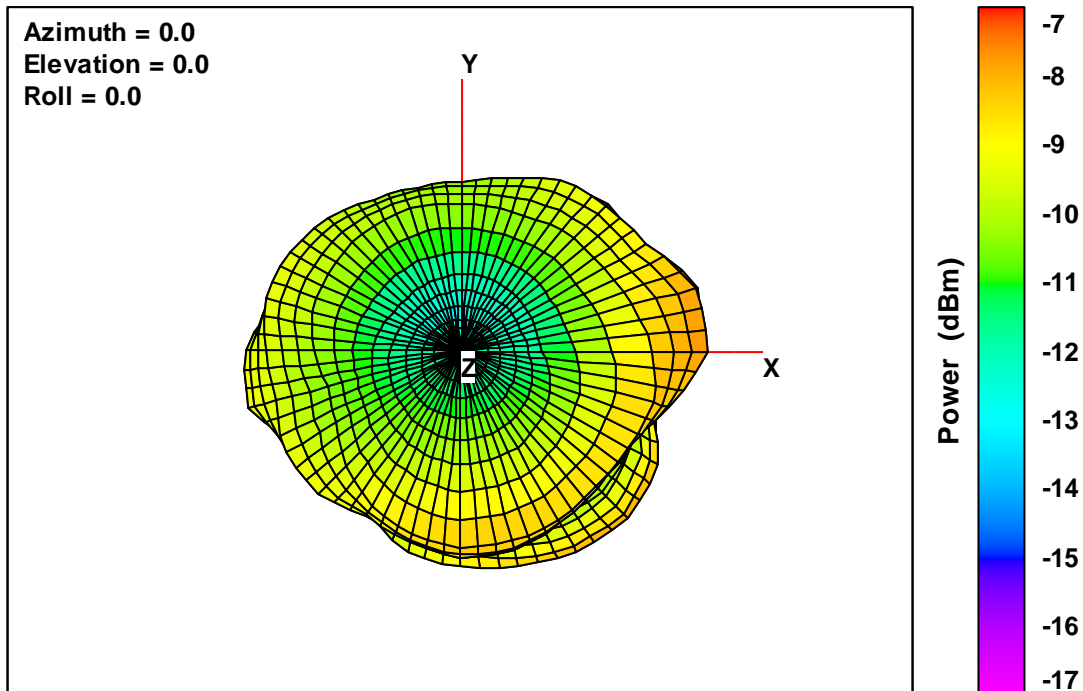
Total EIRP, Back Face View



Free-Space Total EIRP, Back Face View , 2440 MHz

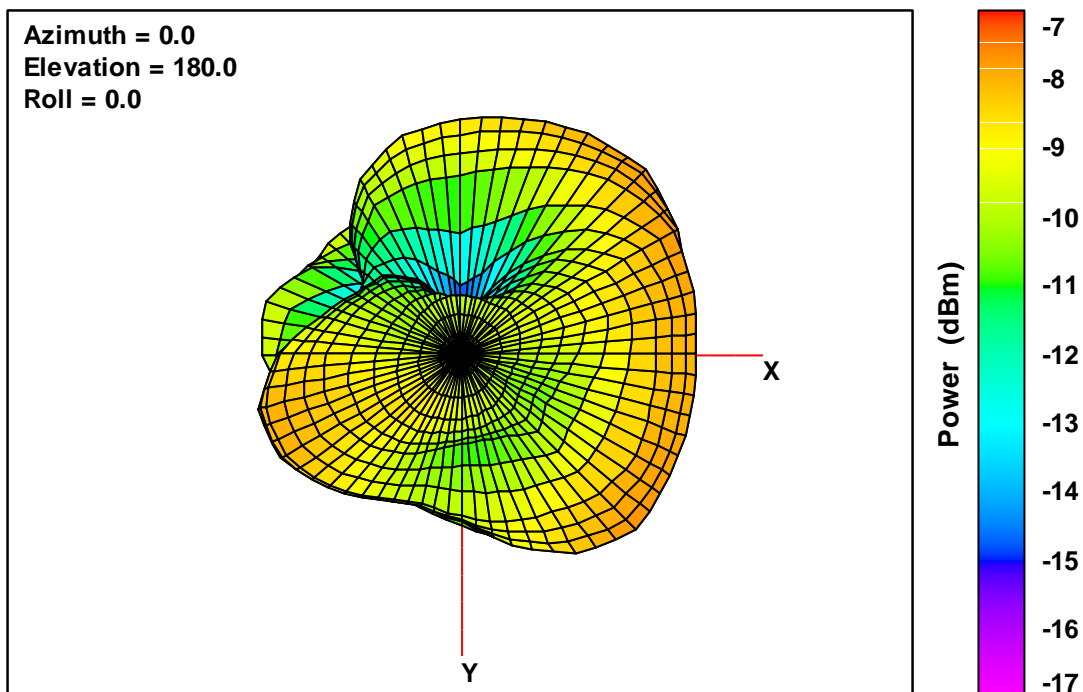
6.6 3D PASSIVE- 2480 MHz

Total EIRP, Top View



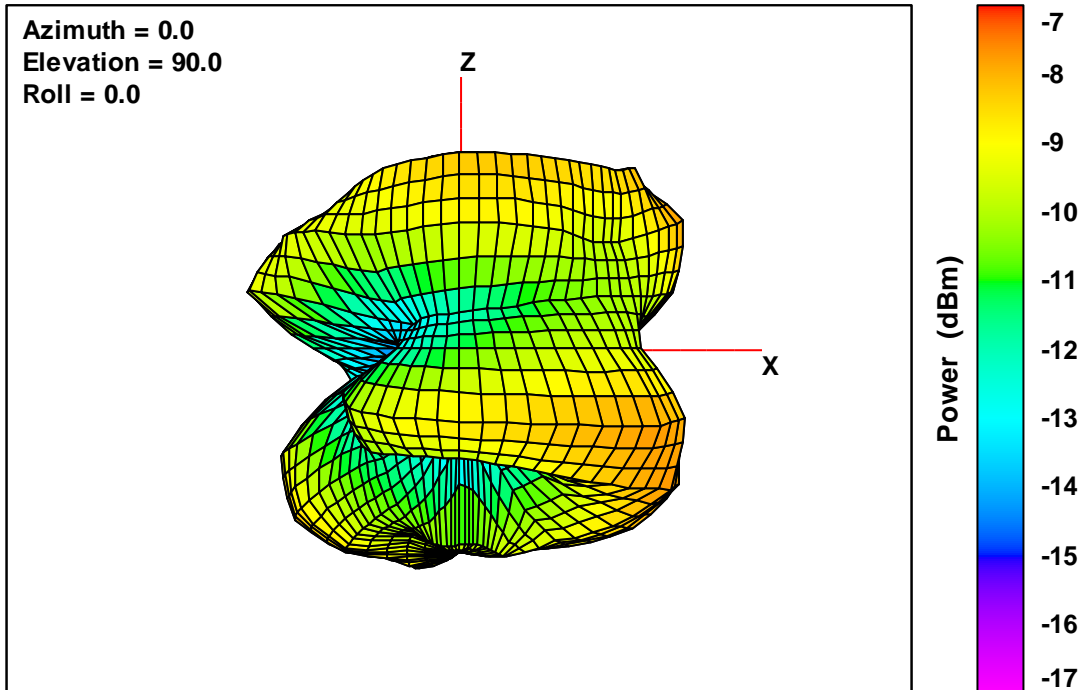
Free-Space Total EIRP, Top View , 2480 MHz

Total EIRP, Bottom View



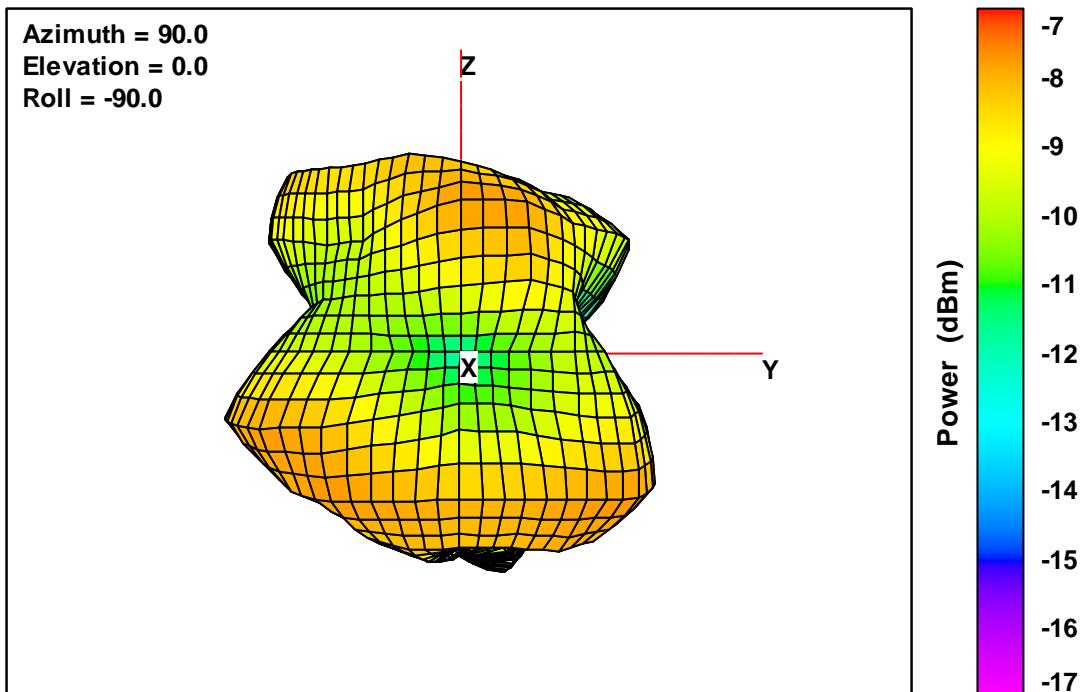
Free-Space Total EIRP, Bottom View , 2480 MHz

Total EIRP, Left Side View



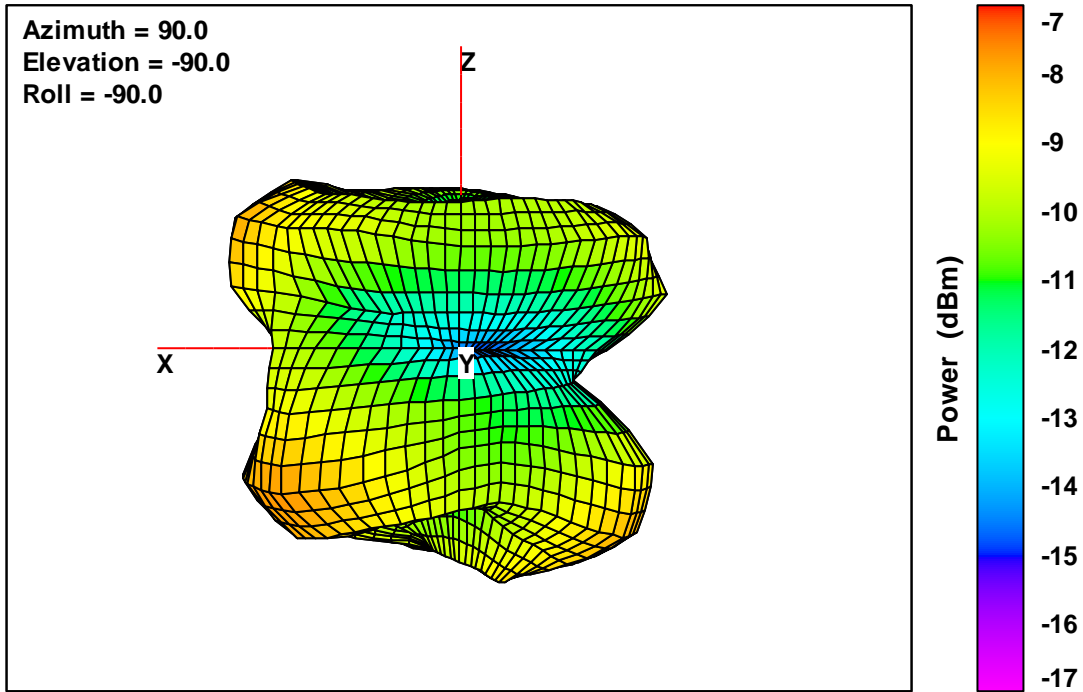
Free-Space Total EIRP, Left Side View , 2480 MHz

Total EIRP, Front Face View



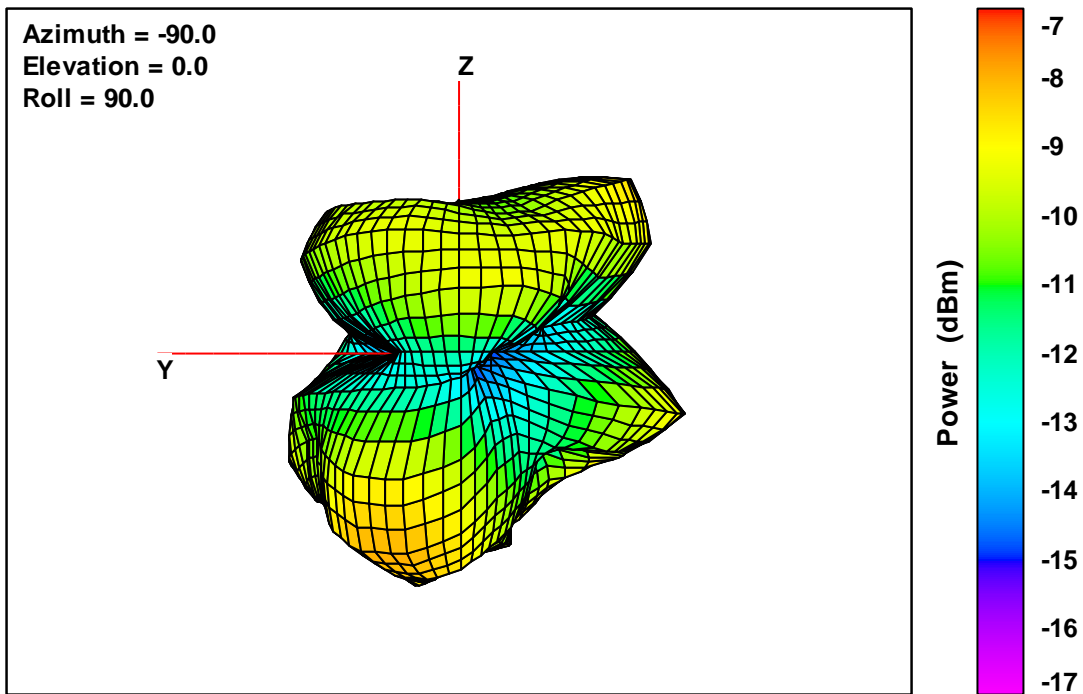
Free-Space Total EIRP, Front Face View , 2480 MHz

Total EIRP, Right Side View



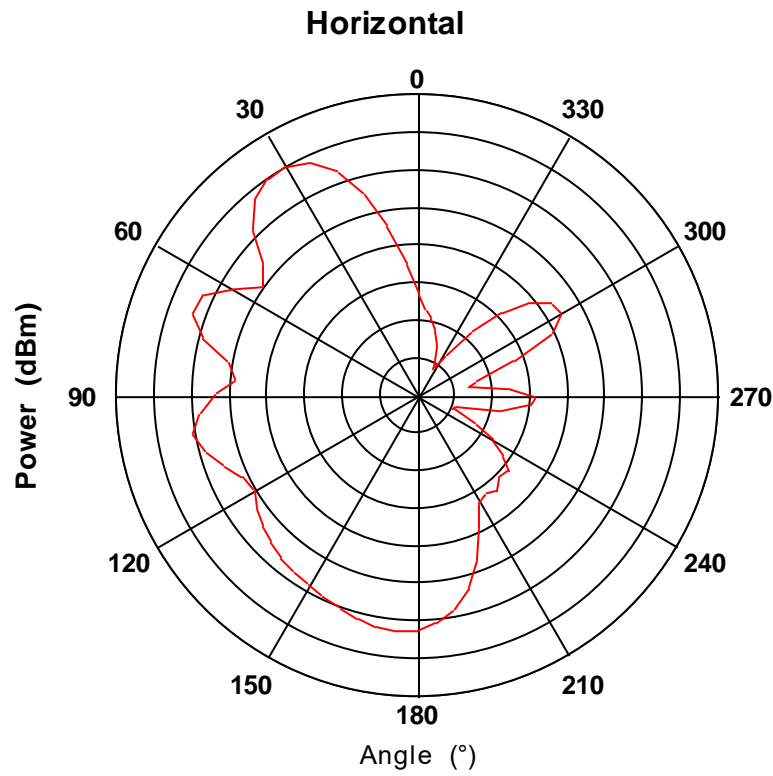
Free-Space Total EIRP, Right Side View , 2480 MHz

Total EIRP, Back Face View

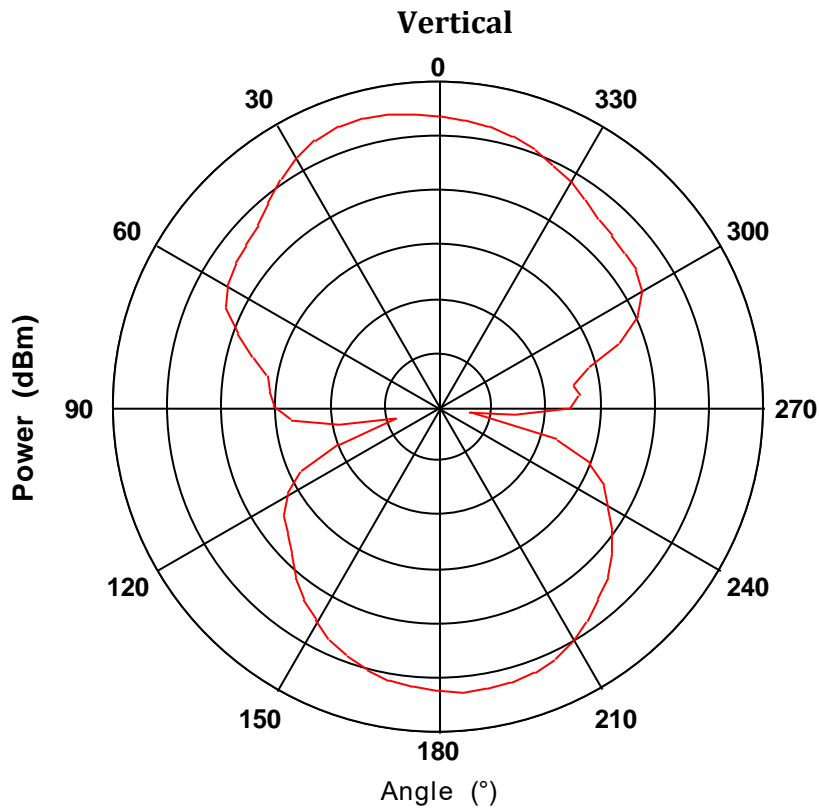


Free-Space Total EIRP, Back Face View , 2480 MHz

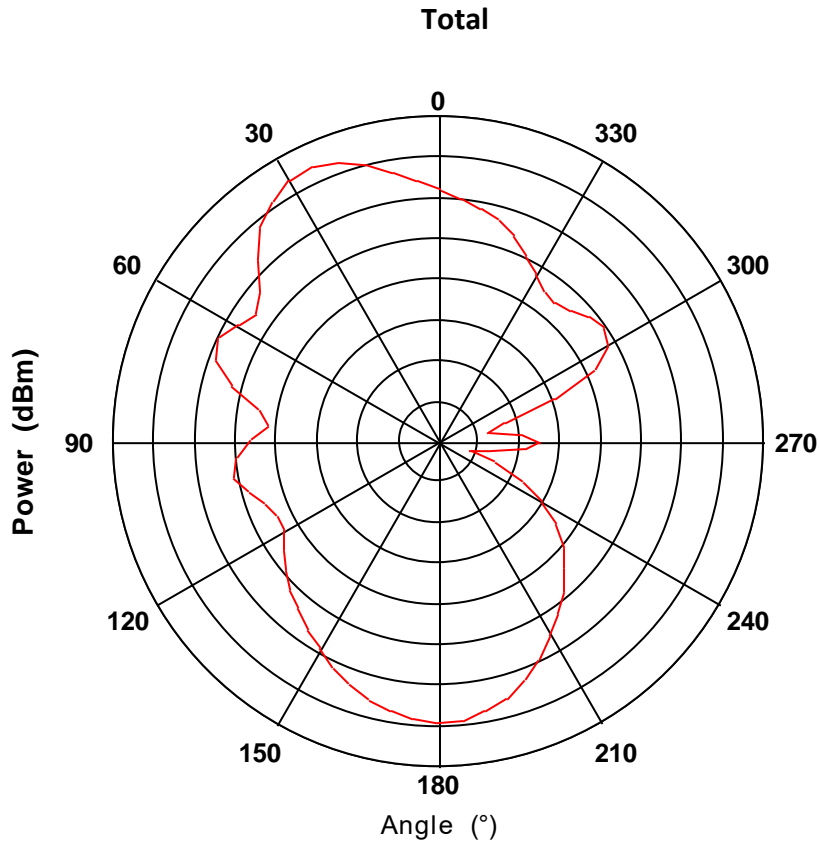
6.7 2D ACTIVE- 2405 MHz



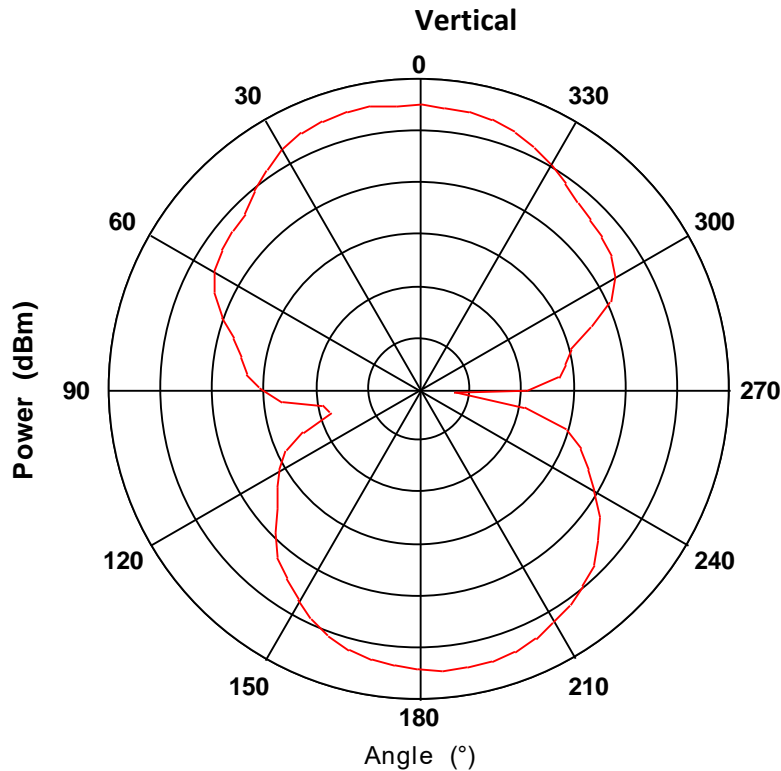
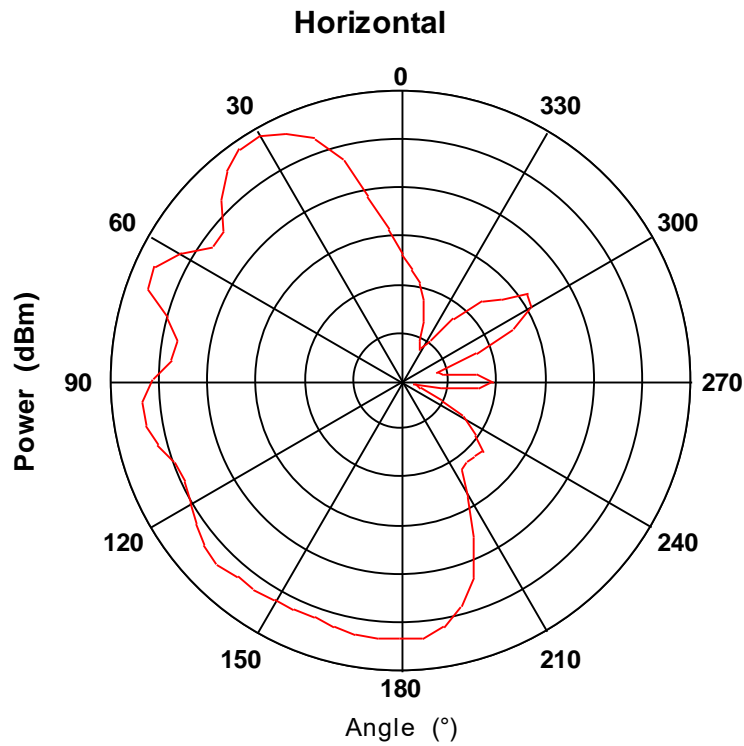
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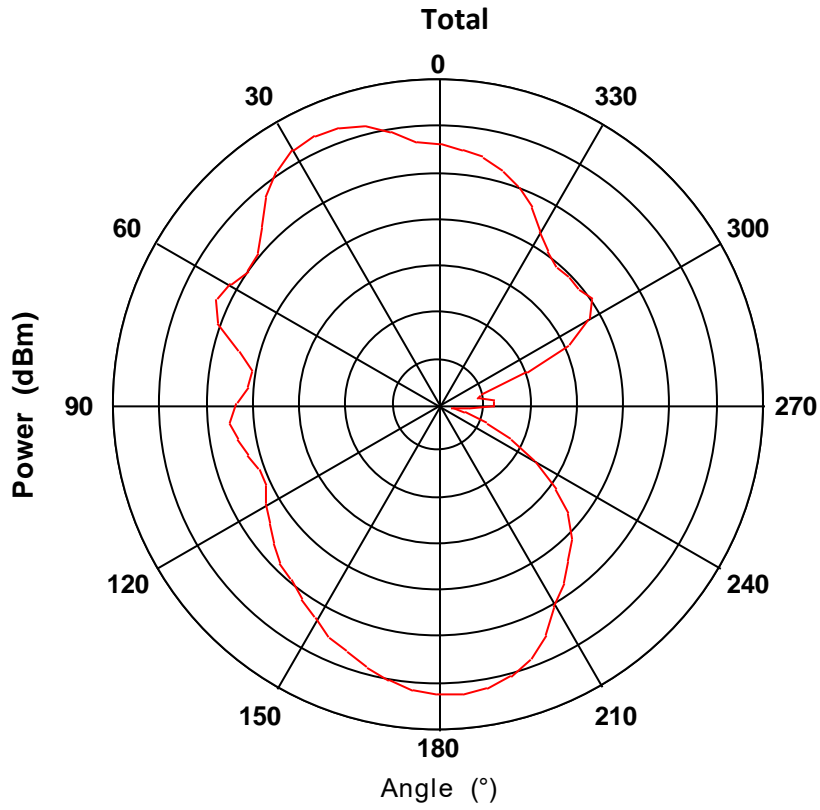


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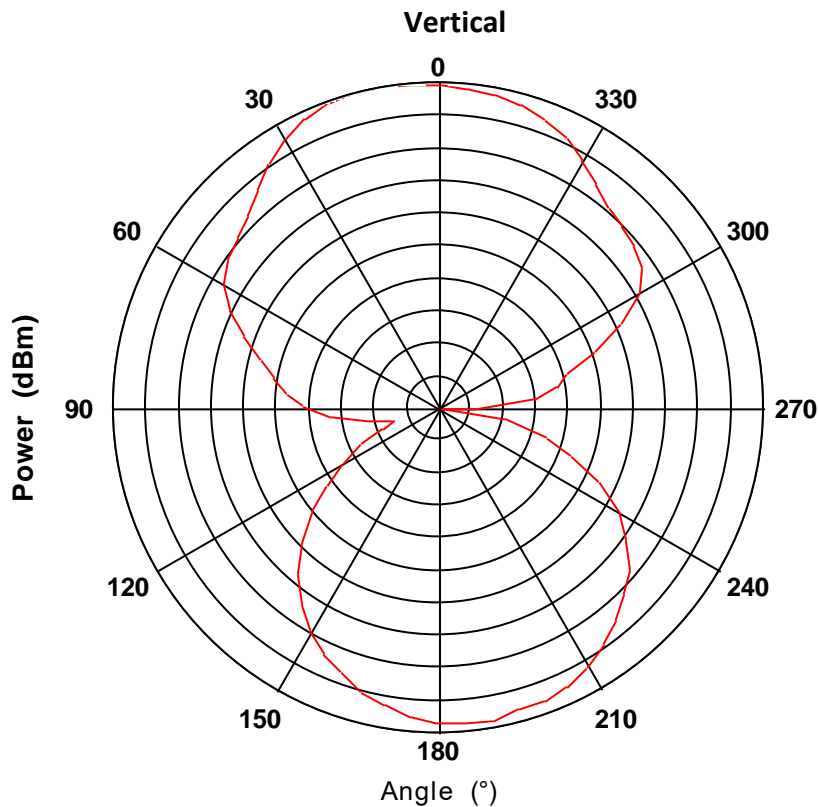
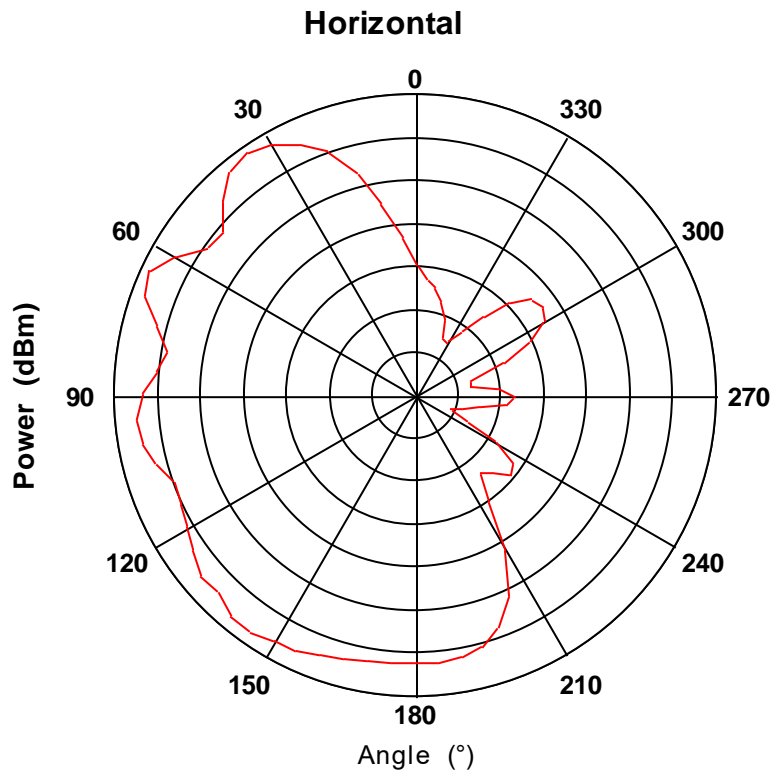


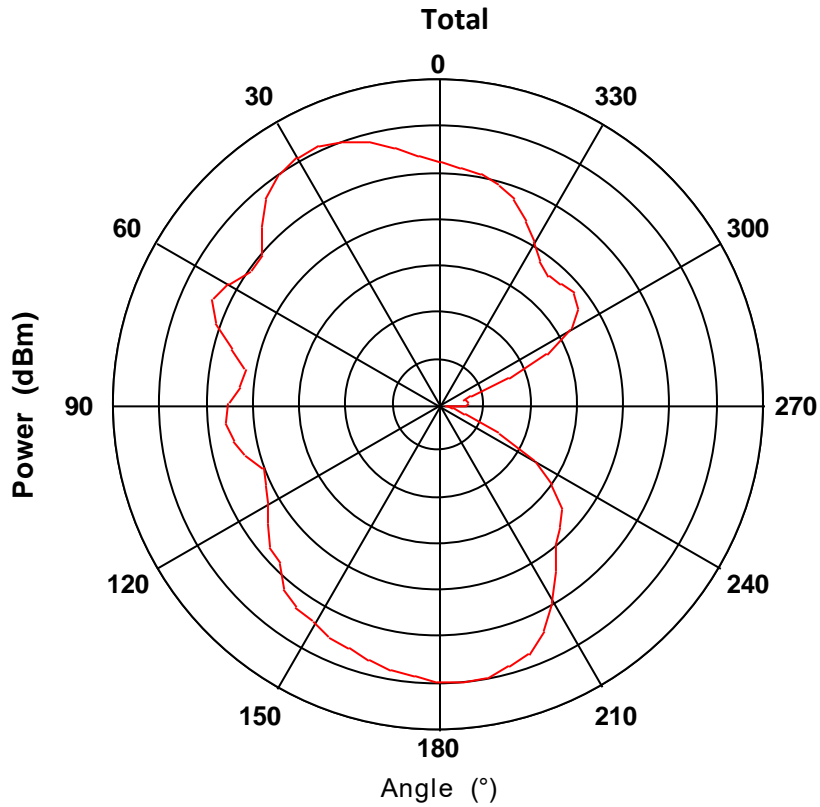
6.8 2D ACTIVE- 2440 MHz



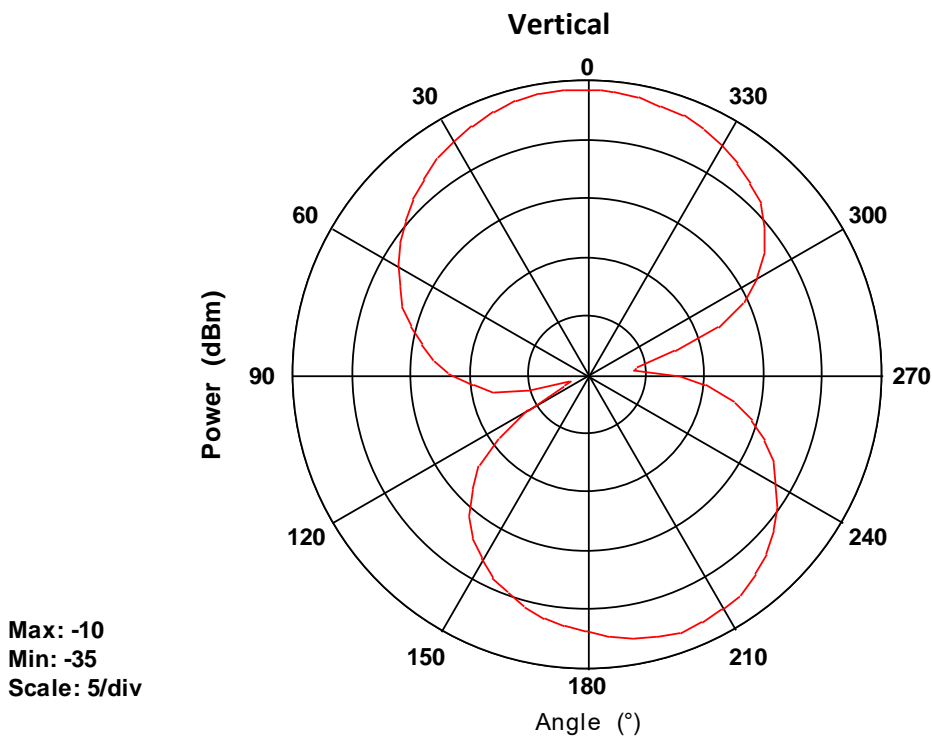
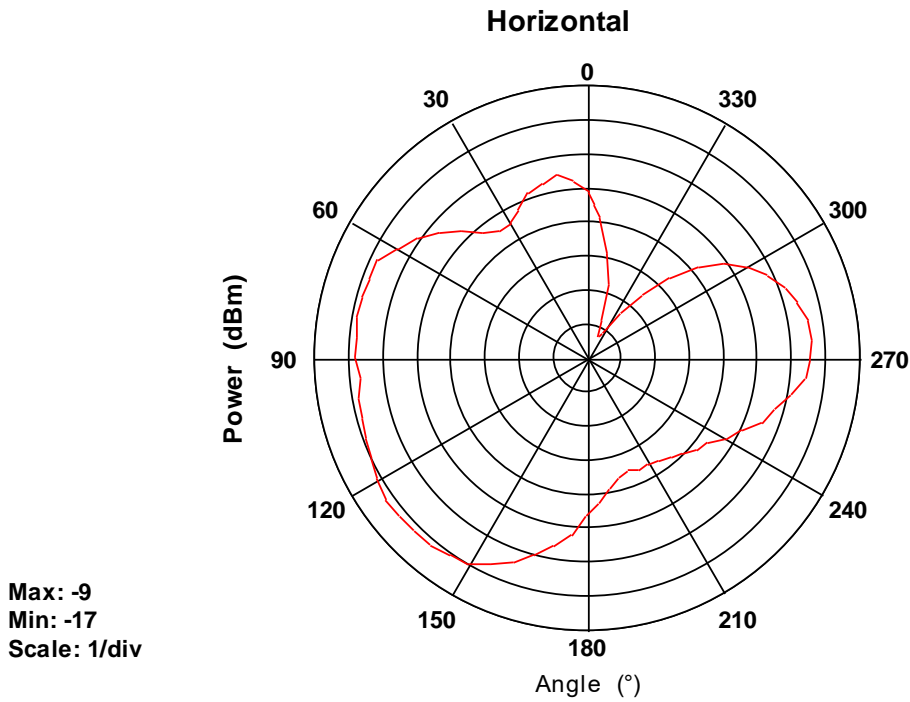


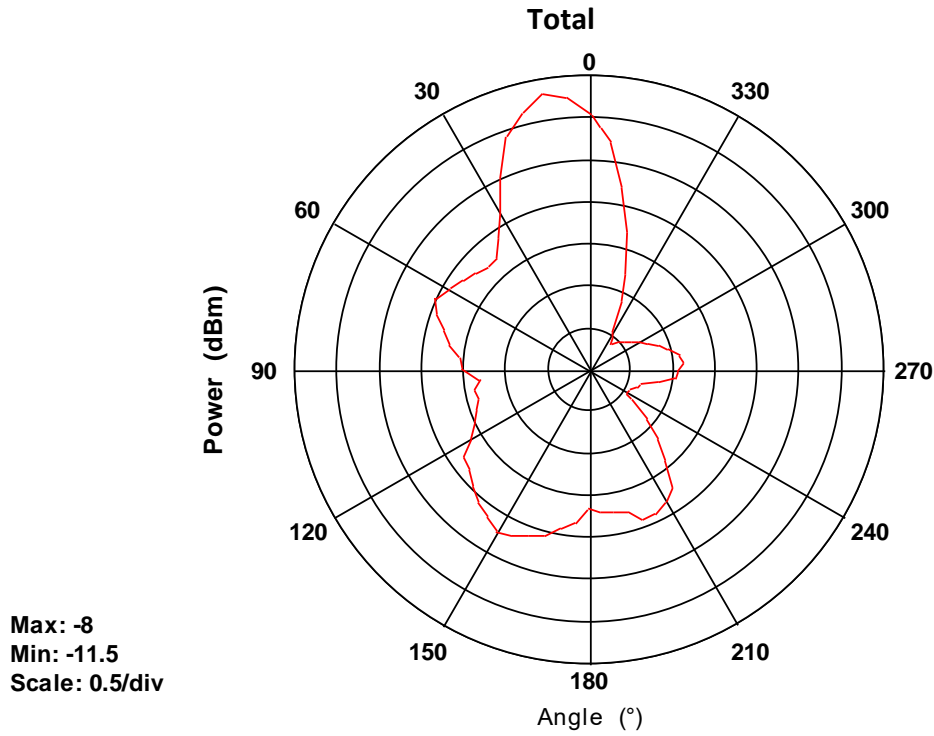
6.9 2D ACTIVE - 2480 MHz



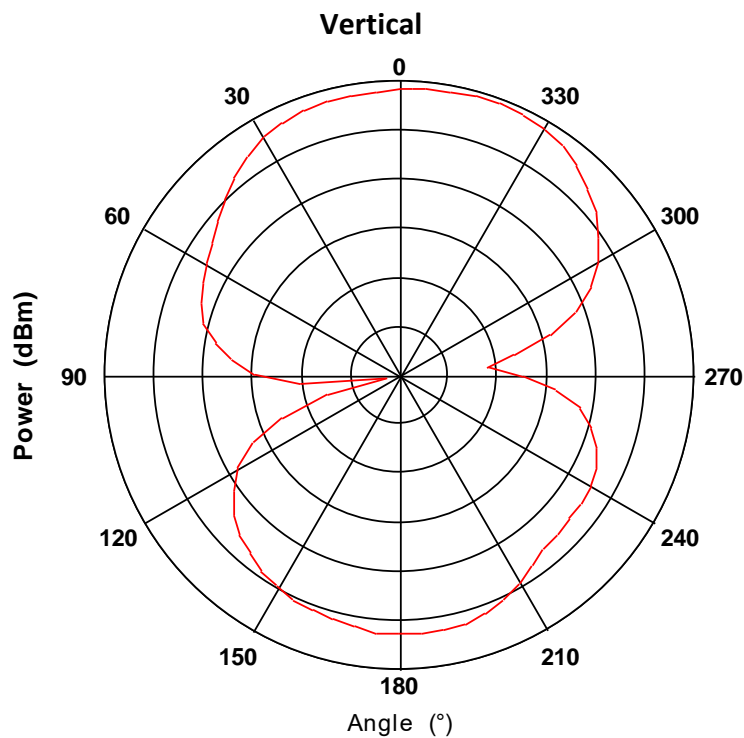
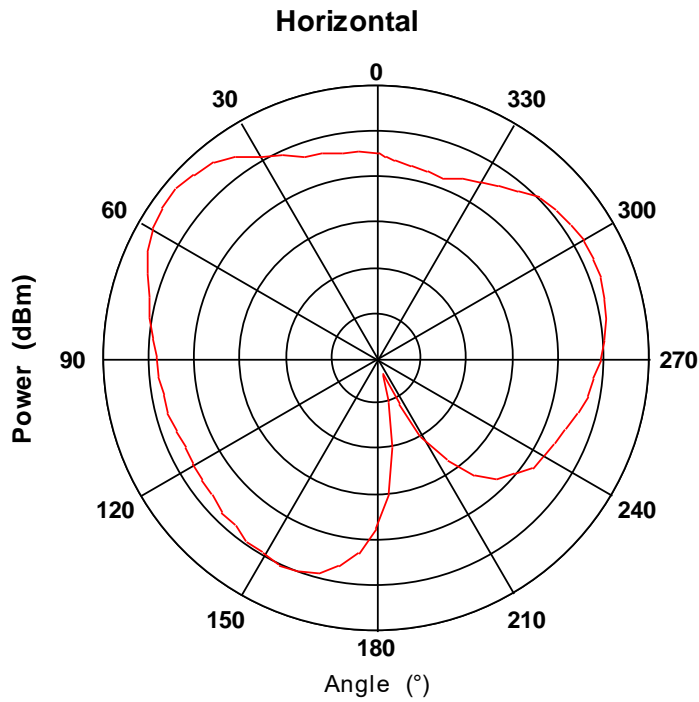


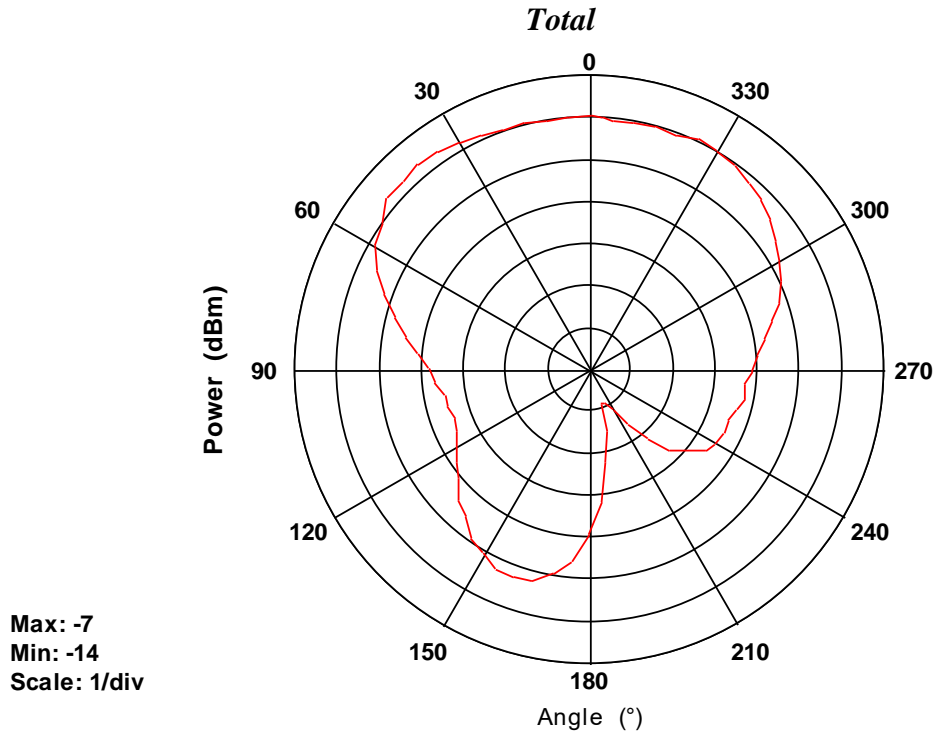
6.10 2D PASSIVE- 2405 MHz



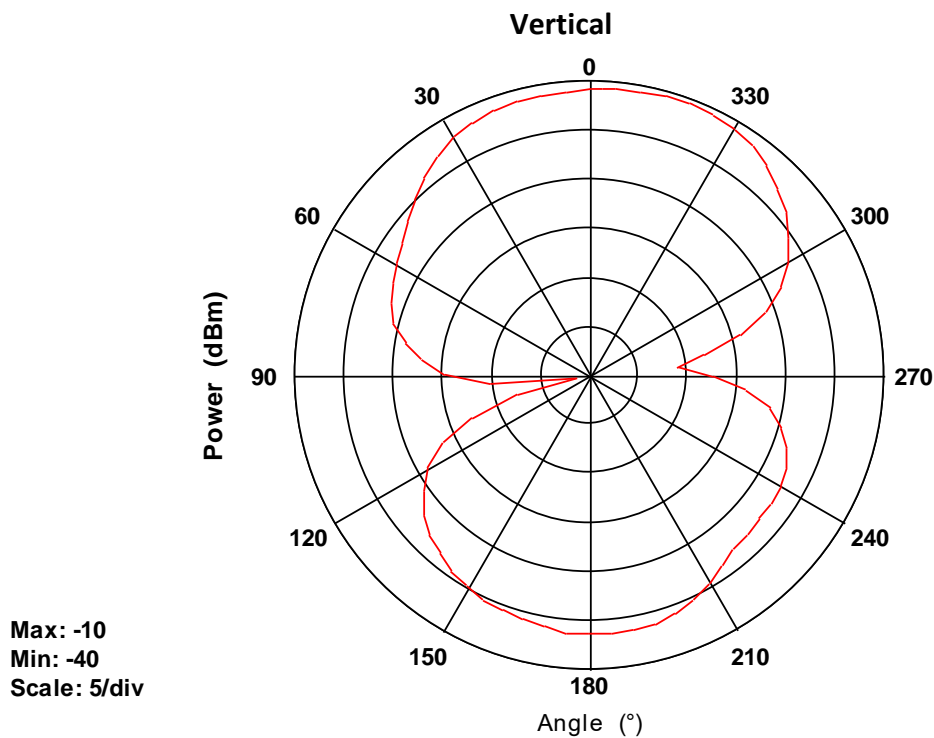
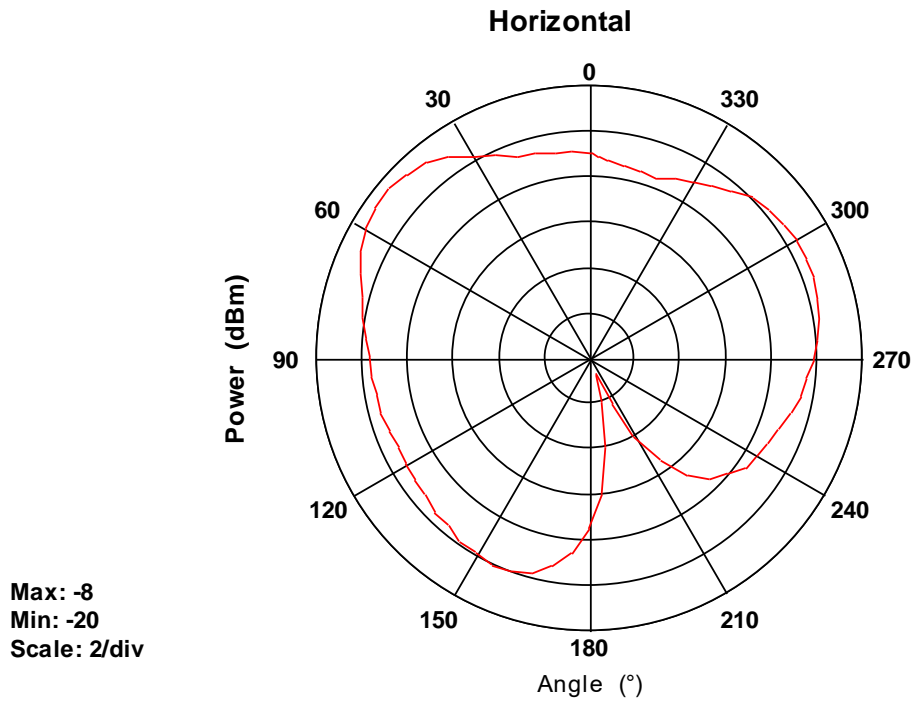


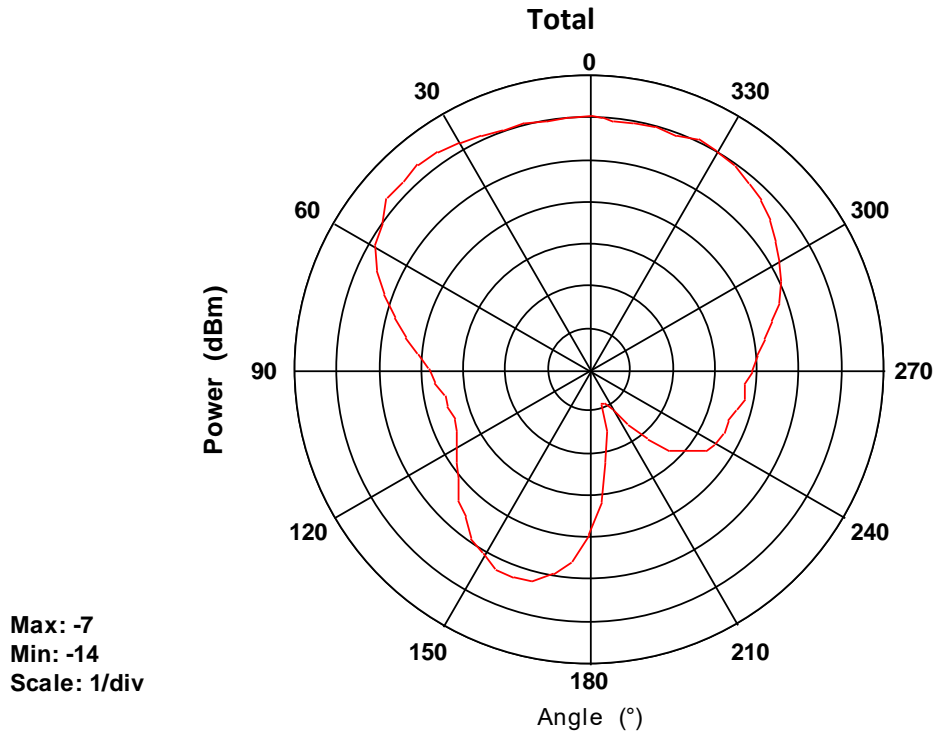
6.11 2D PASSIVE- 2440 MHz



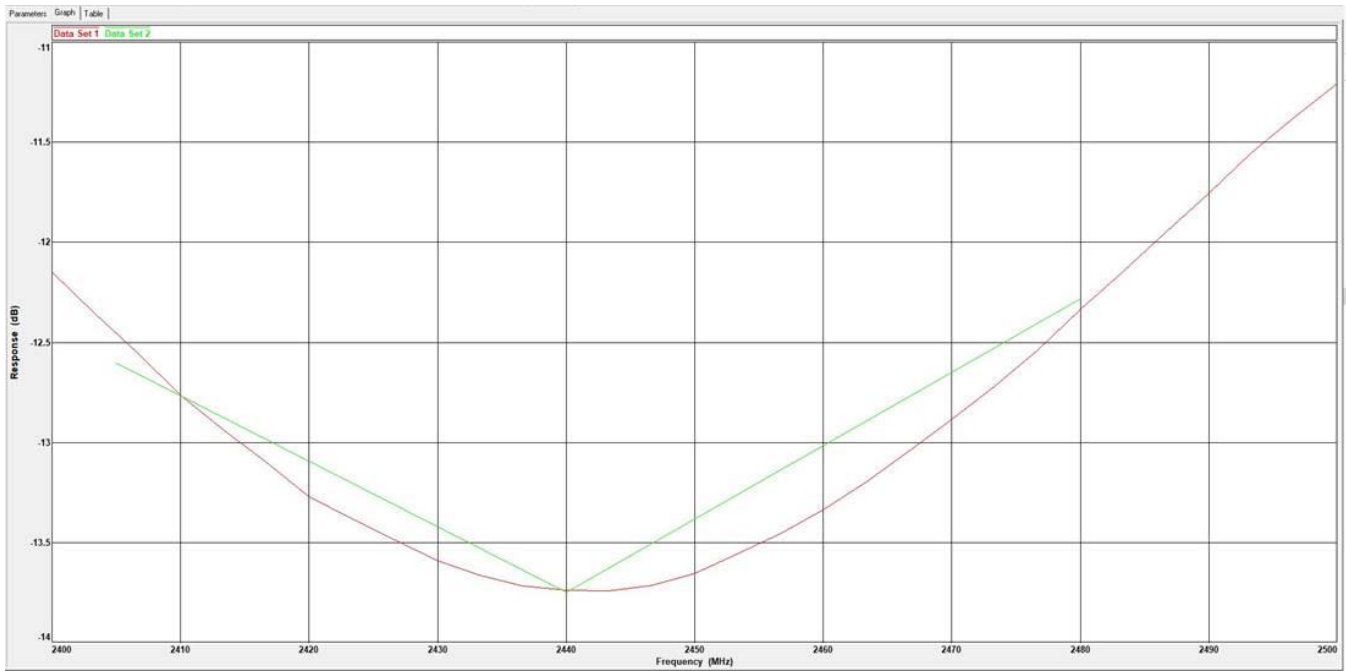


6.12 2D PASSIVE- 2480 MHz



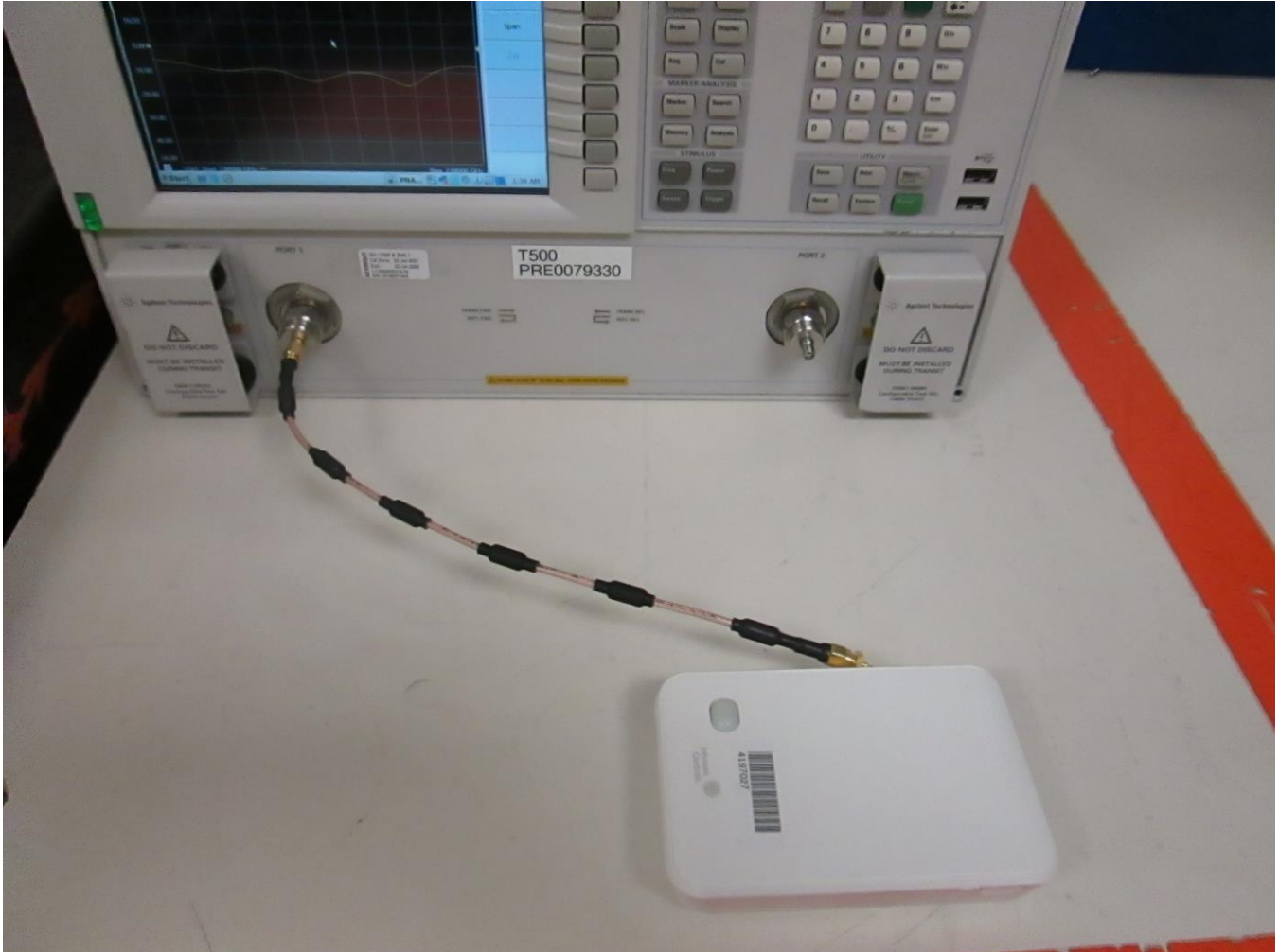


6.13 VSWR Plot

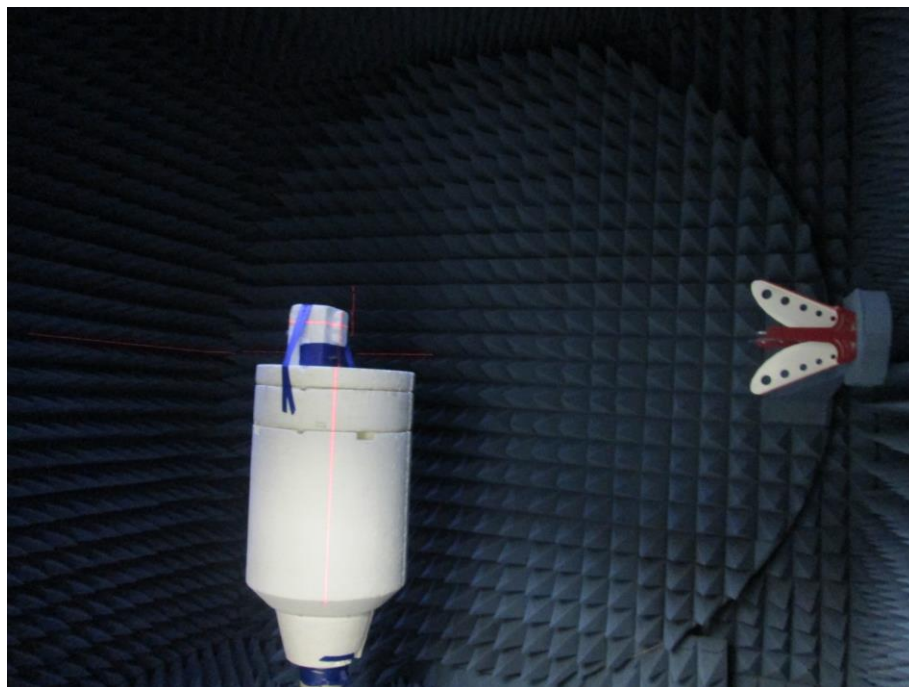
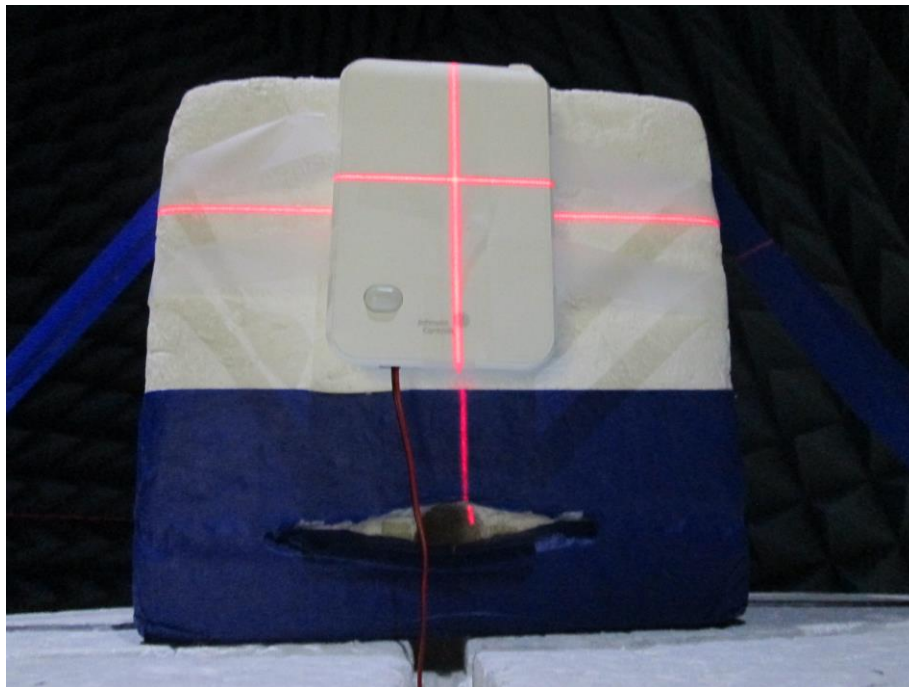


7 TEST SETUP

7.1 VSWR



7.2 Active Antenna Pattern



END OF REPORT

