WLAN Antenna Pattern Measurement Test Report for GEN3 BC7 - MID

Report Reference: MDE_HARMAN_1702_BC7_Mid_WLAN_2_RP
Date: 24.03.2017

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Note:
The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

Content:

1 Test Lab Declaration

All test results stated relate only to the device tested.

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- **in the resulting document it's status (being an excerpt) is clearly stated and**
- **in minimum chapter 3 is included completely.**

2 SIGNATURES

Responsible for Accreditation Scope:	Robert Machulec	Responsible for Test Report:	Dieter Sütthoff

3 Project and Result Summary

DUT	GEN3 BC7 - MID	DUT SN	SN026
Test lab	7layers GmbH Borsigstr. 11 40880 Ratingen Germany	Set up	free space
		Test start	03.03.2017
Customer	Harman International Industries, Inc. 3001 Cabot Drive Novi, MI 48377 USA	Report date	24.03.2017
		Report by	Dieter Sütthoff
		Approved by	Robert Machulec

HW Version	1.6.8
SW Version	2.17.02.00

WLAN 2.4 GHz, Mid Sample						
RMS Detector, RBW 10 MHz	**2412 MHz**	**2437 MHz**	**2462 MHz**	**2472 MHz**		
Antenna Port Input Power (Conducted Sample)	**6.4**	**5.9**	**6.7**	**7.5**		
Tot. Rad. Pwr. (dBm)	-4.0	-2.4	-1.6	-1.3		
Peak EIRP (dBm)	**1.3**	**2.4**	**2.8**	**3.2**		
Directivity (dBi)	5.3	4.8	4.4	4.5		
Efficiency (dB)	-10.4	-8.3	-8.3	-8.8		
Efficiency (%)	9.1	14.7	14.9	13.2		
Gain (dBi)	**-5.1**	**-3.5**	**-3.9**	**-4.3**		
WLAN 5 GHz, Mid Sample						
RMS Detector, RBW 10 MHz	**5180 MHz**	**5220 MHz**	**5240 MHz**	**5600 MHz**	**5785 MHz**	**5825 MHz**
Antenna Port Input Power (Conducted Sample)	**13.3**	**13.6**	**14.3**	**13**	**13**	**12.9**
Tot. Rad. Pwr. (dBm)	9.9	10.5	10.3	8.8	8.3	8.4
Peak EIRP (dBm)	**15.8**	**16.8**	**16.6**	**15.4**	**14.3**	**13.9**
Directivity (dBi)	5.9	6.3	6.3	6.6	6.0	5.5
Efficiency (dB)	-3.4	-3.1	-4.0	-4.2	-4.7	-4.5
Efficiency (%)	46.0	49.0	40.1	38.1	34.2	35.6
Gain (dBi)	2.5	3.2	2.3	2.4	1.3	1.0

Tab. 1: Test result summary WLAN

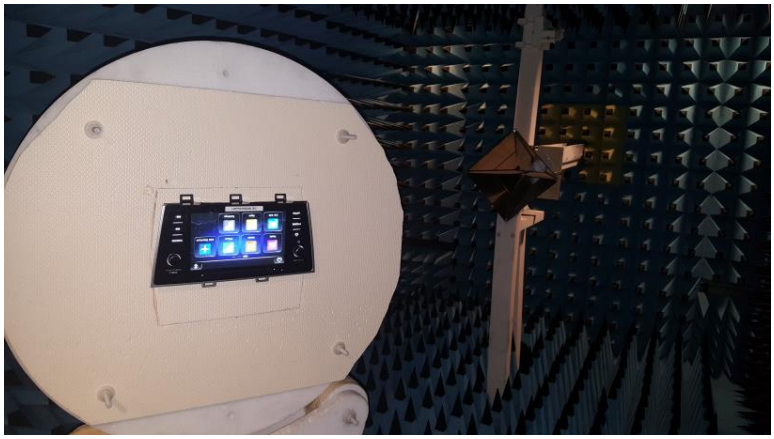


Fig. 1: Photo of test setup.

4 Brief Description of Settings and Test Method

4.1 References and Standards Used

[1] CTIA: "Test Plan for Wireless Device Over the Air Performance", Revision 3.6.1, 11/2016.

[2] 3GPP TS 25.101: "User Equipment (UE) radio transmission and reception (FDD)", (Release 11), Version V11.2.0, June 2012.

[3] 7 layers document: "Test Procedure for Over the Air Performance Estimation Applied by the OTA Test Lab at 7 layers Ratingen", Version January 2009.

4.2 Test Procedure TRP

The method of measurement for radiated RF power and receiver performance are based on the principals of the test standard CTIA: "Test Plan for Mobile Station Over the Air Performance" [1].

In general the following approach is applied for TRP measurements:

- For TRP measurement put OUT in a mode where it transmitting periodical RF energy.
- Rotate the OUT in all room directions with a angle grid of 15°.
- Gather power data for both, vertical and horizontal polarization.
- Calculate total radiated power by integrating over the whole sphere as outlined in [1].

The test setup was placed at the turning device inside a fully anechoic chamber. The object under test (OUT) was set to transmit permanently signal on specific frequencies

The total radiated power (TRP) of the test setup was measured in all angle direction (3D) using a step width of 15° and using two measurement antenna polarizations (vertical and horizontal).

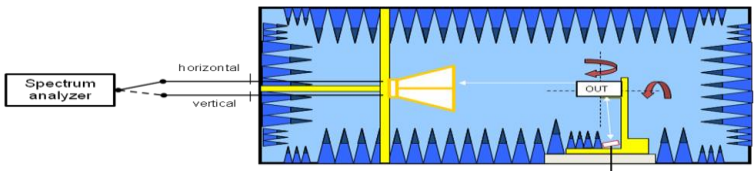


Fig. 1: Block diagram for TRP measurement

4.3 Definitions

3GPP	3rd Generation Partnership Project
BER	Bit error rate or bit error ratio
BS	Base station
CTIA	Cellular Telecommunications & Internet Association
DUT	Device under test
FS	Free space
TP	Talk position (phone is situated at SAM = human head phantom)
TRP	Total Radiated Power
EIRP	Effective Isotropic Radiated Power
TRS	Total Radiated Sensitivity (same as TIS in CTIA), loss of link level
EIRS	Effective Isotropic Radiated Sensitivity

5 Detailed Radiated Test Results and Pattern

5.1 Equipment List

For TRP measurements:

Antenna:	Dual polarized horn ETS3164-03 by ETS	SN 00052619
Receiver:	FSIQ spectrum analyzer by R&S	SN 840061/005

Orientation of EUT compared to a standard device

For orientation of the EUT in the result pictures below the following photos illustrate the used orientation compared to a standard device:

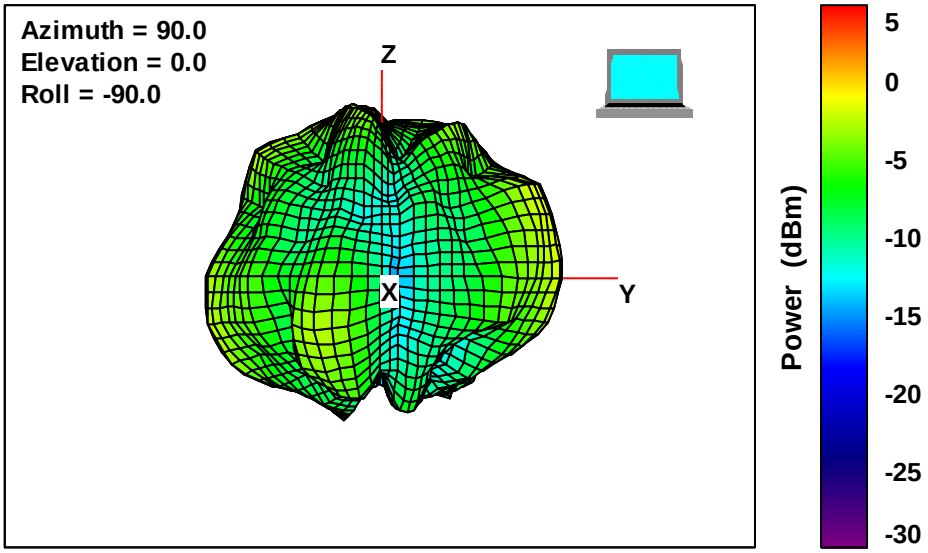
Fig. 2: Photo orientation of DUT.

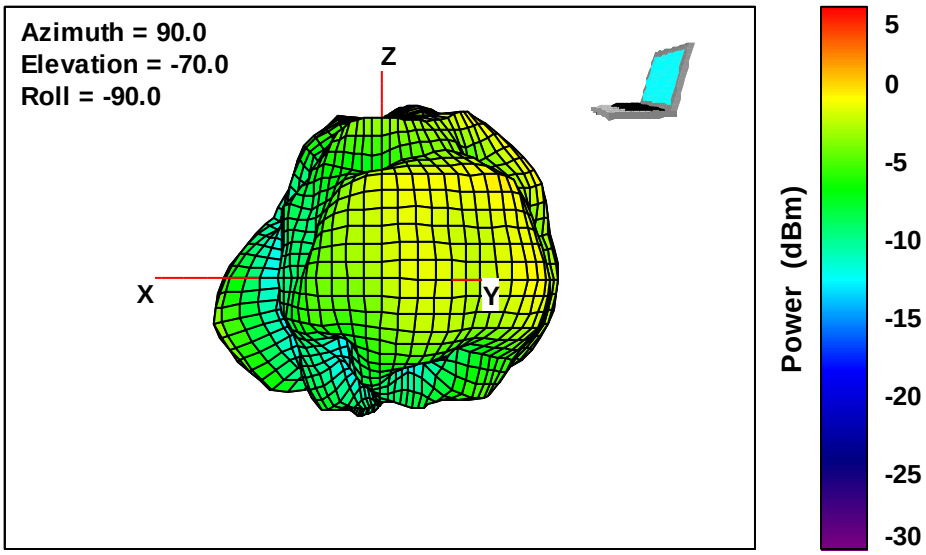
5.2 Radiation Pattern TRP WLAN 2412 MHz

WLAN 2.4 GHz b-mode, TRP

Temperature: 24.0
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	-4.02
Peak EIRP (dBm)	1.28
Directivity (dBi)	5.30
NHPRP ±Pi/4 (dBm)	-5.15
NHPRP ±Pi/6 (dBm)	-6.42
Boresight Phi (°)	198.95
Boresight Th. (°)	45

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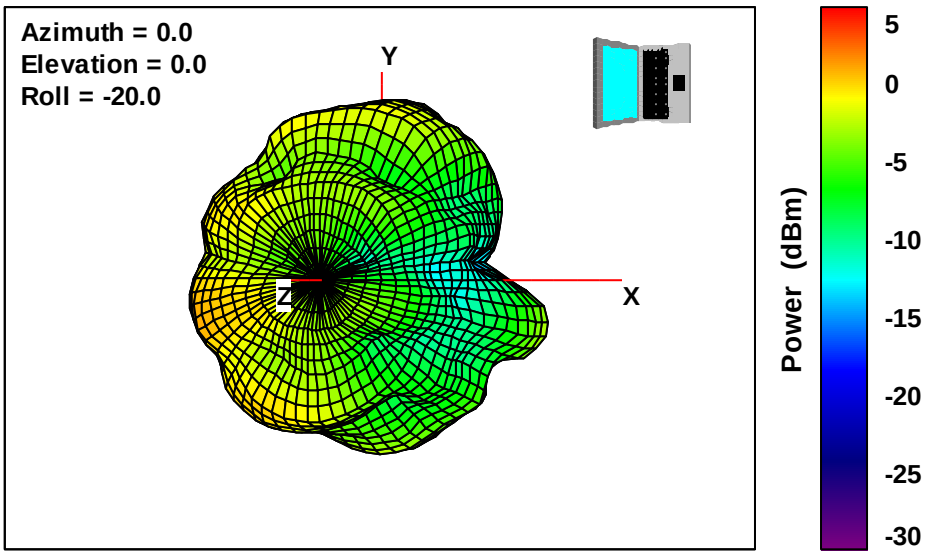
-25
-30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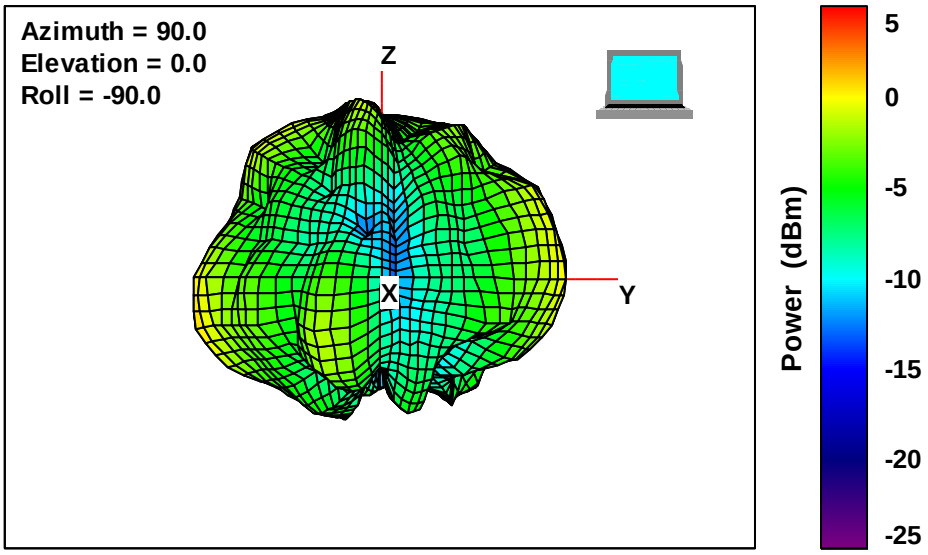
-10
-15
-20
-25
-30

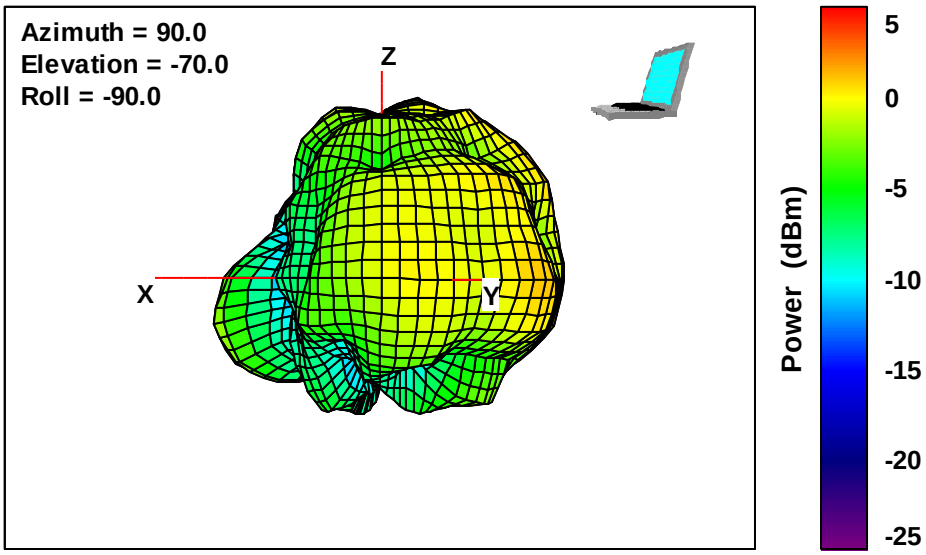
5.3 Radiation Pattern TRP WLAN 2437 MHz

WLAN 2.4 GHz b-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	-2.43
Peak EIRP (dBm)	2.40
Directivity (dBi)	4.83
NHPRP ±Pi/4 (dBm)	-3.57
NHPRP ±Pi/6 (dBm)	-4.82
Boresight Phi (°)	194.45
Boresight Th. (°)	45

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-15
-20
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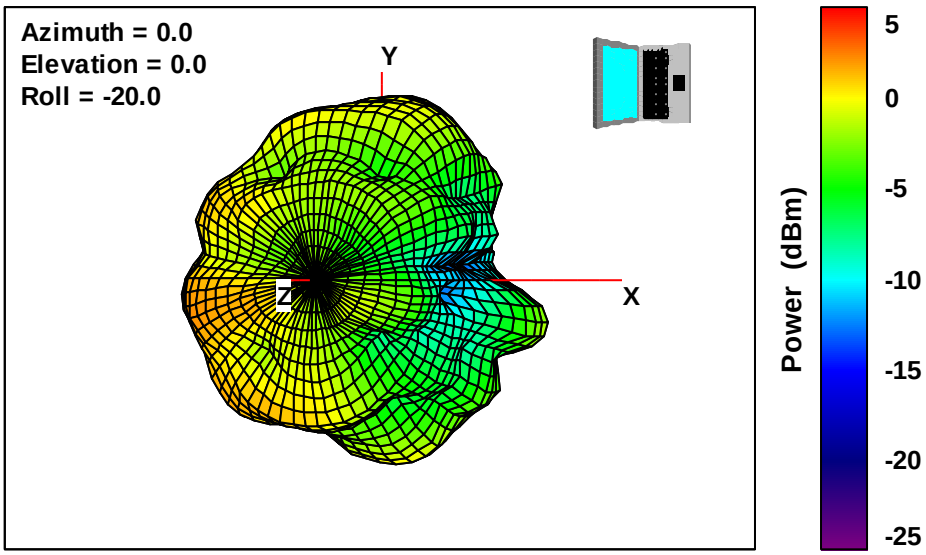
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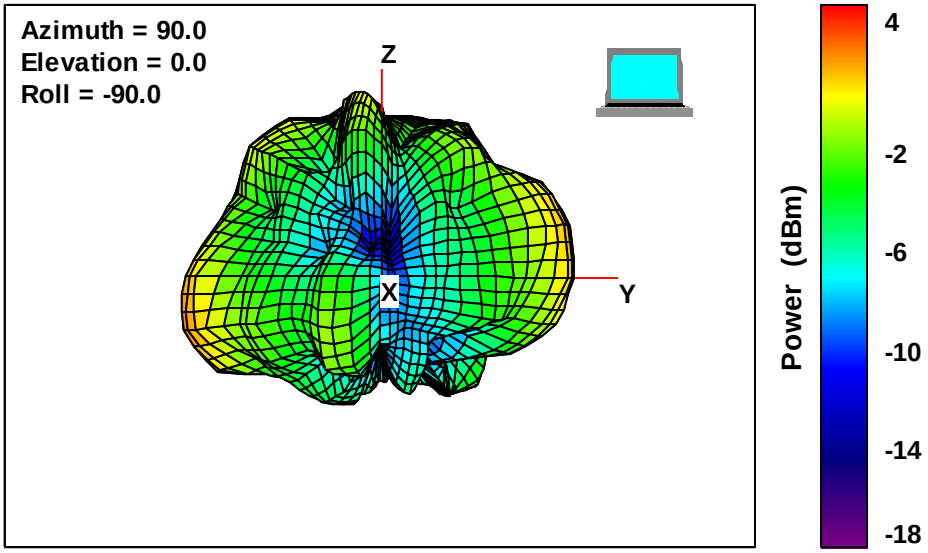
-15
-20
-25

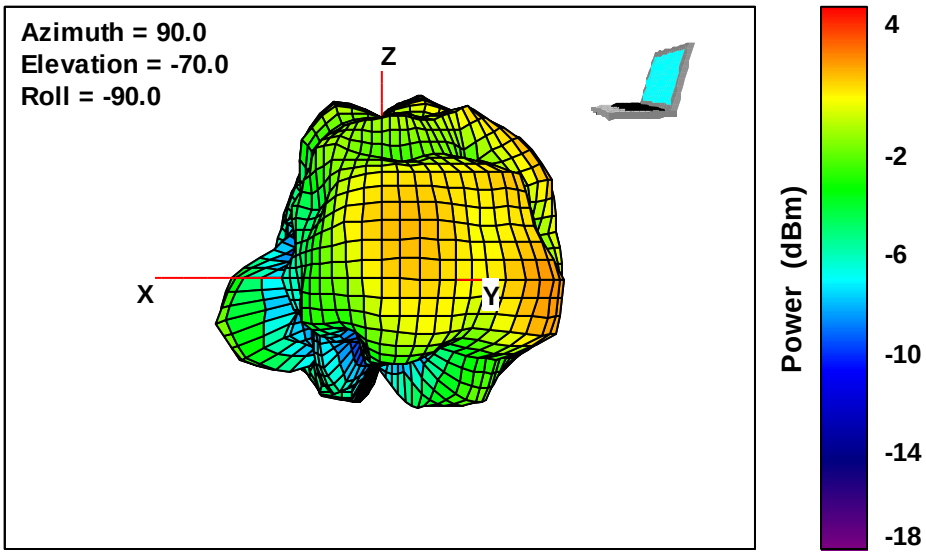
5.4 Radiation Pattern TRP WLAN 2462 MHz

WLAN 2.4 GHz b-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	-1.57
Peak EIRP (dBm)	2.81
Directivity (dBi)	4.38
NHPRP ±Pi/4 (dBm)	-2.66
NHPRP ±Pi/6 (dBm)	-3.88
Boresight Phi (°)	215.4
Boresight Th. (°)	60

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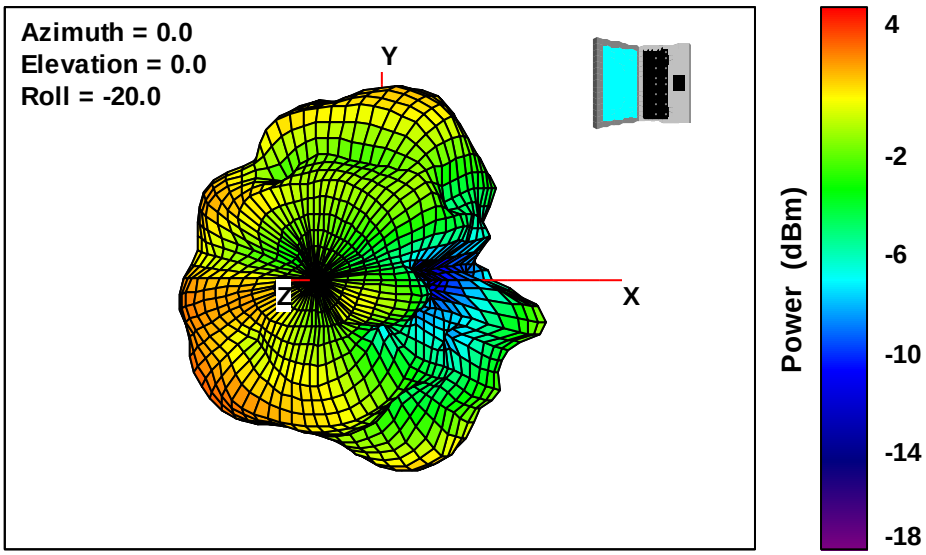
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-6
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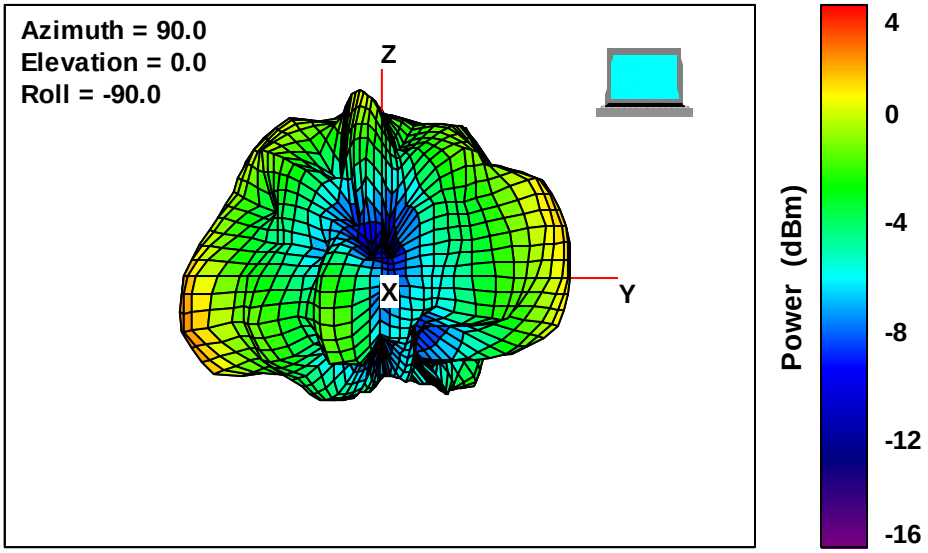
-14
-18

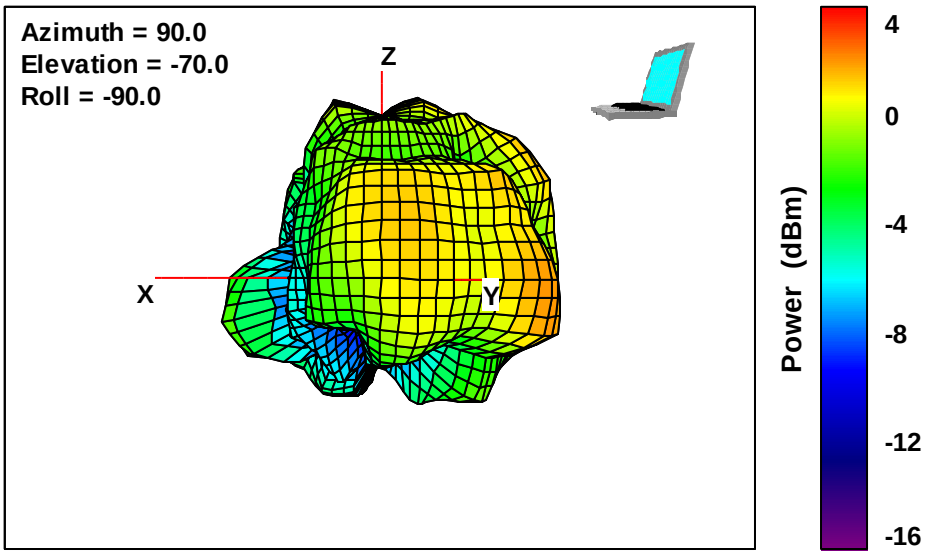
5.5 Radiation Pattern TRP WLAN 2472 MHz

WLAN 2.4 GHz b-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	-1.29
Peak EIRP (dBm)	3.17
Directivity (dBi)	4.46
NHPRP ±Pi/4 (dBm)	-2.34
NHPRP ±Pi/6 (dBm)	-3.56
Boresight Phi (°)	220.4
Boresight Th. (°)	60

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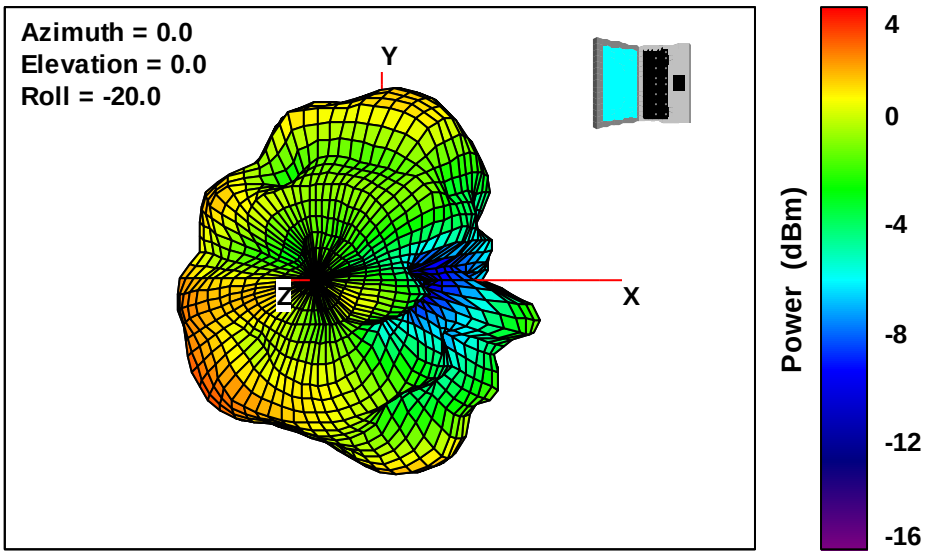
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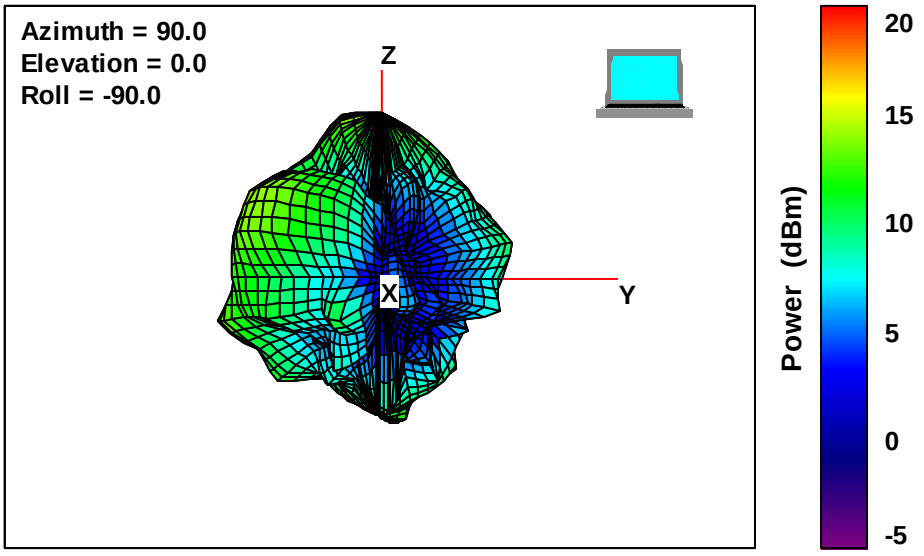
-8
-12
-16

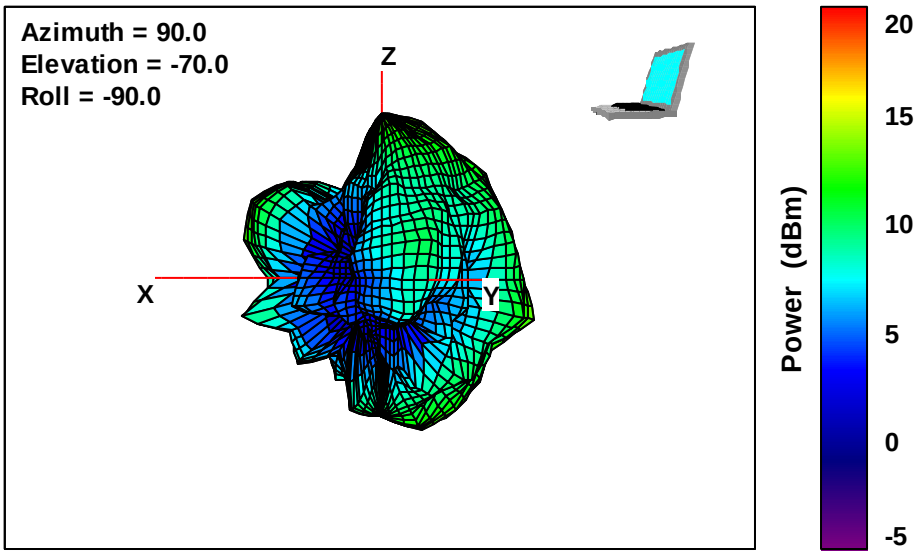
5.6 Radiation Pattern TRP WLAN 5180 MHz

WLAN 5 GHz a-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	9.93
Peak EIRP (dBm)	15.79
Directivity (dBi)	5.86
NHPRP ±Pi/4 (dBm)	8.49
NHPRP ±Pi/6 (dBm)	7.14
Boresight Phi (°)	191.3
Boresight Th. (°)	105

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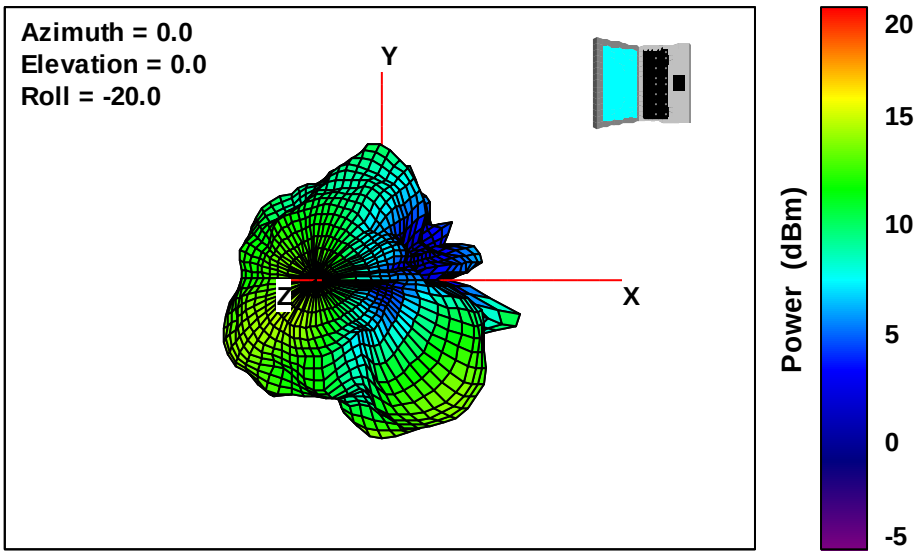
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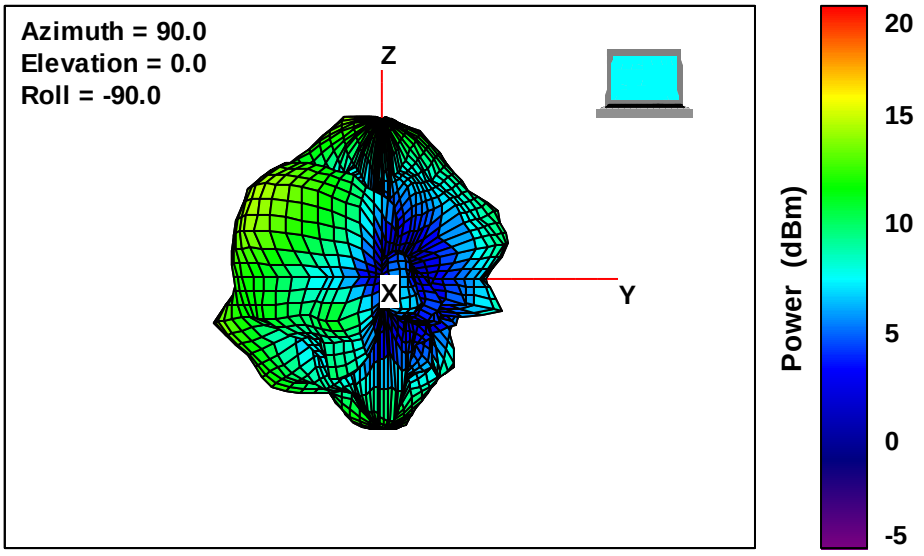
10
5
0
-5

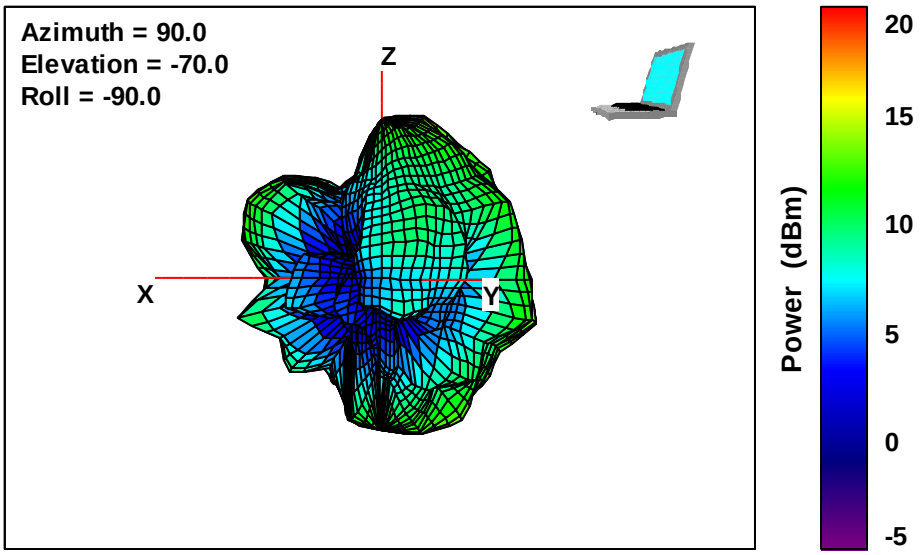
5.7 Radiation Pattern TRP WLAN 5220 MHz

WLAN 5 GHz a-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	10.50
Peak EIRP (dBm)	16.78
Directivity (dBi)	6.28
NHPRP ±Pi/4 (dBm)	9.03
NHPRP ±Pi/6 (dBm)	7.67
Boresight Phi (°)	190.05
Boresight Th. (°)	105

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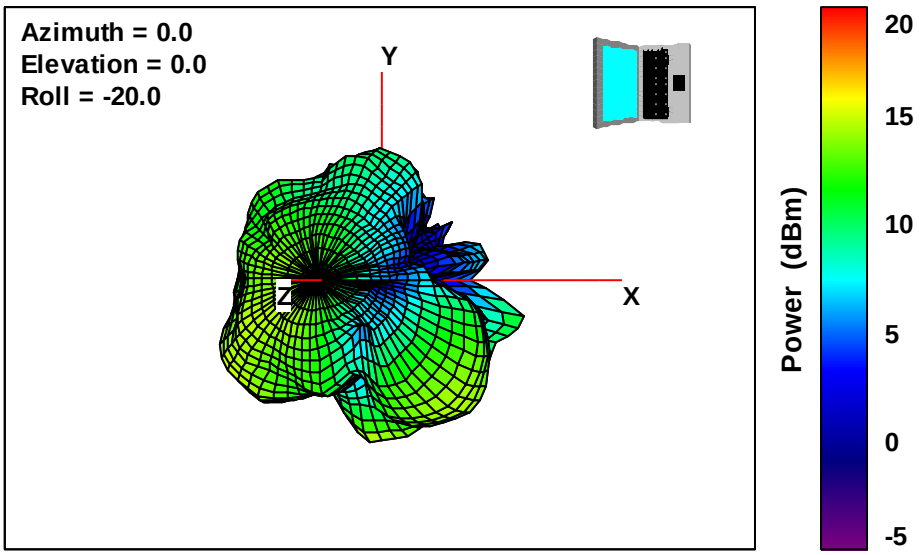
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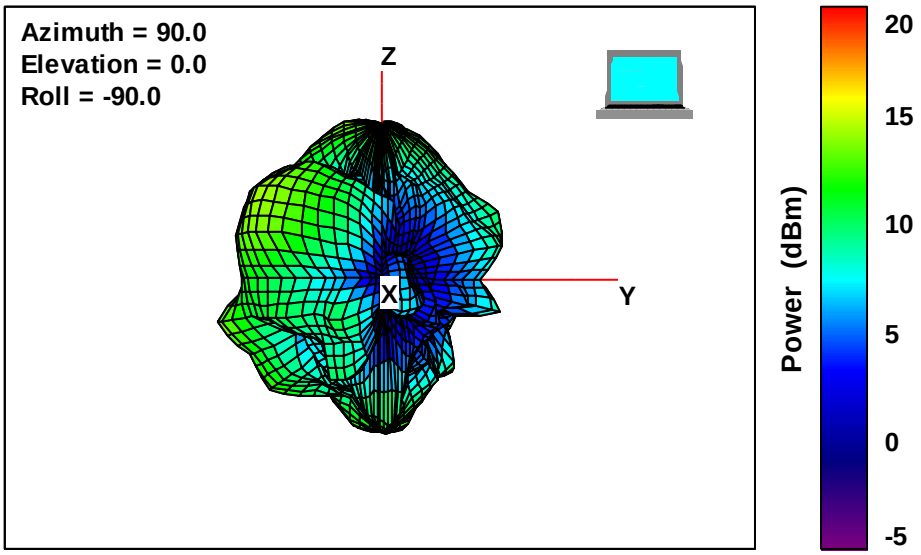
15
10
5
0
-5

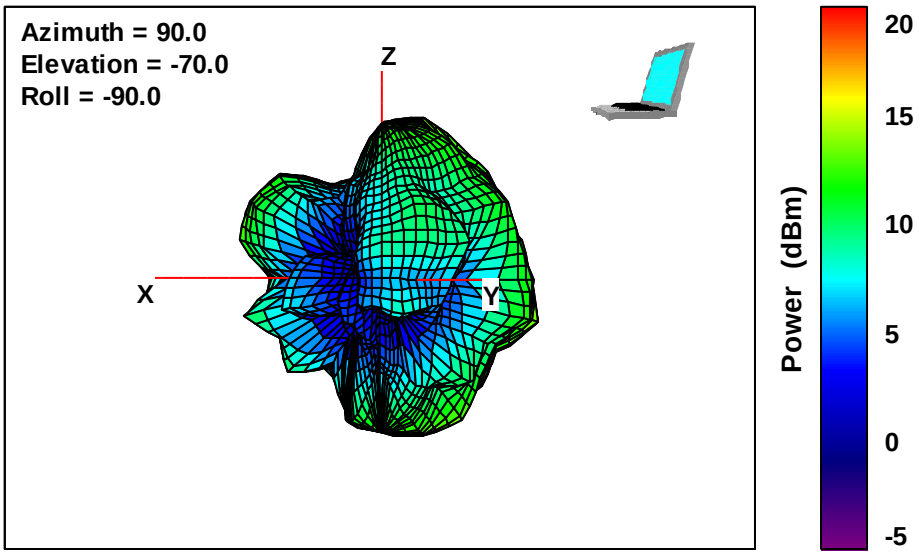
5.8 Radiation Pattern TRP WLAN 5240 MHz

WLAN 5 GHz a-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	10.33
Peak EIRP (dBm)	16.65
Directivity (dBi)	6.32
NHPRP ±Pi/4 (dBm)	8.82
NHPRP ±Pi/6 (dBm)	7.43
Boresight Phi (°)	188.1
Boresight Th. (°)	105

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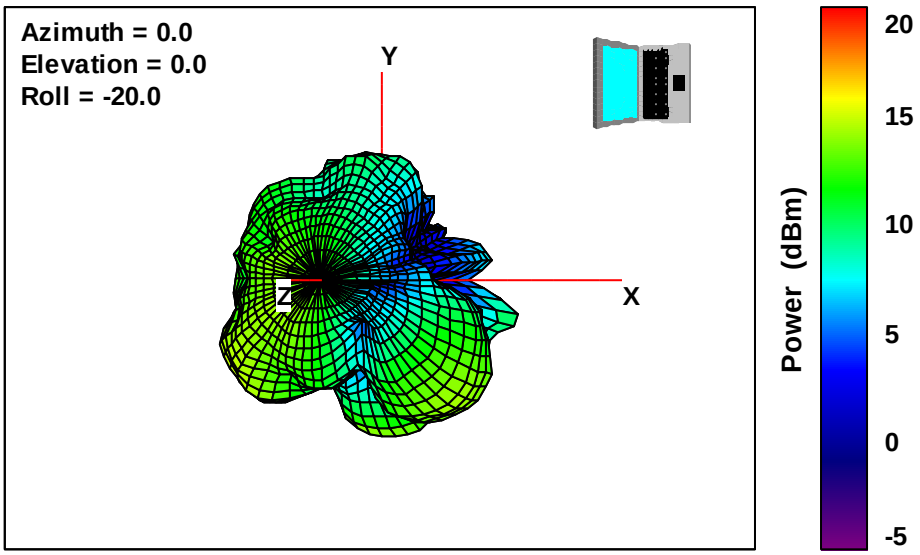
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X
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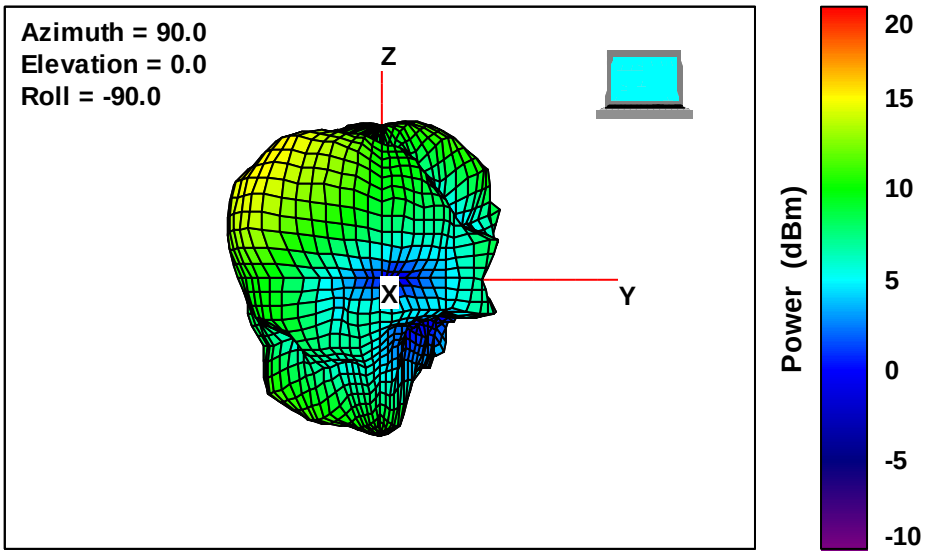
15
10
5
0
-5

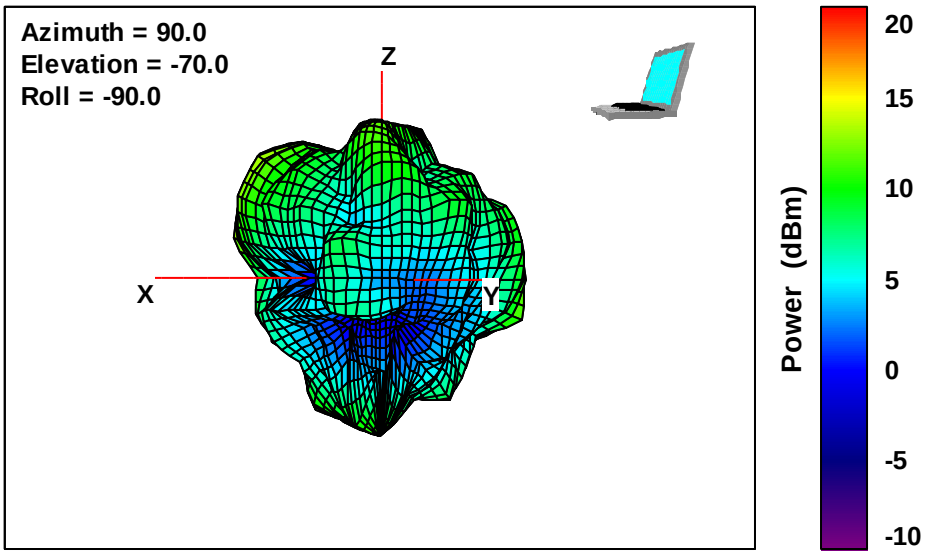
5.9 Radiation Pattern TRP WLAN 5600 MHz

WLAN 5 GHz a-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	8.81
Peak EIRP (dBm)	15.37
Directivity (dBi)	6.56
NHPRP ±Pi/4 (dBm)	7.28
NHPRP ±Pi/6 (dBm)	5.81
Boresight Phi (°)	324.4
Boresight Th. (°)	45

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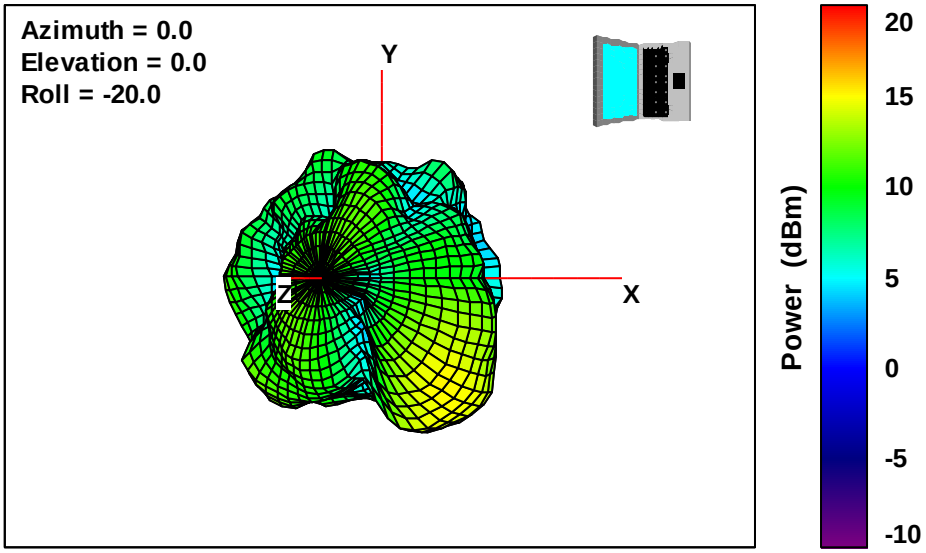
-5
-10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Z
X

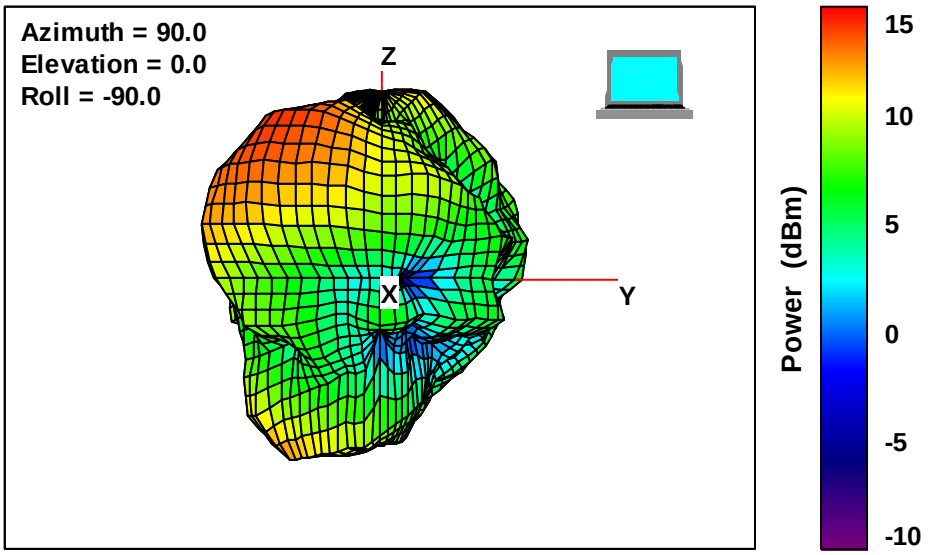
Power (dBm)
20
15
10
5
0
-5
-10

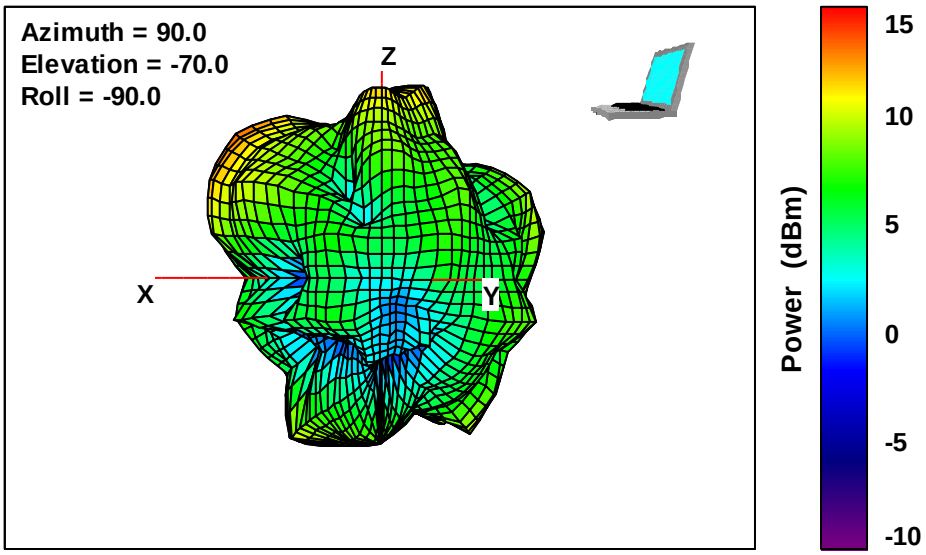
5.10 Radiation Pattern TRP WLAN 5785 MHz

WLAN 5 GHz a-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	8.34
Peak EIRP (dBm)	14.35
Directivity (dBi)	6.00
NHPRP ±Pi/4 (dBm)	6.72
NHPRP ±Pi/6 (dBm)	5.25
Boresight Phi (°)	318.6
Boresight Th. (°)	45

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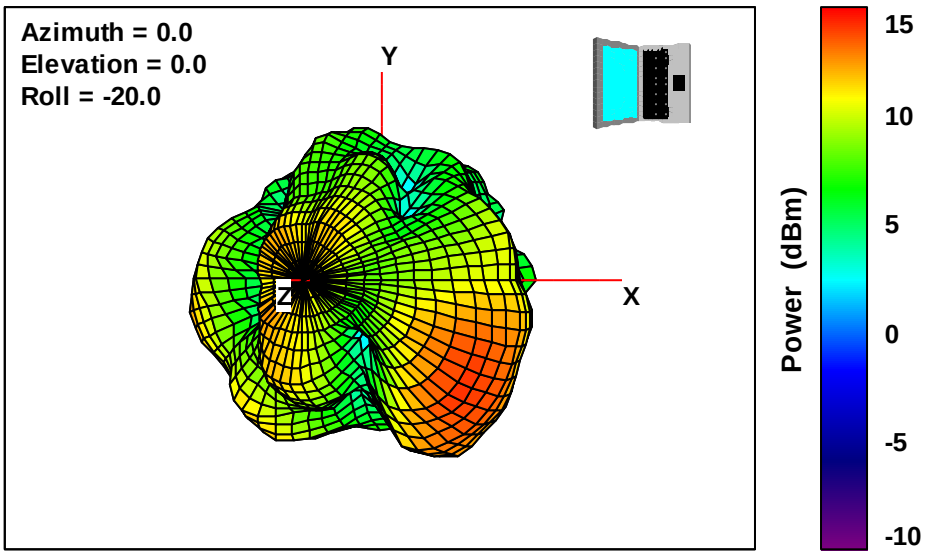
5
0
-5
-10
Power (dBm)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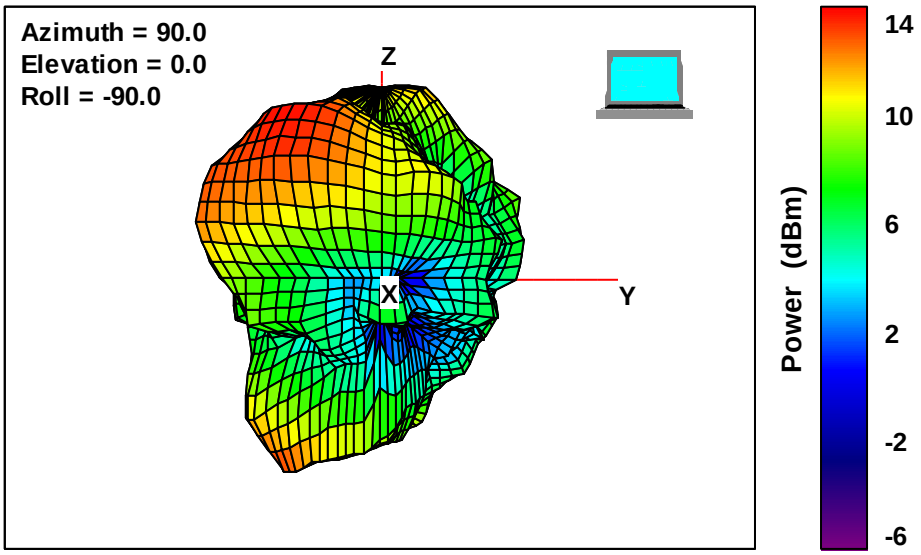
15
10
5
0
-5
-10
Power (dBm)

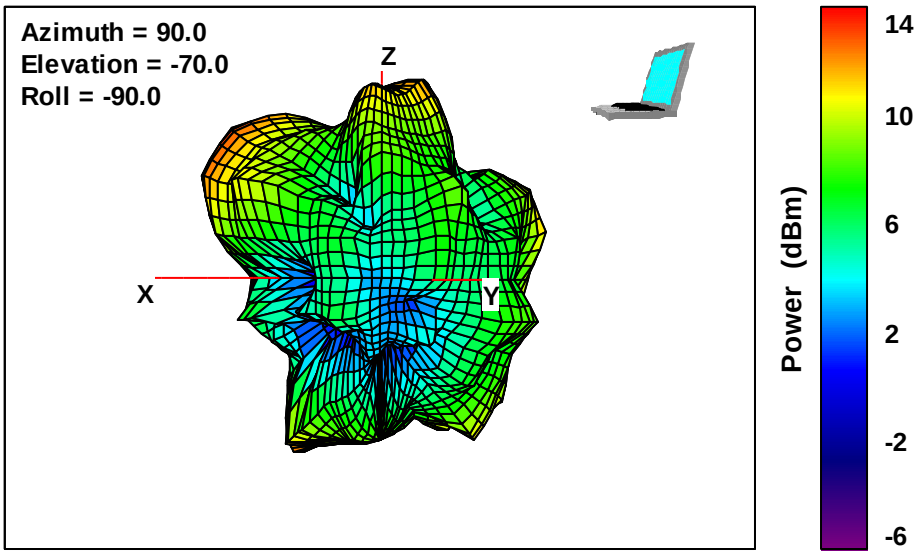
5.11 Radiation Pattern TRP WLAN 5825 MHz

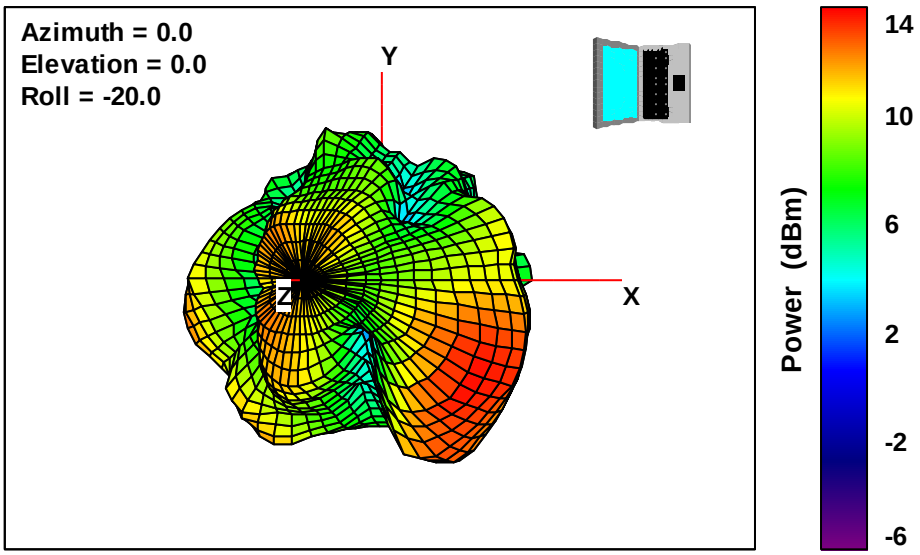
WLAN 5 GHz a-mode, TRP

Temperature: 23.5
Humidity: 28.0
Test start: 03/13/2017

Tot. Rad. Pwr. (dBm)	8.41
Peak EIRP (dBm)	13.94
Directivity (dBi)	5.53
NHPRP ±Pi/4 (dBm)	6.74
NHPRP ±Pi/6 (dBm)	5.20
Boresight Phi (°)	320.2
Boresight Th. (°)	45




Azimuth = 90.0
Elevation = -70.0
Roll = -90.0
Z
X
Y
Power (dBm)
14
10
6
2
-2
-6


Azimuth = 0.0
Elevation = 0.0
Roll = -20.0
Y
Z
X
Power (dBm)
14
10
6
2
-2
-6