Testing Tomorrow's Technology

Application

For

Title 47 USC Part 2, Subpart J, Paragraph 2.907, 2.1043 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, Paragraphs 15.207, 15.209 and 15.249

And

Innovation, Science, and Economic Development Canada Certification per RSS-210 Issue 10: License-Exempt Radio Apparatus: Category I Equipment and RSS-Gen Issue 5: General Requirements for Compliance of Radio Apparatus

For

Den Smart Home
Model: DEN SMARTSTRIKE
FCC ID: 2BDVS-ZWBLE1US
IC: 31766-ZWBLE1US

UST Project: 23-0267
Issue Date: February 2, 2024

Total Pages in This Report: 30

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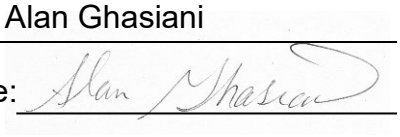
Testing Tomorrow's Technology

I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Consulting Engineer – President

Date: February 2, 2024

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MEASUREMENT TECHNICAL REPORT

Company Name:	Den Smart Home
Address:	228 E 45th St #9E New York, New York
Model:	DEN SMARTSTRIKE
FCC ID:	2BDVS-ZWBLE1US
IC ID:	31766-ZWBLE1US
Date:	February 2, 2024

This report concerns (check one): ☒ Original ☐ Class II Permissive Change

Equipment type: Bluetooth and 904 MHz ISM Radio Transceiver

Technical Information:

Radio Technology:	900MHz ISM band
Frequency of Operation (MHz):	904-926 MHz
Output Power (dBuV):	93.02 dBuV
Type of Modulation:	GFSK
Data/Bit Rate (M)bps:	100kBit/s
Antenna Gain (dBi):	+3.0 dBi
Software used to program EUT:	RAILtest (Simplicity Studio 5)
EUT firmware:	Z-Wave: V1.4.01
Power setting:	(Max)

Report prepared by:

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FCC Agency Agreement
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IC RSS to 15.249 Cross Reference
Confidentiality Request Letter
Test Configuration Photographs
External Photographs
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Confidential Schematics
Confidential Theory of Operation
Confidential Block Diagram
User Manual
Sample Label

1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to the FCC Rules and Regulations Part 15, Section 249.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on December 8, 2023 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Den Smart Home model DEN SmartStrike. The DEN SmartStrike is a smart lock that utilizes Bluetooth and 900 MHz Z-Wave technology to allow users to access their indoor spaces. A consumer would install the lock into the door frame by the handle to the door, establish the electrical connections, and download the corresponding app and from then on will enjoy easy, technology-enhanced access to their building.

The Bluetooth module, BGM220S22A is a FCC & IC certified module bearing FCC ID: QOQ-BGM220S2, IC: 5123A-BGM220S2 Consequently, testing was only needed for the 900 MHz radio. This test report contains the test results for the 900 MHz radio testing.

The EUT operates on two AA batteries, 1.5VDC each.

The rated output power for this device is +6.0 dBm
Type of modulation: GFSK
Data Rate: 100kBit/s

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2014 and ANSI C63.4:2013, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz* for FCC subpart A Digital equipment Verification requirements and per *ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for FCC subpart C Intentional Radiators.

A list of EUT and Peripherals is found in Table 1. A block diagram of the tested system is shown in Figure 1. Test configuration photographs are provided in separate Appendices.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is US5301. Additionally this site has also been fully described and submitted to Industry Canada (ISED), and has been approved under file number 9900A-1.

1.6 Related Submittals

The EUT is subject to the following FCC authorizations:

a) Certification under section 15.207 and 15.209 as a transmitter.
b) SDoC under 15.101 as a digital device.

The SDoC requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the SDoC authorization report (Parts 15.107 and 15.109) for the EUT is included herein.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID	CABLES P/D
EUT/ Den Smart Home.	DEN SMARTSTRIKE	Engineering Sample	Pending: FCC ID: 2BDVS-ZWBLE1US Pending IC: 31766-ZWBLE1US	N/A

U= Unshielded S= Shielded P= Power D= Data

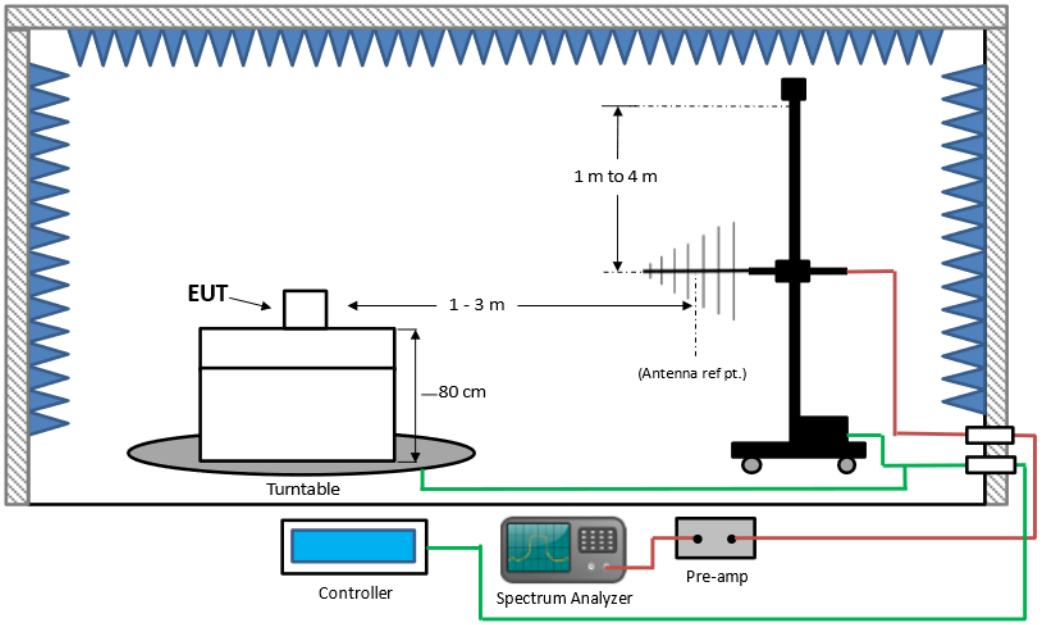

Figure 1. Block Diagram of Test Configuration

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are indicated.

Table 2. Test Instruments

TEST INSTRUMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CALIBRATION DUE DATE
Spectrum Analyzer	Agilent	E4440A	US41442935	9/21/2024 2 yr.
RF Preamp 100 kHz to 1.3 GHz	Hewlett-Packard	8447D	1937A02980	5/27/2024
Preamp 1.0 GHz to 26.0 GHz	Hewlett-Packard	8449B	3008A00914	3/3/2024
Loop Antenna 9 kHz – 30 MHz	EMCO	6502	9810-3246	12/7/2024
BicoLOG Antenna 30 MHz to 1 GHz	AARONIA AG	BicoLOG 20100E	20400600036	9/25/2025 2 yr
Log Periodic Antenna 200 MHz to 1 GHz	EMCO	3146	9110-3236	1/13/2024
Horn Antenna 1 GHz to 18 GHz	A. H. Systems	SAS-571	605	5/9/2025 2 yr
High Pass Filter 6 GHz to 18 GHz	Microwave Circuits	H3R020G2	001DC9528	8/2/2024
High Pass Filter 1700 MHz to 3800 MHz	Mini-Circuits Inc.	VHF-1320 15542	30843	8/2/2024

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

2.2 Modifications to EUT Hardware

No physical modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in Table 3 below.

Table 3. Number of Test Frequencies for Intentional Radiators

Frequency Range over which the device operates	Number of Frequencies	Location in the Range of operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

Because the EUT operates at 904 MHz, 3 test frequencies were used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10th harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz, or to 5 times the highest internal clock frequency.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the parameters outlined following.

2.5.1 Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR Quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the quasi-peak device are used.

2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

2.5.3 Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may be expressed logarithmically in dB.

NOTE: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG), the duty cycle factor calculated will be applied.

2.6 Transmitter Duty Cycle (CFR 15.35 (c))

When the radiated emissions limits are expressed in terms of AVERAGE values and pulse operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals as long as the pulse train does not exceed 0.1 seconds. In cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value.

In this case the Duty Cycle was calculated. The calculation for the Duty Cycle factor is included in the Theory of Operation exhibit.

2.7 EUT Antenna Requirements (CFR 15.203)

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. Only the antenna(s) listed in Table 4 will be used with this module.

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
Antenna	Den Smart	Wire Antenna	N/A	+3.0	Soldered

2.8 Restricted Bands of Operation (CFR 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious emissions cannot exceed the limits of 15.209. Radiated Harmonics and other Spurious Emissions are examined for this requirement; see paragraph 2.1.

2.9 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.249(a)(c)) (IC RSS 210, A2.9 (a))

Radiated Radio measurements: the EUT was placed into a continuous transmit mode of operation and a preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the product. To obtain the worst case results, the EUT was placed on a table top of a non-conductive table, 80 cm above the ground floor. The EUT was positioned 3 meters away from the receiving antenna during testing (1 meter at frequencies above 6 GHz and if the emissions were less than 6 dB from the noise floor). The EUT was tested in X, Y and Z axes or the position of normal operation to determine the worst case orientation. Radiated measurements below 30 MHz were tested with a RBW = 9 kHz; emissions below 1 GHz were tested with a RBW = 120 kHz and radiated measurements above 1 GHz were measured using a RBW =1 MHz. VBW was set to three times the RBW value.

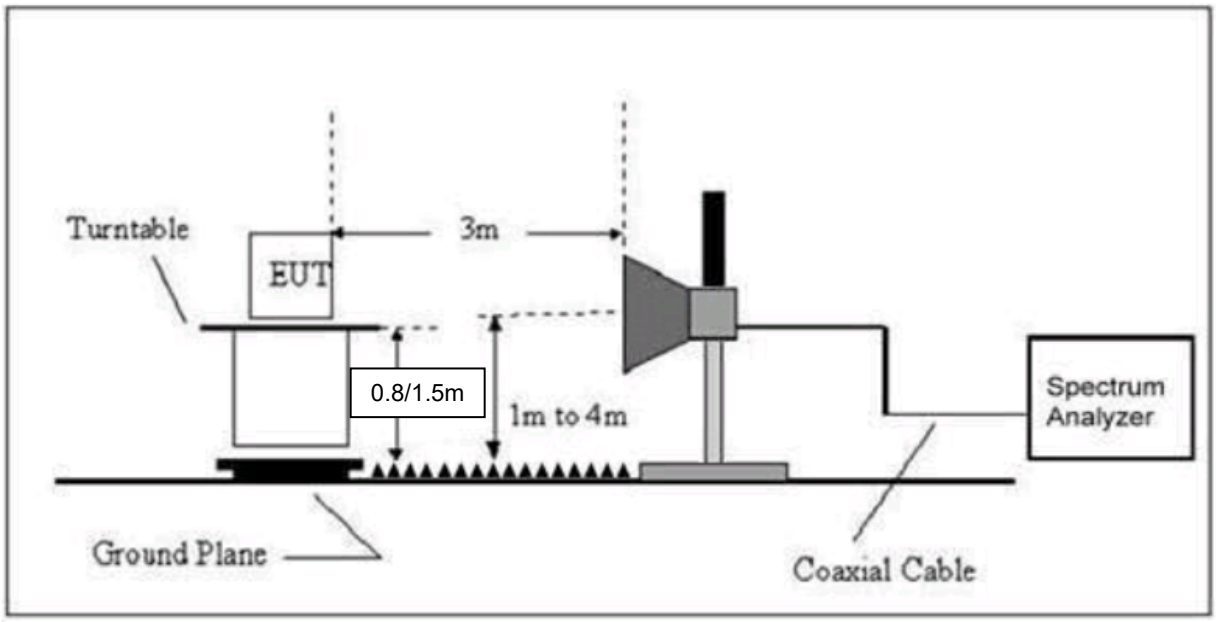

Figure 2. Radiated Emissions Setup (Fundamental and Harmonics)

Note: measurements below 1 GHz were performed at a EUT height of 80cm from the GRP while measurements above 1 GHz were performed at a EUT height of 1.5m from the GRP.

All measurements recorded in the table below were collected using Peak Detection. The Peak values meet AVG limits.

Table 5. Radiated Fundamental & Harmonic Emissions

Test: Part 15C, Para 15.249								
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector**
Low Channel								
904.00	67.18	0.0	26.06	93.24	94.0	3m./HORZ	0.8	**PK**
1808.09	41.53	0.0	-9.52	32.01	54.0	3.0m./HORZ	22.0	**PK**
2714.29	33.74	0.0	-4.91	28.83	54.0	3.0m./HORZ	25.2	**PK**
3617.43	39.05	0.0	-2.83	36.22	54.0	3.0m./HORZ	17.8	**PK**
Mid Channel								
916.00	64.52	0.0	26.26	90.78	94.0	3m./HORZ	3.2	**PK**
1831.88	36.21	0.0	-9.30	26.91	54.0	3.0m./HORZ	27.1	**PK**
2749.37	39.50	0.0	-4.99	34.51	54.0	3.0m./HORZ	19.5	**PK**
3664.06	37.24	0.0	-2.72	34.52	54.0	3.0m./HORZ	19.5	**PK**
High Channel								
926.00	66.15	0.0	26.34	92.49	94.0	3m./HORZ	1.5	**PK**
1847.25	38.26	0.0	-9.19	29.07	54.0	3.0m./HORZ	24.9	**PK**
2771.82	35.71	0.0	-5.08	30.63	54.0	3.0m./HORZ	23.4	**PK**
3695.32	39.90	0.0	-2.95	36.95	54.0	3.0m./HORZ	17.1	**PK**

1. (*) Falls within the restricted bands of CFR 15.205.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. Measurement at 1 meters corrected using inverse extrapolation factor of to correct the value for 3 meter.

Sample Calculation at 904.00 MHz:

Magnitude of Measured Frequency	67.18	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	26.06	dB/m
Corrected Result	93.24	dBuV/m

Test Date: December 11-19, 2023

Tested By
Signature: Elliott T. Chaves

Name: Elliott T. Chaves

2.10 Band Edge Measurements – (CFR 15.249 (d))

Band Edge measurements are made following the guidelines in FCC KDB Publication No. 558074 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Radiated measurements are performed to demonstrate compliance with the requirement of 15.249(d) that all emissions outside of the band edges be attenuated by at least 50 dB or 15.209 limits, when compared to its highest in-band value (contained in a 100 kHz band).

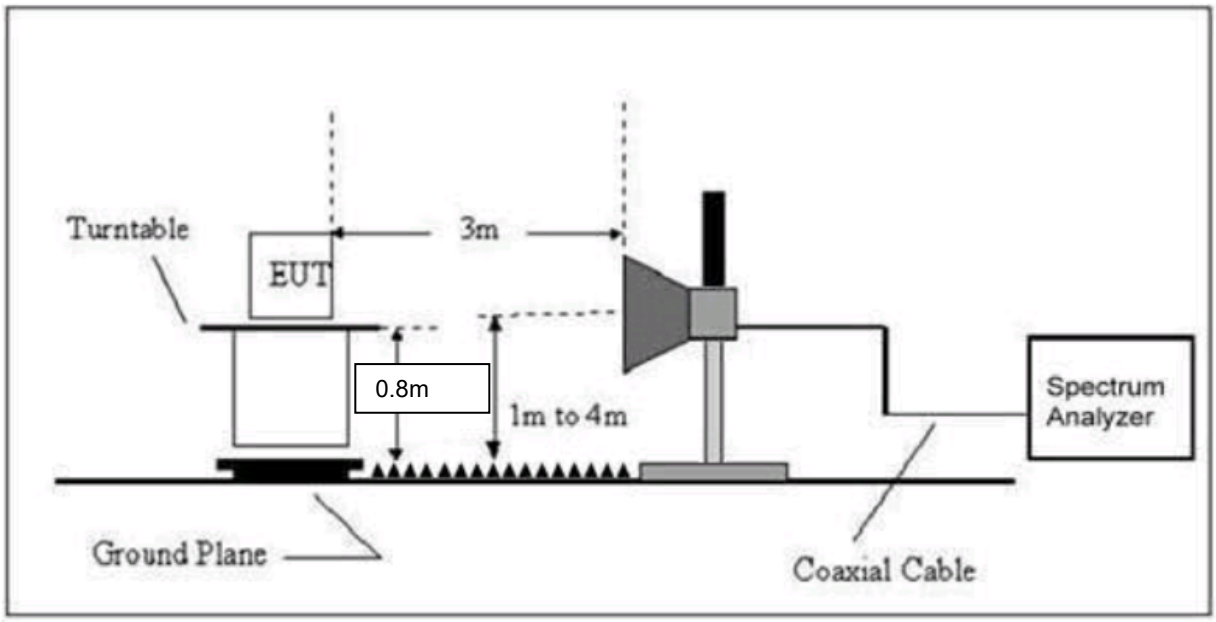

Figure 3. Radiated Emissions Setup
(Radiated Bandedge & Restricted Band)

Test Date: December 13, 2023 & February 2, 2024

Tested By
Signature: Elliott T. Chaves Name: Elliott T. Chaves

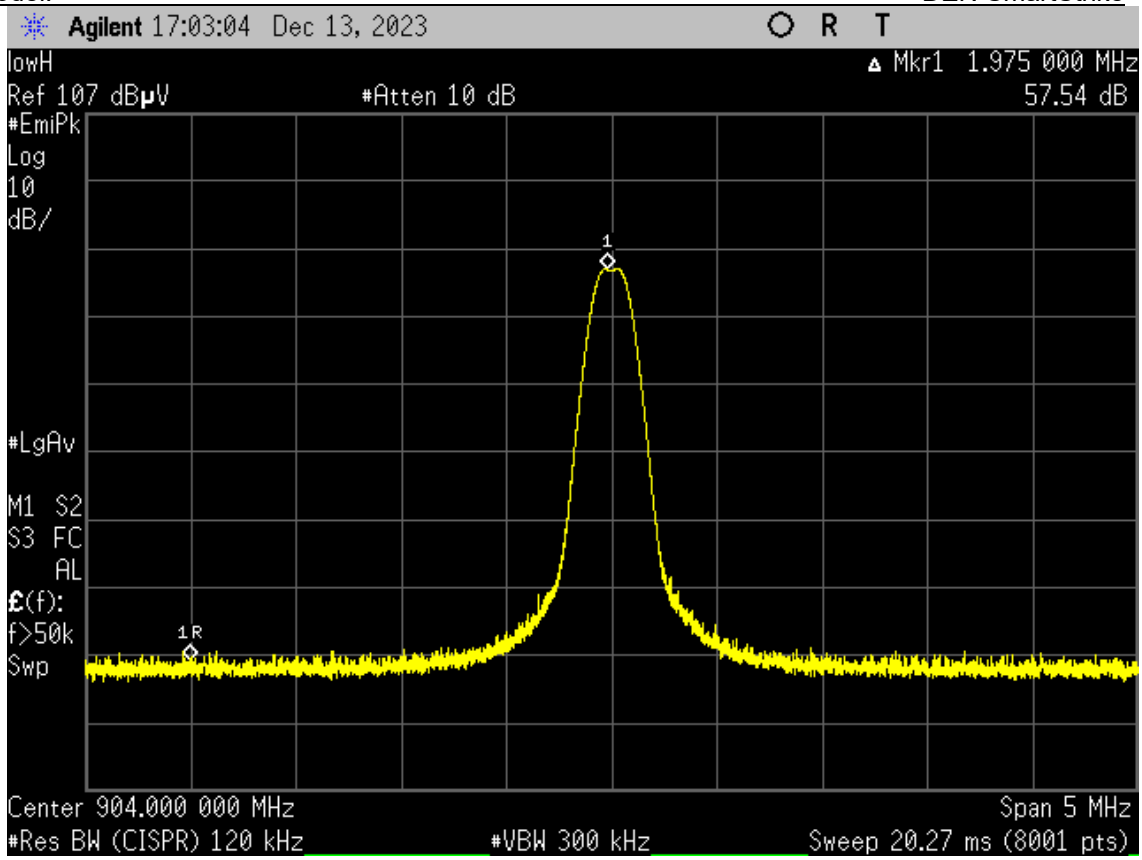

Figure 4. Band Edge Compliance - Low Channel Delta - Peak

Lower band edge must be 50 dB below the fundamental. This requirement is met.

Measured Result	57.54	dB
Band Edge Limit	-50.00	dB
Band Edge Margin	7.54	dB

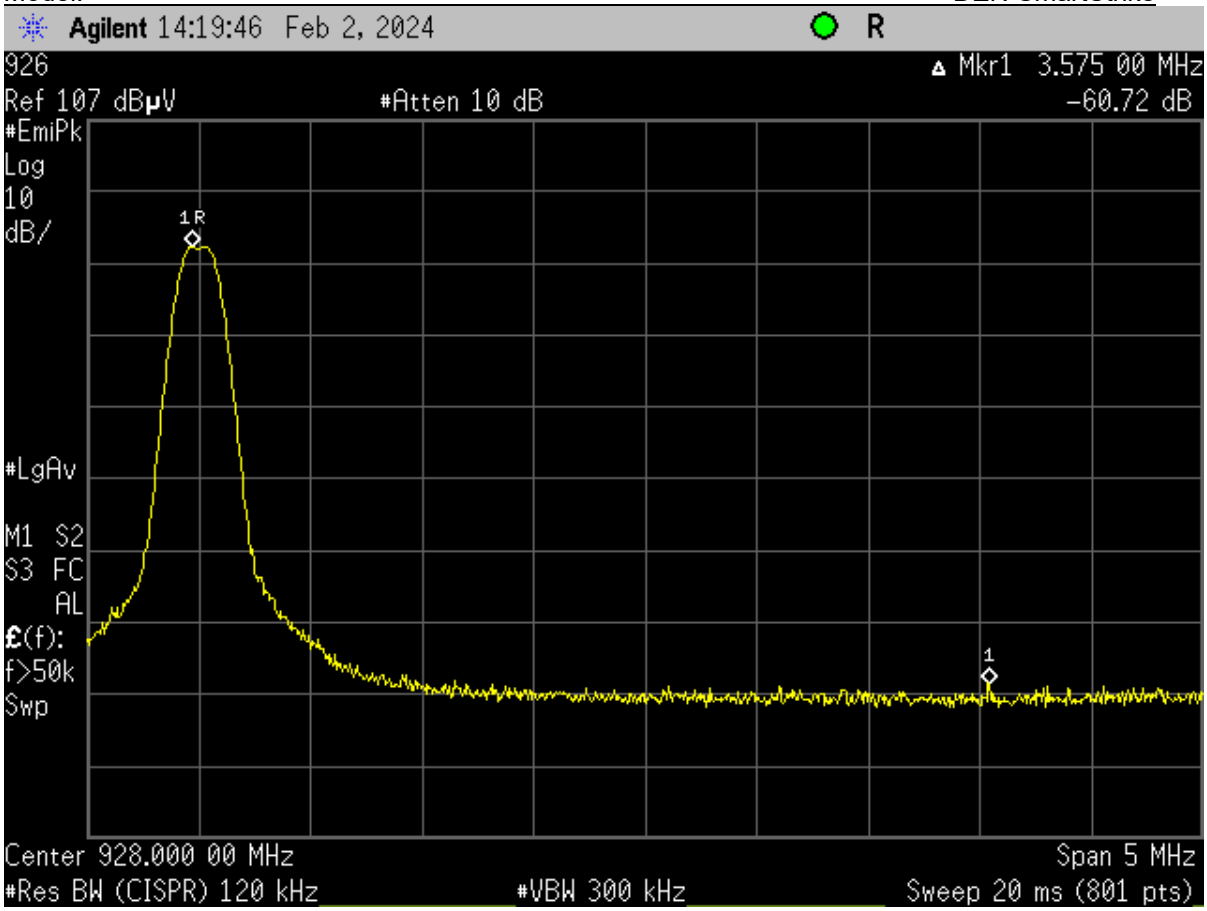

Figure 5. Band Edge Compliance - High Channel Delta – Peak

Lower band edge must be 50 dB below the fundamental. This requirement is met.

Measured Result	60.72	dB
Band Edge Limit	-50.00	dB
Band Edge Margin	10.72	dB

2.11 Occupied Bandwidth (CFR 2.1049)

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.

Figure 6. Bench Test Setup

Table 6. Occupied Bandwidth

Frequency (MHz)	Occupied Bandwidth (MHz)
904.0	0.11335
916.0	0.11333
926.0	0.11322

Test Date: December 13, 2023 & February 2, 2024

Tested By
Signature: Elliott T. Chaves Name: Elliott T. Chaves

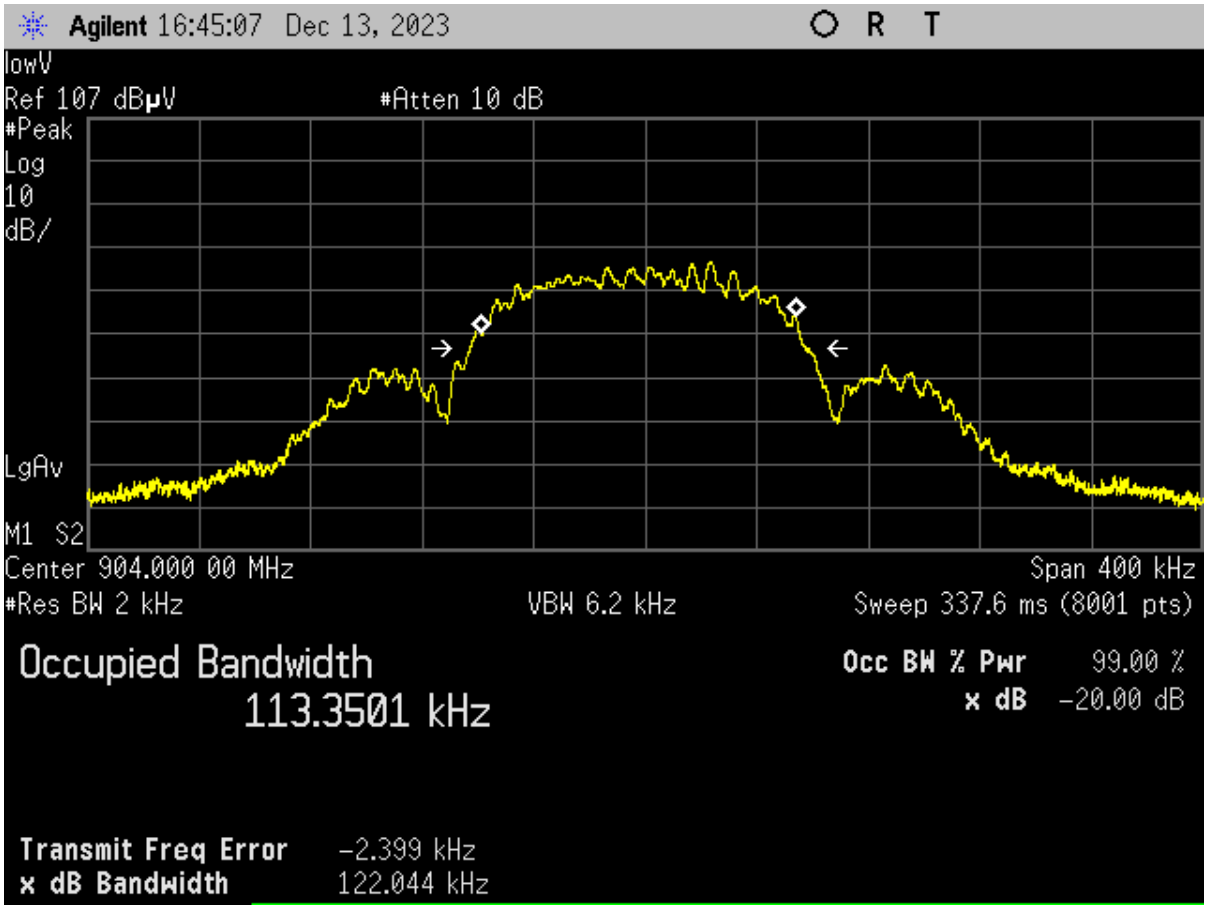

Figure 7. 99% Occupied Bandwidth Low Channel

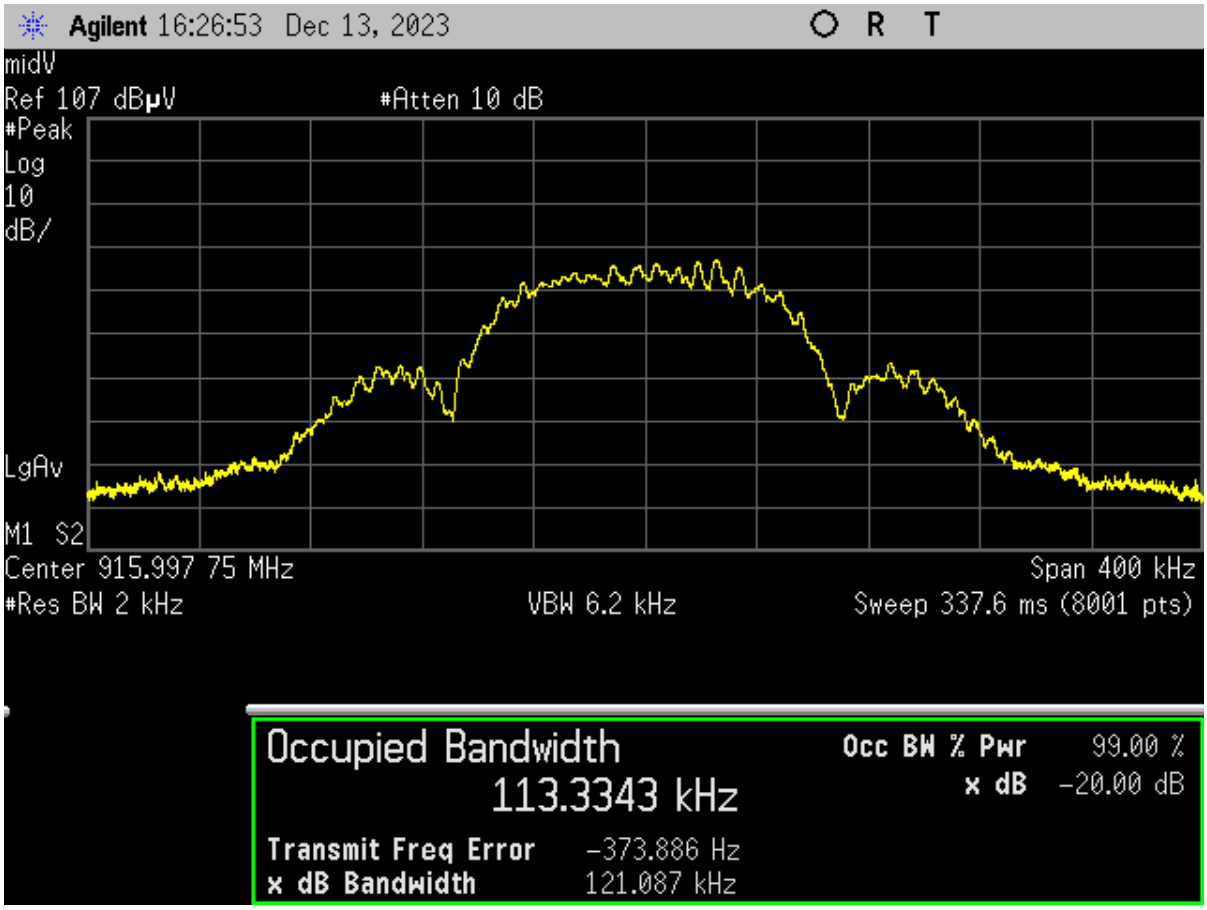

Figure 8. 99% Occupied Bandwidth Mid Channel

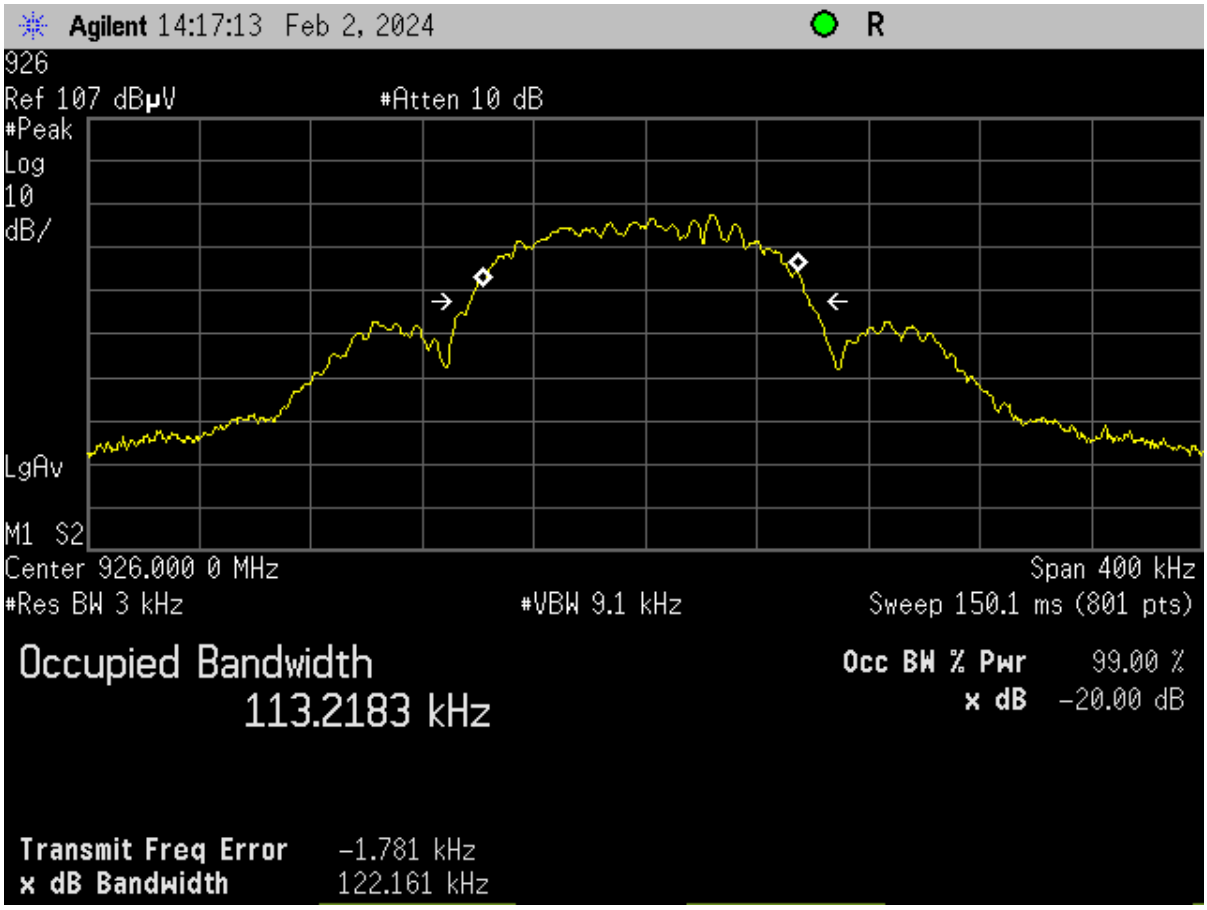

Figure 9. 99% Occupied Bandwidth High Channel

2.12 Powerline Emissions (CFR 15.207)

The power line conducted voltage emission measurements have not been carried out in accordance with CFR 15.207, per ANSI C63.4:2014, Paragraph 7, because the unit is battery-powered.

2.13 Intentional Radiator, Radiated Emissions (CFR 15.209)

Radiated emissions disturbance Measurements were performed with an instrument having both peak and quasi-peak detectors over the frequency range of 9 KHz to 12.5 GHz. Measurements of the radiated emissions were made with the receiver antenna at a distance of 3 m from the boundary of the test unit.

The test antenna was varied from 1 m to 4 m in height while watching the analyzers' display for the maximum magnitude of the signal at the test frequency. The antenna polarization (horizontal or vertical) and test sample azimuth were varied during the measurements to find the maximum field strength readings to record.

2.14 Collocation Testing

During spurious emissions testing both the 900 MHz ISM and 2.4 GHz ISM radio were on and transmitting as normally intended. The results below show no increase in spurious emissions due to intermodulation effects or other effects as a result of having both radios ON and operating simultaneously. The results do not warrant additional testing beyond the testing collected below.

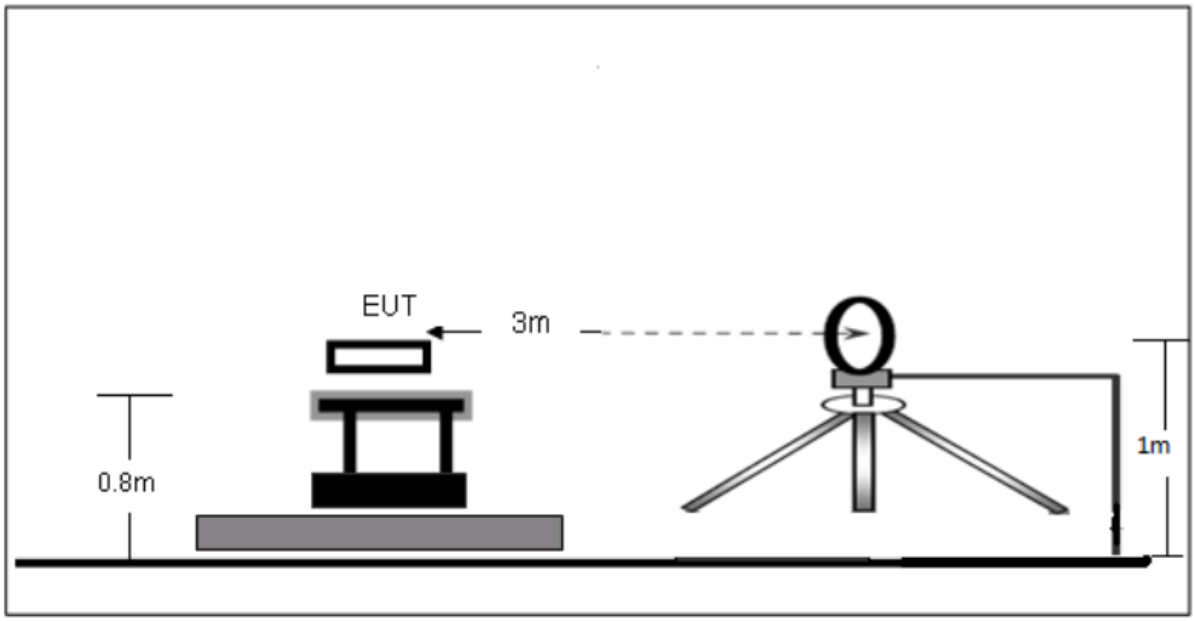

Figure 10. Test Configuration below 30 MHz

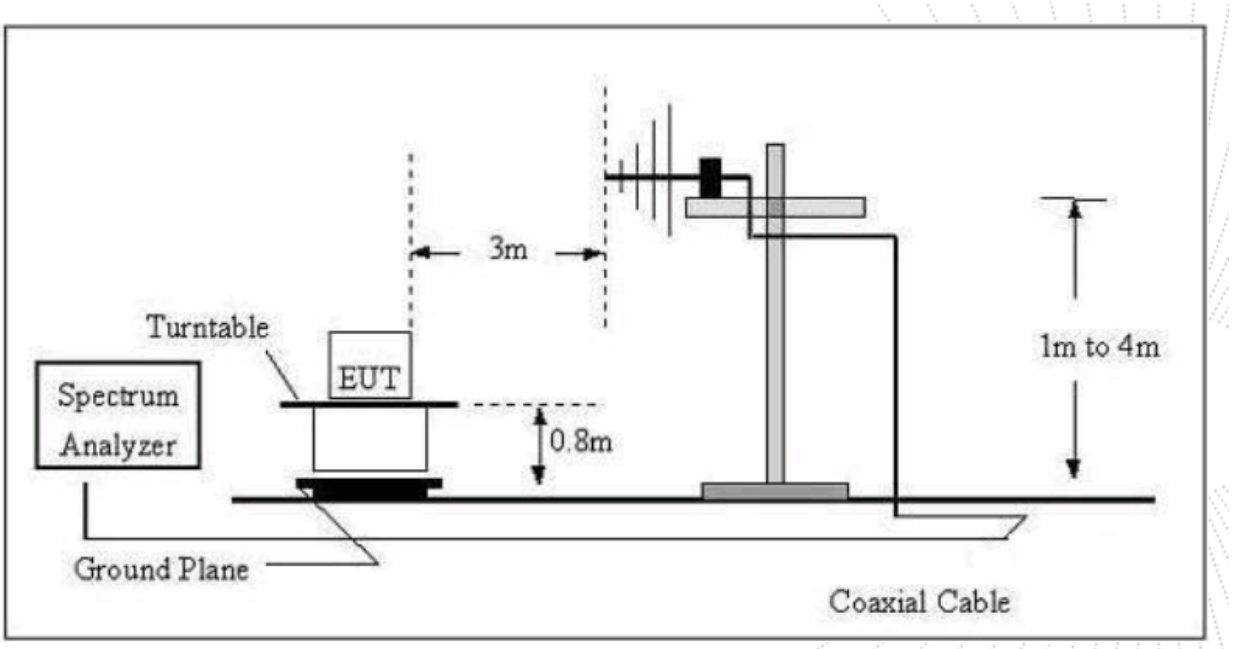

Figure 11. Test Configuration below 1000 MHz

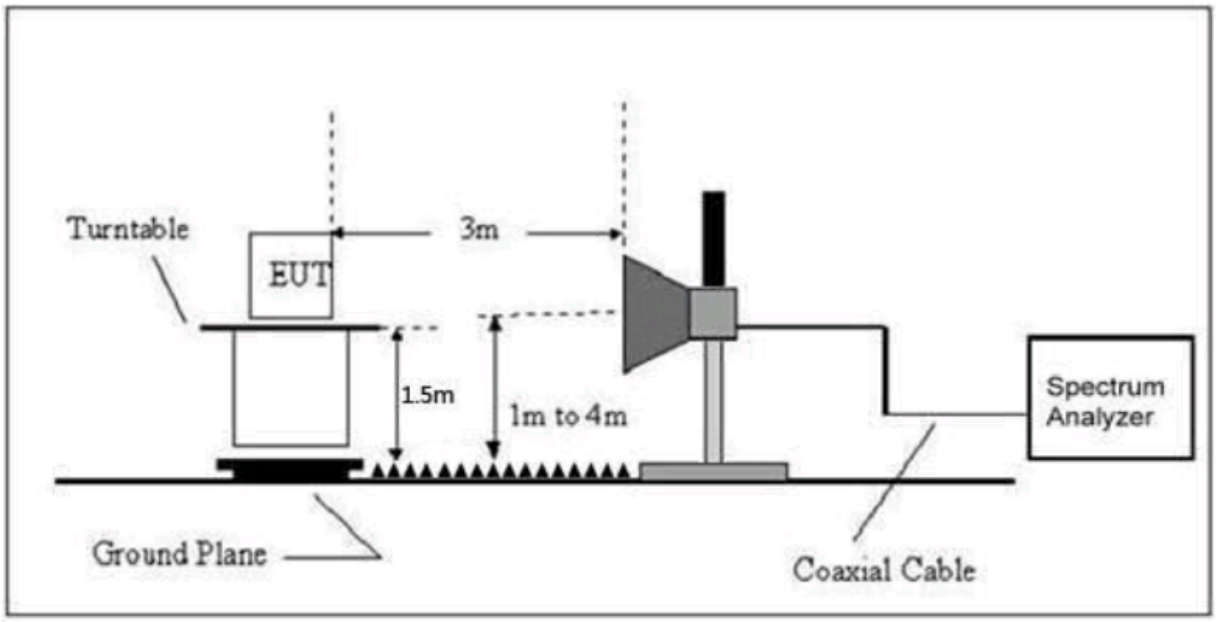

Figure 12. Test Configuration above 1000 MHz

Table 7. Radiated Emissions, 9 kHz - 30 MHz

9 kHz to 30 MHz, 15.209 limits							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
All emissions more than 20 dB below the applicable limit.							

Sample Calculations: N/A

Test Date: December 11-19, 2023

Tested By
Signature: Elliott T. Chaves Name: Elliott Chaves

Table 8. Spurious Radiated Emissions (30 MHz – 1 GHz)

Test: FCC Part 15 2.09 Limits							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
163.25	38.90	-7.97	30.93	43.5	3m./VERT	12.6	**PK**
249.71	35.03	-6.54	28.49	46.0	3m./VERT	17.5	**PK**
369.50	32.08	-1.18	30.90	46.0	3m./VERT	15.1	**PK**
All other emissions more than 20 dB below the applicable limit.							

Sample Calculation at 163.25 MHz:

Magnitude of Measured Frequency	38.90	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-7.97	dB/m
Corrected Result	30.93	dBuV/m

Test Date: December 11-19, 2023

Tested By
Signature: Elliott T. Chaves Name: Elliott Chaves

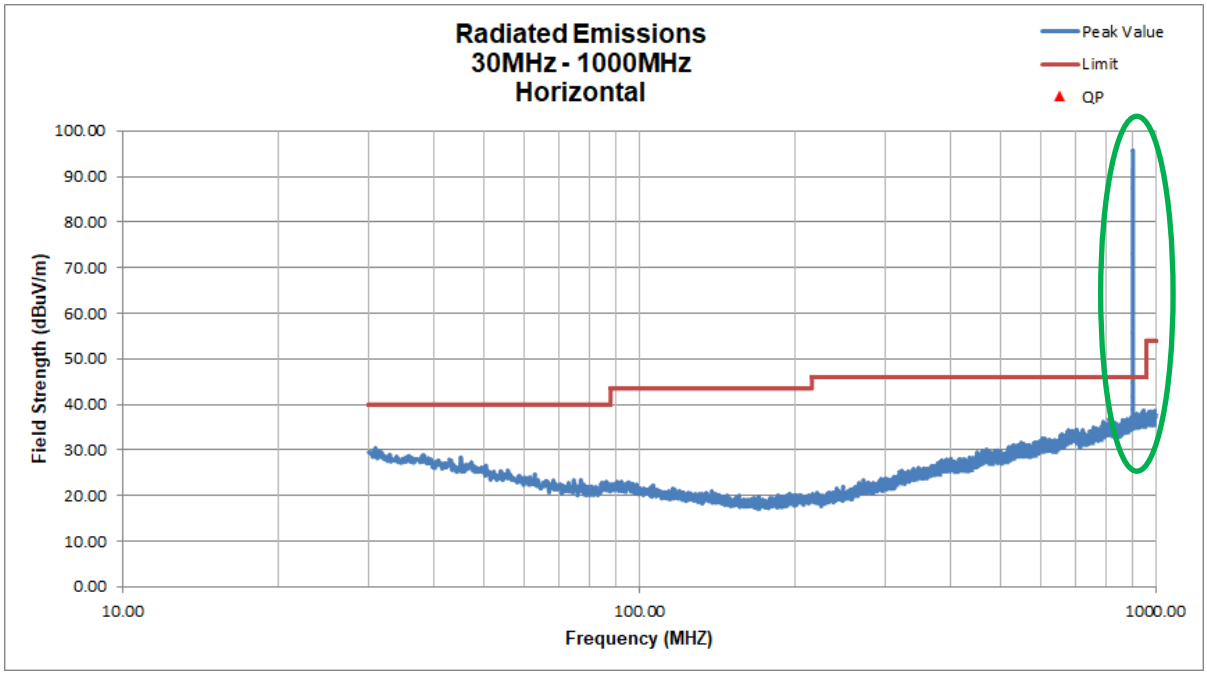

Figure 13. Radiated Emissions, Horizontal 30 – 1000 MHz

Note: Signal identified above is the fundamental signal from the 900 MHz radio.

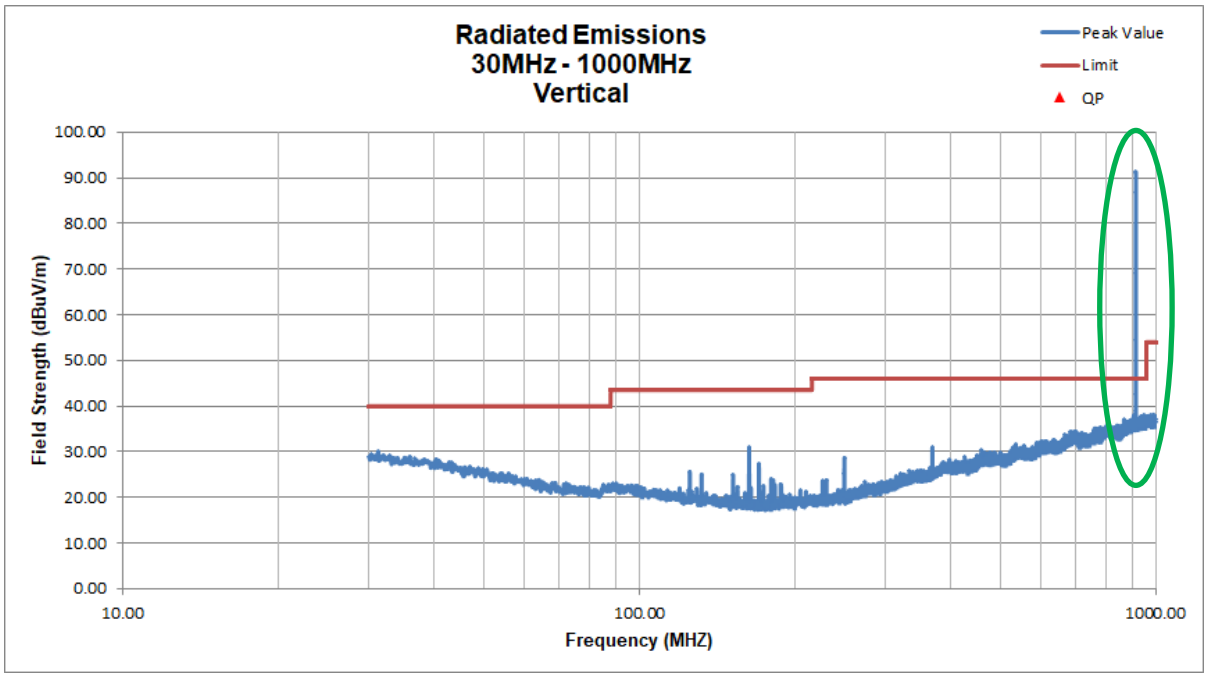

Figure 14. Radiated Emissions, Vertical 30 – 1000 MHz

Note: Signal identified above is the fundamental signal from the 900 MHz radio.

Table 9. Spurious Radiated Emissions (1 GHz – 10 GHz)

Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
All emissions more than 20 dB below the applicable limit.							

Sample Calculation: N/A

Test Date: December 11-19, 2023

Tested By
Signature: Elliott K. Chaves Name: Elliott Chaves

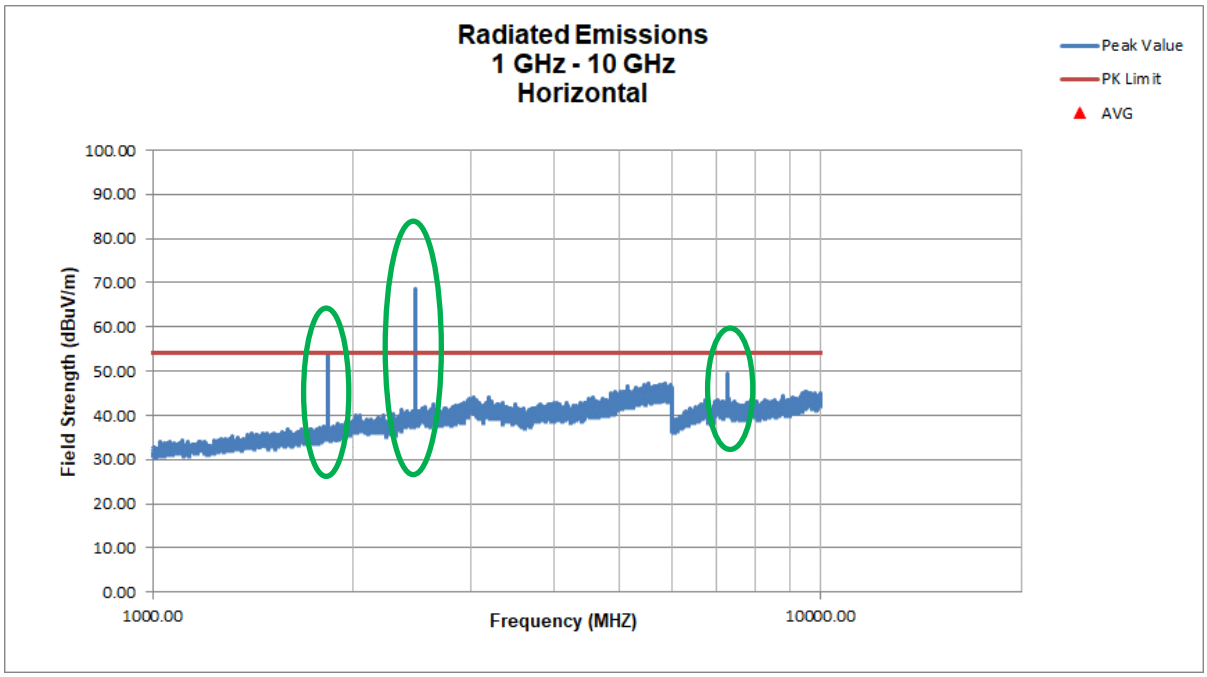

Figure 15. Radiated Emissions, Horizontal 1000 MHz – 13000 MHz

Note: Signal identified above are from the certified BLE radio and from harmonics

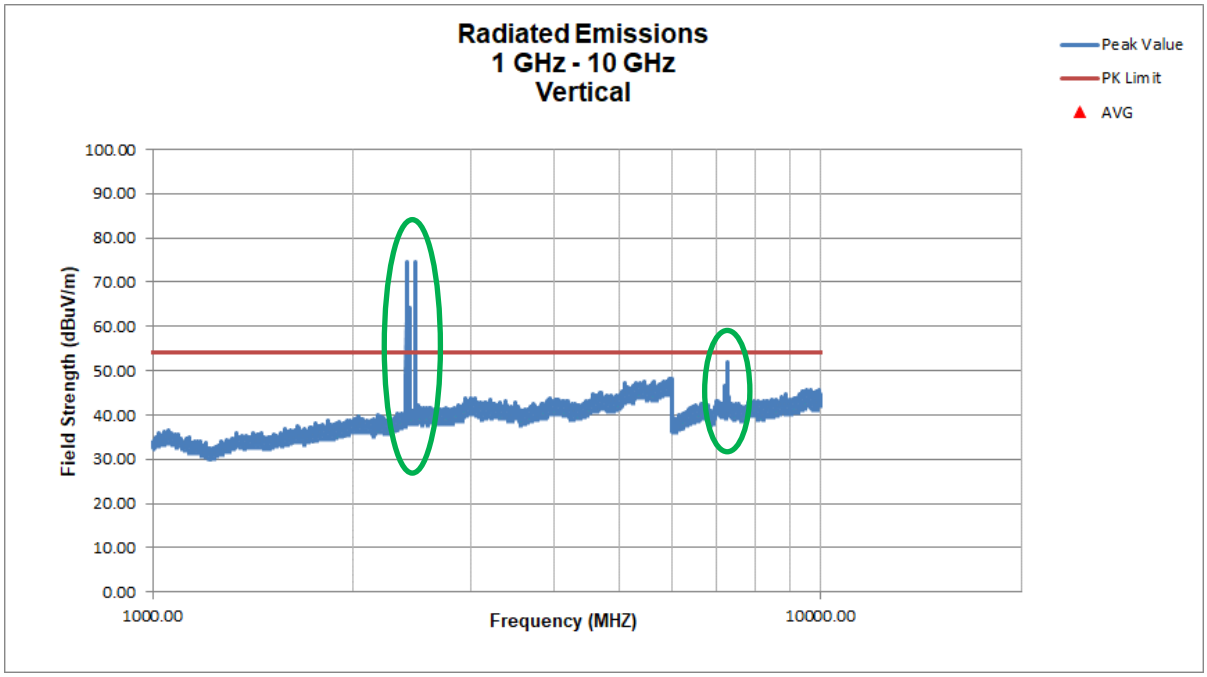

Figure 16. Radiated Emissions, Vertical 1000 MHz – 13000 MHz

Note: Signal identified above are from the certified BLE radio and from harmonics

2.15 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2: 2011. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

2.15.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.85 dB.

2.15.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.40 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.19 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.08 dB.

The data listed in this test report does have sufficient margin to negate the effects of uncertainty. Therefore, the EUT unconditionally meets this requirement.

END REPORT