Emissions
Test Report

EUT Name: Plaqless

Model No.: ADVBTB-C

CFR 47 Part 15.247: 2019 and RSS 247: 2017

Prepared for:

Colgate-Palmolive Company
909 River Road
Piscataway, NJ 08855-1343

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	4/9/2020	Original Document	AS
1	4/20/2020	Updated FCC/IC IDs	AS

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Colgate-Palmolive Company 909 River Road Piscataway, NJ 08855-1343
Requester / Applicant:	Colgate-Palmolive Company
Name of Equipment:	Plaqless
Model No.	ADVBTB-C
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2019 and RSS 247: 2017
Test Dates:	March 9th, 2020 to March 13th, 2020

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.

Alexander J Sowinski	Date April 20, 2020	Rachana Khanduri	Date April 20, 2020

ISED

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 March 9th, 2020 to March 13th, 2020 on the ADVBTB-C manufactured by Colgate-Palmolive Company. 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)	-5.19 dBm @ 2402MHz Channel, 1Mbps	**Complied**
DTS Bandwidth (6dB)	CFR47 15.247 (a)(2), RSS 247 Sect. 5.2 (a)	0.64904 MHz @ 2440MHz Channel, 1Mbps	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 247 Sect. 5.2 (b)	-23.48 dBm @ 2402MHz channel, 1Mbps	**Complied**
Out of Band Emissions: Non-Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	-35.58 dBc @ 24835MHz, Upper Band Edge	**Complied**
Out of Band Emissions: Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	-19.79 dB margin @ 2573.772 MHz, Average	**Complied**
Transmitter Spurious Emissions	CFR47 15.247 (d), RSS 247 Sect.5.5	-15.30dB Margin @ 13932.753 MHz, Average	**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 17025:2017. 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 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 17025:2017. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The Model ADVBTB-C is an Electric Tooth brush that utilizes Bluetooth LE to communicate with a connected smartphone. 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.

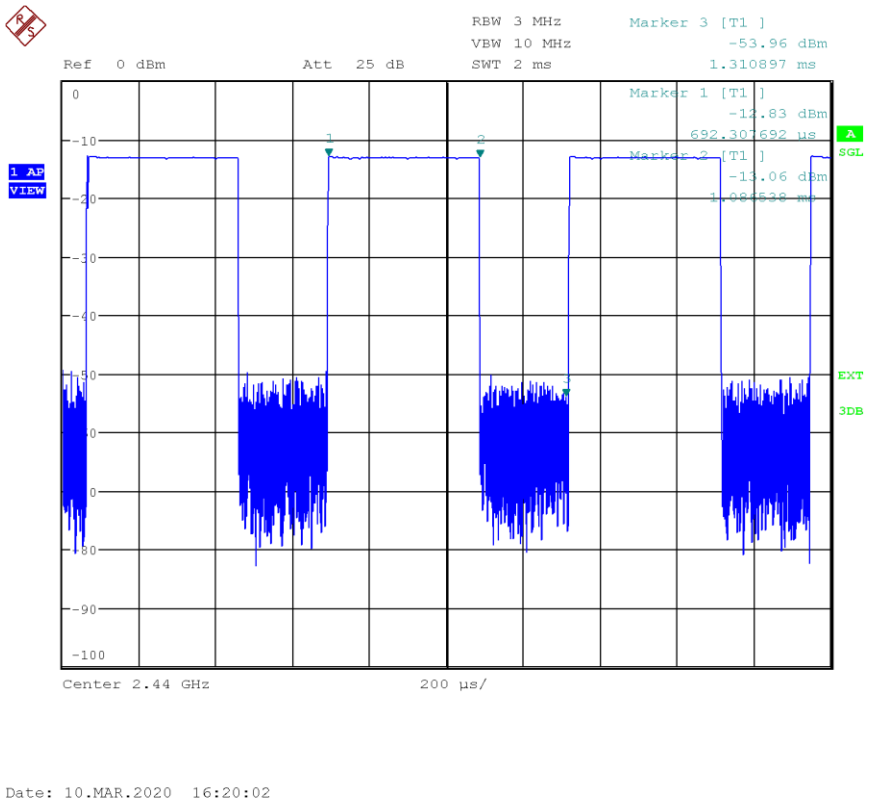
3.4.1 Results

The Plaqless has 1 Chip dedicated Bluetooth antenna that has maximum gain of 2 dBi. It is permanently attached and is not easily accessible to the end user.

3.5 Duty Cycle

The maximum duty cycle of the unit was measured to be 63.73%

3.5.1 Results



Plot 1. Duty cycle measurement of Bluetooth Low Energy

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.

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.

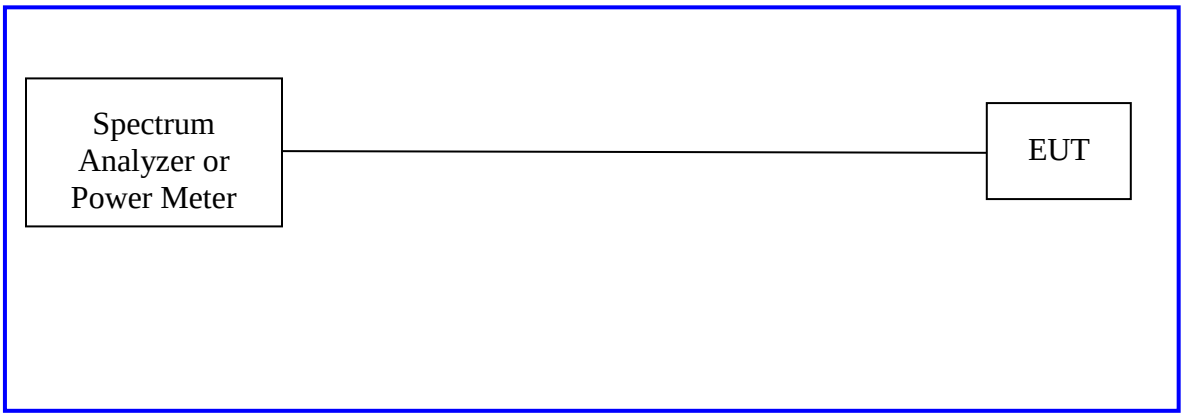
The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b) and RSS 247 5.4 (d).

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:

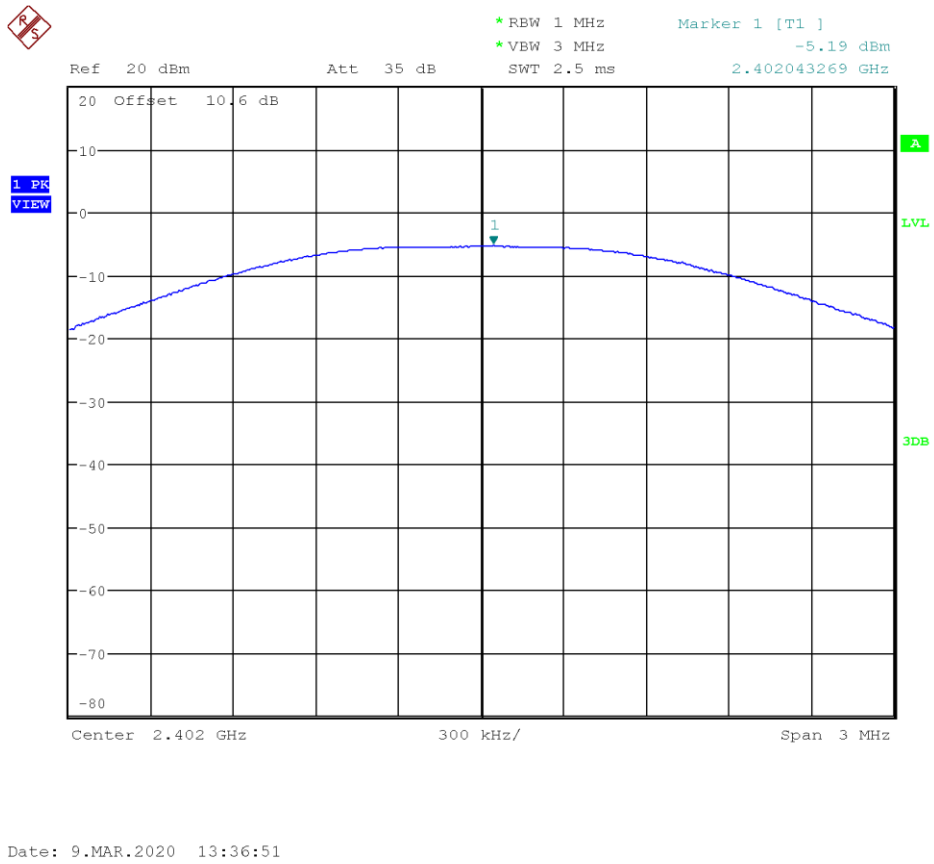


4.1.2 Results

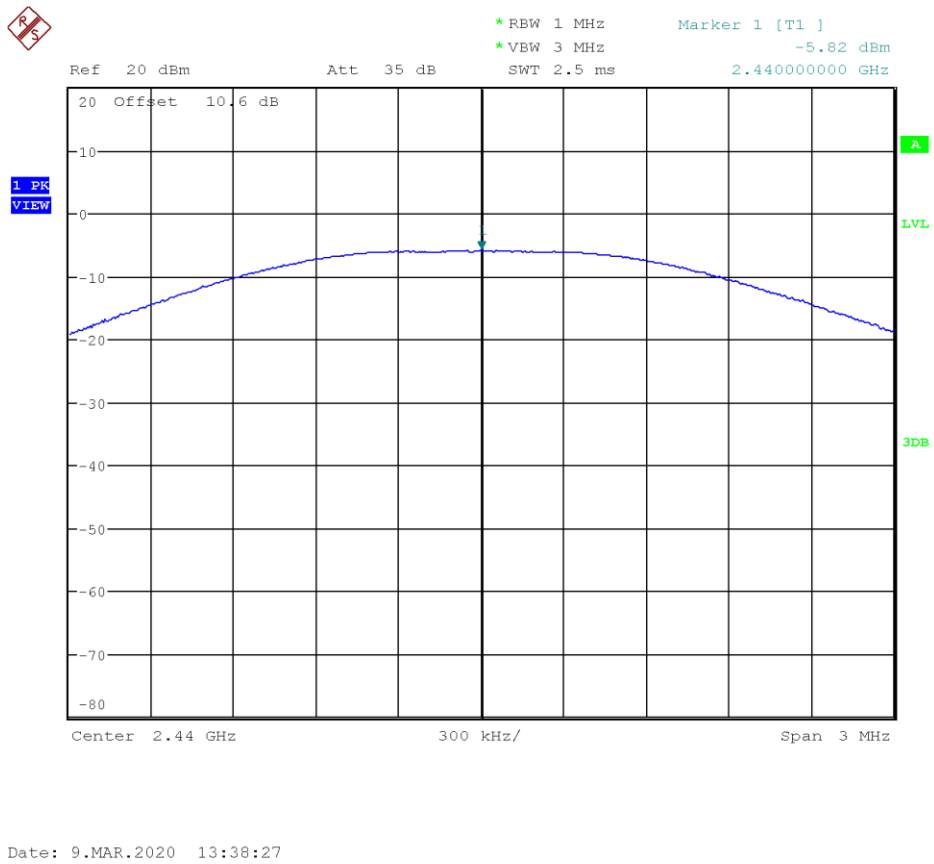
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s). Worse case data for each mode reported below. Plots of highest power included for low, medium, and high channels.

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

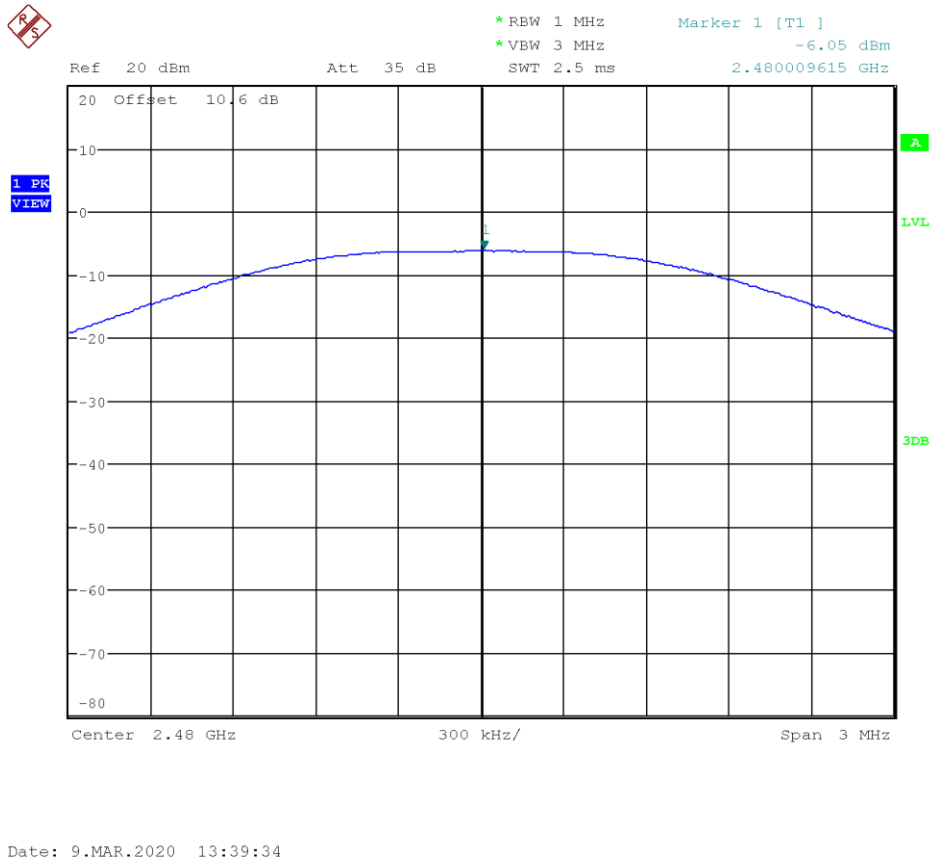
Data Rate	Operating Channel (MHz)	Power [dBm]	Limit [dBm]	Margin [dB]
1Mbps	2402	-5.19	30	-35.19
	2440	-5.82	30	-35.82
	2480	-6.05	30	-36.05



Plot 2. Maximum Conducted Power, 1Mbps 2402MHz



Plot 3. Maximum Conducted Power, 1Mbps 2440MHz



Plot 4. Maximum Conducted Power, 1Mbps 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.

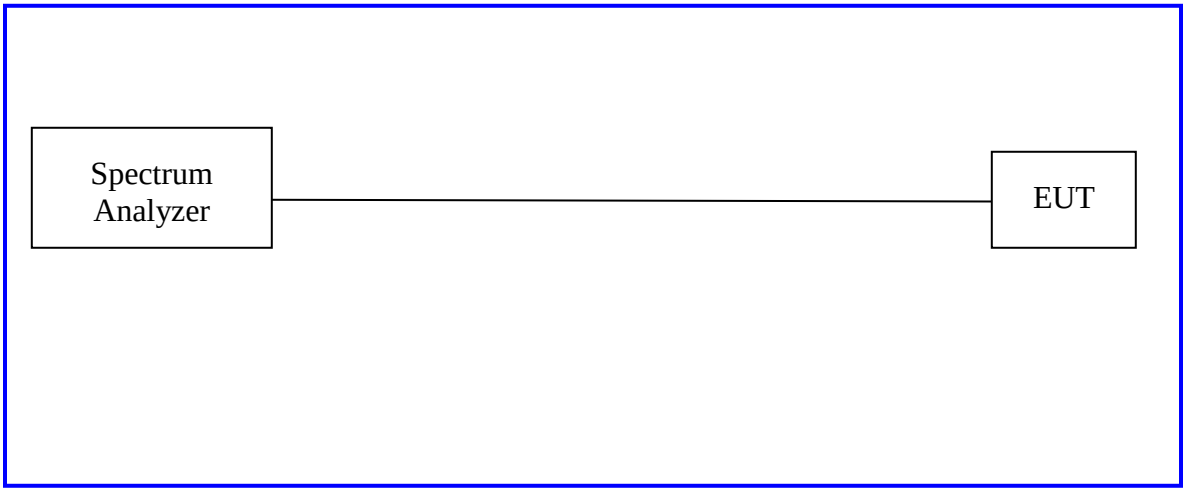
The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

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:

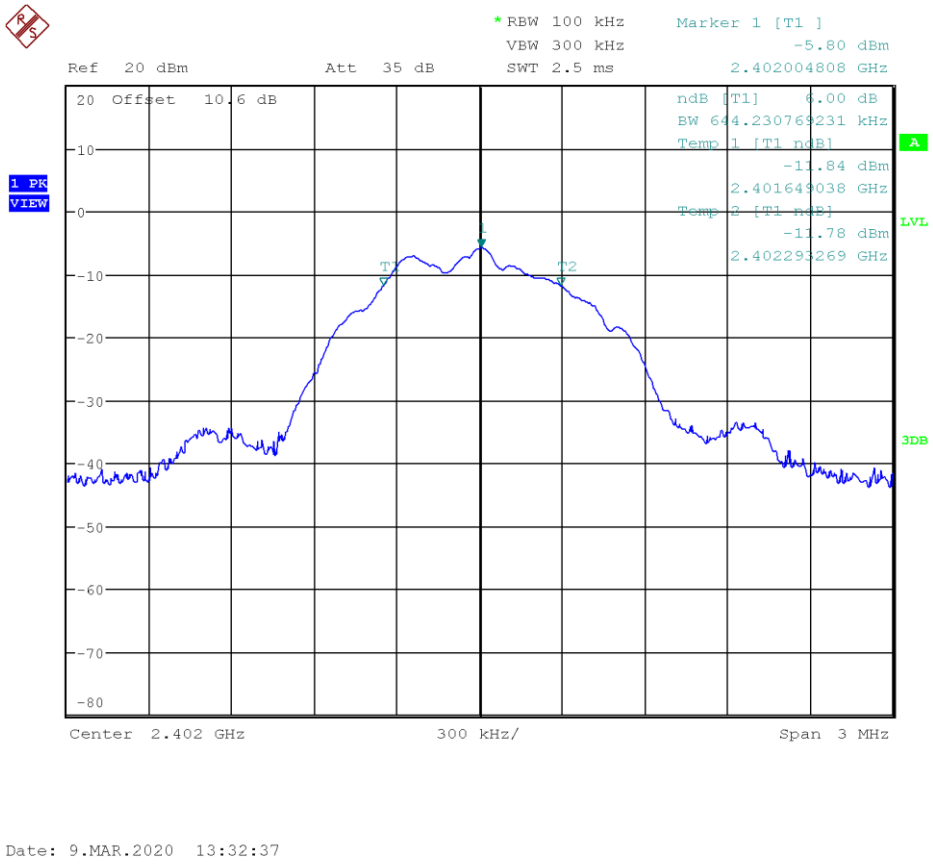


4.2.2 Results

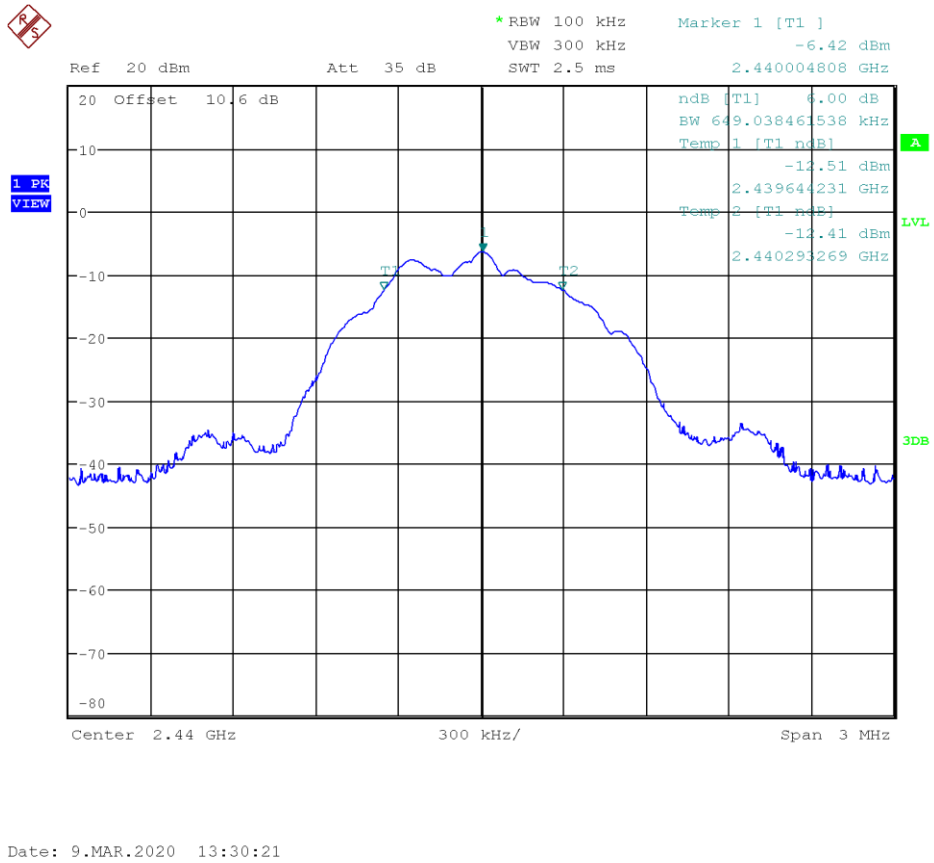
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 3: Occupied Bandwidth – Test Results

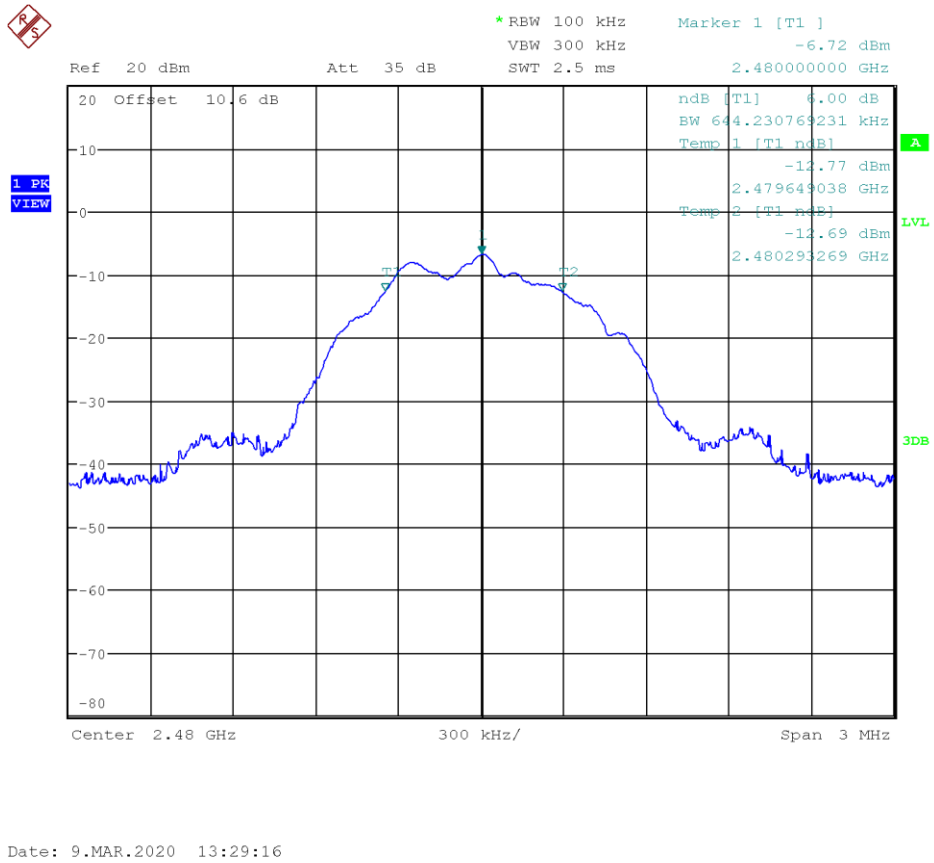
Bandwidth (MHz)			
Data Rate	**Freq. (MHz)**	**99% Bandwidth (MHz)**	**6dB (DTS) Bandwidth (MHz)**
1Mbps	2402	1.087	0.64423
	2440	1.091	0.64904
	2480	1.096	0.64423
	Note: None		



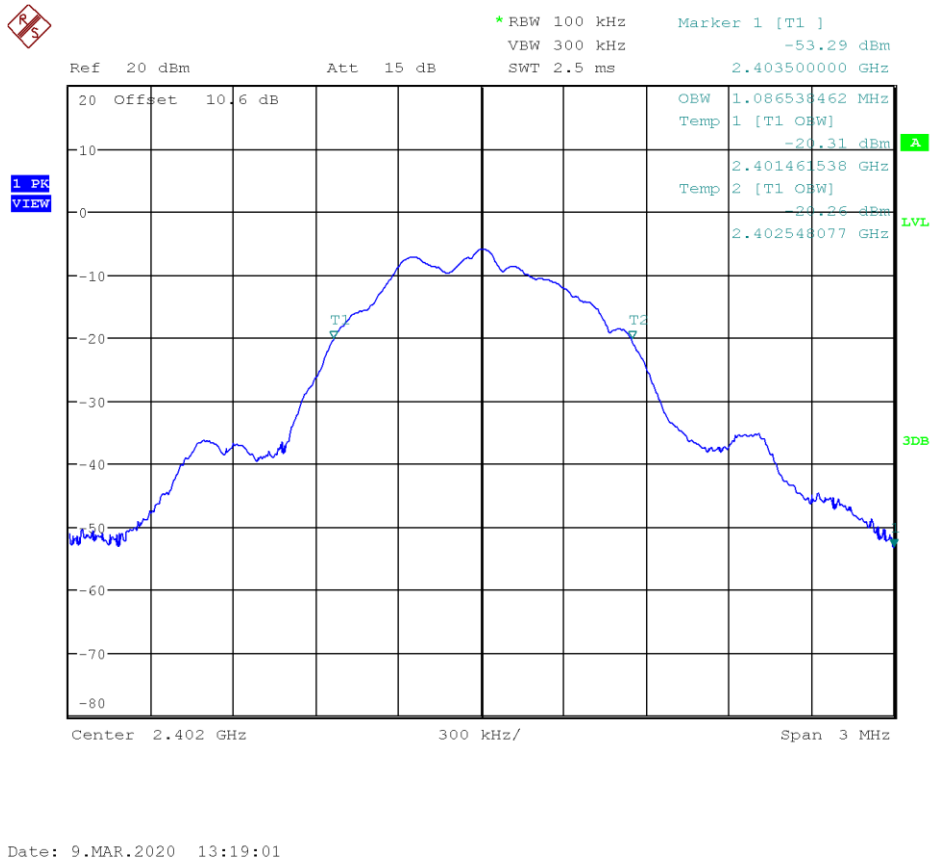
Plot 5. 1Mbps, 2402MHz, 6dB Bandwidth



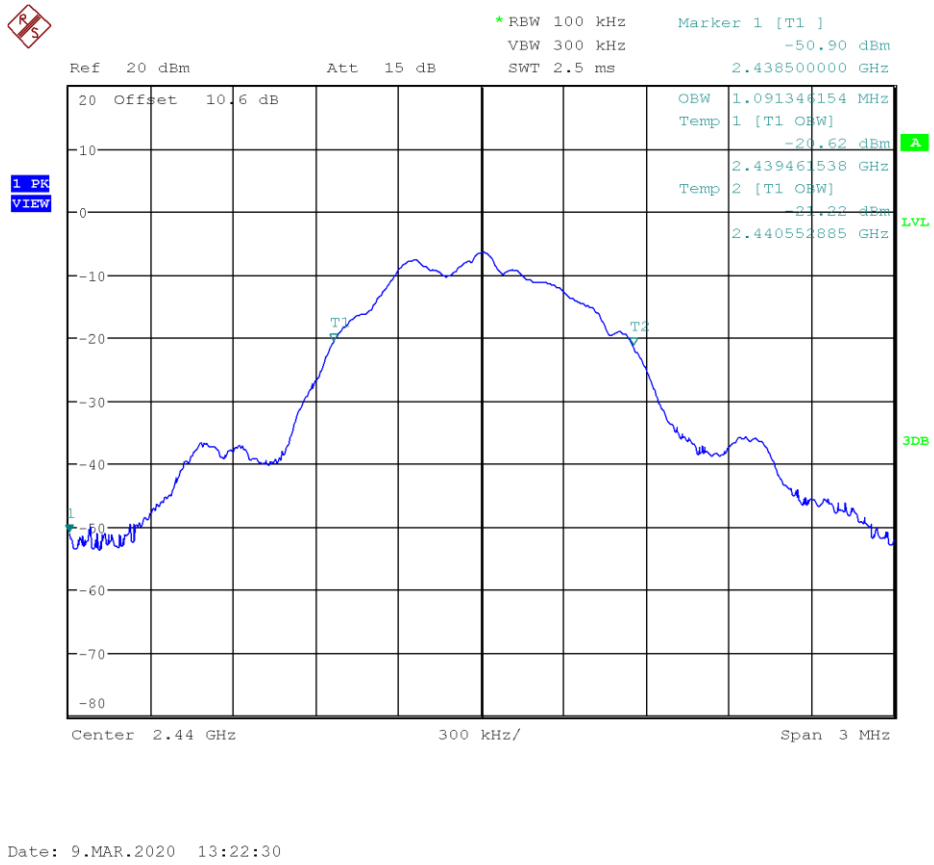
Plot 6. 1Mbps, 2440MHz, 6dB Bandwidth



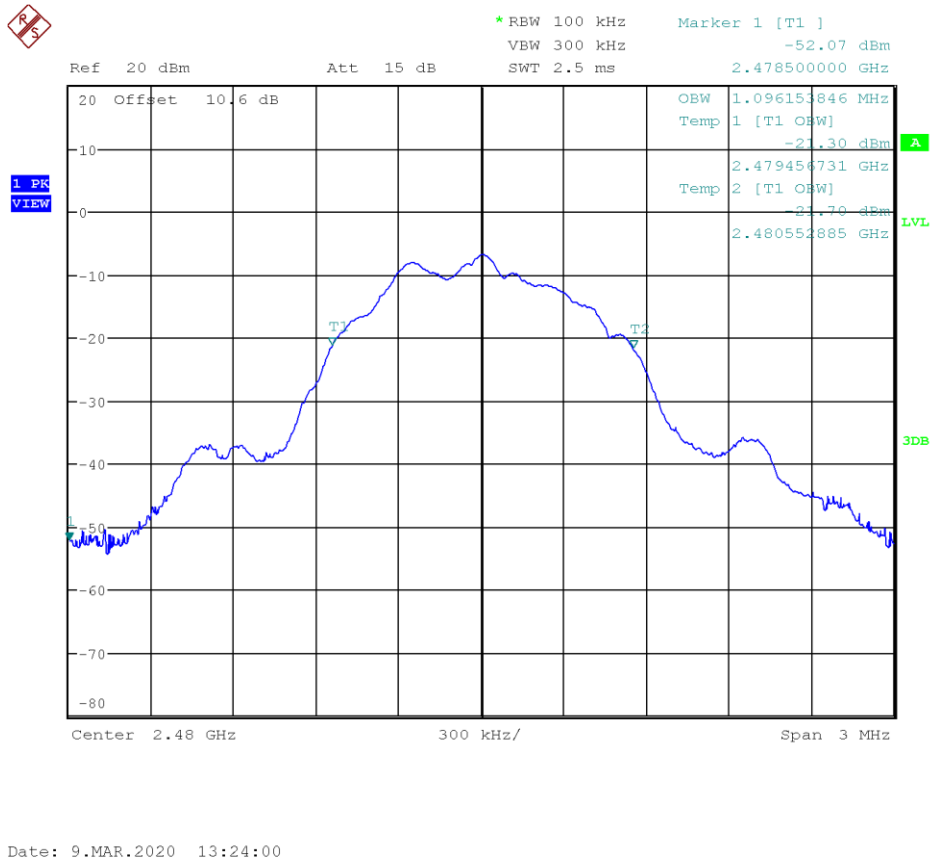
Plot 7. 1Mbps, 2480MHz, 6dB Bandwidth



Plot 8. 1Mbps, 2402MHz, 99% Bandwidth



Plot 9. 1Mbps, 2440MHz, 99% Bandwidth



Plot 10. 1Mbps, 2480MHz, 99% Bandwidth

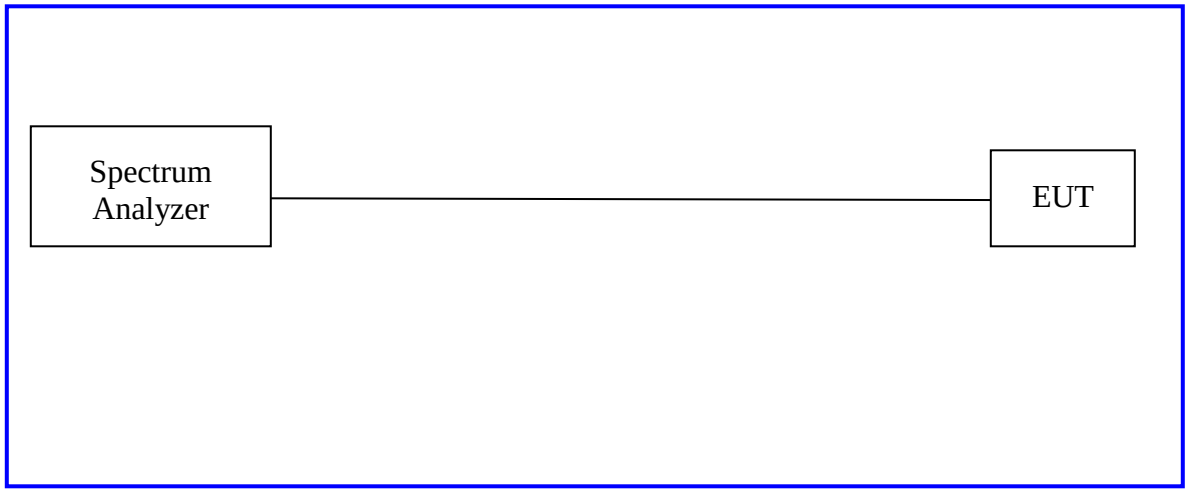
4.3 Peak Power Spectral Density

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:



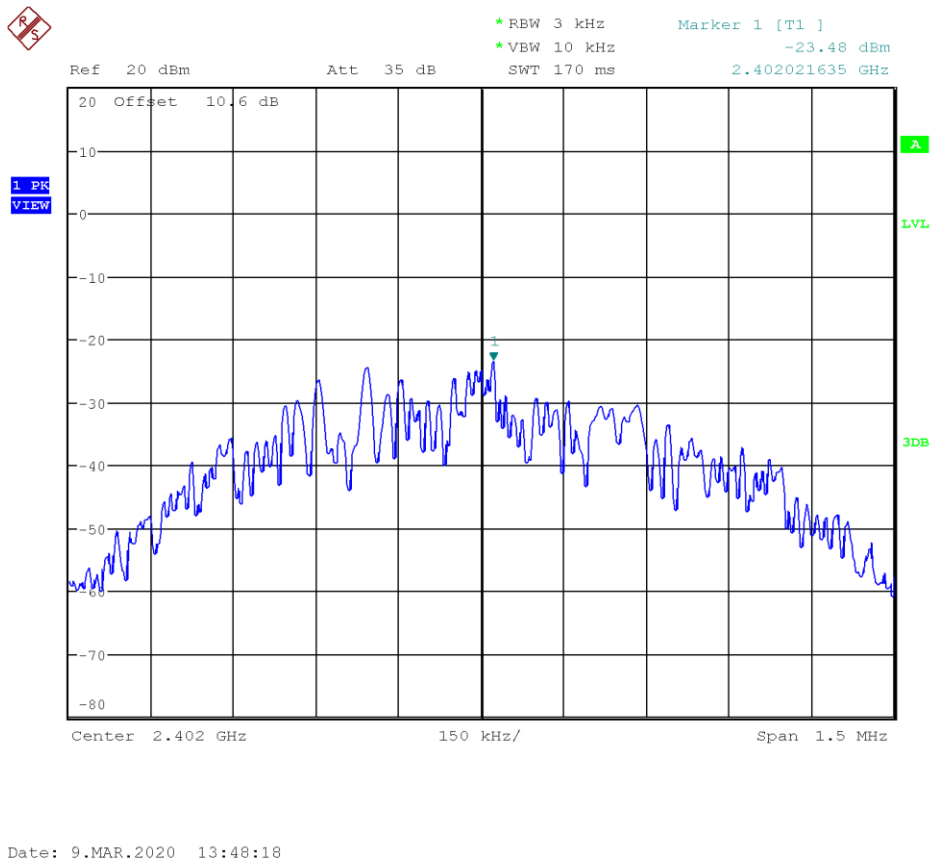
Method PKPSD of "KDB 558074 – DTS Measurement Guidance v04" was used.

4.3.2 Results

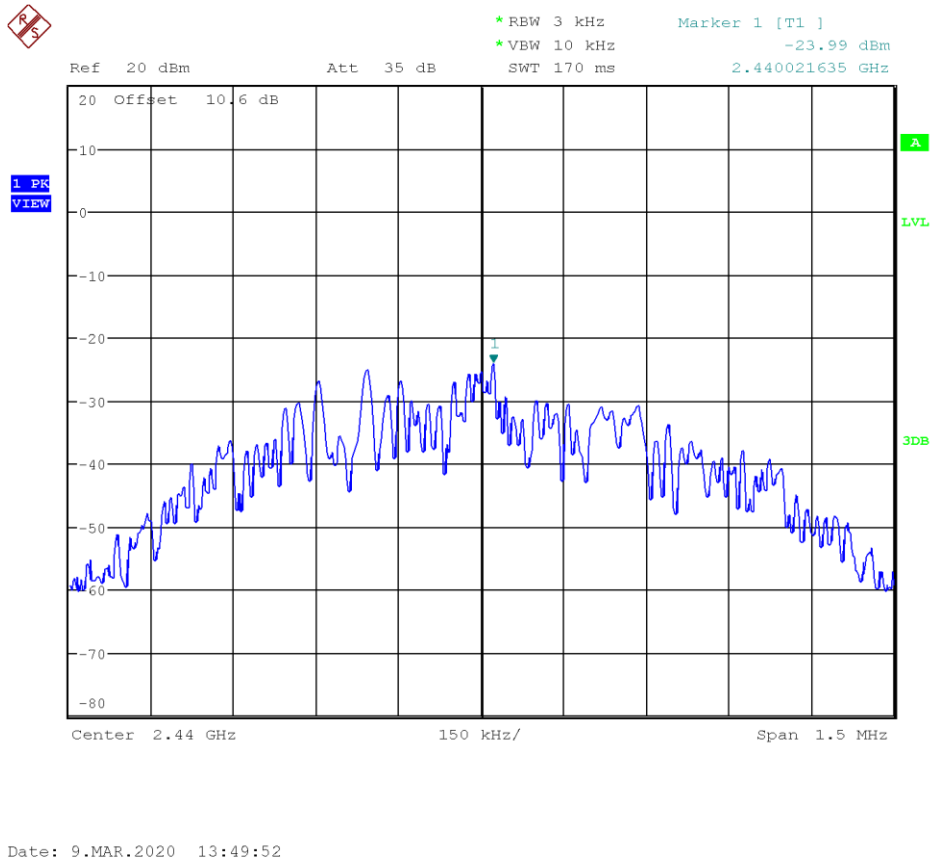
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 4: Peak Power Spectral Density – Test Results

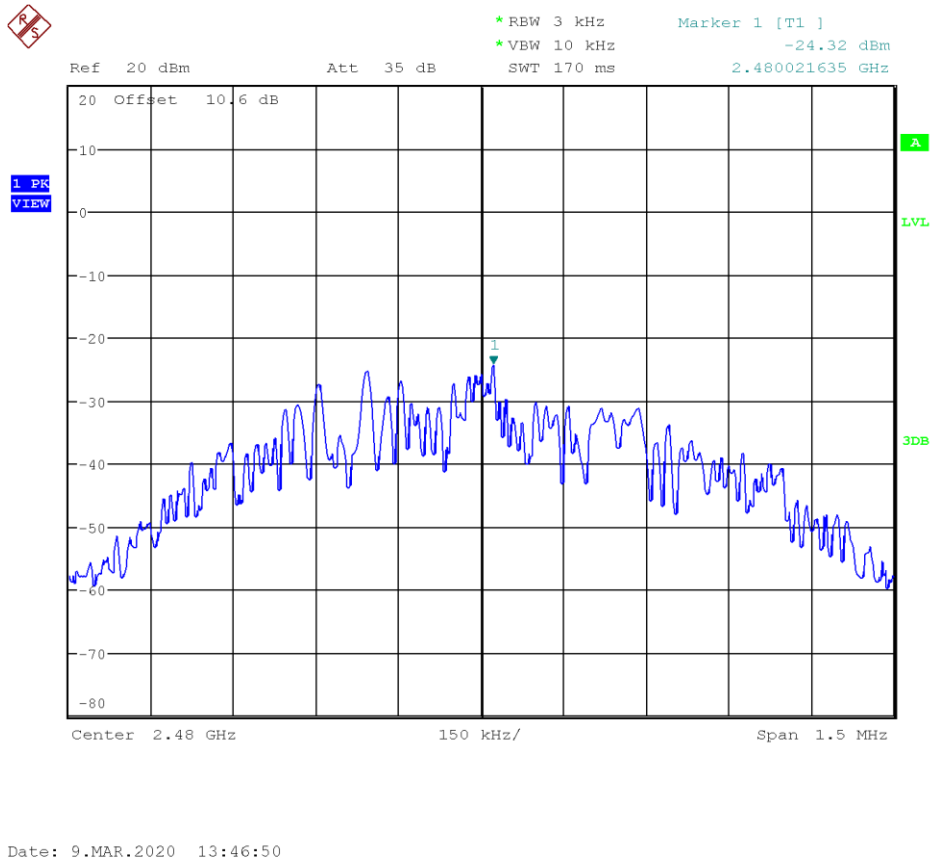
Peak Power Spectral Density				
Data Rate	**Freq. (MHz)**	**Total PSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
1Mbps	2402	-23.48	8	-31.48
	2440	-23.99	8	-31.99
	2480	-24.32	8	-32.32
	Note: None			



Plot 11. 1Mbps, 2402MHz PSD



Plot 12. 1 Mbps, 2440MHz PSD



Plot 13. 1Mbps, 2480MHz PSD

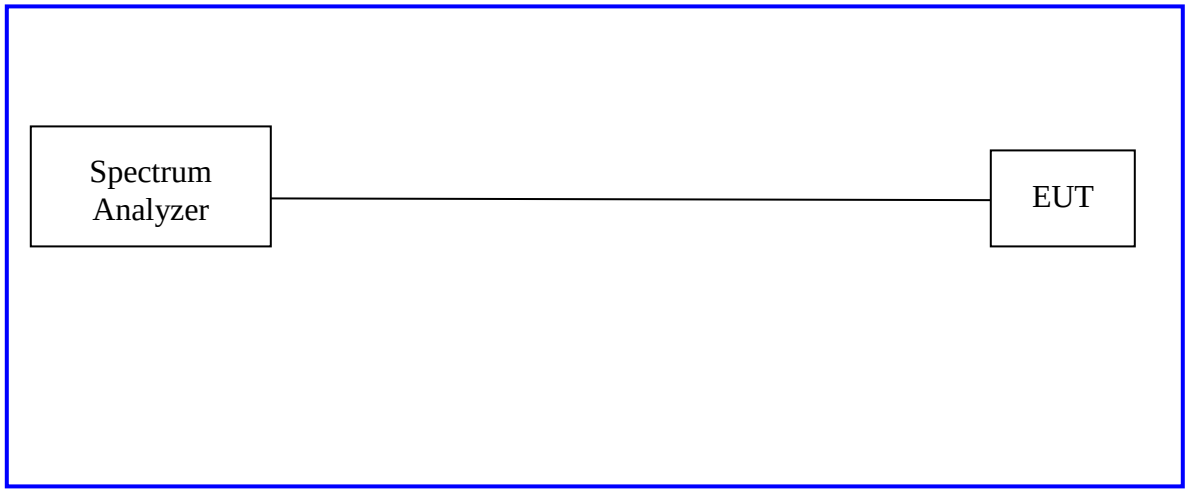
4.4 Out of Band Emissions: Non-Restricted Bands

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:

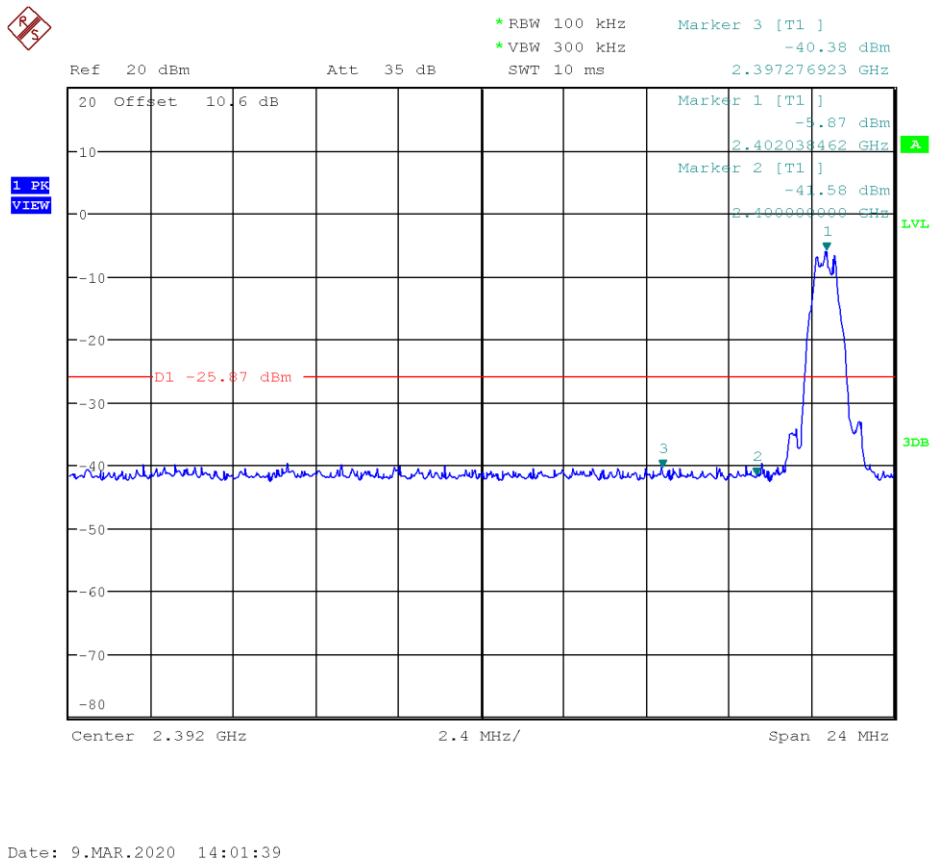


4.4.2 Results

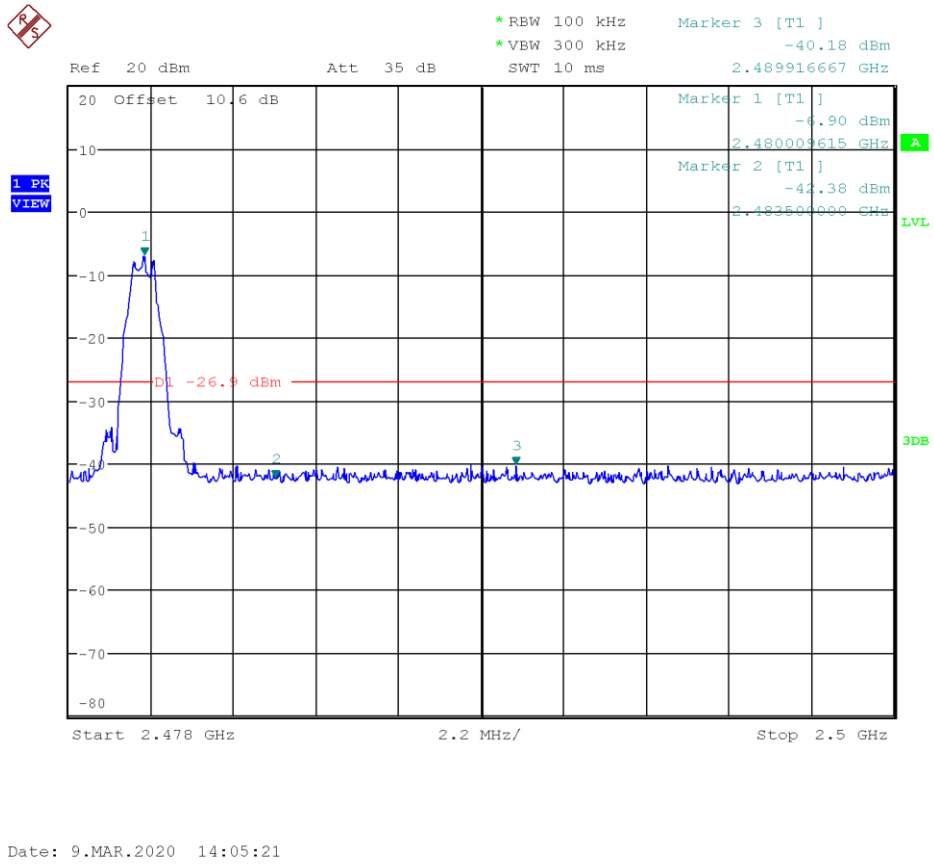
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

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

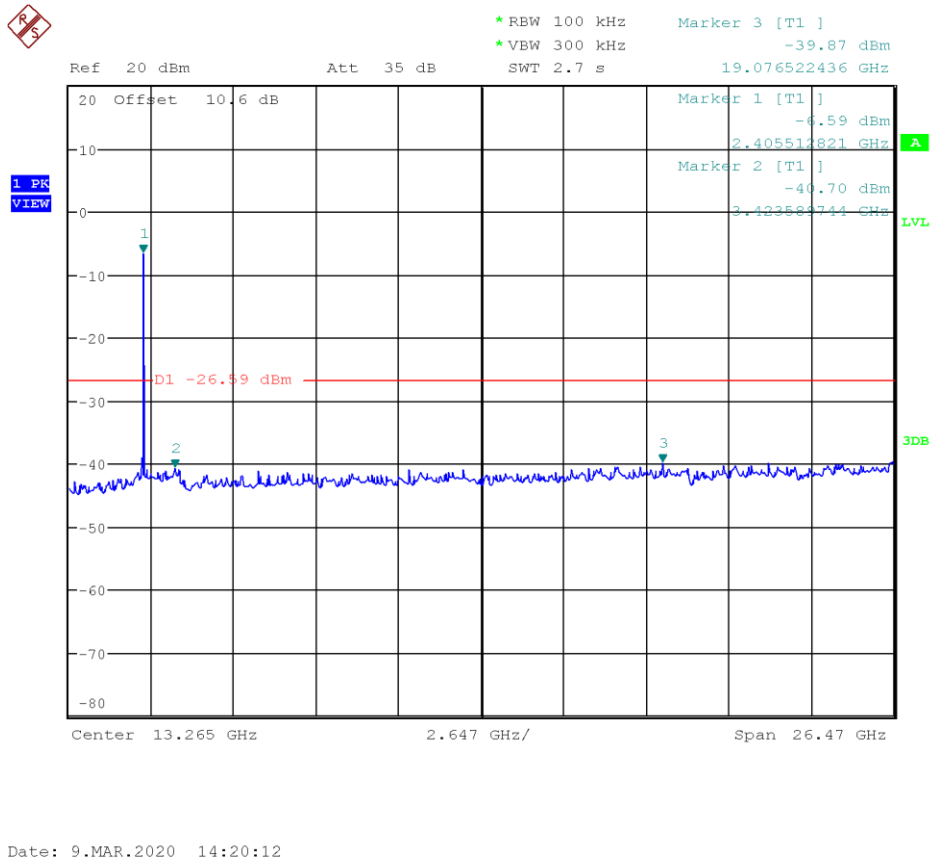
Non-Restricted Frequency Band Edge Emissions						
Data Rate	**Band Edge**	**Center Freq (MHz)**	**Measured (dBc)**	**Limit (dBc)**	**Freq (GHz)**	**Results**
1Mbps	Low	2402	35.71	20	2.400	Pass
	High	2480	35.58	20	2.4835	Pass
	Note:					



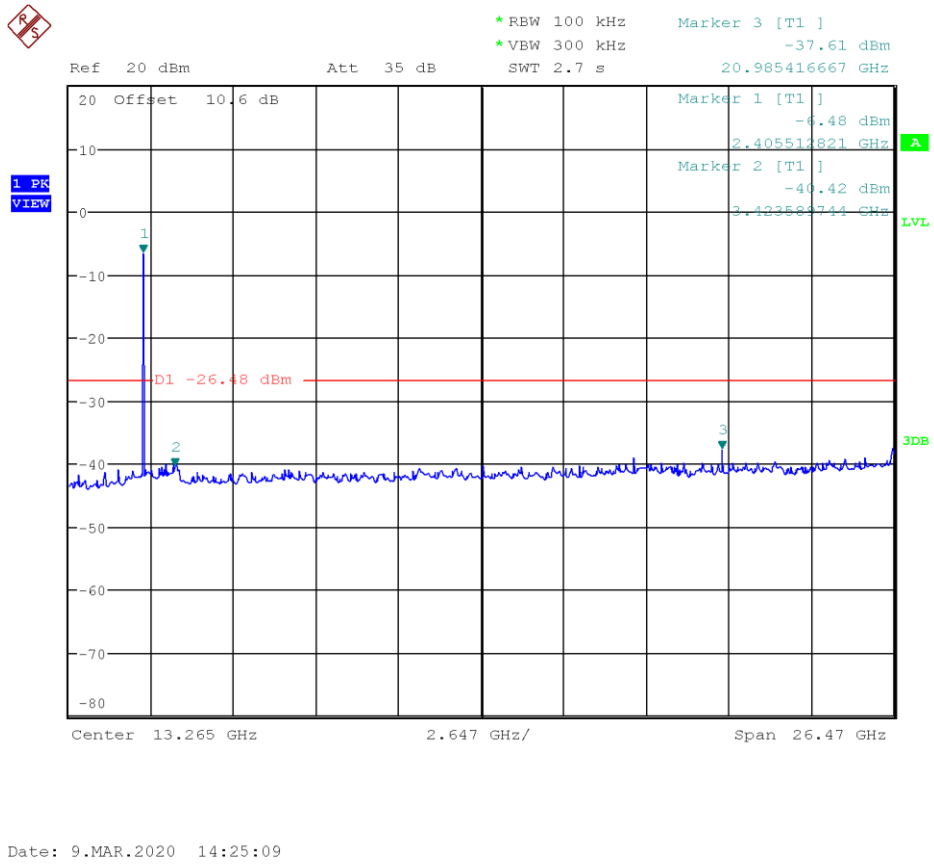
Plot 14. 1Mbps, 2402MHz Lower Band Edge



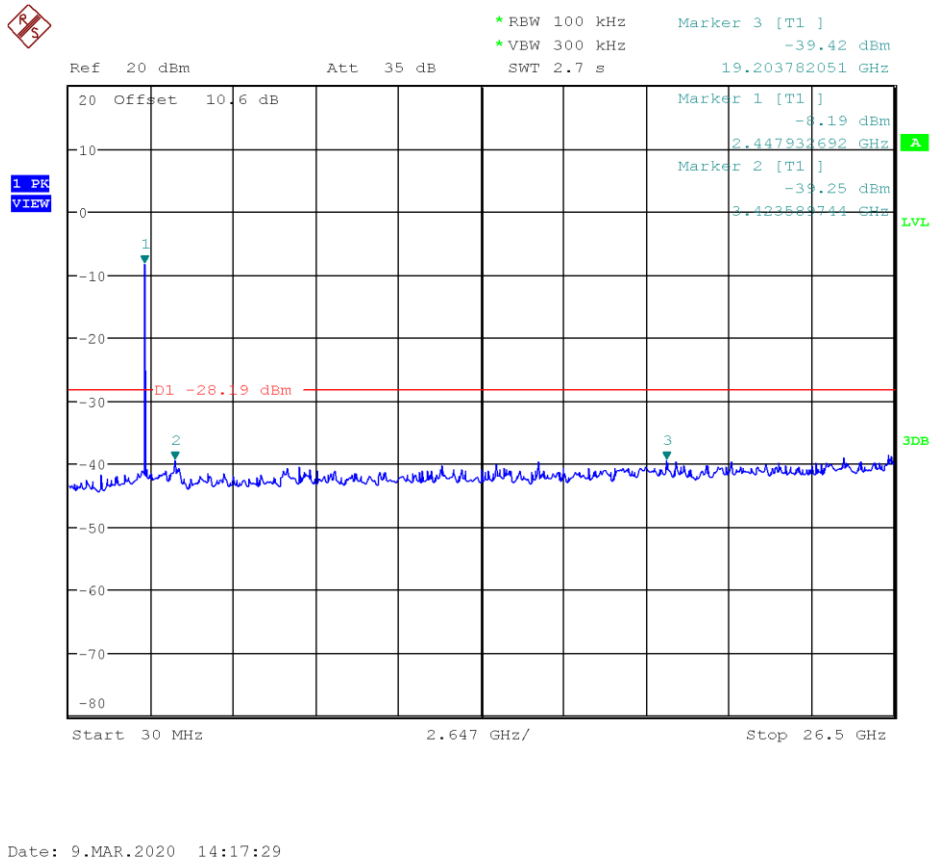
Plot 15. 1Mbps, 2480MHz Upper Band Edge



Plot 16. 1Mbps, 2402MHz 30MHz-26.5GHz Spurious



Plot 17. 1Mbps, 2440MHz 30MHz-26.5GHz Spurious



Plot 18. 1Mbps, 2480MHz 30MHz-26.5GHz Spurious

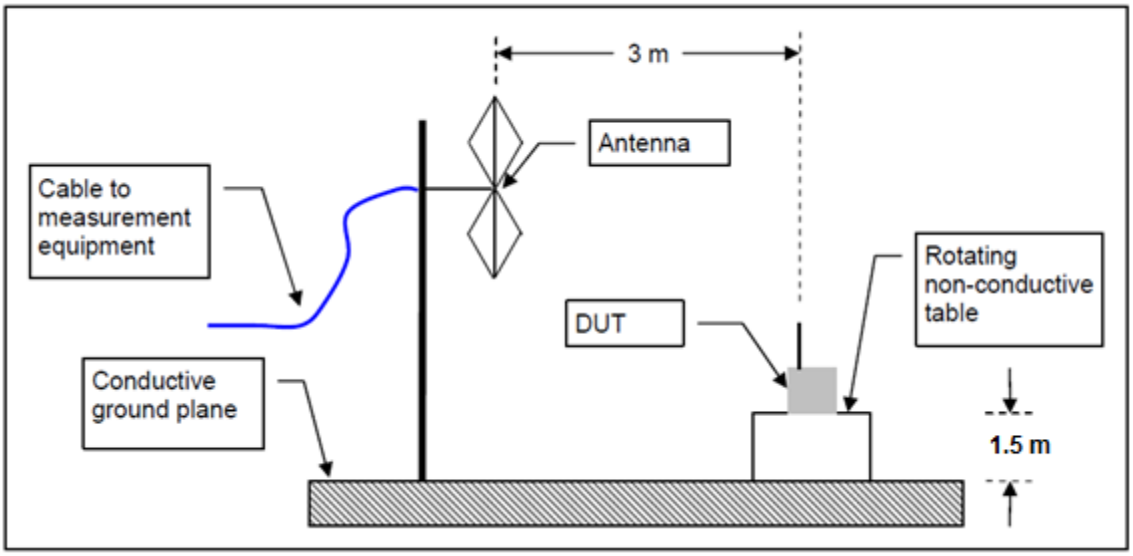
4.5 Out of Band Emissions: Restricted Band Edge

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

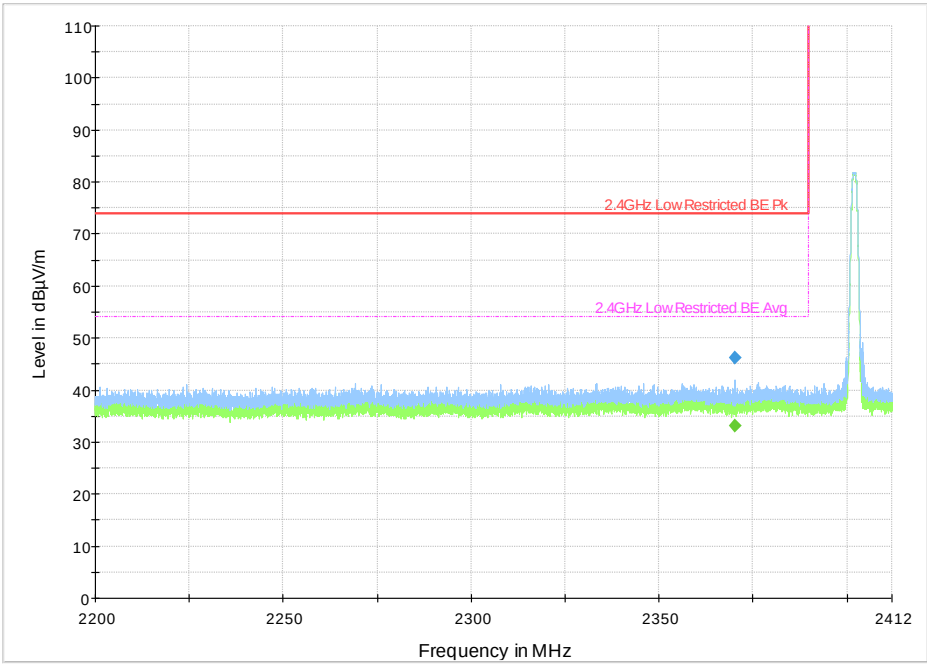


The DUT was stimulated by manufacturer provided test software that is not available to the end user.

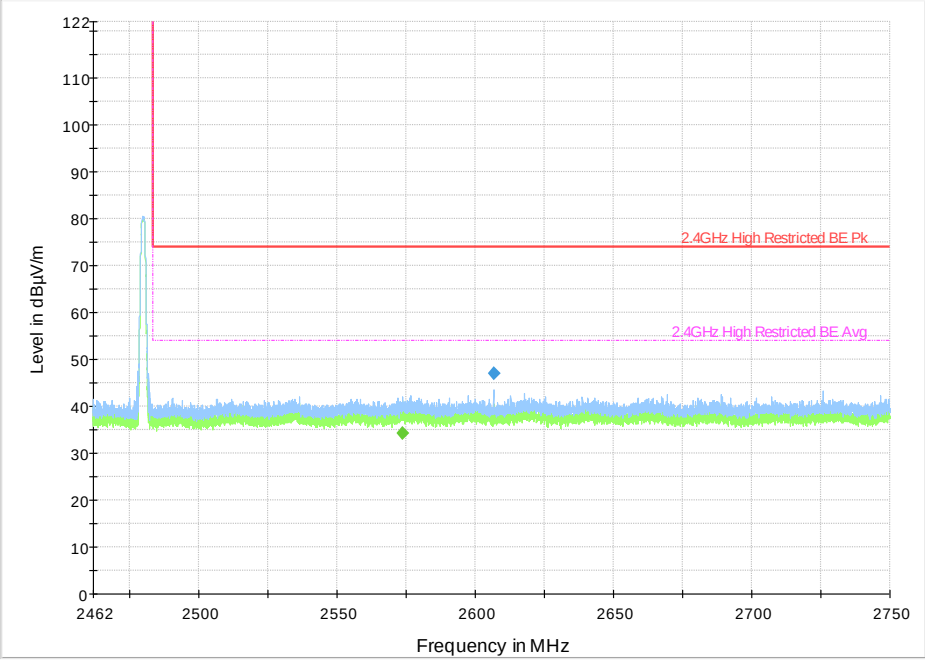
4.5.2 Test Results

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**
2370.278	BLE GFSK 1Mbps	2402	Average	33.05	54	-20.95	Pass
2370.278	BLE GFSK 1Mbps	2402	Peak	46.18	74	-27.82	Pass
Upper Restricted Band Edge							
Freq. (MHz)	**Mode**	**Center Freq (MHz)**	**Detector (Average/ Peak)**	**Measured (dBuV/m)**	**Limit (dBuV/m)**	**Margin**	**Results**
2573.772	BLE GFSK 1Mbps	2480	Average	34.21	54	-19.79	Pass
2606.691	BLE GFSK 1Mbps	2480	Peak	47.08	74	-26.92	Pass
Note:							



Plot 19. 1Mbps, 2402MHz, Lower Band Edge, Restricted



Plot 20. 1Mbps, 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.

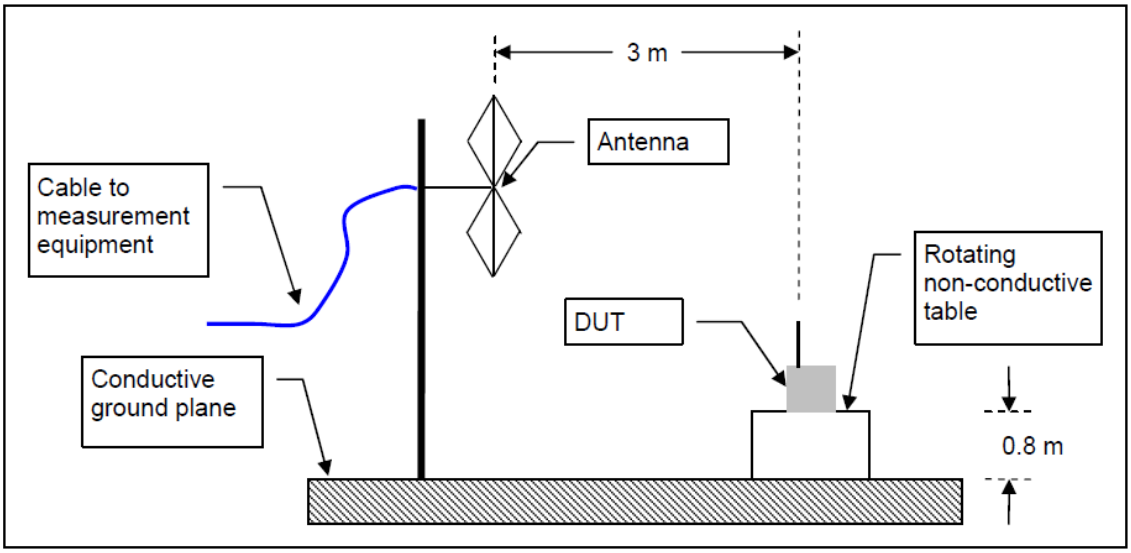
4.6.1.3 Deviations

None.

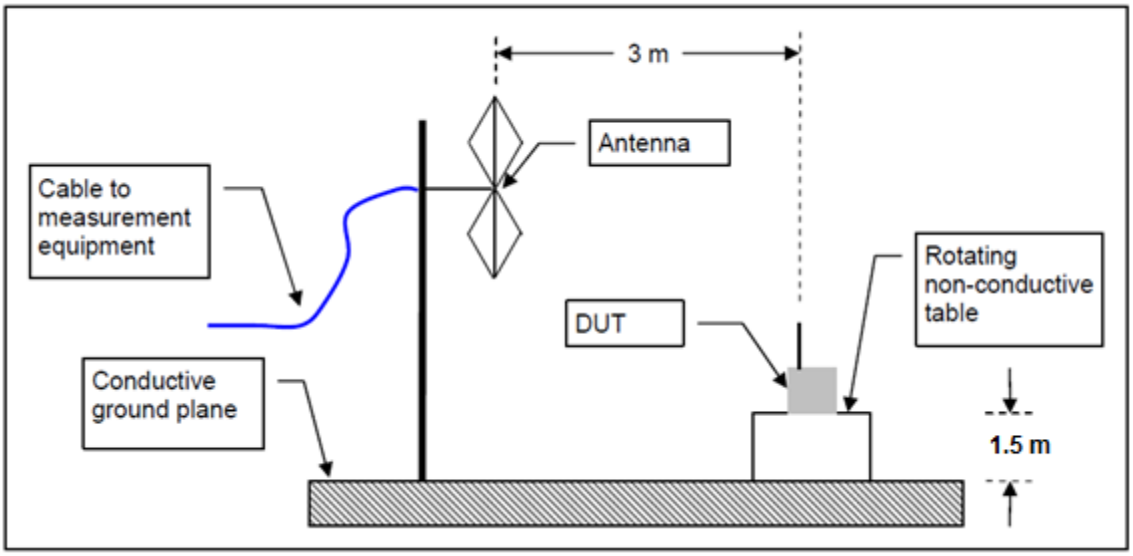
4.6.2 Test Setup:

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

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4.6.4 Test Results

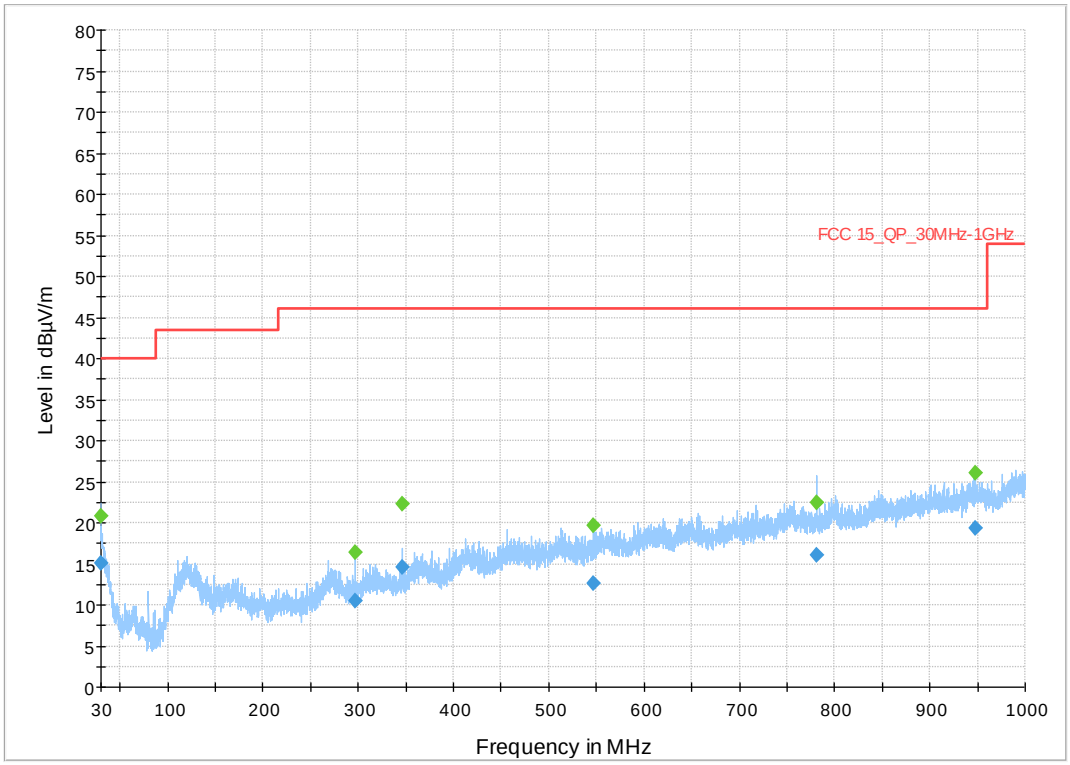
The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and test plan.

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

Worse case configurations/modes shown below, all plots taken using a peak detector in order to identify frequencies of interest. No emissions within 20dB of the applicable limit were observed below 30MHz or above 18GHz.

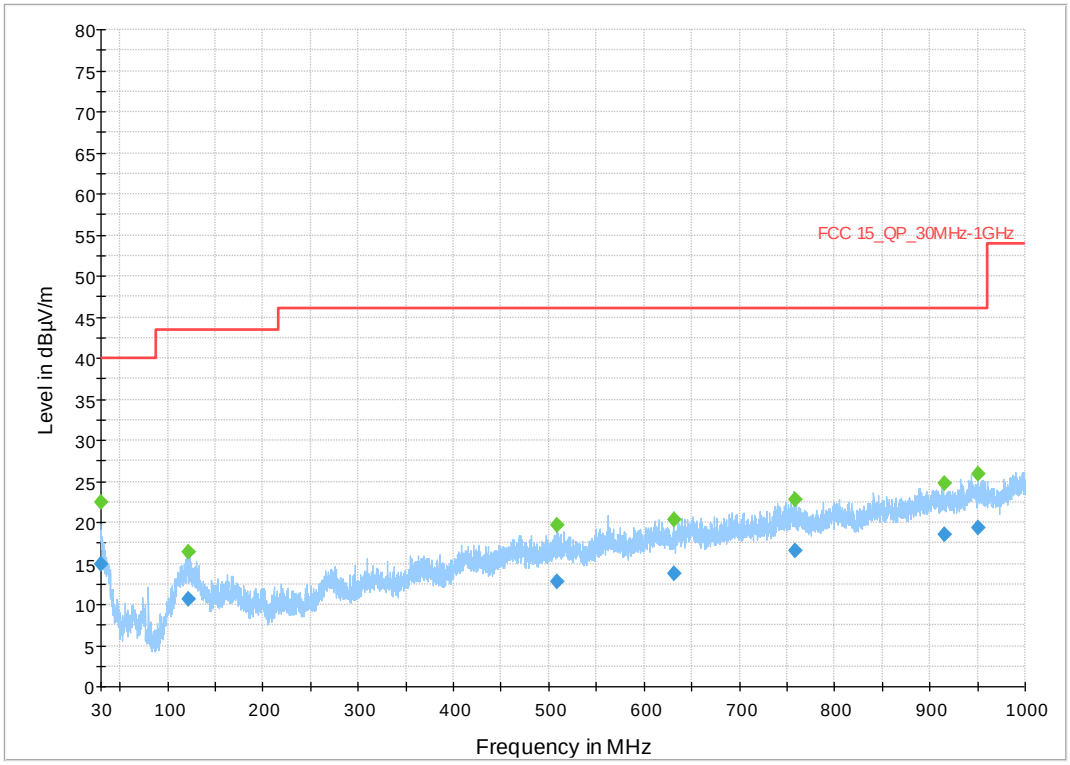
4.6.4.1 Plots

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.207960	15.13	40.00	24.87	1000.0	120.000	400.0	V	58.0
296.713360	10.47	46.00	35.53	1000.0	120.000	202.0	V	167.0
346.182040	14.59	46.00	31.41	1000.0	120.000	103.0	V	-104.0
546.633800	12.67	46.00	33.33	1000.0	120.000	202.0	V	152.0
781.766320	16.02	46.00	29.98	1000.0	120.000	301.0	V	-143.0
948.239520	19.41	46.00	26.59	1000.0	120.000	400.0	V	98.0



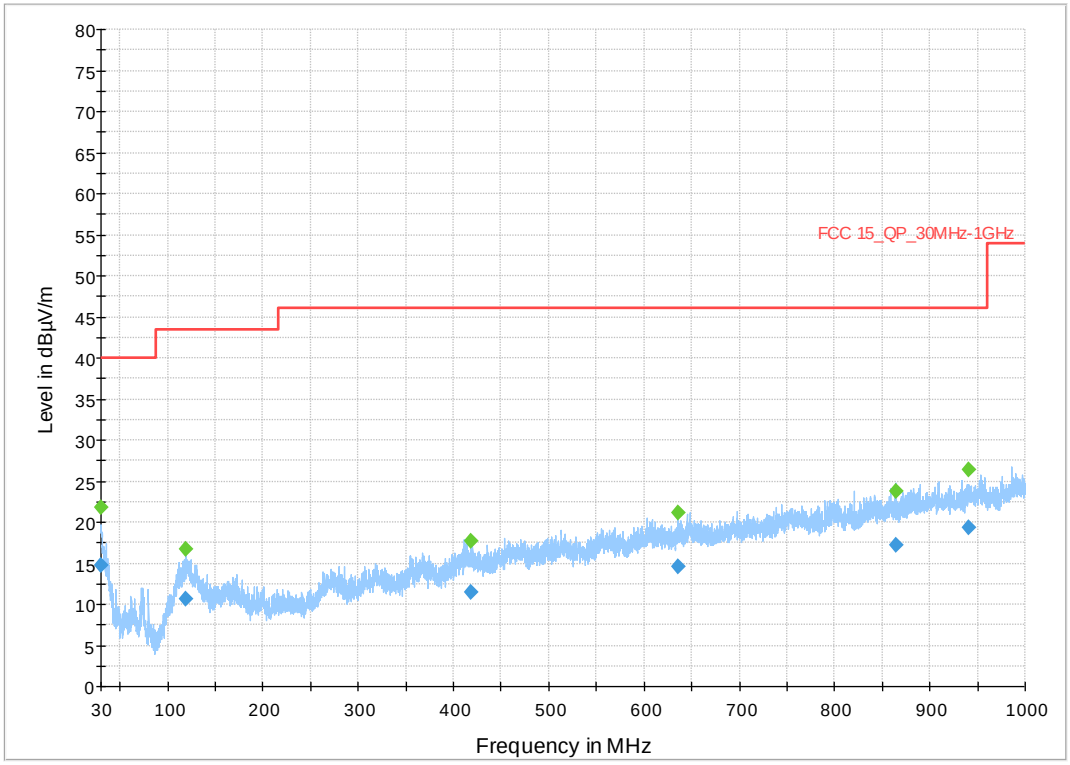
Plot 21. 30MHz-1000MHz, 1Mbps, 2402MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.379895	14.95	40.00	25.05	1000.0	120.000	103.0	V	-160.0
122.100200	10.67	43.52	32.85	1000.0	120.000	301.0	H	127.0
509.214800	12.79	46.00	33.21	1000.0	120.000	202.0	V	-48.0
631.119680	13.82	46.00	32.18	1000.0	120.000	202.0	V	-119.0
758.073240	16.55	46.00	29.45	1000.0	120.000	202.0	V	103.0
914.703920	18.51	46.00	27.49	1000.0	120.000	400.0	V	147.0
950.437080	19.40	46.00	26.60	1000.0	120.000	301.0	H	-49.0



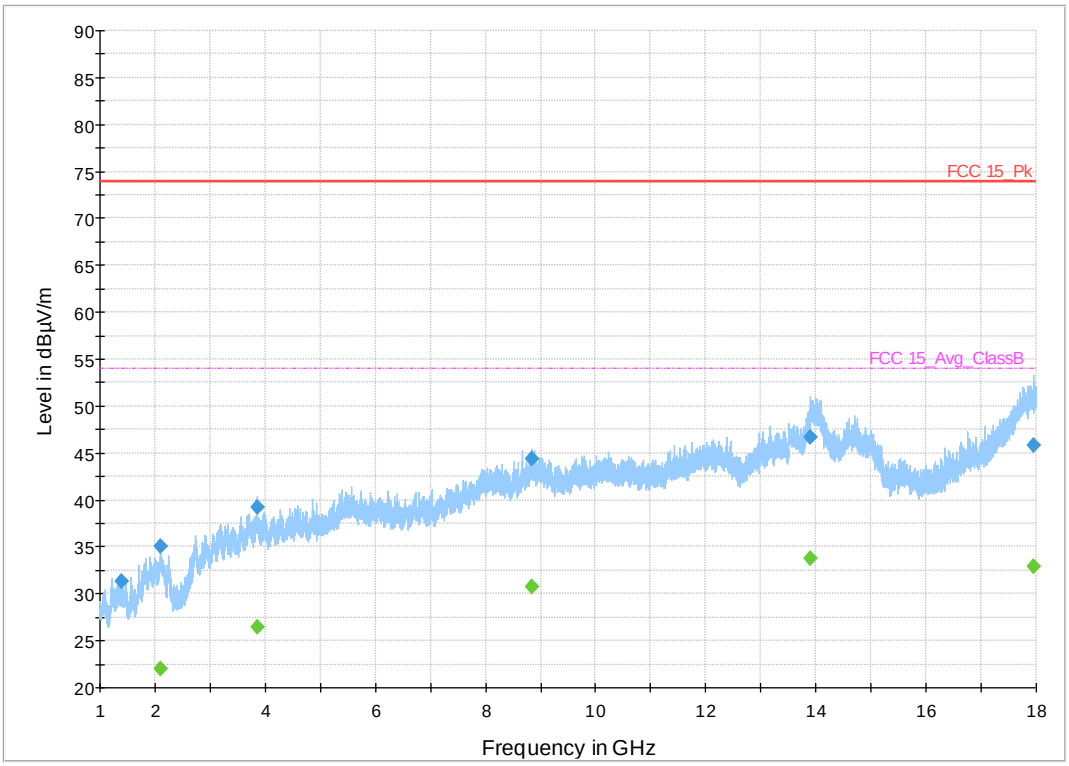
Plot 22. 30MHz-1000MHz, 1Mbps, 2440MHz

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.547720	14.75	40.00	25.25	1000.0	120.000	400.0	H	-75.0
119.117800	10.73	43.52	32.79	1000.0	120.000	400.0	H	119.0
418.334280	11.45	46.00	34.55	1000.0	120.000	400.0	H	67.0
635.841600	14.59	46.00	31.41	1000.0	120.000	103.0	V	-159.0
864.805080	17.27	46.00	28.73	1000.0	120.000	400.0	H	-175.0
941.155360	19.36	46.00	26.64	1000.0	120.000	301.0	V	-91.0



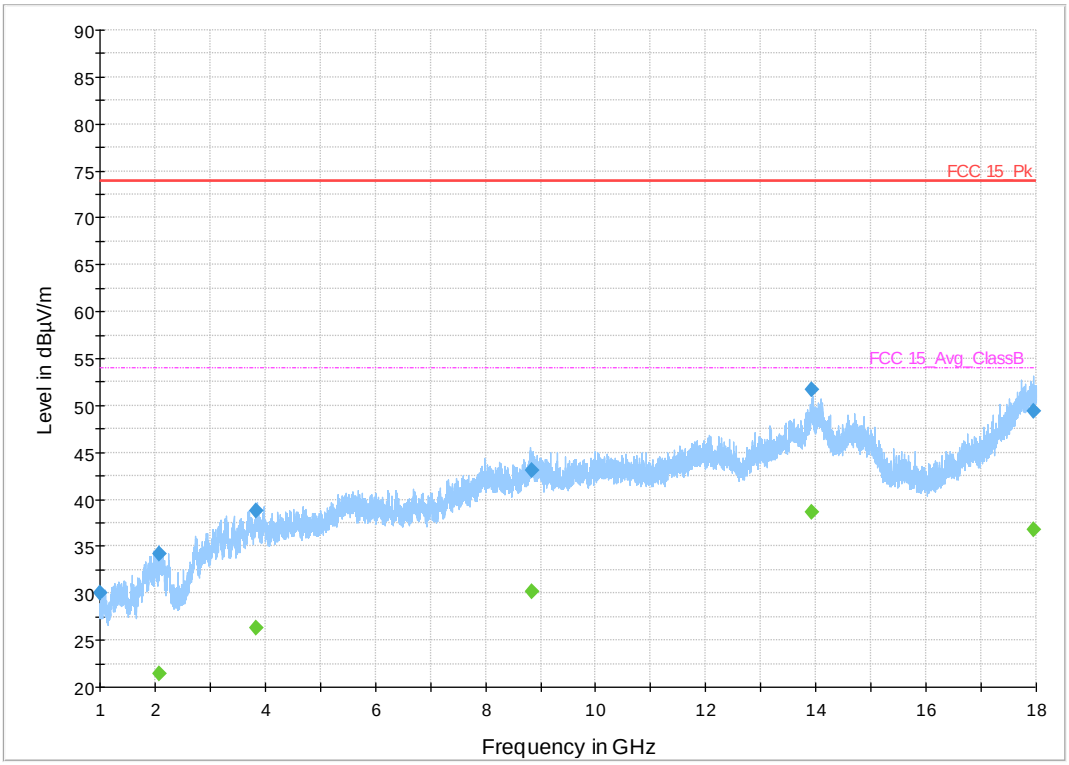
Plot 23. 30-1000MHz, 1Mbps, 2480MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1400.076000	---	18.39	54.00	35.61	1000.0	1000.000	200.0	V	-180.0
1400.076000	31.27	---	74.00	42.73	1000.0	1000.000	200.0	V	-180.0
2096.678500	---	22.01	54.00	31.99	1000.0	1000.000	101.0	H	180.0
2096.678500	35.00	---	74.00	39.00	1000.0	1000.000	101.0	H	180.0
3855.137500	39.26	---	74.00	34.74	1000.0	1000.000	101.0	H	-57.0
3855.137500	---	26.40	54.00	27.60	1000.0	1000.000	101.0	H	-57.0
8850.382500	---	30.71	54.00	23.29	1000.0	1000.000	202.0	H	-62.0
8850.382500	44.40	---	74.00	29.60	1000.0	1000.000	202.0	H	-62.0
13902.475500	46.64	---	74.00	27.36	1000.0	1000.000	202.0	H	180.0
13902.475500	---	33.82	54.00	20.18	1000.0	1000.000	202.0	H	180.0
17942.907000	---	32.93	54.00	21.07	1000.0	1000.000	202.0	V	-26.0
17942.907000	45.75	---	74.00	28.25	1000.0	1000.000	202.0	V	-26.0



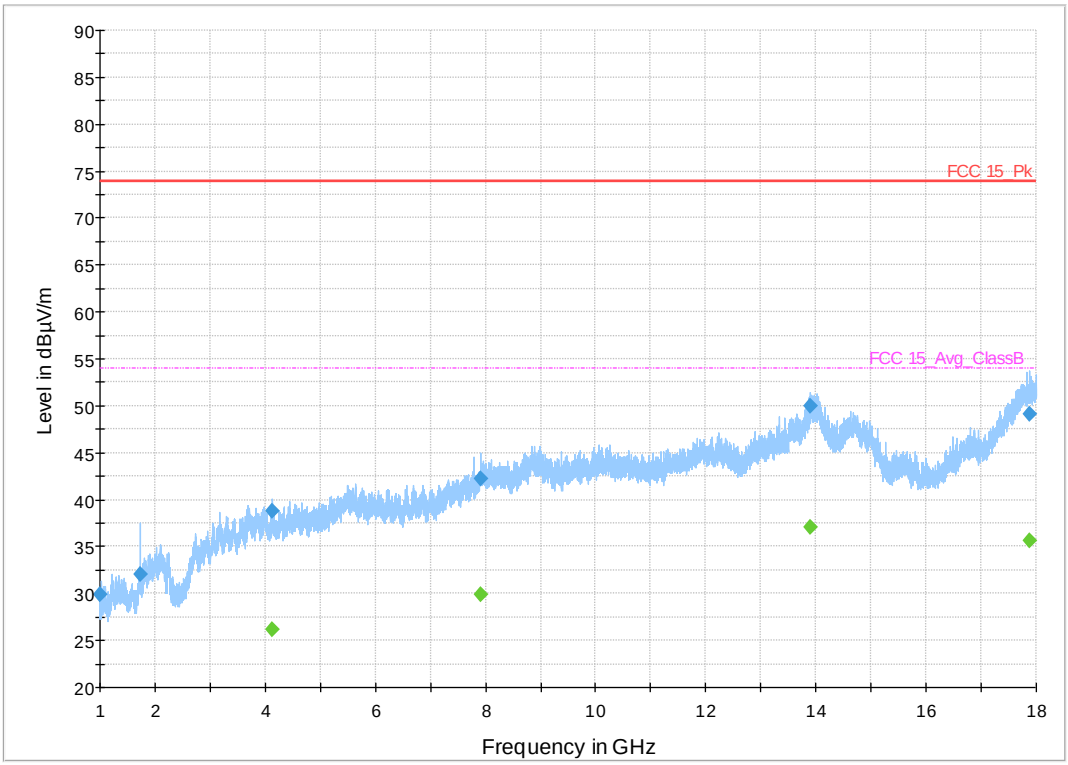
Plot 24. 1-18GHz, 1Mbps, 2402MHz

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
1004.097000	29.99	---	74.00	44.01	1000.0	1000.000	150.0	H	180.0
1004.097000	---	16.76	54.00	37.24	1000.0	1000.000	150.0	H	180.0
2082.509000	34.18	---	74.00	39.82	1000.0	1000.000	150.0	H	-133.0
2082.509000	---	21.50	54.00	32.50	1000.0	1000.000	150.0	H	-133.0
3845.416500	---	26.30	54.00	27.70	1000.0	1000.000	101.0	V	-134.0
3845.416500	38.82	---	74.00	35.18	1000.0	1000.000	101.0	V	-134.0
8831.488000	---	30.18	54.00	23.82	1000.0	1000.000	201.0	V	180.0
8831.488000	43.06	---	74.00	30.94	1000.0	1000.000	201.0	V	180.0
13932.752500	---	38.70	54.00	15.30	1000.0	1000.000	101.0	H	-82.0
13932.752500	51.76	---	74.00	22.24	1000.0	1000.000	101.0	H	-82.0
17948.896500	---	36.81	54.00	17.19	1000.0	1000.000	101.0	H	180.0
17948.896500	49.47	---	74.00	24.53	1000.0	1000.000	101.0	H	180.0



Plot 25. 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)
1001.747750	29.90	---	74.00	44.10	1000.0	1000.000	102.0	H	180.0
1001.747750	---	16.92	54.00	37.08	1000.0	1000.000	102.0	H	180.0
1733.450000	---	19.62	54.00	34.38	1000.0	1000.000	101.0	H	-97.0
1733.450000	32.09	---	74.00	41.91	1000.0	1000.000	101.0	H	-97.0
4136.875000	---	26.10	54.00	27.90	1000.0	1000.000	150.0	H	-180.0
4136.875000	38.78	---	74.00	35.22	1000.0	1000.000	150.0	H	-180.0
7900.612500	42.21	---	74.00	31.79	1000.0	1000.000	101.0	H	133.0
7900.612500	---	29.97	54.00	24.03	1000.0	1000.000	101.0	H	133.0
13897.427000	---	37.00	54.00	17.00	1000.0	1000.000	150.0	H	180.0
13897.427000	49.93	---	74.00	24.07	1000.0	1000.000	150.0	H	180.0
17874.554500	---	35.60	54.00	18.40	1000.0	1000.000	200.0	V	104.0
17874.554500	49.09	---	74.00	24.91	1000.0	1000.000	200.0	V	104.0



Plot 26. 1-18GHz, 1Mbps, 2480MHz

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	11/20/2019	11/20/2021
EMI Receiver	Rohde & Schwarz	ESW44	101663-dv	07/18/2019	07/18/2021
L.I.S.N.	Com-Power	LI-215	192000	01/16/2019	01/16/2021
Transient Limiter	Com-Power	LIT-930	531582	01/16/2019	01/16/2021
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
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	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 7: Customer Information

Company Name	Colgate-Palmolive Company
Address	909 River Road
City, State, Zip	Piscataway, NJ 08855-1343
Country	USA

Table 8: Technical Contact Information

Name	Dan Roman
E-mail	Dan_Roman@colpal.com

6.3 Equipment Under Test (EUT)

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

Table 9: EUT Designation

Product Name	Plaqless
Model Number	ADVBTB-C

6.4 Product Specifications

Table 10: EUT Specifications

EUT Specifications	
Environment	Indoor/Outdoor
Operating Temperature Range:	0-40°C
Multiple Feeds:	☐ Yes and how many ☒ No
Product Marketing Name (PMN)	Plaqless
Hardware Version Identification Number (HVIN)	1.0
Firmware Version Identification Number (FVIN)	1.4.13
RF Software Version	4.2
Operating Modes	BT Low Energy, 1Mbps
Transmitter Frequency Band	2.4 GHz – 2.4835 GHz
Power Setting @ Operating Channel	See section 4.1.2.
Modulation	GFSK
TX/RX Chain (s)	SISO
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 11: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
Antenna 0	Chip	Bluetooth Low Energy	2.0

Table 12: Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
None	N/A	☐ N/A	☐ N/A	☐ N/A

Table 13: Accessory Equipment

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

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

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

Table 15: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.247
ADVBTB-C	N/A	Integrated Antenna	Radiated Emissions
		Direct via SMA Connection	Transmit Power, PSD, Occupied Bandwidth, Out of Band Emission

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

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

6.5 Test Specifications

Table 17: Test Specifications

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

END OF REPORT