





TEST REPORT  
No.: 18-1-0248301T11a-C1

Antenna Pattern  
Measurement

for

Robert Bosch Car Multimedia GmbH

AIVIV10  
Multimedia device with Bluetooth and WLAN

Laboratory Accreditation and Listings	
  <p>Deutsche Akreditierungsstelle D-PL-12047-01-01 D-PL-12047-01-03 D-PL-12047-01-04</p>	
 <p><b>WiFi</b> ALLIANCE</p> <p>AUTHORIZED RF LABORATORY</p>	 <p><b>ctia</b> Authorized<sup>TM</sup> Test Lab</p> <p>Lab Code: 20011130-00</p>
accredited according to DIN EN ISO/IEC 17025	
<p><b>CETECOM GmbH</b> Laboratory Radio Communications &amp; Electromagnetic Compatibility Im Teelbruch 116 • 45219 Essen • Germany Registered in Essen, Germany, Reg. No.: HRB Essen 8984 Tel.: + 49 (0) 20 54 / 95 19-954 • Fax: + 49 (0) 20 54 / 95 19-964 E-mail: info@cetecom.com • Internet: www.cetecom.com</p>	

## Table of contents

<b>1. SUMMARY OF TEST RESULTS.....</b>	<b>3</b>
<b>2. ADMINISTRATIVE DATA .....</b>	<b>4</b>
2.1. Identification of the testing laboratory.....	4
2.2. Test location .....	4
2.3. Organizational items.....	4
2.4. Applicant’s details .....	4
2.5. Manufacturer’s details .....	4
<b>3. EQUIPMENT UNDER TEST (EUT).....</b>	<b>5</b>
3.1. EUT: Type, S/N etc. and short descriptions used in this test report .....	5
3.2. Auxiliary Equipment (AE): Type, S/N etc. and short descriptions.....	5
3.3. EUT set-ups .....	5
3.4. Operating mode .....	5
<b>4. DESCRIPTION OF TEST SYSTEM SET-UP’S .....</b>	<b>6</b>
4.1. Wireless Test Facility .....	6
4.2. Anechoic Cube chamber.....	6
4.3. Distributed Axis Positioning System.....	6
4.4. SAM Head Phantom .....	6
4.5. Hand Phantom .....	6
4.6. Howland Model QR-1 Quad Ridged Horn .....	7
4.7. Circularly Polarized Communication Antenna .....	7
4.8. Test Equipment.....	7
4.9. AMS32 Software .....	7
<b>5. MEASUREMENTS .....</b>	<b>8</b>
5.1. Antenna Pattern Measurement.....	8
<b>6. VERSIONS OF TEST REPORTS (CHANGE HISTORY) .....</b>	<b>34</b>
<b>7. PHOTOGRAPHS AND DRAWINGS.....</b>	<b>35</b>
Photograph 1: Free Space setup (FS), long shot view, Theta=0°, Phi=0° .....	35
Photograph 2: Free Space setup (FS), close up view, Theta=0°, Phi=0° .....	36
Figure 1: EUT reference position for free space setup, Theta=0°, Phi=0° .....	37
Figure 2: Coordinate system in the anechoic chamber .....	37

## 1. Summary of test results

The test results apply exclusively to the test samples as presented in this Report. The CETECOM GmbH does not assume responsibility for any conclusions and generalizations taken in conjunction with other specimens or samples of the type of the item presented to tests.

### Maximum antenna gain

Frequency range	Maximum Antenna Gain
WLAN 2.4 GHz	3.2 dBi
WLAN 5 GHz	3.7 dBi
BT 2.4 GHz	-6.4 dBi

The current version of the Test Report CETECOM\_TR18-1-0248301T11a\_C1 replaces the Test Report CETECOM\_TR18-1-0248301T11a dated 2019-10-23. The replaced test report is herewith invalid.

.....  
Dipl.-Ing. N. Perez  
Responsible for test section

.....  
B.Sc. Mohamed Ahmed  
Responsible for test report

## 2. Administrative Data

### 2.1. Identification of the testing laboratory

Company name:	CETECOM GmbH
Address:	Im Teelbruch 116 45219 Essen - Kettwig Germany
Responsible for testing laboratory:	Volker Wittmann

### 2.2. Test location

#### 2.2.1. Test laboratory "CETECOM"

Company name:	see chapter 2.1. Identification of the testing laboratory
---------------	---

### 2.3. Organizational items

Responsible for test report:	B.Sc. Mohamed Ahmed
Project leader:	Thomas Hauck
Receipt of EUT:	2019-04-29
Date(s) of test:	2019-05-02
Date of report:	2019-10-31
-----	

### 2.4. Applicant's details

Applicant's name:	Robert Bosch Car Multimedia GmbH
Address:	Robert-Bosch-Straße 200 31139 Hildesheim  Germany
Contact person:	Mr. Dirk Zamow

### 2.5. Manufacturer's details

Manufacturer's name:	please see Applicant's details
Address:	please see Applicant's details

### 3. Equipment under test (EUT)

#### 3.1. EUT: Type, S/N etc. and short descriptions used in this test report

Short description*)	EUT	Type	S/N serial number	HW hardware status	SW software status
EUT A S06	AIVIV10	Multimedia device with Bluetooth and WLAN	0005057	001	1049

\*) EUT short description is used to simplify the identification of the EUT in this test report.

#### 3.2. Auxiliary Equipment (AE): Type, S/N etc. and short descriptions

AE short description *)	Auxiliary Equipment	Type	S/N serial number	HW hardware status	SW software status
AE 1	Main Wiring Short	--	--	--	--

\*) AE short description is used to simplify the identification of the auxiliary equipment in this test report.

#### 3.3. EUT set-ups

EUT set-up no. *)	Combination of EUT and AE	Remarks
set. 1	EUT A + AE 1	Free Space

\*) EUT set-up no. is used to simplify the identification of the EUT set-up in this test report.

#### 3.4. Operating mode

With SW labtool frequency was selected and CW signal was sent.

Used commands were:

```
30 0 or 30 1 => to select 2.4 GHz or 5 GHz WLAN
12 x => to select channels
18 1 => CW on
18 2 => CW off
```

For BT the following commands were used in labtool

```
80 // reset
114 2 //PowerClass2
116 1 // PowerLevel Automatic off
16 0 0 // PowerLevel 0dBm BDR
12 x // x for BT channel
225 1 15 2 -1 0 // Duty Cycle Mode on, DH5, Payloadpattern PN9, max. possible PayloadLength, Fixed channel
```

## **4. Description of test system set-up's**

### **4.1. Wireless Test Facility**

All tests were performed in CETECOM's state-of-the-art Wireless Test Facility consisting of a fully anechoic chamber equipped with a distributed-axis positioning system, a dual polarized quad-ridge horn, and two circularly polarized communication antennas. Different kinds of base station simulators depending on which technology is been tested, is used to establish communication with the EUT and place it in the proper mode and two Power Meters and RF switch combination is used for measuring the signal from the EUT at each position and polarization. Rohde and Schwarz's proprietary AMS32 is used for data acquisition, post processing and generation of the required output.

### **4.2. Anechoic Cube chamber**

The cube chamber consists of a shielded enclosure, which is a modular assembly of steel-covered particle board panels and steel framing. A Masonite pad and plastic sheeting under the chamber isolate the structure from the floor of the parent building. A ground rod is installed for connecting to the building's electrical ground. The inside of the chamber is lined with pyramid-shaped RF absorber material. Lighting in the chamber comes from two illuminations units, which are mounted outside the chamber. They contain high-intensity lamps, cooling fans, and lenses that focus the light into large-diameter fiber optic lines. The fiber optic lines run to the top of the chamber and enter through waveguide-beyond-cutoff (WBC) filter penetrations. The chamber has return and supply air vents for connecting to the parent building's air conditioning system. The vents are fitted with honeycomb RF filters to maintain the electromagnetic shield. A single leaf swing type shielded door is provided for equipment and personal access into the chamber. This door uses a pneumatic cam and linkage system to seal the door tightly when the door latch is closed. The Chamber is capable of meeting RF attenuation level of over 85 dB throughout the frequency range of 705 MHz to 6 GHz, so that testing performed within the chamber does not interfere with other testing activities at the facility and vice versa. Power is supplied on separate circuits to the chamber and control area. All power filters provide a minimum of 100 dB attenuation over a frequency range of 10 kHz to 10 GHz and are tested in accordance with MIL STD 220A.

### **4.3. Distributed Axis Positioning System**

The chamber is built with a distributed axis positioning system, so that the Equipment under Test (EUT) is only rotating on phi axis while the probe antenna is moving through the theta axis. The elevation axis is designated Theta, extending from 0° to 165°, with 0° at the top of the chamber and the azimuth axis is designated Phi, extending from 0° to 360°, with 0° facing the chamber door. Both positioning units provide an axis accuracy of +/- 0.05° and an axis resolution of 0.01°. The Motion Control Unit (MCU) provides the interface between the workstation computer and the Theta and Phi positioners. The MCU receives motion commands from the measurement software and converts them into motor pulses sent to the stepper motors on each axis. It also receives limit and interlock signals from the positioner hardware.

EUT is tested on a column which is made of two parts: an open-cell foam cap with a denser closed-cell top, and a thin-walled FRP (Fiberglass) column. The cap has holes for RF cables and mounting surfaces for the SAM phantom head. This foam top can support very heavy loads, up to 100 pounds (45kg) and has a flat surface. This fact and the positioning lasers inside the chamber help to mount an EUT quick and accurate. The base of the column is fitted with absorbers and is attached to the Phi axis turntable. The probe antenna is mounted on a structure consisting of a Theta boom and the side arm which is rotated by the Elevation Drive Unit (EDU).

### **4.4. SAM Head Phantom**

A SAM head phantom meets the requirement for CTIA Certification Program Test Plan is used for the phantom head testing.

### **4.5. Hand Phantom**

The hand phantoms meet the requirement for CTIA Certification Program Test Plan is used for the phantom hand testing.

#### **4.6. Howland Model QR-1 Quad Ridged Horn**

The Model QR-1 is a broad bandwidth, dual polarized horn antenna designed for wireless device measurements. It can be used as the measurement antenna in all Howland Wireless Test Labs. The QR-1 is designed with a minimum overall length in order to maximize the range length in the wireless test lab.

#### **4.7. Circularly Polarized Communication Antenna**

Two Circularly Polarized Communication Antennas (European Antennas flat panel antennas Model: FPA3-0.8-6.0R/1329) are mounted at the entrance of the chamber, one near the ceiling and one near the ground of the chamber. They provide a relatively low loss link to base station simulator in any position.

#### **4.8. Test Equipment**

The test was performed using following additional test equipment:

- Rohde & Schwarz CMU-200 Base Station simulator
- Rohde & Schwarz Power Meter (consists of NRP & two-NRP-Z11)
- Rohde & Schwarz ZVC
- Rohde & Schwarz OSP-B105 RF Switch
- The Howland Company Motion Control Unit (MCU)

#### **4.9. AMS32 Software**

Rohde and Schwarz's proprietary OTA measurement software is used to automate the data acquisition process and provides all post processing calculations and data output required by the CTIA including reports. It's parameterized test configuration system and conscientiously validated design helps to insure repeatable and correct results. Safeguards prevent data tampering and insure that the original "raw" measured data is always available for review.

## 5. Measurements

**Climatic conditions:** T = 22±3 °C, h = 50±10% rel. humidity

### 5.1. Antenna Pattern Measurement

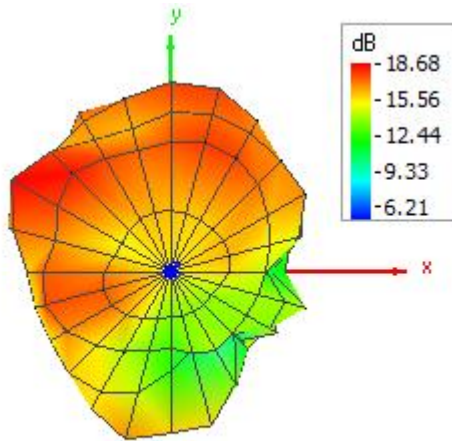
## CTIA Report (RP\_2412.000\_tot)

### OTA Evaluation Results

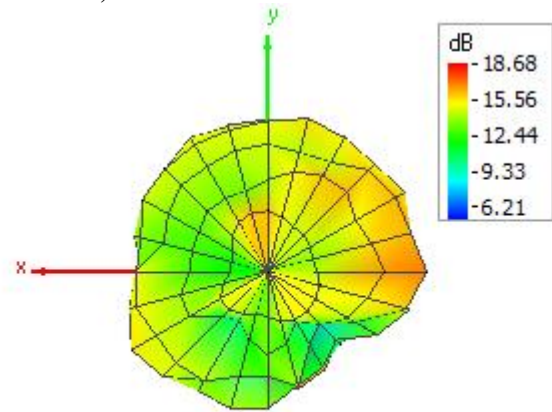
Total Radiated Power	14.69 dBm
Directivity	3.99 dBi
Total Efficiency	14.69 dB
Total Efficiency	2946.33%
Peak Realized Gain	18.68 dBi
NHPRP 45°	12.84 dBm
NHPRP 45° / TRP	-1.85 dB
NHPRP 45° / TRP	65.27%
NHPRP 30°	10.98 dBm
NHPRP 30° / TRP	-3.72 dB
NHPRP 30° / TRP	42.51%
NHPRP 22.5°	9.64 dBm
NHPRP 22.5° / TRP	-5.06 dB
NHPRP 22.5° / TRP	31.22%
UHRP	12.19 dBm
UHRP / TRP	-2.51 dB
UHRP / TRP	56.16%
LHRP	11.10 dBm
LHRP / TRP	-3.59 dB
LHRP / TRP	43.75%
PGRP (0-120°)	13.49 dBm
PGRP / TRP	-1.20 dB
PGRP / TRP	75.87%
Front/Back Ratio	3.64
PhiBW	224.2 deg
PhiBW Up	92.3 deg
PhiBW Down	132.0 deg
ThetaBW	53.3 deg
ThetaBW Up	23.9 deg
ThetaBW Down	29.4 deg
Boresight Phi	150 deg
Boresight Theta	45 deg
Maximum Power	18.68 dBm
Minimum Power	6.21 dBm
Average Power	14.96 dBm
Max/Min Ratio	12.48 dB
Max/Avg Ratio	3.72 dB
Min/Avg Ratio	-8.75 dB
Worst Single Value	-12.59 dBm
Worst Position	Azi = 210 deg; Elev = 90 deg; Pol = Hor
Best Single Value	18.29 dBm
Best Position	Azi = 150 deg; Elev = 45 deg; Pol = Ver



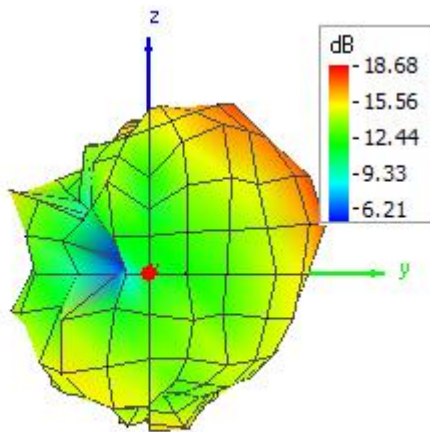
Theta = 0, Phi = 0



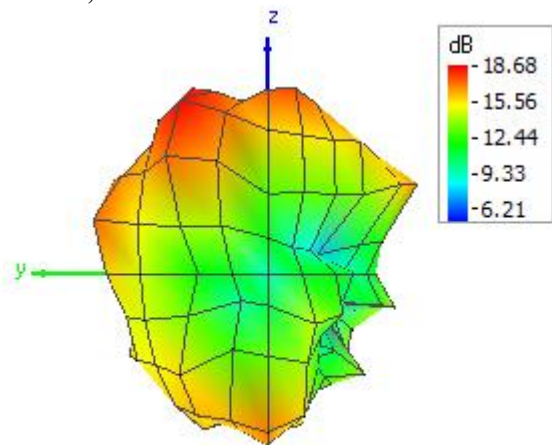
Theta = 180, Phi = 0



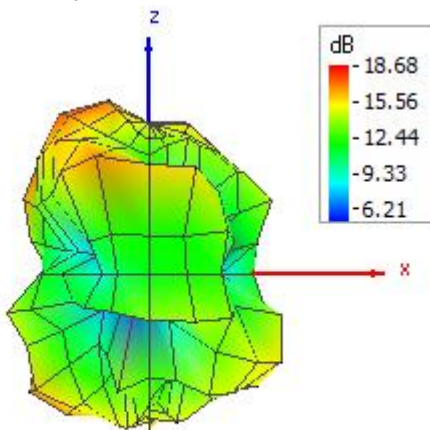
Theta = 90, Phi = 0



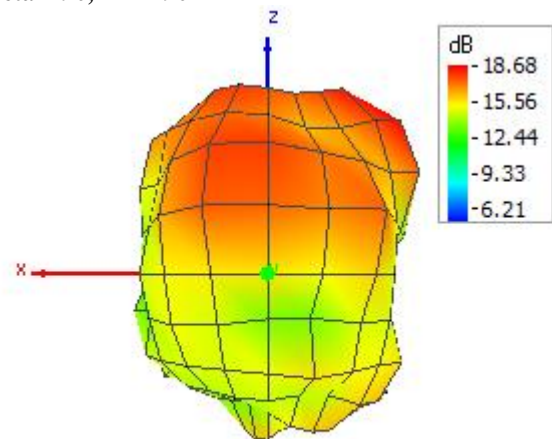
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90

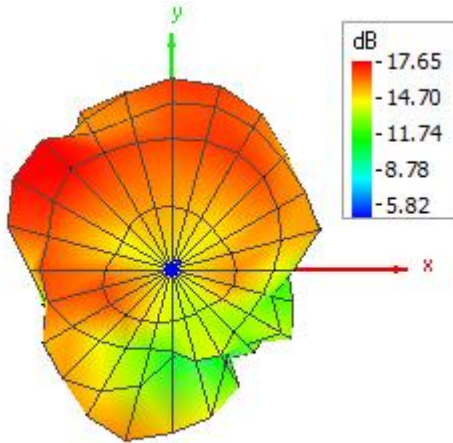


## CTIA Report (RP\_2437.000\_tot)

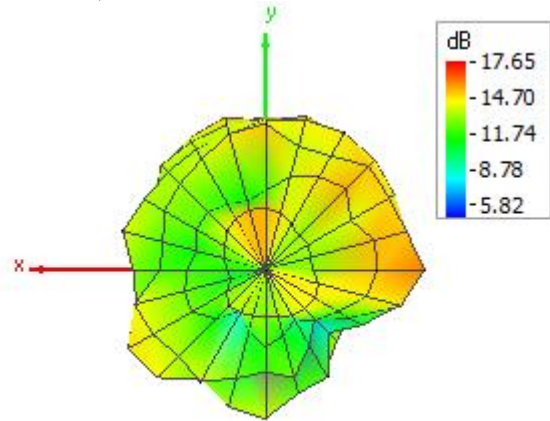
### OTA Evaluation Results

Total Radiated Power	13.89 dBm
Directivity	3.76 dBi
Total Efficiency	13.89 dB
Total Efficiency	2449.06%
Peak Realized Gain	17.65 dBi
NHPRP 45°	12.03 dBm
NHPRP 45° / TRP	-1.86 dB
NHPRP 45° / TRP	65.18%
NHPRP 30°	10.15 dBm
NHPRP 30° / TRP	-3.74 dB
NHPRP 30° / TRP	42.27%
NHPRP 22.5°	8.81 dBm
NHPRP 22.5° / TRP	-5.08 dB
NHPRP 22.5° / TRP	31.06%
UHRP	11.48 dBm
UHRP / TRP	-2.41 dB
UHRP / TRP	57.42%
LHRP	10.19 dBm
LHRP / TRP	-3.70 dB
LHRP / TRP	42.68%
PGRP (0-120°)	12.75 dBm
PGRP / TRP	-1.14 dB
PGRP / TRP	76.92%
Front/Back Ratio	5.98
PhiBW	223.1 deg
PhiBW Up	88.4 deg
PhiBW Down	134.7 deg
ThetaBW	65.7 deg
ThetaBW Up	39.6 deg
ThetaBW Down	26.1 deg
Boresight Phi	135 deg
Boresight Theta	30 deg
Maximum Power	17.65 dBm
Minimum Power	5.82 dBm
Average Power	14.14 dBm
Max/Min Ratio	11.83 dB
Max/Avg Ratio	3.51 dB
Min/Avg Ratio	-8.32 dB
Worst Single Value	-20.00 dBm
Worst Position	Azi = 285 deg; Elev = 105 deg; Pol = Hor
Best Single Value	17.18 dBm
Best Position	Azi = 150 deg; Elev = 45 deg; Pol = Ver

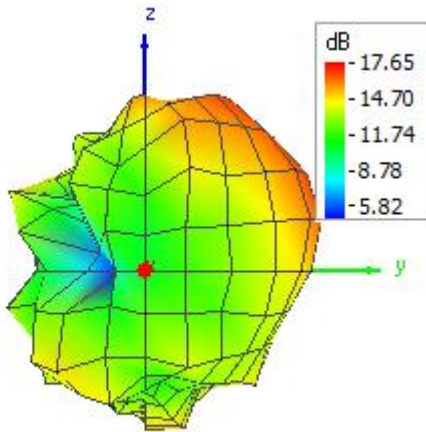
Theta = 0, Phi = 0



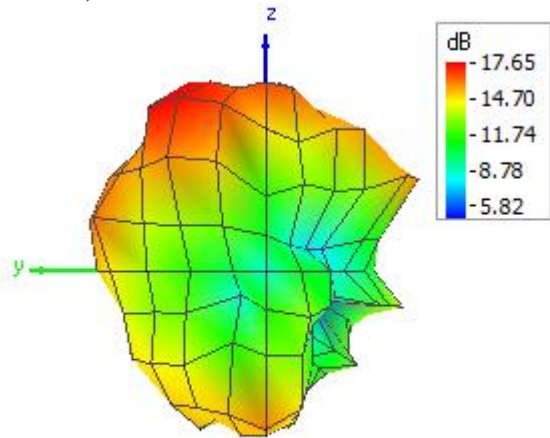
Theta = 180, Phi = 0



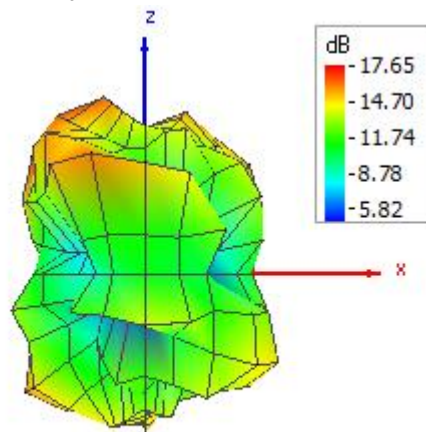
Theta = 90, Phi = 0



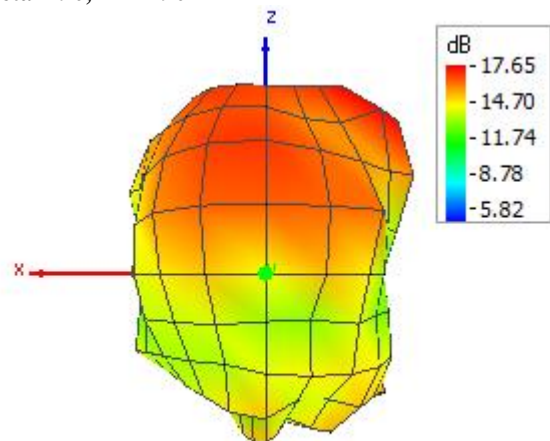
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90

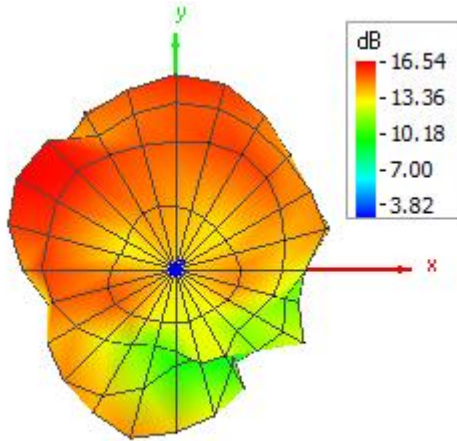


## CTIA Report (RP\_2462.000\_tot)

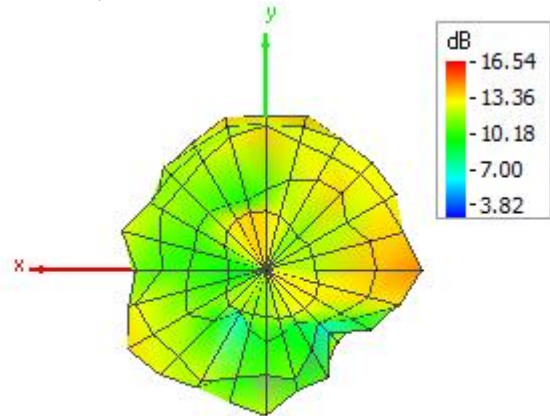
### OTA Evaluation Results

Total Radiated Power	12.64 dBm
Directivity	3.90 dBi
Total Efficiency	12.64 dB
Total Efficiency	1837.26%
Peak Realized Gain	16.54 dBi
NHPRP 45°	10.79 dBm
NHPRP 45° / TRP	-1.86 dB
NHPRP 45° / TRP	65.22%
NHPRP 30°	8.90 dBm
NHPRP 30° / TRP	-3.75 dB
NHPRP 30° / TRP	42.22%
NHPRP 22.5°	7.56 dBm
NHPRP 22.5° / TRP	-5.08 dB
NHPRP 22.5° / TRP	31.03%
UHRP	10.32 dBm
UHRP / TRP	-2.32 dB
UHRP / TRP	58.64%
LHRP	8.80 dBm
LHRP / TRP	-3.84 dB
LHRP / TRP	41.31%
PGRP (0-120°)	11.54 dBm
PGRP / TRP	-1.10 dB
PGRP / TRP	77.67%
Front/Back Ratio	3.58
PhiBW	186.2 deg
PhiBW Up	40.7 deg
PhiBW Down	145.4 deg
ThetaBW	51.2 deg
ThetaBW Up	21.6 deg
ThetaBW Down	29.5 deg
Boresight Phi	150 deg
Boresight Theta	45 deg
Maximum Power	16.54 dBm
Minimum Power	3.82 dBm
Average Power	12.94 dBm
Max/Min Ratio	12.72 dB
Max/Avg Ratio	3.60 dB
Min/Avg Ratio	-9.12 dB
Worst Single Value	-22.14 dBm
Worst Position	Azi = 285 deg; Elev = 105 deg; Pol = Hor
Best Single Value	15.90 dBm
Best Position	Azi = 150 deg; Elev = 45 deg; Pol = Ver

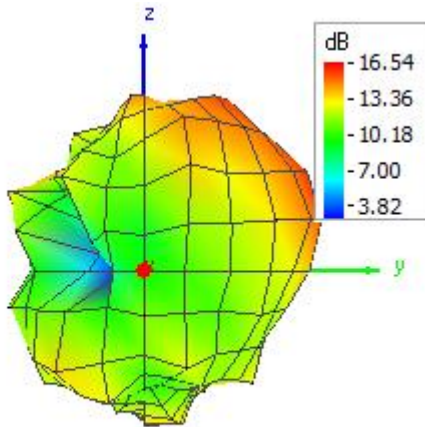
Theta = 0, Phi = 0



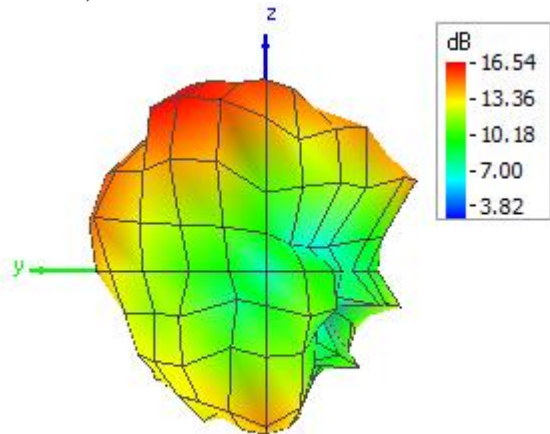
Theta = 180, Phi = 0



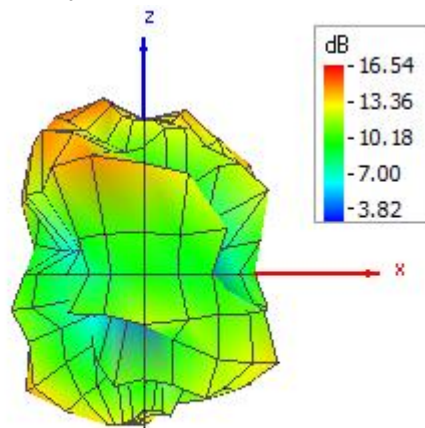
Theta = 90, Phi = 0



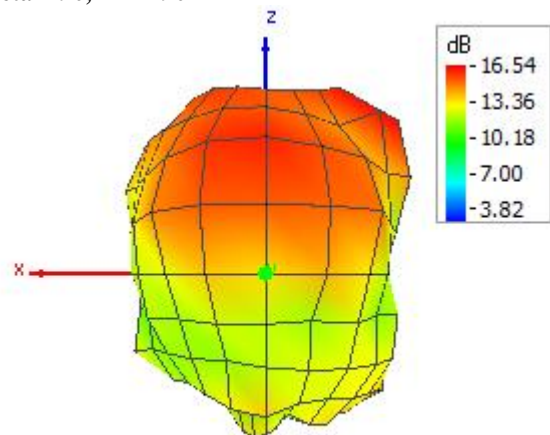
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90

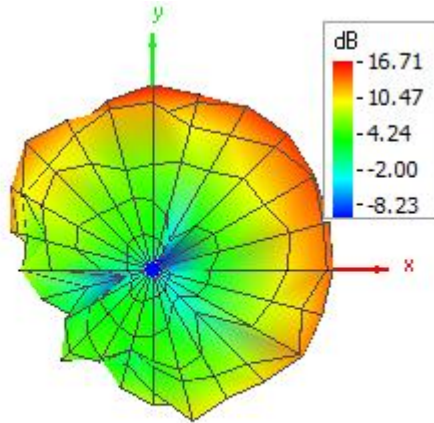


## CTIA Report (RP\_5180.000\_tot)

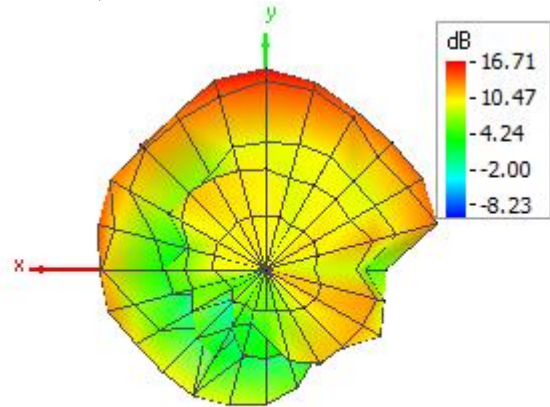
### OTA Evaluation Results

Total Radiated Power	10.44 dBm
Directivity	6.27 dBi
Total Efficiency	10.44 dB
Total Efficiency	1106.45%
Peak Realized Gain	16.71 dBi
NHPRP 45°	9.66 dBm
NHPRP 45° / TRP	-0.78 dB
NHPRP 45° / TRP	83.61%
NHPRP 30°	8.69 dBm
NHPRP 30° / TRP	-1.75 dB
NHPRP 30° / TRP	66.87%
NHPRP 22.5°	7.64 dBm
NHPRP 22.5° / TRP	-2.80 dB
NHPRP 22.5° / TRP	52.49%
UHRP	7.17 dBm
UHRP / TRP	-3.27 dB
UHRP / TRP	47.07%
LHRP	7.67 dBm
LHRP / TRP	-2.77 dB
LHRP / TRP	52.89%
PGRP (0-120°)	9.48 dBm
PGRP / TRP	-0.95 dB
PGRP / TRP	80.27%
Front/Back Ratio	10.15
PhiBW	108.7 deg
PhiBW Up	72.9 deg
PhiBW Down	35.8 deg
ThetaBW	41.5 deg
ThetaBW Up	19.4 deg
ThetaBW Down	22.1 deg
Boresight Phi	90 deg
Boresight Theta	105 deg
Maximum Power	16.71 dBm
Minimum Power	-8.23 dBm
Average Power	9.57 dBm
Max/Min Ratio	24.94 dB
Max/Avg Ratio	7.14 dB
Min/Avg Ratio	-17.80 dB
Worst Single Value	-15.02 dBm
Worst Position	Azi = 0 deg; Elev = 150 deg; Pol = Hor
Best Single Value	16.16 dBm
Best Position	Azi = 90 deg; Elev = 105 deg; Pol = Ver

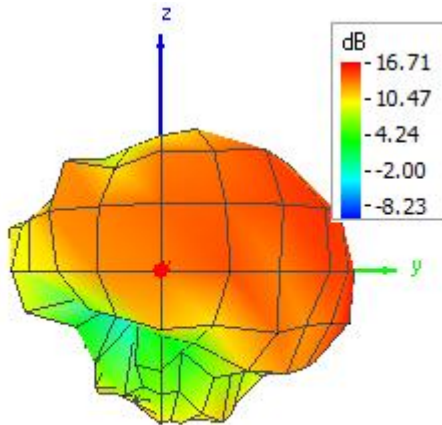
Theta = 0, Phi = 0



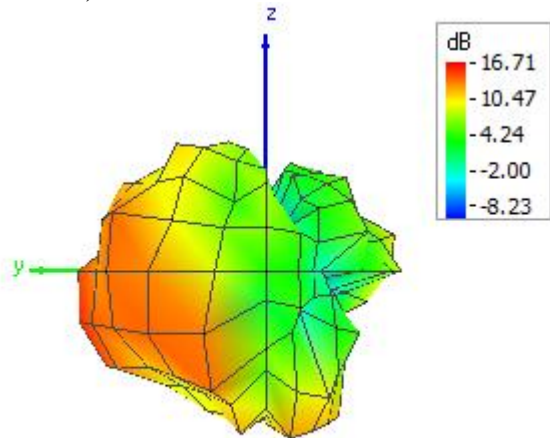
Theta = 180, Phi = 0



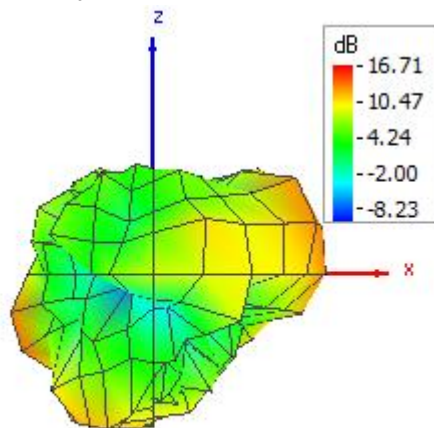
Theta = 90, Phi = 0



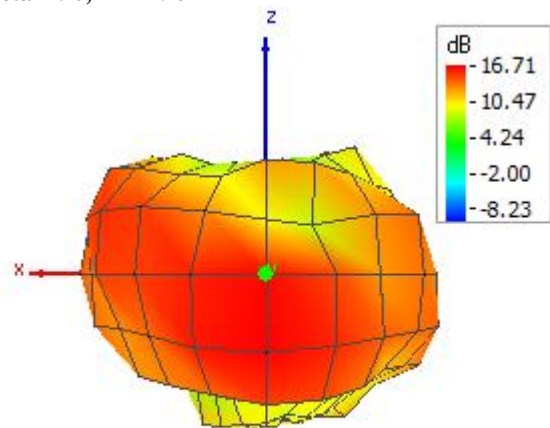
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90



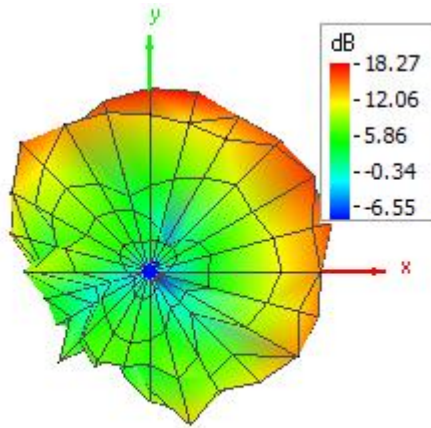
## CTIA Report (RP\_5260.000\_tot)

### OTA Evaluation Results

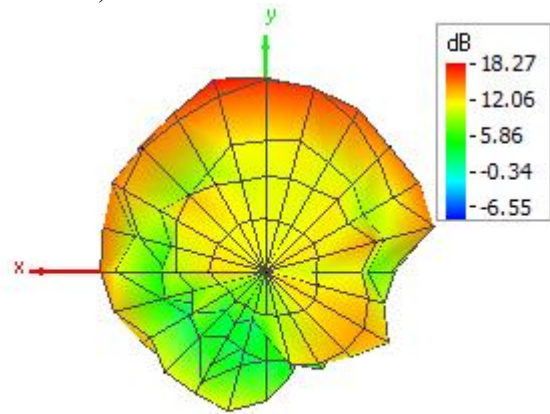
Total Radiated Power	11.80 dBm
Directivity	6.47 dBi
Total Efficiency	11.80 dB
Total Efficiency	1512.03%
Peak Realized Gain	18.27 dBi
NHPRP 45°	10.99 dBm
NHPRP 45° / TRP	-0.81 dB
NHPRP 45° / TRP	83.06%
NHPRP 30°	9.98 dBm
NHPRP 30° / TRP	-1.82 dB
NHPRP 30° / TRP	65.77%
NHPRP 22.5°	8.91 dBm
NHPRP 22.5° / TRP	-2.88 dB
NHPRP 22.5° / TRP	51.48%
UHRP	8.32 dBm
UHRP / TRP	-3.48 dB
UHRP / TRP	44.92%
LHRP	9.18 dBm
LHRP / TRP	-2.61 dB
LHRP / TRP	54.78%
PGRP (0-120°)	10.74 dBm
PGRP / TRP	-1.06 dB
PGRP / TRP	78.38%
Front/Back Ratio	12.05
PhiBW	83.9 deg
PhiBW Up	41.2 deg
PhiBW Down	42.7 deg
ThetaBW	40.5 deg
ThetaBW Up	32.9 deg
ThetaBW Down	7.6 deg
Boresight Phi	75 deg
Boresight Theta	90 deg
Maximum Power	18.27 dBm
Minimum Power	-6.55 dBm
Average Power	10.93 dBm
Max/Min Ratio	24.81 dB
Max/Avg Ratio	7.34 dB
Min/Avg Ratio	-17.47 dB
Worst Single Value	-14.15 dBm
Worst Position	Azi = 0 deg; Elev = 150 deg; Pol = Hor
Best Single Value	16.97 dBm
Best Position	Azi = 75 deg; Elev = 105 deg; Pol = Ver



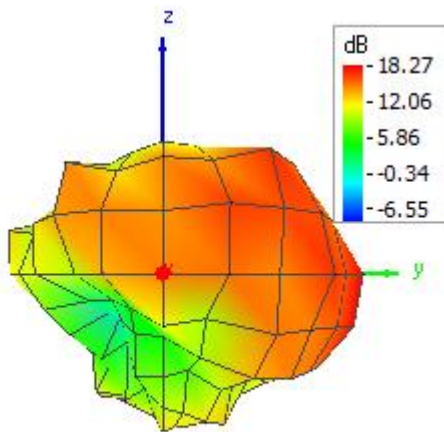
Theta = 0, Phi = 0



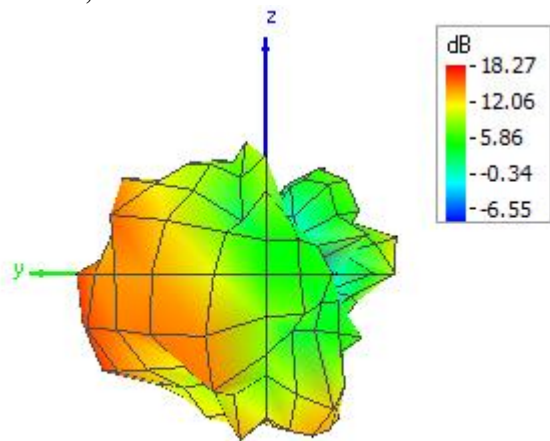
Theta = 180, Phi = 0



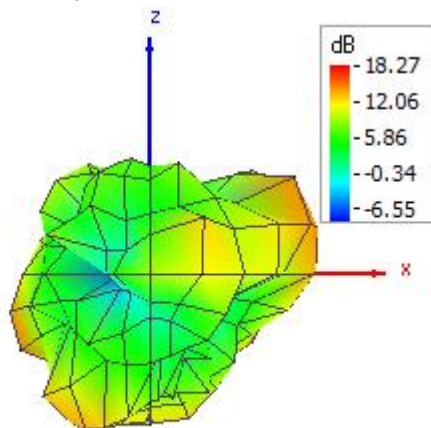
Theta = 90, Phi = 0



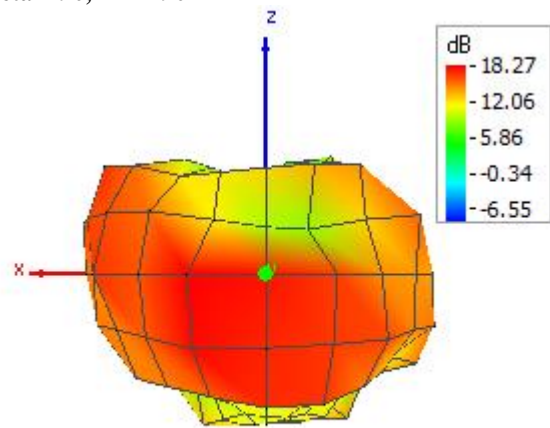
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90

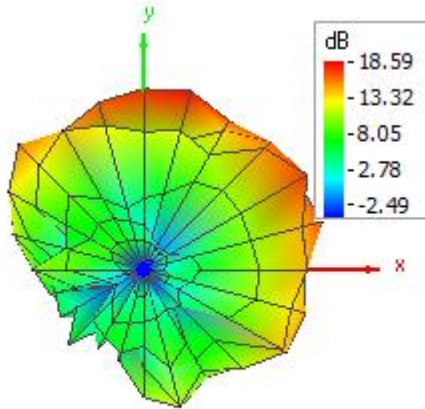


## CTIA Report (RP\_5320.000\_tot)

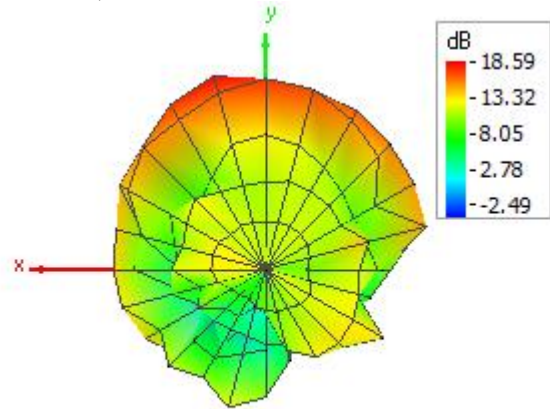
### OTA Evaluation Results

Total Radiated Power	11.89 dBm
Directivity	6.70 dBi
Total Efficiency	11.89 dB
Total Efficiency	1545.65%
Peak Realized Gain	18.59 dBi
NHPRP 45°	11.07 dBm
NHPRP 45° / TRP	-0.82 dB
NHPRP 45° / TRP	82.79%
NHPRP 30°	10.03 dBm
NHPRP 30° / TRP	-1.86 dB
NHPRP 30° / TRP	65.18%
NHPRP 22.5°	8.96 dBm
NHPRP 22.5° / TRP	-2.93 dB
NHPRP 22.5° / TRP	50.94%
UHRP	8.23 dBm
UHRP / TRP	-3.66 dB
UHRP / TRP	43.06%
LHRP	9.44 dBm
LHRP / TRP	-2.45 dB
LHRP / TRP	56.84%
PGRP (0-120°)	10.79 dBm
PGRP / TRP	-1.10 dB
PGRP / TRP	77.67%
Front/Back Ratio	19.32
PhiBW	102.6 deg
PhiBW Up	71.0 deg
PhiBW Down	31.6 deg
ThetaBW	40.4 deg
ThetaBW Up	19.8 deg
ThetaBW Down	20.6 deg
Boresight Phi	75 deg
Boresight Theta	105 deg
Maximum Power	18.59 dBm
Minimum Power	-2.49 dBm
Average Power	11.05 dBm
Max/Min Ratio	21.08 dB
Max/Avg Ratio	7.54 dB
Min/Avg Ratio	-13.54 dB
Worst Single Value	-14.31 dBm
Worst Position	Azi = 45 deg; Elev = 165 deg; Pol = Hor
Best Single Value	17.62 dBm
Best Position	Azi = 75 deg; Elev = 105 deg; Pol = Ver

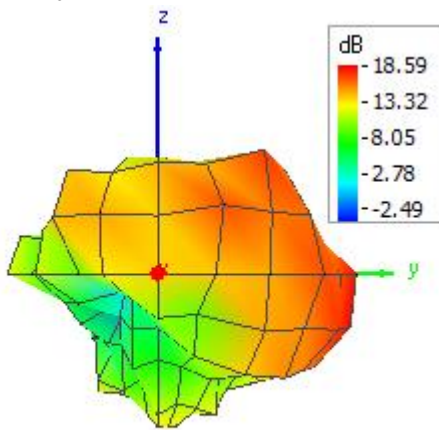
Theta = 0, Phi = 0



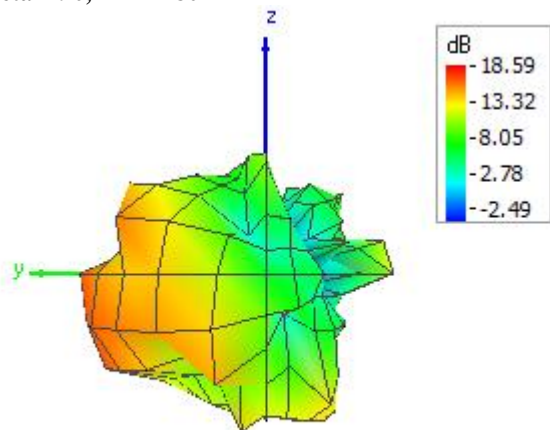
Theta = 180, Phi = 0



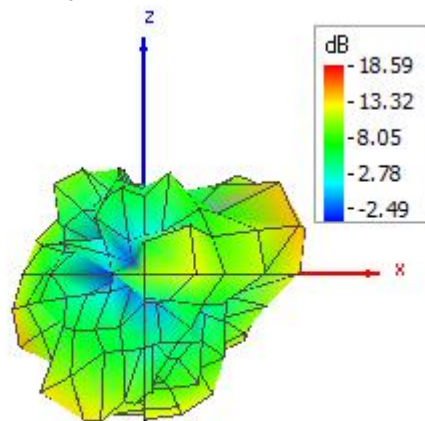
Theta = 90, Phi = 0



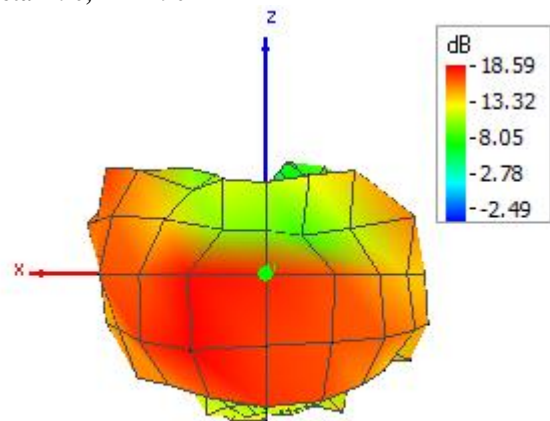
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90

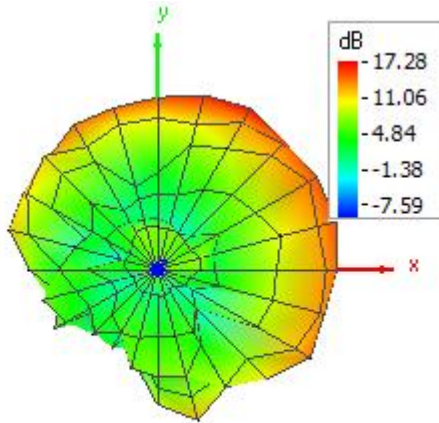


## CTIA Report (RP\_5500.000\_tot)

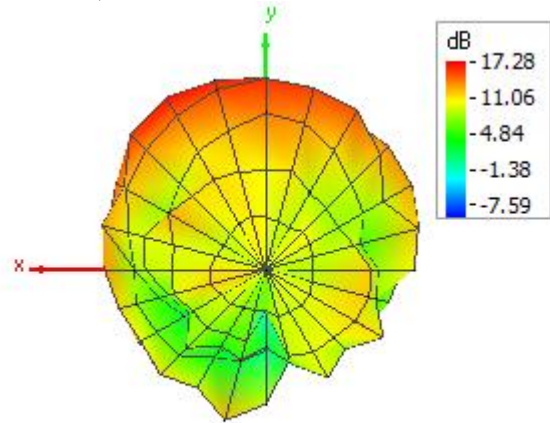
### OTA Evaluation Results

Total Radiated Power	10.61 dBm
Directivity	6.66 dBi
Total Efficiency	10.61 dB
Total Efficiency	1151.02%
Peak Realized Gain	17.28 dBi
NHPRP 45°	9.73 dBm
NHPRP 45° / TRP	-0.89 dB
NHPRP 45° / TRP	81.55%
NHPRP 30°	8.75 dBm
NHPRP 30° / TRP	-1.87 dB
NHPRP 30° / TRP	65.08%
NHPRP 22.5°	7.74 dBm
NHPRP 22.5° / TRP	-2.87 dB
NHPRP 22.5° / TRP	51.61%
UHRP	6.63 dBm
UHRP / TRP	-3.98 dB
UHRP / TRP	39.99%
LHRP	8.32 dBm
LHRP / TRP	-2.29 dB
LHRP / TRP	58.99%
PGRP (0-120°)	9.38 dBm
PGRP / TRP	-1.23 dB
PGRP / TRP	75.33%
Front/Back Ratio	20.04
PhiBW	101.6 deg
PhiBW Up	61.5 deg
PhiBW Down	40.1 deg
ThetaBW	42.9 deg
ThetaBW Up	31.5 deg
ThetaBW Down	11.4 deg
Boresight Phi	60 deg
Boresight Theta	90 deg
Maximum Power	17.28 dBm
Minimum Power	-7.59 dBm
Average Power	9.93 dBm
Max/Min Ratio	24.87 dB
Max/Avg Ratio	7.34 dB
Min/Avg Ratio	-17.53 dB
Worst Single Value	-13.59 dBm
Worst Position	Azi = 270 deg; Elev = 60 deg; Pol = Hor
Best Single Value	15.67 dBm
Best Position	Azi = 75 deg; Elev = 105 deg; Pol = Ver

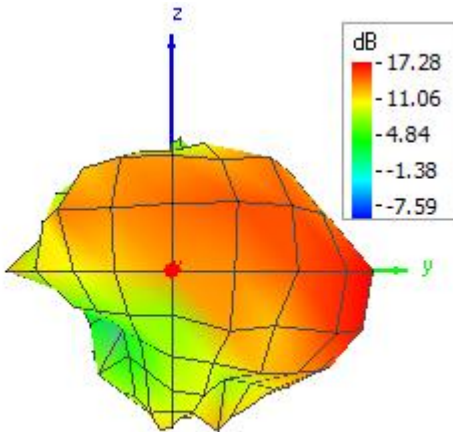
Theta = 0, Phi = 0



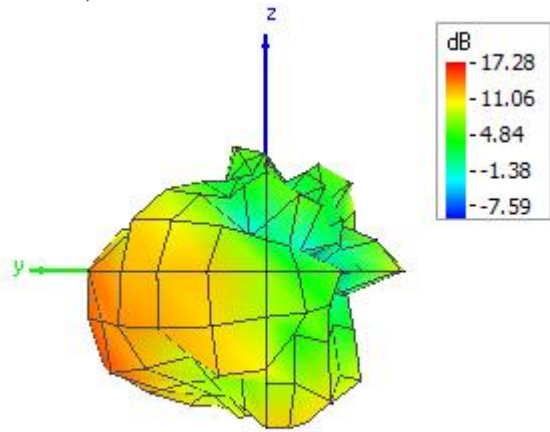
Theta = 180, Phi = 0



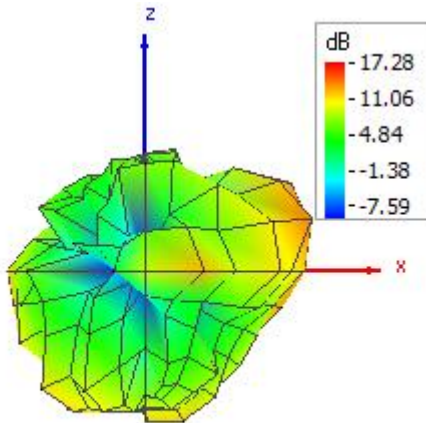
Theta = 90, Phi = 0



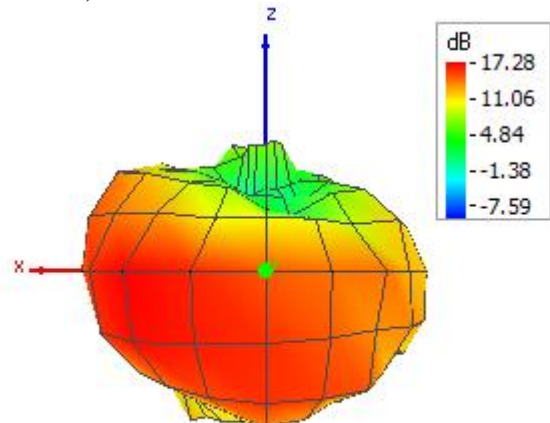
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90



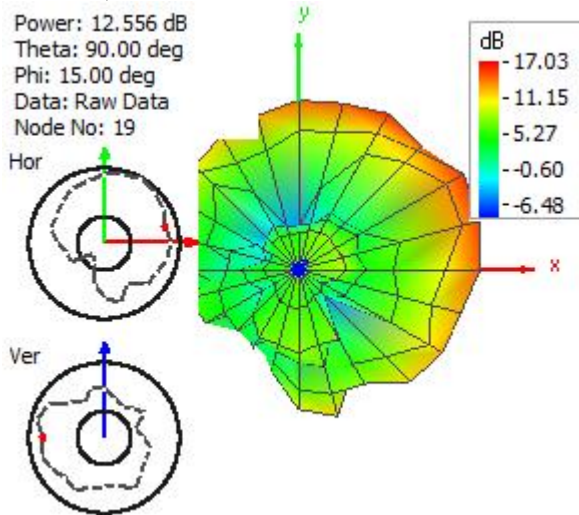
## CTIA Report (RP\_5600.000\_tot)

### OTA Evaluation Results

Total Radiated Power	9.98 dBm
Directivity	7.04 dBi
Total Efficiency	9.98 dB
Total Efficiency	996.52%
Peak Realized Gain	17.03 dBi
NHPRP 45°	9.12 dBm
NHPRP 45° / TRP	-0.86 dB
NHPRP 45° / TRP	82.01%
NHPRP 30°	8.19 dBm
NHPRP 30° / TRP	-1.79 dB
NHPRP 30° / TRP	66.16%
NHPRP 22.5°	7.15 dBm
NHPRP 22.5° / TRP	-2.84 dB
NHPRP 22.5° / TRP	52.03%
UHRP	5.82 dBm
UHRP / TRP	-4.16 dB
UHRP / TRP	38.34%
LHRP	7.86 dBm
LHRP / TRP	-2.13 dB
LHRP / TRP	61.28%
PGRP (0-120°)	8.76 dBm
PGRP / TRP	-1.22 dB
PGRP / TRP	75.49%
Front/Back Ratio	15.26
PhiBW	80.3 deg
PhiBW Up	54.6 deg
PhiBW Down	25.7 deg
ThetaBW	39.9 deg
ThetaBW Up	17.6 deg
ThetaBW Down	22.3 deg
Boresight Phi	60 deg
Boresight Theta	105 deg
Maximum Power	17.03 dBm
Minimum Power	-6.48 dBm
Average Power	9.43 dBm
Max/Min Ratio	23.50 dB
Max/Avg Ratio	7.60 dB
Min/Avg Ratio	-15.90 dB
Worst Single Value	-12.91 dBm
Worst Position	Azi = 15 deg; Elev = 45 deg; Pol = Hor
Best Single Value	16.35 dBm
Best Position	Azi = 75 deg; Elev = 105 deg; Pol = Ver

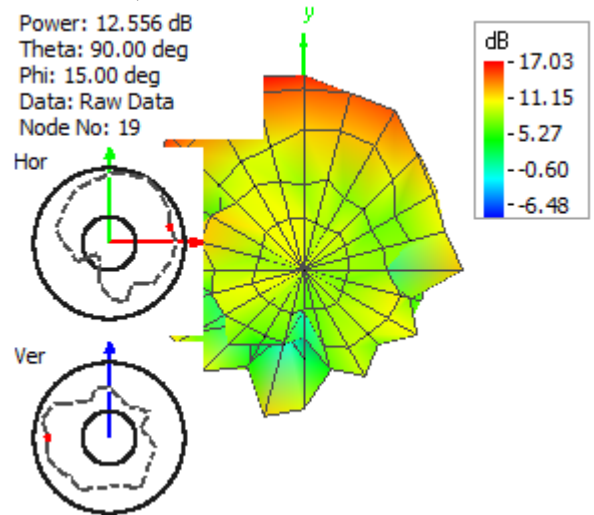
**Theta = 0, Phi = 0**

Power: 12.556 dB  
 Theta: 90.00 deg  
 Phi: 15.00 deg  
 Data: Raw Data  
 Node No: 19



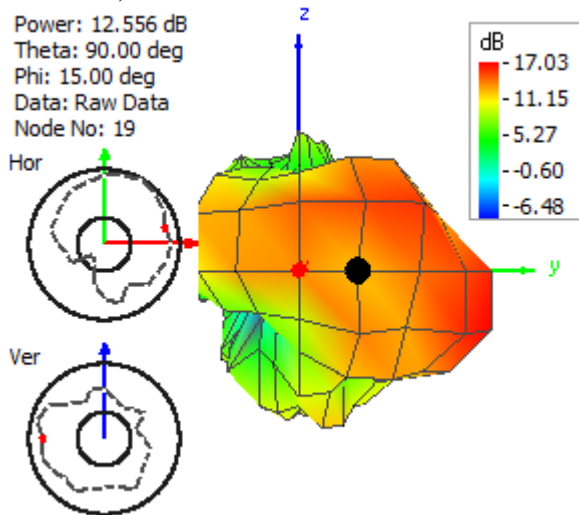
**Theta = 180, Phi = 0**

Power: 12.556 dB  
 Theta: 90.00 deg  
 Phi: 15.00 deg  
 Data: Raw Data  
 Node No: 19



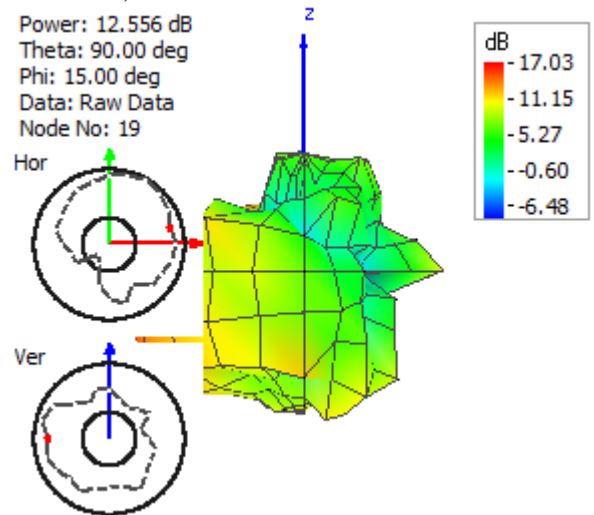
**Theta = 90, Phi = 0**

Power: 12.556 dB  
 Theta: 90.00 deg  
 Phi: 15.00 deg  
 Data: Raw Data  
 Node No: 19



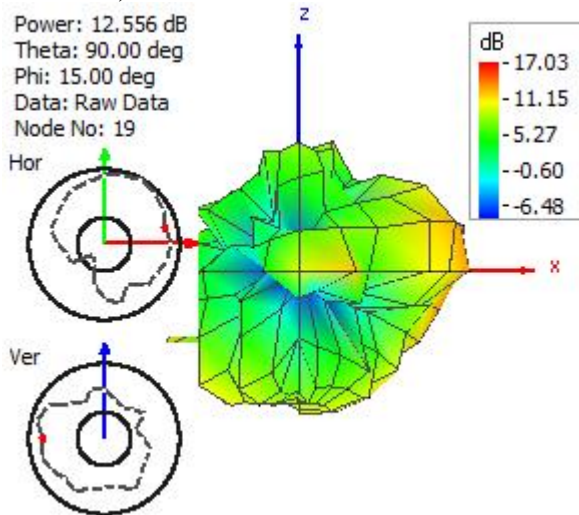
**Theta = 90, Phi = 180**

Power: 12.556 dB  
 Theta: 90.00 deg  
 Phi: 15.00 deg  
 Data: Raw Data  
 Node No: 19



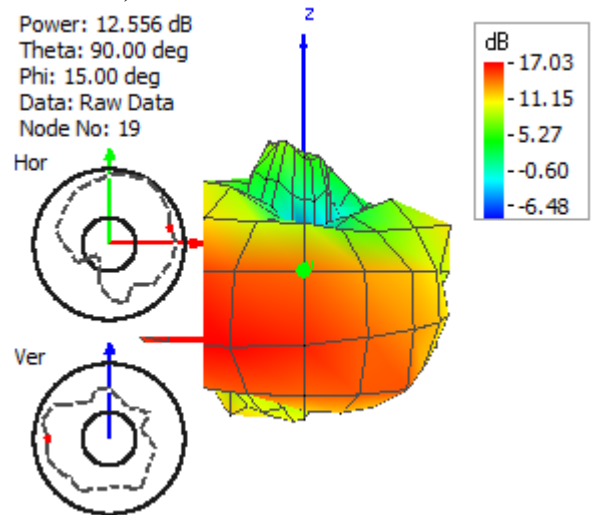
**Theta = 90, Phi = 270**

Power: 12.556 dB  
 Theta: 90.00 deg  
 Phi: 15.00 deg  
 Data: Raw Data  
 Node No: 19



**Theta = 90, Phi = 90**

Power: 12.556 dB  
 Theta: 90.00 deg  
 Phi: 15.00 deg  
 Data: Raw Data  
 Node No: 19



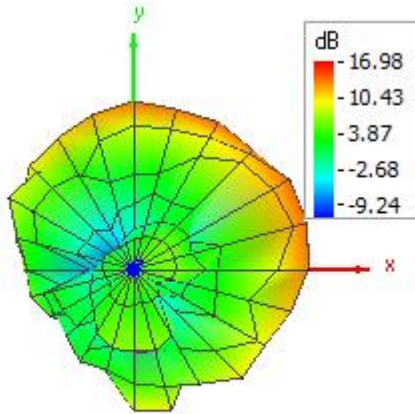
## CTIA Report (RP\_5700.000\_tot)

### OTA Evaluation Results

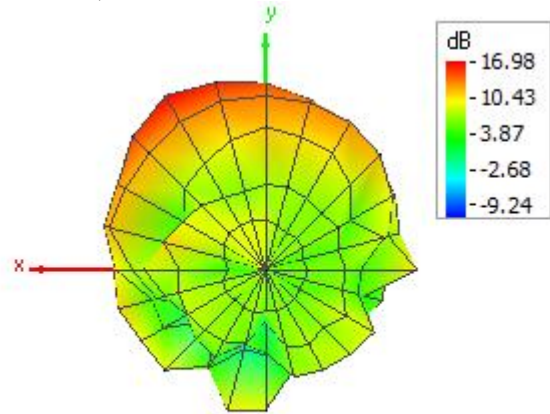
Total Radiated Power	8.75 dBm
Directivity	8.23 dBi
Total Efficiency	8.75 dB
Total Efficiency	750.39%
Peak Realized Gain	16.98 dBi
NHPRP 45°	7.98 dBm
NHPRP 45° / TRP	-0.77 dB
NHPRP 45° / TRP	83.74%
NHPRP 30°	7.06 dBm
NHPRP 30° / TRP	-1.70 dB
NHPRP 30° / TRP	67.67%
NHPRP 22.5°	6.01 dBm
NHPRP 22.5° / TRP	-2.75 dB
NHPRP 22.5° / TRP	53.12%
UHRP	4.46 dBm
UHRP / TRP	-4.29 dB
UHRP / TRP	37.25%
LHRP	6.74 dBm
LHRP / TRP	-2.01 dB
LHRP / TRP	62.91%
PGRP (0-120°)	7.57 dBm
PGRP / TRP	-1.18 dB
PGRP / TRP	76.22%
Front/Back Ratio	12.90
PhiBW	65.7 deg
PhiBW Up	41.9 deg
PhiBW Down	23.8 deg
ThetaBW	29.4 deg
ThetaBW Up	12.4 deg
ThetaBW Down	17.0 deg
Boresight Phi	60 deg
Boresight Theta	105 deg
Maximum Power	16.98 dBm
Minimum Power	-9.24 dBm
Average Power	8.10 dBm
Max/Min Ratio	26.22 dB
Max/Avg Ratio	8.87 dB
Min/Avg Ratio	-17.34 dB
Worst Single Value	-12.82 dBm
Worst Position	Azi = 195 deg; Elev = 60 deg; Pol = Hor
Best Single Value	15.67 dBm
Best Position	Azi = 60 deg; Elev = 105 deg; Pol = Ver



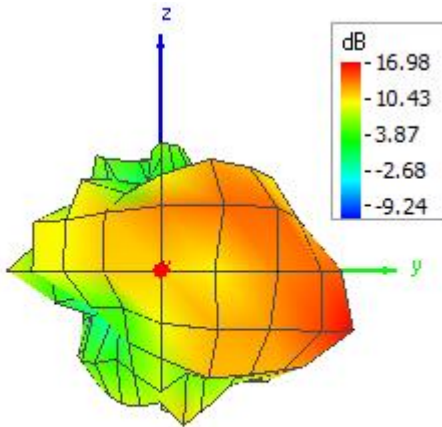
Theta = 0, Phi = 0



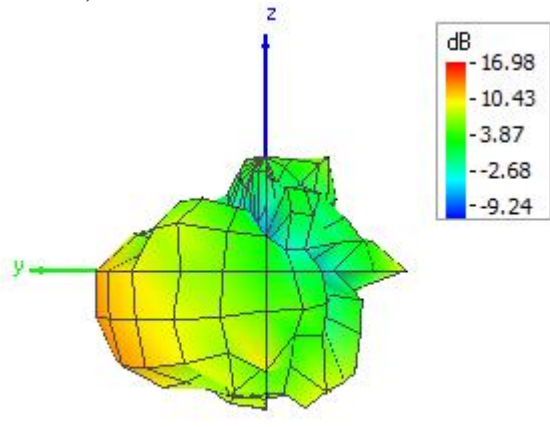
Theta = 180, Phi = 0



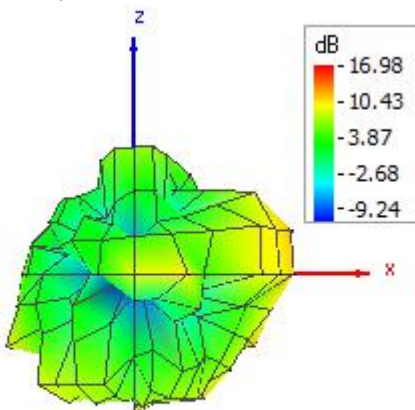
Theta = 90, Phi = 0



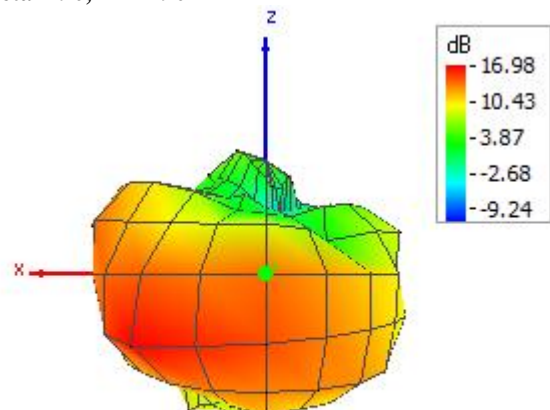
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90

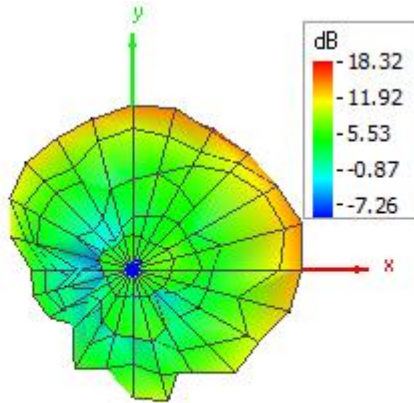


## CTIA Report (RP\_5785.000\_tot)

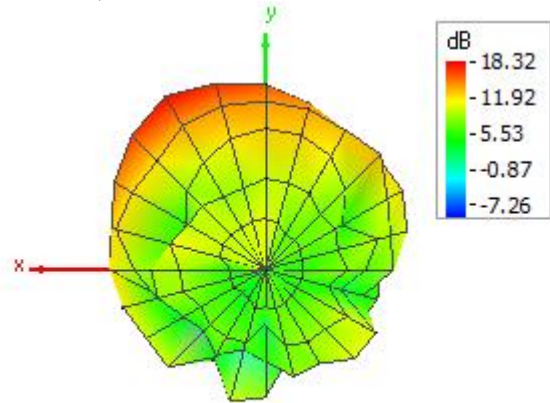
### OTA Evaluation Results

Total Radiated Power	9.66 dBm
Directivity	8.66 dBi
Total Efficiency	9.66 dB
Total Efficiency	924.97%
Peak Realized Gain	18.32 dBi
NHPRP 45°	8.88 dBm
NHPRP 45° / TRP	-0.78 dB
NHPRP 45° / TRP	83.63%
NHPRP 30°	7.96 dBm
NHPRP 30° / TRP	-1.70 dB
NHPRP 30° / TRP	67.58%
NHPRP 22.5°	6.92 dBm
NHPRP 22.5° / TRP	-2.74 dB
NHPRP 22.5° / TRP	53.20%
UHRP	5.13 dBm
UHRP / TRP	-4.53 dB
UHRP / TRP	35.25%
LHRP	7.83 dBm
LHRP / TRP	-1.83 dB
LHRP / TRP	65.56%
PGRP (0-120°)	8.47 dBm
PGRP / TRP	-1.19 dB
PGRP / TRP	76.06%
Front/Back Ratio	11.40
PhiBW	65.8 deg
PhiBW Up	38.7 deg
PhiBW Down	27.1 deg
ThetaBW	21.5 deg
ThetaBW Up	10.7 deg
ThetaBW Down	10.8 deg
Boresight Phi	60 deg
Boresight Theta	105 deg
Maximum Power	18.32 dBm
Minimum Power	-7.26 dBm
Average Power	9.10 dBm
Max/Min Ratio	25.58 dB
Max/Avg Ratio	9.23 dB
Min/Avg Ratio	-16.36 dB
Worst Single Value	-13.25 dBm
Worst Position	Azi = 165 deg; Elev = 45 deg; Pol = Hor
Best Single Value	17.02 dBm
Best Position	Azi = 60 deg; Elev = 105 deg; Pol = Ver

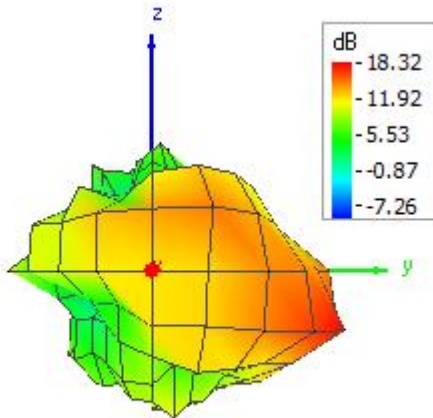
Theta = 0, Phi = 0



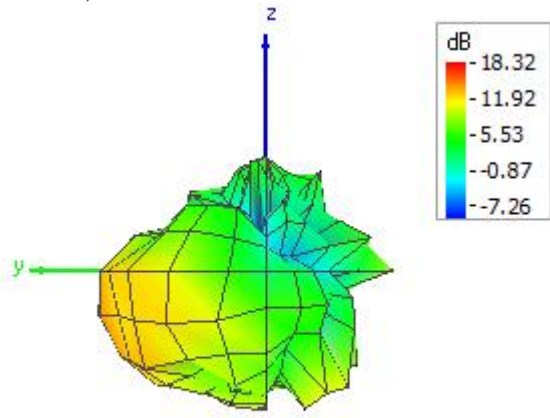
Theta = 180, Phi = 0



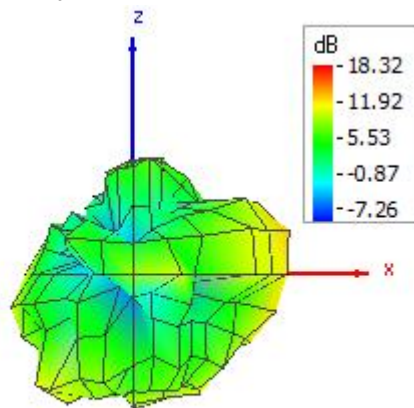
Theta = 90, Phi = 0



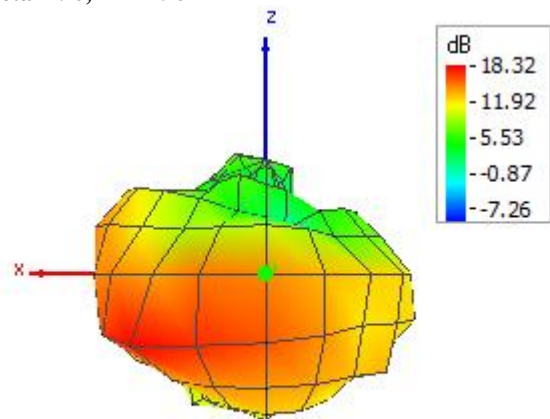
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90



## CTIA Report BT (RP\_2402.000\_tot)

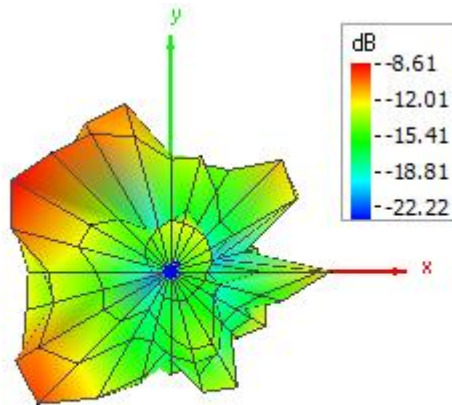
### Test Information

Test Method:	Antenna Measurement
Test Condition:	FS: Free Space
Frequency:	2402.000 MHz

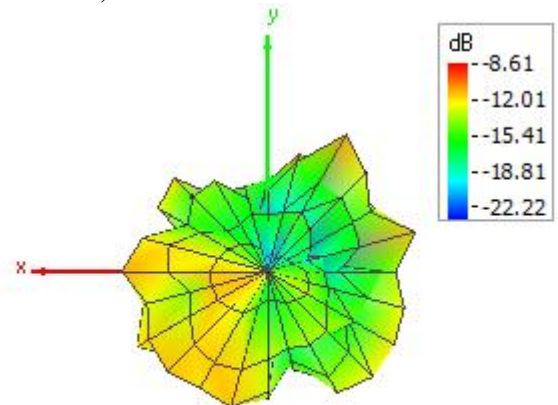
### OTA Evaluation Results

Total Radiated Power	-14.06 dBm
Directivity	5.45 dBi
Total Efficiency	-14.06 dB
Total Efficiency	3.93%
Peak Realized Gain	-8.61 dBi
NHPRP 45°	-15.59 dBm
NHPRP 45° / TRP	-1.54 dB
NHPRP 45° / TRP	70.22%
NHPRP 30°	-17.30 dBm
NHPRP 30° / TRP	-3.24 dB
NHPRP 30° / TRP	47.43%
NHPRP 22.5°	-18.53 dBm
NHPRP 22.5° / TRP	-4.47 dB
NHPRP 22.5° / TRP	35.73%
UHRP	-16.57 dBm
UHRP / TRP	-2.51 dB
UHRP / TRP	56.09%
LHRP	-17.75 dBm
LHRP / TRP	-3.70 dB
LHRP / TRP	42.69%
PGRP (0-120°)	-15.31 dBm
PGRP / TRP	-1.26 dB
PGRP / TRP	74.88%
Front/Back Ratio	2.84
PhiBW	72.7 deg
PhiBW Up	25.4 deg
PhiBW Down	47.3 deg
ThetaBW	26.2 deg
ThetaBW Up	14.4 deg
ThetaBW Down	11.8 deg
Boresight Phi	150 deg
Boresight Theta	45 deg
Maximum Power	-8.61 dBm
Minimum Power	-20.22 dBm
Average Power	-14.19 dBm
Max/Min Ratio	11.61 dB
Max/Avg Ratio	5.58 dB
Min/Avg Ratio	-6.03 dB
Worst Single Value	-23.72 dBm
Worst Position	Azi = 15 deg; Elev = 30 deg; Pol = Hor
Best Single Value	-10.56 dBm
Best Position	Azi = 150 deg; Elev = 45 deg; Pol = Ver

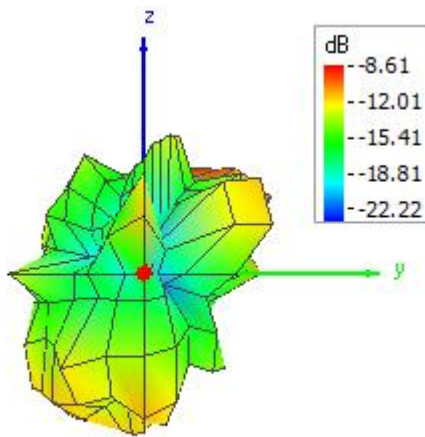
Theta = 0, Phi = 0



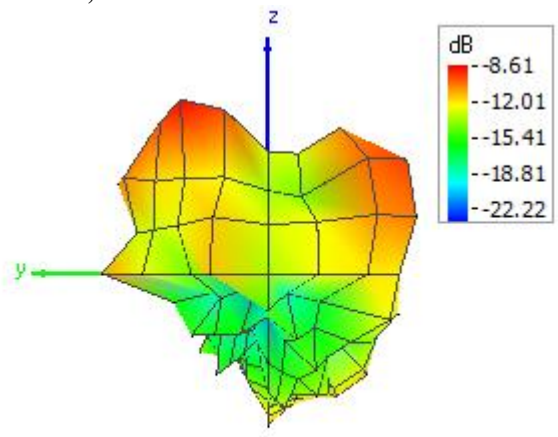
Theta = 180, Phi = 0



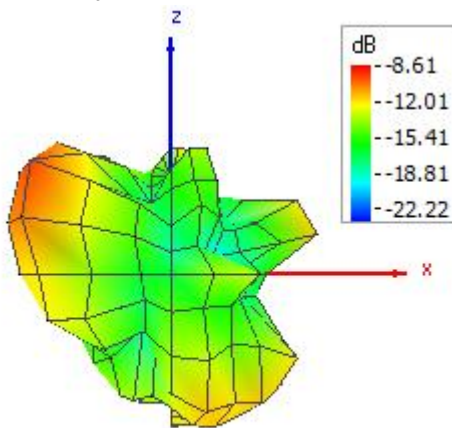
Theta = 90, Phi = 0



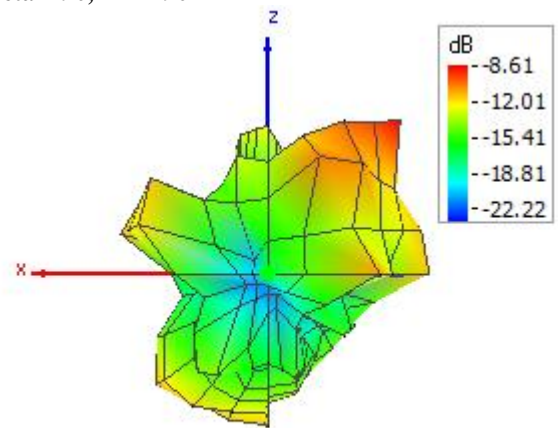
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90



## CTIA Report BT (RP\_2441.000\_tot)

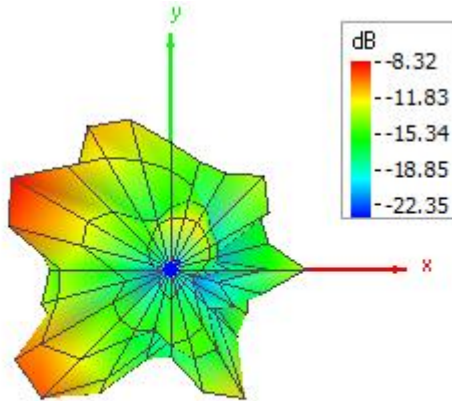
### Test Information

Test Method:	Antenna Measurement
Test Condition:	FS: Free Space
Frequency:	2441.000 MHz

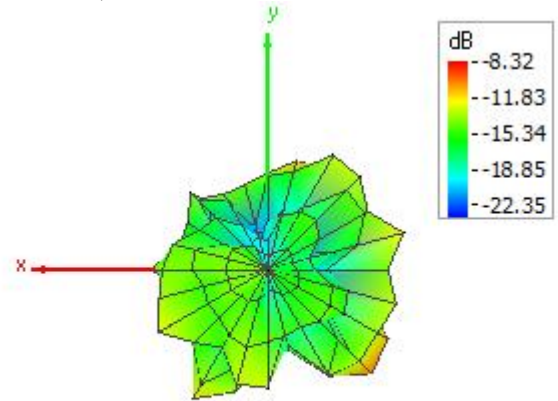
### OTA Evaluation Results

Total Radiated Power	-14.90 dBm
Directivity	6.58 dBi
Total Efficiency	-14.90 dB
Total Efficiency	3.24%
Peak Realized Gain	-8.32 dBi
NHPRP 45°	-16.44 dBm
NHPRP 45° / TRP	-1.54 dB
NHPRP 45° / TRP	70.07%
NHPRP 30°	-18.13 dBm
NHPRP 30° / TRP	-3.23 dB
NHPRP 30° / TRP	47.56%
NHPRP 22.5°	-19.33 dBm
NHPRP 22.5° / TRP	-4.43 dB
NHPRP 22.5° / TRP	36.05%
UHRP	-17.20 dBm
UHRP / TRP	-2.30 dB
UHRP / TRP	58.82%
LHRP	-18.87 dBm
LHRP / TRP	-3.97 dB
LHRP / TRP	40.06%
PGRP (0-120°)	-16.02 dBm
PGRP / TRP	-1.12 dB
PGRP / TRP	77.32%
Front/Back Ratio	3.74
PhiBW	46.6 deg
PhiBW Up	22.9 deg
PhiBW Down	23.8 deg
ThetaBW	24.3 deg
ThetaBW Up	11.8 deg
ThetaBW Down	12.5 deg
Boresight Phi	150 deg
Boresight Theta	45 deg
Maximum Power	-8.32 dBm
Minimum Power	-20.35 dBm
Average Power	-15.20 dBm
Max/Min Ratio	12.03 dB
Max/Avg Ratio	6.87 dB
Min/Avg Ratio	-5.16 dB
Worst Single Value	-23.62 dBm
Worst Position	Azi = 0 deg; Elev = 0 deg; Pol = Hor
Best Single Value	-9.92 dBm
Best Position	Azi = 165 deg; Elev = 45 deg; Pol = Ver

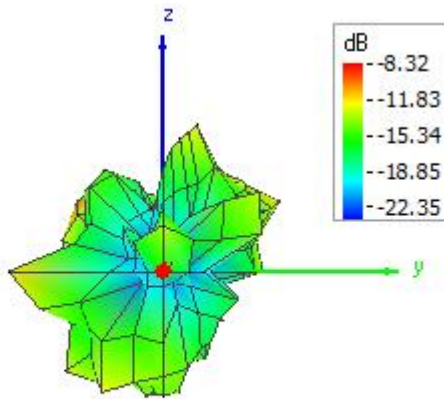
Theta = 0, Phi = 0



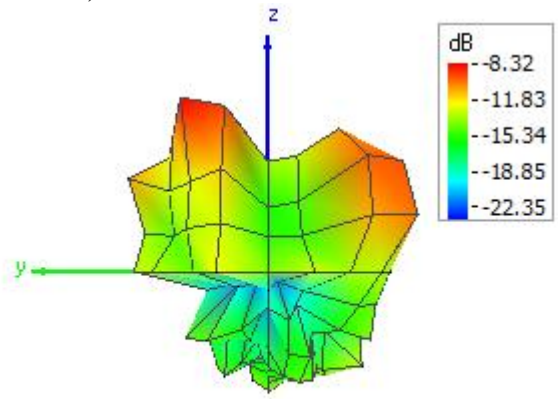
Theta = 180, Phi = 0



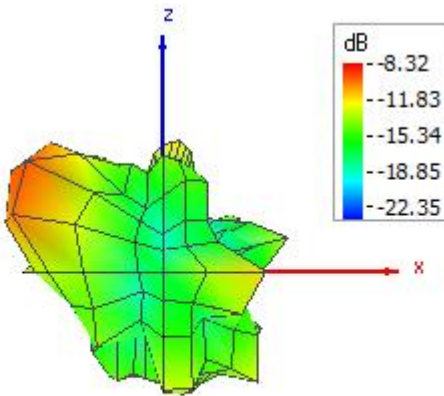
Theta = 90, Phi = 0



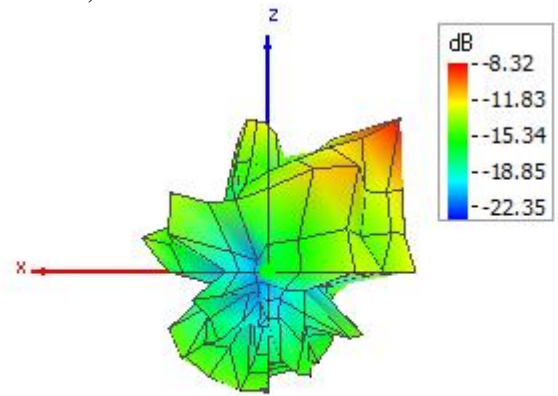
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90



## CTIA Report BT (RP\_2480.000\_tot)

### Test Information

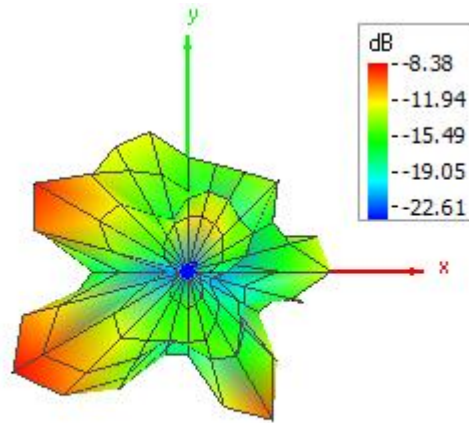
Test Method:	Antenna Measurement
Test Condition:	FS: Free Space
Frequency:	2480.000 MHz

### OTA Evaluation Results

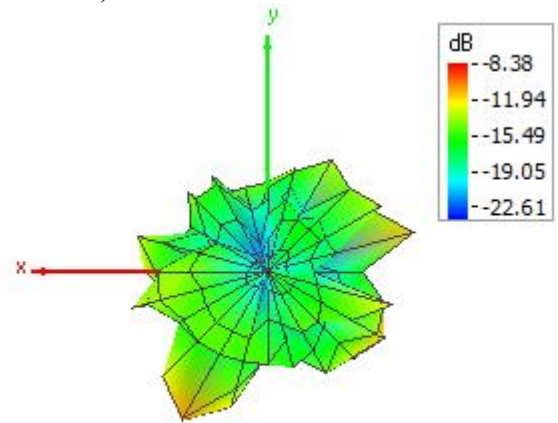
Total Radiated Power	-14.98 dBm
Directivity	6.61 dBi
Total Efficiency	-14.98 dB
Total Efficiency	3.17%
Peak Realized Gain	-8.38 dBi
NHPRP 45°	-16.44 dBm
NHPRP 45° / TRP	-1.45 dB
NHPRP 45° / TRP	71.55%
NHPRP 30°	-18.04 dBm
NHPRP 30° / TRP	-3.06 dB
NHPRP 30° / TRP	49.47%
NHPRP 22.5°	-19.19 dBm
NHPRP 22.5° / TRP	-4.21 dB
NHPRP 22.5° / TRP	37.95%
UHRP	-17.34 dBm
UHRP / TRP	-2.36 dB
UHRP / TRP	58.09%
LHRP	-18.83 dBm
LHRP / TRP	-3.84 dB
LHRP / TRP	41.30%
PGRP (0-120°)	-15.96 dBm
PGRP / TRP	-0.97 dB
PGRP / TRP	79.95%
Front/Back Ratio	9.11
PhiBW	37.4 deg
PhiBW Up	20.8 deg
PhiBW Down	16.6 deg
ThetaBW	38.6 deg
ThetaBW Up	15.4 deg
ThetaBW Down	23.2 deg
Boresight Phi	210 deg
Boresight Theta	60 deg
Maximum Power	-8.38 dBm
Minimum Power	-20.61 dBm
Average Power	-15.40 dBm
Max/Min Ratio	12.23 dB
Max/Avg Ratio	7.03 dB
Min/Avg Ratio	-5.21 dB
Worst Single Value	-23.88 dBm
Worst Position	Azi = 0 deg; Elev = 0 deg; Pol = Hor
Best Single Value	-8.64 dBm
Best Position	Azi = 210 deg; Elev = 60 deg; Pol = Ver



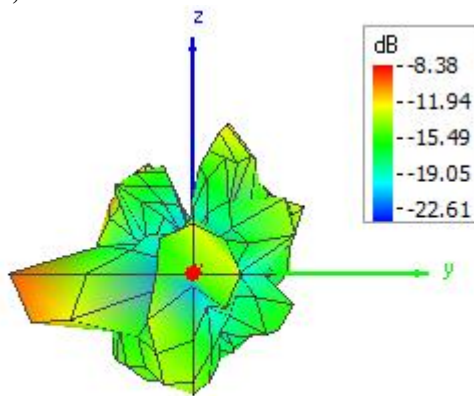
Theta = 0, Phi = 0



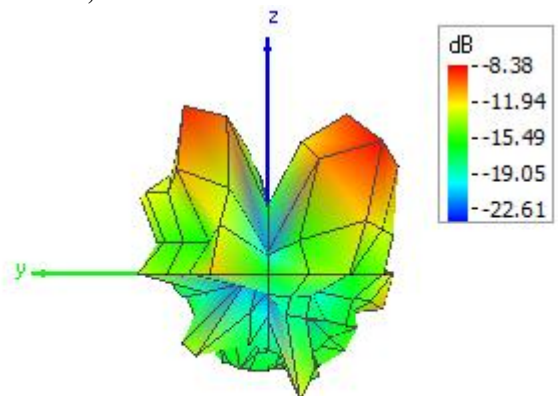
Theta = 180, Phi = 0



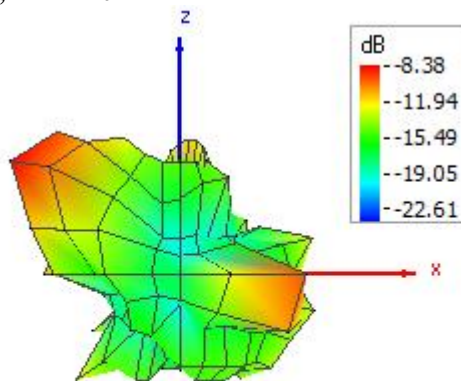
Theta = 90, Phi = 0



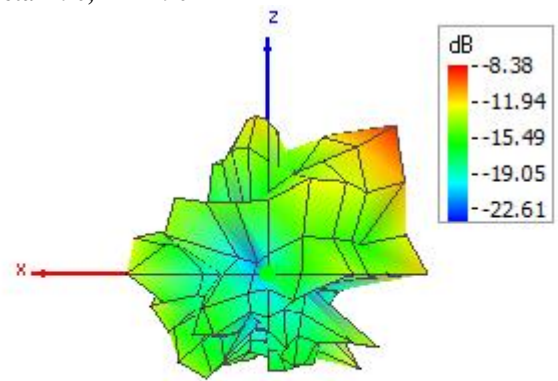
Theta = 90, Phi = 180



Theta = 90, Phi = 270



Theta = 90, Phi = 90



### 5.1.1. Result Maximum Antenna Gain

Best single value radiated– PWR cond = Antenna Gain

channel	frequency	Best single value	PWR cond	Gain
1	2412	18.29	15.05	3.2
6	2437	17.18	14.22	3.0
11	2462	15.90	13.79	2.1
36	5180	16.16	13.32	2.8
52	5260	16.97	13.52	3.5
64	5320	17.62	13.91	3.7
100	5500	15.67	17.36	-1.7
120	5600	16.35	17.45	-1.1
140	5700	15.67	16.48	-0.8
157	5785	17.02	16.28	0.7

Bluetooth	Test Mode DH5			
0	2402	-10.56	-2.36	-8.2
39	2441	-9.92	-2.34	-7.6
78	2480	-8.64	-2.29	-6.4

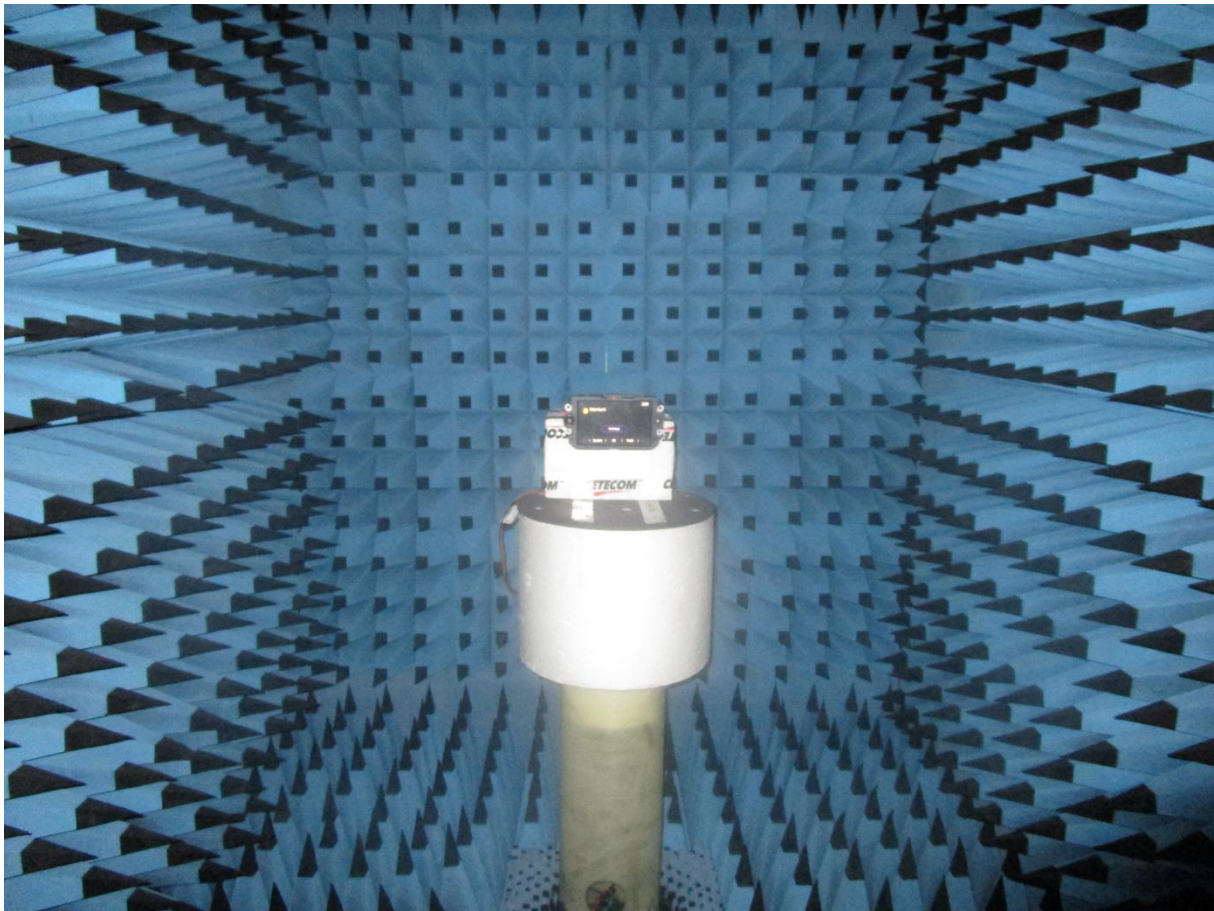
Maximum antenna gain

Frequency range	Maximum Antenna Gain
WLAN 2.4 GHz	3.2dBi
WLAN 5 GHz	3.7dBi
BT 2.4 GHz	-6.4dBi

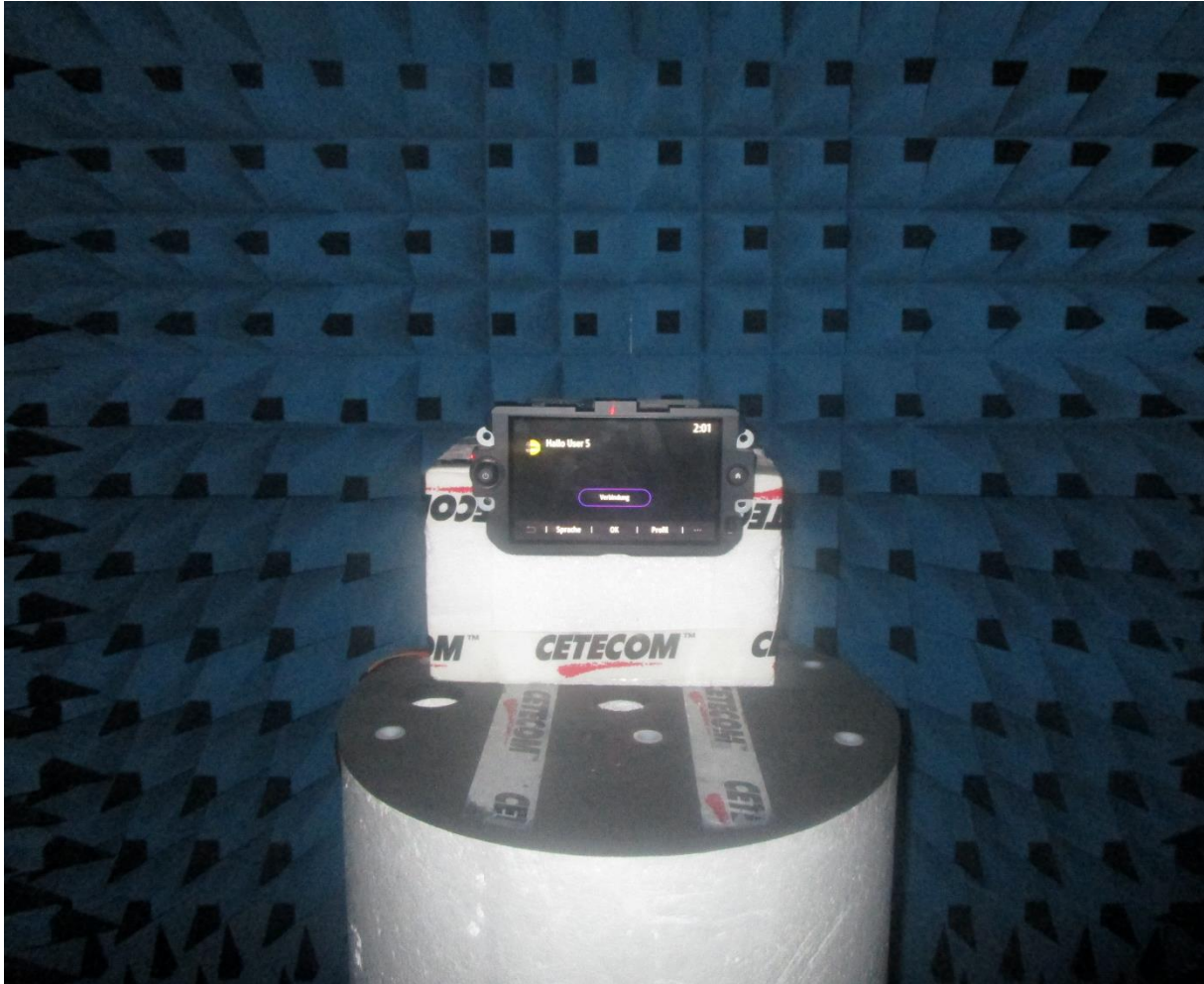
## 6. Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2019-10-23
C1	Administrative Changes	2019-10-31

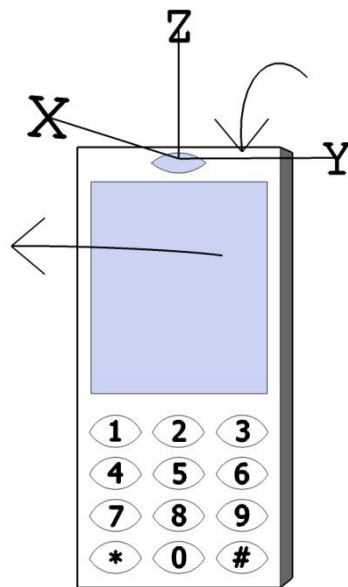
## 7. Photographs and Drawings



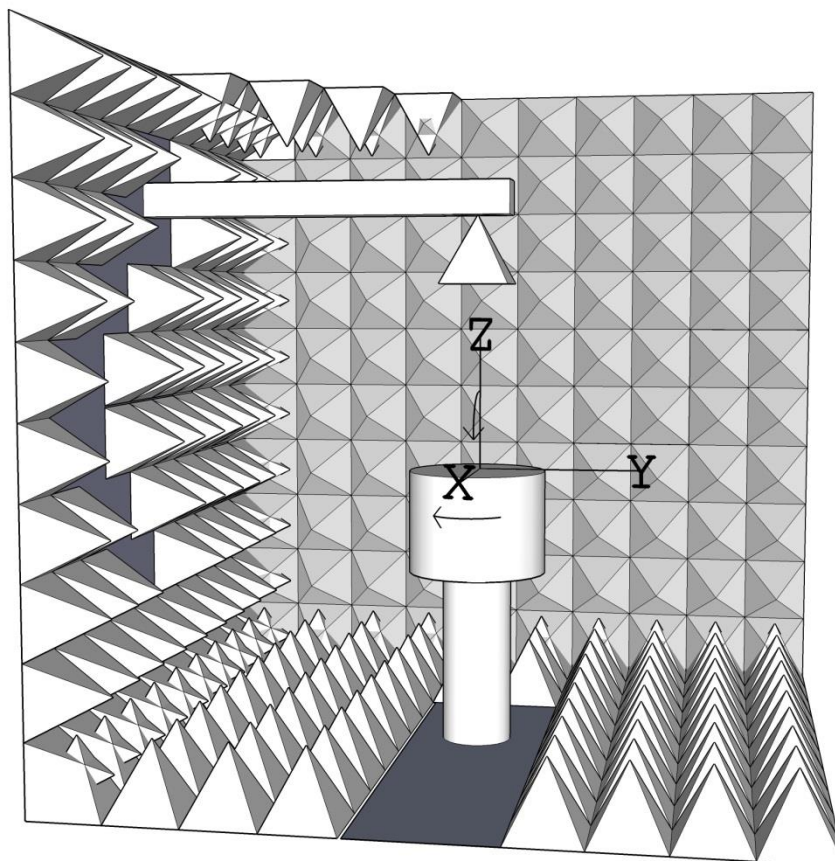
**Photograph 1:** Free Space setup (FS), long shot view, Theta=0°, Phi=0°



**Photograph 2:** Free Space setup (FS), close up view, Theta=0°, Phi=0°



**Figure 1:** EUT reference position for free space setup,  $\Theta=0^\circ$ ,  $\Phi=0^\circ$



**Figure 2:** Coordinate system in the anechoic chamber

**END OF TEST REPORT**