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Zurn Water, LLC

ANTENNA PERFORMANCE CHARACTERIZATION REPORT

SCOPE OF WORK
ANTENNA PERFORMANCE TESTING –
EZ GEAR FAUCET MODEL ZG6913

STANDARDS
IEEE STD 149-2021

REPORT NUMBER
105704106LEX-012

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4/12/2024

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Antenna Performance Characterization Report Shell
Rev. December 2023

ANTENNA PERFORMANCE CHARACTERIZATION REPORT

Report Number:	105704106LEX-012
Project Number:	G105704106
Report Issue Date:	4/12/2024
Model(s) Tested:	EZ Gear Faucet model ZG6913
Variant Model(s) not Tested but Declared By Manufacturer to be Electrically Identical:	ZG6915, ZG6920, ZG6922, ZG6950, ZG6951, ZG6953, ZG6955, ZG6956
Standards:	IEEE Std 149-2021 Clause 7 Measurement of Radiation Patterns Clause 8 Measurement of Gain and Directivity Clause 10 Measurement of Radiation Efficiency

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Dr.
Lexington, KY 40510
USA

Client:
Zurn Water, LLC
3700 Regency Parkway
Suite 100
Cary, NC 27518
USA

Report prepared by

Brian Lackey, EMC Staff Engineer

Report reviewed by

Michael Carlson, Team Leader

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1 Introduction

Passive antenna testing is performed on standalone antennas by injecting a narrowband or CW signal and measuring the magnitude and phase at a receiving antenna across an imaginary sphere in a fully anechoic environment. Integrated antenna testing is performed on host devices under normal operating conditions by measuring the total radiated power in a similar environment and calculating antenna parameters based on the reported output power for each band, mode, modulation, bandwidth, and frequency under test. The results presented in this report are for integrated antenna configurations only.

Tests were performed on the product constructed as described in section 4. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results, and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted. The results obtained in this performance report pertain only to the item(s) tested. Intertek does not make any claims of performance for samples or variants which were not tested.

Measurements are performed in operating configurations comprising the transmission bands, modes, modulations, bandwidths, and frequencies depending on the capabilities of the device under test as described in section 4. The use of measured values in operating configurations or at frequencies other than those presented may be affected.

For devices with access to the antenna terminals, reflection coefficient, VSWR, and impedance measurements are performed. The absolute gain and radiation efficiency are calculated based on the VSWR measurements. For devices without access to the antenna terminals, reflection coefficient, VSWR, and impedance measurements cannot be performed directly, and the realized gain and efficiency are reported.

Operating Configuration	Frequency (MHz)	Power at Antenna (dBm)	TRP (dBm)	Max EIRP (dBm)	Max Directivity (dBi)	Max Realized Gain (dBi)	Antenna Efficiency (%)
Defined	Defined	Measured	Calculated	Measured	Calculated	Calculated	Calculated
BLE 1Mbit/s	2402	1.93	-1.51	3.45	4.96	1.52	45.29%
	2440	1.59	-2.02	1.86	3.88	0.27	43.55%
	2480	1.53	-2.23	0.83	3.06	-0.70	42.07%
BLE 2Mbit/s	2402	2.07	-1.15	3.04	4.19	0.97	47.64%
	2440	1.80	-1.29	2.07	3.36	0.27	49.09%
	2480	1.62	-2.51	0.83	3.34	-0.79	38.64%

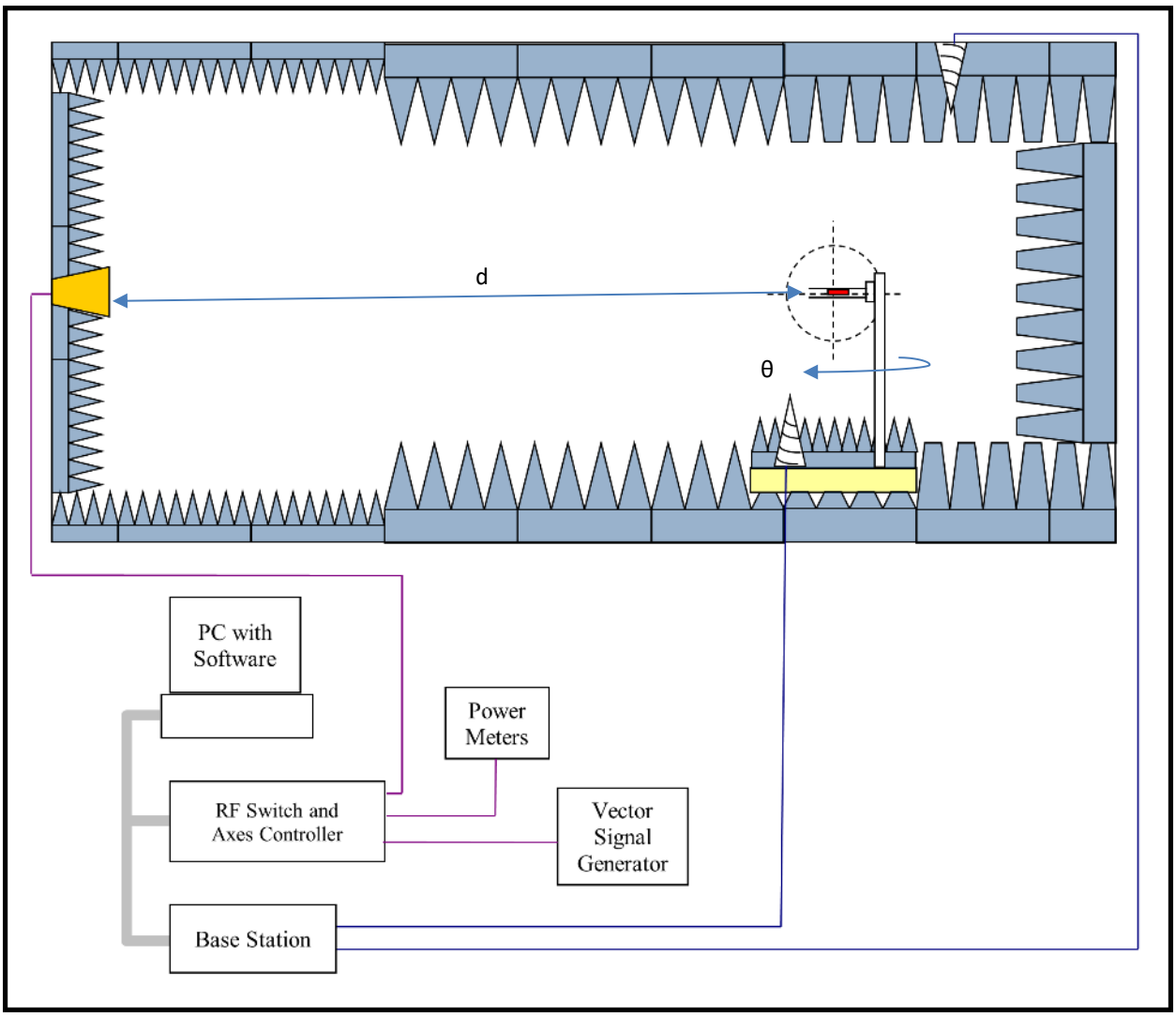
2 Client Information

This product was tested at the request of the following:

Client Information	
Client Name:	Zurn Water, LLC
Address:	3700 Regency Parkway Suite 100 Cary, NC 27518 USA
Contact:	Malcolm James
Telephone:	+1 (919) 777-6413
Email:	malcolm.james@zurn.com
Manufacturer Information	
Manufacturer Name:	Zurn Water, LLC
Manufacturer Address:	5900 Elwin Buckanan Dr. Sanford, NC 27330 USA

3 Test Equipment Utilized

3.1 ETS-Lindgren Chamber Test Configuration



Measurements are performed using a spectrum analyzer. The dotted line around the EUT represents the 30cm diameter spherical quiet zone.

3.2 ETS-Lindgren Chamber Evaluation Equipment

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Spectrum Analyzer	3065	Rohde & Schwarz	FSP	9/18/2023	9/18/2024
Open Switch & Control Unit	3986	Rohde & Schwarz	OSP-130	Calibration Not Required	Calibration Not Required
Open Switch & Control Unit	3988	Rohde & Schwarz	OSP-150	Calibration Not Required	Calibration Not Required
ETS-Lindgren Axes Controller	5075	ETS-Lindgren	-	Calibration Not Required	Calibration Not Required
ETS-Lindgren Anechoic Chamber	12502	ETS-Lindgren	8500	Calibration Not Required	Calibration Not Required
Horn Antenna	2524	ETS-Lindgren	3164-04	Calibration Not Required	Calibration Not Required

3.3 ETS-Lindgren Chamber Evaluation Software

Name	Manufacturer	Version
Controlling Computer TRP/Conducted	Rohde & Schwarz	AMS32 V11.60.00
FSP	Rohde & Schwarz	V2.80

3.4 ETS-Lindgren Chamber Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)
Radiated Power	617 – 698 MHz	1.40 dB
	699 – 798 MHz	1.34 dB
	814 – 894 MHz	1.20 dB
	1695 – 1780 MHz	1.25 dB
	1850 – 2020 MHz	1.30 dB
	2300 – 2800 MHz	1.50 dB
	3300 – 3800 MHz	1.58 dB
	5150 – 5825 MHz	1.55 dB

Measurement uncertainty correction is not applied to measured values.

4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	EZ Gear Faucet
Model Number	ZG6913
Serial Number	ES11
Receive Date	2/8/2024
Test Start Date	2/28/2024
Test End Date	2/28/2024
Device Received Condition	Good
Test Sample Type	Production
Hardware Version	Rev B
Software Version	Valve – 79 Nordic Radio Test 1.17.1
Description of Equipment Under Test (provided by client)	
Electronic Sensor Faucet	

Embedded Module	
Manufacturer	Nordic
Model Number	nRF52180
Supported Transmit Bands[1]	2400-2483.5MHz
Supported Transmit Modes[1]	Bluetooth Low Energy (BLE)
Supported Transmit Modulations[1]	GFSK
Supported Transmit Bandwidths[1]	1.1MHz, 2.2MHz
Supported Transmit Data Rates[1]	1Mbit/s, 2Mbit/s

4.1 Variant Models:

The following variant models were not tested as part of this evaluation, but have been identified by the manufacturer as being electrically identical models, depopulated models, or with reasonable similarity to the model(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

- ZG6915, ZG6920, ZG6922, ZG6950, ZG6951, ZG6953, ZG6955, and ZG6956 – alternate faucet style with identical electronics

[1] See section 4.1 for actual operating configurations used during testing.

4.2 Operating Configurations

The following bands, modes, modulations, and bandwidths – collectively referred to as 'operating configurations' – and frequencies were identified for test by the client. Deviations from these values may affect performance. Intertek does not make any claims of performance for values other than shown below.

Name	Band	Mode	Modulation	Bandwidth	Frequencies
Symbol	-	-	-	BW	f
Unit	-	-	-	MHz	MHz
Type	Defined	Defined	Defined	Reported	Defined
	2400 - 2483MHz	BLE 1Mbit/s	GFSK	1.1	2402, 2440, 2480
	2400 - 2483MHz	BLE 2Mbit/s	GFSK	2.2	2402, 2440, 2480

4.3 EUT Setup Method:

Configuration as required by IEEE Std 149-2021.

No.	Descriptions of EUT Exercising
1	The EUT was placed on a rotating pedestal in a great circle style fully anechoic chamber (FAC). The EUT was configured to transmit continuously (> 98% duty cycle) in each operating configuration as described in section 4.1. The EUT was rotated on the elevation and azimuth axis and the average power at each point was measured. The total average radiated power was calculated. The antenna characteristics were calculated from the total average radiated power.

Cables						
ID	Description	Length (m)	Shielding	Ferrites	From	To
-	N/A	-	-	-	-	-

5 Measurement of Conducted Output Power

5.1 Method

Tests are performed in accordance with ANSI C63.10.

5.2 Results

Output power measurements for each operating configuration under test from Intertek report 105704106LEX-001 are presented in section 5.4.

5.3 Test Conditions

Test Personnel	Supervising / Reviewing Engineer	Test Date	Ambient Temperature	Relative Humidity	Pressure
Brian Lackey	NA	2/8/2024	23.9°C	20.3%	985.4mbar
Brian Lackey	NA	2/14/2024	23.2°C	21.9%	982.0mbar

5.4 Conducted Output Power Results

Name	Operating Configuration	Frequency |Bandwidth	Average Output Power
Symbol	-	f|BW	P_A
Unit	-	MHz	dBm
Type	Defined	Defined	Reported
Source	(§ 4.1) Pg. 8	(§ 4.1) Pg. 8	Intertek report 105704106LEX-001 § 7
	BLE 1Mbit/s	2402 | 1.1	1.93
		2440 | 1.1	1.59
		2480 | 1.1	1.53
	BLE 2Mbit/s	2402 | 2.2	2.07
		2440 | 2.2	1.80
		2480 | 2.2	1.62

6 Measurement of Total Radiated Power and Radiation Patterns

6.1 Method

Tests are performed by measuring the average phi and theta TRP over the sphere in 15-degree increments. Radiation pattern plots are prepared in accordance with IEEE Std 149-2021 Clause 7.

6.2 Test Site

See section 3.1 for TRP testing performed in the ETS-Lindgren chamber. See section 2 for the test equipment, software used, and measurement uncertainty.

6.3 Results:

Measurements of the total radiated power and radiation patterns are shown in section 6.4.

6.4 Test Conditions

Test Personnel	Supervising / Reviewing Engineer	Test Date	Ambient Temperature	Relative Humidity	Pressure
Ryan Claypool	NA	2/28/2024	24.5°C	37.3%	985.4mbar

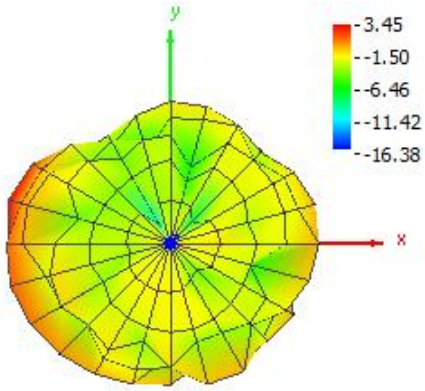
6.5 Total Radiated Power Results and Radiation Patterns

Name	Operating Configuration	Frequency |Bandwidth	Position of Maximum Average EIRP	Maximum Average EIRP	Average TRP
Symbol	-	f|BW	θ_{max} / ϕ_{max}	$EIRP_{max,dBm}$	$P_{R,dBm}$
Unit	-	MHz	°, °	dBm	dBm
Type	Defined	Defined	Measured	Calculated	Calculated
Source	(§ 4.1) Pg. 8	(§ 4.1) Pg. 8	-	-	-
	BLE 1Mbit/s	2402 | 1.1	90/165	3.45	-1.51
		2440 | 1.1	90/180	1.86	-2.02
		2480 | 1.1	90/180	0.83	-2.23
	BLE 2Mbit/s	2402 | 2.2	90/180	3.04	-1.15
		2440 | 2.2	135/0	2.07	-1.29
		2480 | 2.2	135/0	0.83	-2.51

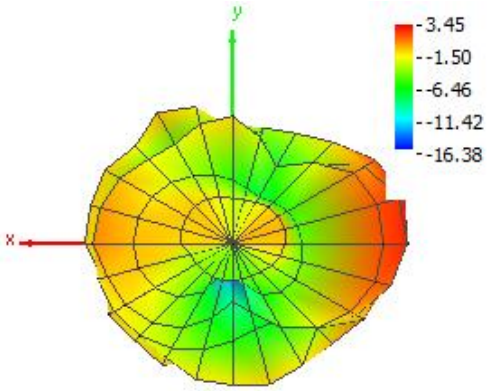
6.6 Radiated Patterns (BLE 1Mbit/s)

6.6.1 2402MHz

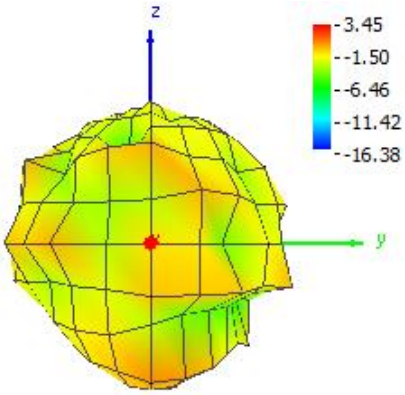
Theta = 0, Phi = 0



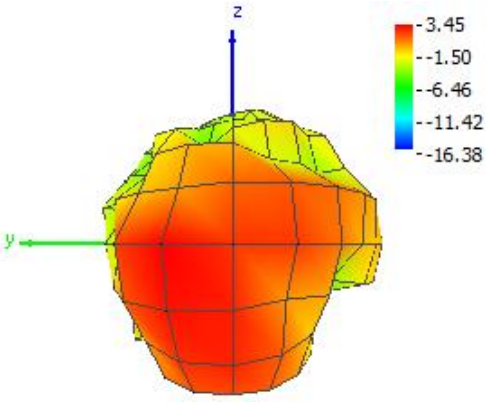
Theta = 180, Phi = 0



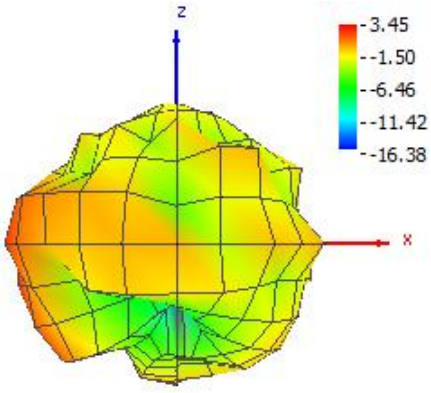
Theta = 90, Phi = 0



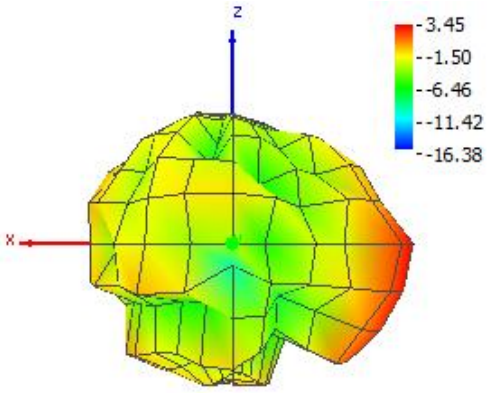
Theta = 90, Phi = 180



Theta = 90, Phi = 270

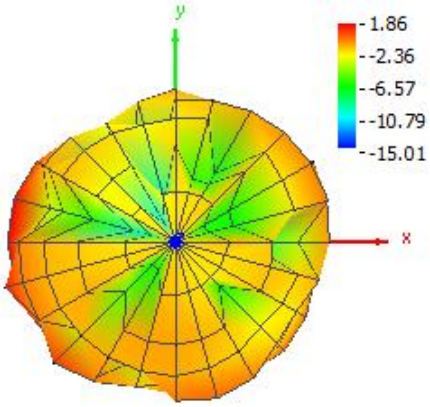


Theta = 90, Phi = 90

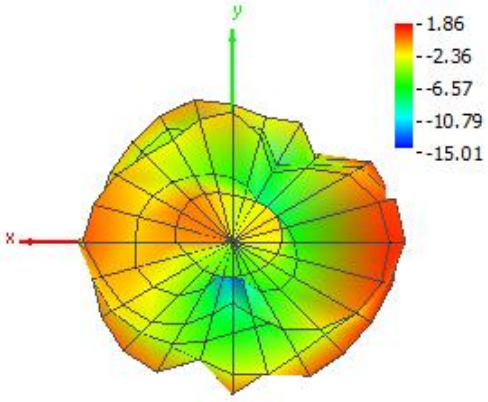


6.6.2 2440MHz

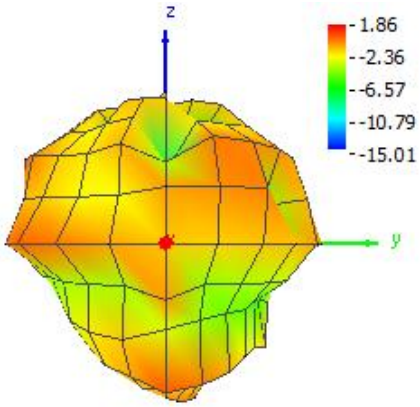
Theta = 0, Phi = 0



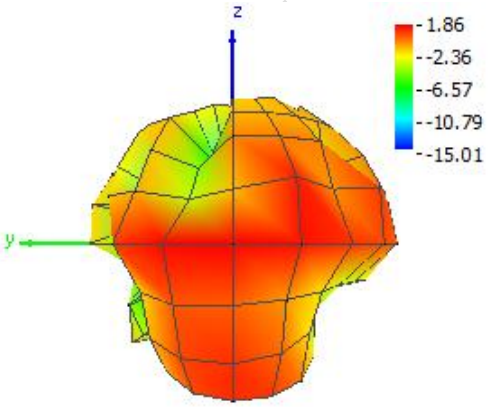
Theta = 180, Phi = 0



Theta = 90, Phi = 0



Theta = 90, Phi = 180



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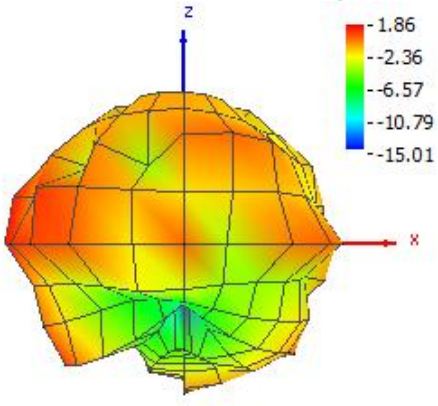
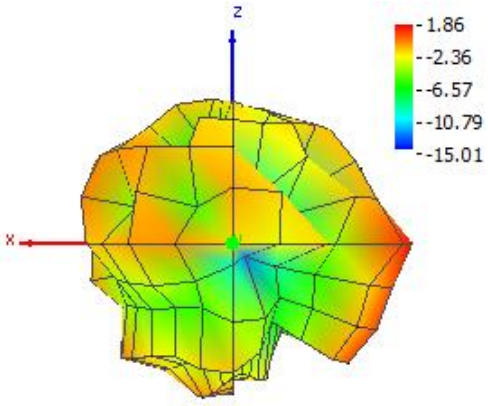
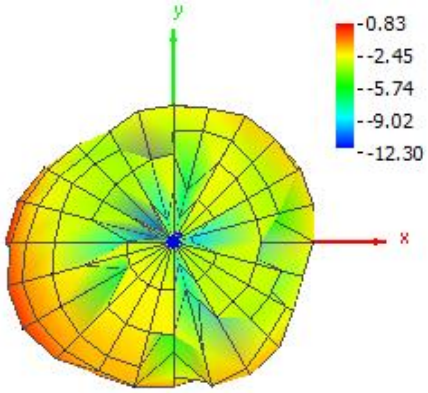


Theta = 90, Phi = 90

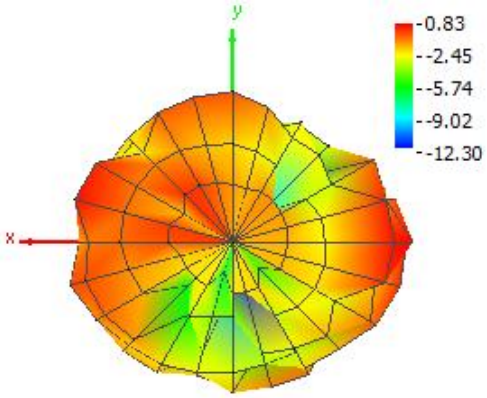


6.6.3 2480MHz

Theta = 0, Phi = 0



Theta = 180, Phi = 0



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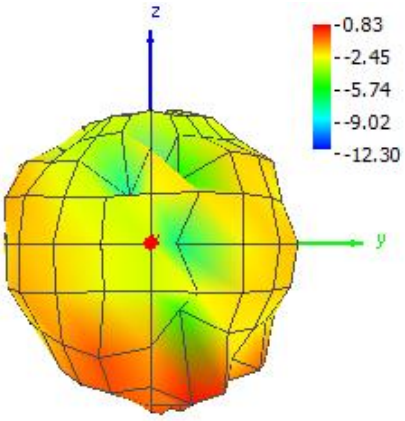

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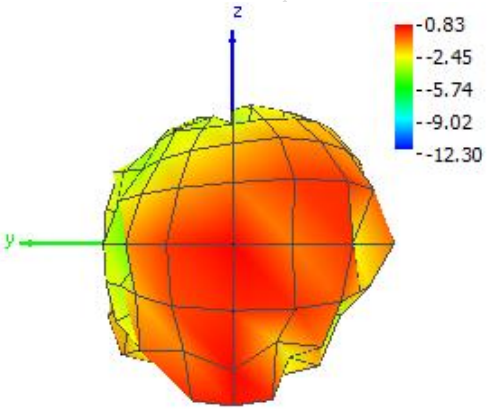
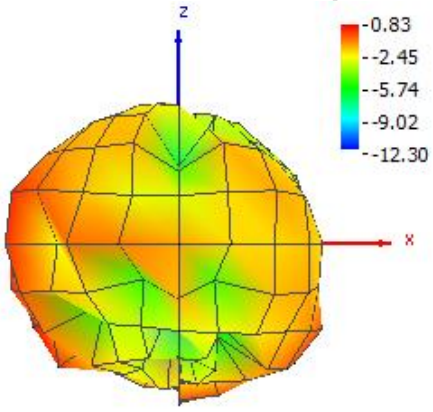
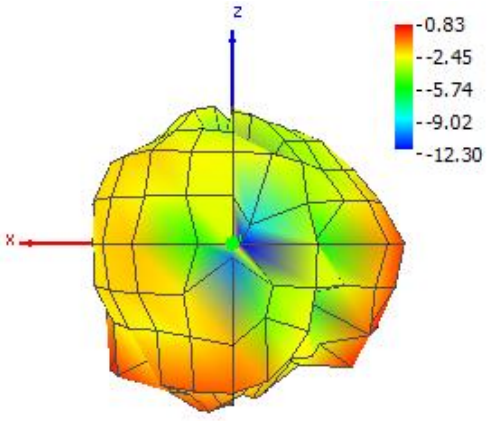


Theta = 90, Phi = 270



Theta = 90, Phi = 90



6.7 Radiated Patterns (BLE 2Mbit/s)

6.7.1 2402MHz

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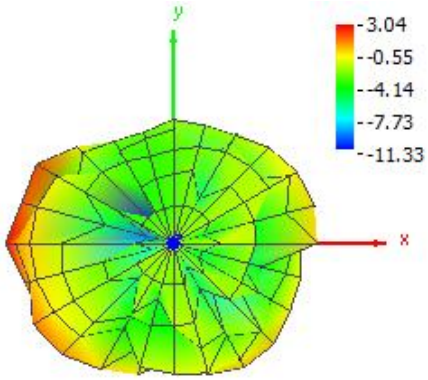
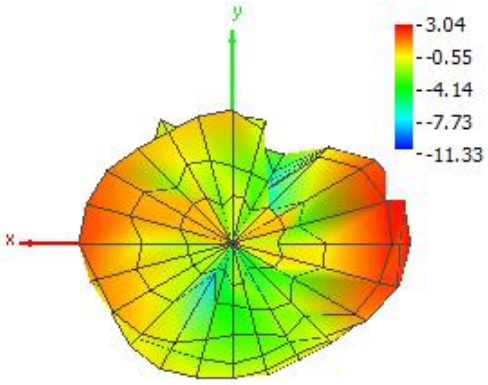
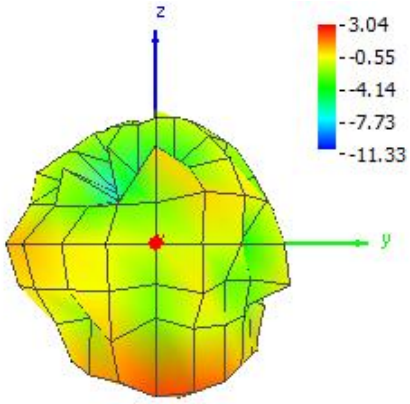


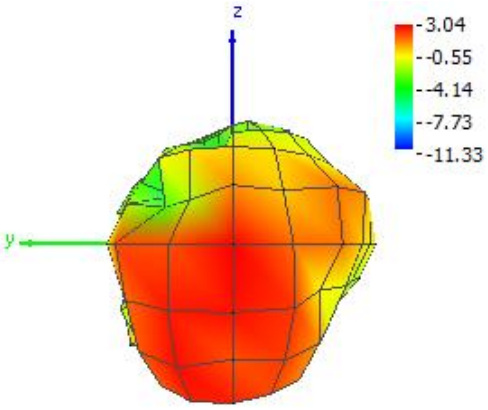
Theta = 180, Phi = 0



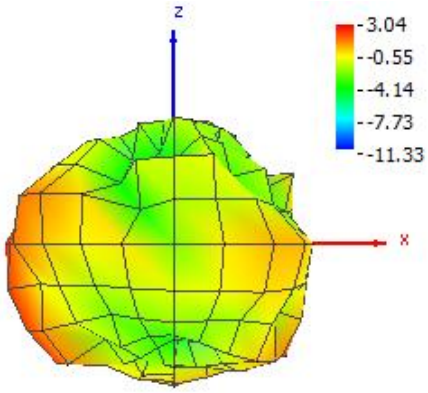
Theta = 90, Phi = 0



Theta = 90, Phi = 180



Theta = 90, Phi = 270



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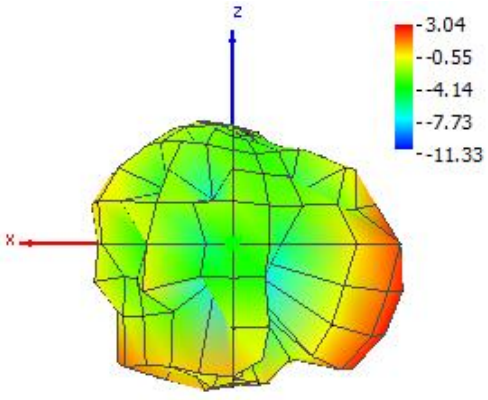
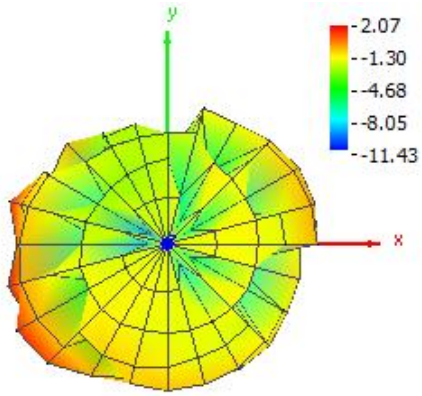


6.7.2 2440MHz

Theta = 0, Phi = 0



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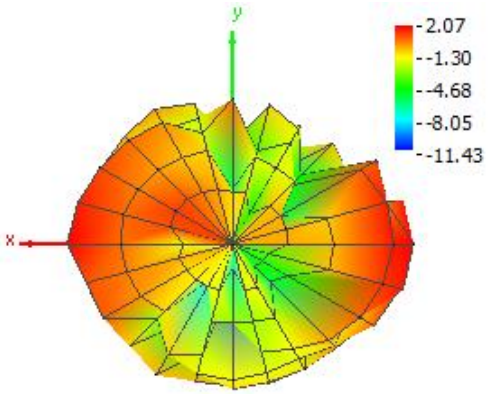

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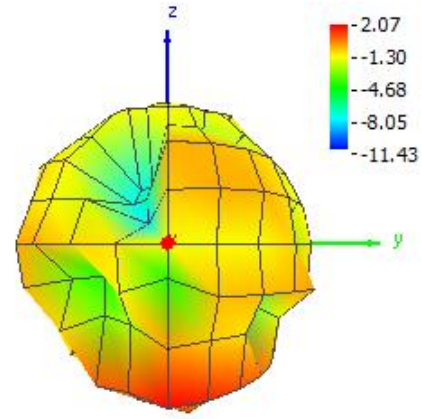

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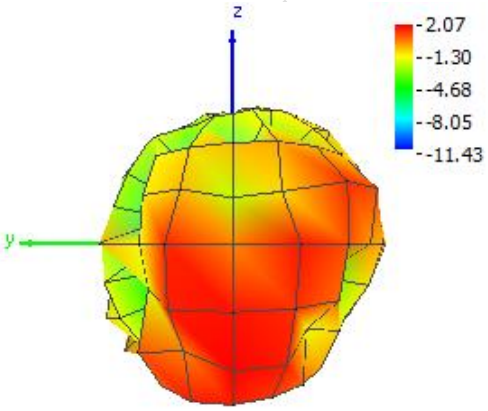
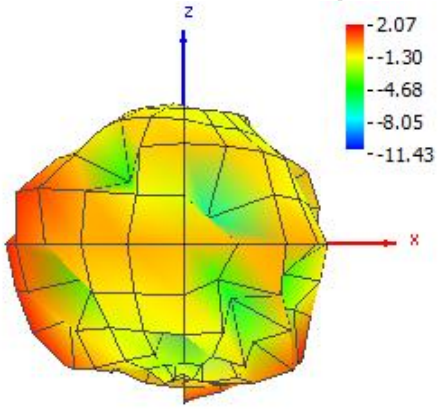


Theta = 90, Phi = 270



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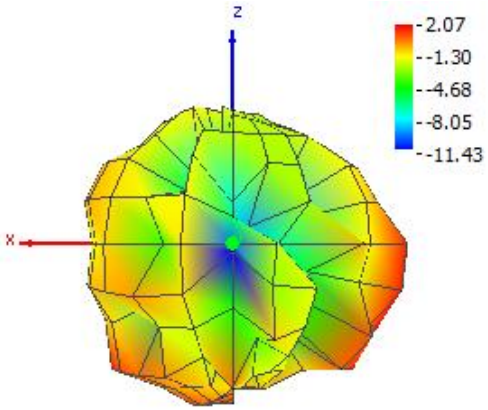

6.7.3 2480MHz

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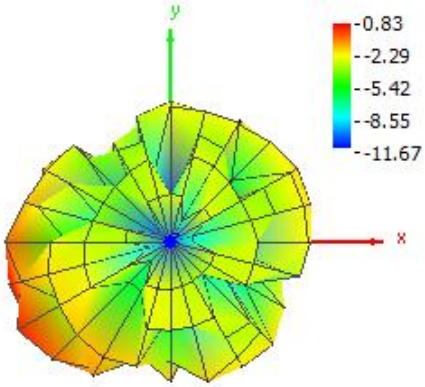

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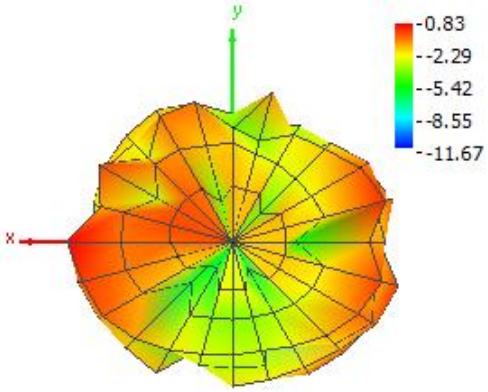
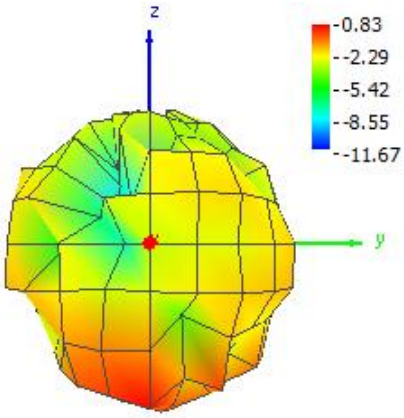
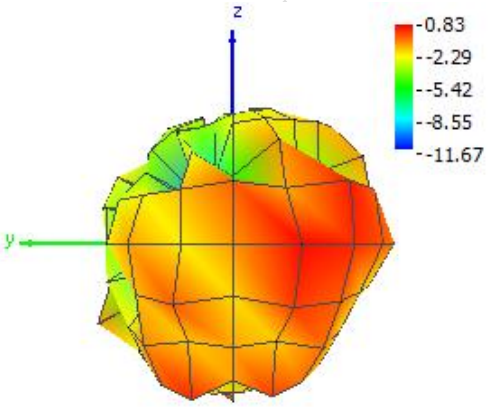


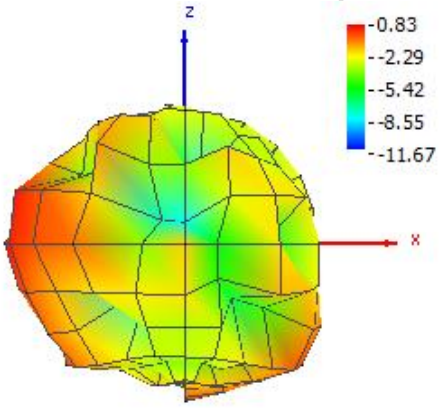
Theta = 90, Phi = 0



Theta = 90, Phi = 180



Theta = 90, Phi = 270



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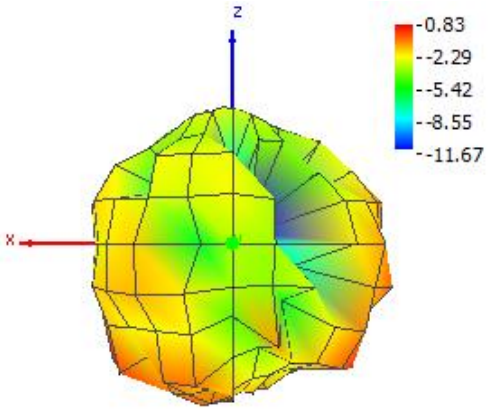

7 Calculation of Gain and Directivity

7.1 Method

Tests are performed in accordance with IEEE Std 149-2021 Clause 8. For devices without access to the antenna terminal, the realized gain is presented. The maximum directivity is calculated as the ratio of the maximum average EIRP to the average total radiated power. The maximum realized gain is calculated as the ratio of the maximum average EIRP to the average power at the antenna terminal.

7.2 Results:

The maximum realized gain and directivity are reported in section 7.3.

7.3 Plots/Data: Gain and Directivity

Name	Operating Configuration	Frequency |Bandwidth	Average Power at Antenna Terminal	Average Total Radiated Power	Maximum Average EIRP	Maximum Directivity	Maximum Realized Gain
Symbol	-	f|BW	$P_{M,dBm}$	$P_{R,dBm}$	$EIRP_{max,dBm}$	$D_{max,dBi}$	$G_{R,max,dBi}$
Unit	-	MHz	dBm	dBm	dBm	dBi	dBi
Type	Defined	Defined	Reported	Reported	Reported	Calculated	Calculated
Source	(§ 4.1) Pg. 8	(§ 4.1) Pg. 8	(§ 5.2) Pg. 11	(§ 6.4) Pg. 12	(§ 6.4) Pg. 12	-	-
	BLE 1Mbit/s	2402 | 1.1	1.93	-1.51	3.45	4.96	1.52
		2440 | 1.1	1.59	-2.02	1.86	3.88	0.27
		2480 | 1.1	1.53	-2.23	0.83	3.06	-0.70
	BLE 2Mbit/s	2402 | 2.2	2.07	-1.15	3.04	4.19	0.97
		2440 | 2.2	1.80	-1.29	2.07	3.36	0.27
		2480 | 2.2	1.62	-2.51	0.83	3.34	-0.79

8 Calculation of Radiation Efficiency

8.1 Method

Tests are performed in accordance with IEEE Std 149-2021 Clause 10. Realized radiation efficiency is calculated as the ratio of maximum realized gain to maximum directivity.

8.2 Results:

The radiation efficiency is reported in section 8.3.

8.3 Plots/Data: Radiation Efficiency

Name	Operating Configuration	Frequency |Bandwidth	Maximum Directivity	Maximum Realized Gain	Realized Radiation Efficiency
Symbol	-	f|BW	$D_{max,dBi}$	$G_{R,max,dBi}$	η_R
Unit	-	MHz	dBi	dBi	% (dB)
Type	Defined	Defined	Reported	Reported	Calculated
Source	(§ 4.1) Pg. 8	(§ 4.1) Pg. 8	(§ 7.3) Pg. 19	(§ 7.3) Pg. 19	-
	BLE 1Mbit/s	2402 | 1.1	4.96	1.52	45.29% (-3.44dB)
		2440 | 1.1	3.88	0.27	43.55% (-3.61dB)
		2480 | 1.1	3.06	-0.70	42.07% (-3.76dB)
	BLE 2Mbit/s	2402 | 2.2	4.19	0.97	47.64% (-3.22dB)
		2440 | 2.2	3.36	0.27	49.09% (-3.09dB)
		2480 | 2.2	3.34	-0.79	38.64% (-4.13dB)

9 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	4/12/2024	105704106LEX-012	BL	MC	Original Issue