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Emissions
Test Report

EUT Name: Z4NEU3

Model No.: Z4NEU3

CFR 47 Part 15.247: 2020

Prepared for:

Eleven Forty Three A.M. LLC
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Prepared by:

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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	08/04/2020	Original Document	JB
1	10/13/2020	Customer Info Corrections	JB

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Eleven Forty Three A.M. LLC 1661 International Drive, Suite 400 Memphis, TN 38120
Requester / Applicant:	Eleven Forty Three A.M. LLC
Name of Equipment:	Z4NEU3
Model No.	Z4NEU3
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2020
Test Dates:	June 22nd, 2020 to June 30th, 2020

Guidance Documents:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v05r02

Test Methods:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v05r02

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.

James Borrott		Richard Decker	
Engineer	Date October 13, 2020	Reviewer	Date October 13, 2020

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: 2020 based on the results of testing performed on June 22nd, 2020 to June 30th, 2020 on the Z4NEU3 manufactured by Eleven Forty Three A.M. 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 C63.10	Worse Case (Measured)	Result
Maximum Output Power	CFR47 15.247 (b), RSS 247 Sect. 5.4 (d)	11.32dBm @ 2440MHz Channel, 1Mbps	**Complied**
DTS Bandwidth (6dB)	CFR47 15.247 (a)(2), RSS 247 Sect. 5.2 (a)	0.668 MHz @ 1Mbps	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 247 Sect. 5.2 (b)	-2.96 dBm @ 2440MHz Channel, 1Mbps	**Complied**
Out of Band Emissions: Non-Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	-32.74 dBc Lower Band Edge	**Complied**
Transmitter Spurious Emissions	CFR47 15.247 (d), RSS 247 Sect.5.5	-7.92 dB Margin @ 44.1296 MHz, Quasi Peak	**Complied**
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.8.8	-10.71 dB Margin @ 0.466403MHz, QP, Line	**Complied**

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 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 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

Measurement Uncertainty – Radio Testing

The estimated combined standard uncertainty for frequency error measurements is ± 3.88 Hz
The estimated combined standard uncertainty for carrier power measurements is ± 0.7 dB.
The estimated combined standard uncertainty for adjacent channel power measurements is ± 1.47 dB.
The estimated combined standard uncertainty for modulation frequency response measurements is ± 0.46 dB.
The estimated combined standard uncertainty for transmitter conducted emission measurements is ± 2.06 dB

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 Z4NEU3 utilizes Bluetooth LE. The EUT is intended to work within the 2.4GHz frequency band and utilizes a single antenna transceiver chain.

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 the testes standard. 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 Z4NEU3 has 1 PIFA antenna that has maximum gain of 2.1 dBi.

It is integrated into the PCB of the device and is not easily accessible to the end user.

4 Emissions

Testing was performed in accordance with FCC 47 CFR Part 15.247: 2020. 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.

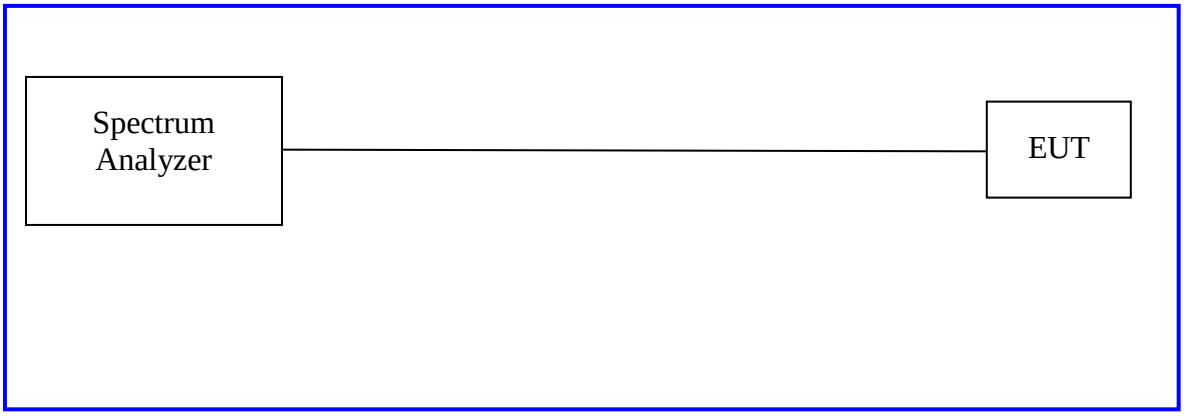
The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b) and RSS 247 5.4 (d).

The maximum transmitted power in the frequency band 2400-2483.5 MHz: 1 W

4.1.1 Test Method

Conducted method according to ANSI C63.10:2013 Section 11.9.1 was used to measure the channel power output on lowest, center and highest supported channel within the allocated frequency band. 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: (Conducted)



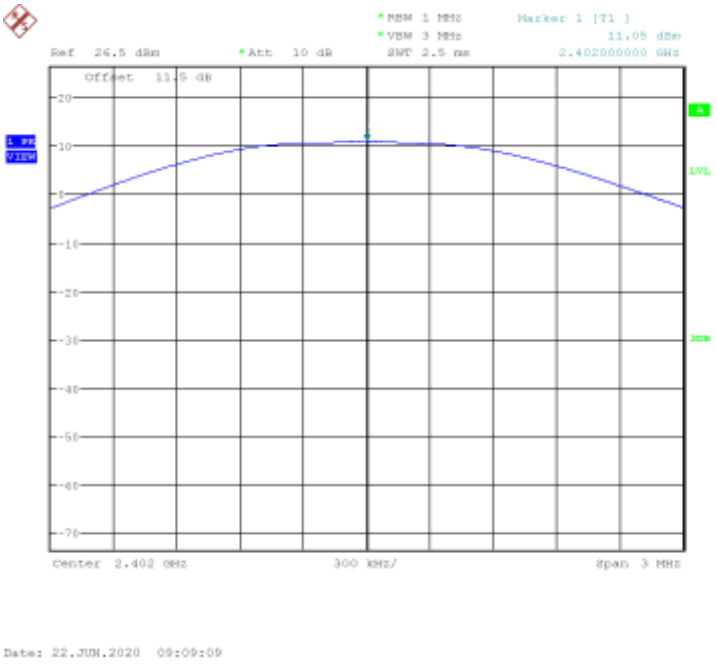
4.1.2 Results

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

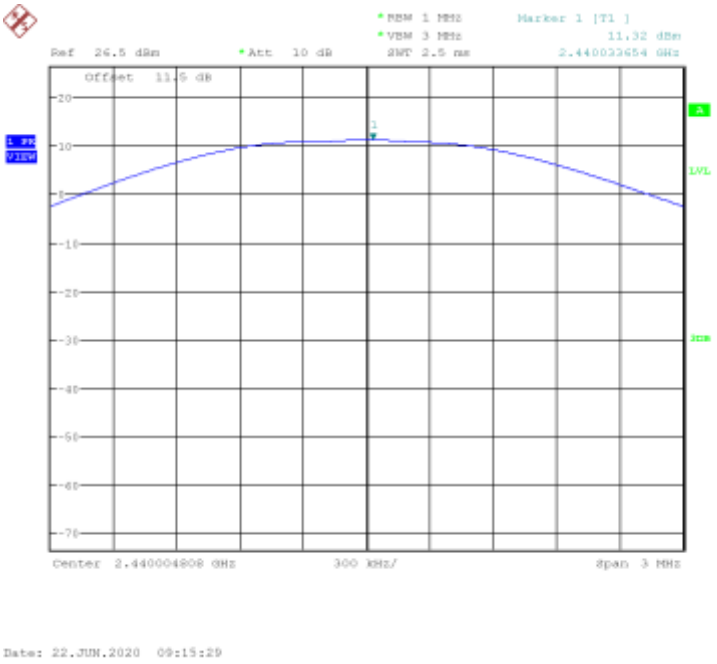
4.1.3 Measurement Data

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: PIFA		**Power Setting:** FW default		
Max. Directional Gain: 2.1 dBi				
RF Output Power – BT LE				
Data Rate	**Operating Channel (MHz)**	**Measured Peak Power [dBm]**	**Limit [dBm]**	**Margin [dB]**
1Mbps	2402	11.05	30	-18.95
	2440	11.32	30	-18.68
	2480	11.12	30	-18.88
2Mbps	2402	10.85	30	-19.15
	2440	11.18	30	-18.82
	2480	11.09	30	-18.91
Note: All insertion loss corrections are accounted for in the measurement plots.				

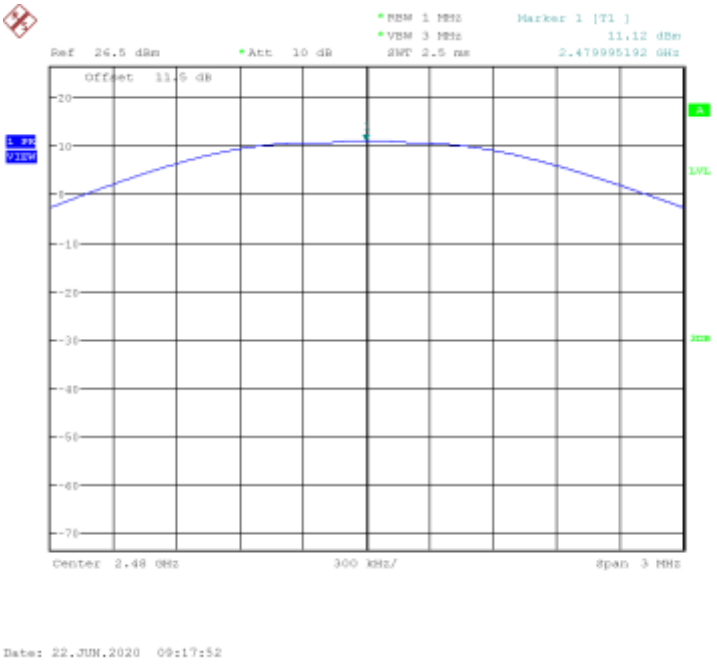
4.1.4 Measurement Plots



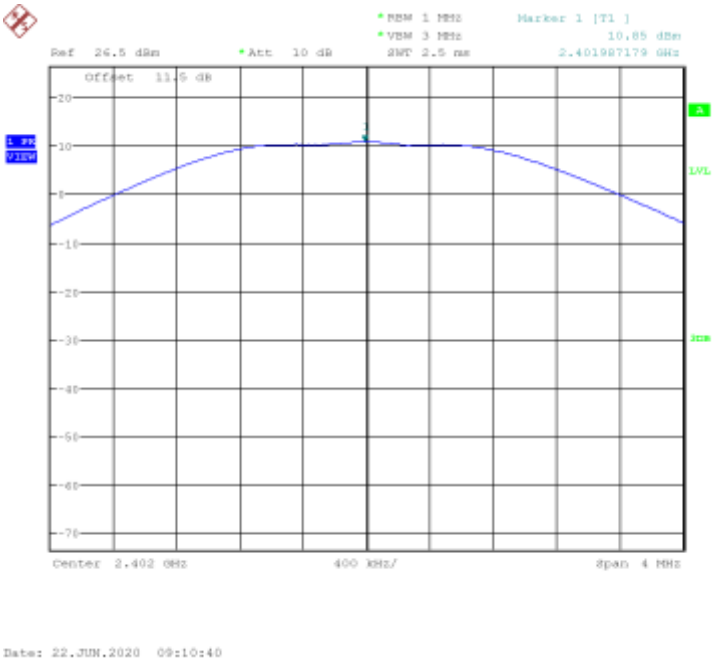
Plot 1. Maximum Conducted Power, 2402 MHz, 1Mbps



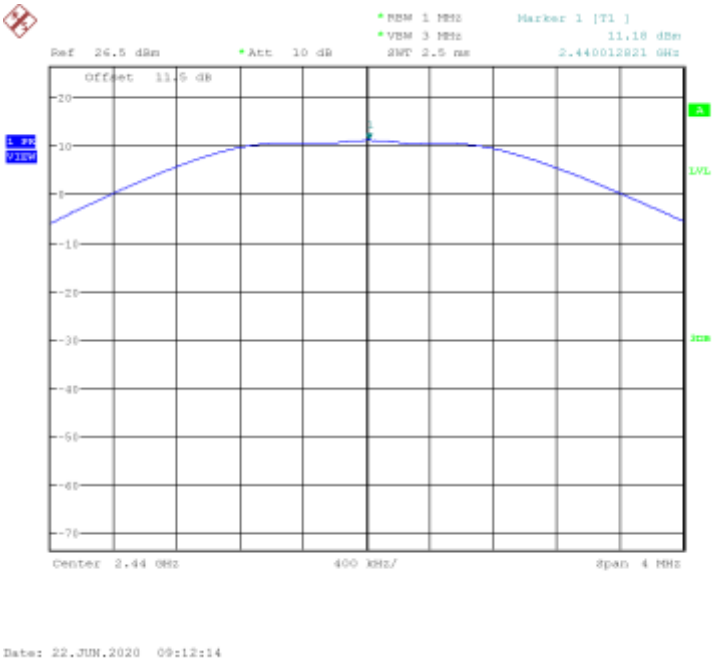
Plot 2. Maximum Conducted Power, 2440MHz, 1Mbps



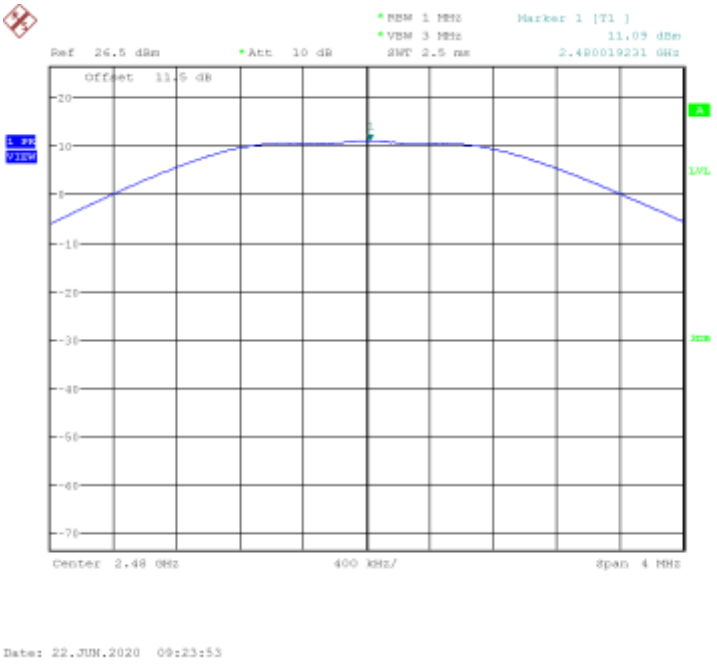
Plot 3. Maximum Conducted Power, 2480MHz, 1Mbps



Plot 4. Maximum Conducted Power, 2402 MHz, 2Mbps



Plot 5. Maximum Conducted Power, 2440MHz, 2Mbps



Plot 6. Maximum Conducted Power, 2480MHz, 2Mbps

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.

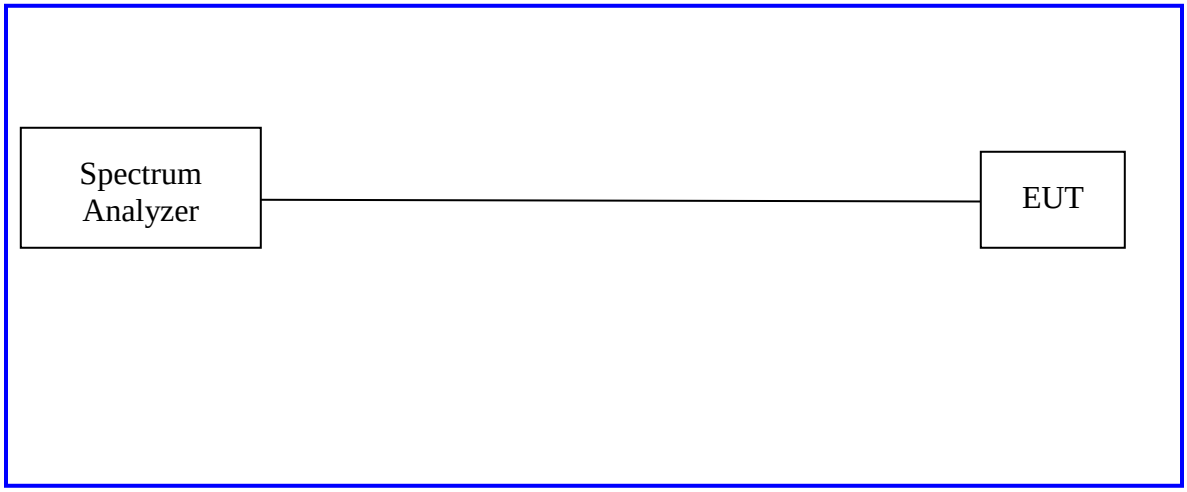
The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

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: (conducted)



4.2.2 Results

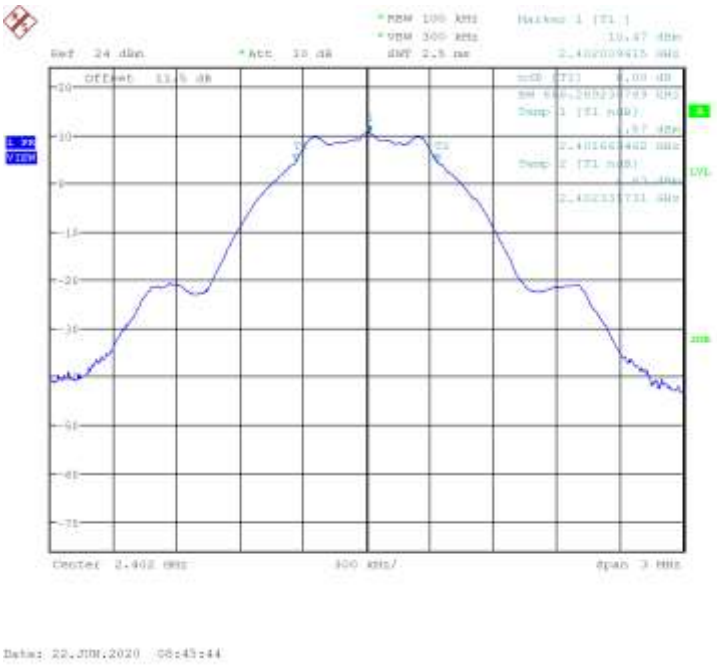
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.2.3 Measurement Data

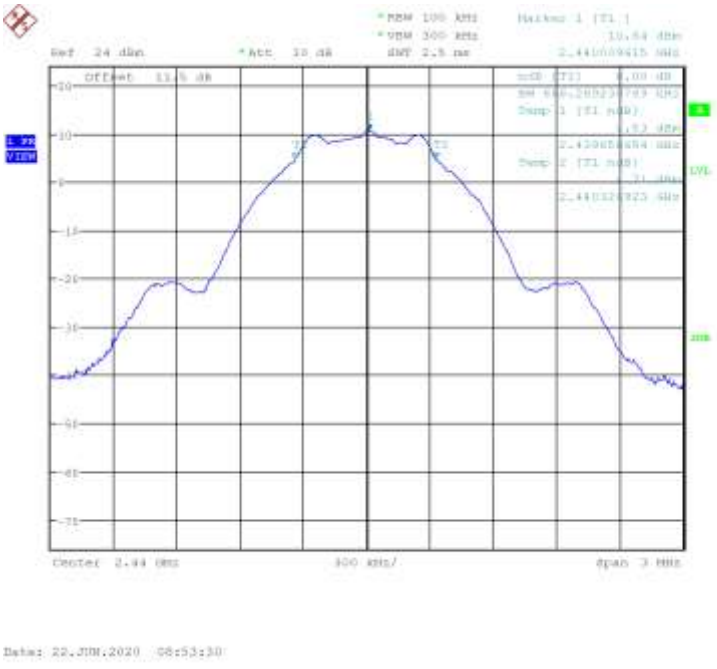
Table 2: Occupied Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: PIFA		**Power Setting:** FW default	
Max. Directional Gain: 2.1 dBi			
Bandwidth for BT BLE			
Data Rate	**Freq. (MHz)**	**99% Bandwidth (MHz)**	**6dB (DTS) Bandwidth (kHz)**
1Mbps	2402	1.048	668.269
	2440	1.053	668.269
	2480	1.053	668.269
2Mbps	2402	2.077	1128.205
	2440	2.071	1134.615
	2480	2.071	1141.026

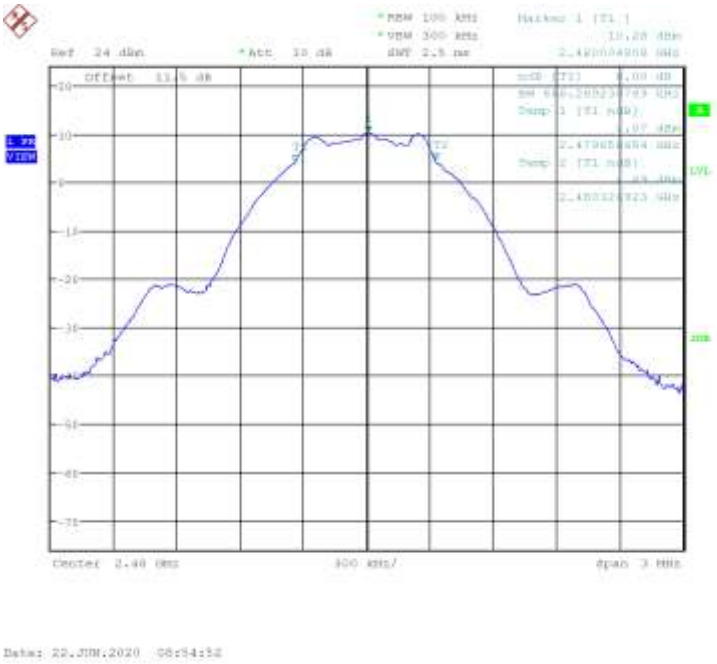
4.2.4 Measurement Plots



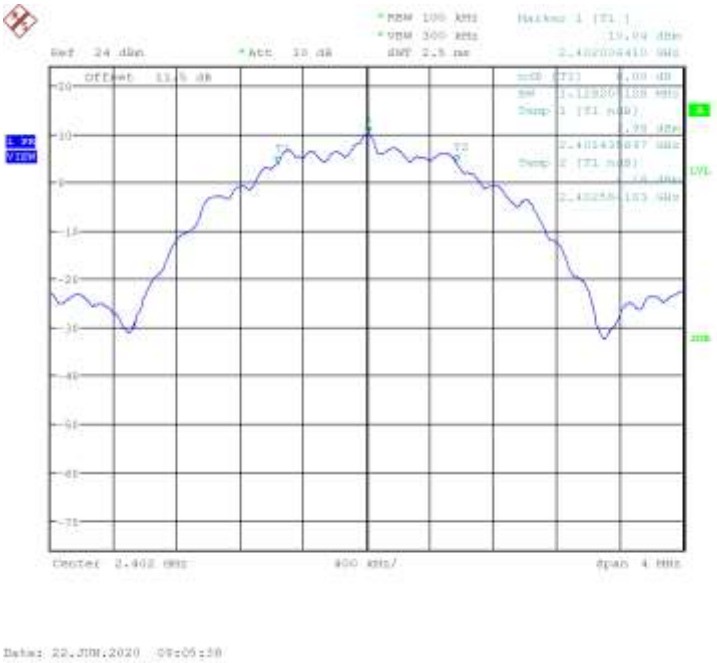
Plot 7. 2402MHz, 1Mbps, 6dB Bandwidth



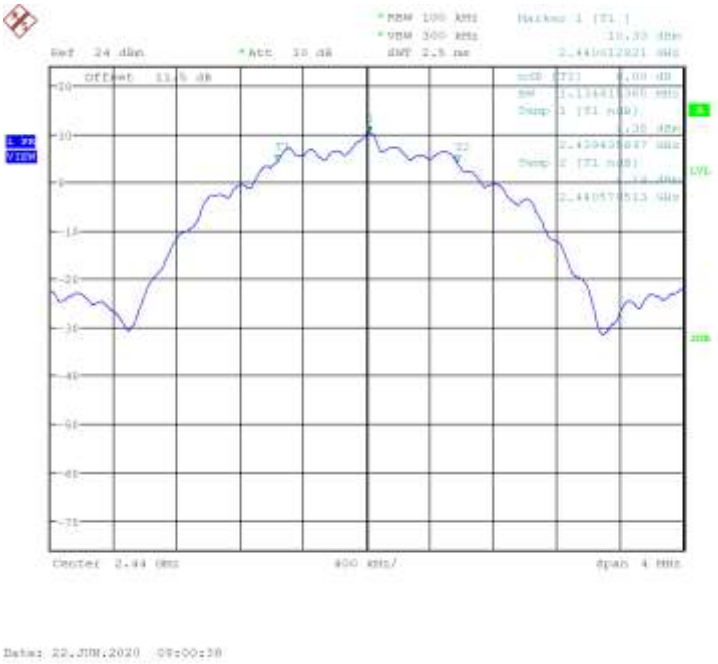
Plot 8. 2440MHz, 1Mbps, 6dB Bandwidth



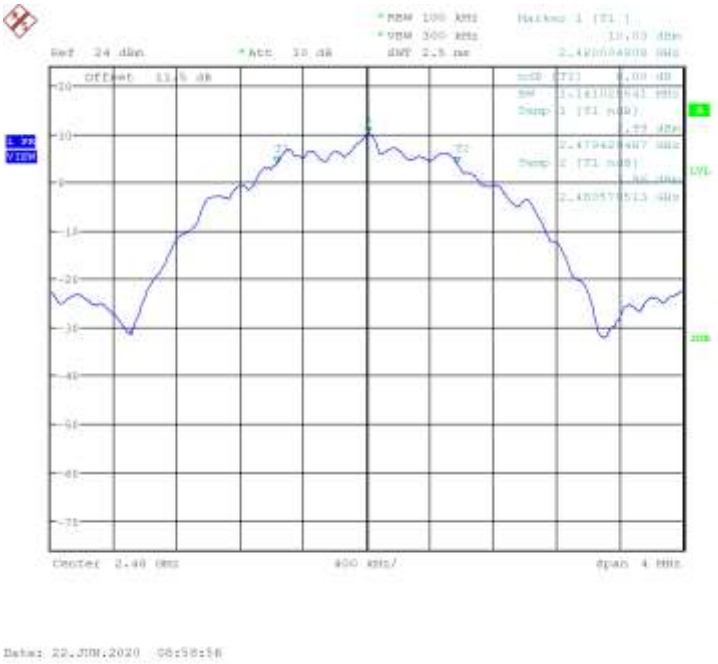
Plot 9. 2480MHz, 1Mbps, 6dB Bandwidth



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

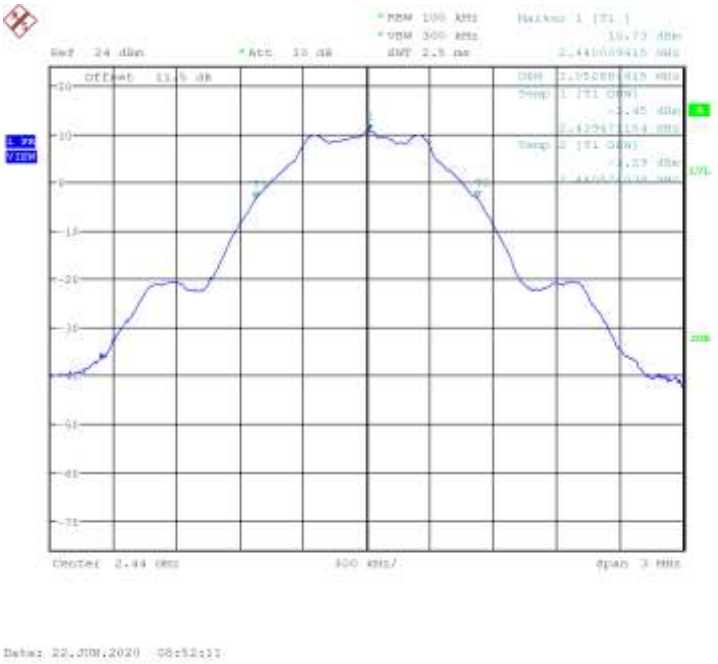


Plot 11. 2440MHz, 2Mbps, 6dB Bandwidth



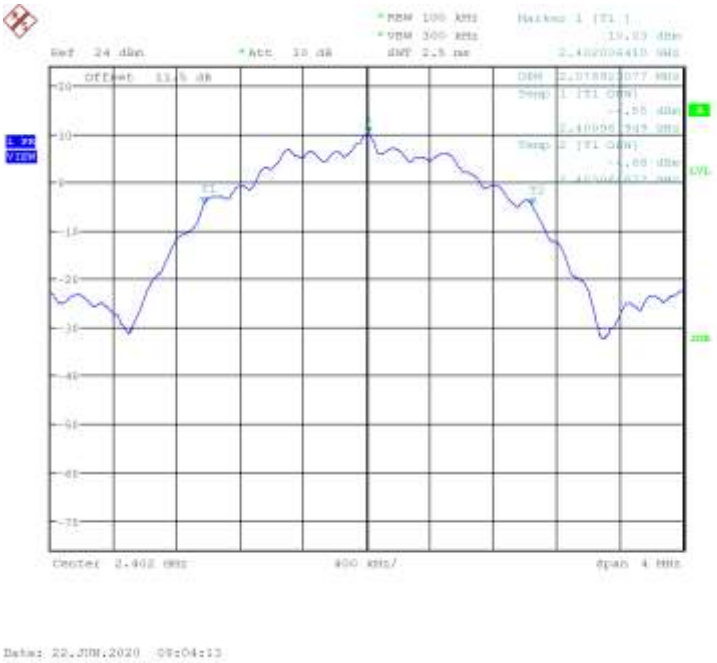
Plot 12. 2480MHz, 2Mbps, 6dB Bandwidth

Plot 13. 2402MHz, 1Mbps, 99% Bandwidth

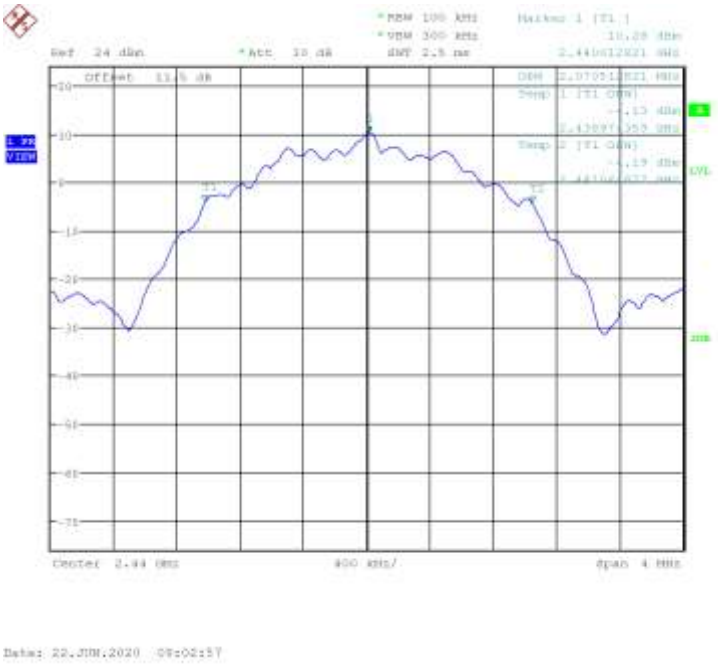


Plot 14. 2440MHz, 1Mbps, 99% Bandwidth

Plot 15. 2480MHz, 1Mbps, 99% Bandwidth



Plot 16. 2402MHz, 2Mbps, 99% Bandwidth



Plot 17. 2440MHz, 2Mbps, 99% Bandwidth

Plot 18. 2480MHz, 2Mbps, 99% Bandwidth

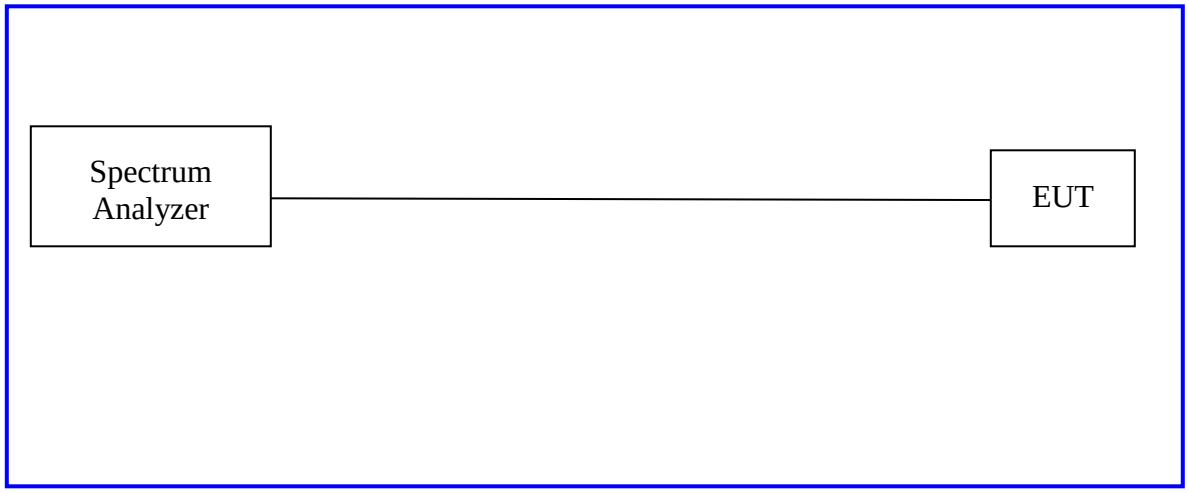
4.3 Peak Power Spectral Density

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: (Conducted)



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

4.3.2 Results

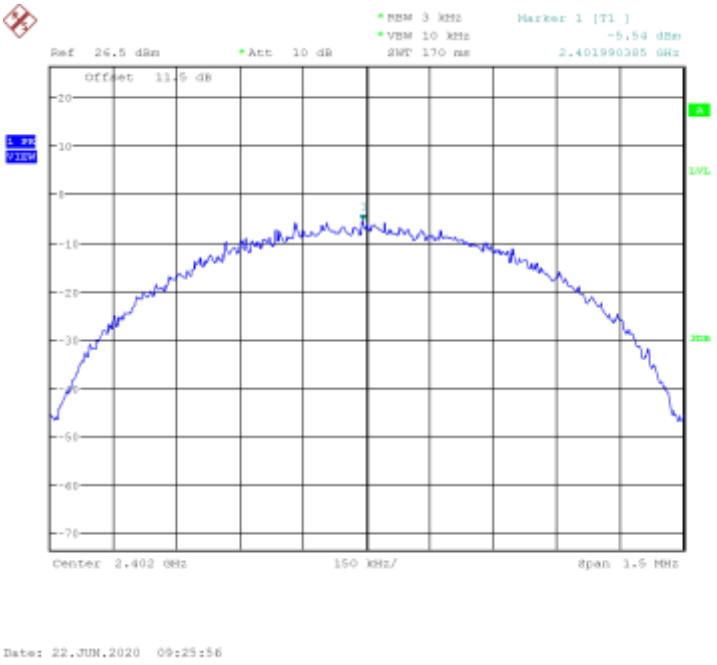
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.3.3 Measurement Data

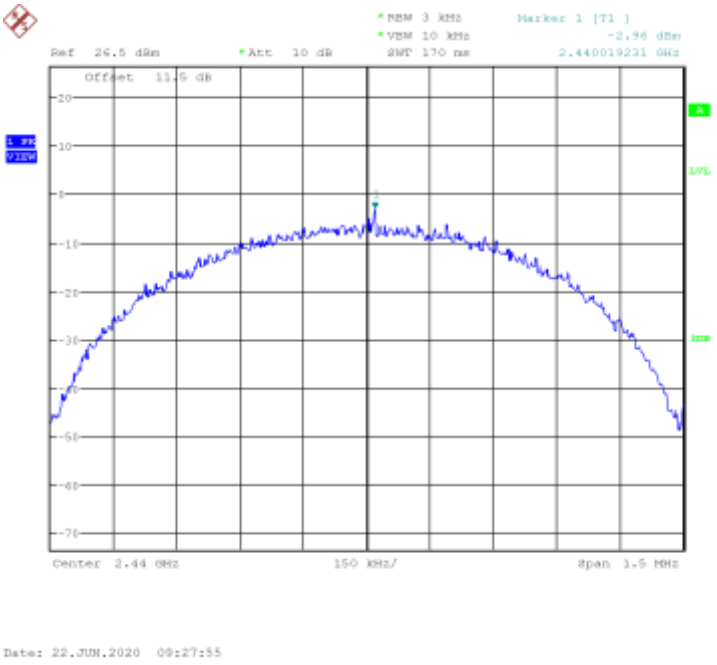
Table 3: Peak Power Spectral Density – Test Results

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: PIFA		**Power Setting:** FW default		
Max. Directional Gain: 2.1 dBi				
Peak Power Spectral Density – BLE				
Data rate	**Freq. (MHz)**	**Measured PSD [dBm/3kHz]**	**Limit [dBm/3kHz]**	**Margin [dB]**
1Mbps	2402	-5.54	8	-13.54
	2440	-2.96	8	-10.96
	2480	-3.86	8	-11.86
2Mbps	2402	-8.15	8	-16.15
	2440	-7.75	8	-15.75
	2480	-7.64	8	-15.64
Note: All insertion loss corrections are accounted for in the measurement plots.				

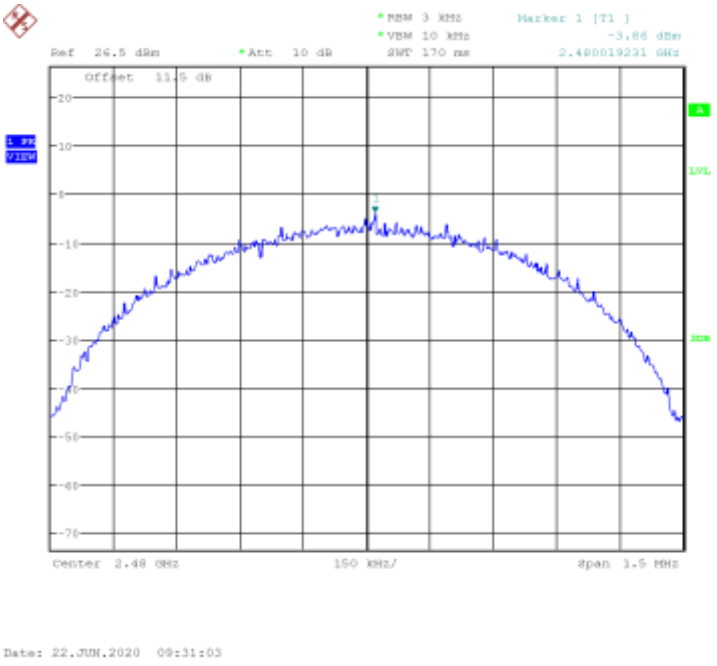
4.3.4 Measurement Plots



Plot 19. 2402 MHz, 1Mbps, PSD

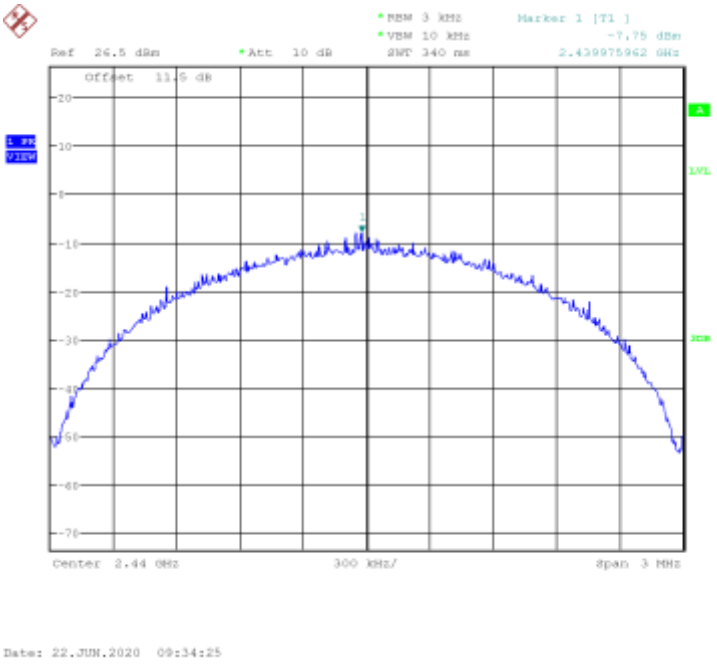


Plot 20. 2440 MHz, 1Mbps, PSD

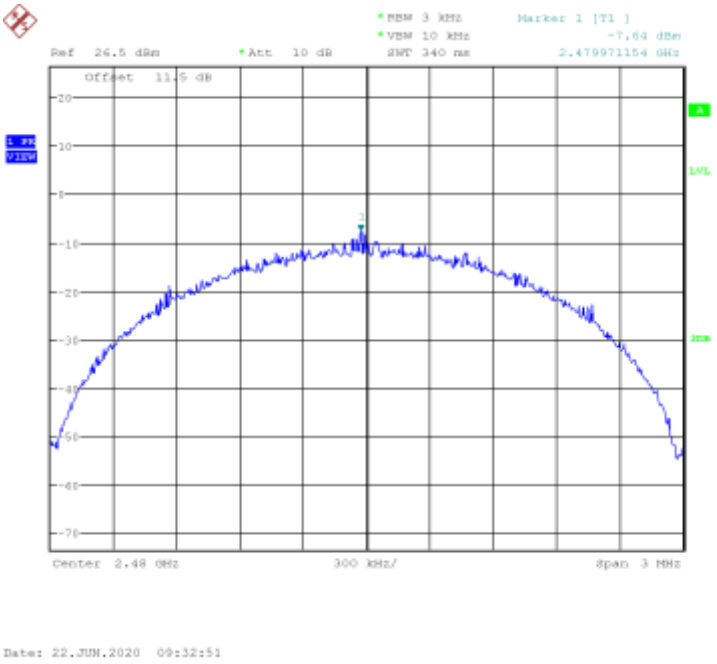


Plot 21. 2480MHz, 1Mbps, PSD

Plot 22. 2402 MHz, 2Mbps, PSD



Plot 23. 2440 MHz, 2Mbps, PSD



Plot 24. 2480MHz, 2Mbps, 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), RSS-247 Sect. 5.5, RSS-GEN Sect. 8.9 and 8.10.

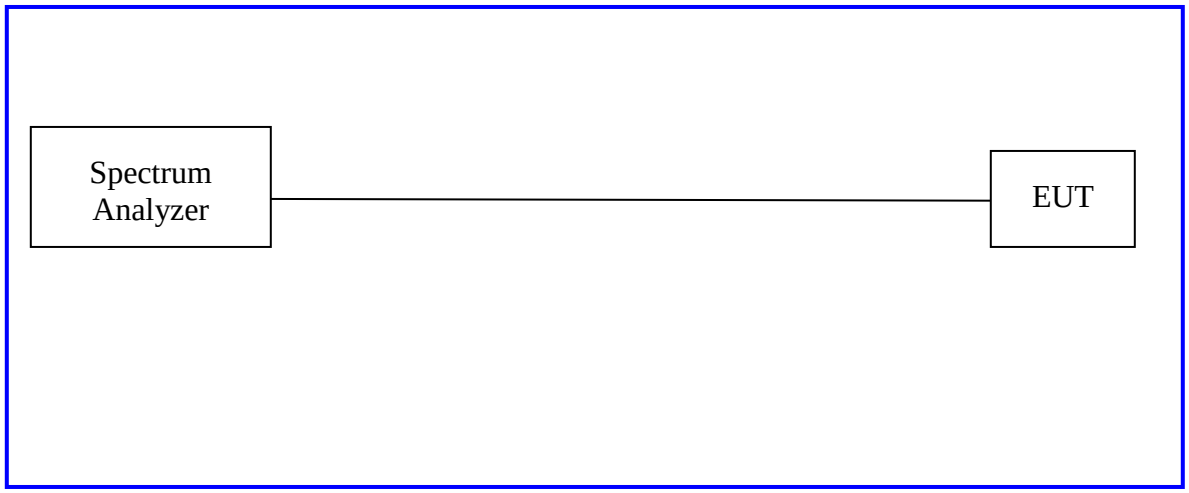
4.4.1 Test Method

The conducted method and radiated method was used to measure the undesirable emission requirement for non-restricted bands. The radiated method was used to measure the undesirable emission requirement for non-restricted bands. The measurement was performed with modulation.

Duty Cycle Measurements were performed according to ANSI 63.10 Section 11.6. Measurements for emissions in nonrestricted frequency bands were performed according to ANSI 63.10-2013 sections 6.10.4 and 11.11.

The utilized test setup for radiated measurements is identical to the described setup for radiated spurious emissions.

Test Setup: (Conducted)



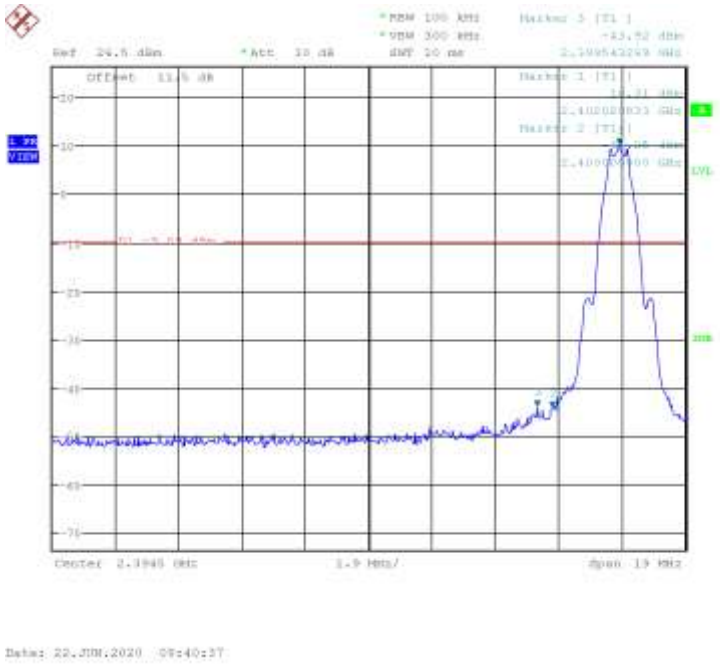
4.4.2 Results

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

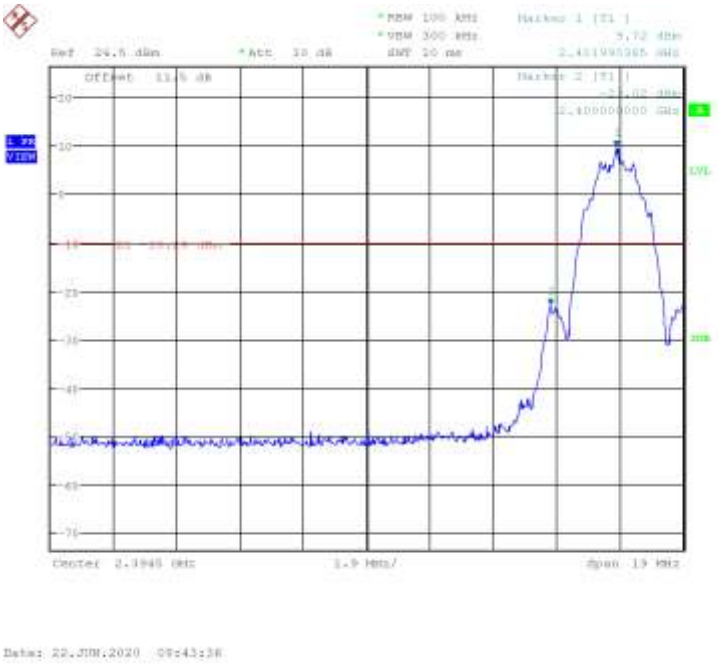
Table 4: Out of Band Emissions including the Band-Edge – Test Results – BT LE

Non-Restricted Frequency Band Edge Emissions						
Data Rate	**Band Edge**	**Center Freq (MHz)**	**Measured (dBc)**	**Limit (dBc)**	**Freq (MHz)**	**Results**
1Mbps	Low	2402	54.24	>20	2399.54	Pass
	High	2480	59.07	>20	2483.50	Pass
2Mbps	Low	2402	32.74	>20	2400.00	Pass
	High	2480	57.33	>20	2483.50	Pass
Note:						

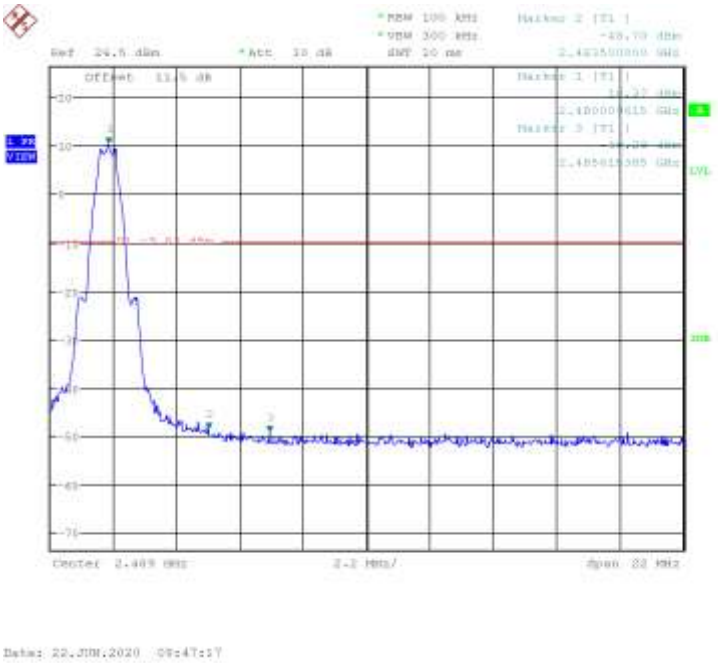
4.4.2.1 **Band Edge - conducted**



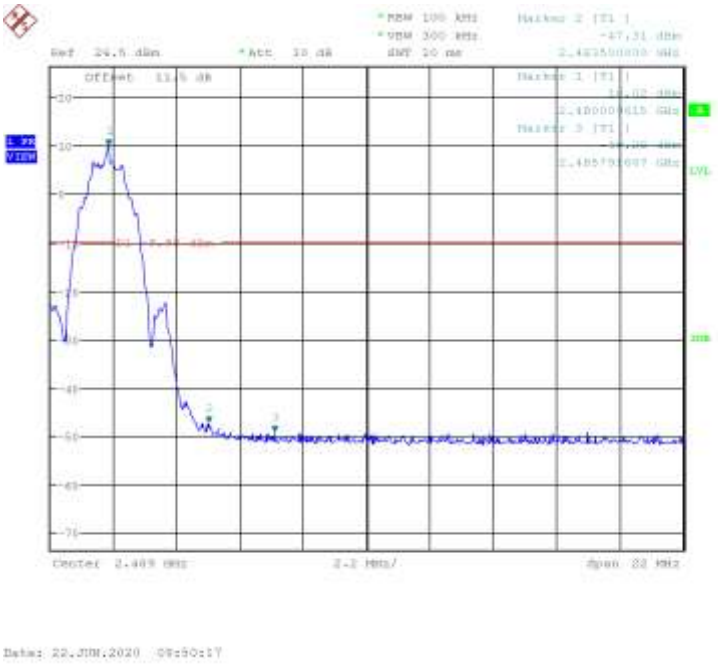
Plot 25. 2402MHz, 1Mbps, Lower Band Edge



Plot 26. 2402MHz, 2Mbps, Lower Band Edge

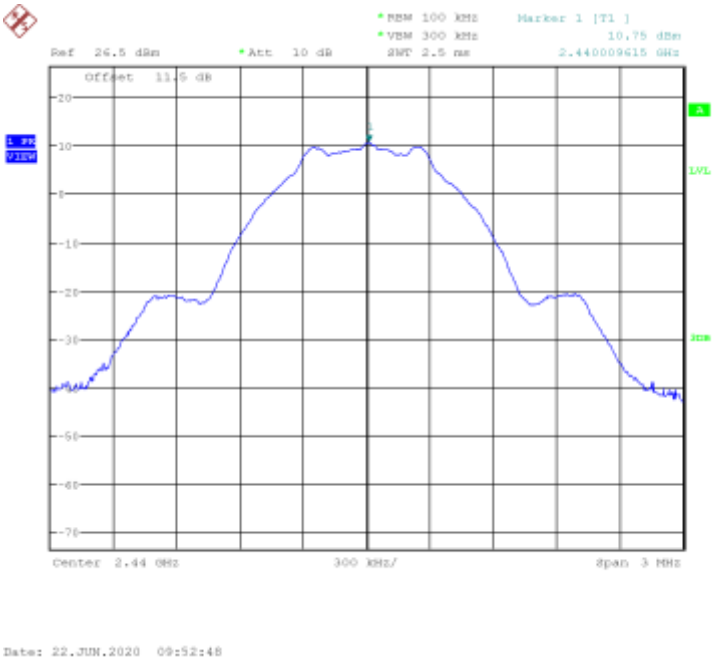


Plot 27. 2480MHz, 1Mbps Upper Band Edge

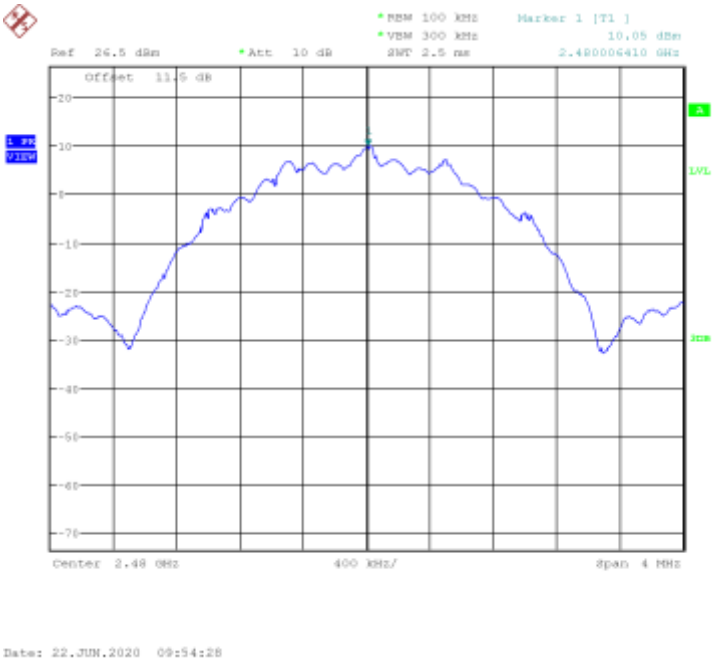


Plot 28. 2480MHz, 2Mbps Upper Band Edge

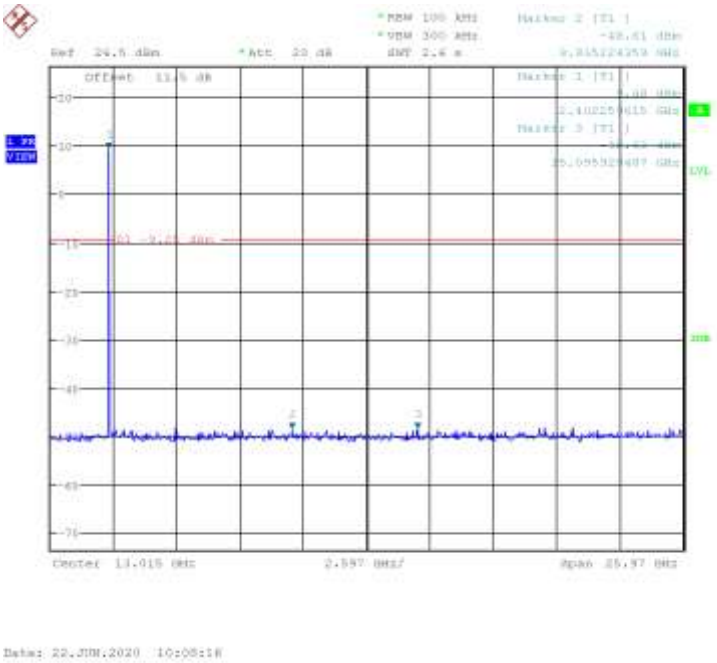
4.4.2.2 **Conducted Spurious**



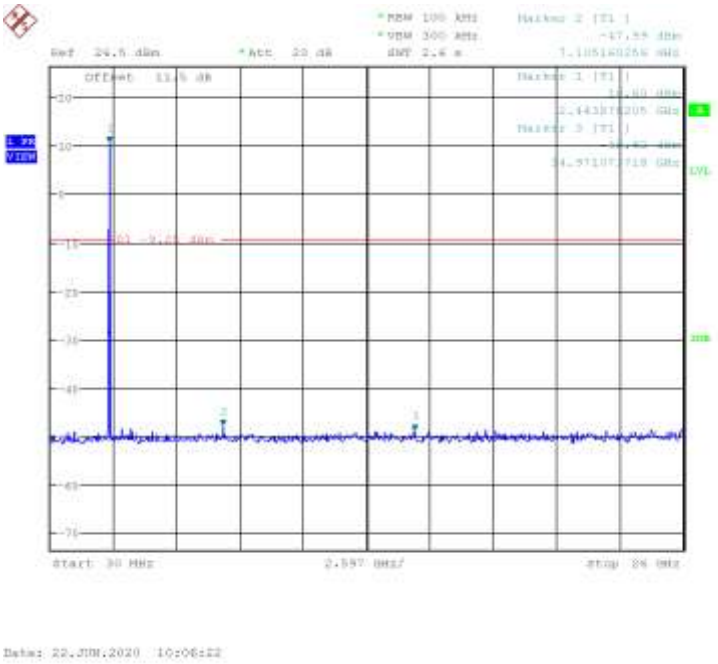
Plot 29. 1Mbps Ref Measurement



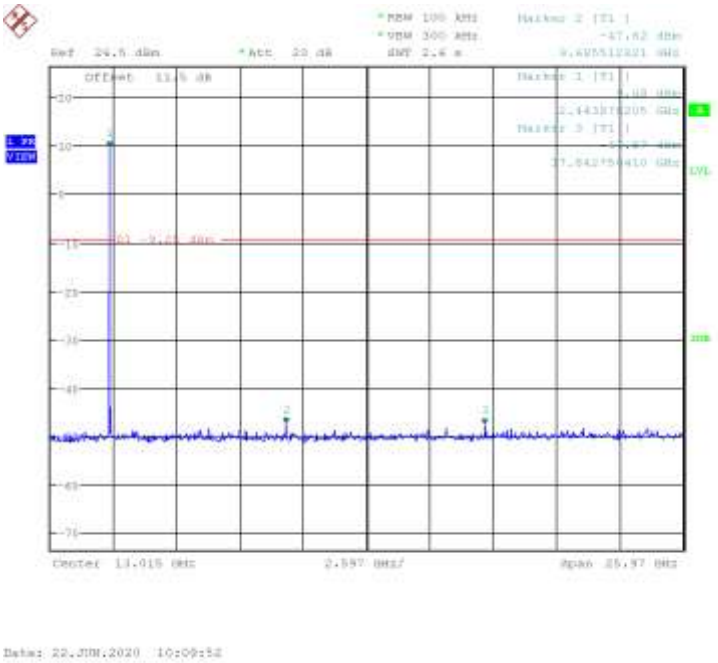
Plot 30. 2Mbps Ref Measurement



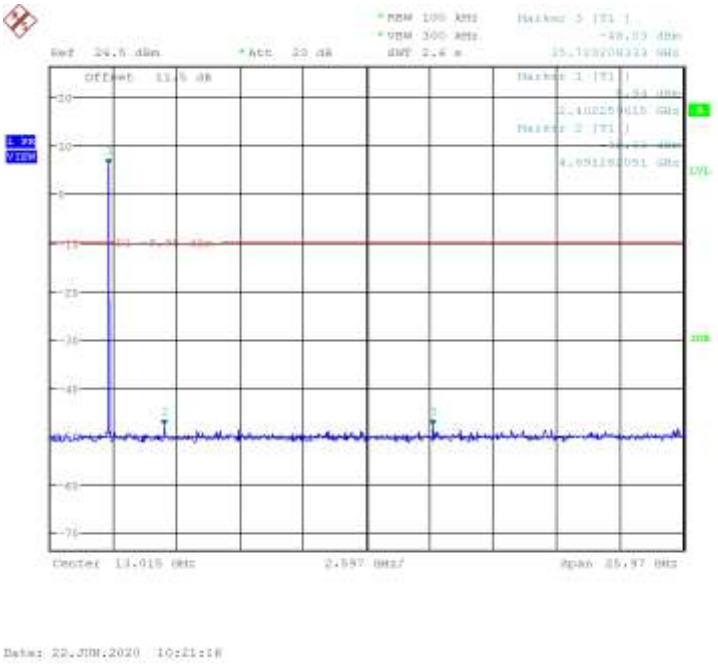
Plot 31. Conducted Emissions, 2402 MHz, 1Mbps



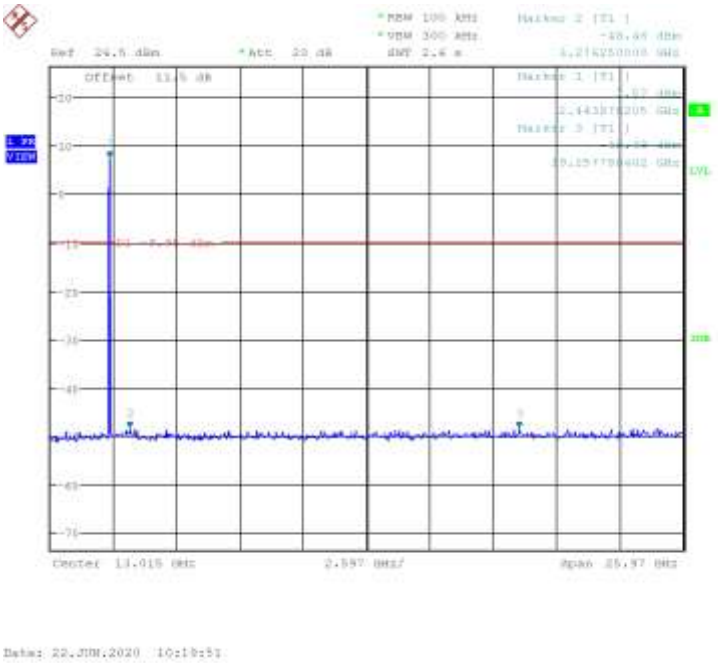
Plot 32. Conducted Emissions, 2440 MHz, 1Mbps



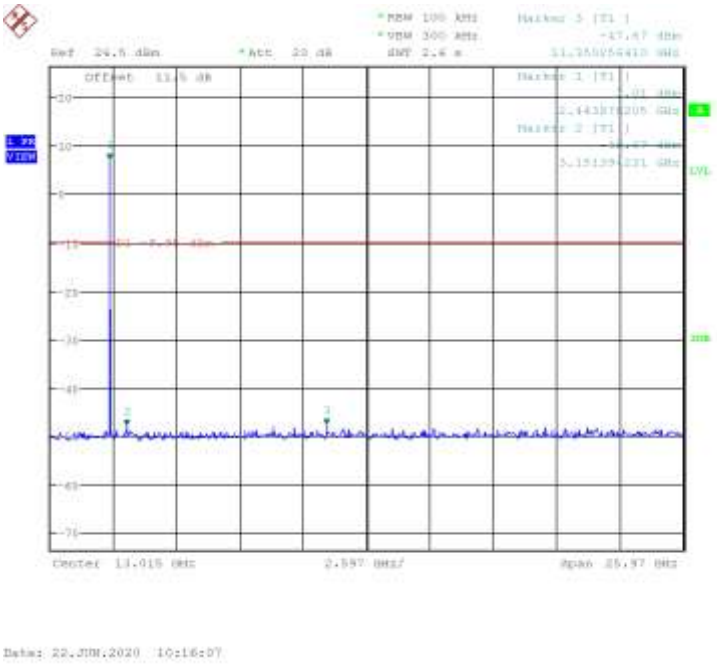
Plot 33. Conducted Emissions, 2480 MHz, 1Mbps



Plot 34. Conducted Emissions, 2402 MHz, 2Mbps



Plot 35. Conducted Emissions, 2440 MHz, 2Mbps



Plot 36. Conducted Emissions, 2480 MHz, 2Mbps

4.5 Out of Band Emissions: Restricted Band Edge

4.5.1 Test Methodology

4.5.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emissions test procedure. The frequency range of interest was divided into sub-ranges. For each sub-range peak emission data was recorded and plotted while the turntable was rotated 360° in 90° steps and the measurement antenna was rotated in horizontal and vertical antenna polarization. For Frequency Sweeps above 1GHz a RBW of 1MHz and VBW of 3MHz was used.

Preliminary emission profile testing was performed inside a semi-anechoic chamber. The EUT was placed on a non-conductive table 150cm above the floor for emissions greater than 1 GHz. The EUT was positioned as shown in the setup photographs. The measurement antenna was placed at a distance of 3m.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 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.

4.5.1.2 Final Test

Final testing was performed on an NSA compliant test site.

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. Preliminary emissions within 10 dB of the limit were measured.

The final scans were performed on the worst EUT axis for three operating channels in the operating mode with the highest power.

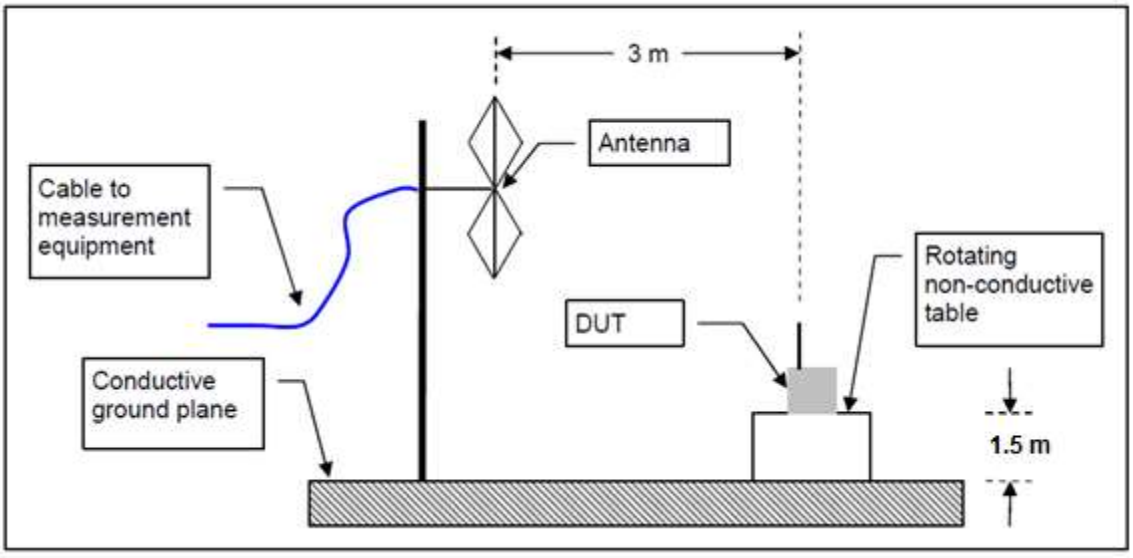
4.5.1.3 Deviations

None.

4.5.2 Test Setup

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

1-26GHz



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

All harmonics and spurious emission which are outside of the restricted band shall be 20dB below the in-band emission.

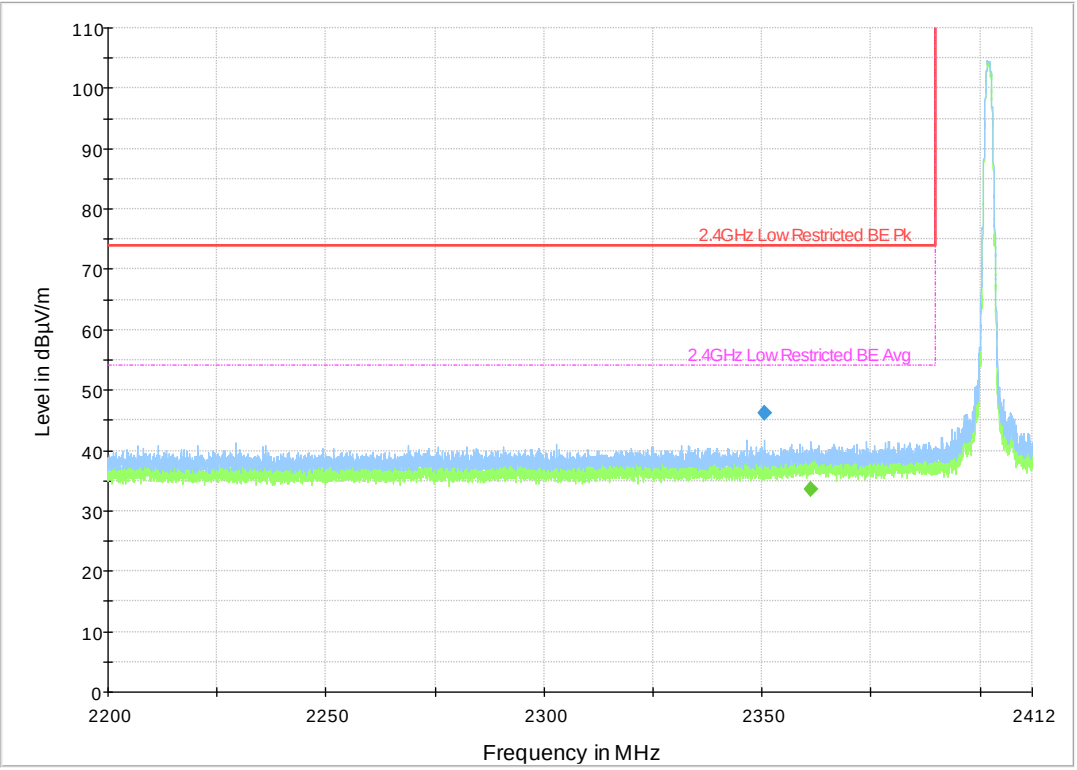
4.5.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions.

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

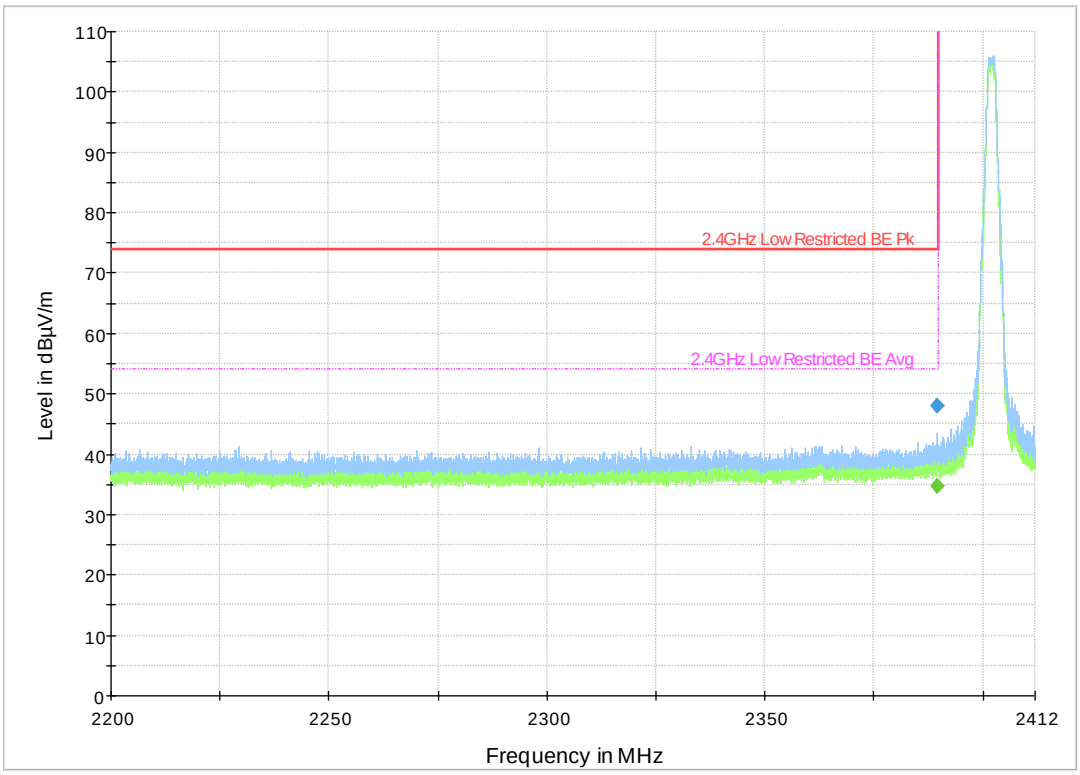
4.5.4 Radiated Test Data

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2350.477600	46.29	---	74.00	27.71	1000.000	197.0	V	76.0
2361.183600	---	33.58	54.00	20.42	1000.000	203.0	H	-93.0



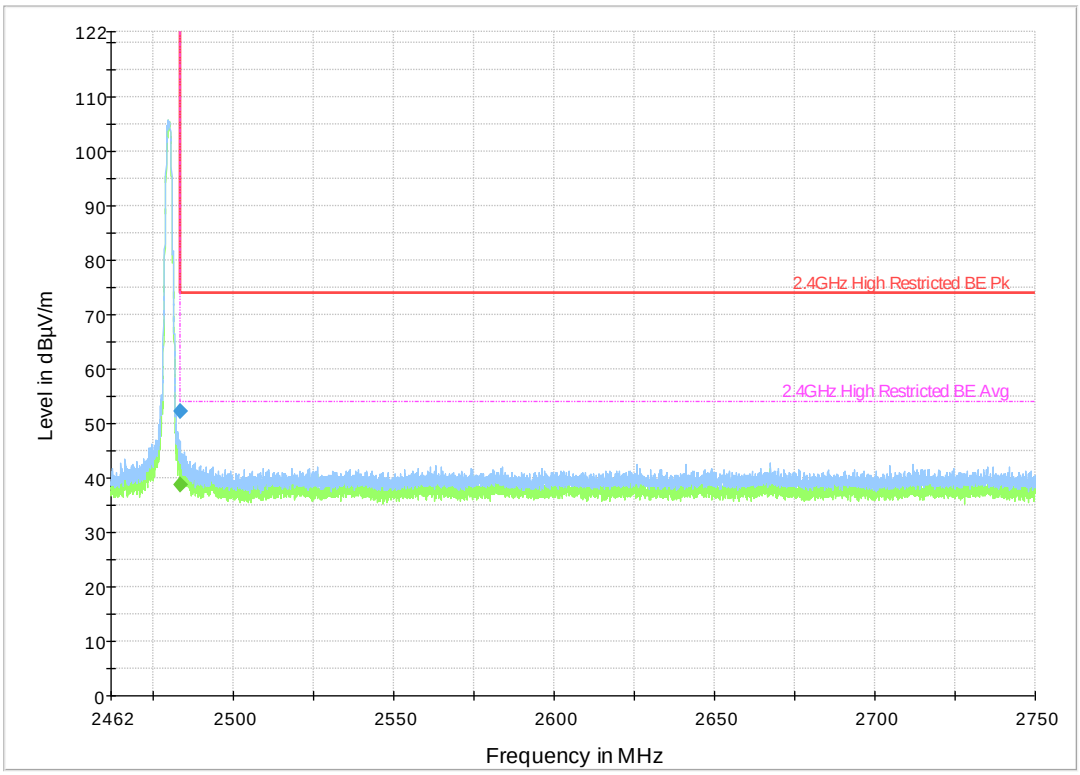
Plot 37. Restricted Band Edge, Low, 2402MHz, 1 Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2389.655200	---	34.70	54.00	19.30	1000.000	204.0	H	-39.0
2389.655200	47.98	---	74.00	26.02	1000.000	203.0	H	-39.0



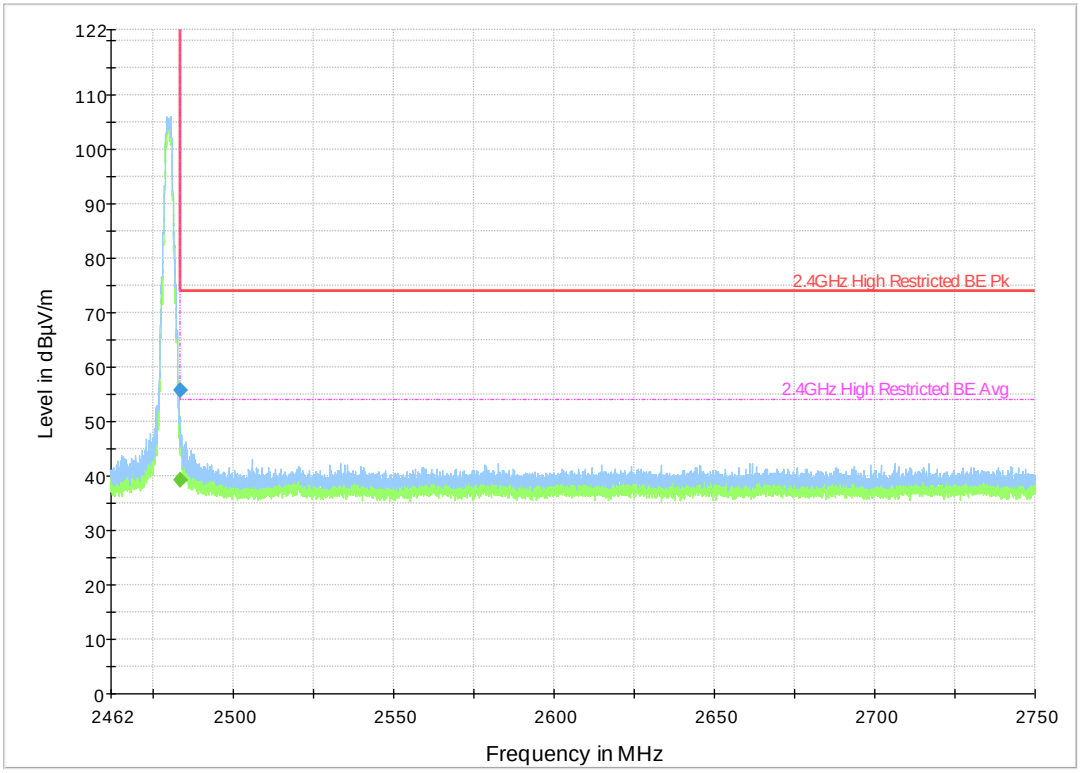
Plot 38. Restricted Band Edge, Low, 2402MHz, 2 Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2483.744000	---	38.65	54.00	15.35	1000.000	197.0	H	-45.0
2483.744000	52.27	---	74.00	21.73	1000.000	197.0	H	-45.0



Plot 39. Restricted Band Edge, High, 2480MHz, 1 Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2483.571200	55.67	---	74.00	18.33	1000.000	104.0	H	-40.0
2483.744000	---	39.29	54.00	14.71	1000.000	154.0	H	-45.0



Plot 40. Restricted Band Edge, High, 2480MHz, 2 Mbps

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 emissions test procedure. The frequency range of interest was divided into sub-ranges. For each sub-range peak emission data was recorded and plotted while the turntable was rotated 360° in 90° steps and the measurement antenna was rotated in horizontal and vertical antenna polarization. For Frequency Sweeps from 30MHz-1GHz a RBW of 120kHz and VBW of 300kHz were used. Above 1GHz a RBW of 1MHz and VBW of 3MHz was used.

Preliminary emission profile testing was performed inside a semi-anechoic chamber. The EUT was placed on a non-conductive table 80 cm above the floor for emissions less than 1 GHz and 150cm above the floor for emissions greater than 1 GHz. The EUT was positioned as shown in the setup photographs. The measurement antenna was placed at a distance of 3m.

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

Final testing was performed on an NSA compliant test site.

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. Preliminary emissions within 10 dB of the limit were measured.

The final scans were performed on the worst EUT axis for three operating channels in the operating mode with the highest power.

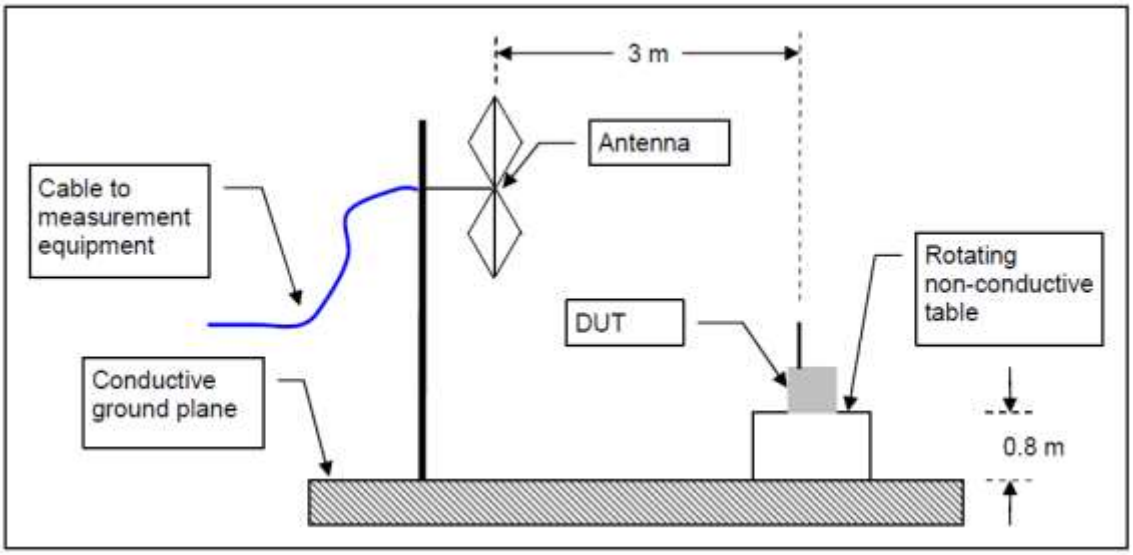
4.6.1.3 Deviations

None.

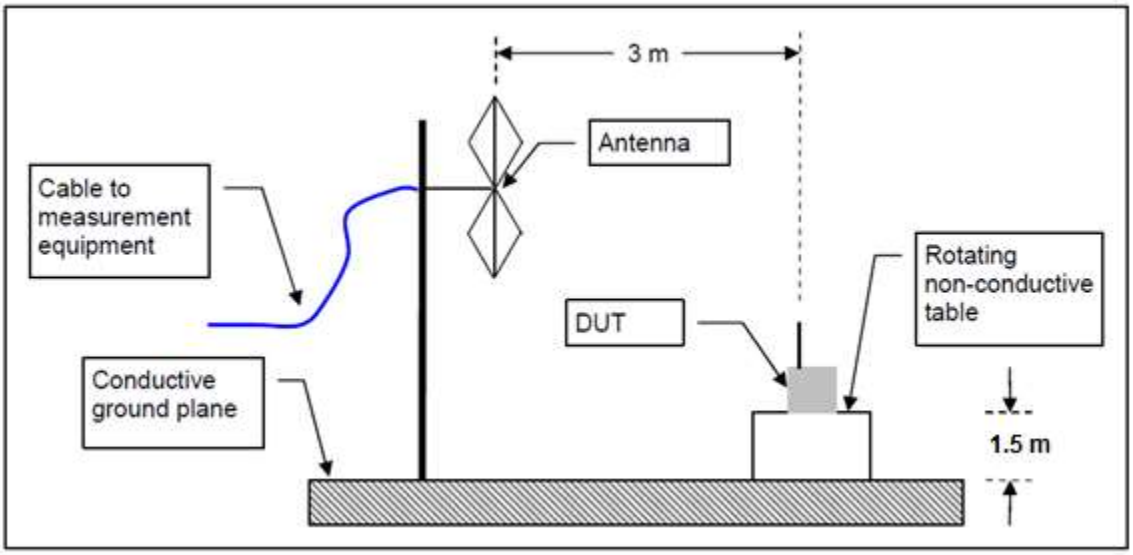
4.6.2 Test Setup

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



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

All harmonics and spurious emission which are outside of the restricted band shall be 20dB below the in-band emission.

4.6.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions.

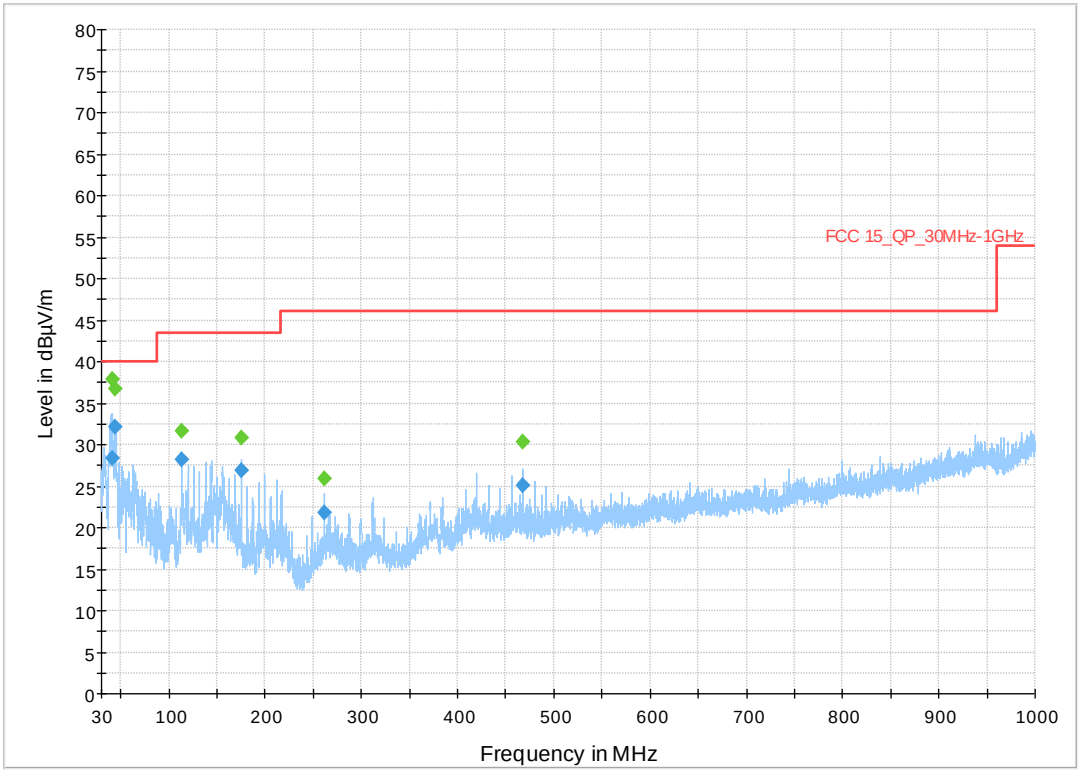
Frequencies below 30MHz were investigated and no emissions were found above the noise floor. No emissions above the noise floor were observed above 18GHz.

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

4.6.4 Measurement Data

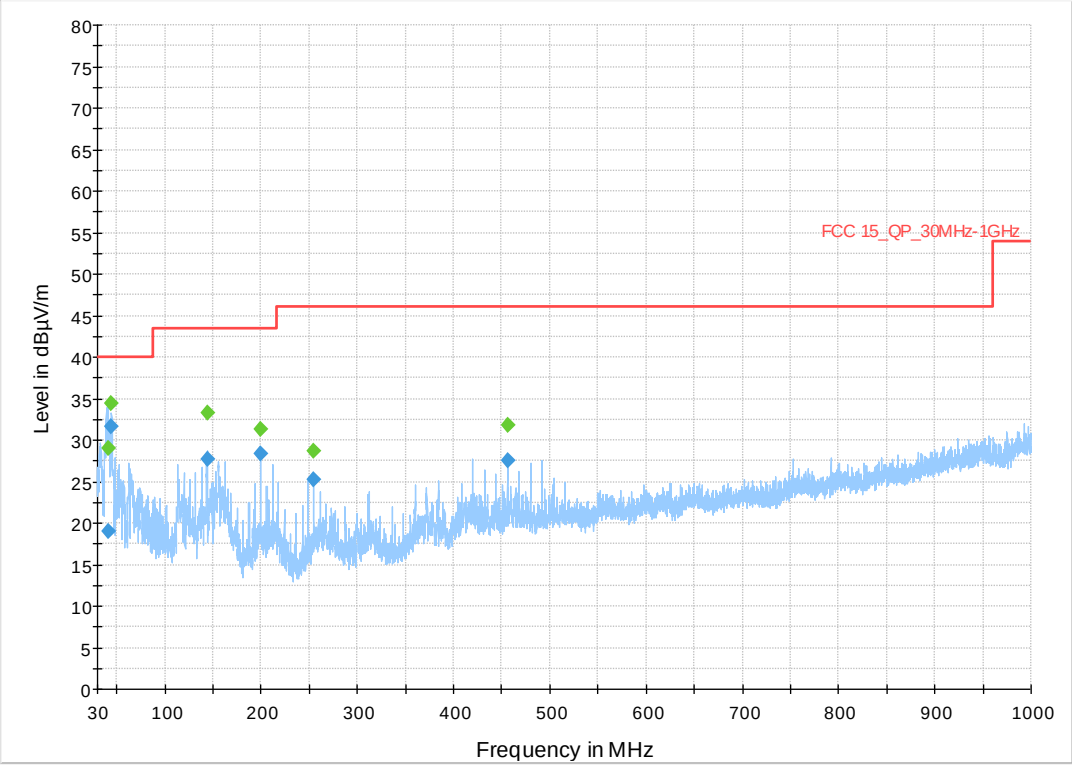
4.6.4.1 30MHz – 1GHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
41.250440	28.42	40.00	11.58	120.000	103.0	V	-113.0
44.129600	32.08	40.00	7.92	120.000	103.0	V	121.0
113.684920	28.19	43.52	15.33	120.000	103.0	V	-149.0
175.086680	26.89	43.52	16.63	120.000	103.0	V	-146.0
261.098200	21.88	46.00	24.12	120.000	103.0	V	151.0
468.089880	25.10	46.00	20.90	120.000	103.0	V	-16.0



Plot 41. Radiated Spurious Emissions 30MHz – 1GHz, 2402MHz, 1Mbps

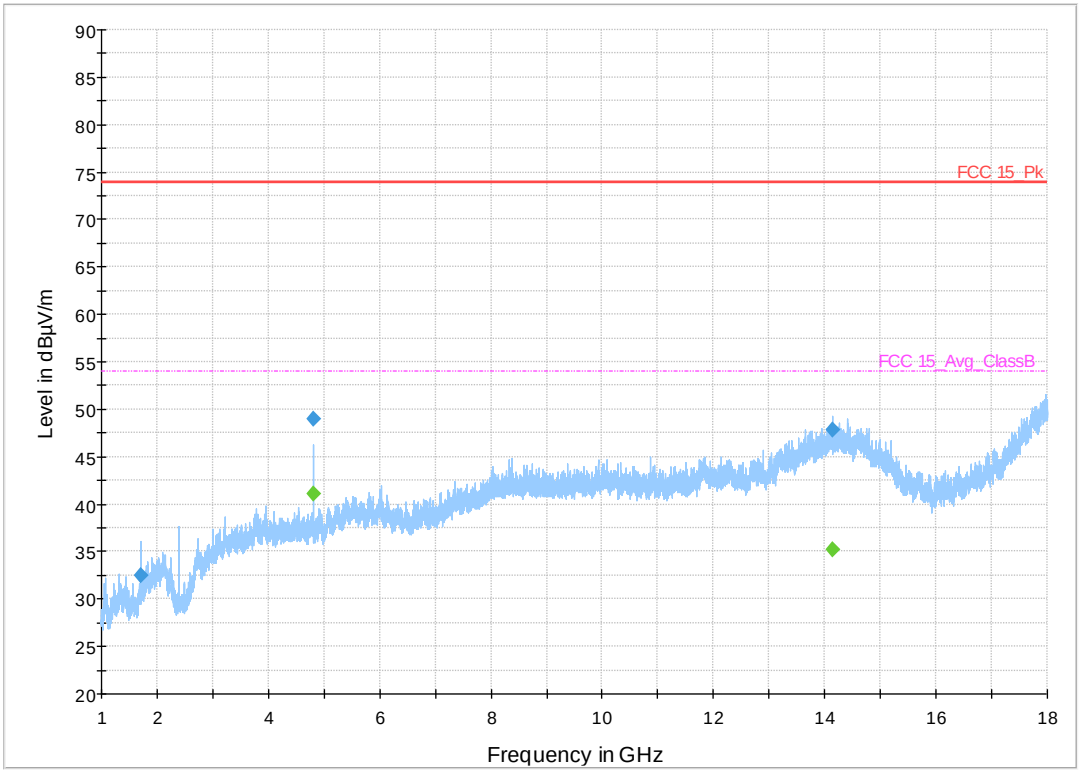
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
41.253560	19.08	40.00	20.92	120.000	103.0	V	180.0
44.233760	31.61	40.00	8.39	120.000	103.0	V	-36.0
143.941120	27.68	43.52	15.84	120.000	103.0	V	94.0
199.681440	28.41	43.52	15.11	120.000	103.0	V	130.0
254.948640	25.32	46.00	20.68	120.000	103.0	V	154.0



Plot 42. Radiated Spurious Emissions 30MHz – 1GHz, 2440MHz, 2Mbps

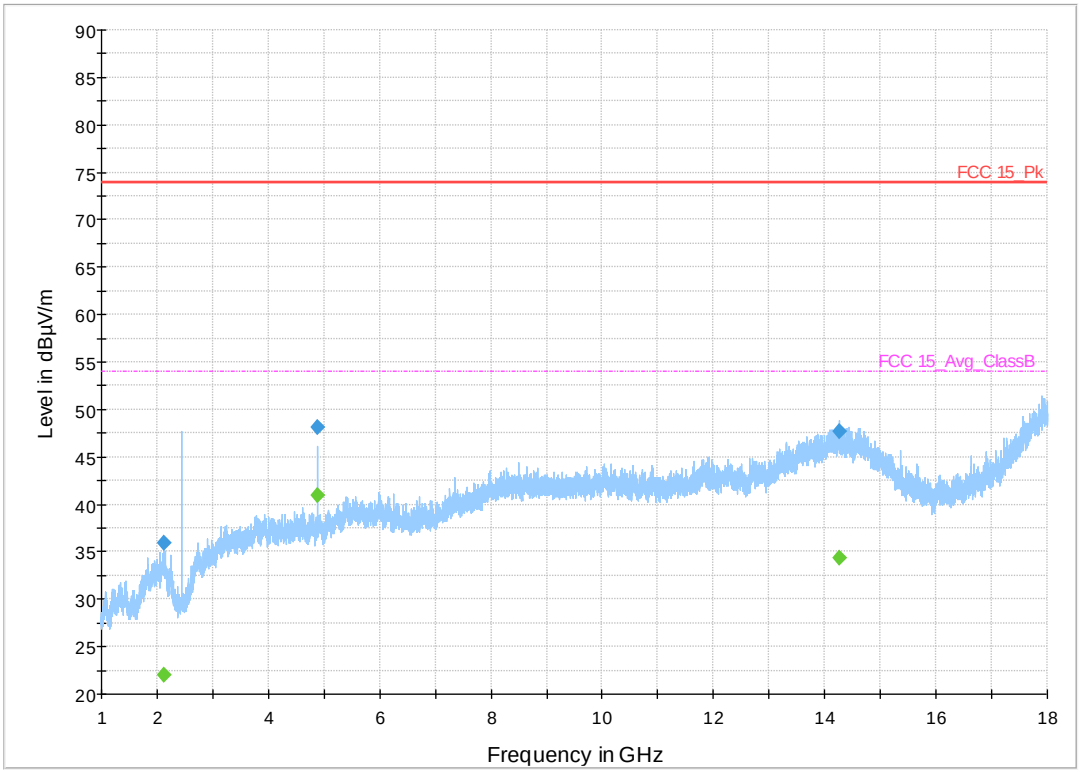
4.6.4.2 **1GHz – 18GHz**

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1716.529000	---	19.55	54.00	34.45	1000.000	103.0	H	-180.0
1716.529000	32.45	---	74.00	41.55	1000.000	103.0	H	-180.0
4804.283000	---	41.04	54.00	12.96	1000.000	104.0	H	148.0
4804.283000	49.01	---	74.00	24.99	1000.000	104.0	H	148.0
14132.352000	---	35.26	54.00	18.74	1000.000	104.0	H	180.0
14132.352000	47.78	---	74.00	26.22	1000.000	104.0	H	180.0



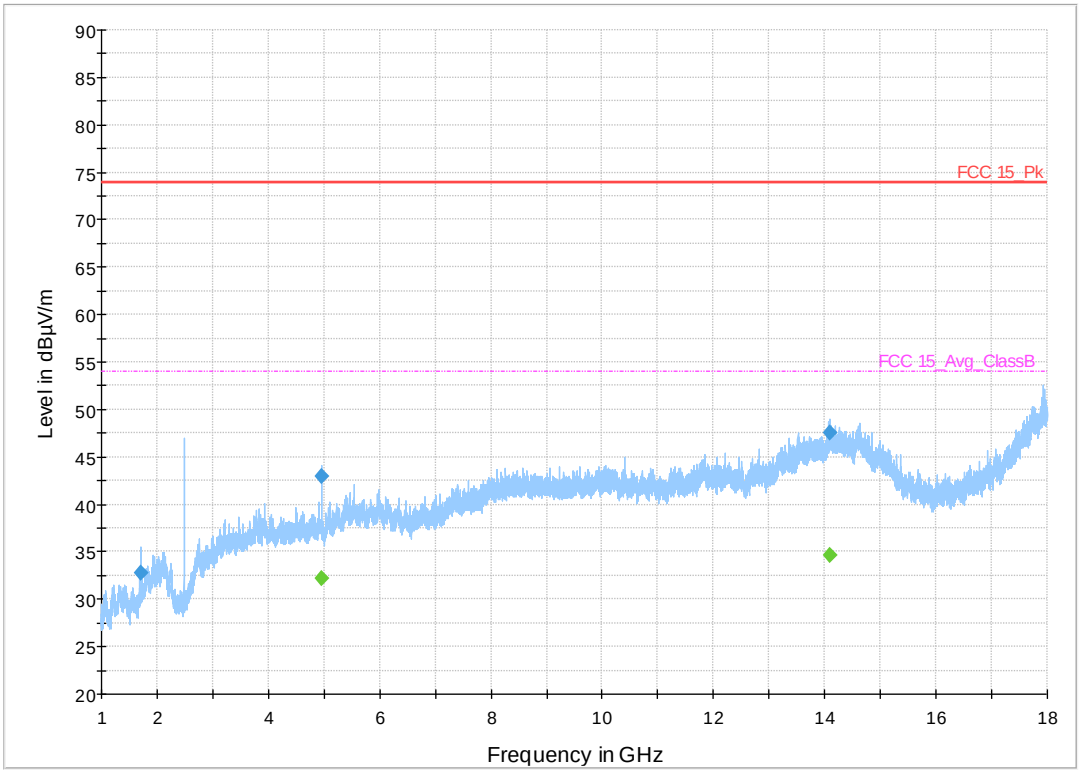
Plot 43. Radiated Spurious Emissions 1GHz - 18GHz , 2402MHz, 1Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2128.968000	---	22.00	54.00	32.00	1000.000	201.0	V	180.0
2128.968000	35.99	---	74.00	38.01	1000.000	201.0	V	180.0
4880.171000	48.08	---	74.00	25.92	1000.000	104.0	H	147.0
4880.171000	---	40.90	54.00	13.10	1000.000	104.0	H	147.0
14262.821500	47.74	---	74.00	26.26	1000.000	201.0	V	-54.0
14262.821500	---	34.37	54.00	19.63	1000.000	201.0	V	-54.0



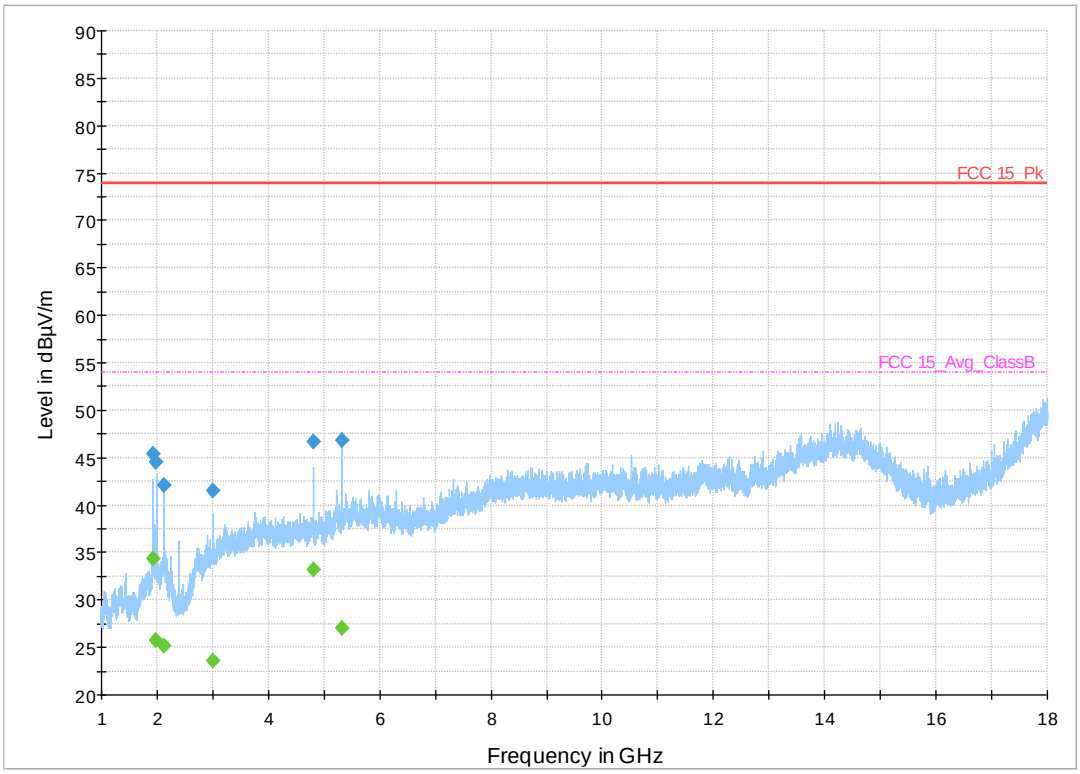
Plot 44. Radiated Spurious Emissions 1GHz - 18GHz , 2440MHz, 1Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1715.905000	---	19.59	54.00	34.41	1000.000	104.0	H	180.0
1715.905000	32.71	---	74.00	41.29	1000.000	104.0	H	180.0
4959.540000	---	32.25	54.00	21.75	1000.000	152.0	H	139.0
4959.540000	43.01	---	74.00	30.99	1000.000	152.0	H	139.0
14097.904500	---	34.61	54.00	19.39	1000.000	200.0	V	-180.0
14097.904500	47.57	---	74.00	26.43	1000.000	200.0	V	-180.0



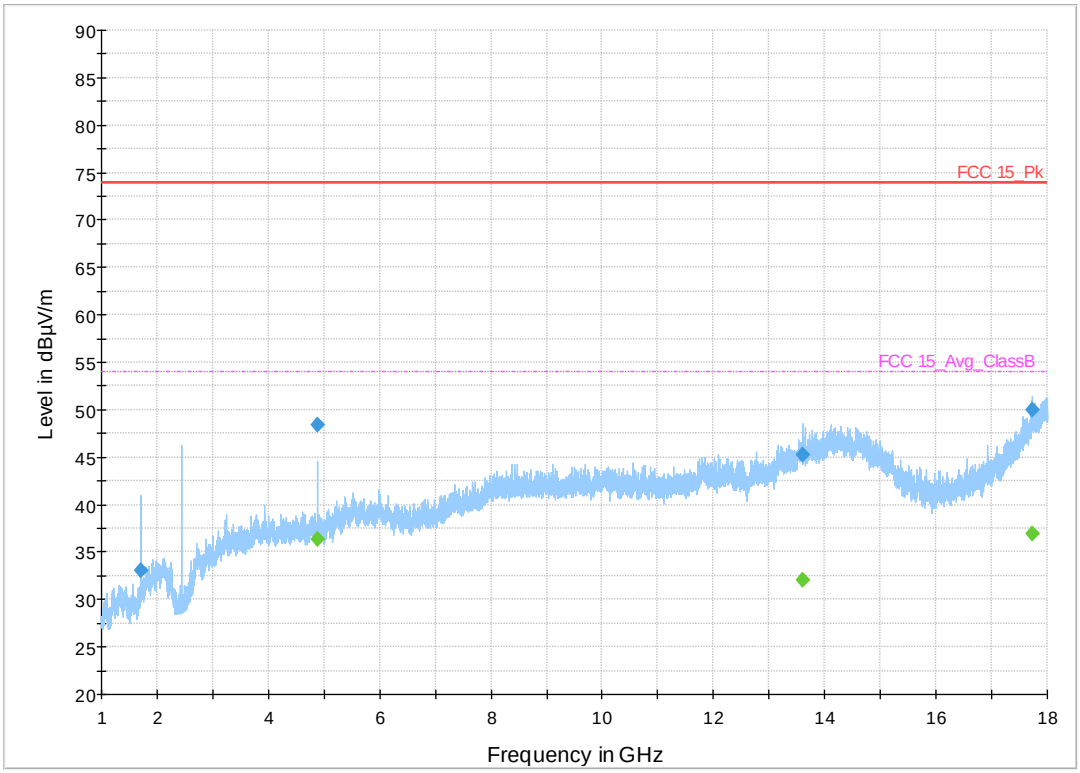
Plot 45. Radiated Spurious Emissions 1GHz - 18GHz , 2480MHz, 1Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1932.450000	---	34.37	54.00	19.63	1000.000	200.0	V	-180.0
1932.450000	45.36	---	74.00	28.64	1000.000	200.0	V	-180.0
1986.669500	44.60	---	74.00	29.40	1000.000	200.0	V	-180.0
1986.669500	---	25.74	54.00	28.26	1000.000	200.0	V	-180.0
2125.668000	---	25.19	54.00	28.81	1000.000	202.0	V	-180.0
2125.668000	42.13	---	74.00	31.87	1000.000	202.0	V	-180.0
3003.482000	41.47	---	74.00	32.53	1000.000	103.0	V	180.0
3003.482000	---	23.61	54.00	30.39	1000.000	103.0	V	180.0
4803.970500	46.72	---	74.00	27.28	1000.000	200.0	H	148.0
4803.970500	---	33.18	54.00	20.82	1000.000	200.0	H	148.0
5311.869500	46.77	---	74.00	27.23	1000.000	104.0	H	-180.0
5311.869500	---	27.05	54.00	26.95	1000.000	104.0	H	-180.0



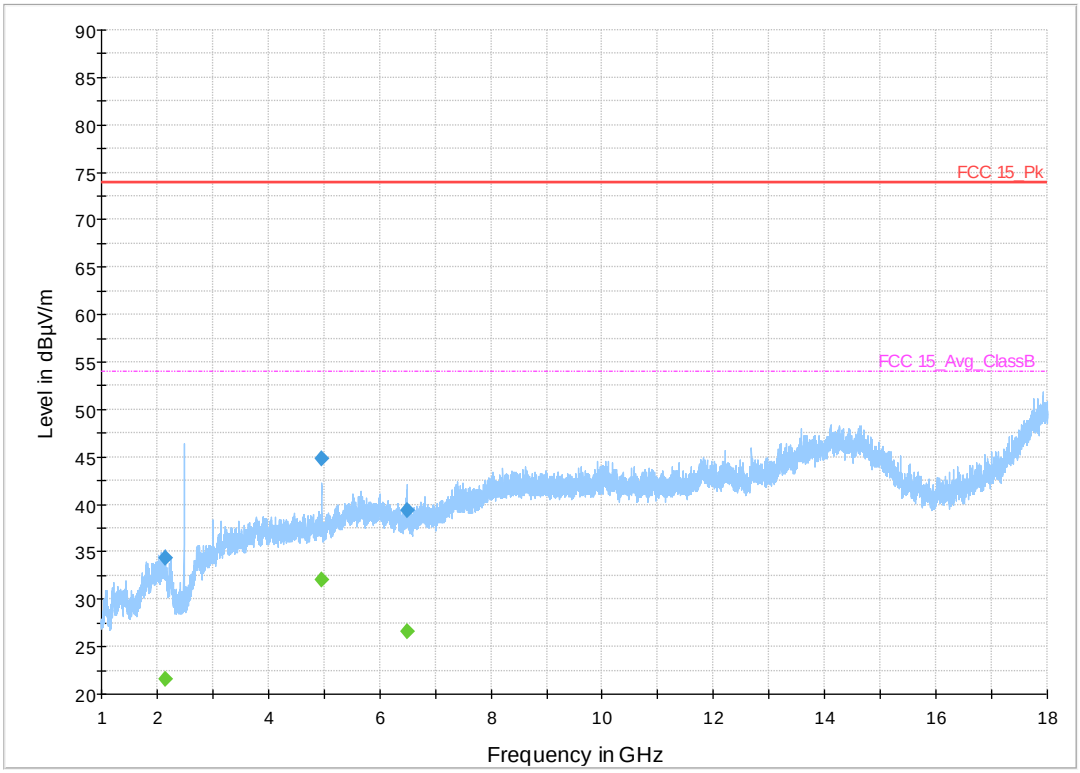
Plot 46. Radiated Spurious Emissions 1GHz - 18GHz , 2402MHz, 2Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1718.653000	---	19.60	54.00	34.40	1000.000	152.0	H	-141.0
1718.653000	33.01	---	74.00	40.99	1000.000	152.0	H	-141.0
4879.160000	48.40	---	74.00	25.60	1000.000	104.0	H	147.0
4879.160000	---	36.40	54.00	17.60	1000.000	104.0	H	147.0
13613.279000	---	32.02	54.00	21.98	1000.000	200.0	V	-180.0
13613.279000	45.20	---	74.00	28.80	1000.000	200.0	V	-180.0
17725.919500	49.93	---	74.00	24.07	1000.000	104.0	H	180.0
17725.919500	---	36.89	54.00	17.11	1000.000	104.0	H	180.0



Plot 47. Radiated Spurious Emissions 1GHz - 18GHz , 2440MHz, 2Mbps

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
2144.509500	---	21.59	54.00	32.41	1000.000	151.0	H	21.0
2144.509500	34.34	---	74.00	39.66	1000.000	151.0	H	21.0
4960.917000	44.89	---	74.00	29.11	1000.000	200.0	H	154.0
4960.917000	---	32.08	54.00	21.92	1000.000	200.0	H	154.0
6505.407500	39.41	---	74.00	34.59	1000.000	200.0	H	6.0
6505.407500	---	26.60	54.00	27.40	1000.000	200.0	H	6.0



Plot 48. Radiated Spurious Emissions 1GHz - 18GHz , 2480MHz, 2Mbps

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 5m Chamber.. 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.

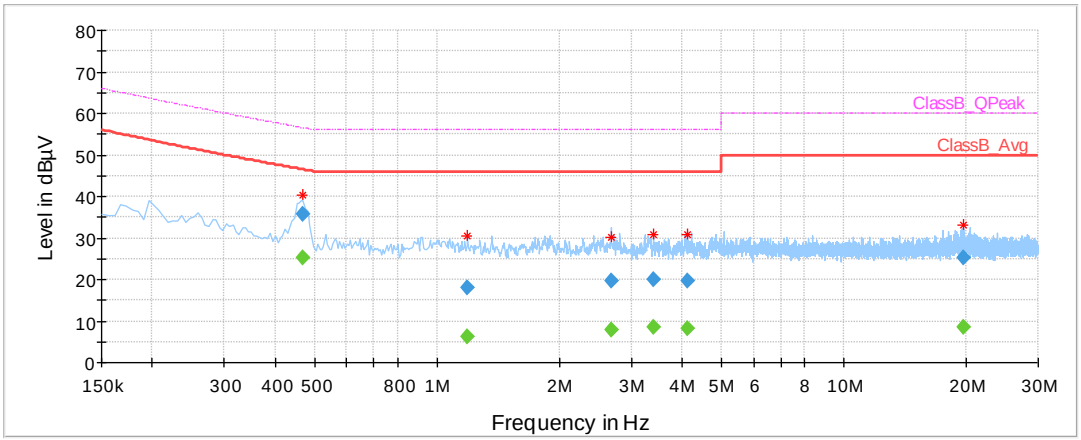
4.7.1.1 Deviations

There were no deviations from this test methodology.

4.7.2 Test Results

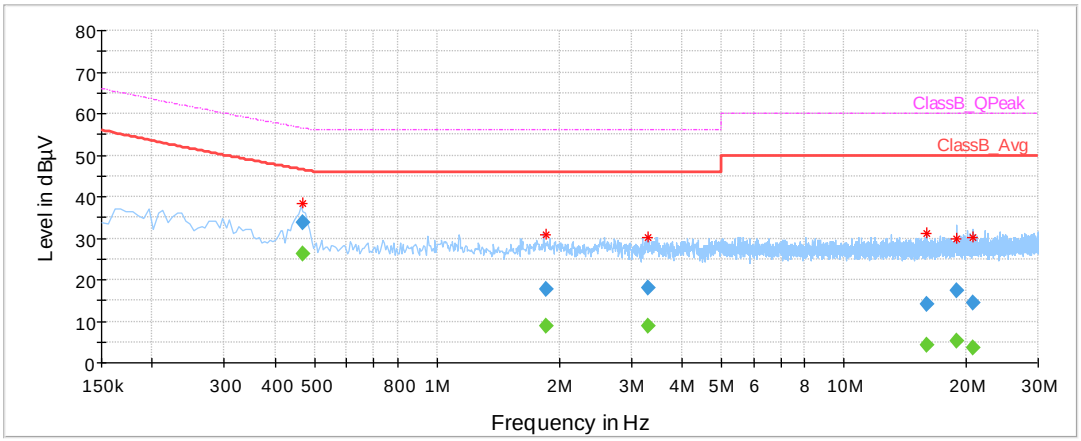
Live Results

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Bandwidth (kHz)	Line
0.466403	---	25.10	56.53	31.44	10.000	L1
0.466403	35.81	---	46.53	10.71	10.000	L1
1.184676	---	6.28	56.00	49.72	10.000	L1
1.184676	17.94	---	46.00	28.06	10.000	L1
2.688190	---	7.78	56.00	48.22	10.000	L1
2.688190	19.53	---	46.00	26.47	10.000	L1
3.407486	---	8.41	56.00	47.59	10.000	L1
3.407486	20.02	---	46.00	25.98	10.000	L1
4.112786	---	8.16	56.00	47.84	10.000	L1
4.112786	19.56	---	46.00	26.44	10.000	L1
19.600919	---	8.42	60.00	51.58	10.000	L1
19.600919	25.25	---	50.00	24.75	10.000	L1



Neutral Results

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Bandwidth (kHz)	Line
0.467485	---	26.08	56.52	30.43	10.000	N
0.467485	33.78	---	46.51	12.72	10.000	N
1.848046	---	8.88	56.00	47.12	10.000	N
1.848046	17.57	---	46.00	28.43	10.000	N
3.308667	---	8.87	56.00	47.13	10.000	N
3.308667	17.91	---	46.00	28.09	10.000	N
15.979910	---	4.13	60.00	55.87	10.000	N
15.979910	14.10	---	50.00	35.90	10.000	N
18.854459	---	5.34	60.00	54.66	10.000	N
18.854459	17.30	---	50.00	32.70	10.000	N
20.774198	---	3.57	60.00	56.43	10.000	N
20.774198	14.57	---	50.00	35.43	10.000	N



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	1166.1660.26	02/23/2020	02/23/2021
EMI Receiver	Rohde & Schwarz	ESW44	101663-dv	07/18/2019	07/18/2021
Preamplifier, 9 kHz – 1 GHz	Sonoma	310N	213221	01/16/2019	01/16/2021
Bilog Antenna	Sunol Sciences	JB3	A061907	12/19/2018	12/19/2020
Amplifier	Miteq	TTA1800-30-HG	1842452	01/15/2019	01/15/2021
Horn Antenna	Sunol Sciences	DRH-118	A040806	03/05/2019	03/05/2021
Amplifier	HP	8449B	3008A01013	01/15/2019	01/15/2021
Horn Antenna	EMCO	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
2.4GHZ Band Filter	Microtronics	BRM50702	009	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 5: Customer Information

Company Name	Eleven Forty Three A.M. LLC
Address	1661 International Drive, Suite 400
City, State, Zip	Memphis, TN 38120
Country	USA

Table 6: Technical Contact Information

Name	Pamela A. Jasinski
E-mail	1143amllc@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 7: EUT Designation

Product Name	Z4NEU3
Model Number	Z4NEU3

6.4 Product Specifications

Table 8: EUT Specifications

EUT Specifications	
Environment	Indoor
Operating Temperature Range:	0 to 35 C
Multiple Feeds:	☐ Yes and how many ☒ No
Product Marketing Name (PMN)	--
Hardware Version	Ver1
Firmware Version	1125306
Operating Modes	BT BLE
Transmitter Frequency Band	2400 – 2483.5 MHz
Power Setting	Set by Manufacturer
Modulation	GFSK
TX/RX Chain (s)	1
Type of Equipment	☐ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other: Body Worn

Table 9: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
1	PIFA	Internal	2.1

Table 10: 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?
Serial	Serial to USB	☐ Yes	☒ Metric: < 3.0m	☒ M
Note: Cable required for EUT configuration for regulatory test mode. Serial cable not utilized within final product. EUT powered via DC power supply during testing.				

Table 11: Accessory Equipment

Equipment	Manufacturer	Model	Serial	Comment
USB to Serial Connector	N/A (generic)	N/A (generic)	N/A	Used between test cases to configure EUT operational test mode. Cable removed during radiated testing.

Table 12: Ancillary Equipment (used for test purposes only)

Equipment	Manufacturer	Model	Serial	Used for
Laptop	Lenovo	X220	N/A	Setup EUT operating channels via serial connection to EUT
Note: None.				

Table 13: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.247
Z4NEU3E	N/A	Integrated Antenna	Radiated Emissions, Radiated Band Edge
		Direct via temporary SMA connector	Transmit Power, Occupied Bandwidth, Out of Band Emission, PSD, Duty Cycle

Table 14: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup (X-Axis)	Setup (Y-Axis)	Setup (Z-Axis)
Z4NEU3	PIFA	Transmit	EUT Flat	EUT side	EUT Upright
Note: EUT was tested on its X-Axis as this was worse case					

6.5 Test Specifications

Table 15: Test Specifications

Emissions	
Standard	**Requirement**
CFR 47 Part 15.247: 2020	All

END OF REPORT