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Emissions
Test Report

EUT Name: Smart Sensor

Model No.: SU-5S

CFR 47 Part 15.247 and RSS 247

Prepared for:

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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	05/10/2017	Original Document	N/A

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Enlighted, Inc. 930 Benecia Ave Sunnyvale, CA 94085 (408) 385-9479
Requester / Applicant:	Stewart Kuan
Name of Equipment:	Smart Sensor
Model No.	SU-5S
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247 and RSS 247
Test Dates:	21 March 2017 to 22 April 2017

Guidance Documents:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v03r05

Test Methods:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v03r05

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 contains data that are not covered by A2LA accreditation. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.

Eddie Mariscal		David Spencer	
Test Engineer	Date May 10, 2017	A2LA Signatory	Date May 10, 2017

Testing Cert #3331.02 **US1131** **2932M-1**

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 and RSS 247 based on the results of testing performed on 21 March 2017 to 22 April 2017 on the Smart Sensor Model SU-5S manufactured by Enlighted, Inc. 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 2400 MHz to 2483.5 MHz frequency band is covered in this document.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C63.4	Test Parameters (Measured)	Result
Spurious Emission in Transmit Mode	CFR47 15.209, RSS-GEN Sect.8.9	Class B	**Complied**
Restricted Bands of Operation	CFR47 15.205, RSS GEN Sect.8.10	Class B	**Complied**
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.8.8	Class B	**Complied**
Occupied Bandwidth	CFR47 15.247 (a2), RSS 247 Sect. 5.2.1	See plots	**Complied**
Maximum Output Power	CFR47 15.247 (b), RSS 247 Sect. 5.4.4	BLE: 3.23dBm 802.15.4: 3.47dBm	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 247 Sect. 5.2.2	BLE: -5.18dBm/3kHz 802.15.4: -9.51dBm/3kHz	**Complied**
Out of Band Emission	CFR47 15.247 (d), RSS 247 Sect.5.5	9kHz - 25 GHz < -19.53 dBm/100kHz	**Complied**
RF Exposure	CFR47 15.247 (i), 2.1093 RSS-102 Issue 5	General Population	**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 at 1279 Quarry Ln, Pleasanton, CA 94566 is 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 (US1131). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 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 17025:1999 and ISO 9002 (Lab Code Testing Cert #3331.02). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

TUV Rheinland of North America at the 1279 Quarry Ln, Pleasanton, CA 94566 address is accredited by Industry Canada for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by Industry Canada (File Number 2932M). This reference number is the indication to the Industry Canada Certification Officers that the site meets the requirements of RSS 212, Issue 1 (Provisional). The accreditation is updated every 3 years.

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 at 1279 Quarry Ln, Pleasanton, CA 94566 has been assessed and approved in accordance with the Regulations for Voluntary Control Measures.

VCCI Registration No. for Pleasanton: A-0261

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

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Lab Code Testing Cert #3331.02). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 meter and 5 meters. A report detailing this site can be obtained from TUV Rheinland of North America.

2.2.2 Immunity Test Facility

ESD, EFT, Surge, PQF: These tests are performed in an environmentally controlled room with a 3.7 m x 4.8 m x 3.175 mm thick aluminum floor connected to PE ground.

For ESD testing, tabletop equipment is placed on an insulated mat with a surface resistivity of 10^9 Ohms/square on a 1.6 m x 0.8 m x 0.8 m high non-conductive table with a 3.175 mm aluminum top (Horizontal Coupling Plane). The HCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors. The Vertical Coupling Plane consists of an aluminum plate 50 cm x 50 cm x 3.175 mm thick. The VCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors.

For EFT, Surge, PQF, the HCP and VCP are removed.

RF Field Immunity testing is performed in a 7.3m x 4.3m x 4.1m anechoic chamber.

RF Conducted and Magnetic Field Immunity testing is performed on a 4.8m x 3.7m x 3.175mm thick aluminum ground plane.

All test areas allow a minimum distance of 1 meter from the EUT to walls or conducting objects.

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.

2.3.1 Sample Calculation – radiated & conducted emissions

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

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

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

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

Sample radiated emissions calculation @ 30 MHz

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

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

2.3.2 Measurement Uncertainty

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

Voltech PM6000A

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

2.3.3 Measurement Uncertainty Immunity

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

Thermo KeyTek EMC Pro

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

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

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The Model SU-5S, Smart Sensor, is a wireless-capable sensor that simultaneously monitors temperature, light, IR and power.

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..

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

3.4 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 Smart Sensor employs a single integral antenna inaccessible to the end user. The antenna has a declared maximum gain of 0dBi.

Refer to Table 13 for additional antenna information.

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.247: 2015 and RSS 247: 2015. 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):2015 and RSS 247: 2015 Sect. 5.4.4.

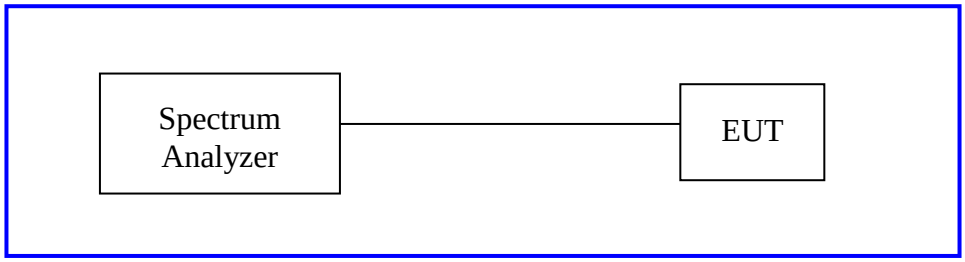
The maximum transmitted powers are:

Band 2400-2483.5 MHz: 1 W

4.1.1 Test Method

The ANSI C63.10-2013 Section 11.9.2.2.2 conducted method was used to measure the channel power output. The measurements were conducted on 3 channels in each operating range per CFR47 Part 15.247(b): 2015 and RSS 247 Sect. 5.4.4; 2400 MHz to 2483.5 MHz

Test Setup:



The method described in section 9.1.1 of "KDB 558074 – DTS Measurement Guidance v03r05" applies and was used.

4.1.2 Results

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

Table 2: RF Output Power at the Antenna Port – Test Results – BLE 4.0

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: Custom Integrated			**Power Setting:** See test plan	
Max. Directional Gain: +0 dBi				
Signal State: Modulated				
Ambient Temp.: 24° C			**Relative Humidity:**39%	
RF Output Power – BLE 4.0				
Voltage	**Operating Channel (MHz)**	**Measured Power [dBm]**	**Limit [dBm]**	**Margin [dB]**
15.0VDC	2402	3.239	30.0	-26.761
	2442	3.087	30.0	-26.913
	2480	2.493	30.0	-27.507
12.75VDC	2402	3.19	30.0	-26.81
	2442	2.992	30.0	-27.008
	2480	2.387	30.0	-27.613
17.25VDC	2402	3.19	30.0	-26.81
	2442	3.002	30.0	-26.998
	2480	2.387	30.0	-27.613
Note: All insertion loss corrections are accounted for in the measurement plots.				

Table 3: RF Output Power at the Antenna Port – Test Results – IEEE 802.15.4

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: Custom Integrated			**Power Setting:** See test plan	
Max. Directional Gain: +0 dBi				
Signal State: Modulated				
Ambient Temp.: 24° C			**Relative Humidity:**39%	
RF Output Power – IEEE 802.15.4				
Voltage	**Operating Channel (MHz)**	**Measured Power [dBm]**	**Limit [dBm]**	**Margin [dB]**
15.0VDC	2405	3.28	30.0	-26.72
	2440	3.465	30.0	-26.535
	2480	3.226	30.0	-26.774
12.75VDC	2405	3.278	30.0	-26.722
	2440	3.471	30.0	-26.529
	2480	3.212	30.0	-26.788
17.25VDC	2405	3.281	30.0	-26.719
	2440	3.469	30.0	-26.531
	2480	3.212	30.0	-26.788
Note: All insertion loss corrections are accounted for in the measurement plots.				

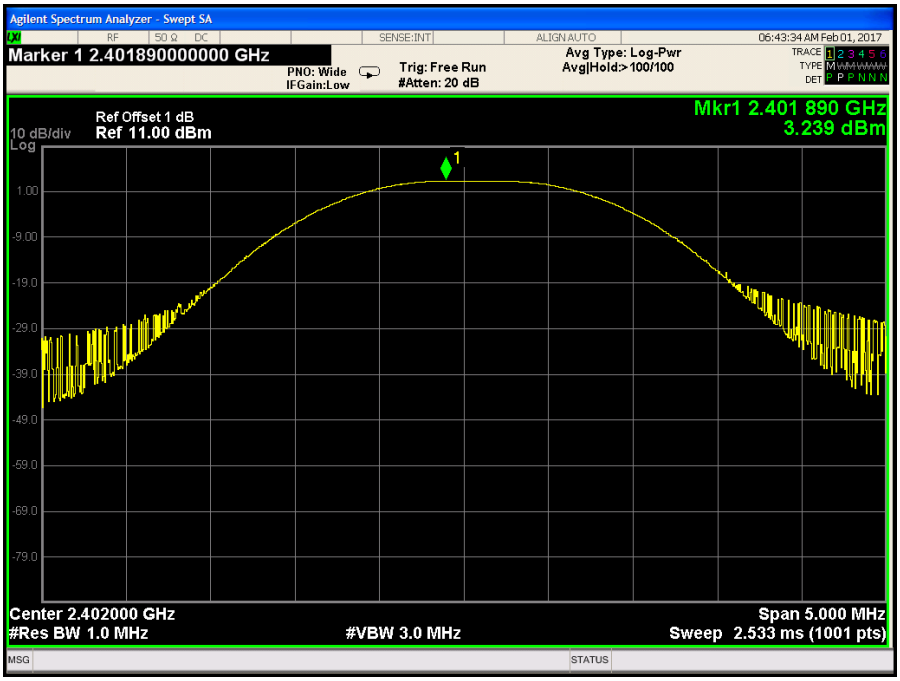


Figure 1 : Maximum peak conducted output power – BLE – 2402MHz

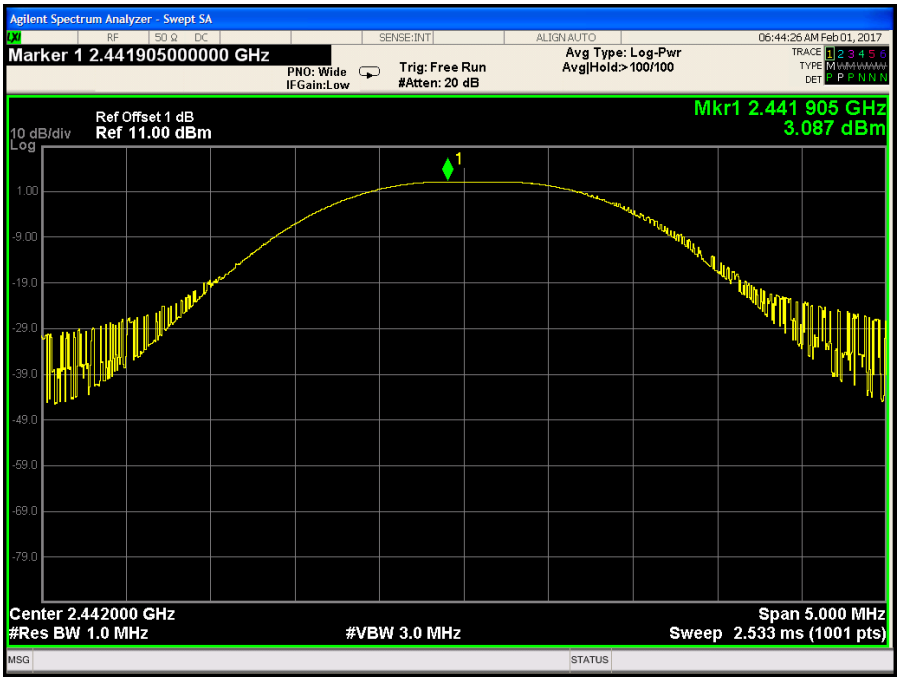


Figure 2 : Maximum peak conducted output power – BLE – 2442MHz

Figure 3 : Maximum peak conducted output power – BLE – 2480MHz

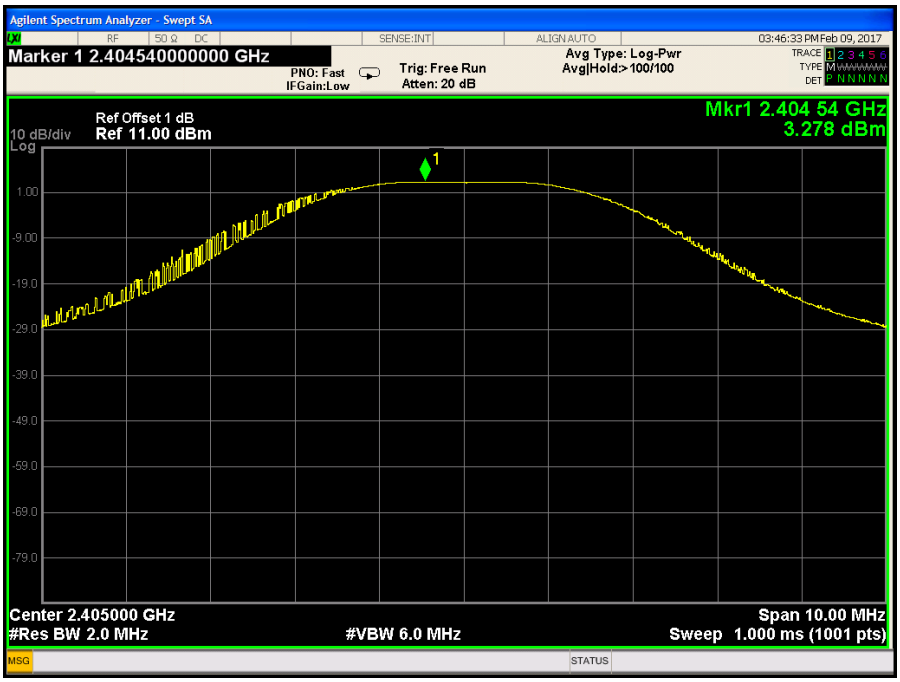


Figure 4 : Maximum peak conducted output power – IEEE 802.15.4 – 2405MHz

Figure 5 : Maximum peak conducted output power – IEEE 802.15.4 – 2440MHz

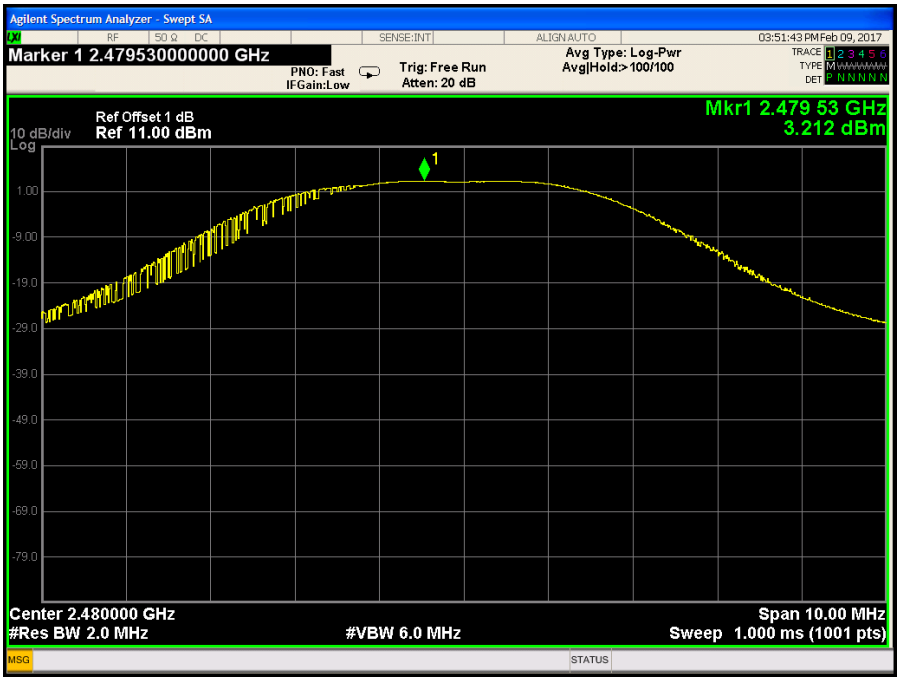


Figure 6 : Maximum peak conducted output power – IEEE 802.15.4 – 2480MHz

4.2 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.

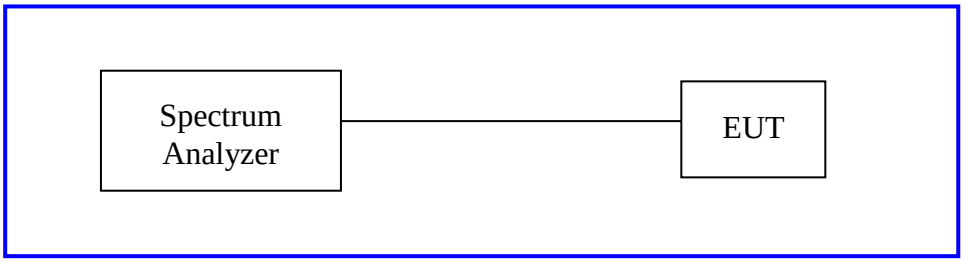
The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

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) 2015 and RSS 247 Sect. 5.2.1:2015. Measurements were performed on 3 channels in each operating frequency range; 2400 MHz to 2483.5 MHz, a 6 dB bandwidth was used.

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 4: Occupied Bandwidth – Test Results – BLE 4.0

Test Conditions: Conducted Measurement, Normal Temperature		
Antenna Type: Custom Integrated		**Power Setting:** See test plan
Max. Directional Gain: +0 dBi		
Signal State: Modulated		
Ambient Temp.: 24° C		**Relative Humidity:**39%
Bandwidth for BLE 4.0		
Freq. (MHz)	**6dB Bandwidth (kHz)**	**99% Bandwidth (MHz)**
2402	500.9	1.0023
2442	500.4	1.0083
2480	500.4	1.0069

Table 5: Occupied Bandwidth – Test Results – IEEE 802.15.4

Test Conditions: Conducted Measurement, Normal Temperature		
Antenna Type: Custom Integrated		**Power Setting:** See test plan
Max. Directional Gain: +0 dBi		
Signal State: Modulated		
Ambient Temp.: 24° C		**Relative Humidity:**39%
Bandwidth for IEEE 802.15.4		
Freq. (MHz)	**6dB Bandwidth (kHz)**	**99% Bandwidth (MHz)**
2405	1.592	2.5313
2440	1.552	2.5553
2480	1.666	2.6769

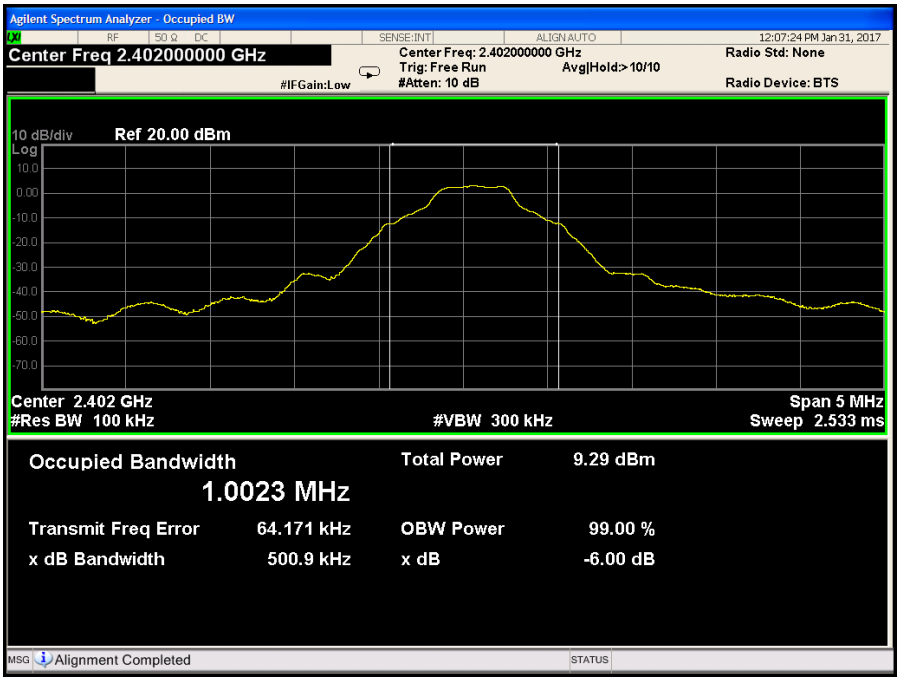


Figure 7 : 6dB & 99% Occupied Bandwidth – BLE – 2402MHz

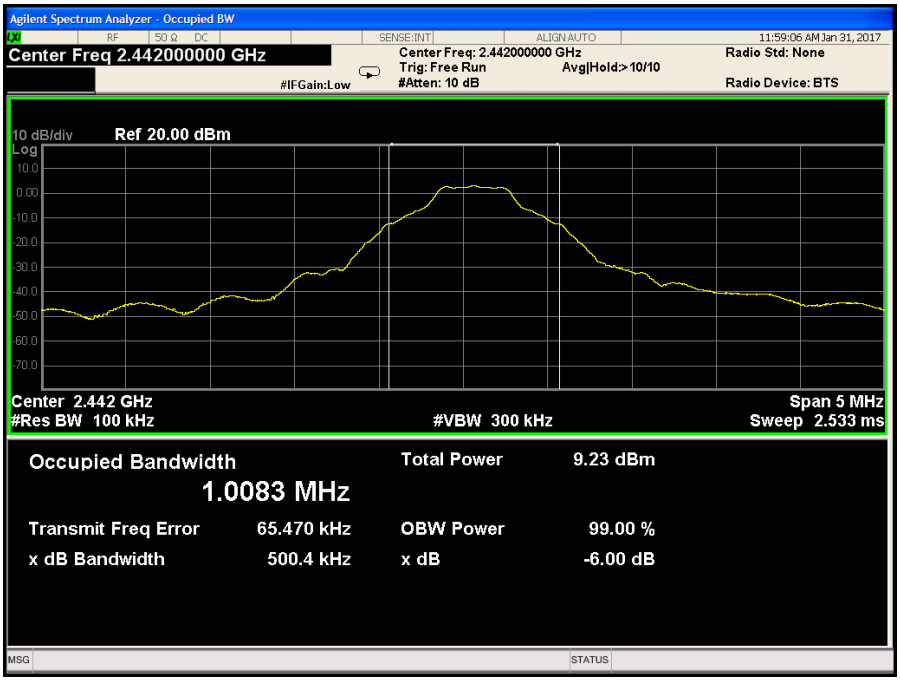


Figure 8 : 6dB & 99% Occupied Bandwidth – BLE – 2442MHz

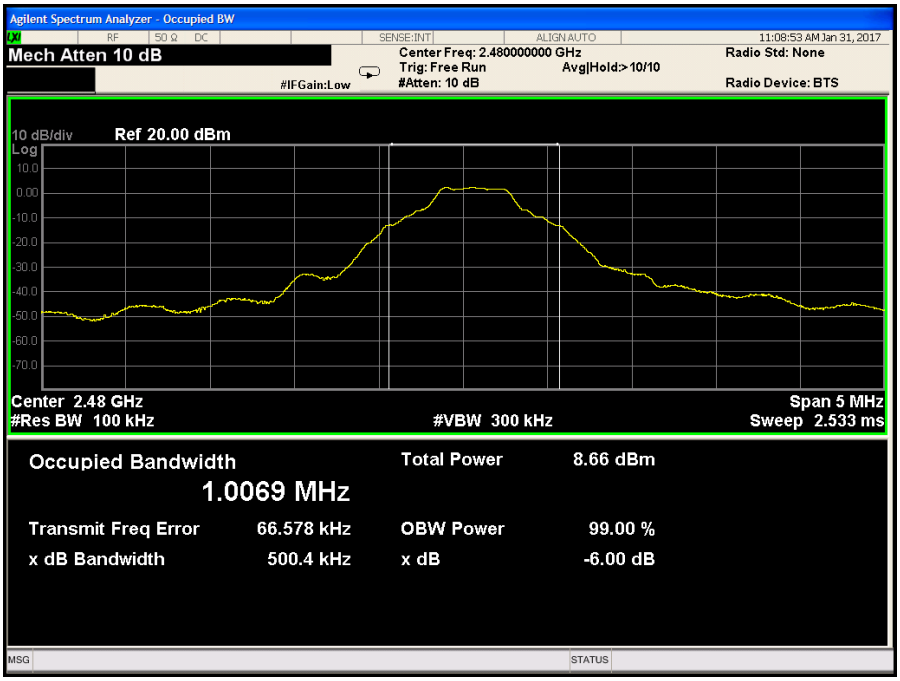


Figure 9 : 6dB & 99% Occupied Bandwidth – BLE – 2480MHz

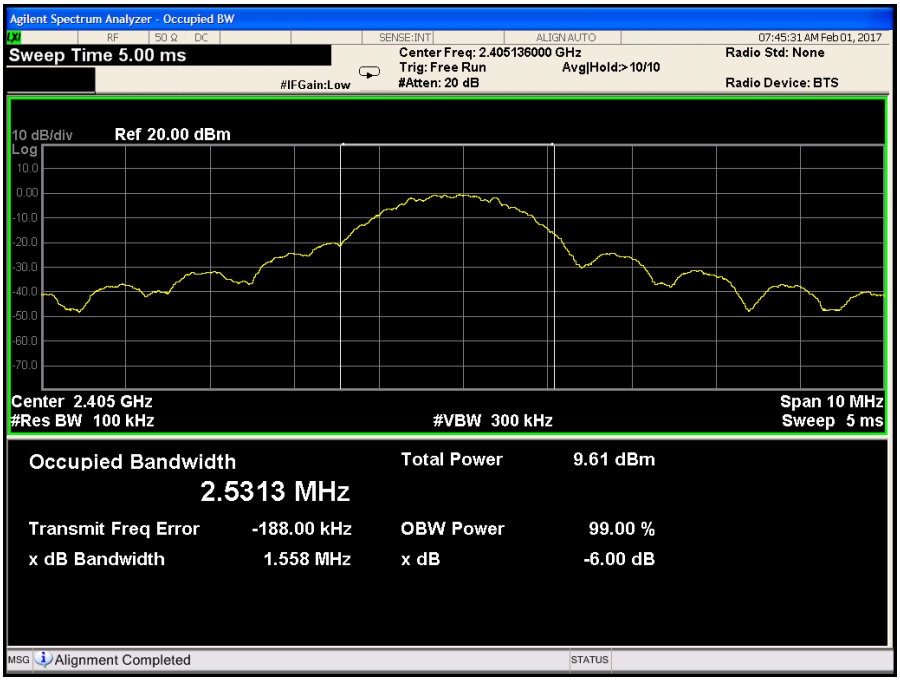


Figure 1 0 : 6dB & 99% Occupied Bandwidth – IEEE 802.15.4 – 2405MHz

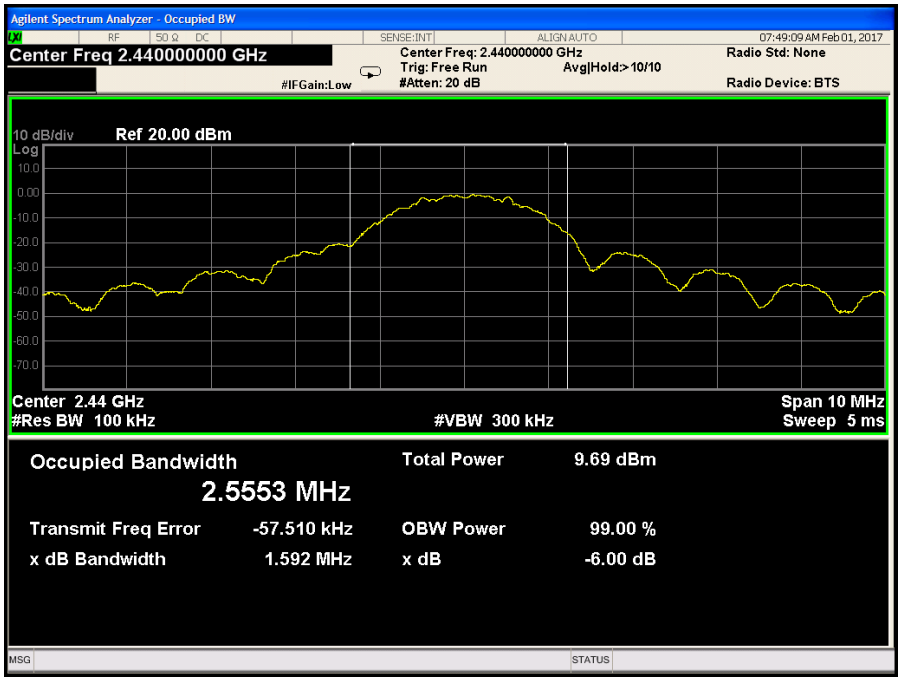


Figure 1 1 : 6dB & 99% Occupied Bandwidth – IEEE 802.15.4 – 2440MHz

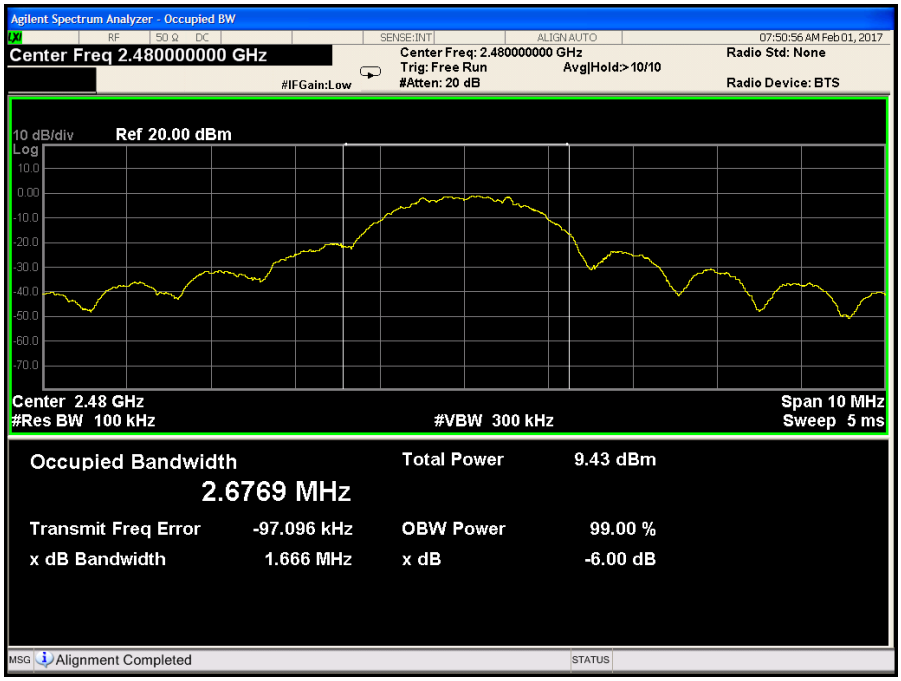


Figure 1 2 : 6dB & 99% Occupied Bandwidth – IEEE 802.15.4 – 2480MHz

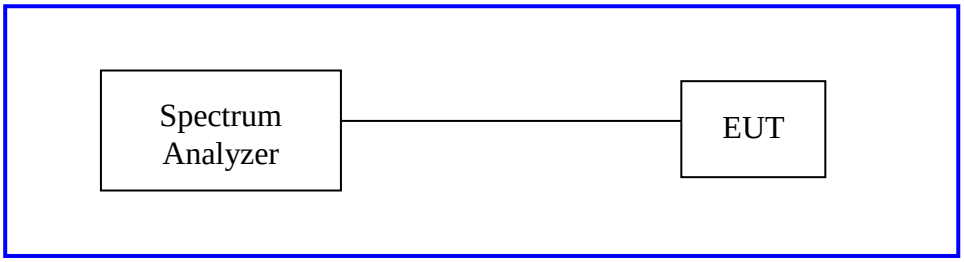
4.3 Peak Power Spectral Density

According to the CFR47 Part 15.247 (e) and RSS 247 Sect.5.2.2, 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.5.2.2.

Test Setup:



4.3.2 Results

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

Table 6: Peak Power Spectral Density – Test Results – BLE 4.0

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: Custom Integrated		**Power Setting:** See test plan	
Max. Directional Gain: +0 dBi			
Signal State: Modulated			
Ambient Temp.: 24° C		**Relative Humidity:**39%	
Peak Power Spectral Density – BLE 4.0			
Freq. (MHz)	**Measured PSD [dBm/3kHz]**	**Limit [dBm/3kHz]**	**Margin [dB]**
2402	-5.180	8	-13.18
2442	-6.727	8	-14.727
2480	-8.020	8	-16.02
Note: All insertion loss corrections are accounted for in the measurement plots.			

Table 7: Peak Power Spectral Density – Test Results – IEEE 802.15.4

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: Custom Integrated		**Power Setting:** See test plan	
Max. Directional Gain: +0 dBi			
Signal State: Modulated			
Ambient Temp.: 24° C		**Relative Humidity:**39%	
Peak Power Spectral Density – IEEE 802.15.4			
Freq. (MHz)	**Measured PSD [dBm/3kHz]**	**Limit [dBm/3kHz]**	**Margin [dB]**
2402	-10.008	8	-18.008
2442	-9.507	8	-17.507
2480	-10.488	8	-18.488
Note: All insertion loss corrections are accounted for in the measurement plots.			

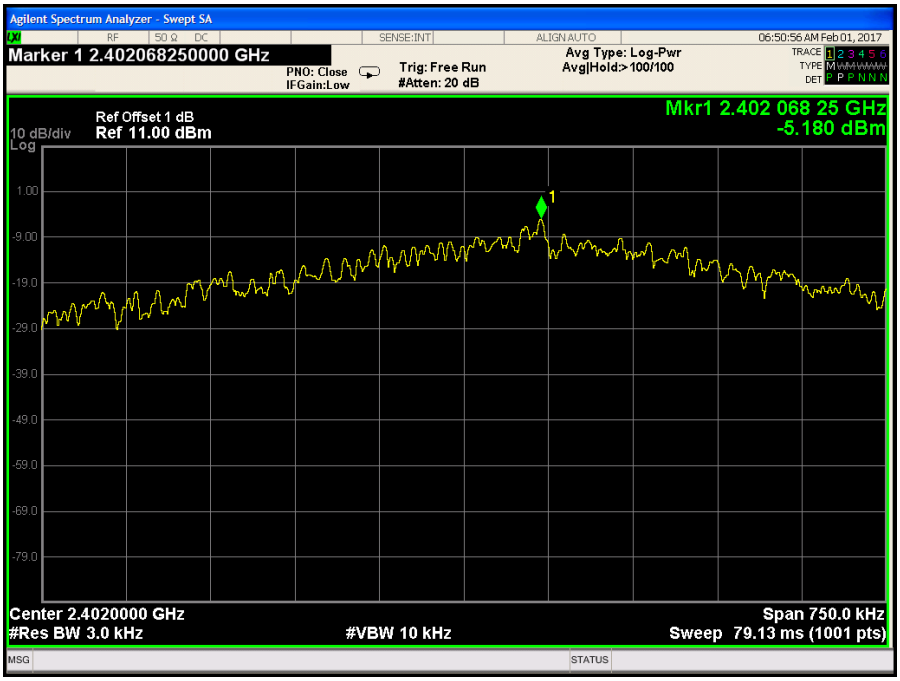


Figure 13: Power Spectral Density – BLE – 2402 MHz

Figure 14: Power Spectral Density – BLE – 2442 MHz

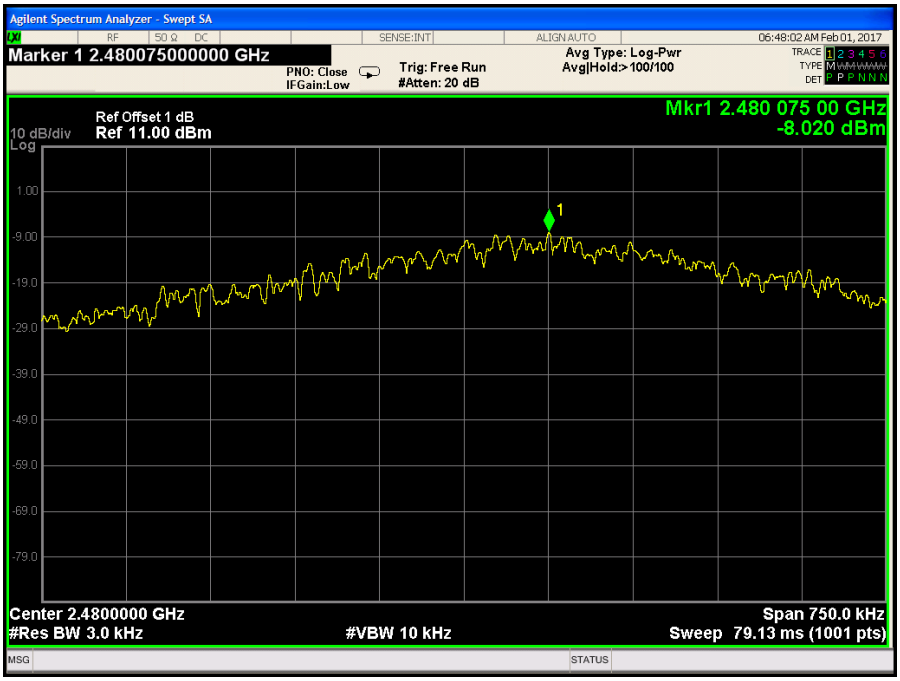


Figure 15: Power Spectral Density – BLE – 2480 MHz

Figure 16: Power Spectral Density – IEEE 802.15.4 – 2405 MHz

Figure 17: Power Spectral Density – IEEE 802.15.4 – 2440 MHz

Figure 18: Power Spectral Density – IEEE 802.15.4 – 2480 MHz

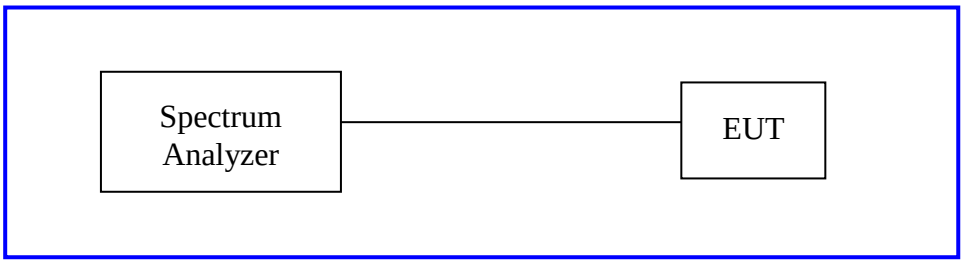
4.4 Out of Band Emissions

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.

4.4.1 Test Method

The conducted method was used to measure the undesirable emission requirement. The measurement was performed with modulation.

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 8: Out of Band Emissions including the Band-Edge – Test Results – BLE 4.0

Test Conditions: Conducted Measurement, Normal Temperature					
Antenna Type: Custom Integrated			**Power Setting:** See test plan		
Max. Directional Gain: +0 dBi			**Highest Level in 100kHz BW:** 3.109dBm		
Signal State: Modulated					
Ambient Temp.: 24° C			**Relative Humidity:**39%		
Non-Restricted Frequency Band Emissions – BLE 4.0					
Operating Freq. (MHz)	**Measured Freq. (MHz)**	**Measured (dBm)**	**Limit (dBm)**	**Margin**	**Result**
2402	4800	-36.423	-16.891	-19.532	Pass
2442	4875	-38.764	-16.891	-21.873	Pass
2480	4950	-39.672	-16.891	-22.781	Pass
Note: 1. The stated limits are -20dBc relative to the max output measured in a 100kHz bandwidth					

Table 9: Out of Band Emissions including the Band-Edge – Test Results – IEEE 802.15.4

Test Conditions: Conducted Measurement, Normal Temperature					
Antenna Type: Custom Integrated		**Power Setting:** See test plan			
Max. Directional Gain: +0 dBi		**Highest Level in 100kHz BW:** -0.585dBm			
Signal State: Modulated					
Ambient Temp.: 24° C		**Relative Humidity:**39%			
Non-Restricted Frequency Band Emissions – IEEE 802.15.4					
Operating Freq. (MHz)	**Measured Freq. (MHz)**	**Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**	**Result**
2405	4800	-52.915	-20.585	-32.330	Pass
2440	4875	-55.502	-20.585	-34.917	Pass
2480	1725	-48.210	-20.585	-27.625	Pass
Note: 1. The stated limits are -20dBc relative to the max output measured in a 100kHz bandwidth					

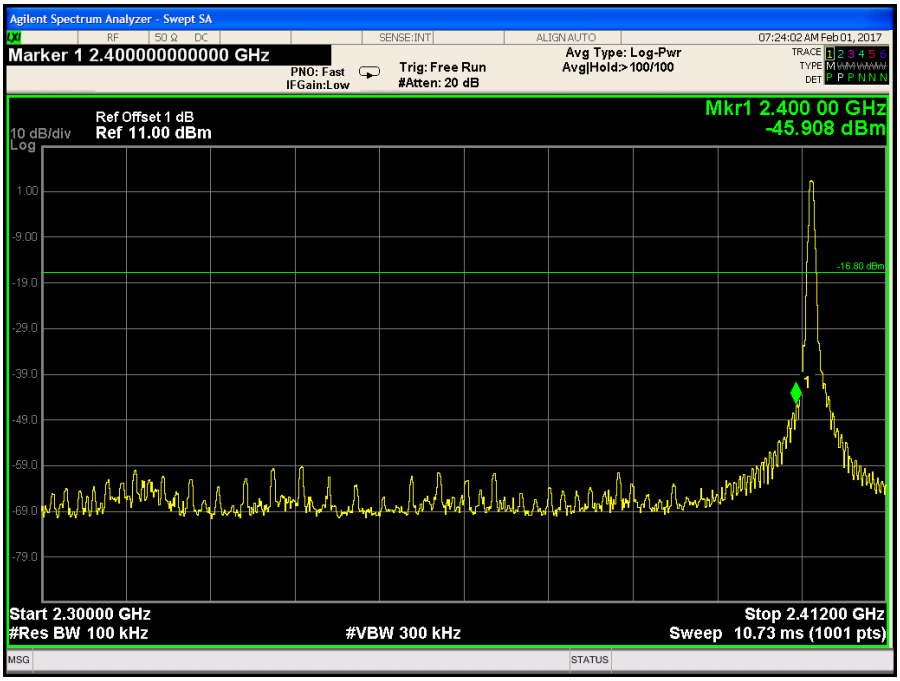


Figure 19: Measured Low Bandedge at 2402MHz – BLE

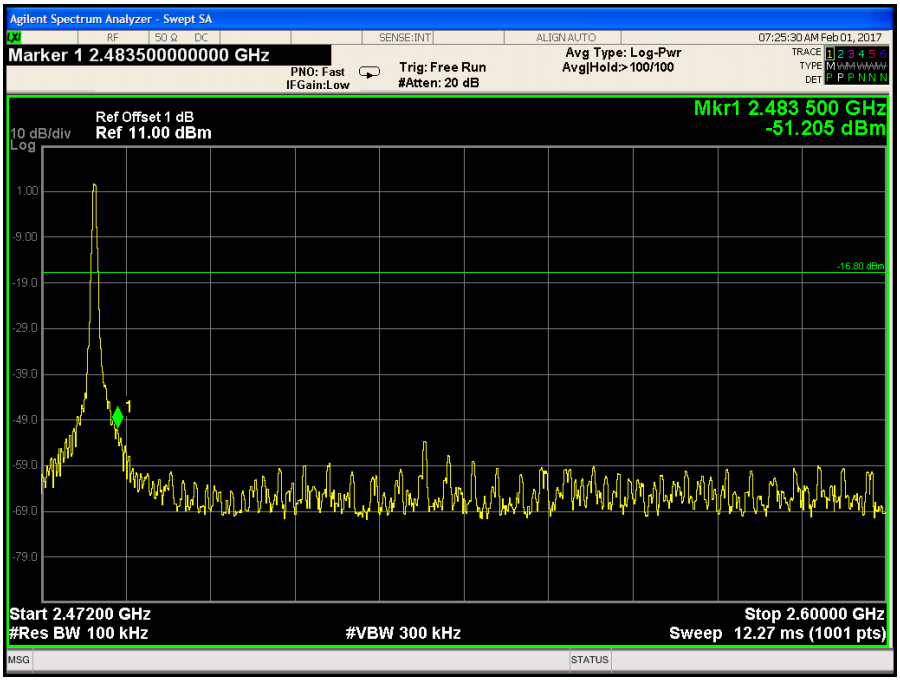


Figure 20: Measured High Bandedge at 2480MHz – BLE

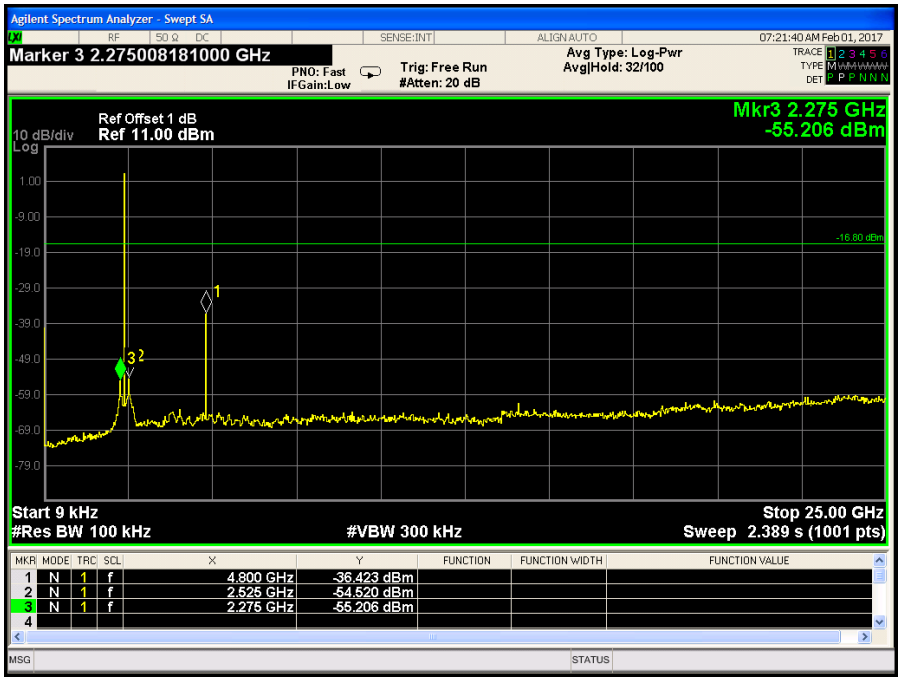


Figure 21: Out of Band Emissions at 2402 MHz, 9kHz-25GHz – BLE

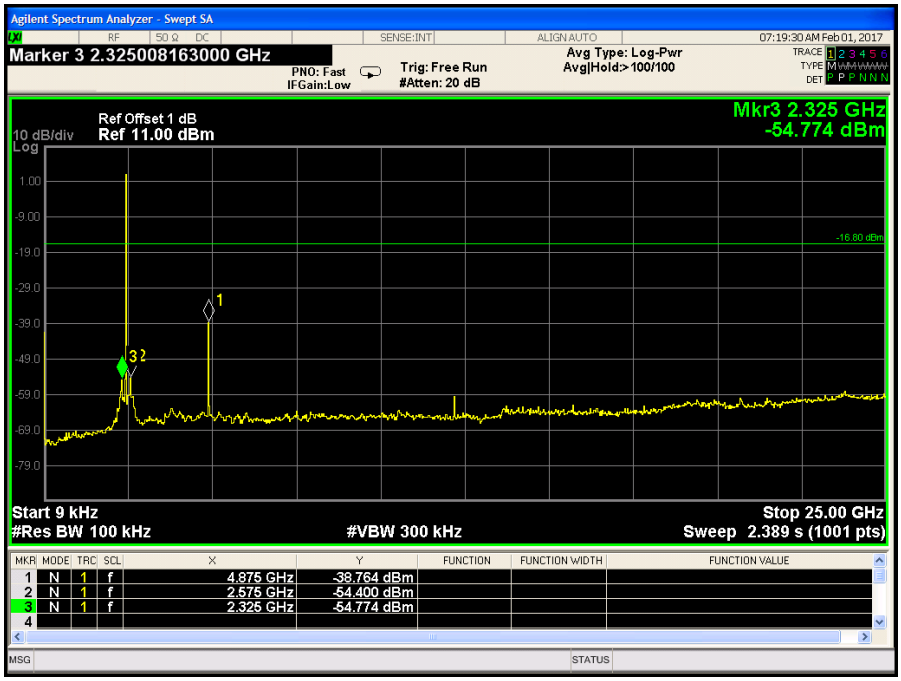


Figure 22: Out of Band Emissions at 2442 MHz, 9kHz-25GHz – BLE

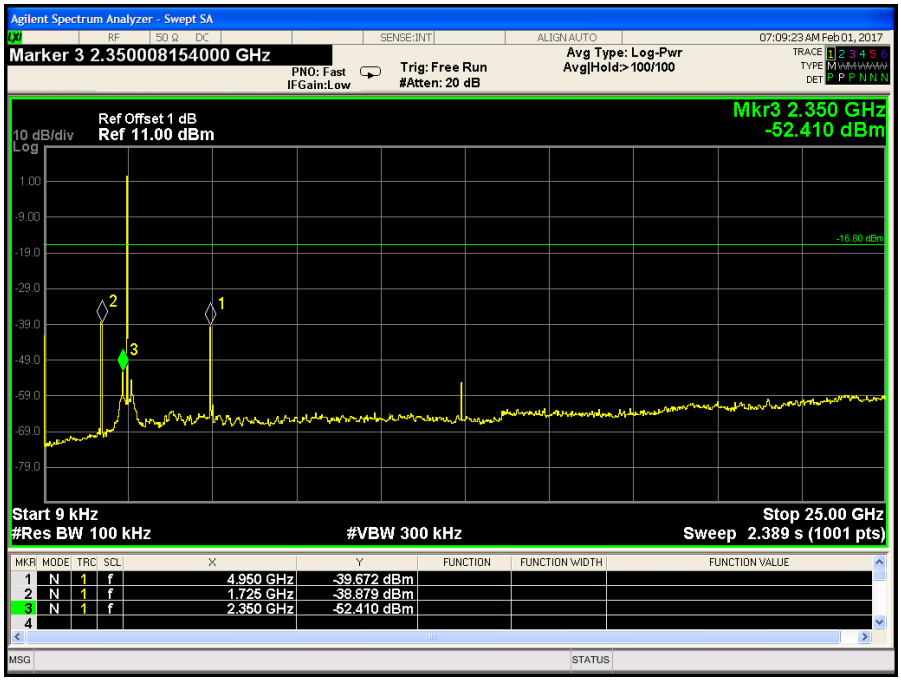


Figure 23: Out of Band Emissions at 2480 MHz, 9kHz-25GHz – BLE

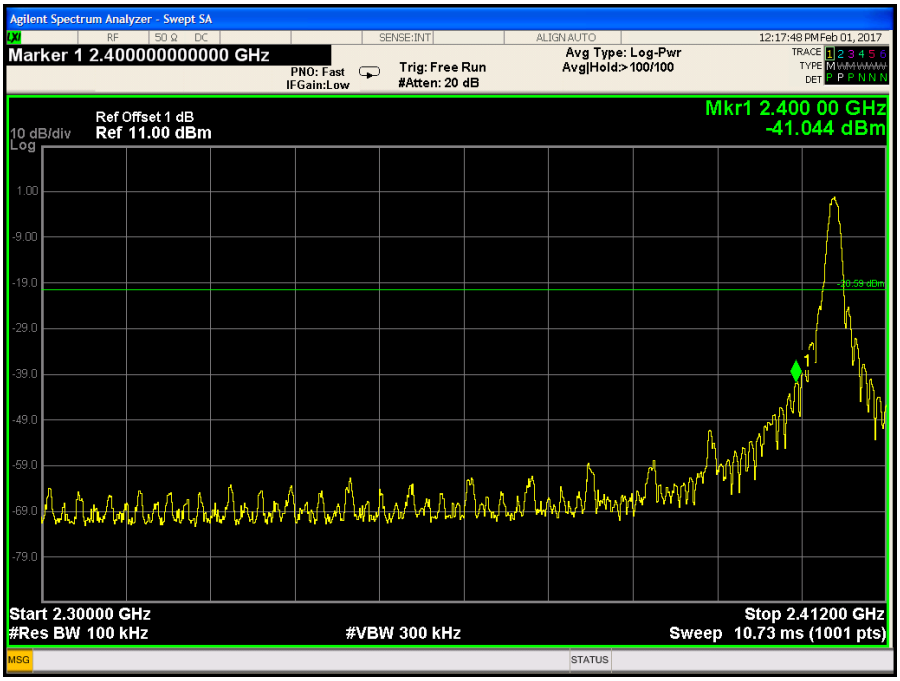


Figure 24: Measured Low Bandedge at 2402MHz – IEEE 802.15.4

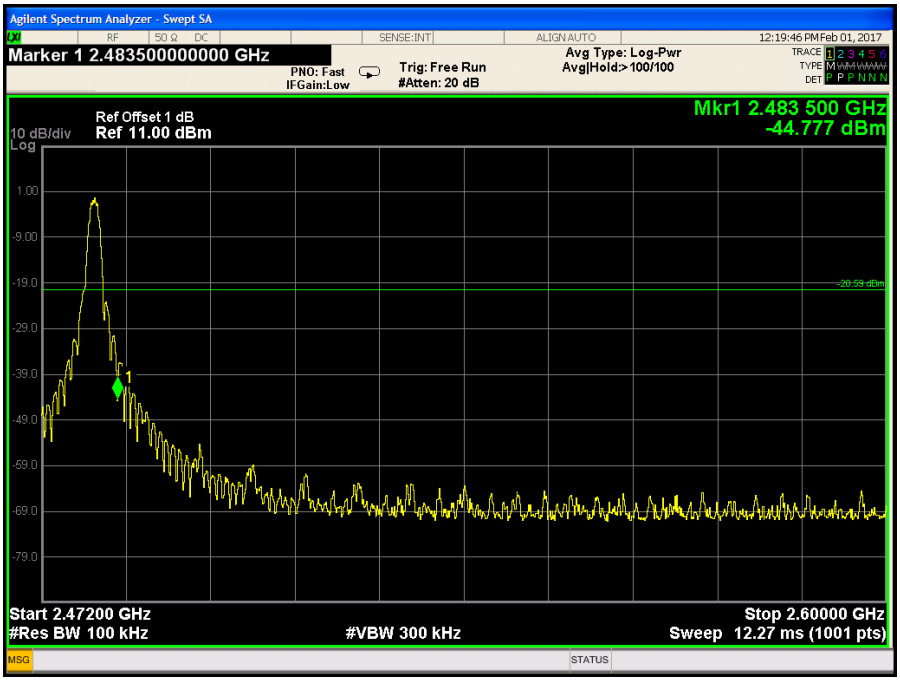


Figure 25: Measured High Bandedge at 2480MHz – IEEE 802.15.4

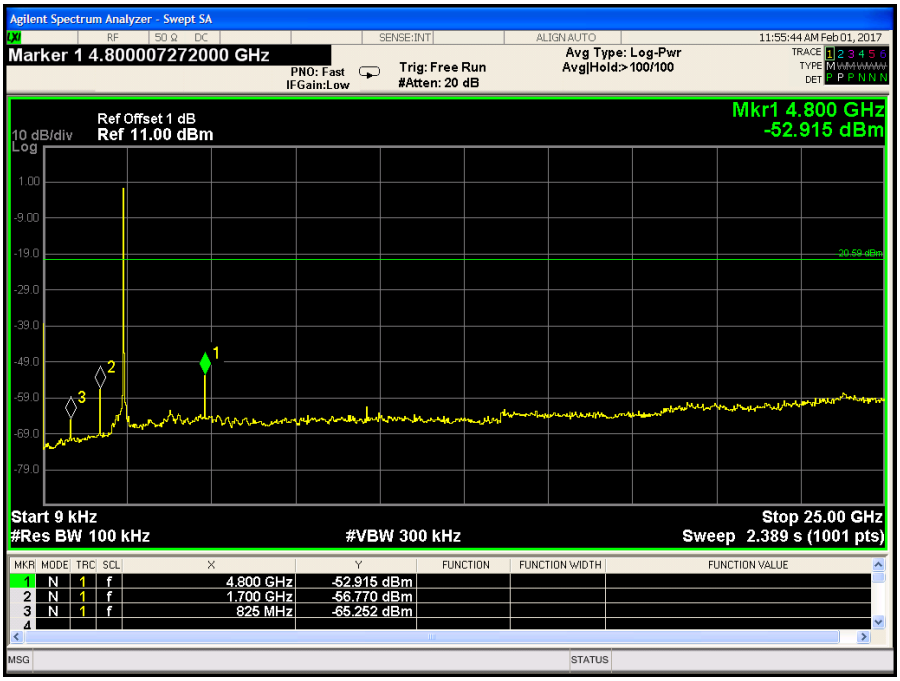


Figure 26: Out of Band Emissions at 2402 MHz, 9kHz-25GHz – IEEE 802.15.4

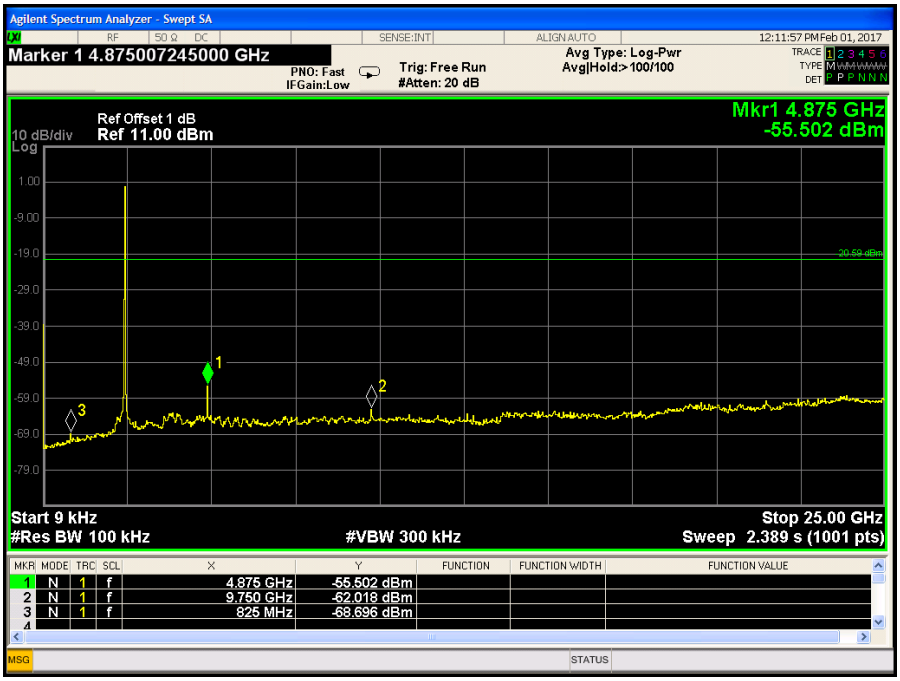


Figure 27: Out of Band Emissions at 2442 MHz, 9kHz-25GHz – IEEE 802.15.4

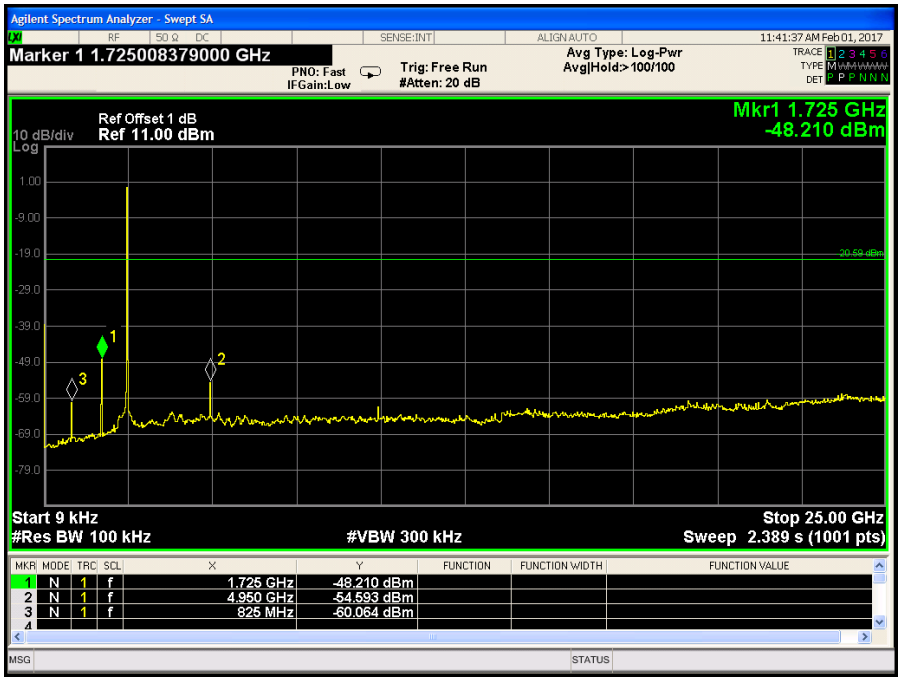


Figure 28: Out of Band Emissions at 2480 MHz, 9kHz-25GHz – IEEE 802.15.4

4.5 Transmit Radiated 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.

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 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.

4.5.1.2 Final Test

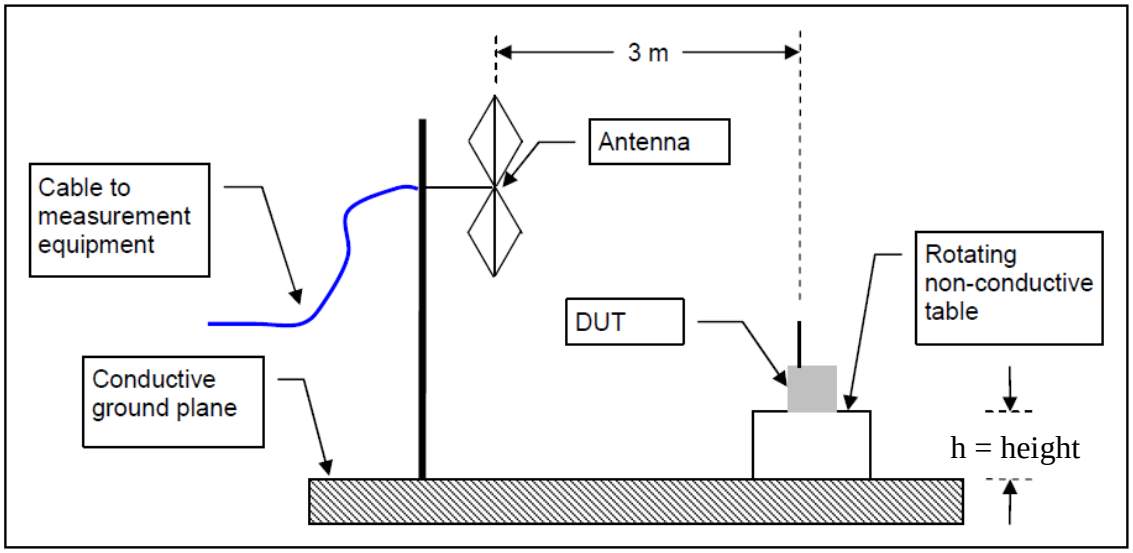
For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and 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.

4.5.1.3 Deviations

None.

Test Setup:



Where h = 80cm for <1GHz and 150cm for >1GHz

4.5.2 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. 8.10: 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. 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).

Table 10: Transmit Spurious Emission Band-Edge Requirements – BLE 4.0

Test Conditions: Radiated Measurement									
Antenna Type: Custom Integrated				**Power Setting:** See test plan					
Max. Directional Gain: +0dBi									
Signal State: Modulated									
Ambient Temp.: 24° C				**Relative Humidity:**37%					
Radiated Band-Edge – BLE 4.0									
Channel	Freq (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Pol. (H/V)	Det.	Table Deg.	Tower (cm)	Note
1	2385.71	56.18	74	-17.82	H	Pk	233.5	228.5	
1	2384.06	41.64	54	-12.36	H	Ave	233.5	228.5	
39	2483.50	61.26	74	-12.74	H	Pk	226.25	249.0	
39	2483.5	42.83	54	-11.17	H	Ave	226.25	249.0	

Note: 1. The emissions were measured at the adjacent restricted band of the fundamental signal.
2. All the band-edge measurements met the restricted band requirements of CFR47 15.205.
3. The EUT was investigated about three orthogonal axes. The worst-case orientation is presented.
4. Vertical and Horizontal measurement antenna polarities were investigated. Horizontal was determined to be the worst-case.

Table 11: Transmit Spurious Emission Band-Edge Requirements – IEEE 802.15.4

Test Conditions: Radiated Measurement									
Antenna Type: Custom Integrated				**Power Setting:** See test plan					
Max. Directional Gain: +0dBi									
Signal State: Modulated									
Ambient Temp.: 24° C				**Relative Humidity:**37%					
Radiated Band-Edge – IEEE 802.15.4									
Channel	Freq (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Pol. (H/V)	Det.	Table Deg.	Tower (cm)	Note
1	2388.5	59.21	74	-14.78	H	Pk	320.2	236	
1	2390.0	42.15	54	-11.85	H	Ave	320.2	236	
39	2483.5	63.77	74	-10.02	H	Pk	314.3	288	
39	2483.5	52.44	54	-1.56	H	Ave	314.3	288	

Note: 1. The emissions were measured at the adjacent restricted band of the fundamental signal.
2. All the band-edge measurements met the restricted band requirements of CFR47 15.205.
3. The EUT was investigated about three orthogonal axes. The worst-case orientation is presented.
4. Vertical and Horizontal antenna polarities were investigated. Horizontal was determined to be the worst-case.

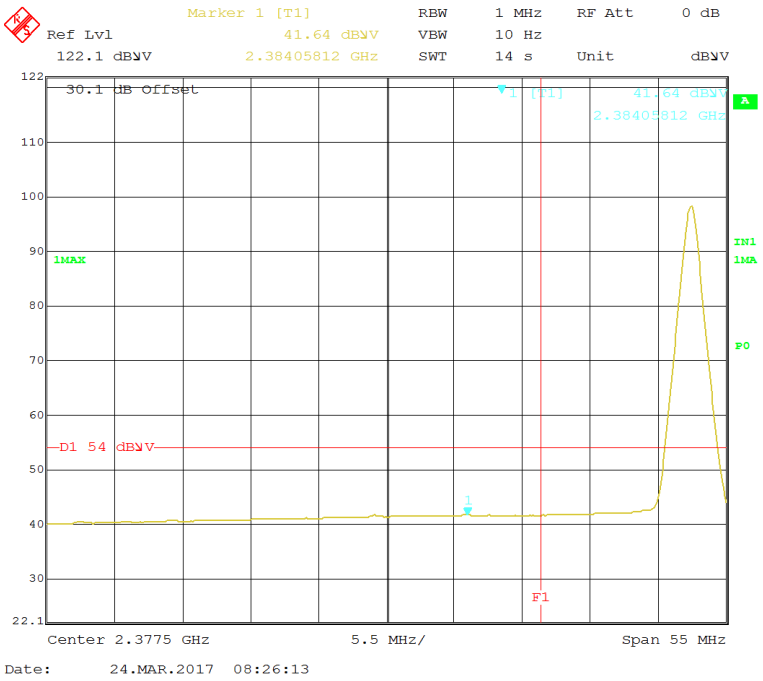


Figure 29: Radiated Bandedge at 2390MHz – BLE – Horz. (Ave)

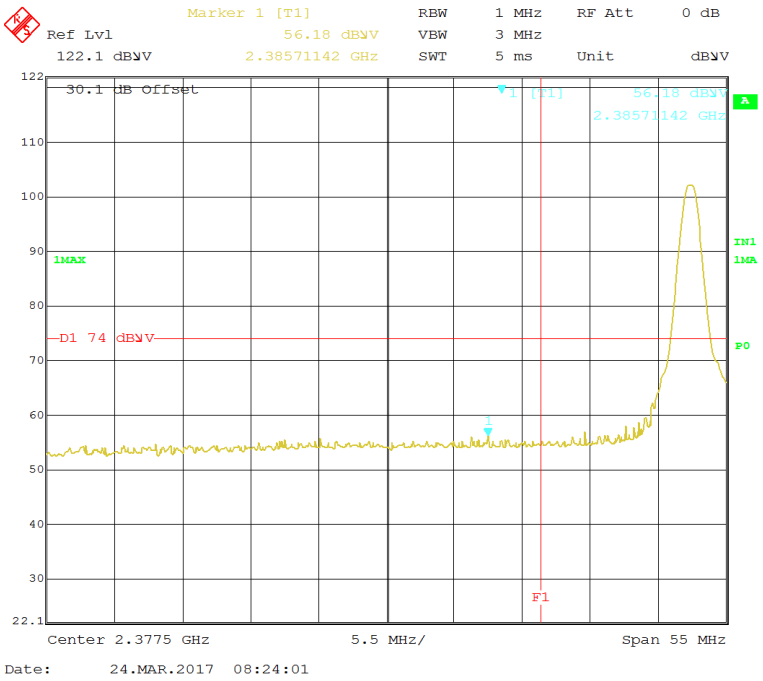


Figure 30: Radiated Bandedge at 2390MHz – BLE – Horz. (Peak)

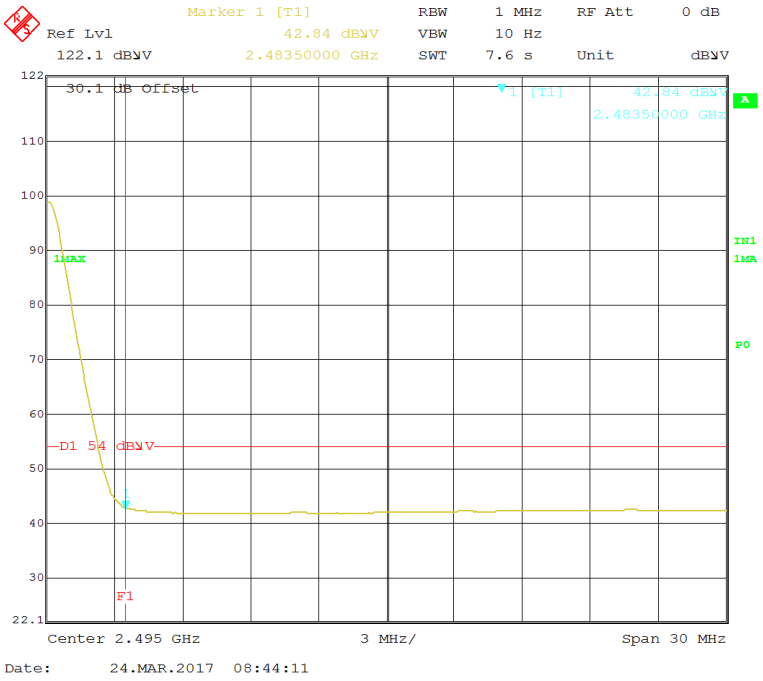


Figure 31: Radiated Bandedge at 2483.5MHz – BLE – Horz. (Ave)

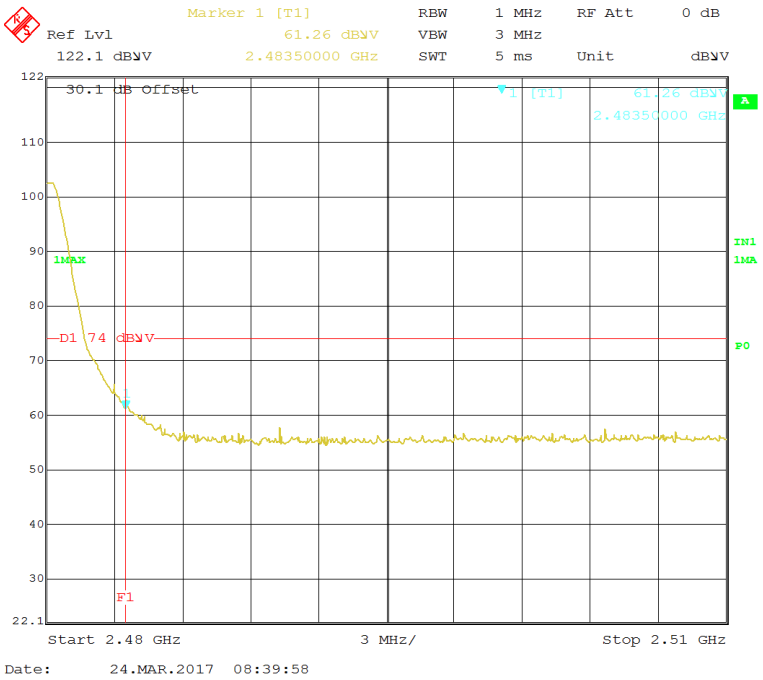


Figure 32: Radiated Bandedge at 2483.5MHz – BLE – Horz. (Peak)

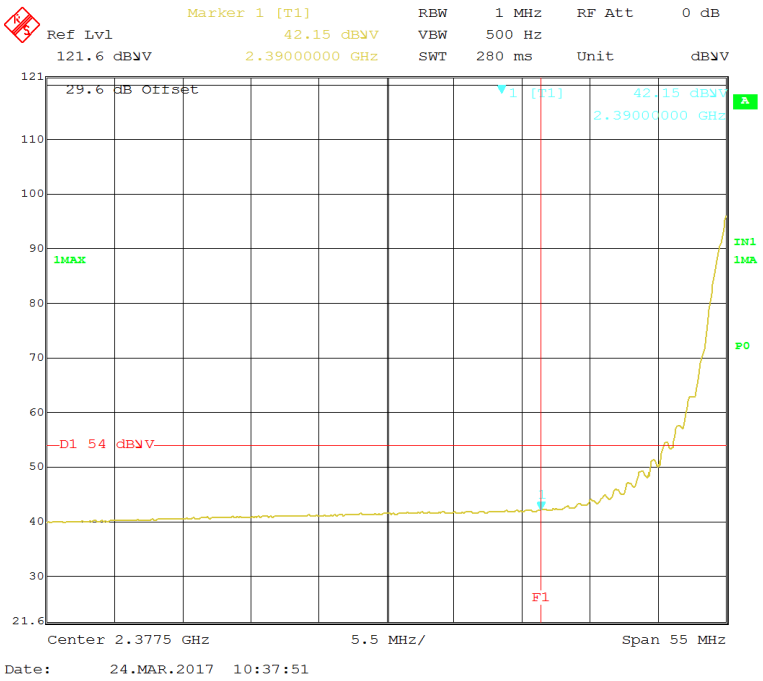


Figure 33: Radiated Bandedge at 2390MHz – IEEE 802.15.4 – Horz. (Ave)

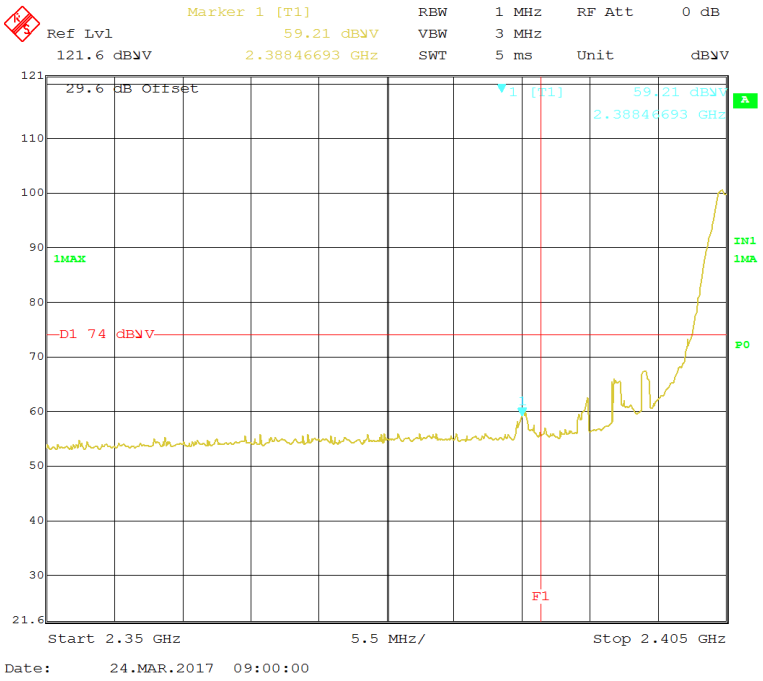


Figure 34: Radiated Bandedge at 2390 MHz – IEEE 802.15.4 – Horz. (Peak)

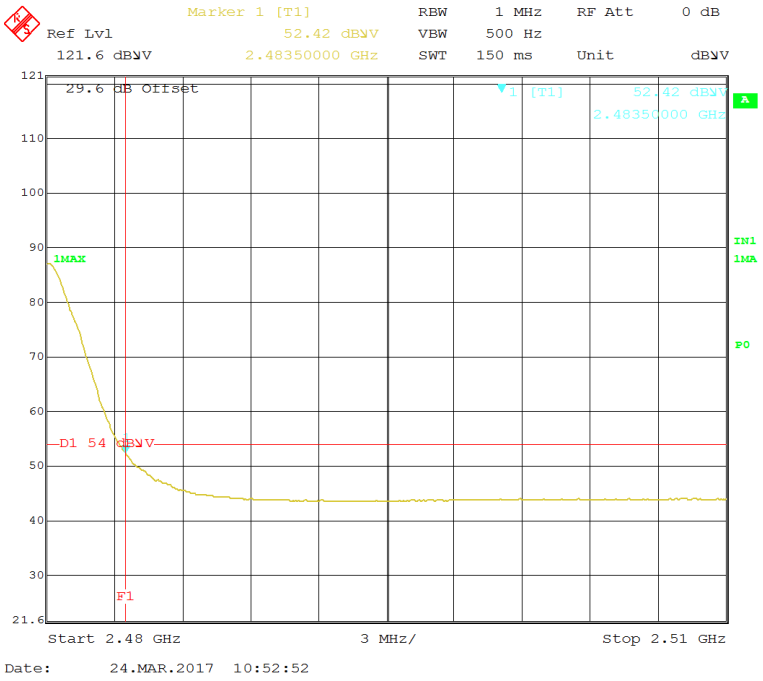


Figure 35: Radiated Bandedge at 2483.5 MHz – IEEE 802.15.4 – Horz. (Ave)

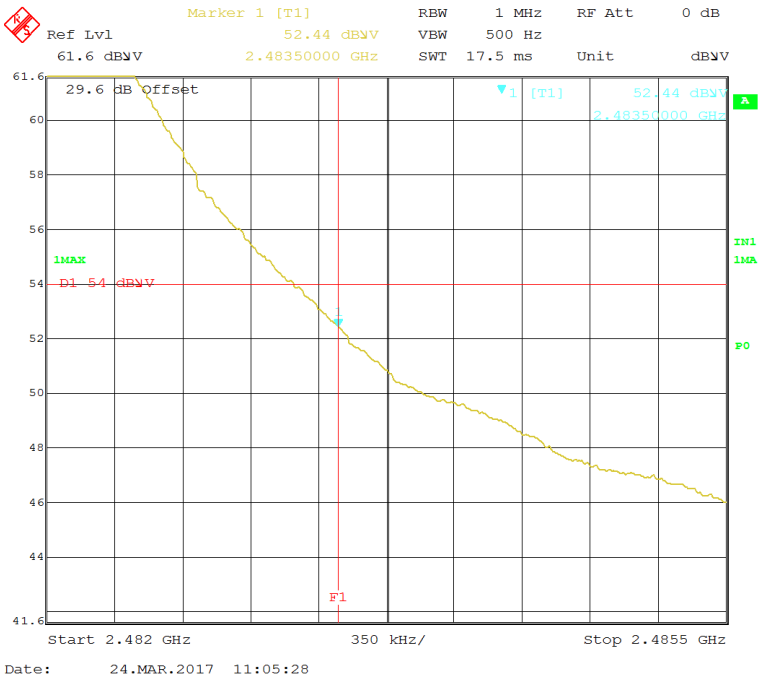


Figure 36: Radiated Bandedge at 2483.5MHz – IEEE 802.15.4 – Horz. (Ave-Zoom)

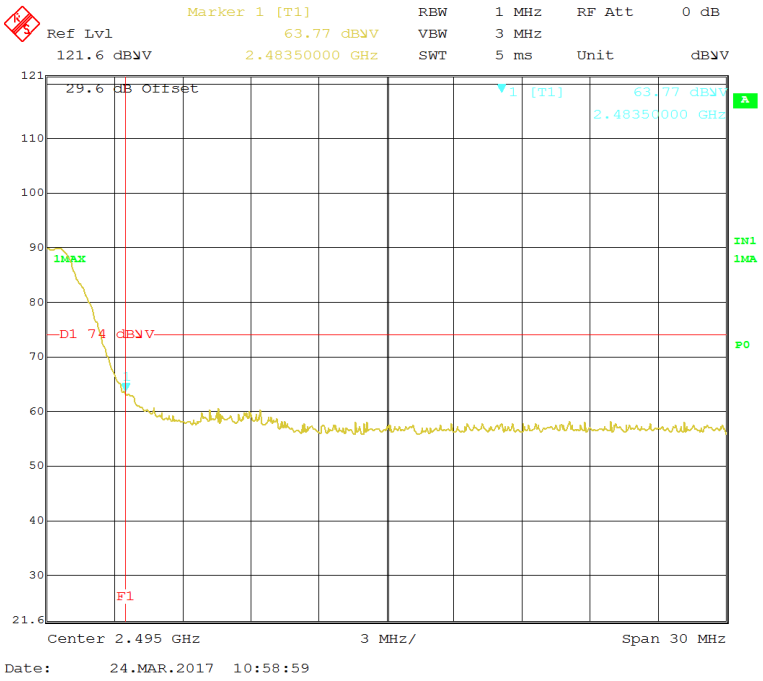


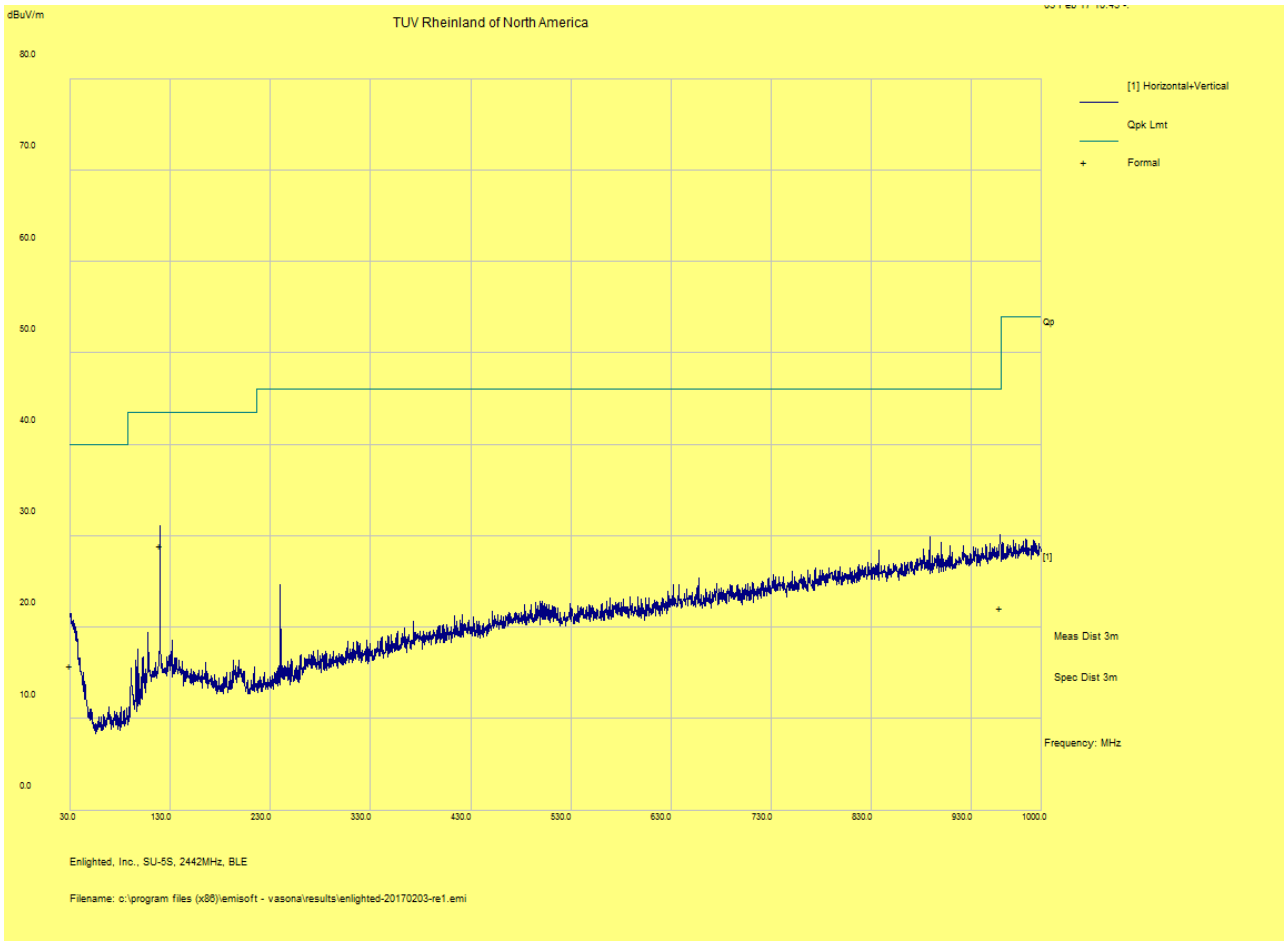
Figure 37: Radiated Bandedge at 2483.5MHz – IEEE 802.15.4 – (Peak)

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 3, 2017
EUT Model	SU-5S	**Temp / Hum in**	24° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2440MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / JB3	**Performed by**	Eddie Mariscal

30 MHz – 1 GHz Transmit at 2440 MHz

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
958.7094	21.14	4.13	-3.16	22.11	QP	H	171	94	46	-23.9



Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

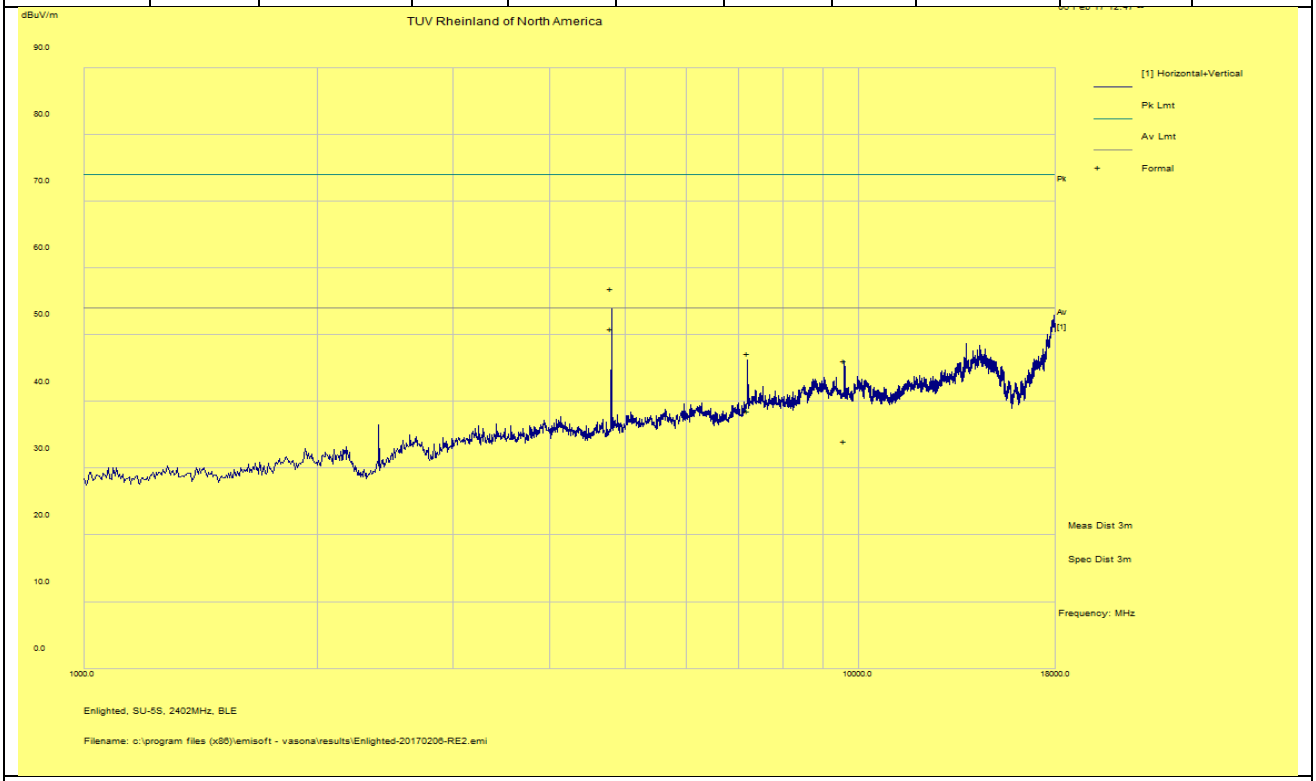
Note: 1. Center channel was determined to be the worst-case.

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 6, 2017
EUT Model	SU-5S	**Temp / Hum in**	21° C / 37%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2402MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m – EMCO3115	**Performed by**	Eddie Mariscal

1 – 18 GHz Transmit at 2402 MHz (Low Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
4803.99	75.27	1.75	-20.11	56.91	Pk	H	166	222	74	-17.09
7205.73	61.49	2.19	-16.51	47.17	Pk	V	243	40	74	-26.83
9607.63	56.99	2.55	-13.39	46.15	Pk	H	143	162	74	-27.85
4803.99	69.3	1.75	-20.11	50.94	Ave	H	166	222	54	-3.06
7205.73	52.96	2.19	-16.51	38.64	Ave	V	243	40	54	-15.36
9607.63	44.92	2.55	-13.39	34.07	Ave	H	143	162	54	-19.93



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

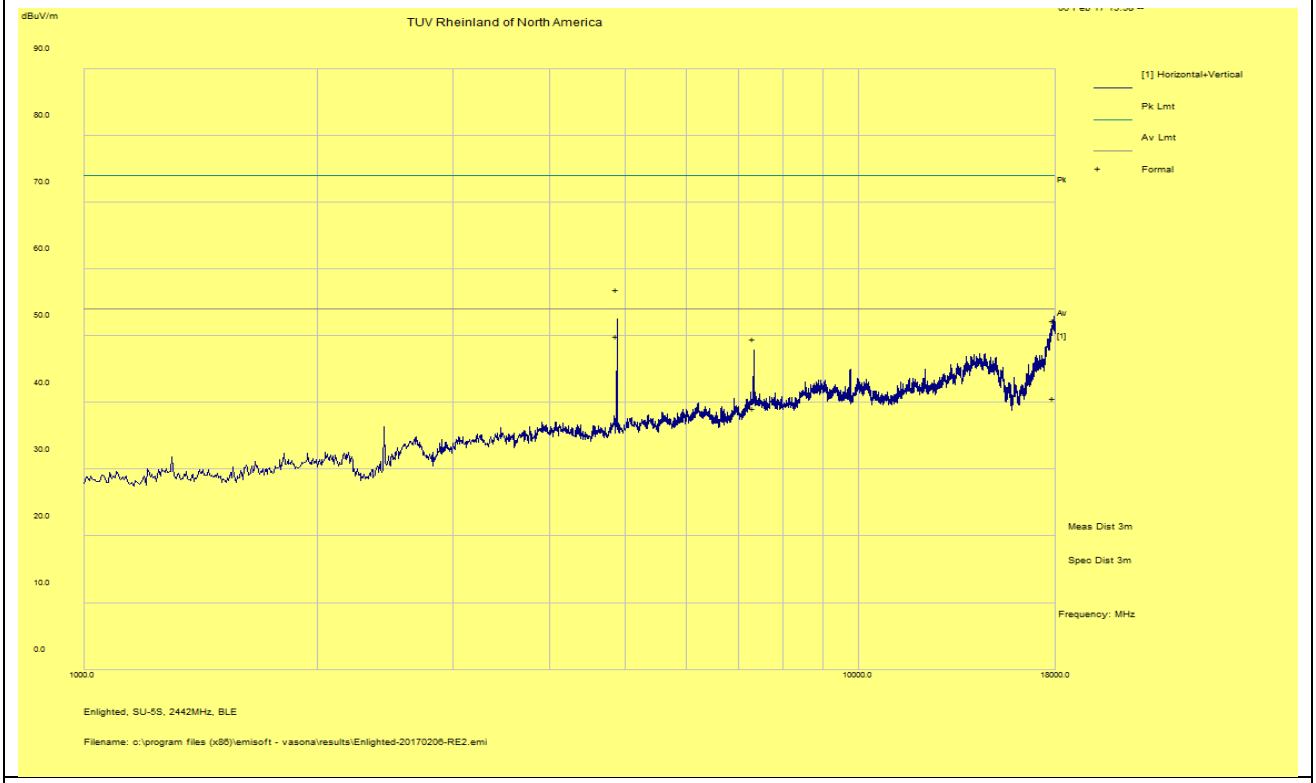
Note:

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 6, 2017
EUT Model	SU-5S	**Temp / Hum in**	21° C / 37%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2440MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m – EMCO3115	**Performed by**	Eddie Mariscal

1 – 18 GHz Transmit at 2442 MHz (Mid Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
17903.88	51.87	3.72	-3.35	52.24	Pk	V	227	292	74	-21.76
4884.025	75.33	1.77	-20.14	56.95	Pk	H	203	242	74	-17.05
7326.815	62.93	2.21	-15.62	49.52	Pk	H	239	176	74	-24.48
17903.88	40.32	3.72	-3.35	40.69	Ave	V	227	292	54	-13.31
4884.025	68.27	1.77	-20.14	49.9	Ave	H	203	242	54	-4.1
7326.815	52.52	2.21	-15.62	39.11	Ave	H	239	176	54	-14.89



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

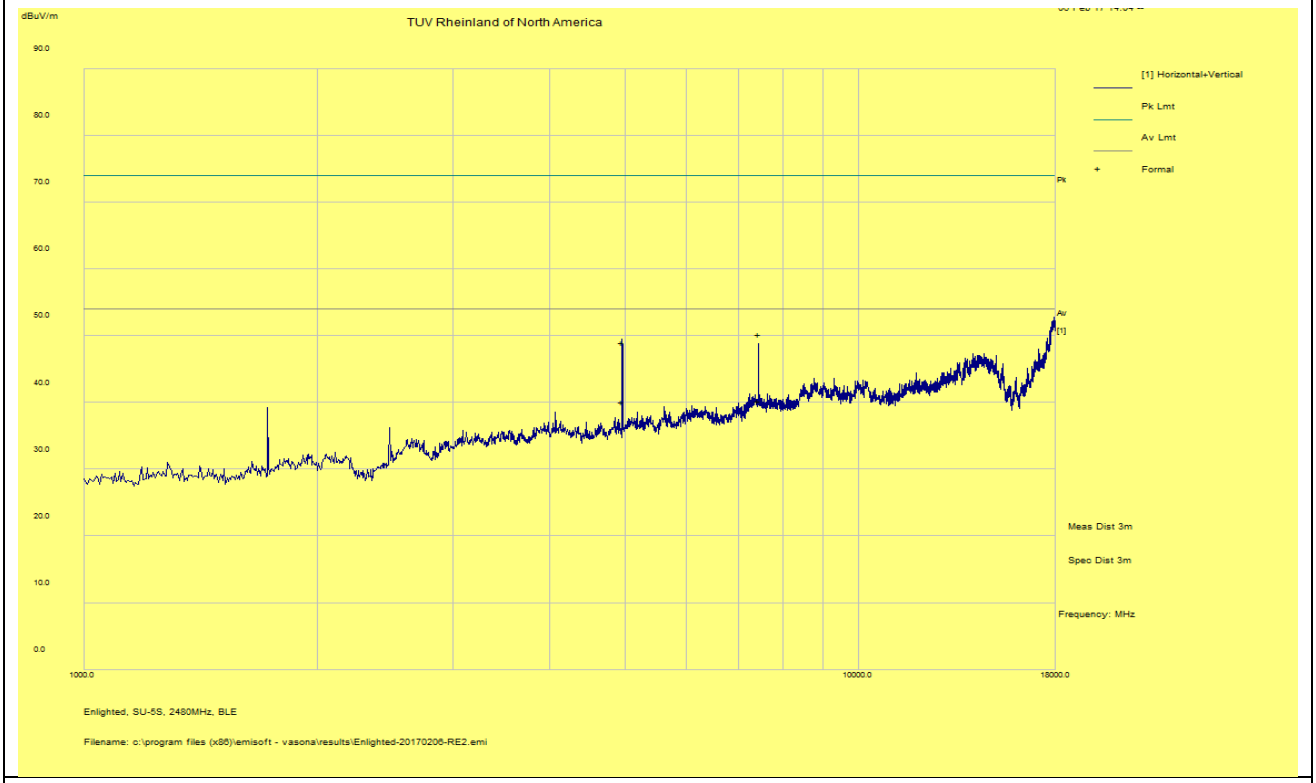
Note:

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 6, 2017
EUT Model	SU-5S	**Temp / Hum in**	21° C / 37%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2480MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m – EMCO3115	**Performed by**	Eddie Mariscal

1 – 18 GHz Transmit at 2480 MHz (High Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
4959.813	67.32	1.79	-20.16	48.94	Pk	H	175	120	74	-25.06
7439.778	63.6	2.23	-15.59	50.24	Pk	H	222	134	74	-23.76
4959.813	58.46	1.79	-20.16	40.08	Ave	H	175	120	54	-13.92
7439.778	53.54	2.23	-15.59	40.19	Ave	H	222	134	54	-13.82



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note:

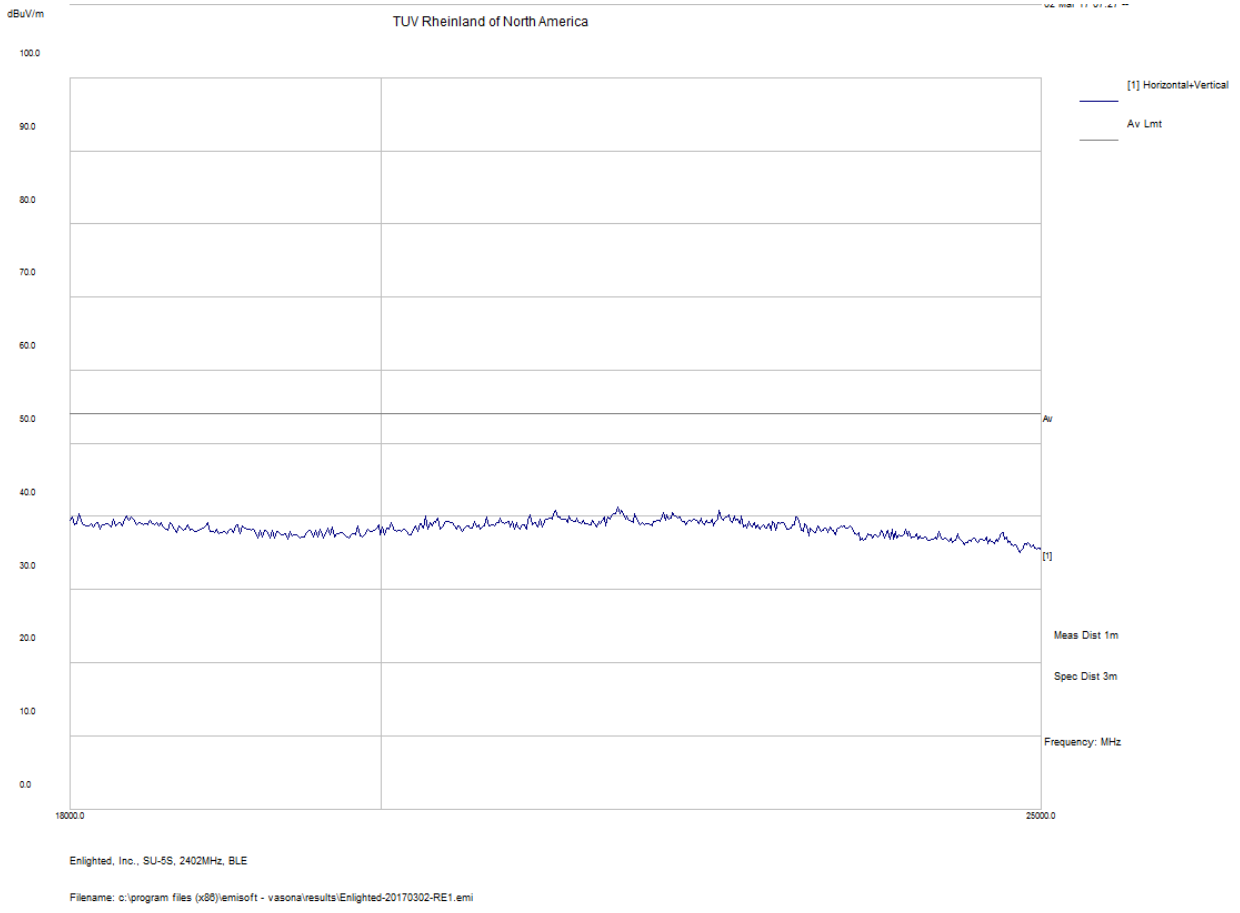
SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	March 2, 2017
EUT Model	SU-5S	**Temp / Hum in**	20° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2402MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	1m – AHA-840	**Performed by**	Eddie Mariscal

18 – 25 GHz Transmit at 2402 MHz (Low Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB

No EUT emissions were detected above the noise floor from 18-25GHz.



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note:

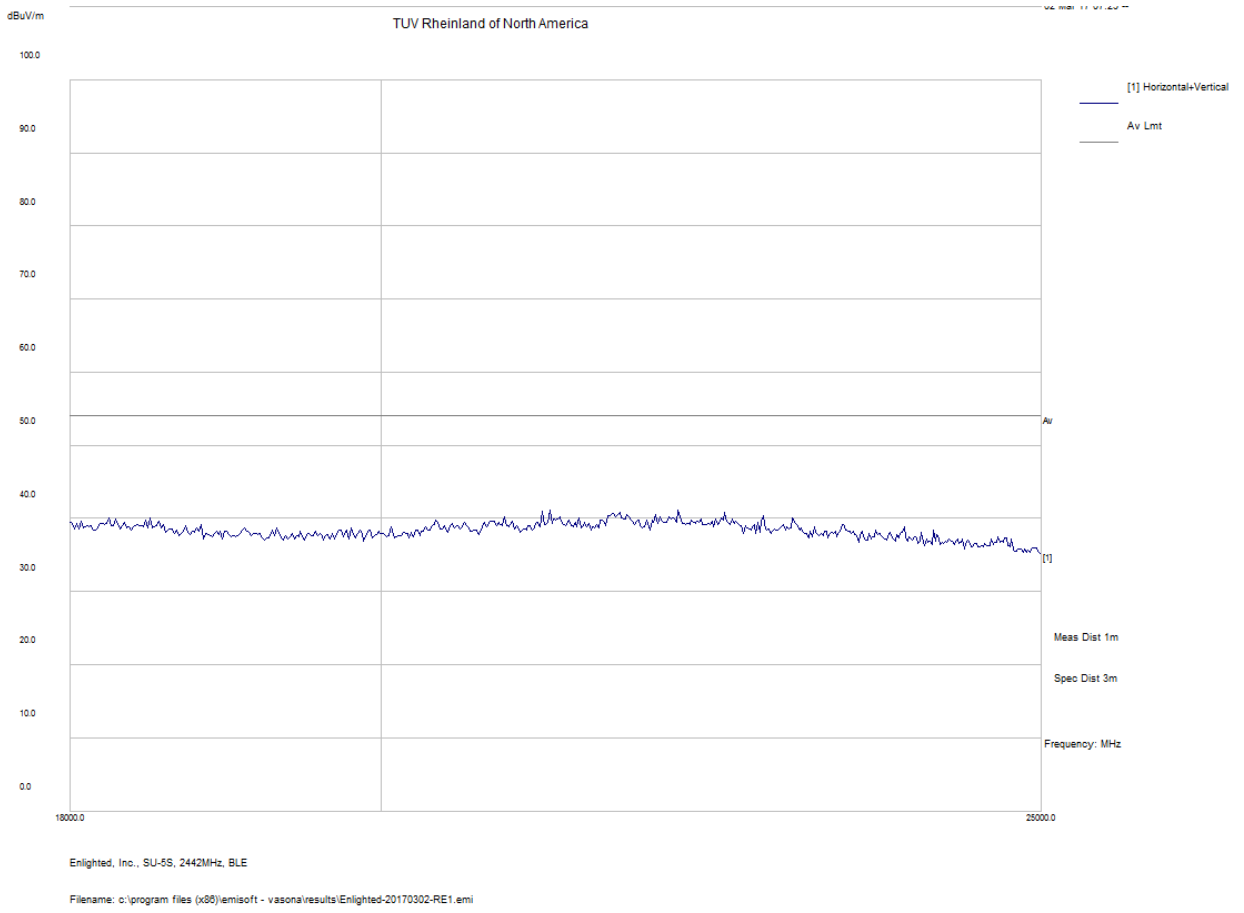
SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	March 2, 2017
EUT Model	SU-5S	**Temp / Hum in**	20° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2440MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	1m – AHA-840	**Performed by**	Eddie Mariscal

18 – 25 GHz Transmit at 2442 MHz (Mid Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB

No EUT emissions were detected above the noise floor from 18-25GHz.



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note:

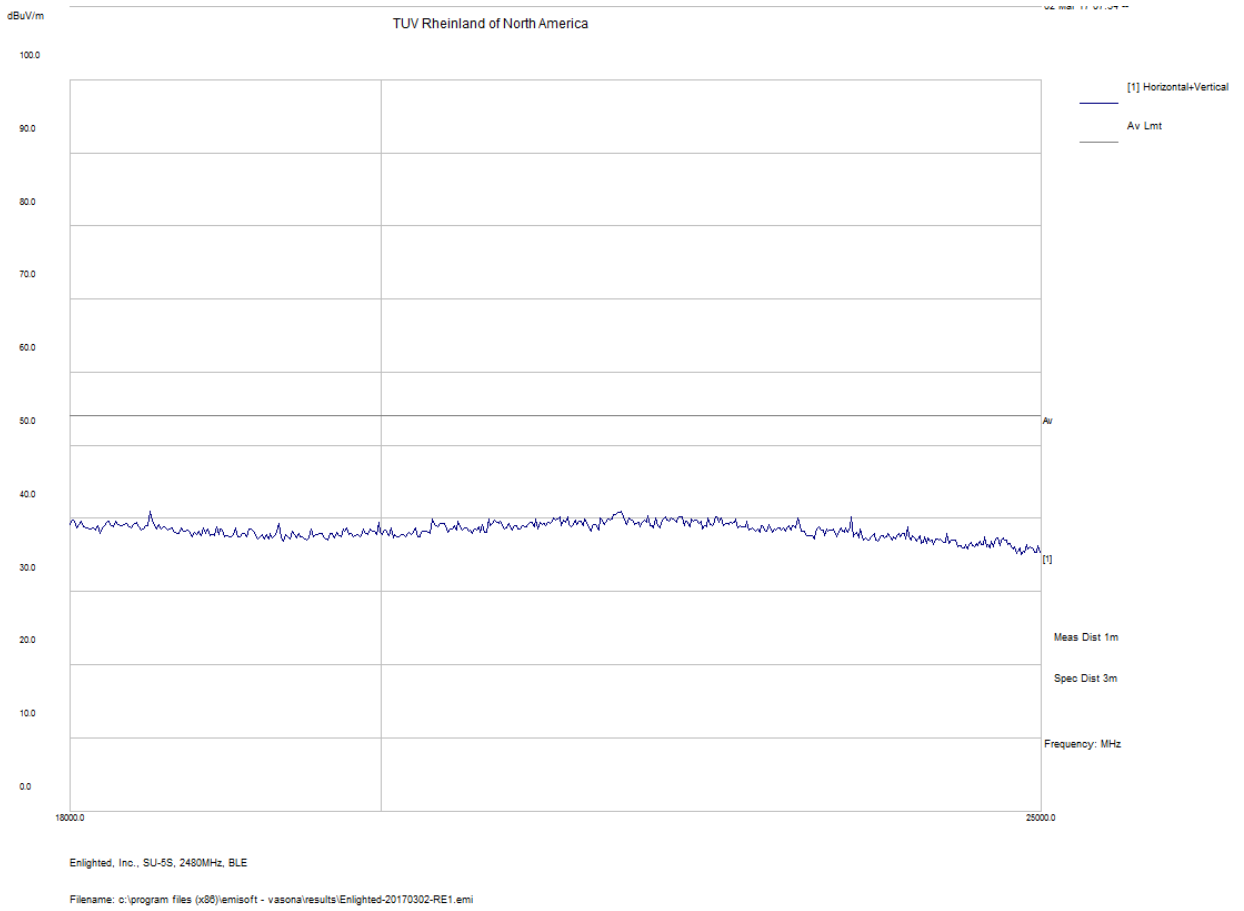
SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	March 2, 2017
EUT Model	SU-5S	**Temp / Hum in**	20° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2480MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	1m – AHA-840	**Performed by**	Eddie Mariscal

18 – 25 GHz Transmit at 2480 MHz (High Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB

No EUT emissions were detected above the noise floor from 18-25GHz.



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

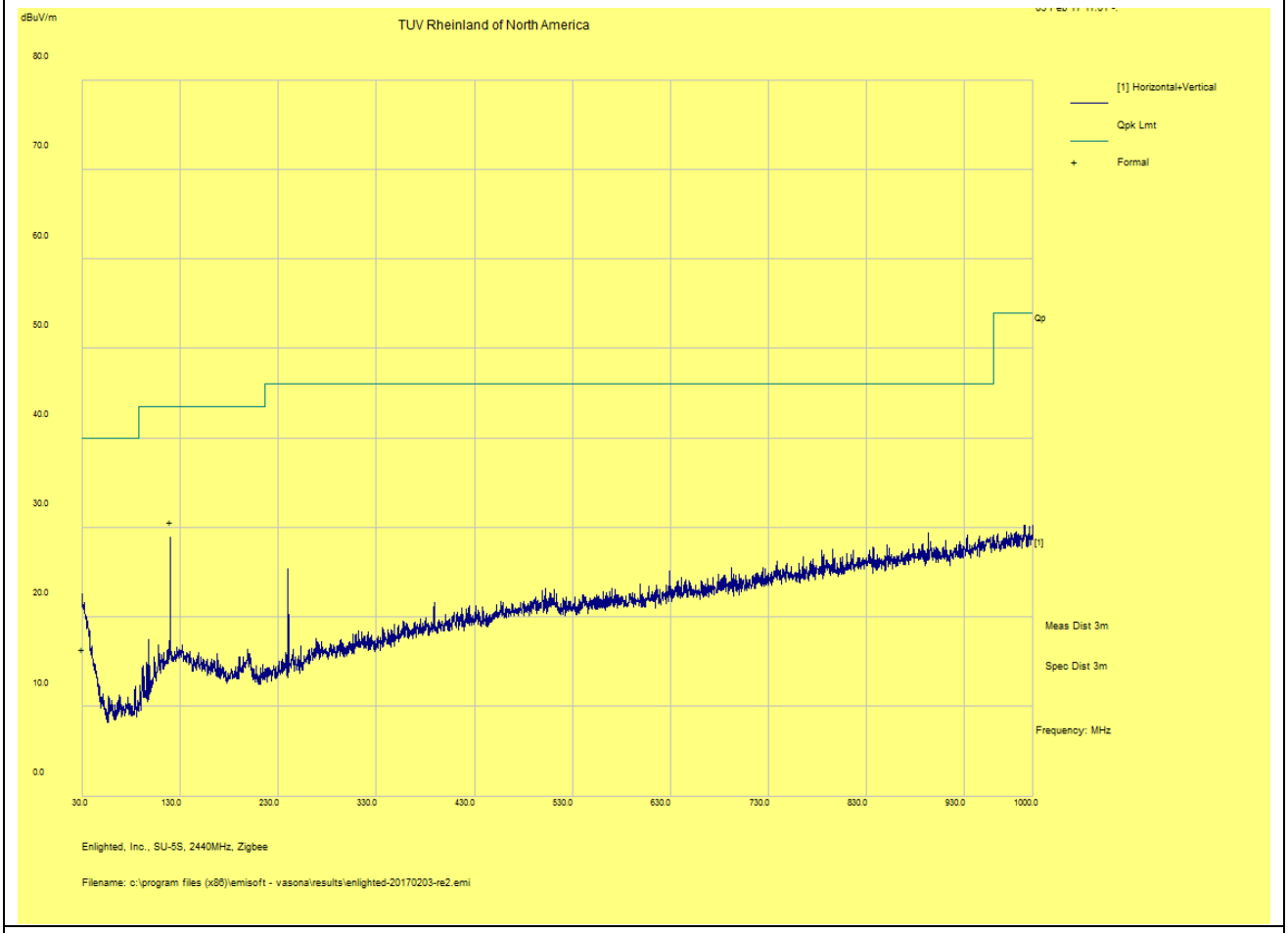
Note: No significant emissions were observed above the spectrum noise floor.

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 3 2017
EUT Model	SU-5S	**Temp / Hum in**	24° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2440MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / JB3	**Performed by**	Eddie Mariscal

30 MHz – 1 GHz Transmit at 2440 MHz

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB



Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

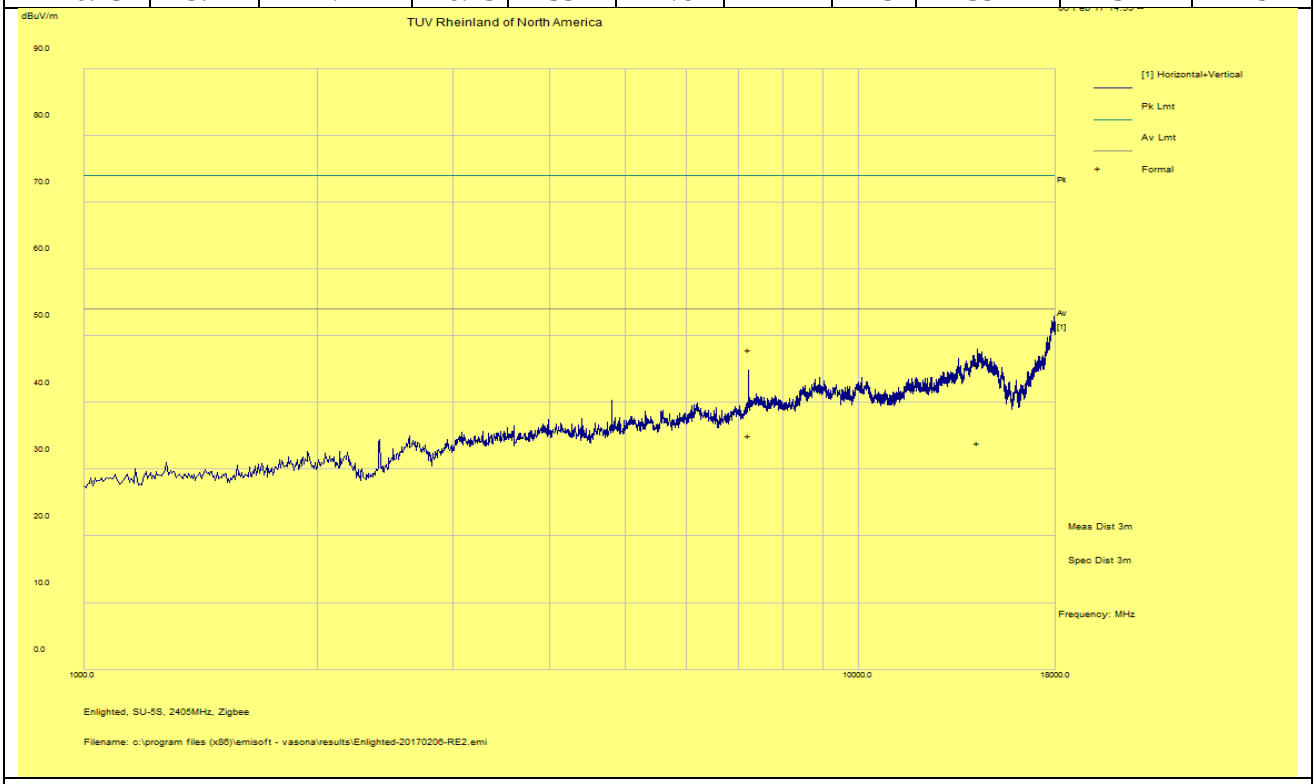
Note: 1. Center channel was determined to be the worst-case.

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 6 2017
EUT Model	SU-5S	**Temp / Hum in**	21° C / 37%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2402MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m – EMCO3115	**Performed by**	Eddie Mariscal

1 – 18 GHz Transmit at 2402 MHz (Low Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
14280.52	50.71	3.14	-8.24	45.61	Pk	H	244	108	74	-28.39
7216.45	62.16	2.2	-16.43	47.94	Pk	H	243	334	74	-26.06
14280.52	39.1	3.14	-8.24	34	Ave	H	244	108	54	-20
7216.45	49.22	2.2	-16.43	35	Ave	H	243	334	54	-19



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

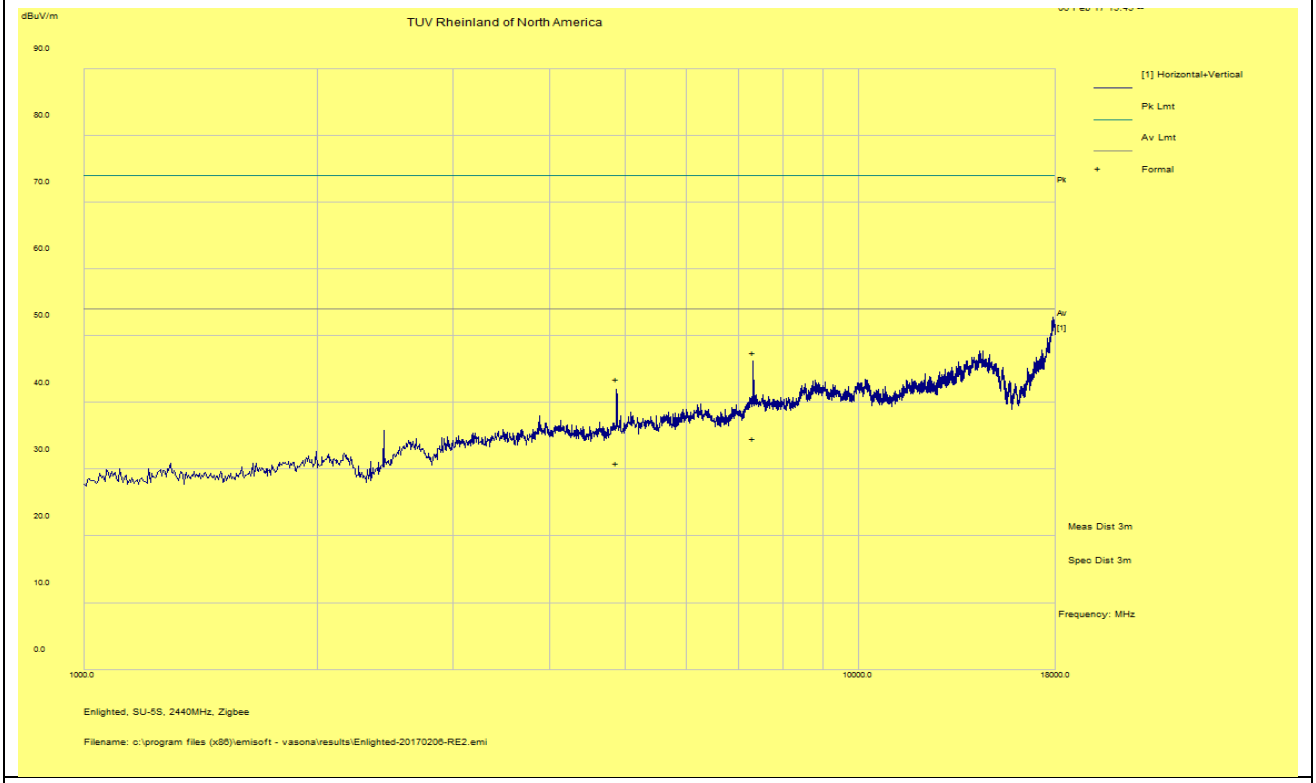
Note:

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 6 2017
EUT Model	SU-5S	**Temp / Hum in**	21° C / 37%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2440MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m – EMCO3115	**Performed by**	Eddie Mariscal

1 – 18 GHz Transmit at 2442 MHz (Mid Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
7321.525	60.87	2.21	-15.64	47.44	Pk	H	223	338	74	-26.56
4879.035	61.93	1.77	-20.14	43.56	Pk	H	230	361	74	-30.44
7321.525	48.02	2.21	-15.64	34.59	Ave	H	223	338	54	-19.41
4879.035	49.3	1.77	-20.14	30.93	Ave	H	230	361	54	-23.07



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

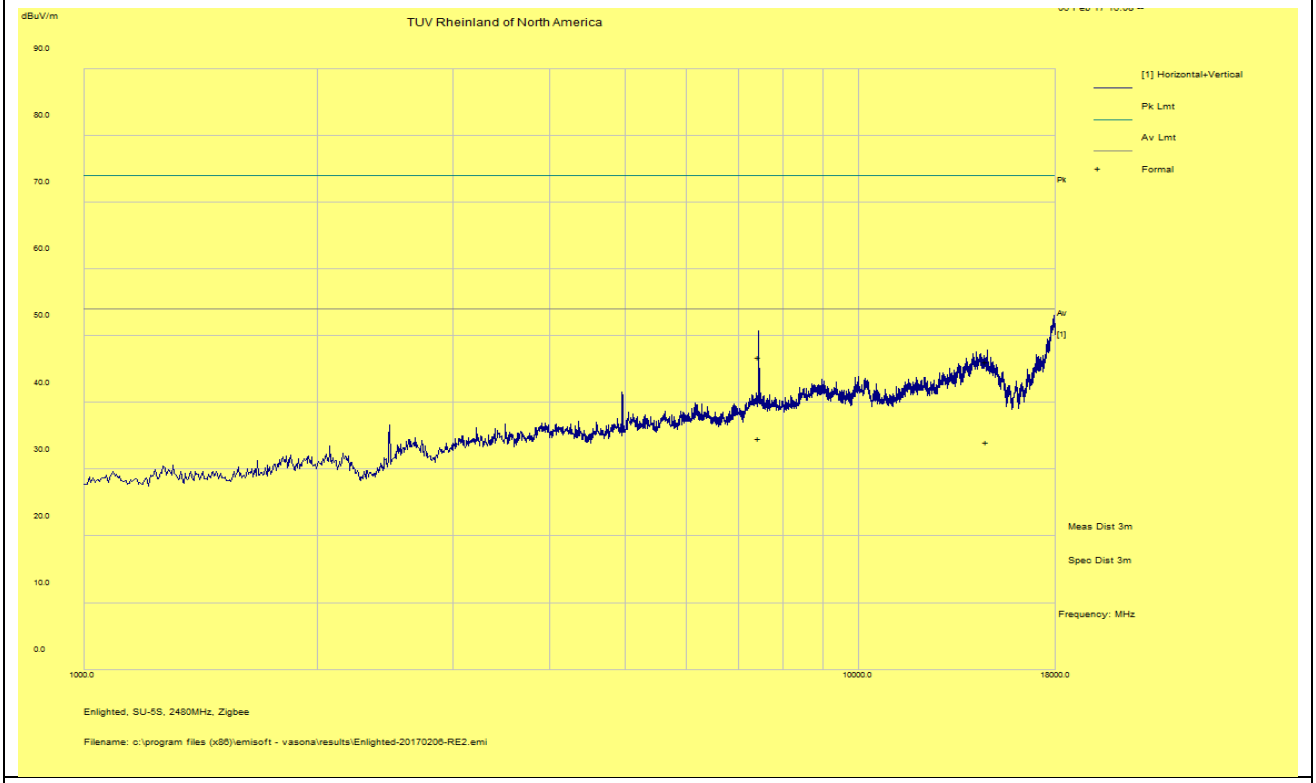
Note:

SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	Feb 6 2017
EUT Model	SU-5S	**Temp / Hum in**	21° C / 37%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2480MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m – EMCO3115	**Performed by**	Eddie Mariscal

1 – 18 GHz Transmit at 2480 MHz (High Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
7442.103	60.11	2.23	-15.59	46.74	Pk	H	226	344	74	-27.26
14674.85	51.92	3.33	-9.07	46.18	Pk	H	233	361	74	-27.82
7442.103	47.96	2.23	-15.59	34.6	Ave	H	226	344	54	-19.4
14674.85	39.82	3.33	-9.07	34.08	Ave	H	233	361	54	-19.92



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note:

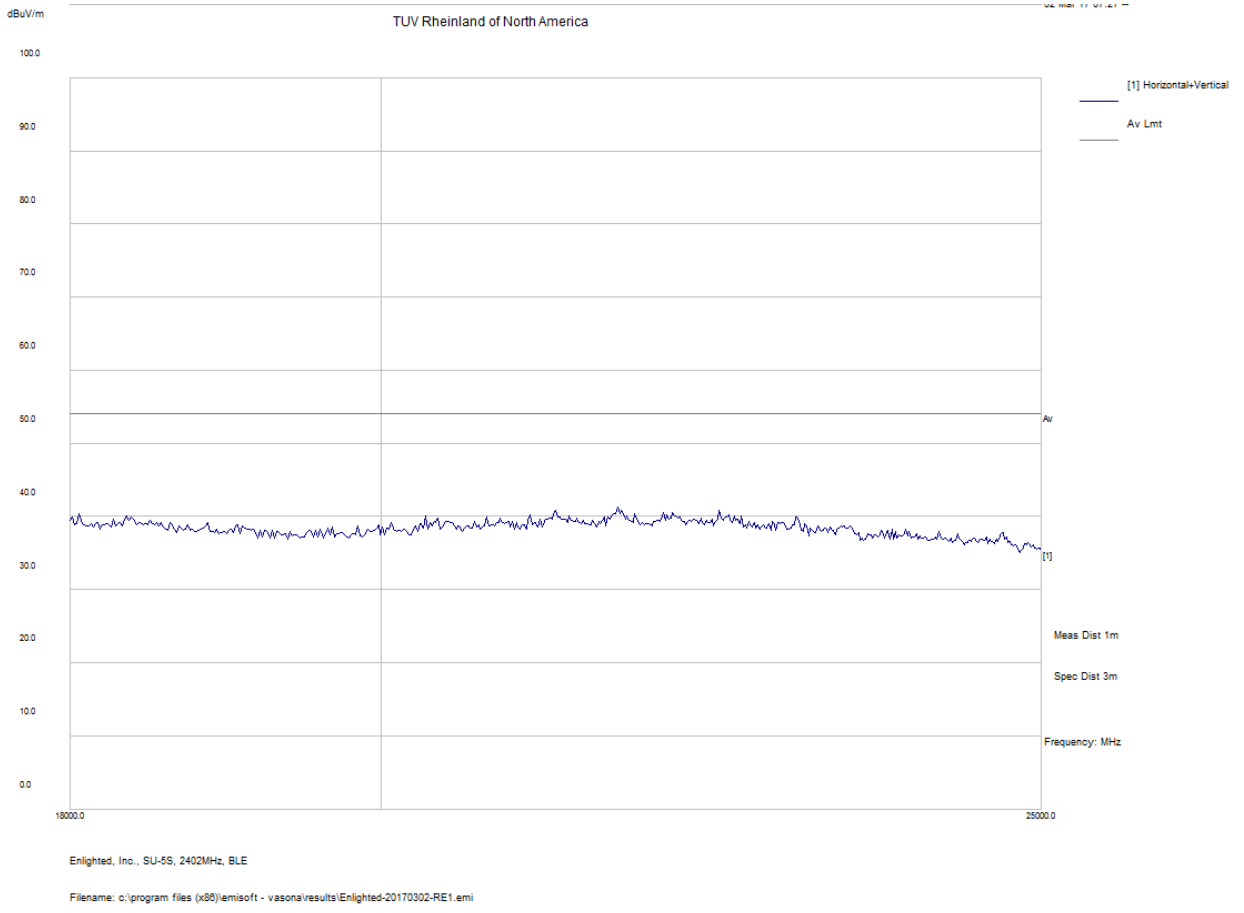
SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	March 2, 2017
EUT Model	SU-5S	**Temp / Hum in**	20° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2402MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	1m – AHA-840	**Performed by**	Eddie Mariscal

18 – 25 GHz Transmit at 2402 MHz (Low Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB

No EUT emissions were detected above the noise floor from 18-25GHz.



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note:

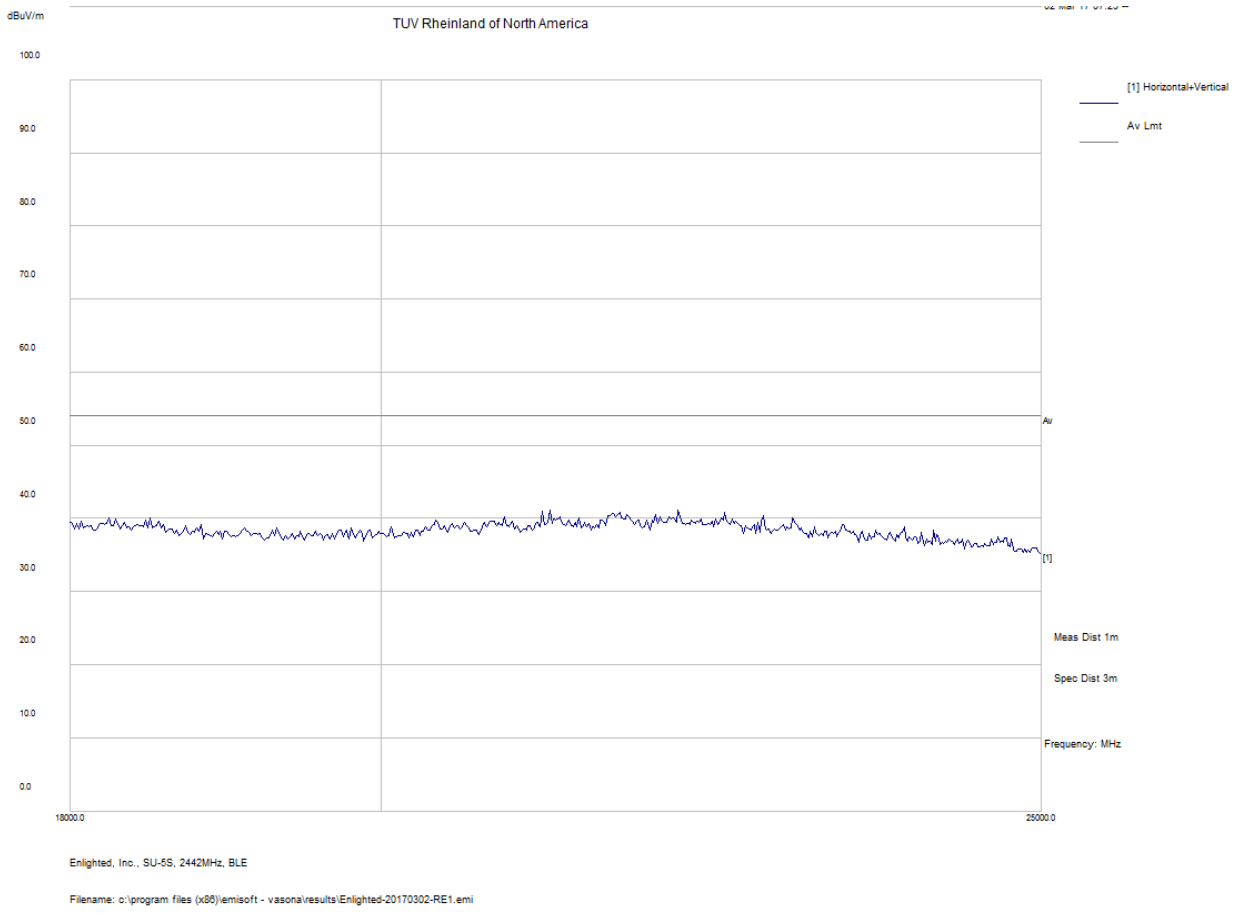
SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	March 2, 2017
EUT Model	SU-5S	**Temp / Hum in**	20° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2440MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	1m – AHA-840	**Performed by**	Eddie Mariscal

18 – 25 GHz Transmit at 2442 MHz (Mid Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB

No EUT emissions were detected above the noise floor from 18-25GHz.



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note:

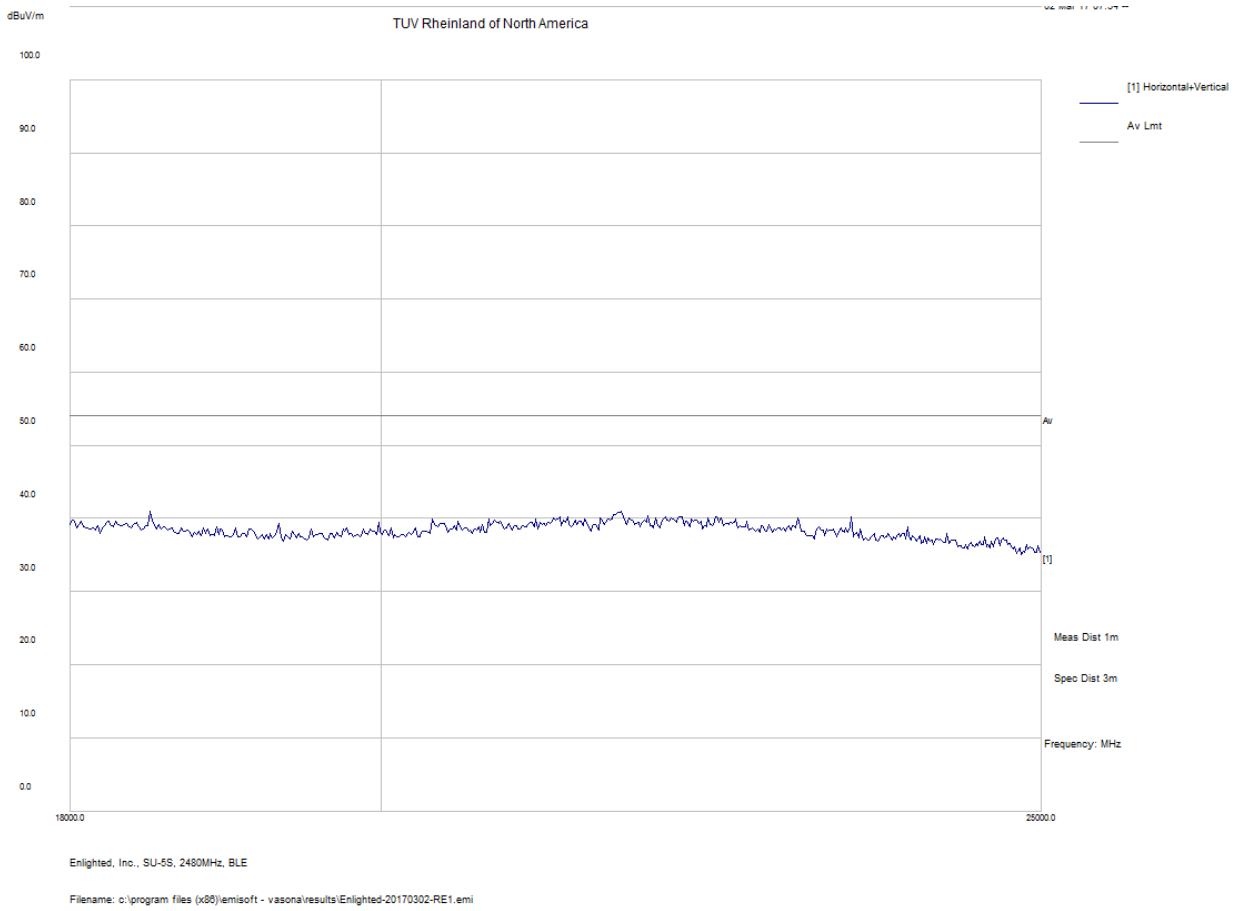
SOP 1 Radiated Emissions

EUT Name	Smart Sensor	**Date**	March 2, 2017
EUT Model	SU-5S	**Temp / Hum in**	20° C / 34%rh
EUT Serial	6854F5DE414E	**Temp / Hum out**	N/A
EUT Config.	2480MHz - BLE	**Line AC / Freq**	15VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	1m – AHA-840	**Performed by**	Eddie Mariscal

18 – 25 GHz Transmit at 2480 MHz (High Channel)

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB

No EUT emissions were detected above the noise floor from 18-25GHz.



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note: No significant emissions were observed above the spectrum noise floor.

4.6 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: 2015 and RSS Gen: 2015 Sect. 8.8.

4.6.1 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 Lab 5. 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.

4.6.1.1 Deviations

There were no deviations from this test methodology.

4.6.2 Test Results

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

Table 12: AC Conducted Emissions – Test Results

SOP 2 Conducted Emissions

EUT Name	Smart Sensor	**Date**	22 Apr 2017
EUT Model	SU-5S	**Temp / Hum in**	23° C / 37% rh
EUT Serial	6854F5DE4386	**Temp / Hum out**	N/A
EUT Config.	Normal Operating mode	**Line AC / Freq**	120Vac / 60Hz
Standard	CFR47 Part 15.207 and RSS Gen	**RBW / VBW**	9 kHz / 30 kHz
Lab/LISN	Lab #5 /Com-Power, Line 1	**Performed by**	Eddie Mariscal

Frequency	Raw	Limiter	Ins. Loss	Level	Detector	Line	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV		Line	dBuV	dB	
0.17	33.42	9.82	0.05	43.29	QP	Neutral	65.01	-21.71	Pass
0.17	33.34	9.82	0.05	43.21	QP	Neutral	64.93	-21.71	Pass
24.00	28.62	10.08	-0.06	38.64	QP	Neutral	60	-21.36	Pass
29.82	21.2	10.12	-0.06	31.26	QP	Neutral	60	-28.74	Pass
0.20	27.47	9.83	0.04	37.34	QP	Neutral	63.67	-26.33	Pass
29.99	19.19	10.12	-0.06	29.25	QP	Neutral	60	-30.75	Pass
0.17	8.78	9.82	0.05	18.65	Ave	Neutral	55.01	-36.35	Pass
0.17	5.83	9.82	0.05	15.7	Ave	Neutral	54.93	-39.23	Pass
24.00	26.48	10.08	-0.06	36.5	Ave	Neutral	50	-13.5	Pass
29.82	2.43	10.12	-0.06	12.49	Ave	Neutral	50	-37.51	Pass
0.20	13.05	9.83	0.04	22.92	Ave	Neutral	53.67	-30.74	Pass
29.99	12.09	10.12	-0.06	22.15	Ave	Neutral	50	-27.85	Pass
0.16	33.15	9.82	0.05	43.02	QP	Live	65.31	-22.29	Pass
0.18	32.83	9.83	0.05	42.71	QP	Live	64.62	-21.92	Pass
24.00	29.41	10.08	-0.06	39.43	QP	Live	60	-20.57	Pass
0.20	26.08	9.83	0.04	35.95	QP	Live	63.63	-27.68	Pass
29.83	18.98	10.12	-0.06	29.04	QP	Live	60	-30.96	Pass
12.04	19.86	10	0.01	29.87	QP	Live	60	-30.13	Pass
0.16	6.51	9.82	0.05	16.38	Ave	Live	55.31	-38.94	Pass
0.18	5.34	9.83	0.05	15.22	Ave	Live	54.62	-39.41	Pass
24.00	27.04	10.08	-0.06	37.06	Ave	Live	50	-12.94	Pass
0.20	14.38	9.83	0.04	24.25	Ave	Live	53.63	-29.38	Pass
29.83	0.5	10.12	-0.06	10.56	Ave	Live	50	-39.44	Pass
12.04	19.72	10	0.01	29.73	Ave	Live	50	-20.27	Pass

Spec Margin = QP./Ave. - Limit, ± Uncertainty

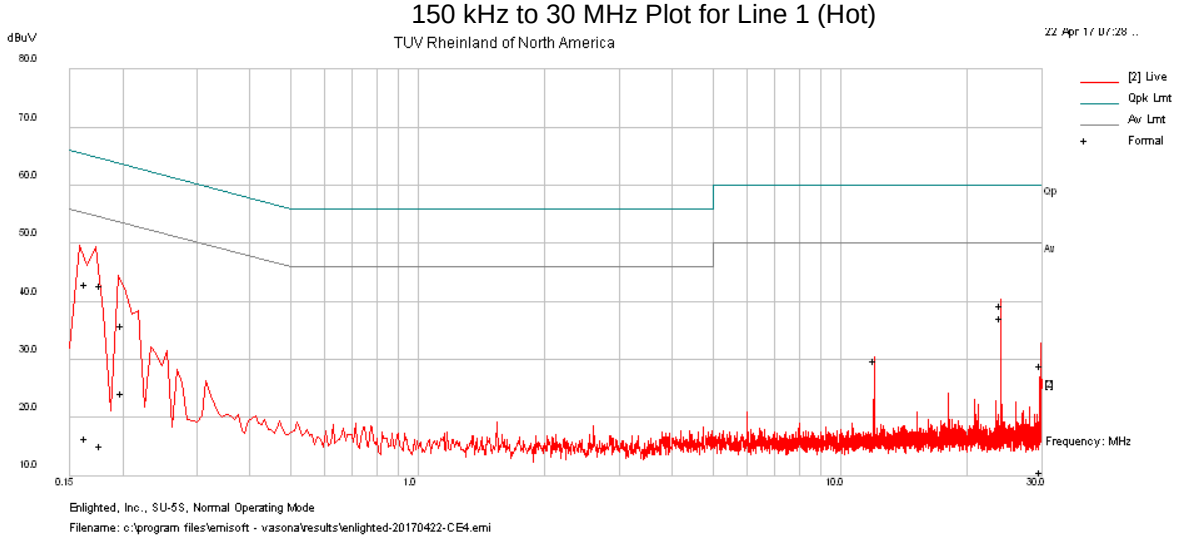
Combined Standard Uncertainty $u_c(y)$ = ± 1.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes:

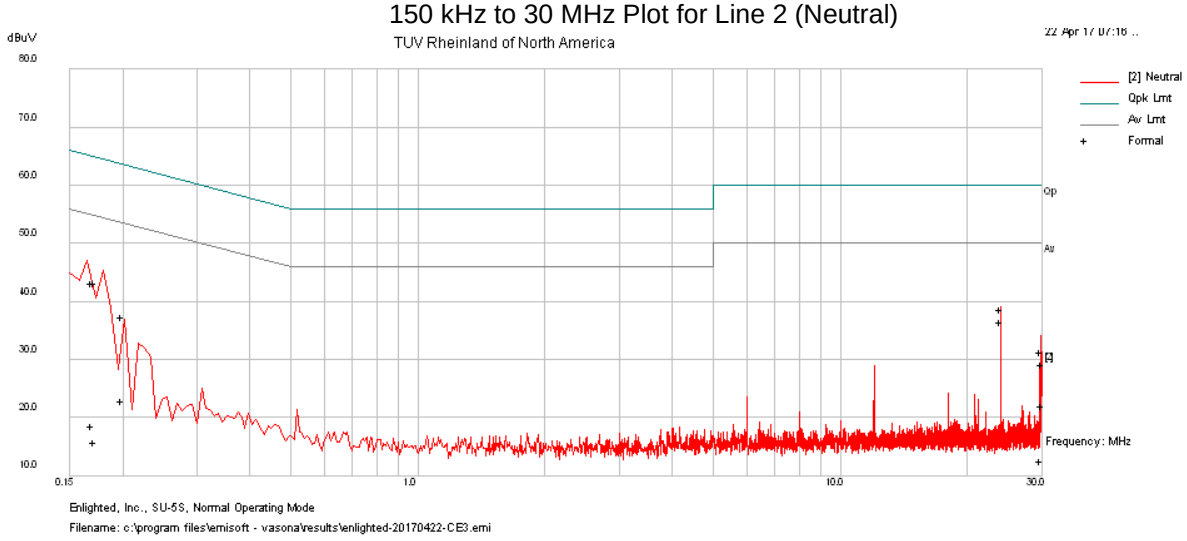
SOP 2 Conducted Emissions

EUT Name	Smart Sensor	**Date**	22 Apr 2017
EUT Model	SU-5S	**Temp / Hum in**	23° C / 37% rh
EUT Serial	6854F5DE4386	**Temp / Hum out**	N/A
EUT Config.	Normal Operating mode	**Line AC**	120Vac / 60Hz
Standard	CFR47 Part 15.207 and RSS Gen	**RBW / VBW**	9 kHz / 30 kHz
Lab/LISN	Lab #5 /Com-Power, Line 1	**Performed by**	Eddie Mariscal

150 kHz to 30 MHz Plot for Line 1 (Hot)



150 kHz to 30 MHz Plot for Line 2 (Neutral)



4.7 Maximum Permissible Exposure

4.7.1 Test Methodology

In this section, we try to prove the safety of radiation harmfulness to the human body for our product. The KDB 447498 D01v06 General RF Exposure Guidance is followed. The Gain of the antenna used in this calculation is declared by the manufacturer, and the maximum average power input to the antenna is measured. Using the general SAR test exclusion guidance in Section 4.3 of KDB 447498 D01v06, we show that the device meets the SAR exclusion threshold found in Appendix A of KDB 447498 D01v06 and the SAR exemption limits found in table 1 of RSS-102 Issue 5.

ISED accepts the KDB 447498 D01v06 Procedure.

4.7.2 FCC KDB 447498 D01v06 – General SAR Test Exclusion Guidance

The SAR exclusion threshold conditions are listed:
1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by the following formula:

$$\text{Exclusion Threshold} = [\ P / d\ ] * [\sqrt{f}]$$

Where

P = max power of channel (including tune-up tolerance) in mW
d = min. test separation distance in mm
f = the RF channel transmit frequency in GHz
Power and distance are rounded to the nearest mW and mm before calculation
The result is rounded to one decimal place for comparison

Limits: ≤ 3.0 for 1-g SAR ≤ 7.5 for 10-g extremity SAR

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

4.7.3 EUT Operating Condition

The software provided by the manufacturer enabled the EUT to transmit data at lowest, middle and highest channel individually.

4.7.4 Classification

The antenna of the product, under normal use condition, is less than 20cm away from the body of the user. This device is classified as a **Portable Device**.

4.7.5 SAR Test Exclusion Evaluation

FCC SAR Exclusion Threshold Calculation

Mode	Frequency (GHz)	Min. Distance (mm)	Max Power (dBm)	Max Power (mW)	Calulated Excl. Threshold	1-g SAR Limit	10-g extremity SAR Limit	Result
BLE 4.0	2.402	5	3.24	2.11	0.653	≤3.0	≤7.5	Exempted *
802.15.4	2.440	5	3.47	2.22	0.688	≤3.0	≤7.5	Exempted *

Note:
1. Since EUT can operate at distance less than 50 mm, the minimum distance, 5 mm, was used for calculation per condition #1 of SAR Exclusion Threshold.
2. The maximum output power was taken from Table 2 of "Enlighted - FCC –IC 2.4GHz Report – 31760333 001".
3. (*) The calculated threshold is less than 3.0; therefore, EUT is SAR exempted for head and body usage.

RSS-102 SAR Exclusion Calculation

Mode	Frequency (GHz)	Min. Distance (mm)	Max Power (dBm)	Max Power (mW)	SAR Exemption Limit (mW)	Result
BLE 4.0	2.402	5	3.24	2.11	≤4	Exempted *
802.15.4	2.440	5	3.47	2.22	≤4	Exempted *

Note:
1. Since EUT can operate at distance less than 50 mm, the minimum distance, 5 mm, was used for calculation per condition #1 of SAR Exclusion Threshold.
2. The maximum output power was taken from Table 2 of "Enlighted - FCC –IC 2.4GHz Report – 31760333 001".
3. (*) The maximum power in mW is below the limit of 4mW, therefore, the EUT is SAR exempted for head and body usage.

5 Test Equipment List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Bilog Antenna	Sunol Sciences	JB3	A102606	06/15/2016	06/15/2017
Horn Ant. (1-18GHz)	EMCO	3115	9710-5301	10/08/2015	10/08/2017
Antenna (18-40 GHz)	Com-Power	AHA-840	105005	07/08/2015	07/08/2017
Spectrum Analyzer	Agilent	N9030A	MY52350885	05/17/2016	05/17/2017
Spectrum Analyzer	Agilent	N9038A	MY52260210	01/16/2017	01/16/2018
Preamplifier	Sonoma Instruments	310	185516	01/19/2017	01/19/2018
Preamplifier	Miteq	8449B	2020728	11/12/2016	11/12/2017
Notch Filter	Micro-Tronics	BRM50716	037	07/29/2016	07/29/2017
EMI Receiver	Rohde & Schwarz	ESIB 40	100180	04/28/2017	04/28/2018
Transient Limiter	HP	11947A	2820A00154	01/18/2017	01/18/2018
LISN	Com-Power	LI-200	12100	01/16/2017	01/16/2018

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 13: Customer Information

Company Name	Enlighted, Inc.
Address	930 Benecia Ave
City, State, Zip	Sunnyvale, CA 94085
Country	USA
Phone	(408) 385-9479

Table 14: Technical Contact Information

Name	Stewart Kuan
E-mail	Stewart.kuan@enlightedinc.com
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6.3 Equipment Under Test (EUT)

Table 15: EUT Specifications

EUT Specifications	
Dimensions	Height: 20mm Length: 80mm Width: 80mm
Power Input	12DC to 24VDC (15VDC Nominal)
Environment	Home/Indoor/Light Industrial
Operating Temperature Range:	-10 to +50 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No
Hardware Version	Nordic nRF52832 v1.2
RF Software Version	Serial Console via PuTTY
Operating Modes	1. BLE 4.0 2. IEEE 802.15.4
Transmitter Frequency Band	2.4 GHz – 2.4835 GHz
Max. Rated Power Output	See Channel Planning Table.
Power Setting @ Operating Channel	See Channel Planning Table.
Antenna Type	Qty 1: Meandered PIFA on Main PCBA
Antenna Gain	+0 dBi
Modulation Type	☐ AM ☐ FM ☐ DSSS ☐ OFDM ☒ Other describe: GFSK
Data Rate	BLE: 1Mbps IEEE 802.15.4: 250kbps
TX/RX Chain (s)	Single
Type of Equipment	☐ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other: Ceiling-mount
Note:	

Table 16: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
Antenna 1	Meandered PIFA	2.4GHz Integral Antenna	0.0

Table 17: EUT Channel Power Specifications – BLE 4.0

Software Power Setting	Channel No.	Frequency (MHz)	Target Power Value dBm
			BLE 4.0
0	37	2402	4.0
0	18	2442	4.0
0	39	2480	4.0
Note 1: The adjusted power target values are updated at the evaluated frequencies. **Note 2:** The target power is the conducted power that should be produced by the given software power setting.			

Table 18: EUT Channel Power Specifications – IEEE 802.15.4

Software Power Setting	Channel No.	Frequency (MHz)	Target Power Value dBm
			IEEE 802.15.4
0	11	2405	4.0
0	18	2440	4.0
13	26	2480	-6.0 (Note 3)
Note 1: The adjusted power target values are updated at the evaluated frequencies. **Note 2:** The target power is the conducted power that should be produced by the given software power setting. **Note 3:** The power level was reduced to comply with the radiated bandedge measurement.			

Table 19: 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	Cat3 Patch cable	No	Not specified	Not Applicable

Table 20: Support Equipment

Equipment	Manufacturer	Model	Serial	Used for
Laptop	Lenovo	X201	71Y3514	Configure channel, power, etc.
Note: None.				

Table 21: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.247
Smart Sensor (SU-5S)	6854F5DE4386	Integrated Antenna	AC Conducted Emissions
	6854F5DE414E	Integrated Antenna	Radiated Bandedge Emissions, Radiated Spurious Emissions
	6854F5DE409E	Female SMA	RF Output Power, Power Spectral Density, Occupied Bandwidth, Band-Edge, Out-of-Band Emissions

Table 22: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Photo (X-Axis)	Setup Photo (Y-Axis)	Setup Photo (Z-Axis)
Smart Sensor	Custom Integrated	Transmit	EUT Upright	EUT lying down with interface cable exiting upward	EUT lying down with interface cable exiting right of EUT
Note: X-Axis was determined to be the worst-case.					

6.4 Test Specifications

Table 23: Test Specifications

Emissions and Immunity	
Standard	**Requirement**
CFR 47 Part 15.247	All
RSS 247 Issue 1	All

END OF REPORT