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Emissions
Test Report

EUT Name: JAET2L Holdings

Model No.: A, ISS001US

CFR 47 Part 15.247: 2019

Prepared for:

JAET2L Holdings
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Lafayette, CO 80026

Prepared by:

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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	8/28/2019	Original Document	OC
1	9/23/2019	Added additional Model Name	OC

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	JAET2L Holdings 8555 Hollyhock St. Lafayette, CO 80026
Requester / Applicant:	JAET2L Holdings
Name of Equipment:	JAET2L Holdings
Model No.	A, ISS001US
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2019
Test Dates:	August 14th, 2019 to August 23rd, 2019

Guidance Documents:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v05r02, KDB 662911 D01 Multiple Transmitter Output v02r01

Test Methods:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v05r02, KDB 662911 D01 Multiple Transmitter Output v02r01

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by A2LA or any agency of the U.S. Government. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.

Osvaldo Casorla		Josie Sabado	
Test Engineer	Date September 23, 2019	A2LA Signatory	Date September 23, 2019

Testing Cert #3331.02 **US1131** **2932D**

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.247: 2019 based on the results of testing performed on August 14th, 2019 to August 23rd, 2019 on the JAET2L Holdings Model A, ISS001US manufactured by JAET2L Holdings. This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report. The 2402 MHz to 2480 MHz frequency band for Bluetooth, Low Energy is covered in this document.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C 63.10 & C63.4	Worse Case (Measured)	Result
Maximum Output Power	CFR47 15.247 (b)	0.21dBm @ 2440MHz Channel, 1Mbps	**Complied**
DTS Bandwidth (6dB)	CFR47 15.247 (a)(2)	0.712MHz @ 2402MHz Channel, 1Mbps	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e)	-15.89 dBm @ 2440MHz channel, 1Mbps	**Complied**
Out of Band Emissions: Non-Restricted	CFR47 15.247 (d)	-49.41 dBc @ 2399.10 MHz, Lower Band Edge	**Complied**
Out of Band Emissions: Restricted	CFR47 15.247 (d)	-28.48dB margin @ 2387.008 MHz, Average	**Complied**
Transmitter Spurious Emissions	CFR47 15.247 (d)	-7.82dB Margin @ 26386.45 MHz, Average	**Complied**
AC Power Conducted Emission	CFR47 15.207	Class B	**N/A**

Note 1: This test report covers 2400 MHz to 2483.5 MHz band. * = summed power.

Note 2: Class B limits were applied where applicable.

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.5 Equipment Modifications

None

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America EMC test facilities located at 1279 Quarry Lane, Ste. A, Pleasanton, CA, 94566, and 5015 Brandin Ct, Fremont, CA 94538, are recognized by the Commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (Registration No. US1131). The laboratory Scopes of Accreditation include Title 47 CFR Parts 15, 18 and 90. The accreditations are updated every three years.

2.1.2 NIST / A2LA

TUV Rheinland of North America is accredited by the National Voluntary Laboratory Accreditation Program, which is administered under the auspices of the National Institute of Standards and Technology. The laboratory has been assessed and accredited in accordance with ISO Guide 17025:2017. The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

Industry Canada Industrie Canada

The Pleasanton 5-meter Semi-Anechoic Chamber, Registration No. 2932M-1, has been accepted by Industry Canada to perform testing to 3 and 5 meters based on the test procedures described in ANSI C63.4-2014. The Fremont 10-meter Semi-Anechoic Chamber, Registration No. 2932D-1, has been accepted by Industry Canada to perform testing to 3 and 10 meters based on the test procedures described in ANSI C63.4-2014.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland of North America EMC test facilities located at 1279 Quarry Lane, Ste. A, Pleasanton, CA, 94566, and 5015 Brandin Ct, Fremont, CA 94538, have been assessed and approved in accordance with the Regulations for Voluntary Control Measures.

VCCI Registration No. for Pleasanton: A-0268

VCCI Registration No. for Fremont: A-0268

2.1.5 Acceptance by Mutual Recognition Arrangement

The United States has an established agreement with specific countries under the Asia Pacific Laboratory Accreditation Corporation (APLAC) Mutual Recognition Arrangement. Under this agreement, all TUV Rheinland at 1279 Quarry Ln, Pleasanton, CA 94566 test results and test reports within the scope of the laboratory NIST / A2LA accreditation will be accepted by each member country.

2.2 Test Facilities

Test facilities are located at 5015 Brandin Ct, Fremont, California, 94538, USA and 1279 Quarry Lane, Pleasanton, California 94566, USA (Fremont is the Pleasanton Annex).

2.2.1 Emission Test Facility

The Semi-Anechoic Chambers and AC Line Conducted measurement facilities used to collect radiated and conducted emissions data have been constructed in accordance with ANSI C63.7:1992. The Fremont 10 meter semi-anechoic chamber has been measured in accordance with and verified to comply with the theoretical volumetric normalized site attenuation of ANSI C63.4:2014 and SVSWR requirements of CISPR 16-1-4 Consol. Ed. 3.0 (2010-04), at test distances of 3 and 10 meters. This site has been described in reports dated November 1st, 2006, submitted to the FCC, and accepted by letter dated November 28, 2006. The site is listed with the FCC and accredited by A2LA (Testing Certificate #3331.02). The Pleasanton 5 meter semi-anechoic chamber has been verified to comply with the theoretical volumetric normalized site attenuation of ANSI C63.4:2009 and SVSWR requirements of CISPR 16-1-4 Consol. Ed. 3.0 (2010-04) at a test distance of 3 meters. This site has been described in reports dated November 1st, 2006, submitted to the FCC, and accepted by letter dated November 28, 2006. The site is listed with the FCC and accredited by A2LA (Testing Certificate #3331.02).

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

The Expanded Uncertainty defines an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurement and the fraction may be viewed as the coverage probability or level of confidence of the interval.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainty

Per CISPR 16-4-2	**U_{lab}**	**U_{cispr}**
Radiated Disturbance @ 10 meters		
30 – 1,000 MHz	2.25 dB	4.51 dB
Radiated Disturbance @ 3 meters		
30 – 1,000 MHz	2.26 dB	4.52 dB
1 – 6 GHz	2.12 dB	4.25 dB
6 – 18 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB
Disturbance Power		
30 MHz – 300 MHz	3.92 dB	4.3 dB

Voltech PM6000A

The estimated combined standard uncertainty for harmonic current and flicker measurements is ± 5.0%.	Per CISPR 16-4-2 Methods

2.3.3 Measurement Uncertainty Immunity

The estimated combined standard uncertainty for ESD immunity measurements is ± 8.2%.	Per IEC 61000-4-2
The estimated combined standard uncertainty for radiated immunity measurements is ± 4.10 dB.	Per IEC 61000-4-3
The estimated combined standard uncertainty for conducted immunity measurements with CDN is ± 3.66 dB	Per IEC 61000-4-6
The estimated combined standard uncertainty for power frequency magnetic field immunity is ± 2.9%.	Per IEC 61000-4-8

Thermo KeyTek EMC Pro

The estimated combined standard uncertainty for EFT fast transient immunity measurements is ± 2.6%.
The estimated combined standard uncertainty for surge immunity measurements is ± 2.6%.
The estimated combined standard uncertainty for voltage variation and interruption measurements is ± 1.74%.

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2017. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The Model A, ISS001US, JAET2L Holdings, is a Bluetooth BLE. The EUT will be in compliance with regulatory standards of regions it will be operating in.

3.2 Equipment Configuration

A description of the equipment configuration is given in the Test Plan Section. The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with its intended use. The EUT was connected to rated power and allowed to reach intended operating conditions. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In the case of an EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

The final configuration was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible state for immunity testing.

3.3 Operating Mode

A description of the operation mode is given in the Test Plan Section. In the case of an EUT that can operate in more than one state, preliminary testing was performed to determine the operating mode that produced maximum radiation.

The final operating mode was selected to produce the worst case radiation for emissions testing.

3.4 Unique Antenna Connector

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. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of CFR47 Parts 15.211, 15.213, 15.217, 15.219, or 15.221.

3.4.1 Results

The JAET2L Holdings has 1 Trace Antenna dedicated Bluetooth antenna that has maximum gain of + 0dBi. It is connected via RF connector that is not easily accessible to the end user.

Refer to Table 30 for additional antenna information.

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.247: 2019. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. Procedures described in section 8 of the standard were used.

4.1 Output Power Requirements

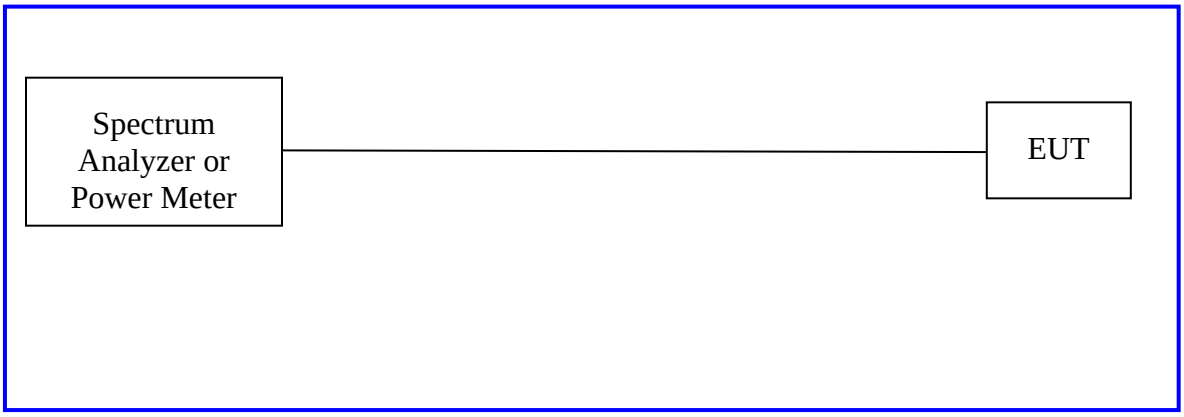
The maximum output power requirement is the maximum equivalent isotropic radiated power delivering at the transmitting antenna under specified conditions of measurements in the presence of modulation.

The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b) The maximum transmitted power in the band 2400-2483.5 MHz: 1 W

4.1.1 Test Method

Conducted method was used to measure the channel power output. The worst findings were conducted on 3 channels in each operating range per CFR47 Part 15.247(b). The worst mode results indicated below.

Test Setup:

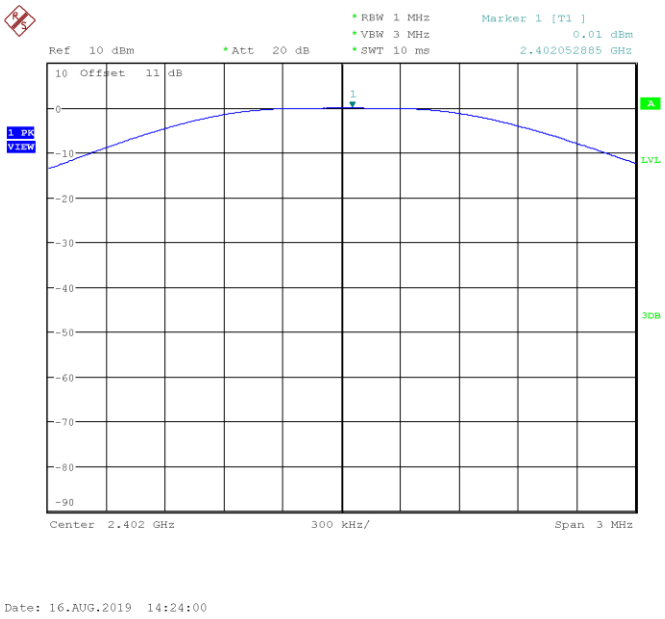


4.1.2 Results

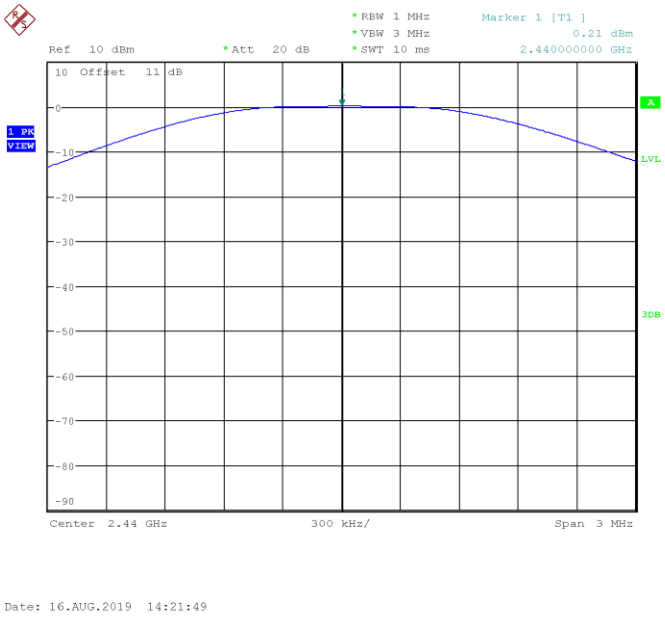
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s). Worse case data for each mode reported below. Plots of highest power included for low, medium, and high channels.

Table 2: RF Output Power at the Antenna Port – Test Results

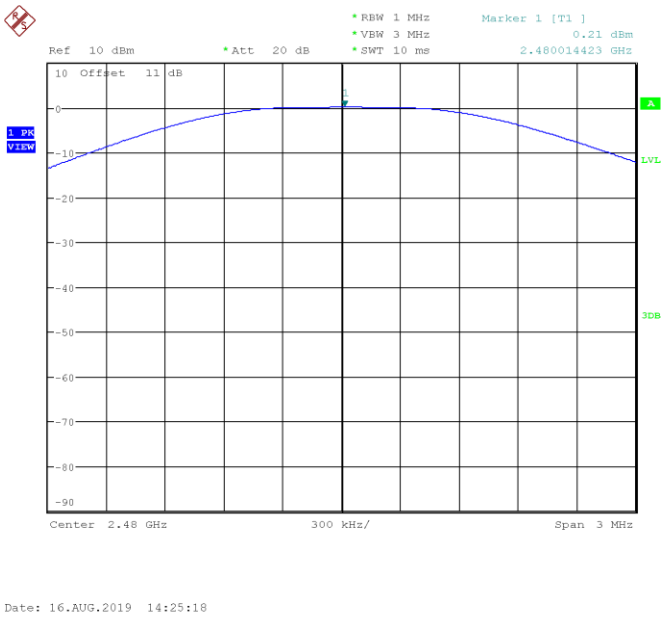
Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: Trace Antenna			
Max. Antenna Gain: 0			
Operating Channel (MHz)	**Limit [dBm]**	**Total Power [dBm]**	**Margin [dB]**
2402.00	30.00	0.01	-29.99
2440.00	30.00	0.21	-29.79
2480.00	30.00	0.21	-29.79



Plot 1. Maximum Conducted Power, 2402MHz



Plot 2. Maximum Conducted Power, 2440MHz



Plot 3. Maximum Conducted Power, 2480MHz

4.2 DTS Bandwidth (6dB) and Occupied Bandwidth

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

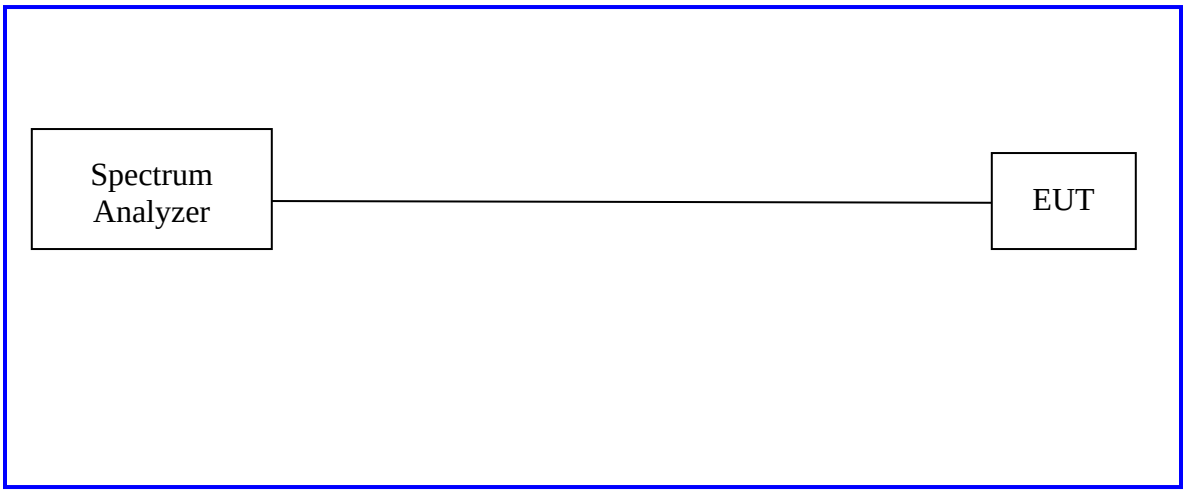
The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

The minimum 6 dB bandwidth shall be at least 500 kHz.

4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth according to ANSI C63.10:2013 Section 11.8. The measurement was performed with modulation per CFR47 15.247 (a) (2). Measurements were performed on the low, middle and high channels of the operating frequency range; 2400 MHz to 2483.5 MHz.

Test Setup:

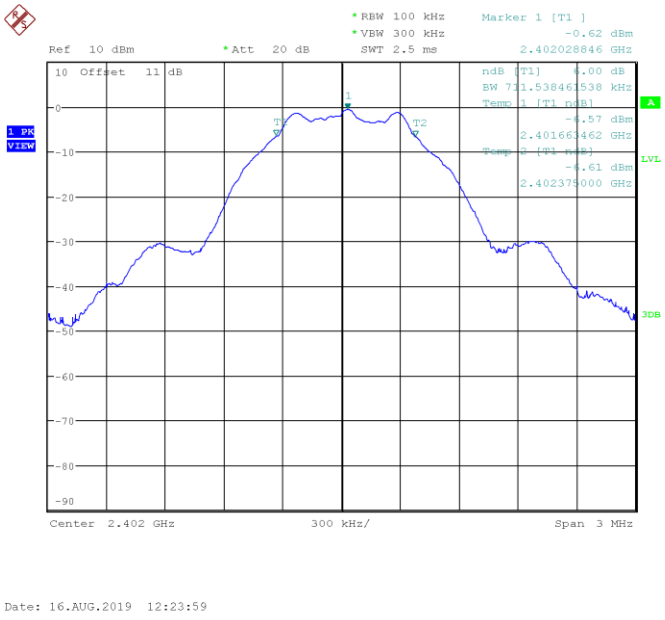


Results
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

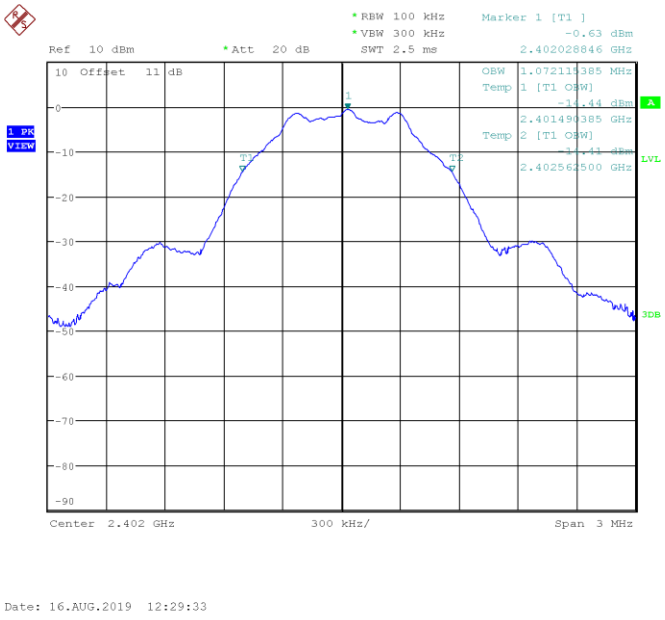
Table 3: Occupied Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature

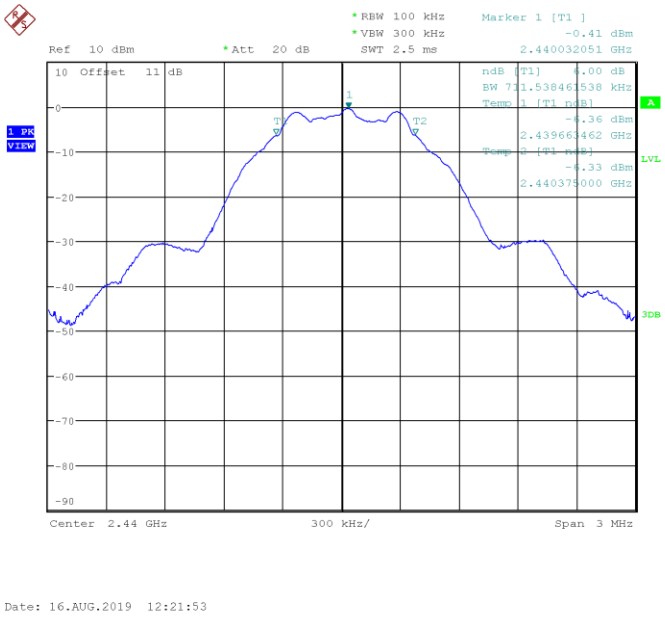
Bandwidth (MHz)		
Freq. (MHz)	**99% Bandwidth (MHz)**	**6dB (DTS) Bandwidth (MHz)**
2402	1.0721	0.712
2440	1.0769	0.712
2480	1.0769	0.712
Note: None		



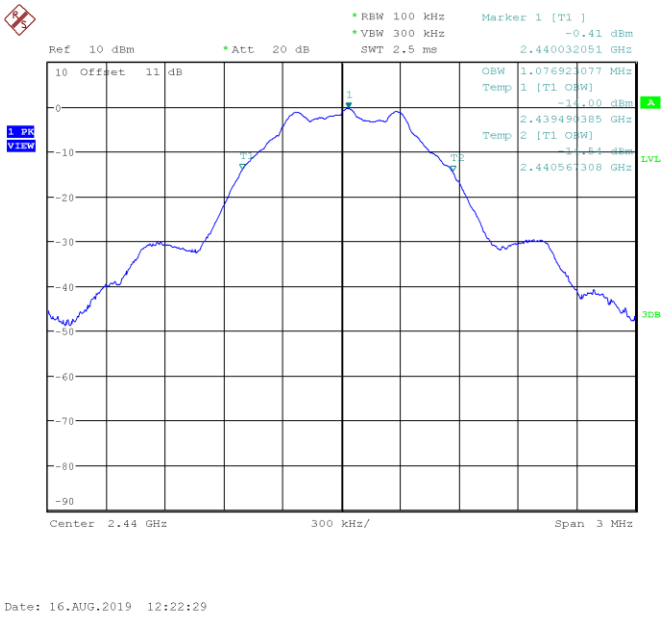
Plot 4. 2402MHz, 6dB Bandwidth



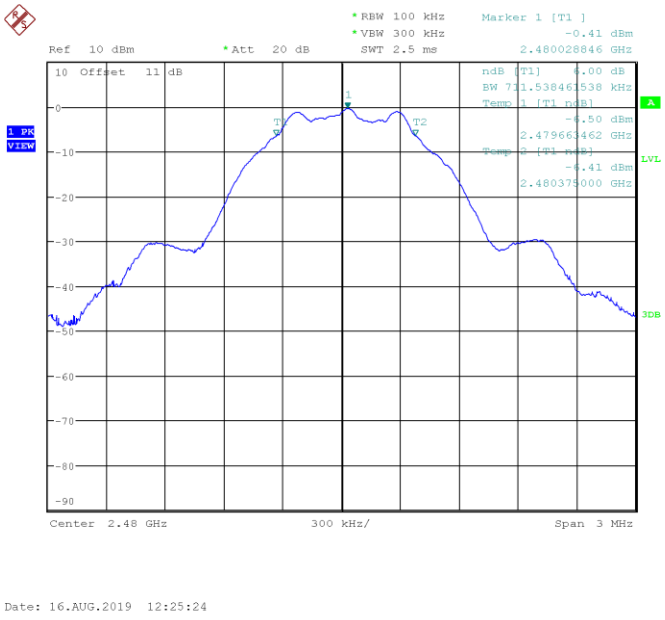
Plot 5. 2402MHz, 99% Bandwidth



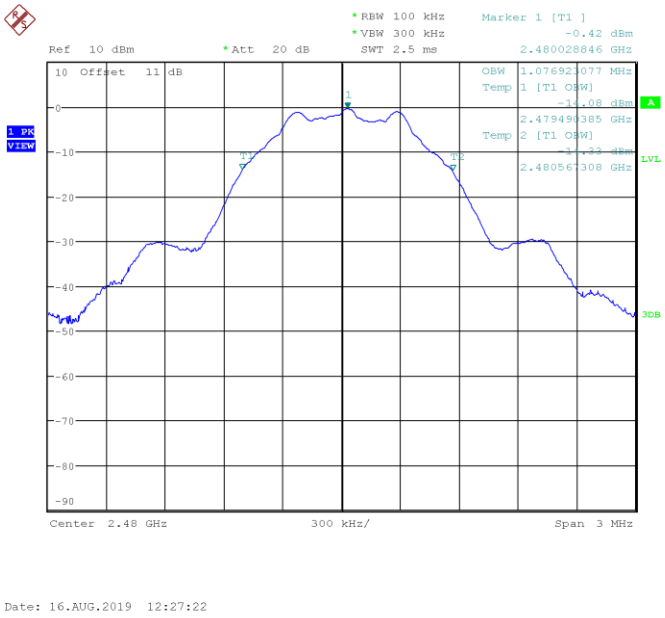
Plot 6. 2440MHz, 6dB Bandwidth



Plot 7. 2440MHz, 99% Bandwidth



Plot 8. 2480MHz, 6dB Bandwidth



Plot 9. 2480MHz, 99% Bandwidth

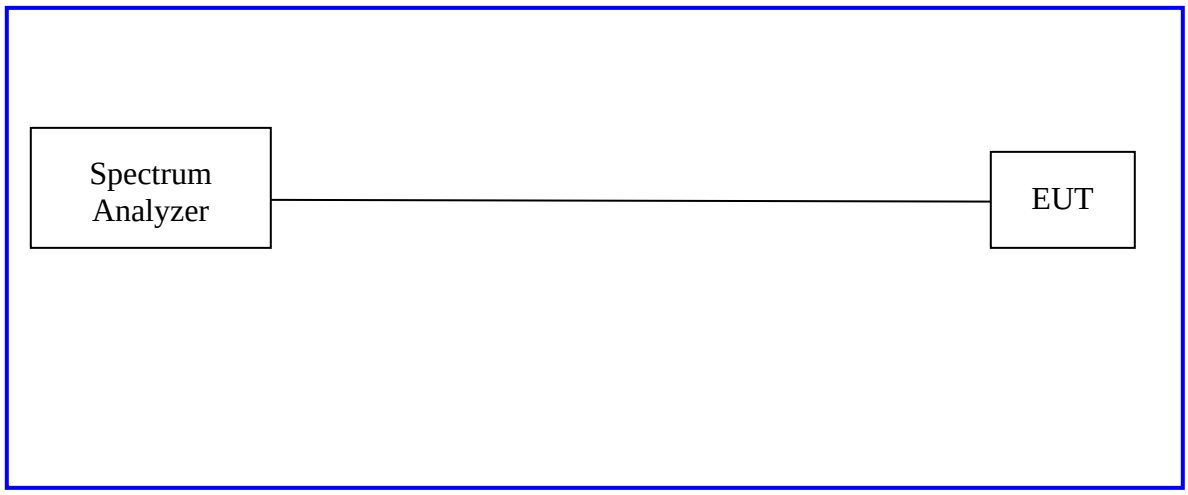
4.3 Peak Power Spectral Density

According to the CFR47 Part 15.247 (e), the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.3.1 Test Method

The conducted method was used to measure the channel power output per ANSI C63.10-2013 Section 11.10.2. The measurement was performed with modulation per CFR47 Part 15.247 (e). The worst findings were conducted on 3 channels in each operating frequency range of 2400 MHz to 2483.5 MHz.

Test Setup:



Method PKPSD of "KDB 558074 – DTS Measurement Guidance v04" was used.

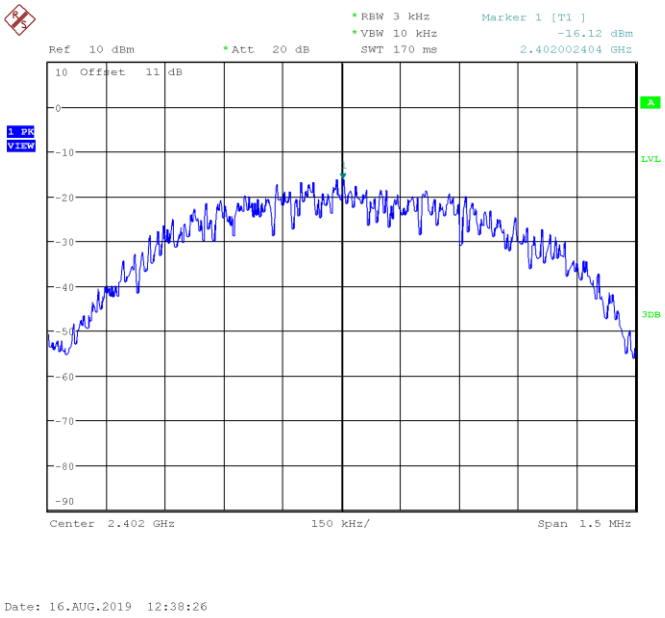
4.3.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

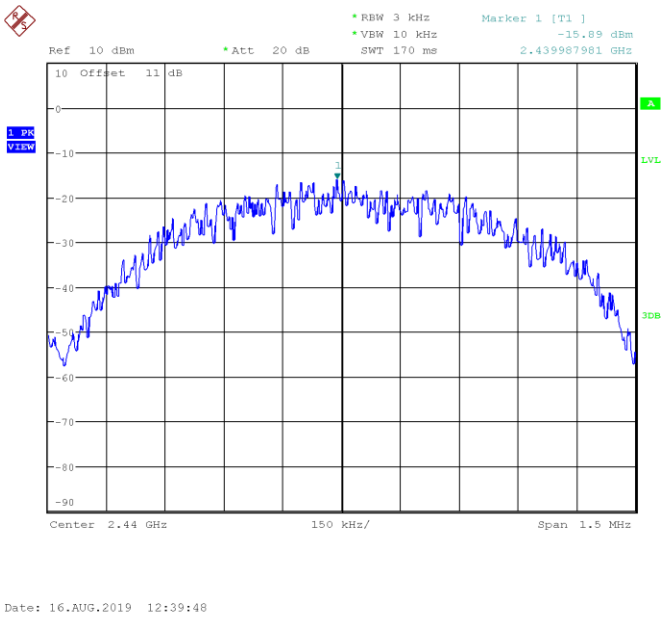
Table 4: Peak Power Spectral Density – Test Results

Test Conditions: Conducted Measurement, Normal Temperature

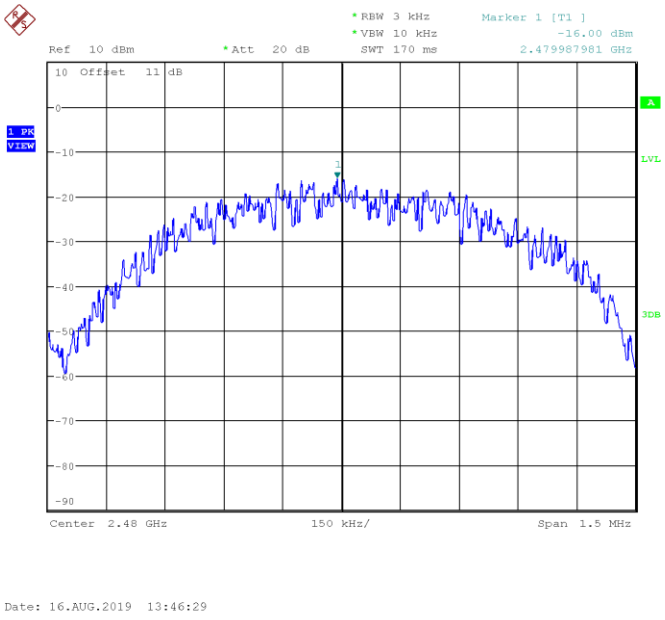
Peak Power Spectral Density			
Freq. (MHz)	**Total PSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
2402	-16.12	8.0	-24.12
2440	-15.89	8.0	-23.89
2480	-16.00	8.0	-24.00
Note: None			



Plot 10. 2402MHz PSD



Plot 11. 2440MHz PSD



Plot 12. 2480MHz PSD

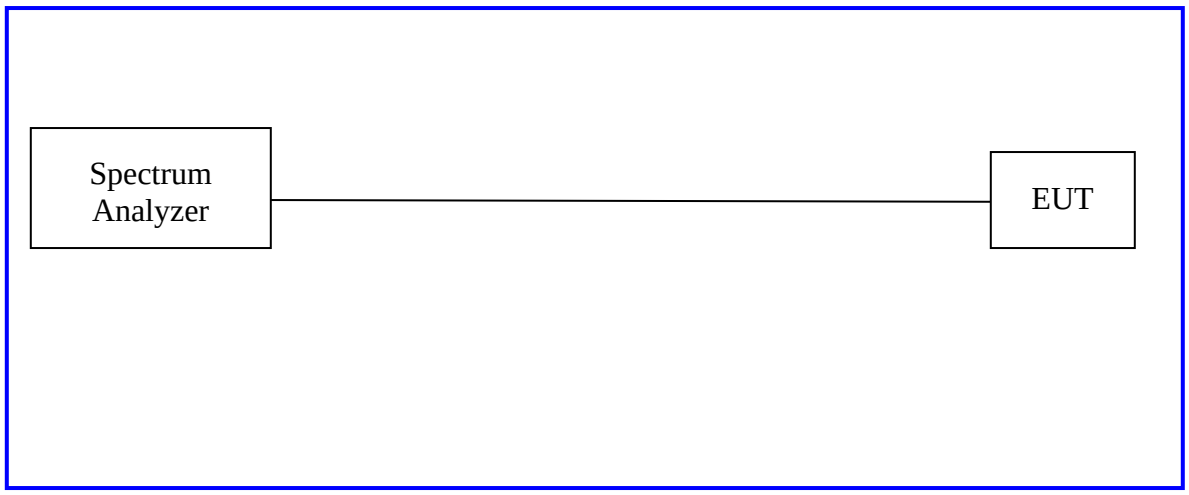
4.4 Out of Band Emissions: Non-Restricted Bands

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d).

4.4.1 Test Method

Conducted measurements per ANSI C63.10-2013 Sections 6.10, 11.11, 14.3.3 were used to measure the undesirable emission requirement in non-restricted bands. The measurement was performed with modulation. The measurement was conducted from 30MHz to 26.5GHz on 3 channels in each mode on the EUT. Reference level was established on the channel with highest measured PSD (2440MHz) as stated in ANSI C63.10-2013 Section 11.11.2. Band edge tests were conducted on the low and high channel of each mode. The worst case measurement of each mode is recorded in this report.

Test Setup:

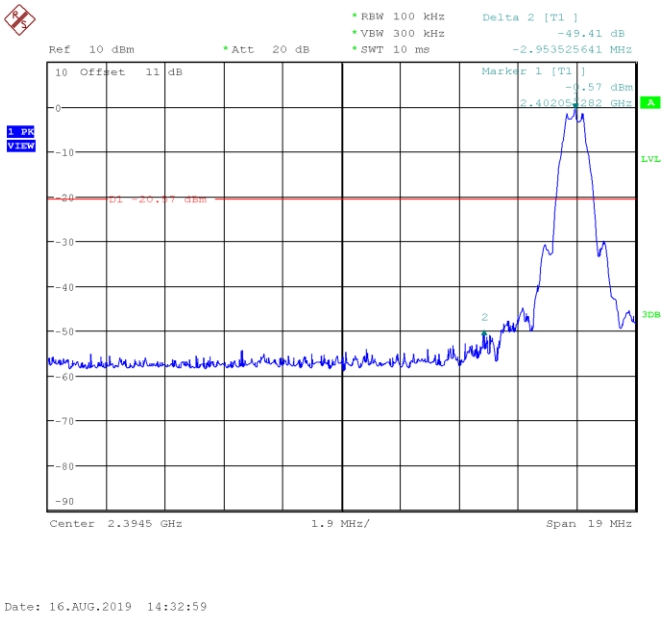


4.4.2 Results

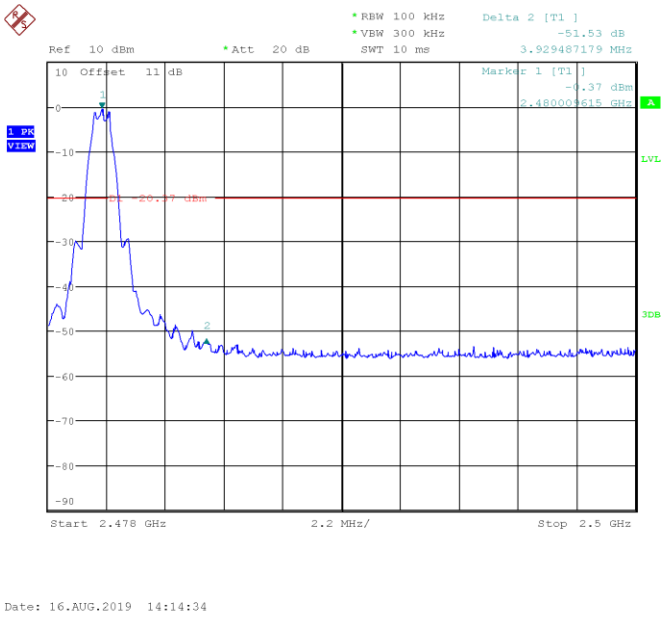
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 5: Emissions at the Band-Edge – Test Results

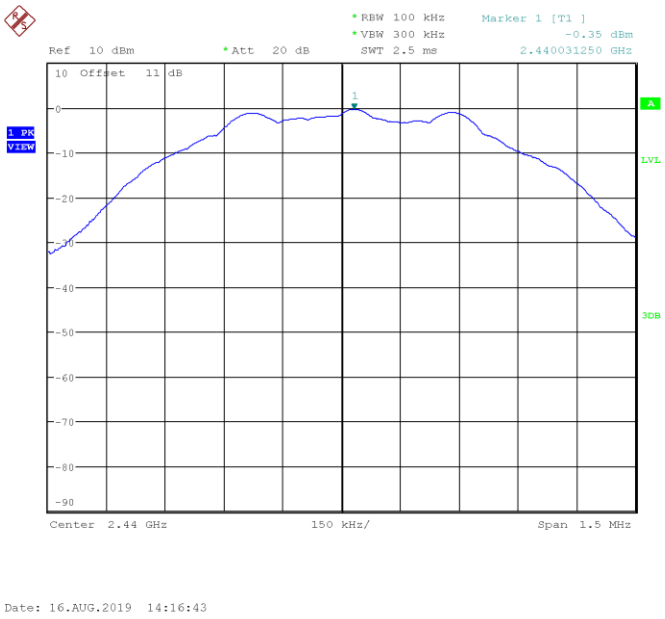
Test Conditions: Conducted Measurement, Normal Temperature and Voltage only					
Non-Restricted Frequency Band Edge Emissions – Worse Case					
Band Edge	**Center Freq (MHz)**	**Measured (dBc)**	**Limit (dBc)**	**Freq (MHz)**	**Results**
Low	2402	-49.41	20	2399.10	Pass
High	2480	-51.53	20	2483.94	Pass
Note:					



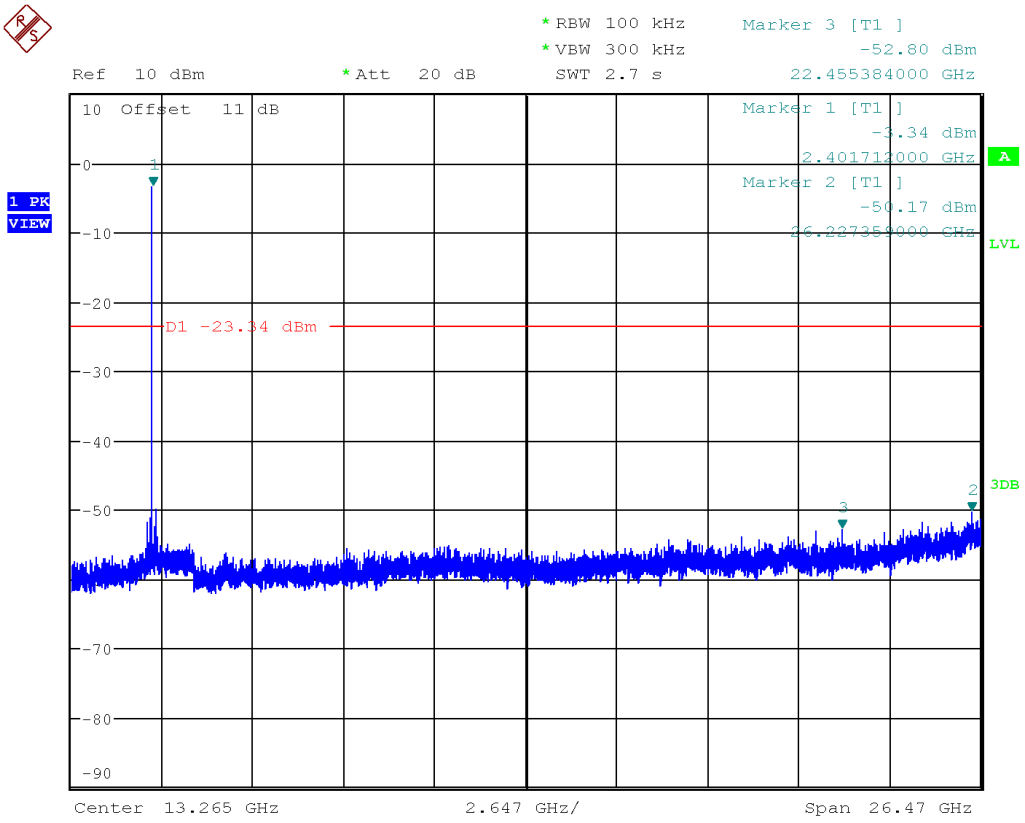
Plot 13. 2402MHz Lower Band Edge



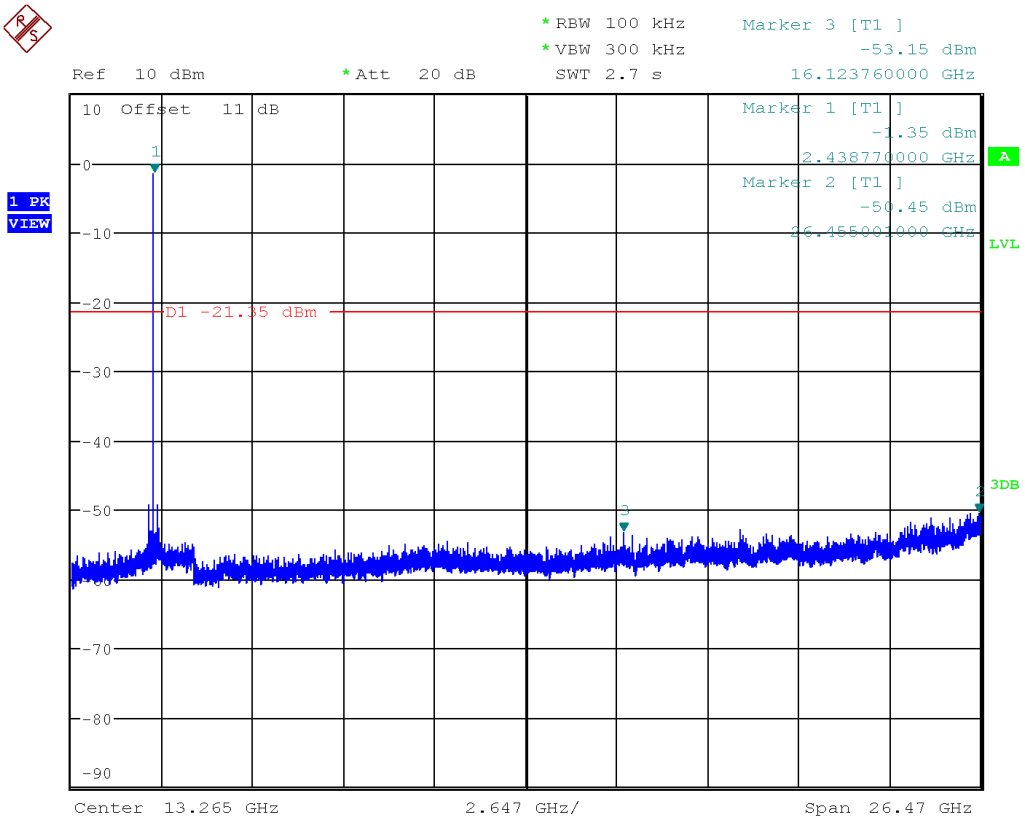
Plot 14. 2480MHz Upper Band Edge



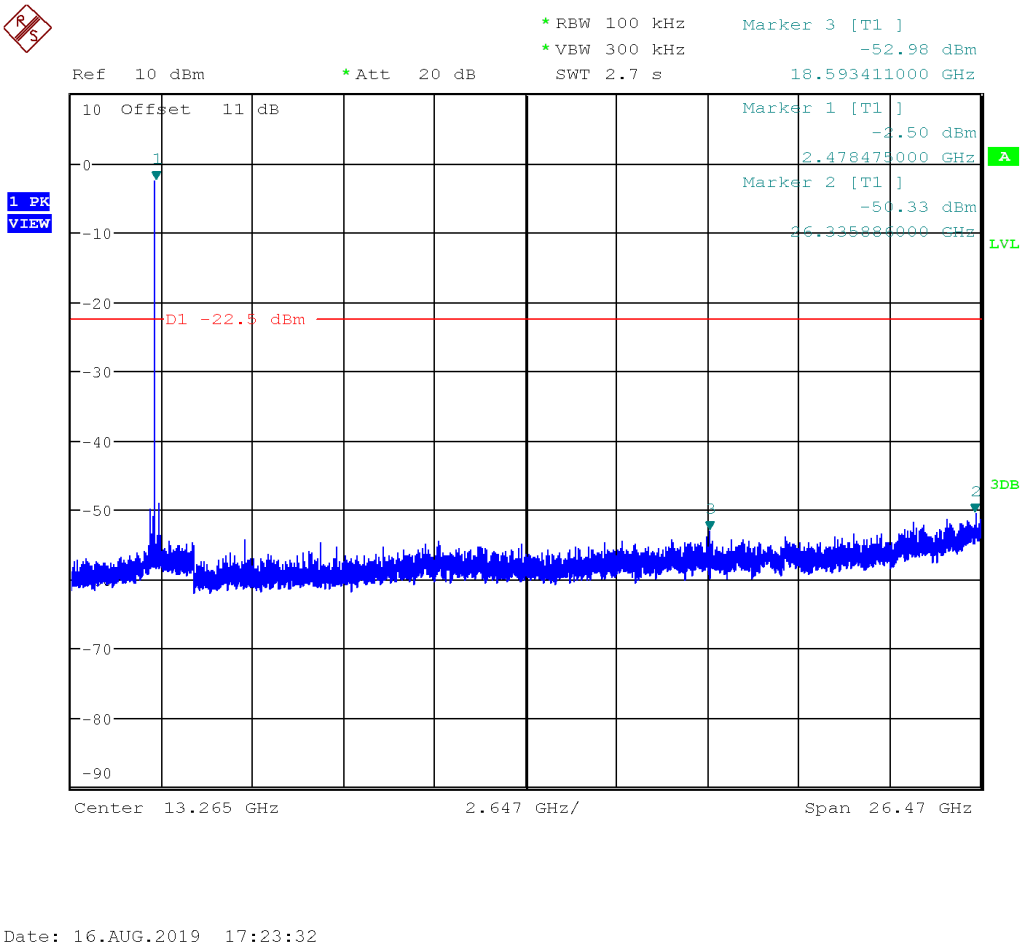
Plot 15. Non-Restricted Reference Measurement, 2440MHz



Plot 16. 2402MHz 30MHz-26.5GHz Spurious



Plot 17. 2440MHz 30MHz-26.5GHz Spurious



Plot 18. 2480MHz 30MHz-26.5GHz Spurious

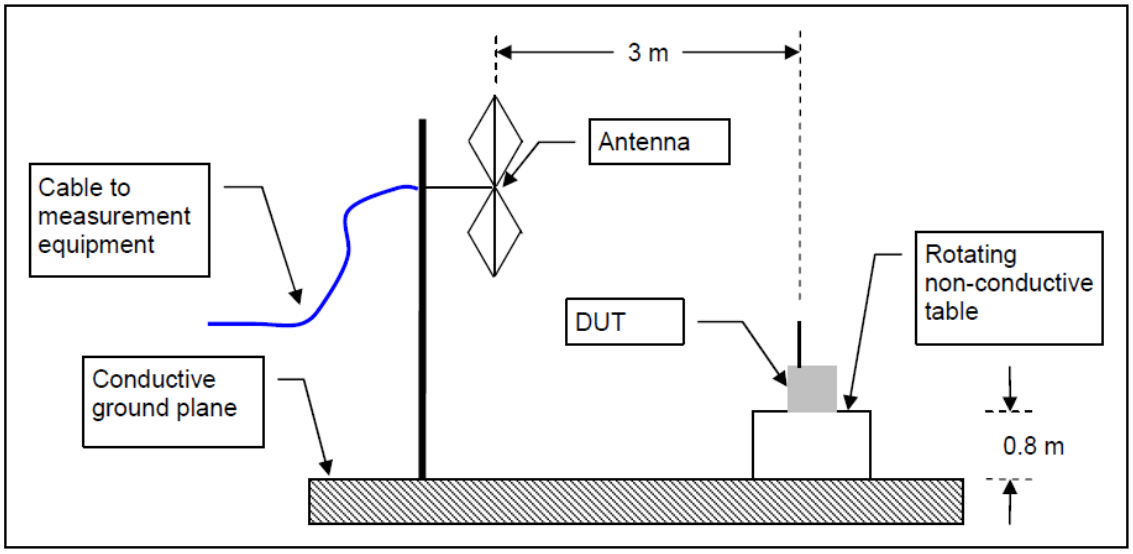
4.5 Out of Band Emissions: Restricted Band Edge

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d).

4.5.1 Test Method

Radiated measurements per ANSI C63.10-2013 Section 6.10.5 were used to measure the undesirable emission requirement in restricted bands. Peak points were found and RMS Average was taken for each point found. The measurement was performed with modulation. This test was conducted on 3 channels in each mode on the EUT. The worst case measurement of each channel is recorded in this report. All channels were tested at highest power settings.

Test Setup

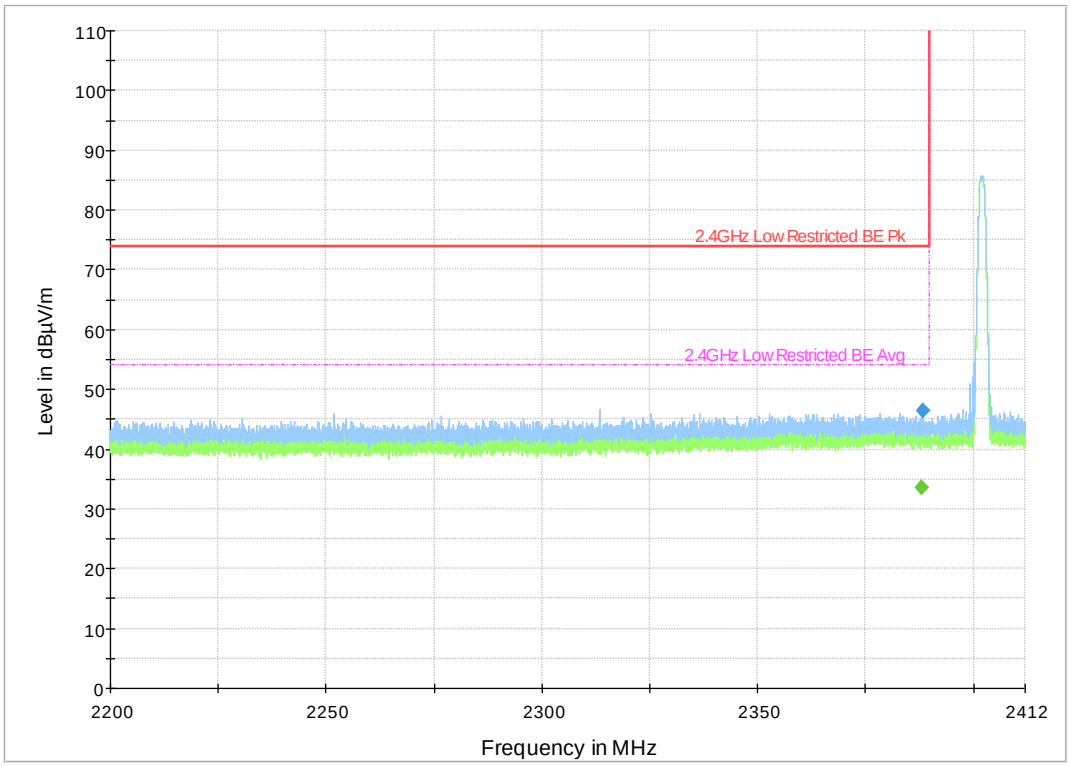


The DUT was stimulated by manufacturer provided test software that is not available to the end user.

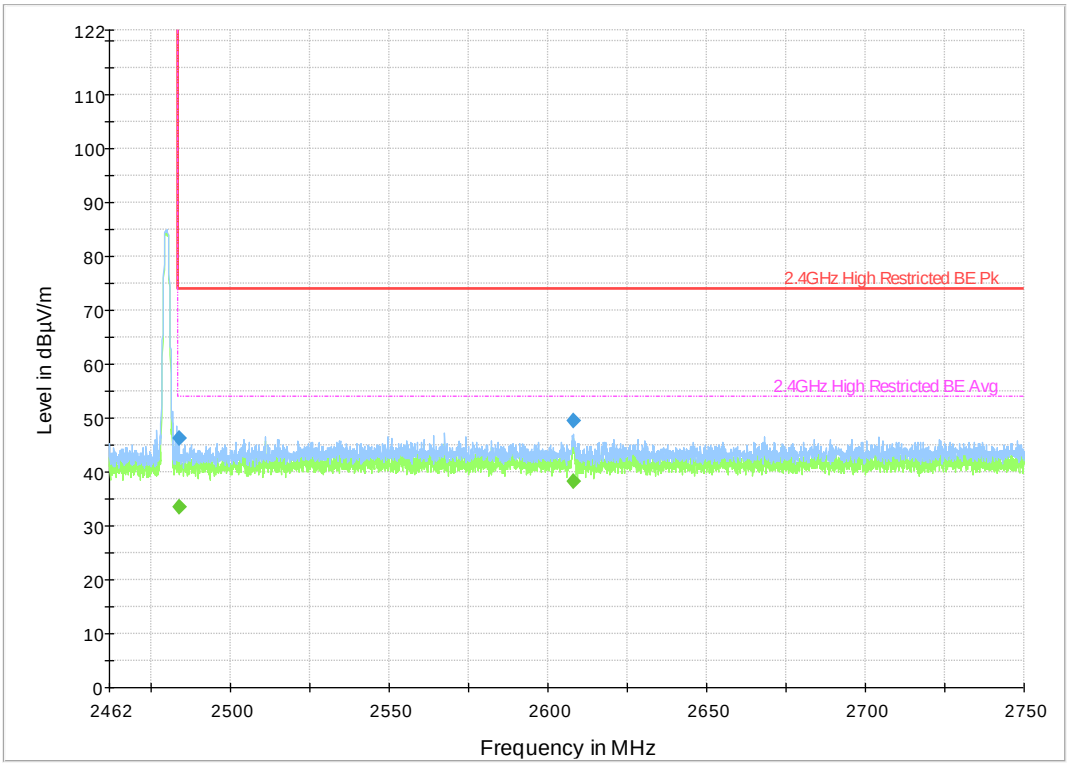
4.5.2 Test Results

Table 6: Emissions at the Band-Edge – Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage							
Lower Restricted Band Edge							
Freq. (MHz)	**Mode**	**Center Freq (MHz)**	**Detector (Average/ Peak)**	**Measured (dBuV/m)**	**Limit (dBuV/m)**	**Margin**	**Results**
2388.044	BLE GFSK 1Mbps	2402	Average	33.54	54	-20.46	Pass
2388.404	BLE GFSK 1Mbps	2402	Peak	46.53	74	-27.47	Pass
Upper Restricted Band Edge							
Freq. (MHz)	**Mode**	**Center Freq (MHz)**	**Detector (Average/ Peak)**	**Measured (dBuV/m)**	**Limit (dBuV/m)**	**Margin**	**Results**
2608.131	BLE GFSK 1Mbps	2480	Average	38.20	54	-15.80	Pass
2608.188	BLE GFSK 1Mbps	2480	Peak	49.44	74	-24.56	Pass
Note: 1. The DCCF (Average Detector) is included in this table, the following plots are of peak values							



Plot 19. 2402MHz, Lower Band Edge, Restricted.
RBW = 1MHz, VBW = 3MHz



Plot 20. 2480MHz, Upper Band Edge, Restricted
RBW = 1MHz, VBW = 3MHz

4.6 Transmitter Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR47 15.205, 15.209, 15.247(d).

4.6.1 Test Methodology

4.6.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

Pre-scans were performed to determine the worst data rate / chains.

4.6.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

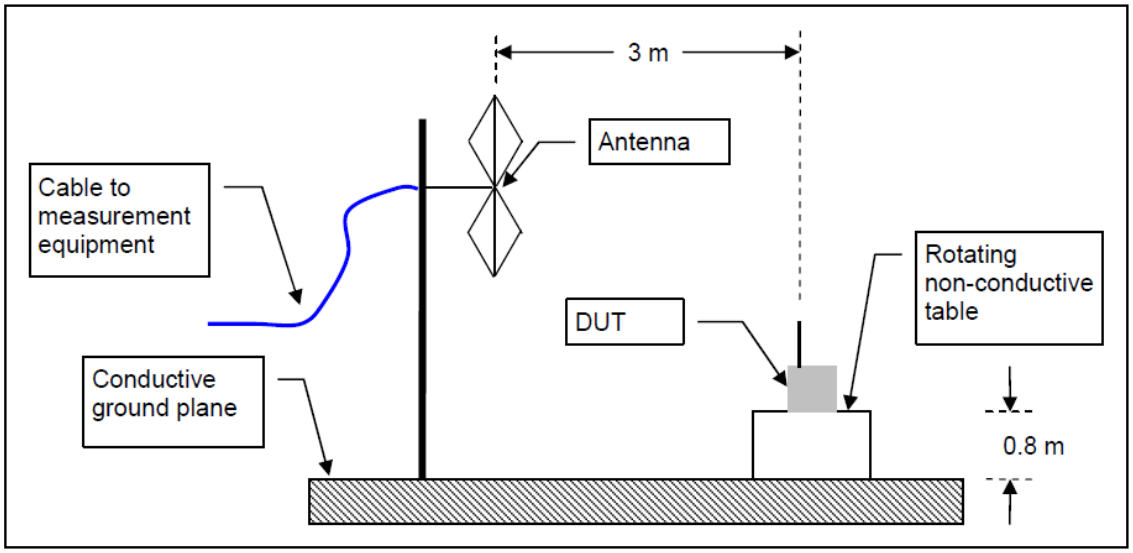
4.6.1.3 Deviations

None.

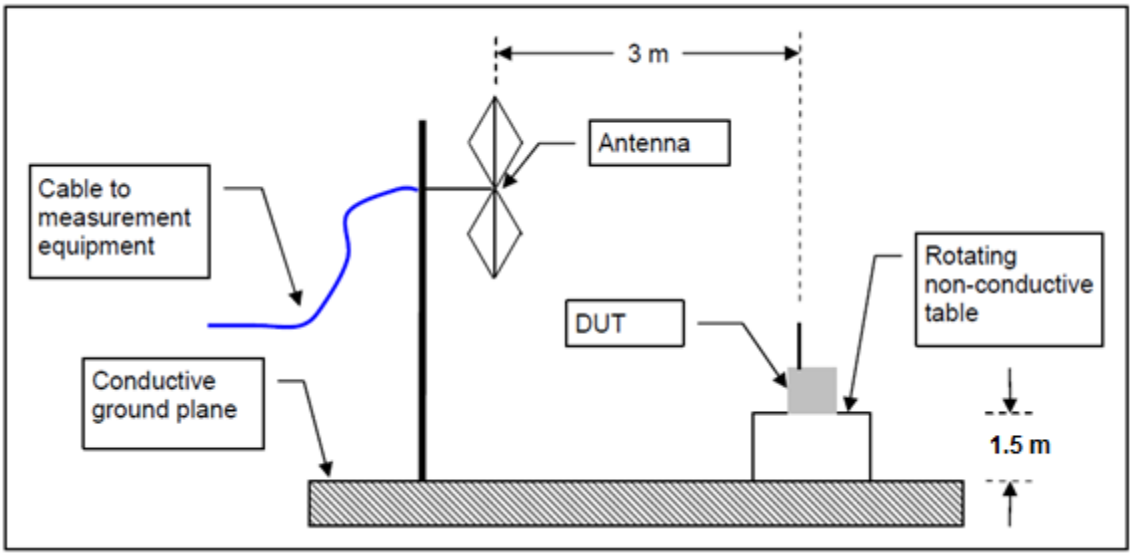
4.6.2 Test Setup:

All tests were conducted at full power on low, middle, and high channels. The DUT was stimulated by manufacturer provided test software that is not available to the end user.

30MHz-1GHz



1-26GHz



4.6.3 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2015.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490.....	2400/F(kHz)	300
0.490-1.705.....	24000/F(kHz)	30
1.705-30.0.....	30	30
30-88.....	100 **	3
88-216.....	150 **	3
216-960.....	200 **	3
Above 960.....	500	3

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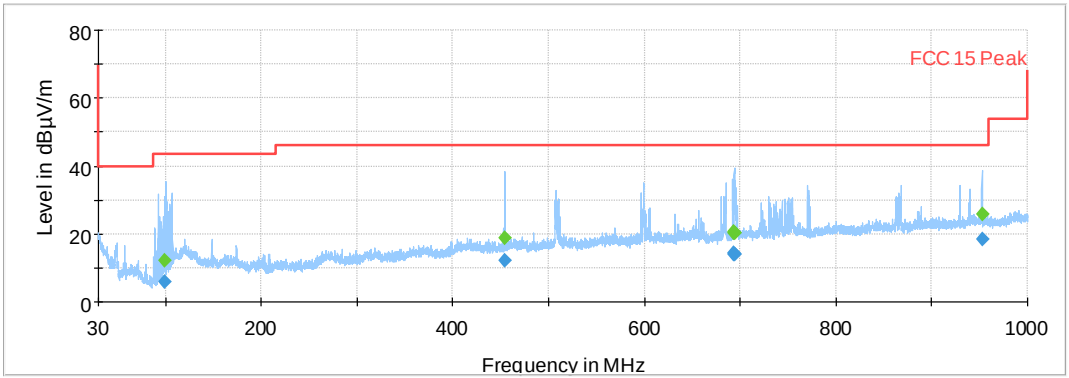
4.6.4 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and test plan.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

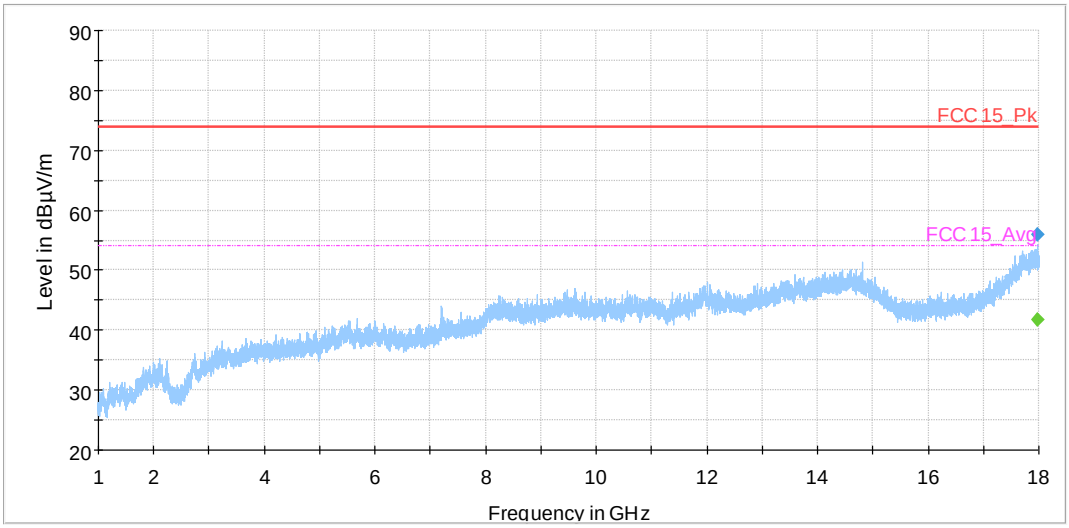
4.6.4.1 Plots

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
99.79	5.95	43.52	37.57	1000.0	120.000	155.0	V	175.0	-16.2
454.39	12.25	46.00	33.75	1000.0	120.000	101.0	V	180.0	-8.4
693.25	14.30	46.00	31.70	1000.0	120.000	200.0	V	179.0	-5.1
693.76	13.95	46.00	32.05	1000.0	120.000	101.0	V	175.0	-5.1
694.25	14.06	46.00	31.94	1000.0	120.000	100.0	V	175.0	-5.0
952.62	18.56	46.00	27.44	1000.0	120.000	200.0	V	180.0	-0.2



Plot 21. 30MHz-1GHz, 2402MHz

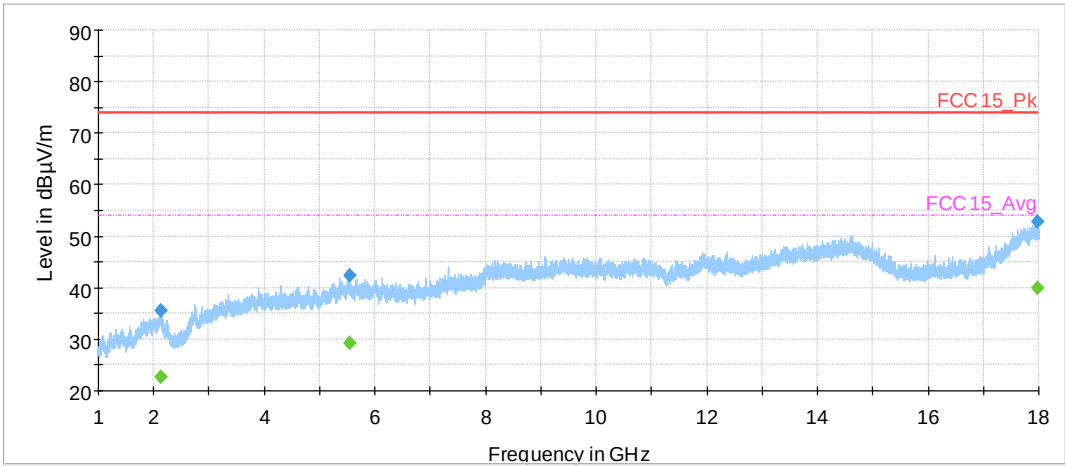
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
17975.31	---	41.71	54.00	12.29	1000.0	1000.000	242.0	V	-74.0	-6.7
17975.31	55.88	---	74.00	18.12	1000.0	1000.000	242.0	V	-74.0	-6.7



Plot 22. 1-18GHz, 2402MHz

Note: The 2.4 GHz notch filter was used to protect the front end of the analyzer

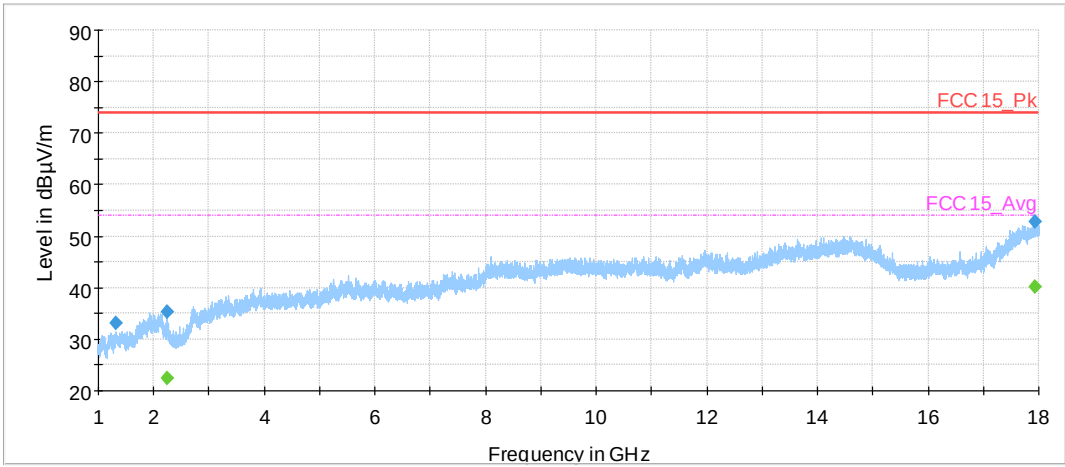
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2127.00	---	22.79	54.00	31.21	1000.0	1000.000	141.0	H	97.0	-31.3
2127.00	35.52	---	74.00	38.48	1000.0	1000.000	141.0	H	97.0	-31.3
5535.57	---	29.24	54.00	24.76	1000.0	1000.000	201.0	H	-180.0	-22.0
5535.57	42.31	---	74.00	31.69	1000.0	1000.000	201.0	H	-180.0	-22.0
17971.67	---	39.94	54.00	14.06	1000.0	1000.000	100.0	V	97.0	-6.7
17971.67	52.79	---	74.00	21.21	1000.0	1000.000	100.0	V	97.0	-6.7



Plot 23. 1-18GHz, 2440MHz

Note: The 2.4 GHz notch filter was used to protect the front end of the analyzer

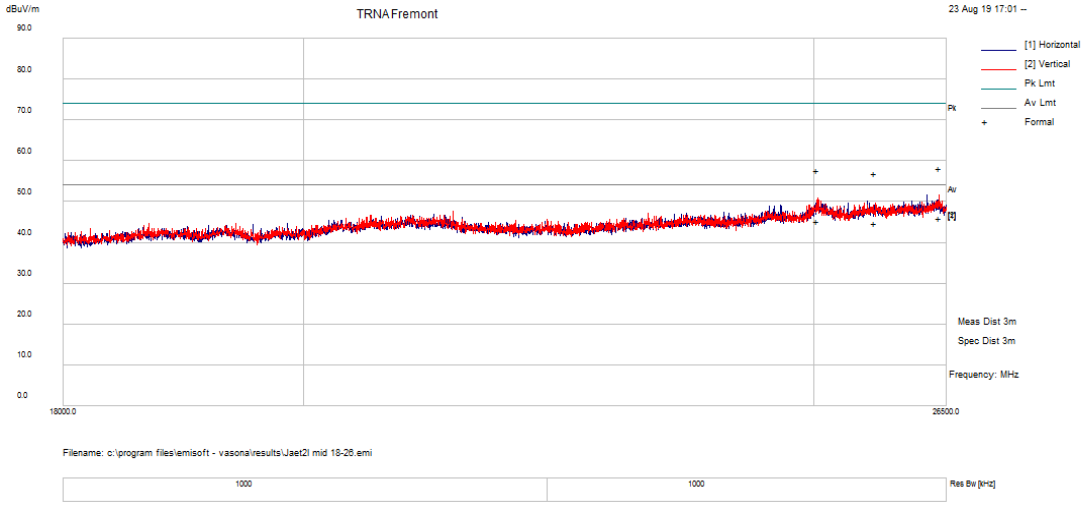
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1313.60	33.05	---	74.00	40.95	1000.0	1000.000	200.0	V	-28.0	-35.4
1313.60	---	19.62	54.00	34.38	1000.0	1000.000	200.0	V	-28.0	-35.4
2247.07	35.42	---	74.00	38.58	1000.0	1000.000	250.0	H	-180.0	-31.6
2247.067	---	22.42	54.00	31.58	1000.0	1000.000	250.0	H	-180.0	-31.6
17941.11	---	40.14	54.00	13.86	1000.0	1000.000	150.0	V	97.0	-6.9
17941.11	52.77	---	74.00	21.23	1000.0	1000.000	150.0	V	97.0	-6.9



Plot 24. 1-18GHz, 2480MHz

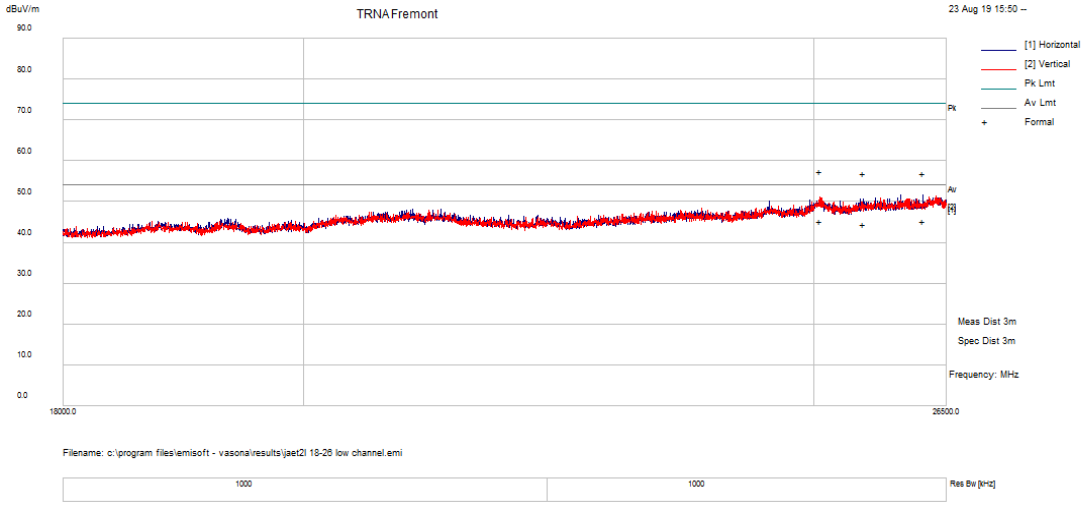
Note: The 2.4 GHz notch filter was used to protect the front end of the analyzer

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail
26418.21	46.11	8.07	4.13	58.31	Peak Max	V	170	238	74	-15.69	Pass
25045.04	46.84	7.87	3.12	57.83	Peak Max	V	152	262	74	-16.17	Pass
25679.53	45.62	7.95	3.39	56.96	Peak Max	V	161	240	74	-17.05	Pass
26418.21	33.85	8.07	4.13	46.05	Average Max	V	170	238	54	-7.95	Pass
25045.04	34.37	7.87	3.12	45.36	Average Max	V	152	262	54	-8.64	Pass
25679.53	33.51	7.95	3.39	44.85	Average Max	V	161	240	54	-9.15	Pass



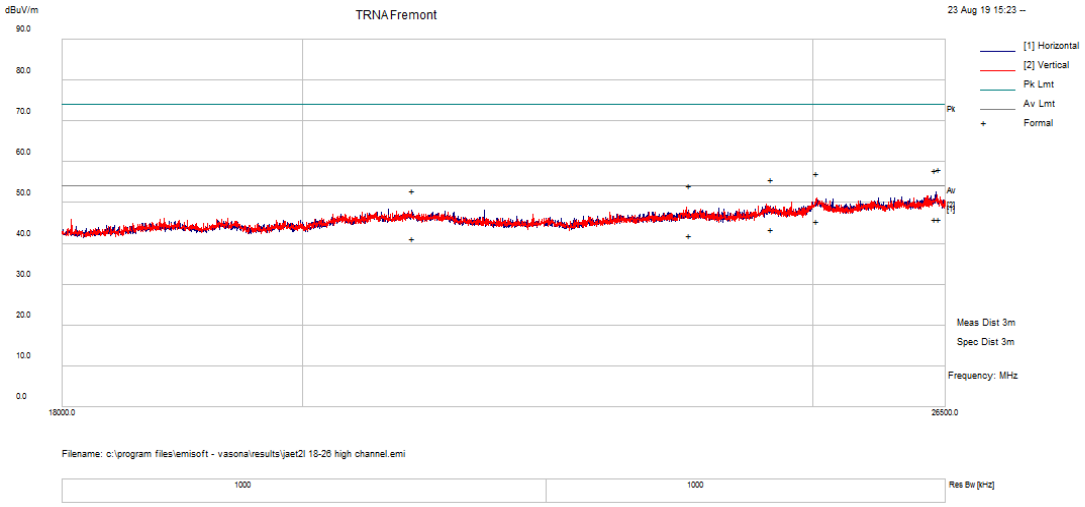
Plot 25. 18-26.5GHz, 2402MHz

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail
25069.6	34.36	7.86	3.13	45.36	Average Max	V	152	259	54	-8.64	Pass
25069.6	46.47	7.86	3.13	57.46	Peak Max	V	152	259	74	-16.54	Pass
25553.96	45.71	7.98	3.33	57.02	Peak Max	H	171	244	74	-16.98	Pass
25553.96	33.27	7.98	3.33	44.58	Average Max	H	171	244	54	-9.42	Pass
26225.7	44.97	8.07	4.05	57.09	Peak Max	H	181	243	74	-16.91	Pass
26225.7	33.13	8.07	4.05	45.25	Average Max	H	181	243	54	-8.75	Pass
20954.92	30.18	7.22	4.04	41.45	Average Max	V	149	253	54	-12.55	Pass
20954.92	42.1	7.22	4.04	53.37	Peak Max	V	149	253	74	-20.63	Pass
21353.3	29.54	7.31	3.83	40.68	Average Max	V	154	265	54	-13.32	Pass
21353.3	41.47	7.31	3.83	52.61	Peak Max	V	154	265	74	-21.39	Pass
23219.41	30.38	7.59	3.05	41.01	Average Max	V	160	264	54	-12.99	Pass
23219.41	42.34	7.59	3.05	52.98	Peak Max	V	160	264	74	-21.03	Pass



Plot 26. 18-26.5GHz, 2440MHz

Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail
20985.65	41.86	7.22	4.05	53.14	Peak Max	V	160	252	74	-20.86	Pass
20985.65	30.04	7.22	4.05	41.31	Average Max	V	160	252	54	-12.69	Pass
23689.66	43.71	7.73	2.74	54.18	Peak Max	V	178	266	74	-19.82	Pass
23689.66	31.48	7.73	2.74	41.95	Average Max	V	178	266	54	-12.05	Pass
24555.47	32.81	7.85	2.83	43.48	Average Max	V	155	264	54	-10.52	Pass
24555.47	45.2	7.85	2.83	55.88	Peak Max	V	155	264	74	-18.12	Pass
25048.39	34.47	7.87	3.12	45.46	Average Max	V	158	247	54	-8.54	Pass
25048.39	46.25	7.87	3.12	57.24	Peak Max	V	158	247	74	-16.76	Pass
26386.45	45.73	8.06	4.12	57.91	Peak Max	H	188	237	74	-16.09	Pass
26386.45	34	8.06	4.12	46.18	Average Max	H	188	237	54	-7.82	Pass
26425	46	8.08	4.13	58.2	Peak Max	V	179	255	74	-15.8	Pass
26425	33.85	8.08	4.13	46.05	Average Max	V	179	255	54	-7.95	Pass



Plot 27. 18-26.5GHz, 2480MHz

4.7 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.4: 2014. These test methods are listed under the laboratory's A2LA Scope of Accreditation.

This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207.

4.7.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-

ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50µH / 50Ω LISNs.

Testing is performed in Lab1. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

4.7.1.1 Deviations

There were no deviations from this test methodology.

4.7.2 Test Results

Test not applicable since it is coin cell battery operated.

5 Test Equipment List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Spectrum Analyzer	Rohde & Schwarz	FSU26.5	200050	11/20/2018	11/20/2019
Spectrum Analyzer	Rohde & Schwarz	FSU8	101358	12/07/2018	12/07/2019
EMI Receiver	Rohde & Schwarz	ESIB40	100180	05/31/2018	05/31/2020
L.I.S.N.	Com-Power	LI-215	192000	01/16/2019	01/16/2020
Transient Limiter	Com-Power	LIT-930	531582	01/16/2019	01/16/2020
EMI Receiver	Agilent	MXE N9038A	MY51210195	01/16/2019	01/16/2020
Preamplifier, 9 kHz – 1 GHz	Sonoma	310N	213221	01/16/2019	01/16/2020
Bilog Antenna	Sunol Sciences	JB3	A060502	05/27/2018	05/27/2020
Amplifier	Miteq	TTA1800-30-HG	1842452	01/15/2019	01/15/2020
Horn Antenna	Sunol Sciences	DRH-118	A040806	03/05/2019	03/05/2020
Amplifier	HP	8449B	3008A01013	01/15/2019	01/15/2020
Amplifier	Sonoma	310N	185516	N/A (See Note)	
1.6 GHz Low Pass Filter	K&L Microwave	8L120-X1600-0/09135-0249	UA691-35	N/A (See Note)	
3.5 GHz High Pass Filter	Hewlett Packard	84300-80038	820004	N/A (See Note)	
2.4 GHz Notch Filter	Micro-Tronics	BRM50702	009	01/15/2019	01/15/2020

Note: Equipment is characterized before use.

6 EMC Test Plan

6.1 Introduction

This section provides a description of the Equipment Under Test (EUT), configurations, operating conditions, and performance acceptance criteria. It is an overview of information provided by the manufacturer so that the test laboratory may perform the requested testing.

6.2 Customer

Table 7: Customer Information

Company Name	JAET2L Holdings
Address	8555 Hollyhock St.
City, State, Zip	Lafayette, CO 80026
Country	USA

Table 8: Technical Contact Information

Name	Isaac Davenport
E-mail	isaac@isaacdavenport.com

6.3 Equipment Under Test (EUT)

The information provided in the following table should be listed as it should appear in the final report. For those products that have only a model name, list the model number as *non-applicable* and vice-versa.

Table 9: EUT Designation

Product Name	JAET2L Holdings
Model Number	A, ISS001US
System Name	Nordic nrf52810 BLE 2.4GHz
Product Description	Bluetooth BLE 2.4GHz

6.4 Product Specifications

Table 10: EUT Specifications

EUT Specifications	
Input Power	3VDC, CR2032 coin cell
Environment	Indoor
Operating Temperature Range:	-10 C to + 60 C
Multiple Feeds:	☐ Yes and how many ☒ No
Product Marketing Name (PMN) Note 2	A, ISS001US
Hardware Version Identification Number (HVIN)	D
Firmware Version Identification Number (FVIN)	1.0
RF Test Software Version	-
Operating Modes	BT Low Energy, 1Mbps
Transmitter Frequency Band	2.4 GHz – 2.4835 GHz
Power Setting @ Operating Channel	See section 4.1.2.
Modulation	GFSK
TX/RX Chain (s)	SISO
Directional Gain Type	CCD
Type of Equipment	☒ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☐ Other:
Note 1: EUT will be on / transmitted at all times with the highest power levels and antenna gains per channel. **Note 2:** The differences and similarities between models: Both models uses the same PCBA board contains no modifications. The difference is they have different soft goods around them. One has a lanyard and one has a cloth bag.	

Table 11: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
Antenna 0	Trace Antenna	Bluetooth Low Energy	0 dBi

Table 12: Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
N/A		☐	☐	☐

Table 13: Accessory Equipment

Equipment	Manufacturer	Model	Serial	Comment
N/A				
Note: None.				

Table 14: Ancillary Equipment (used for test purposes only)

Equipment	Manufacturer	Model	Serial	Used for
N/A				
Note: None.				

Table 15: Description of Sample used for Testing

Sample Number	Device	Serial Number	Configuration	Used For
1	Model A, ISS001US	Unit #1	Radiated Sample	TX Spurious Emissions, Bandedge
2	Model A, ISS001US	Unit #2	Conducted Sample	All other conducted Measurments
Note: None.				

Table 16: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Photo (X-Axis)	Setup Photo (Y-Axis)	Setup Photo (Z-Axis)
Model A, ISS001US	Trace Antenna	Transmit	EUT upright	N/A	N/A
Note: Manufacturer has declared that the EUT is designed to operate in a fixed, upright position.					

6.5 Test Specifications

Table 17: Test Specifications

Emissions and Immunity	
Standard	**Requirement**
CFR 47 Part 15.247: 2019	All

END OF REPORT