Emissions
Test Report

EUT Name: Halo Band

Model No.: C9X87E

CFR 47 Part 15.247: 2019 and RSS 247: 2017

Prepared for:

Conde Verdon Company LLC
3200 Greenfield Rd., Ste 300
Dearborn, MI 48120

Prepared by:

TUV Rheinland of North America, Inc.
5015 Brandin Ct.
Fremont, CA 94538
Tel: (925) 249-9123
Fax: (925) 249-9124
http://www.tuv.com/

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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	11/20/2019	Original Document	JB

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Conde Verdon Company LLC 3200 Greenfield Rd., Ste 300 Dearborn, MI 48120
Requester / Applicant:	Conde Verdon Company LLC
Name of Equipment:	Halo Band
Model No.	C9X87E
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2019 and RSS 247: 2017
Test Dates:	July 29th, 2019 to August 9th, 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.

Test Engineer	Date November 20, 2019	A2LA Signatory	Date November 20, 2019

Testing Cert #3331.02 **US1131** **US0185**

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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 and RSS 247: 2017 based on the results of testing performed on July 29th, 2019 to August 9th, 2019 on the C9X87E manufactured by Conde Verdon Company LLC. 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), RSS 247 Sect. 5.4 (d)	10.82dBm @ 2480MHz Channel, 1Mbps	**Complied**
DTS Bandwidth (6dB)	CFR47 15.247 (a)(2), RSS 247 Sect. 5.2 (a)	0.6645MHz @ 2402MHz Channel, 1Mbps	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 247 Sect. 5.2 (b)	-0.4 dBm @ 2480MHz channel, 1Mbps	**Complied**
Out of Band Emissions: Non-Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	-32.24 dBc @ 2400MHz, 2Mbps, Lower Band Edge	**Complied**
Out of Band Emissions: Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	-18.87dB margin @ 2484.867MHz, 2Mbps, Average	**Complied**
Transmitter Spurious Emissions	CFR47 15.247 (d), RSS 247 Sect.5.5	-12.96dB Margin @ 17922.4425 MHz, Average	**Complied**
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.8.8	-20.77dB Margin @ 0.181213 MHz, Quasi Peak	**Complied**

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 17025:2005. The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 ISED

The Pleasanton 5-meter Semi-Anechoic Chamber, has been accepted by ISED 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, has been accepted by ISED to perform testing to 3 and 10 meters based on the test procedures described in ANSI C63.4-2014. Under US0185

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-0326

VCCI Registration No. for Fremont: A-0327

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 17025:2005. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The Model C9X87E utilizes Bluetooth LE. 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

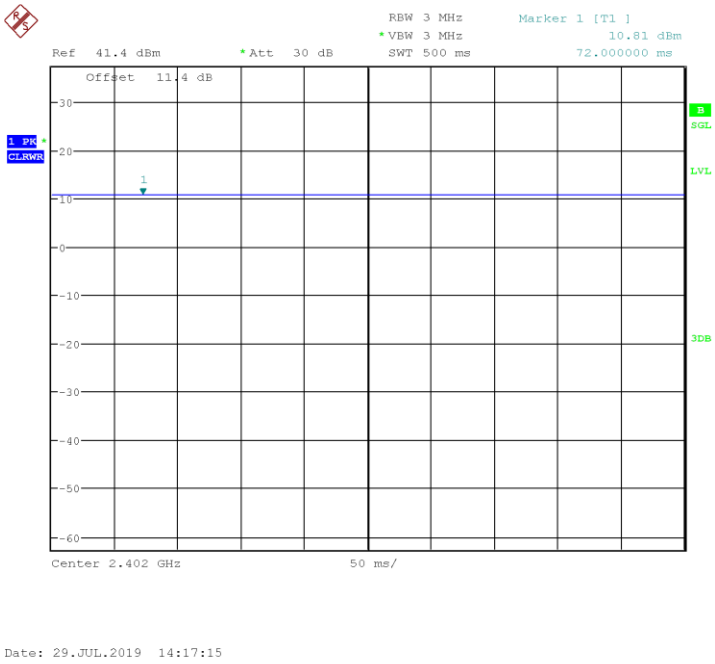
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply 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

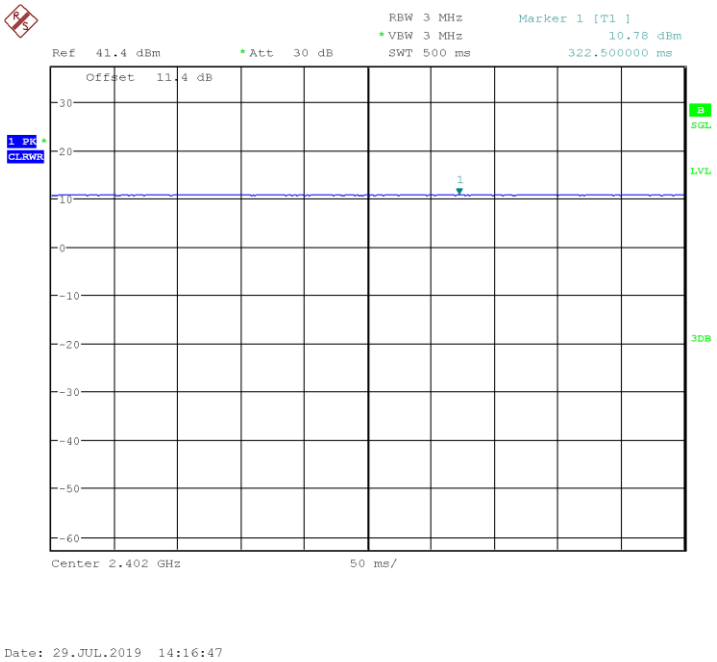
The Halo Band has 1 Folded Monopole dedicated Bluetooth antenna that has maximum gain of -2.2dBi. It is connected via RF connector that is not easily accessible to the end user.

3.5 Duty Cycle

While in test mode, the device was set to continuous transmit, yielding in a 100% duty cycle for both 1M and 2M configurations



Duty Cycle Measurement – 1M



Duty Cycle Measurement – 2M

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.247: 2019 and RSS 247: 2017. 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.

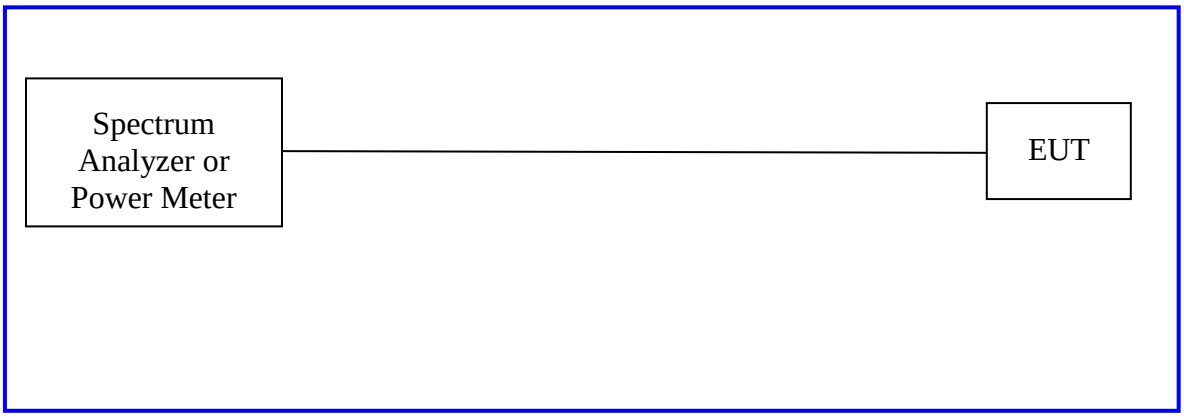
The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b) and RSS 247 5.4 (d).

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) and RSS 247 Sect. 5.4(d); 2400 MHz to 2483.5 MHz. The worst mode results indicated below.

Test Setup:

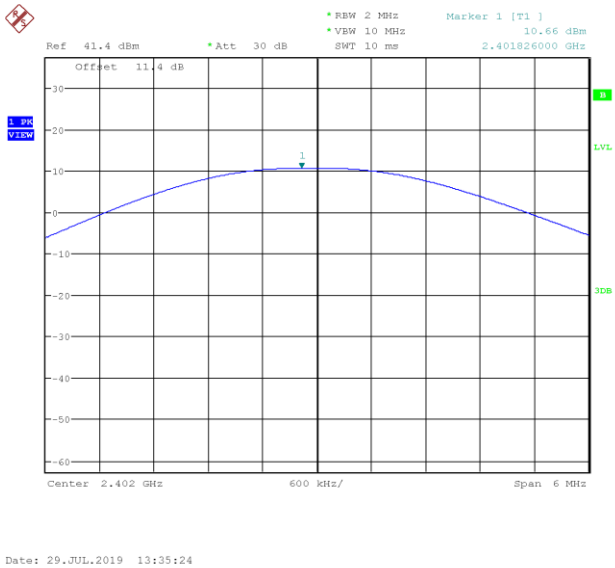


4.1.2 Results

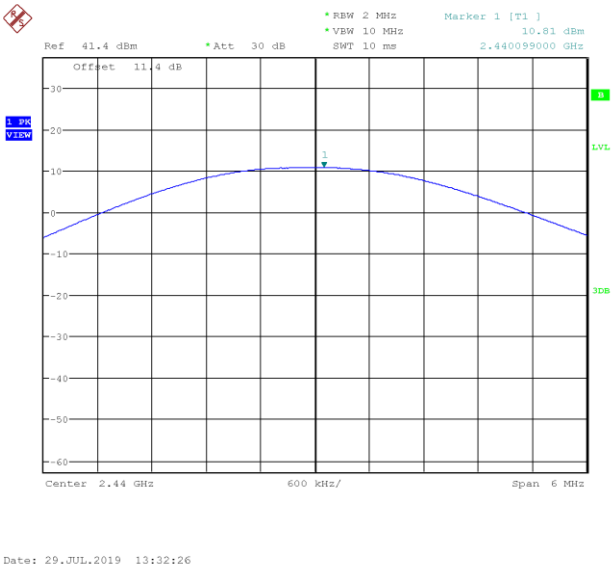
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s). Worse case data for each mode reported below. Plots of highest power included for low, medium, and high channels.

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

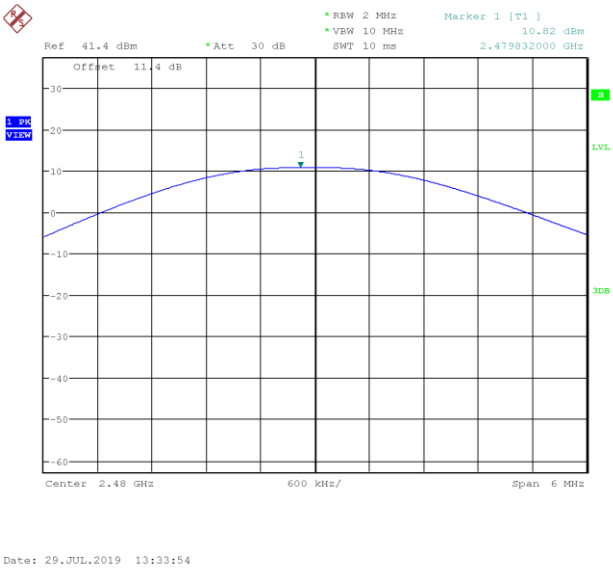
Data Rate	Operating Channel (MHz)	Power [dBm]	Limit [dBm]	Margin [dB]
1Mbps	2402	10.66	30	-19.34
	2440	10.81	30	-19.19
	2480	10.82	30	-19.18
2Mbps	2402	10.59	30	-19.41
	2440	10.63	30	-19.37
	2480	10.75	30	-19.25



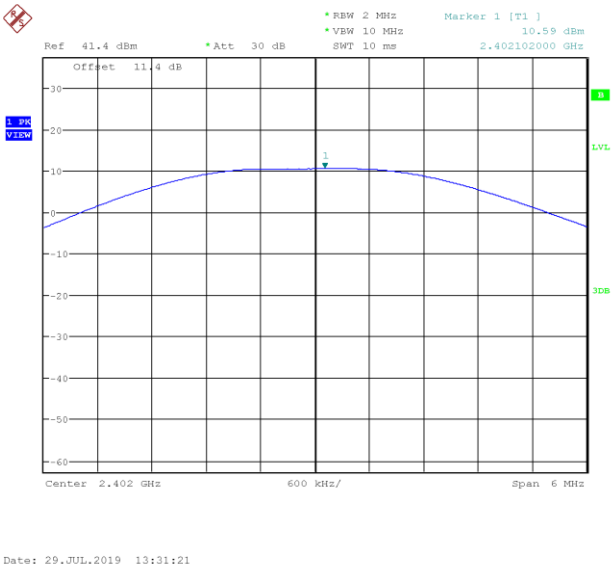
Plot 1. Maximum Conducted Power, 1Mbps 2402MHz



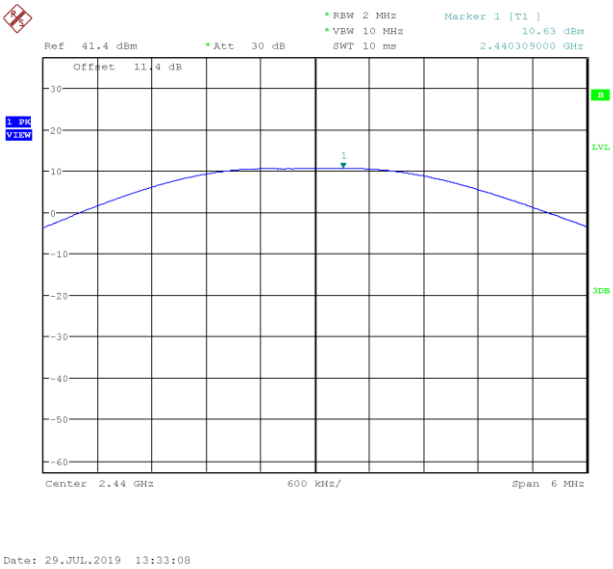
Plot 2. Maximum Conducted Power, 1Mbps 2440MHz



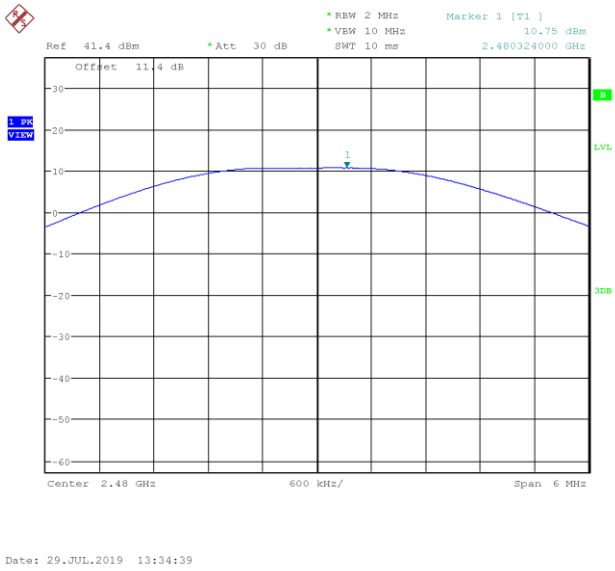
Plot 3. Maximum Conducted Power, 1Mbps 2480MHz



Plot 4. Maximum Conducted Power, 2Mbps 2402MHz



Plot 5. Maximum Conducted Power, 2Mbps 2440MHz



Plot 6. Maximum Conducted Power, 2Mbps 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.

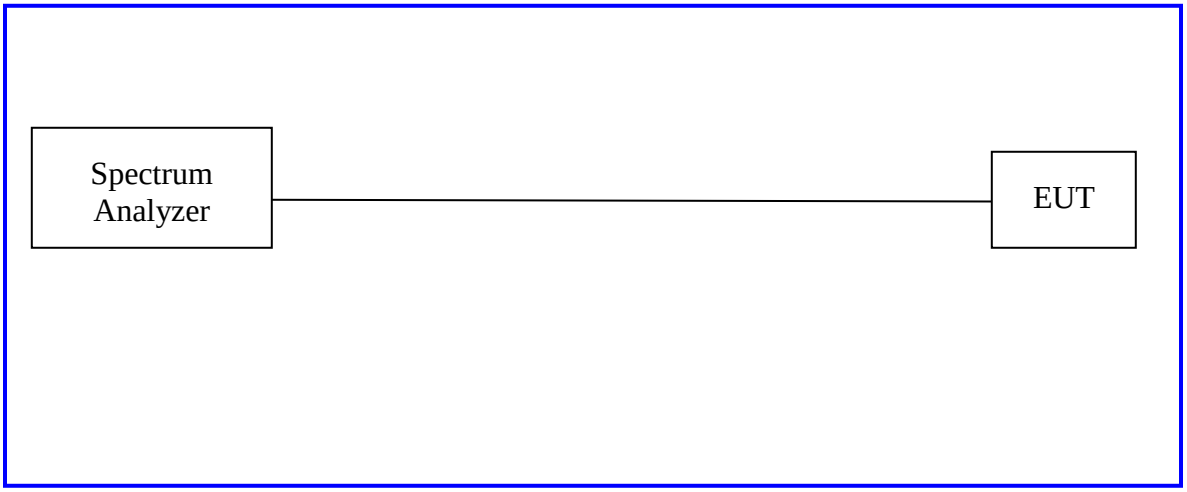
The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

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) and RSS Gen Sect. 6.6. Measurements were performed on the low, middle and high channels of the operating frequency range; 2400 MHz to 2483.5 MHz.

Test Setup:

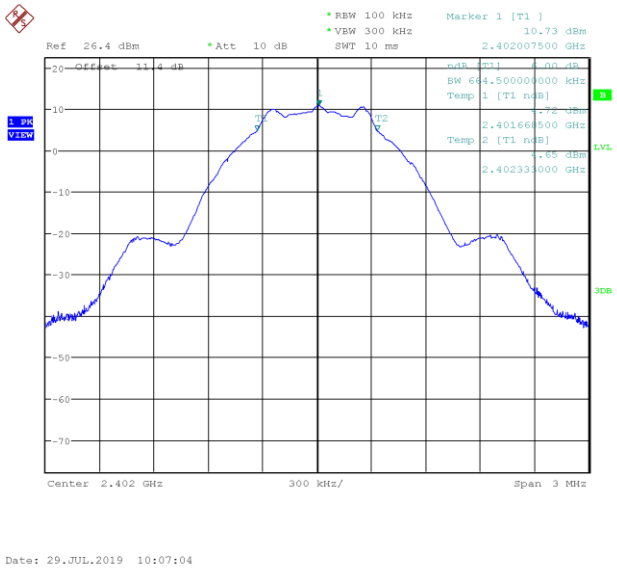


4.2.2 Results

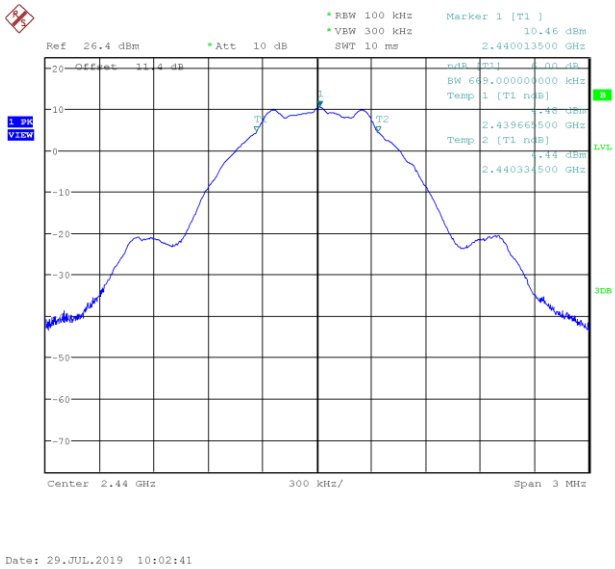
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 3: Occupied Bandwidth – Test Results

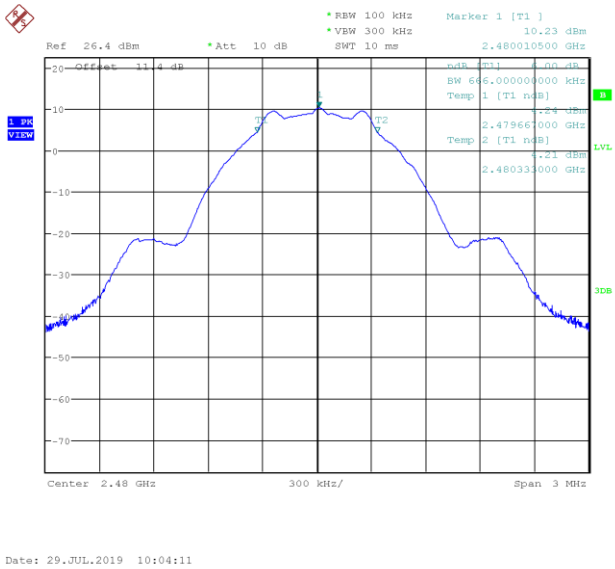
Bandwidth (MHz)			
Data Rate	**Freq. (MHz)**	**99% Bandwidth (MHz)**	**6dB (DTS) Bandwidth (MHz)**
1Mbps	2402	1.047	0.6645
	2440	1.05	0.669
	2480	1.0485	0.666
2Mbps	2402	2.0775	1.1225
	2440	2.075	1.125
	2480	2.0725	1.1325
	Note: None		



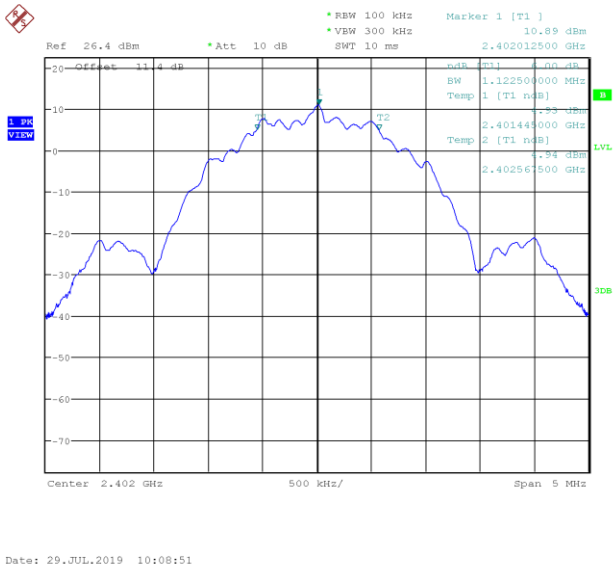
Plot 7. 1Mbps, 2402MHz, 6dB Bandwidth



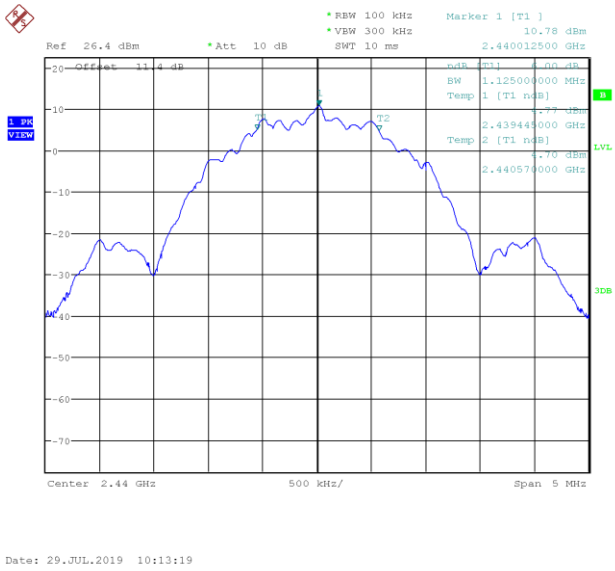
Plot 8. 1Mbps, 2440MHz, 6dB Bandwidth



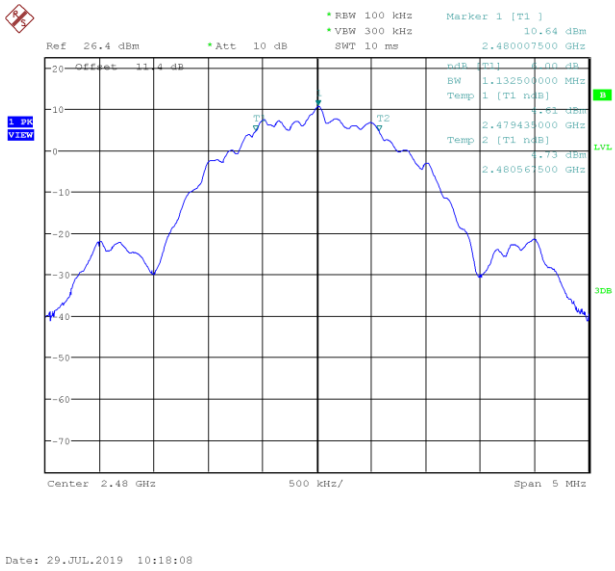
Plot 9. 1Mbps, 2480MHz, 6dB Bandwidth



Plot 10. 2Mbps, 2402MHz, 6dB Bandwidth



Plot 11. 2Mbps, 2440MHz, 6dB Bandwidth



Plot 12. 2Mbps, 2480MHz, 6dB Bandwidth

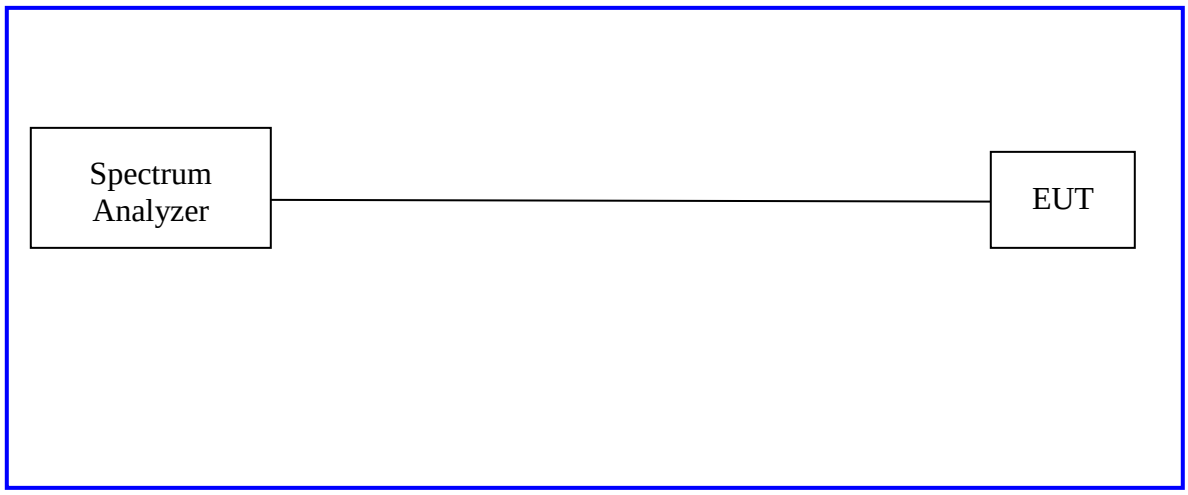
4.3 Peak Power Spectral Density

According to the CFR47 Part 15.247 (e) and RSS 247 Sect.5.2 (b), 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) and RSS 247 Sect.5.2 (b). The worst findings were conducted on 3 channels in each operating frequency range of 2400 MHz to 2483.5 MHz.

Test Setup:



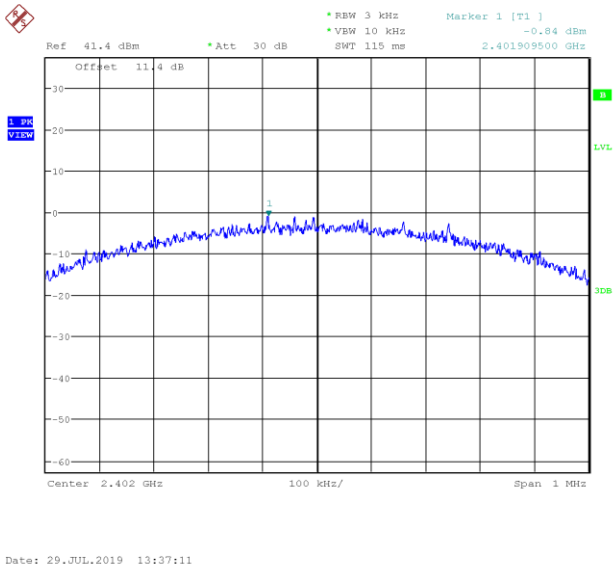
Method PKPSD of "KDB 558074 – DTS Measurement Guidance v04" was used.

4.3.2 Results

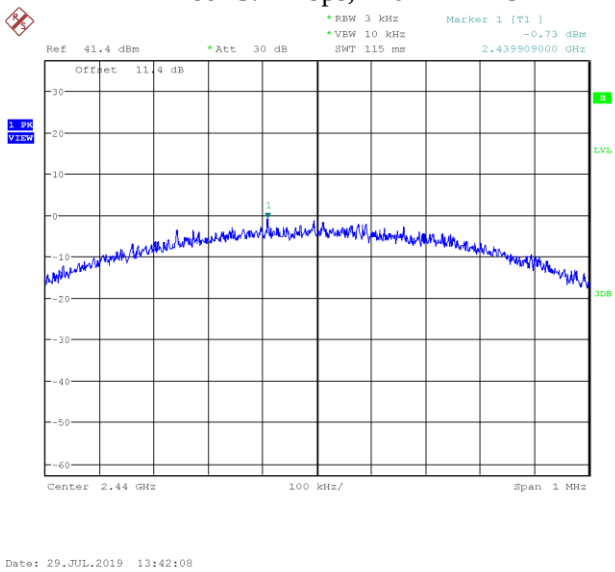
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 4: Peak Power Spectral Density – Test Results

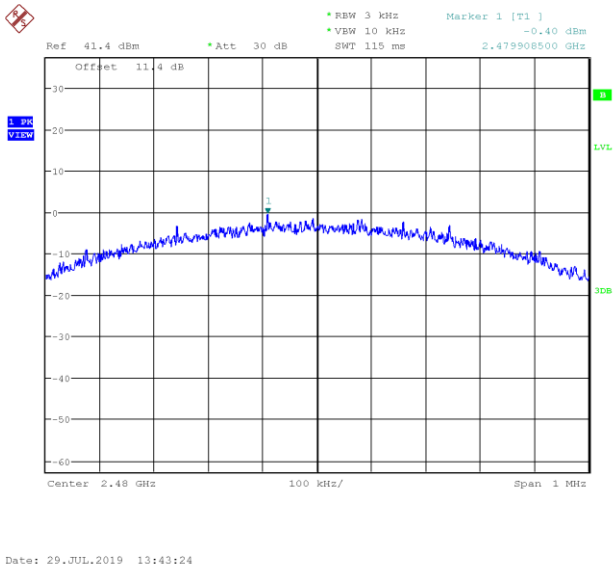
Peak Power Spectral Density				
Data Rate	**Freq. (MHz)**	**Total PSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
1Mbps	2402	-0.84	8	-8.84
	2440	-0.73	8	-8.73
	2480	-0.4	8	-8.4
2Mbps	2402	-4.02	8	-12.02
	2440	-4.05	8	-12.05
	2480	-3.91	8	-11.91
	Note: None			



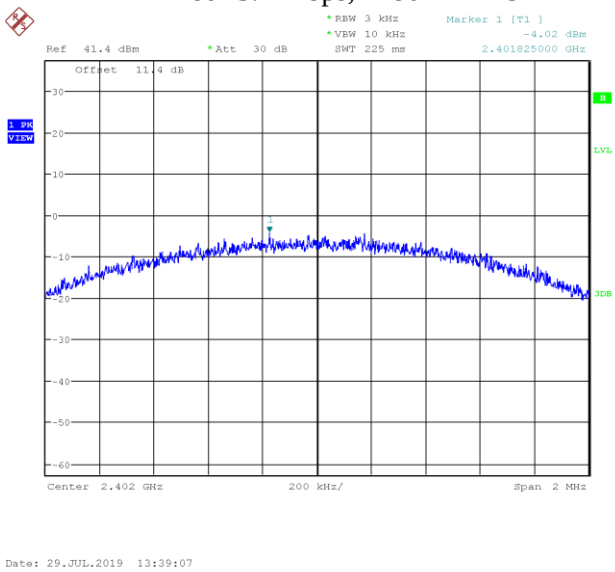
Plot 13. 1Mbps, 2402MHz PSD



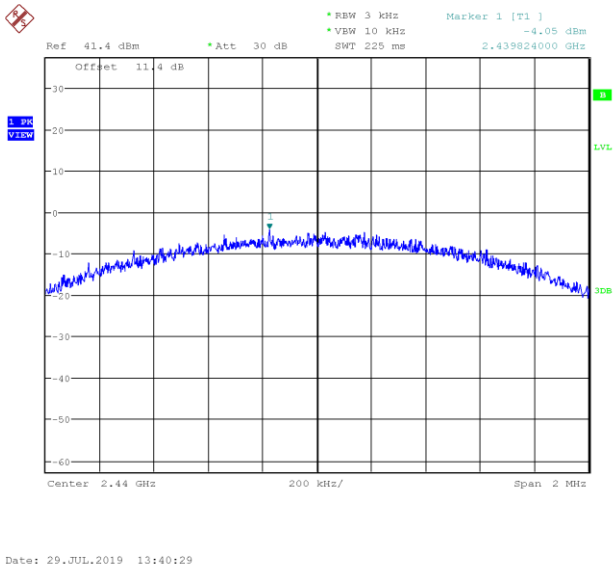
Plot 14. 1 Mbps, 2440MHz PSD



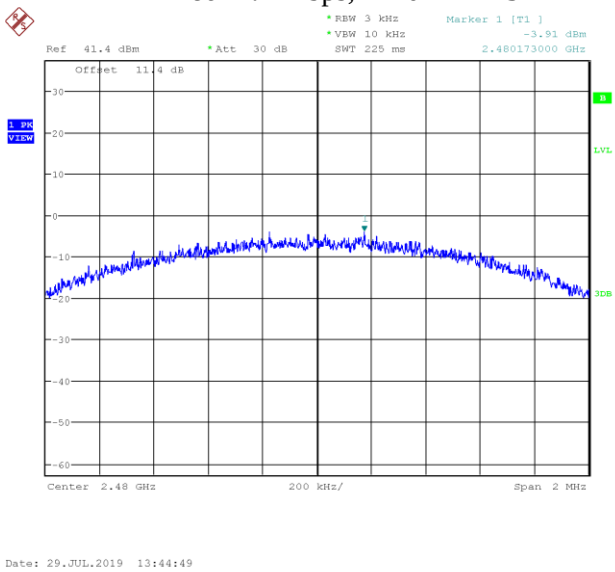
Plot 15. 1Mbps, 2480MHz PSD



Plot 16. 2Mbps, 2402MHz PSD



Plot 17. 2Mbps, 2440MHz PSD



Plot 18. 2Mbps, 2480MHz PSD

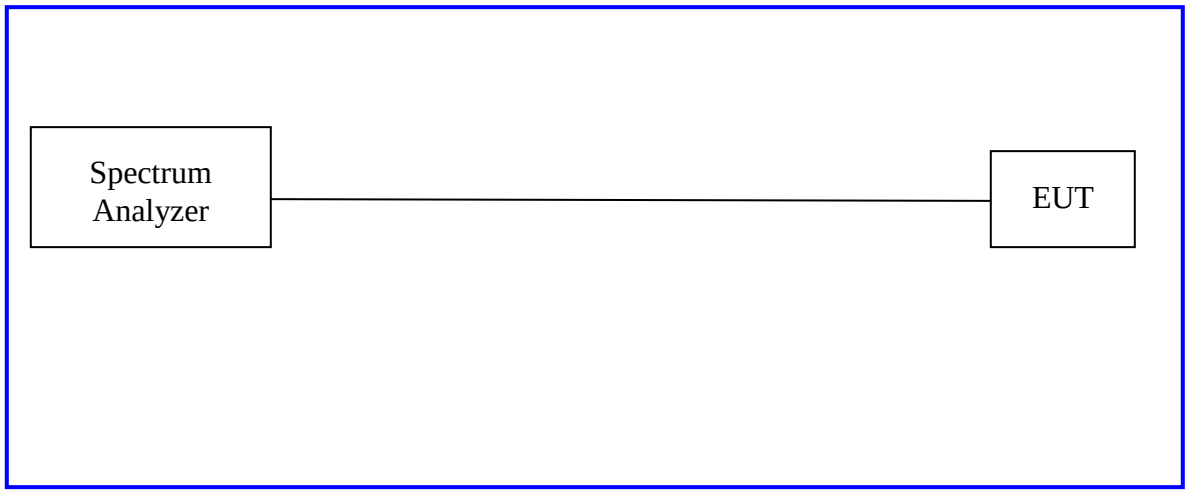
4.4 Out of Band Emissions: Non-Restricted Bands

Any frequency outside the band of 2400 MHz to 2483.5 MHz, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under the regulation, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. ; CFR 47 Part 15.247(d) and RSS 247 Sect. 5.5.

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 (2480MHz/1Mbps and 2402MHz/2Mbps) 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:

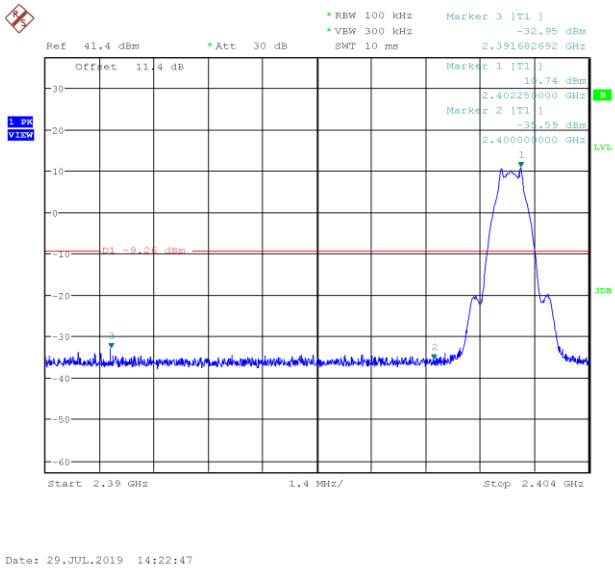


4.4.2 Results

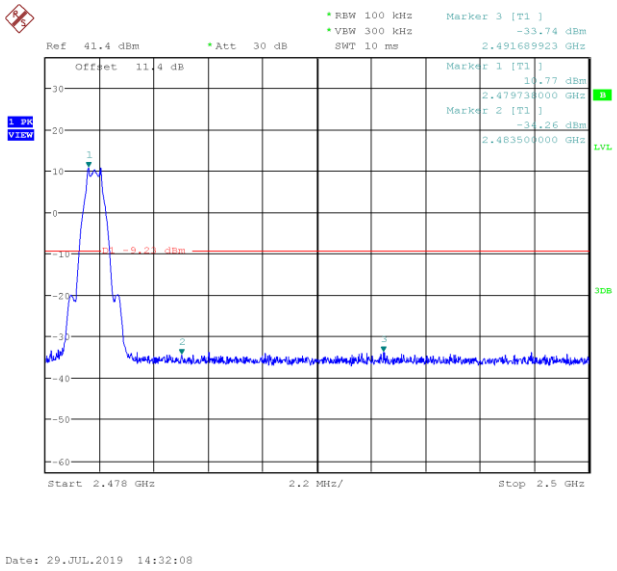
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

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

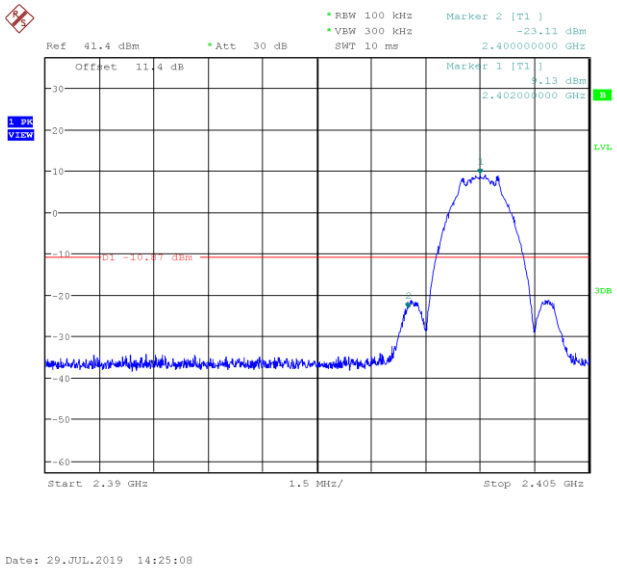
Non-Restricted Frequency Band Edge Emissions						
Data Rate	**Band Edge**	**Center Freq (MHz)**	**Measured (dBc)**	**Limit (dBc)**	**Freq (MHz)**	**Results**
1Mbps	Low	2402	43.69	20	2391.68	Pass
	High	2480	44.51	20	2491.68	Pass
2Mbps	Low	2402	32.24	20	2400	Pass
	High	2480	42.14	20	2484.58	Pass
	Note:					



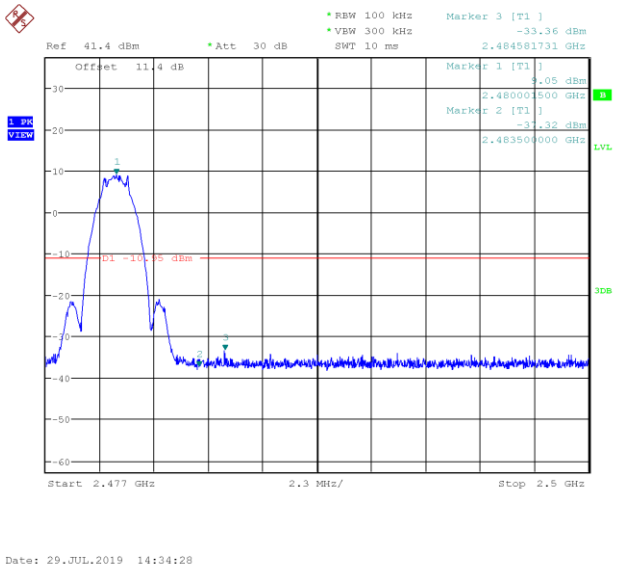
Plot 19. 1Mbps, 2402MHz Lower Band Edge



Plot 20. 1Mbps, 2480MHz Upper Band Edge

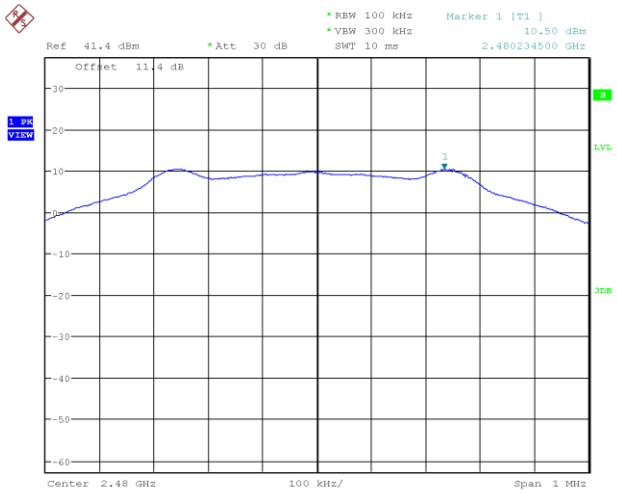


Plot 21. 2Mbps, 2402MHz Lower Band Edge



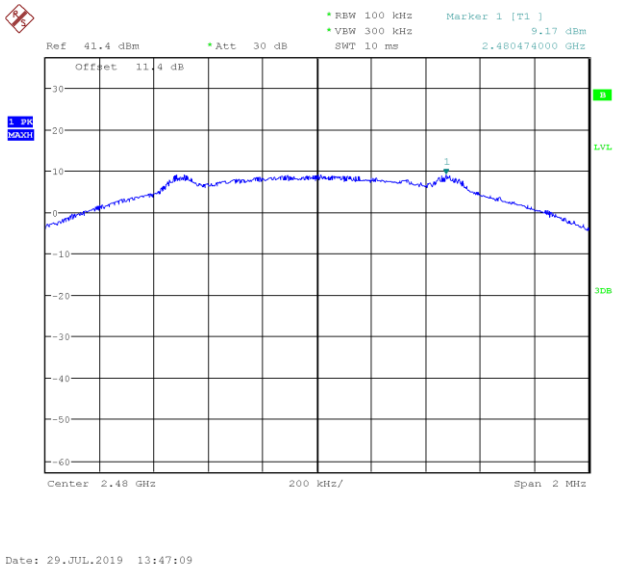
Date: 29.JUL.2019 14:34:28

Plot 22. 2Mbps, 2480MHz Upper Band Edge

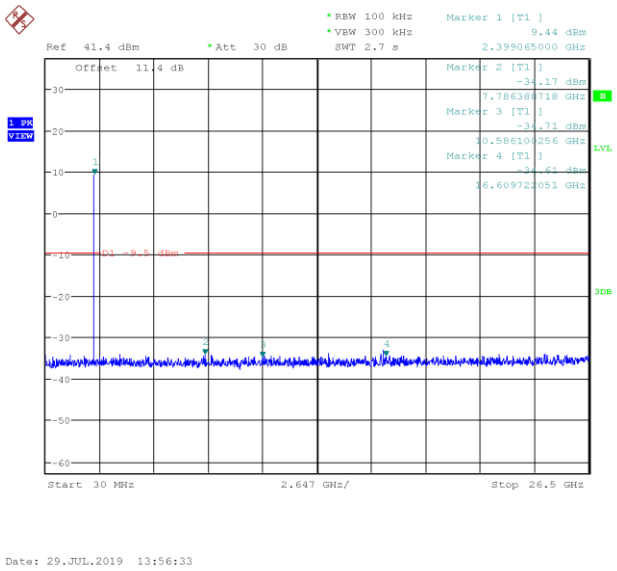


Date: 29.JUL.2019 13:48:16

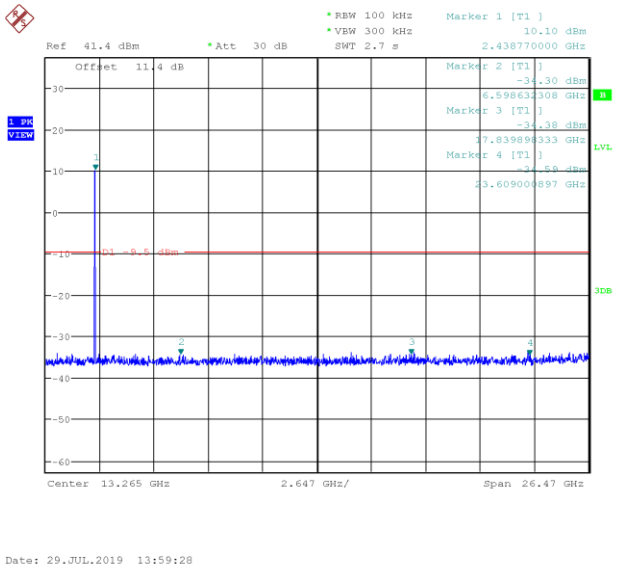
Plot 23. Non-Restricted Reference Measurement, 1Mbps 2480MHz



Plot 24. Non-Restricted Reference Measurement, 2Mbps 2480MHz

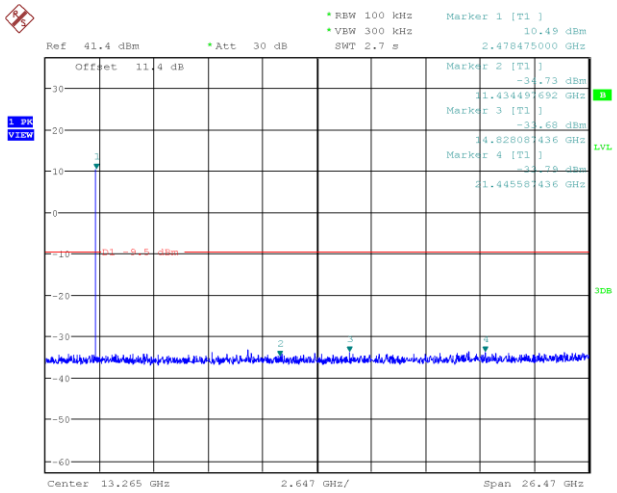


Plot 25. 1Mbps, 2402MHz 30MHz-26.5GHz Spurious



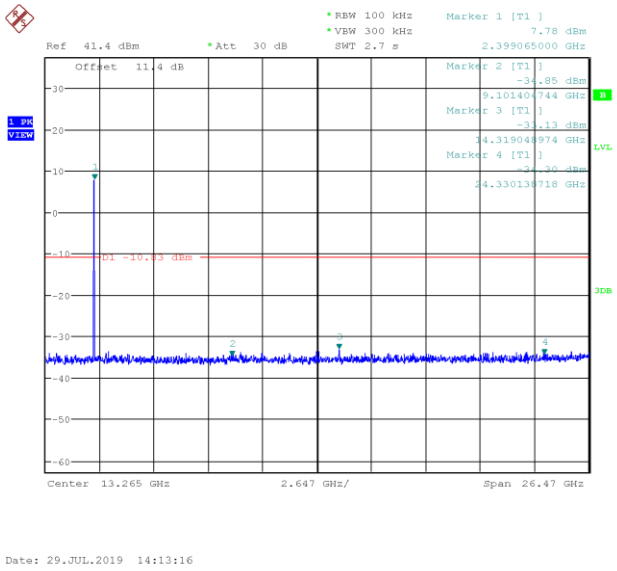
Date: 29.JUL.2019 13:59:28

Plot 26. 1Mbps, 2440MHz 30MHz-26.5GHz Spurious

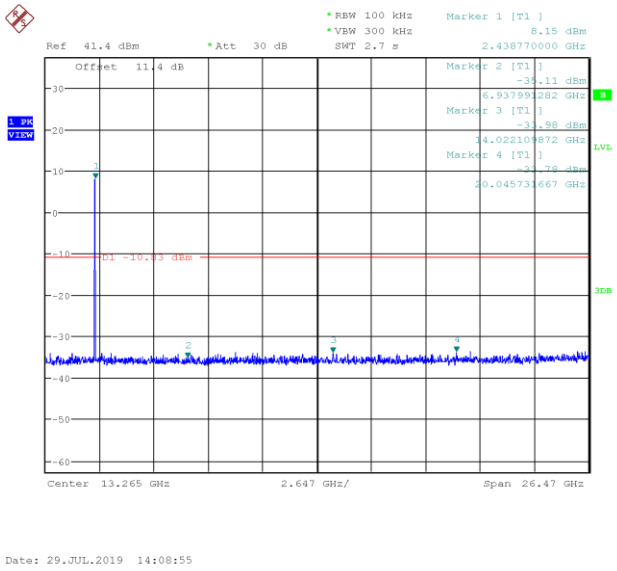


Date: 29.JUL.2019 14:03:37

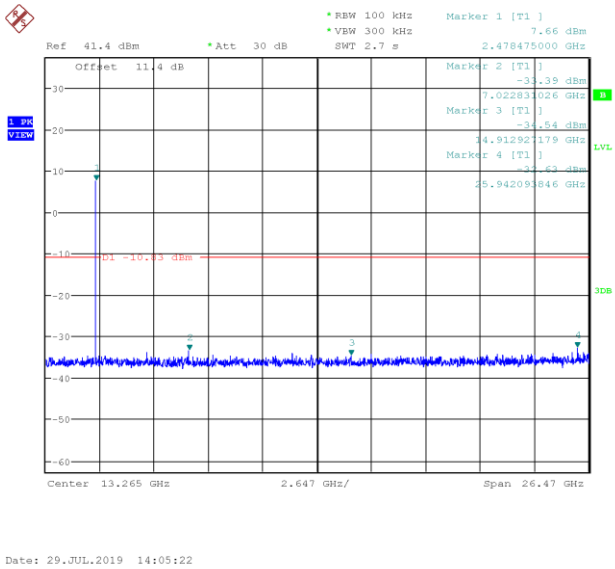
Plot 27. 1Mbps, 2480MHz 30MHz-26.5GHz Spurious



Plot 28. 2Mbps, 2402MHz 30MHz-26.5GHz Spurious



Plot 29. 2Mbps, 2440MHz 30MHz-26.5GHz Spurious



Plot 30. 2Mbps, 2480MHz 30MHz-26.5GHz Spurious

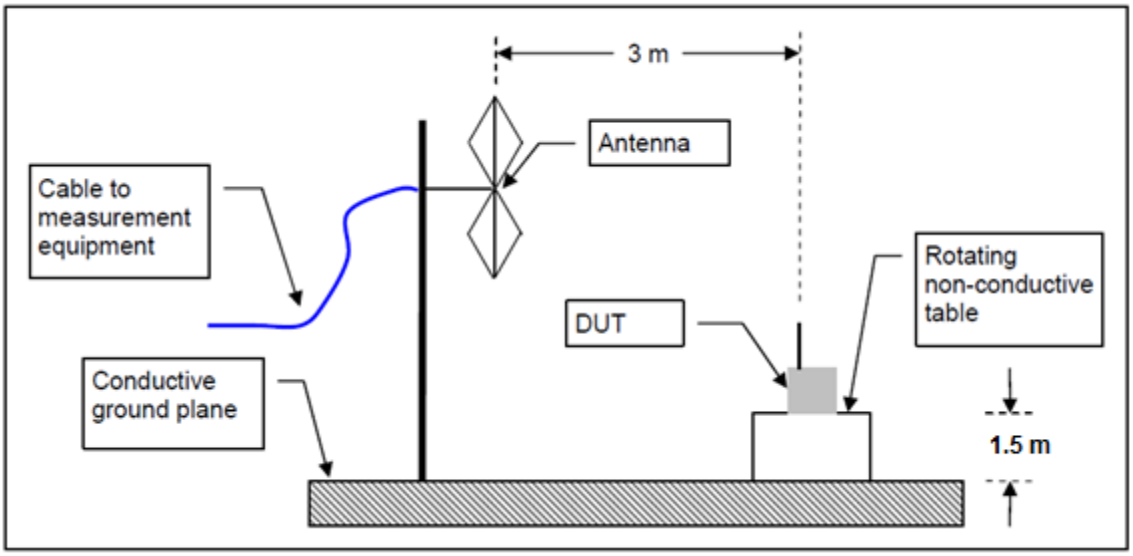
4.5 Out of Band Emissions: Restricted Band Edge

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), RSS-247 Sect. 5.5, RSS-GEN Sect. 8.9 and 8.10.

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 the upper and lower most 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

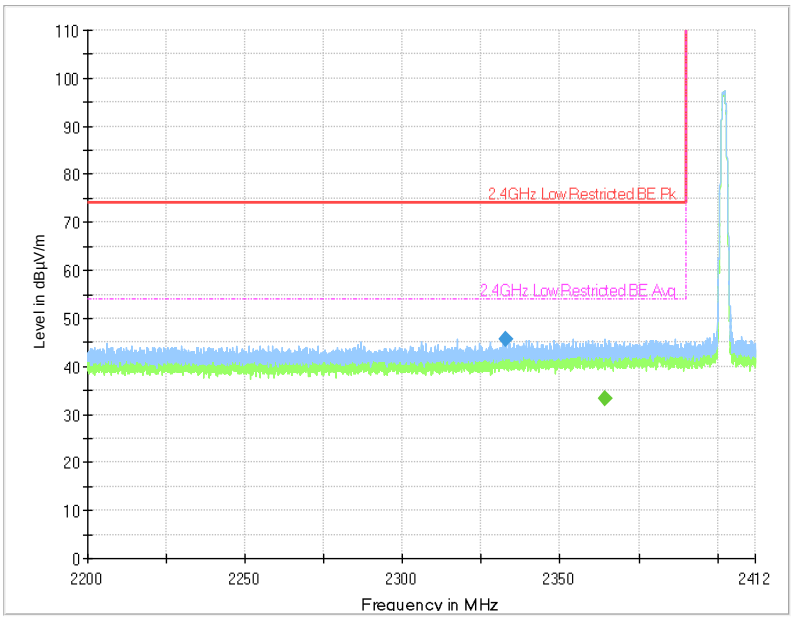


The DUT was stimulated by manufacturer provided test software that is not available to the end user.

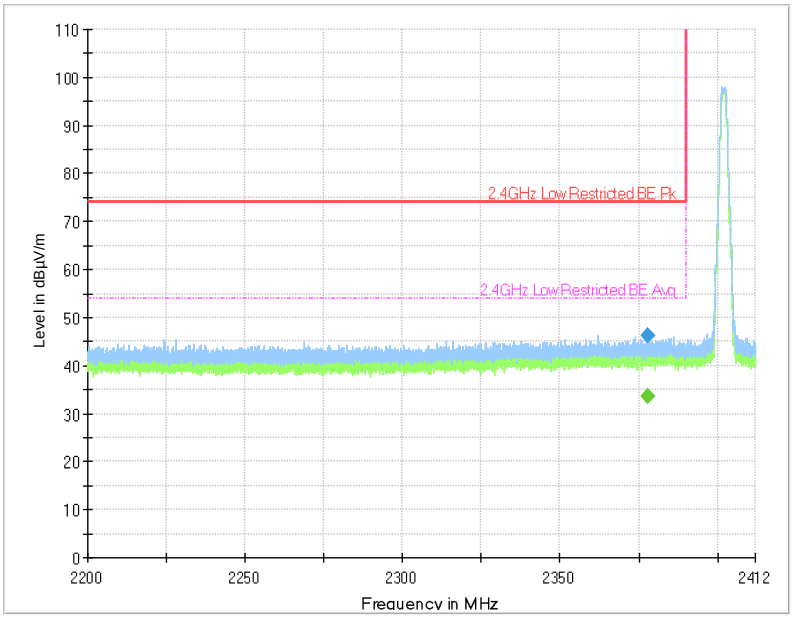
4.5.2 Test Results

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

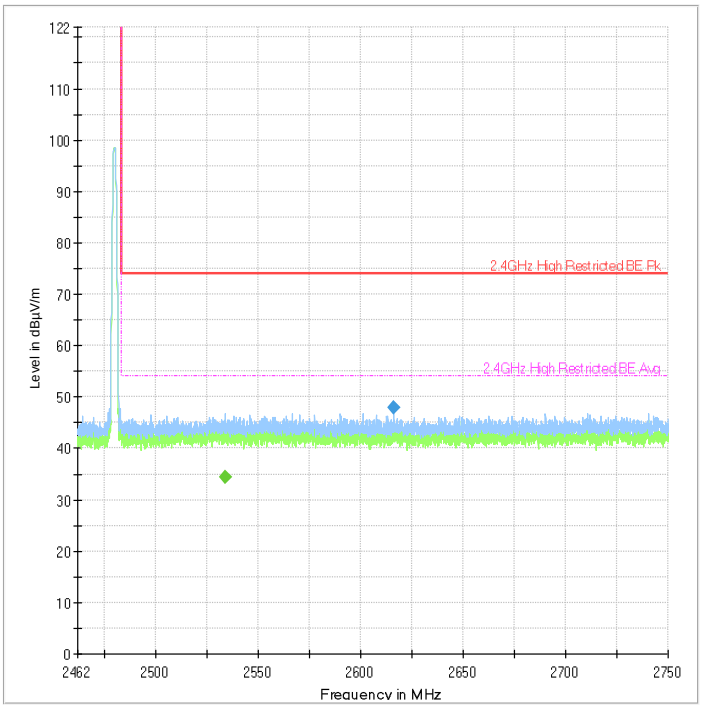
Test Conditions: Radiated Measurement, Normal Temperature and Voltage							
Lower Restricted Band Edge							
Freq. (MHz)	**Mode/Data Rate**	**Center Freq (MHz)**	**Detector (Average/ Peak)**	**Measured (dBuV/m)**	**Limit (dBuV/m)**	**Margin**	**Results**
2364.427	BLE GFSK 1Mbps	2402	Average	33.36	54	-20.64	Pass
2332.606	BLE GFSK 1Mbps	2402	Peak	45.74	74	-28.26	Pass
2377.974	BLE GFSK 2Mbps	2402	Average	33.66	54	-20.34	Pass
2377.974	BLE GFSK 2Mbps	2402	Peak	46.27	74	-27.73	Pass
Upper Restricted Band Edge							
Freq. (MHz)	**Mode**	**Center Freq (MHz)**	**Detector (Average/ Peak)**	**Measured (dBuV/m)**	**Limit (dBuV/m)**	**Margin**	**Results**
2533.884	BLE GFSK 1Mbps	2480	Average	34.43	54	-19.57	Pass
2616.137	BLE GFSK 1Mbps	2480	Peak	47.88	74	-26.12	Pass
2484.867	BLE GFSK 2Mbps	2480	Average	35.13	54	-18.87	Pass
2534.460	BLE GFSK 2Mbps	2480	Peak	47.43	74	-26.57	Pass
Note:							



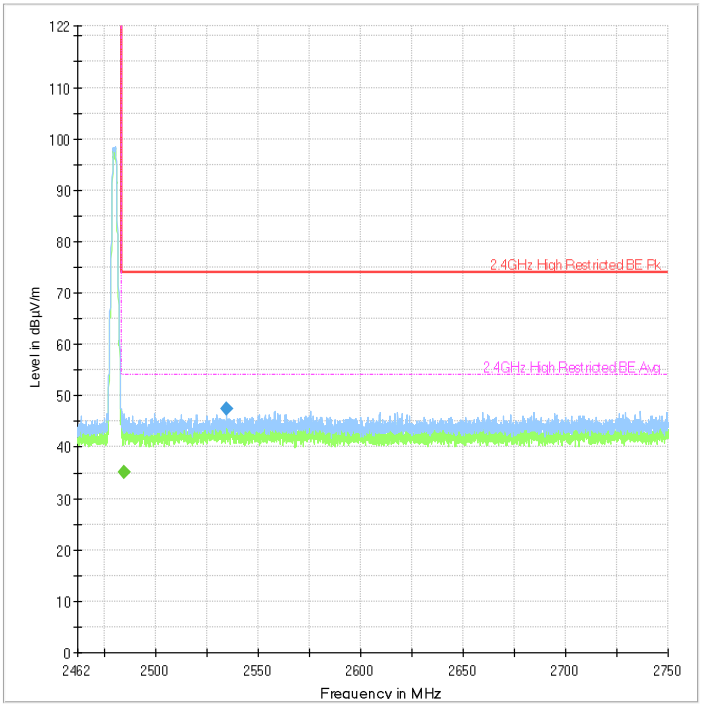
Plot 31. 1Mbps, 2402MHz, Lower Band Edge, Restricted



Plot 32. 2Mbps, 2402MHz, Lower Band Edge, Restricted



Plot 33. 1Mbps, 2480MHz, Upper Band Edge, Restricted



Plot 34. 2Mbps, 2480MHz, Upper Band Edge, Restricted

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), RSS 247 Sect.5.5, RSS-GEN Sect. 8.9 and 8.10.

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.

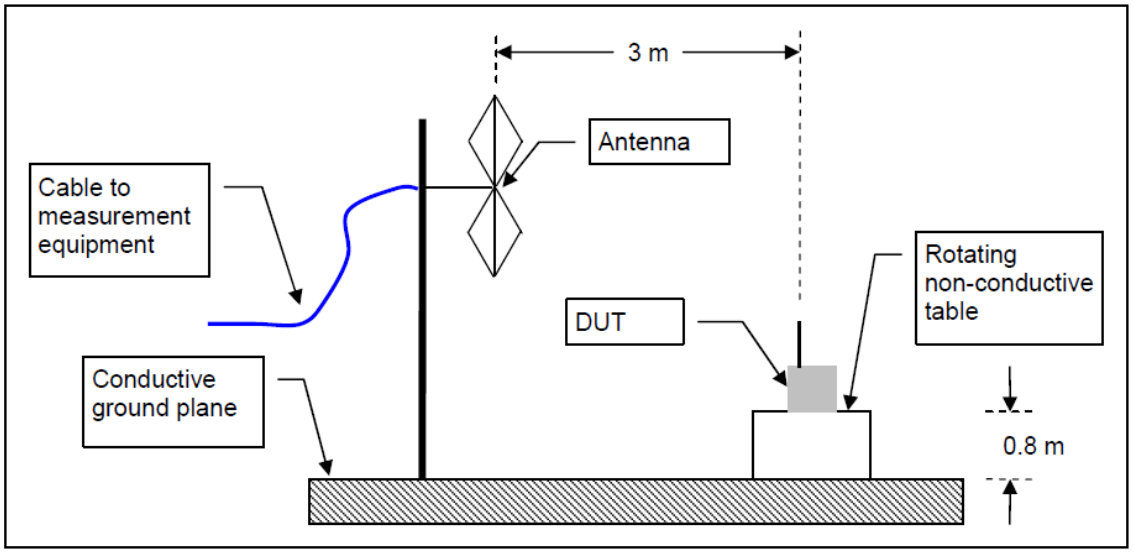
4.6.1.3 Deviations

None.

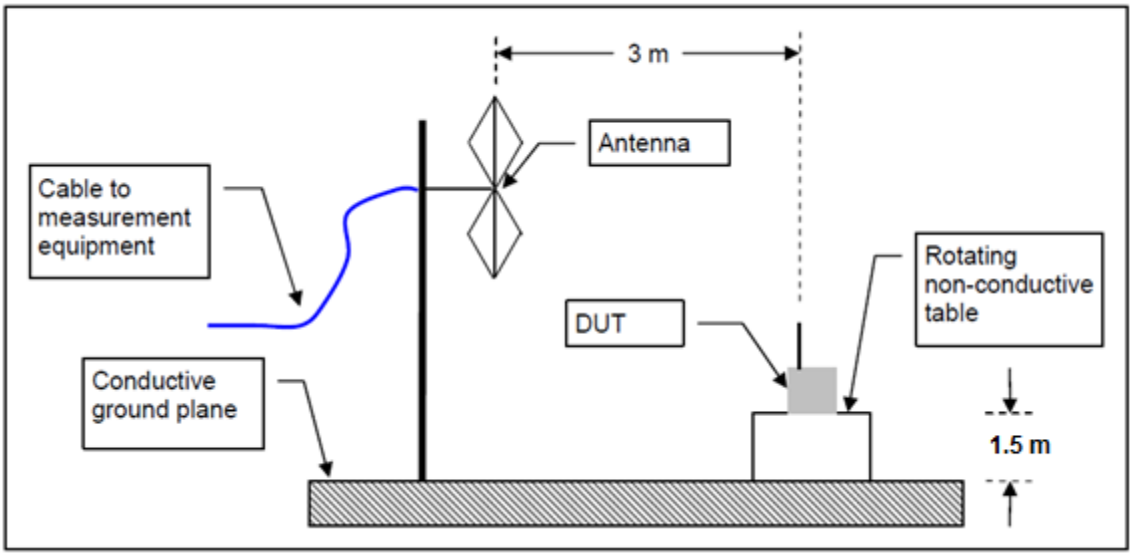
4.6.2 Test Setup:

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 and RSS Gen Sect. 8.9 and 8.10: 2014.

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

.

4.6.4 Test Results

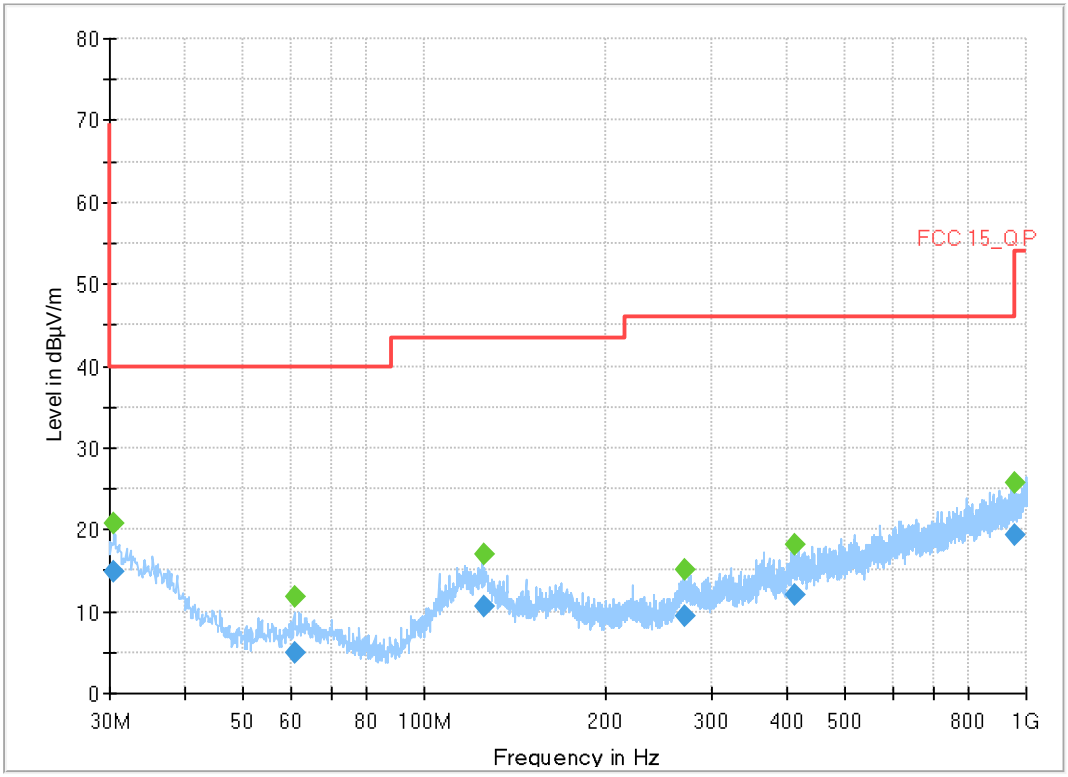
The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and test plan.

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

Worse case configurations/modes shown below, all plots taken using a peak detector in order to identify frequencies of interest.

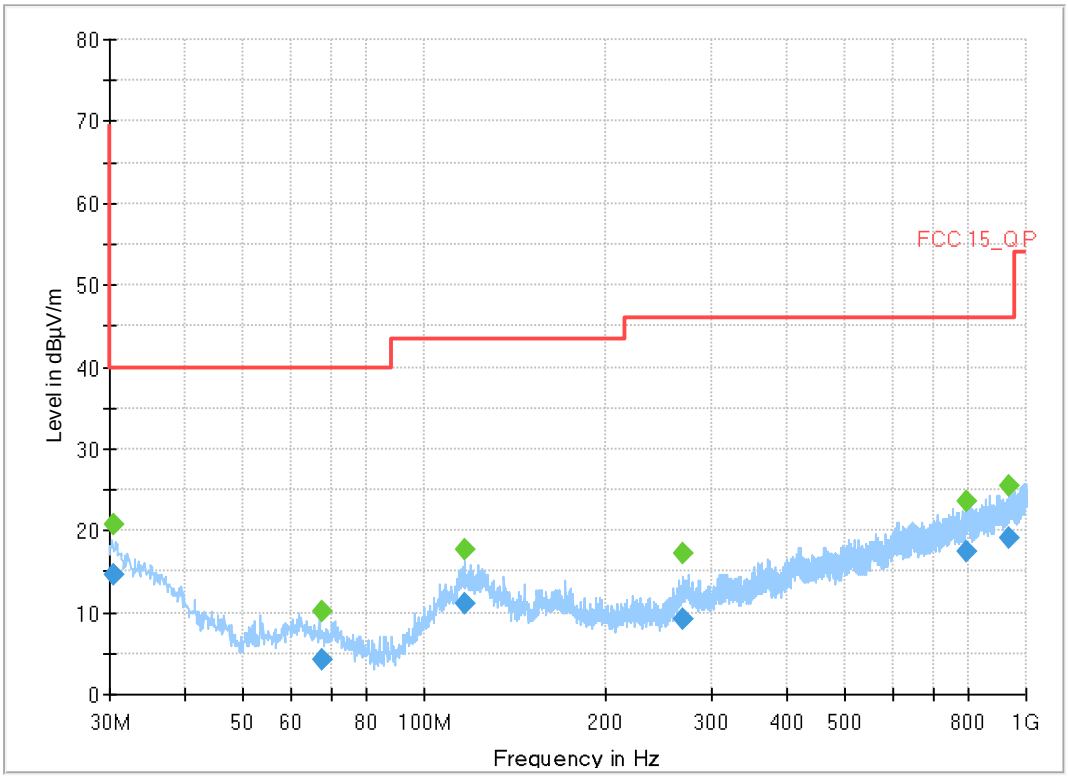
4.6.4.1 Plots

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.42174	14.81	40	25.19	1000	120	151	V	-40
60.93692	4.97	40	35.03	1000	120	151	V	4
125.33084	10.68	43.51	32.83	1000	120	310	V	20
271.23972	9.37	46	36.63	1000	120	257	H	-103
412.29144	12	46	34	1000	120	200	H	-21
957.91948	19.25	46	26.75	1000	120	180	H	-142



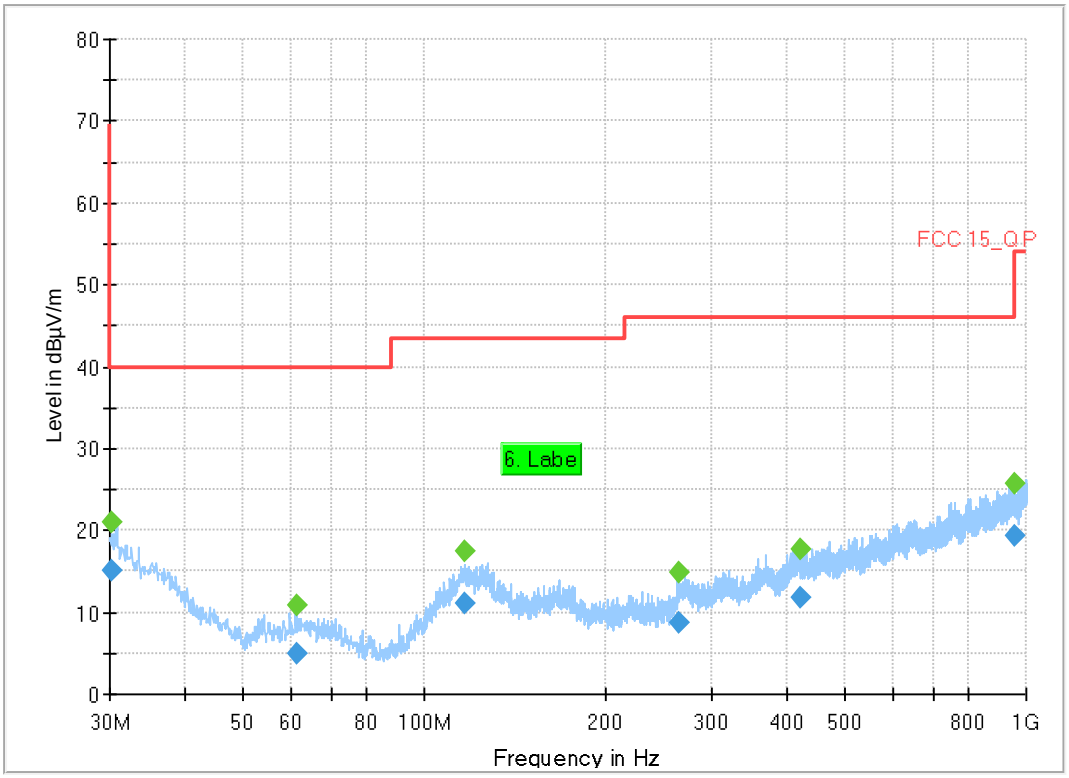
Plot 35. 30MHz-1000MHz, 1Mbps, 2402MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.434184	14.72	40	25.28	1000	120	150	H	110
67.40516	4.19	40	35.81	1000	120	100	V	-103
116.3466	11.05	43.51	32.46	1000	120	100	V	-95
268.893	9.11	46	36.89	1000	120	101	H	124
794.6586	17.55	46	28.45	1000	120	232	V	33
938.20284	19.09	46	26.91	1000	120	350	H	66



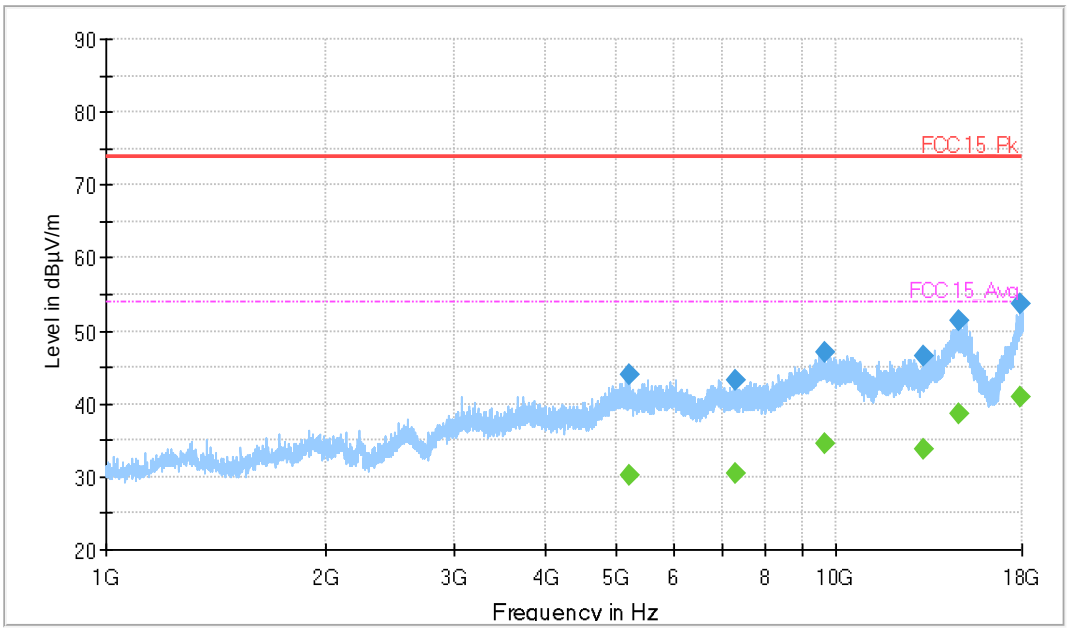
Plot 36. 30MHz-1000MHz, 1Mbps, 2440MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.20444	15.09	40	24.91	1000	120	300	H	-7
61.23924	5.04	40	34.96	1000	120	283	H	-66
116.41216	11.09	43.51	32.43	1000	120	300	H	-43
264.20916	8.69	46	37.31	1000	120	300	V	-90
422.77308	11.89	46	34.11	1000	120	131	V	4
953.8396	19.41	46	26.59	1000	120	350	H	81



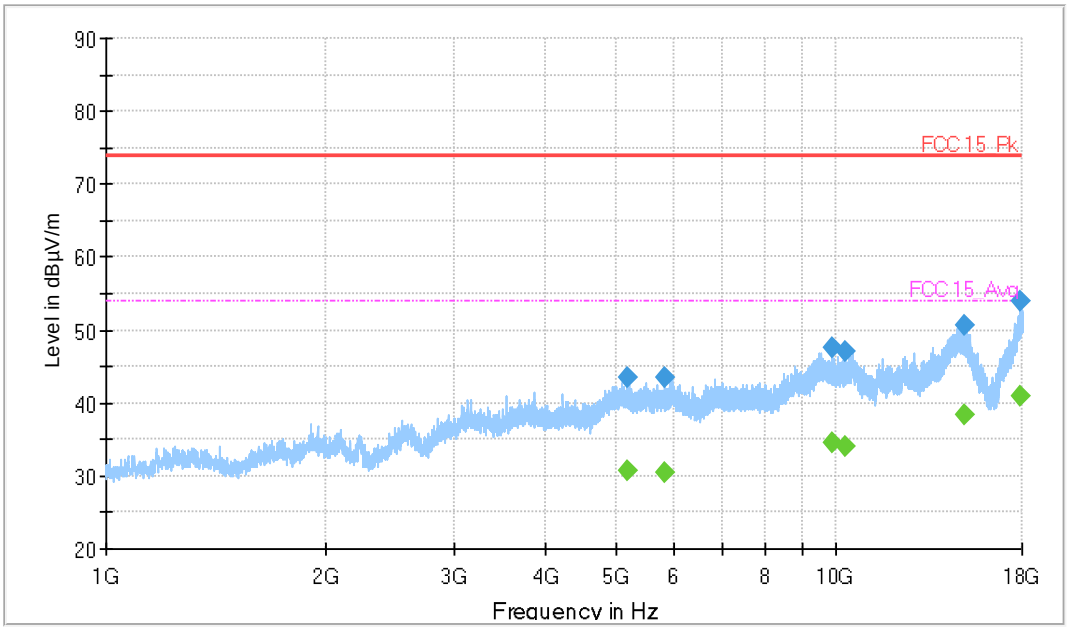
Plot 37. 30-1000MHz, 1Mbps, 2480MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
5202.0615	---	30.31	54	23.69	1000	1000	230	V	-95
5202.0615	43.9	---	74	30.1	1000	1000	230	V	-95
7287.639	---	30.39	54	23.61	1000	1000	230	H	-26
7287.639	43.32	---	74	30.68	1000	1000	230	H	-26
9668.7085	---	34.63	54	19.37	1000	1000	191	V	-75
9668.7085	47.19	---	74	26.81	1000	1000	191	V	-75
13211.424	---	33.81	54	20.19	1000	1000	101	V	-180
13211.424	46.62	---	74	27.38	1000	1000	101	V	-180
14720.2615	51.5	---	74	22.5	1000	1000	180	V	101
14720.2615	---	38.73	54	15.27	1000	1000	180	V	101
17922.4425	53.79	---	74	20.21	1000	1000	250	H	-47
17922.4425	---	41.04	54	12.96	1000	1000	250	H	-47



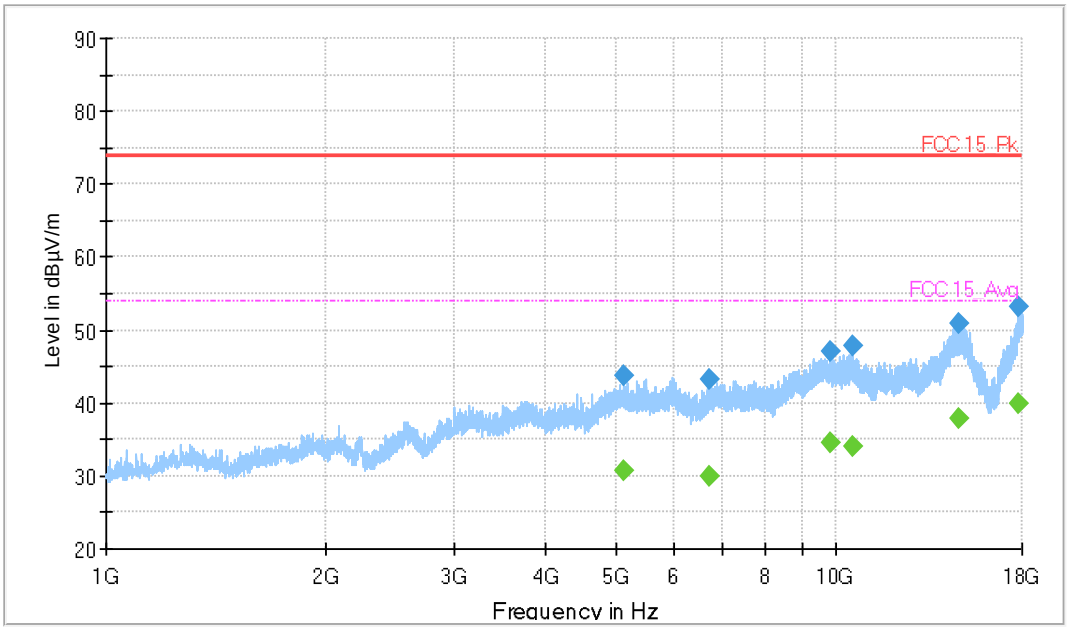
Plot 38. 1-18GHz, 1Mbps, 2402MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
5174.2575	43.42	---	74	30.58	1000	1000	100	V	94
5174.2575	---	30.78	54	23.22	1000	1000	100	V	94
5839.7355	---	30.52	54	23.48	1000	1000	167	V	-145
5839.7355	43.56	---	74	30.44	1000	1000	167	V	-145
9912.9255	47.48	---	74	26.52	1000	1000	250	H	-106
9912.9255	---	34.51	54	19.49	1000	1000	250	H	-106
10291.1345	47.17	---	74	26.83	1000	1000	200	H	112
10291.1345	---	34.09	54	19.91	1000	1000	200	H	112
15044.6985	50.7	---	74	23.3	1000	1000	250	H	163
15044.6985	---	38.3	54	15.7	1000	1000	250	H	163
17875.544	---	40.89	54	13.11	1000	1000	250	V	-68
17875.544	54.06	---	74	19.94	1000	1000	250	V	-68



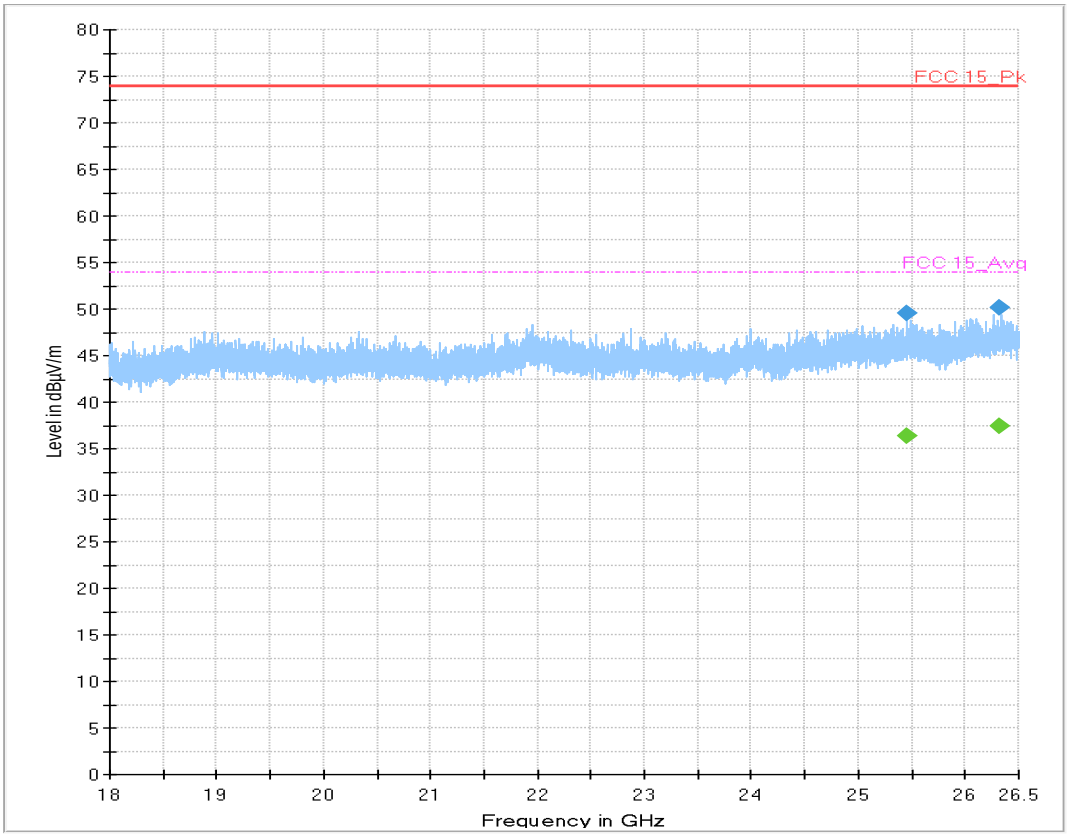
Plot 39. 1-18GHz, 1Mbps, 2440MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
5128.8	43.66	---	74	30.34	1000	1000	183	V	-180
5128.8	---	30.72	54	23.28	1000	1000	183	V	-180
6699.782	---	30.01	54	23.99	1000	1000	100	V	85
6699.782	43.13	---	74	30.87	1000	1000	100	V	85
9827.699	47.12	---	74	26.88	1000	1000	204	V	153
9827.699	---	34.57	54	19.43	1000	1000	204	V	153
10543.037	---	34.13	54	19.87	1000	1000	154	V	61
10543.037	47.86	---	74	26.14	1000	1000	154	V	61
14754.775	50.82	---	74	23.18	1000	1000	200	V	-105
14754.775	---	37.96	54	16.04	1000	1000	200	V	-105
17787.4775	53.14	---	74	20.86	1000	1000	233	H	-19
17787.4775	---	39.86	54	14.14	1000	1000	233	H	-19



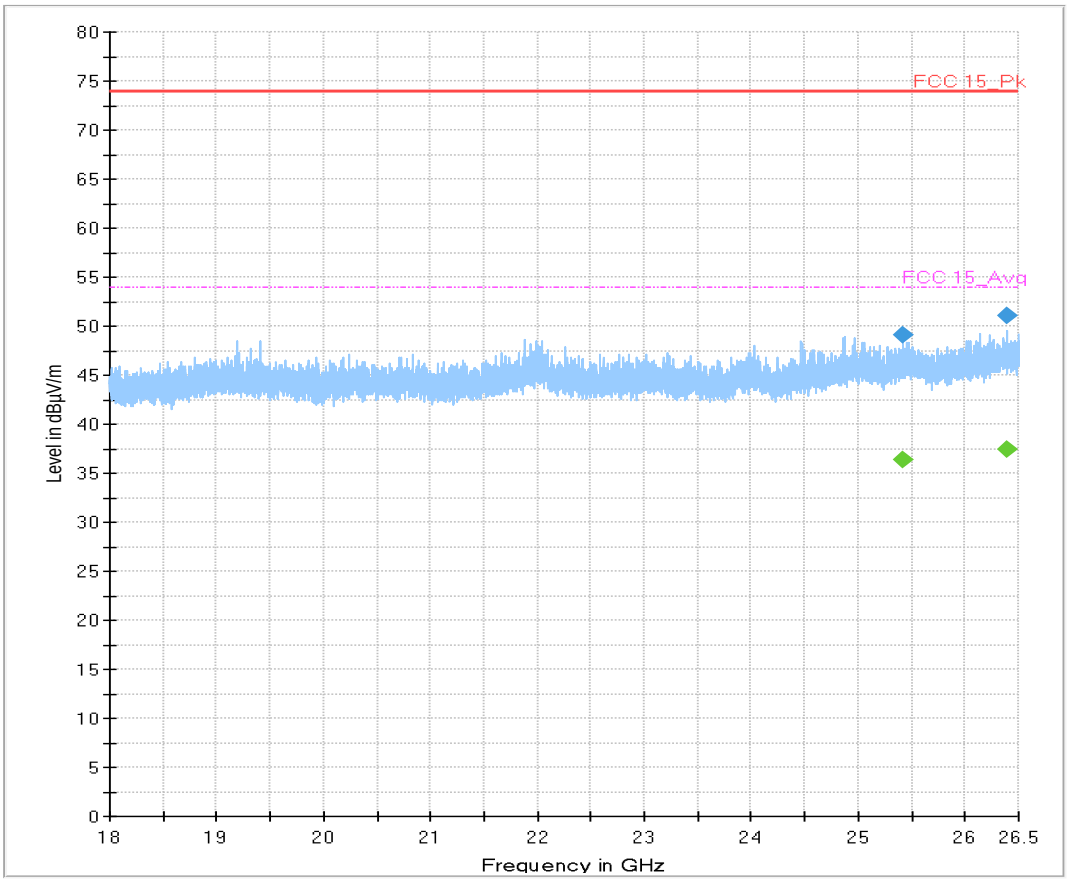
Plot 40. 1-18GHz, 1Mbps, 2480MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
25456.5556	49.47	---	74	24.53	1000	1000	175	V	-129
25456.5556	---	36.44	54	17.56	1000	1000	175	V	-129
26324.59	50.23	---	74	23.77	1000	1000	175	V	-177
26324.59	---	37.41	54	16.59	1000	1000	175	V	-177



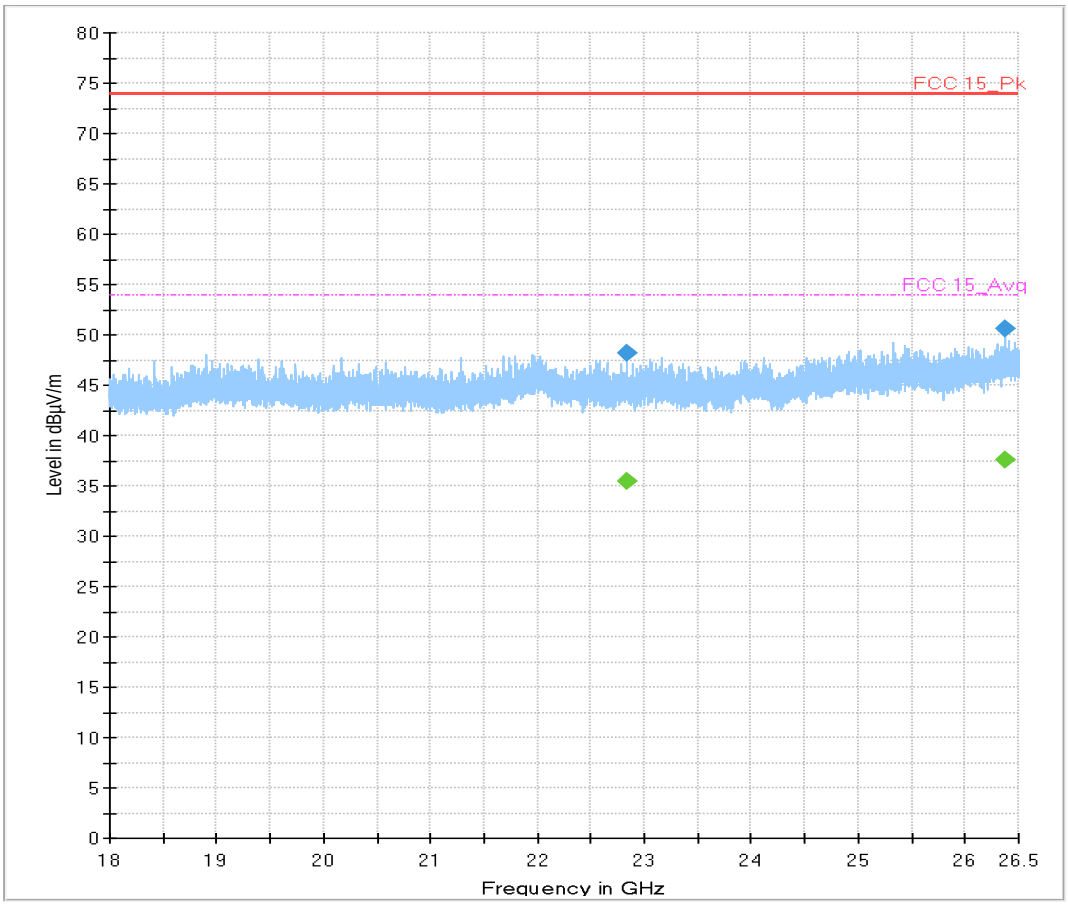
Plot 41. 18-26.5GHz, 1Mbps, 2402MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
25426.1525	49.1	---	74	24.9	1000	1000	166	V	77
25426.1525	---	36.33	54	17.67	1000	1000	166	V	77
26394.545	51.01	---	74	22.99	1000	1000	153	H	180
26394.545	---	37.46	54	16.54	1000	1000	153	H	180



Plot 42. 18-26.5GHz, 1Mbps, 2440MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
22842.3444	---	35.44	54	18.56	1000	1000	126	H	-103
22842.3444	48.17	---	74	25.83	1000	1000	126	H	-103
26369.9038	---	37.53	54	16.47	1000	1000	166	H	0
26369.9038	50.54	---	74	23.46	1000	1000	166	H	0



Plot 43. 18-26.5GHz, 1Mbps, 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 and RSS-GEN. Sect. 8.8.

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

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

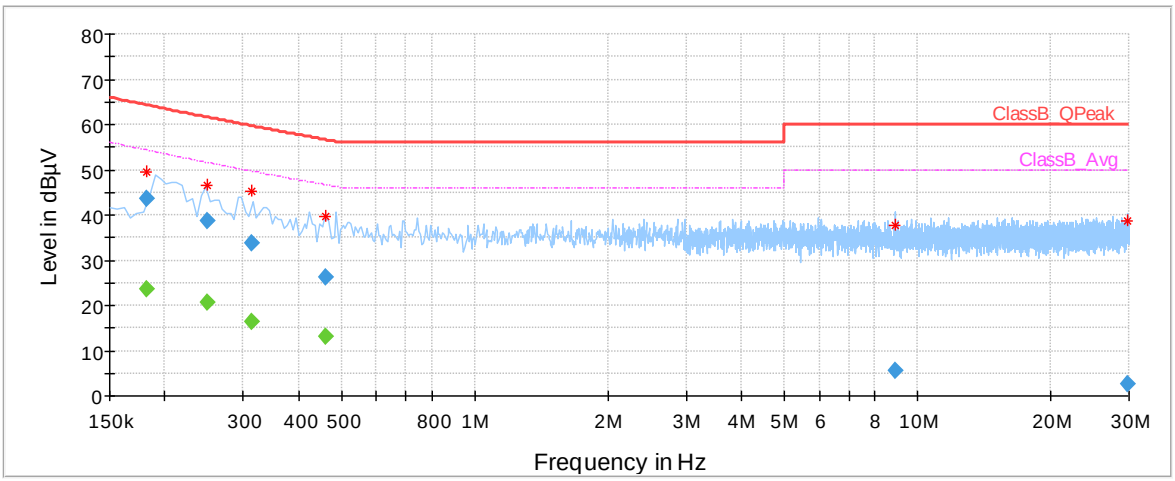
Table 7: AC Conducted Emissions – Test Results

Test Conditions: Conducted Measurement at Normal Conditions only		
AC Power: 120 Vac/60 Hz	**Configuration:** Tabletop	
Configuration	**Frequency Range**	**Test Result**
Line 1 (Live)	0.15 to 30 MHz	Pass

Line 2 (Neutral)	0.15 to 30 MHz	Pass

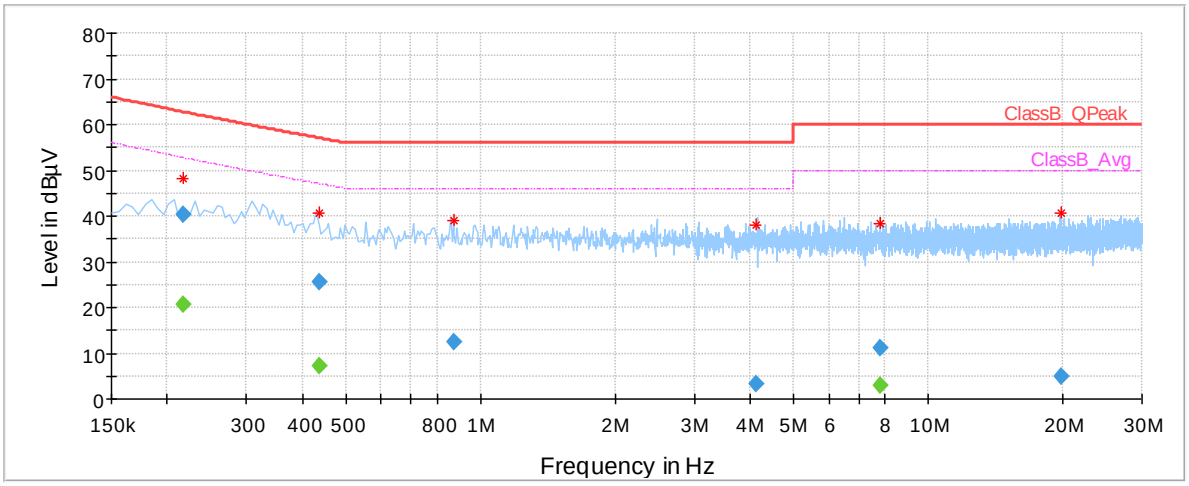
4.7.2.1 Live Line

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.181213	---	23.44	54.3	30.85	L1	10
0.181213	43.55	---	64.32	20.77	L1	10
0.248447	---	20.68	51.57	30.89	L1	9.8
0.248447	38.69	---	61.61	22.92	L1	9.8
0.314479	---	16.23	49.62	33.39	L1	9.7
0.314479	33.92	---	59.66	25.74	L1	9.7
0.462475	---	13.23	46.59	33.36	L1	9.7
0.462475	26.26	---	56.6	30.34	L1	9.7
8.871193	---	-1.4	50	51.4	L1	9.8
8.871193	5.55	---	60	54.45	L1	9.8
29.872596	---	-4.8	50	54.8	L1	9.8
29.872596	2.51	---	60	57.49	L1	9.8



4.7.2.2 Neutral Line

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.217385	---	20.53	52.71	32.18	N	9.8
0.217385	40.25	---	62.74	22.49	N	9.8
0.436624	---	7.35	47.03	39.68	N	9.6
0.436624	25.58	---	57.05	31.46	N	9.6
0.873096	---	-0.37	46	46.37	N	9.7
0.873096	12.47	---	56	43.53	N	9.7
4.135321	---	-4.46	46	50.46	N	9.7
4.135321	3.4	---	56	52.6	N	9.7
7.821092	---	2.91	50	47.09	N	9.7
7.821092	11.07	---	60	48.93	N	9.7
19.776202	---	-2.51	50	52.51	N	10
19.776202	4.83	---	60	55.17	N	10



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
EMI Receiver	Rohde & Schwarz	ESW44	101663-dv	07/18/2019	07/18/2020
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
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
Horn Antenna		RA42-K-F-B-C	020131-004	03/04/2019	03/04/2021
Amplifier	Rohde & Schwarz	TS-PR26	3545.7014.03	03/04/2019	03/04/2021
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)	
2.4GHZ Band Pass Filter	Microtronics	BRM50702	009	1/15/2019	1/15/2020
3.5 GHz High Pass Filter	Hewlett Packard	84300-80038	820004	N/A (See Note)	

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 8: Customer Information

Company Name	Conde Verdon Company LLC
Address	3200 Greenfield Rd., Ste 300
City, State, Zip	Dearborn, MI 48120
Country	USA

Table 9: Technical Contact Information

Name	Pamela A. Jasinksi
E-mail	CondeVerdonCompanyLLC@gmail.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 10: EUT Designation

Product Name	Halo Band
Model Number	C9X87E

6.4 Product Specifications

Table 11: EUT Specifications

EUT Specifications	
Environment	Indoor/Outdoor
Operating Temperature Range:	0-35°C
Multiple Feeds:	☐ Yes and how many ☒ No
Product Marketing Name (PMN)	Halo Band
Hardware Version Identification Number (HVIN)	DVT
Firmware Version Identification Number (FVIN)	N/A
Operating Modes	BT Low Energy, 1Mbps, 2Mbps
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
Type of Equipment	☐ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other:
Note: EUT will be on / transmitted at all times with the highest power levels and antenna gains per channel.	

Table 12: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
Antenna 0	Internal, Folded Monopole	Bluetooth Low Energy	-2.2

Table 13: 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?
USB	USB	☐ Yes	☒ Metric: < 3.0m	☒ M

Table 14: Accessory Equipment

Equipment	Manufacturer	Model	Serial	Comment
Fabric Strap	N/A	N/A	N/A	Detachable strap
Sport Strap	N/A	N/A	N/A	Detachable strap
1. **Note:**				

Table 15: Ancillary Equipment (used for test purposes only)

Equipment	Manufacturer	Model	Serial	Used for
Laptop	HP	Pavilion	N/A	Setup EUT operating channels via Ethernet connection to EUT
EUT Interface	N/A	N/A	N/A	Setup EUT operating channels via connection to EUT and USB Connection to Laptop
Note: None.				

Table 16: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.247
Halo Band	N/A	Integrated Antenna	Radiated Emissions Conducted Emissions
		Direct via SMA Connection	Transmit Power, Occupied Bandwidth, Out of Band Emission, Hopping Requirement

Table 17: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Photo (X-Axis)	Setup Photo (Y-Axis)	Setup Photo (Z-Axis)
Halo Band	Folded Monopole	Transmit	EUT Flat	EUT On Side	EUT Upright
Note: Worse case during radiated measurements were found when EUT was set on its "Y-Axis". All testing completed from this Axis (See Test setup for Images)					

6.5 Test Specifications

Table 18: Test Specifications

Emissions and Immunity	
Standard	**Requirement**
CFR 47 Part 15.247: 2019	All
RSS 247 Issue 2, 2017	All

END OF REPORT