Emissions
Test Report

EUT Name: Compact Sensor

Model No.: SU-4E

CFR 47 Part 15.247:2015 and RSS-247:2015

Prepared for:

Enlighted , Inc.
930 Benecia Avenue
Sunnyvale, CA 94085 USA

Prepared by:

TUV Rheinland of North America, Inc.
1279 Quarry Lane, Ste. A
Pleasanton, CA 94566 U.S.A.
Tel: (925) 249-9123
Fax: (925) 249-9124
http://www.tuv.com/

Report/Issue Date:	April 10, 2016
Report Number:	31563521.001
Project Number:	0000134928
Revision Number	0

Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	04/10/2016	Original Document	N/A

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Enlighted , Inc. 930 Benecia Avenue Sunnyvale, CA 94085 USA
Requester / Applicant:	Deepak Kumar
Name of Equipment:	Compact Sensor
Model No.	SU-4E
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247:2015 and RSS-247:2015
Test Dates:	25 March 2016 to 10 April 2016

Guidance Documents:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v03r02

Test Methods:

Emissions: ANSI C63.10-2013, KDB 558074 D01 DTS Measurement Guidance v03r02

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.

Suresh Kondapalli	April 10, 2016	David Spencer	April 10, 2016
Test Engineer	Date	Laboratory Signature	Date

Testing Cert #3331.02 **US5254** **2932M-1**

1 Executive Summary 7

1.1 Scope 7

1.2 Purpose 7

1.3 Summary of Test Results 8

1.4 Special Accessories 9

1.5 Equipment Modifications 9

2 Laboratory Information 9

2.1 Accreditations & Endorsements 9

2.1.1 US Federal Communications Commission 9
2.1.2 NIST / A2LA 9
2.1.3 Canada – Industry Canada 9
2.1.4 Japan – VCCI 9
2.1.5 Acceptance by Mutual Recognition Arrangement 10

2.2 Test Facilities 10

2.2.1 Emission Test Facility 10
2.2.2 Immunity Test Facility 10

2.3 Measurement Uncertainty 11

2.3.1 Sample Calculation – radiated & conducted emissions 11
2.3.2 Measurement Uncertainty Emissions 11
2.3.3 Measurement Uncertainty Immunity 12

2.4 Calibration Traceability 12

3 Product Information 13

3.1 Product Description 13

3.2 Operating Mode 13

3.3 Unique Antenna Connector 14

3.3.1 Results 14

4 Emission Requirements – 2400 MHz to 2483.5 MHz Band 15

4.1 Output Power Requirements 15

4.1.1 Test Method 15
4.1.2 Results 16

4.2 Occupied Bandwidth 23

4.2.1 Test Method 23
4.2.2 Results 24

4.3 Power Spectral Density Requirements 31

4.1.1 Test Method 31
4.3.2 Results 31
Table 4: BLE mode 31

4.4 Out of Band Emission requirements 39

4.1.2 Results 39

4.5 Transmitter Spurious Emissions 48

4.6.1 Test Methodology 48

4.6.2 Transmitter Spurious Emission Limit 49
4.6.3 Test Results 49
4.6.4 Sample Calculation 72

4.3 Maximum Permissible Exposure 73
4.3.1 Test Methodology 73
4.3.2 RF Exposure Limit 73
4.3.3 EUT Operating Condition 73
4.3.4 Classification 74
4.3.5 Test Results 74
4.3.6 Sample Calculation 74

5 Test Equipment Use List 75

5.1 Equipment List 75

6 EMC Test Plan 76

6.1 Introduction 76

6.2 Customer 76

6.3 Equipment Under Test (EUT) 77

6.4 Test Specifications 80

Table 1: Summary of Test Results 8
Table 2: RF Output Power at the Antenna Port – Test Results 16
Table 3: Occupied Bandwidth – Test Results BLE 24
Table 3: Occupied Bandwidth – Test Results **ZigBee** 24
Table 4: **BLE mode** 31
Table 5: Band Edge Requirements – Test Results BLE 39
Table 6: Transmit Spurious Emission at Restricted Band Edge Requirements 50
Table 8: Customer Information 76
Table 9: Technical Contact Information 76
Table 10: EUT Specifications 77
Table 11: Interface Specifications 78
Table 12: Supported Equipment 78
Table 13: Description of Sample used for Testing 78
Table 14: Description of Test Configuration used for Radiated Measurement. 78
Table 15: Final Test Mode for 2402 MHz to 2480MHz Channels 79
Table 16: Test Specifications 80

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.247:2015 and RSS-247:2015 based on the results of testing performed on 25 March 2016 to 10 April 2016 on the Compact Sensor Model SU-4E 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 report documents the 2.4GHz radio characteristics for the SU-4E

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C63.4:2014/ ANSI C63.10:2013	Test Parameters	Measured Value	Result
2402 MHz to 2480 MHz Band BLE				
Spurious Emission in Transmitted Mode	CFR47 15.209, CFR47 15.247 (d) RSS-GEN Sect.8.9, RSS 247 Sect. 6.2.1.2	Class B	36.44 dBuV -3.56dB (Margin)	**Complied**
Restricted Bands of Operation	CFR47 15.205, RSS GEN Sect.8.10	Class B		**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS-247 Sect. 5.2 (2)	8 dBm/ 3 kHz	-40.92dBm	**Complied**
Occupied Bandwidth	CFR47 15.247 (a1), RSS GEN Sect.6.6	≥ 500 kHz	6dB BW = 675 kHz 99% BW =1.092 kHz	**Complied**
Maximum Transmitted Power	CFR47 15.247 (b1), RSS 247 Sect. 5.4.4	30 dBm w/ 6 dBi antenna	-20.52dB (0.009mW)	**Complied**
Out of Band Emission	CFR47 15.247 (d), RSS 247 Sect. 5.5	-30 dBr	-51.73dBm	**Complied**
RF Exposure	CFR47 15.247 (i), 2.1091/ RSS-102 Section 2.5.2	General Population	Within the limits	**Complied**

Note: 1. Meet restricted band emission requirements.
2. This report is only documented for 2402 – 2480MHz.

Test	Test Method ANSI C63.4:2014/ ANSI C63.10:2013	Test Parameters	Measured Value	Result
2402 MHz to 2480 MHz Band ZigBee				
Spurious Emission in Transmitted Mode	CFR47 15.209, CFR47 15.247 (d) RSS-GEN Sect.8.9, RSS 247 Sect. 6.2.1.2	Class B	32.59dBuV/m -7.41dB (Margin)	**Complied**
Restricted Bands of Operation	CFR47 15.205, RSS GEN Sect.8.10	Class B		**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS-247 Sect. 5.2 (2)	8 dBm/ 3 kHz	-3.05dBm	**Complied**
Occupied Bandwidth	CFR47 15.247 (a1), RSS GEN Sect.6.6	≥ 500 kHz	6dB BW = 1333 kHz 99% BW = 2.054 kHz	**Complied**
Maximum Transmitted Power	CFR47 15.247 (b1), RSS 247 Sect. 5.4.4	30 dBm w/ 6 dBi antenna	2.89dBm (1.94mW)	**Complied**
Out of Band Emission	CFR47 15.247 (d), RSS 247 Sect. 5.5	-30dBr	Margin - 3.21 dB	**Complied**
RF Exposure	CFR47 15.247 (i), 2.1091 / RSS -102 Section 2.5.2	General Population	Within the limits	**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 (US5254). 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 17025:2005 and ISO 9002 (Lab Code 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-0031

VCCI Registration No. for Santa Clara: A-0032

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. The 2305 Mission College, Santa Clara, 95054, USA location is considered a Pleasanton annex.

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 C63.4-2009, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Lab Code 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 C63.4-2009, 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 Emissions

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 ± 11.6%.	Per IEC 61000-4-8

Thermo KeyTek EMC Pro

The estimated combined standard uncertainty for EFT fast transient immunity measurements is ± 5.84%.
The estimated combined standard uncertainty for surge immunity measurements is ± 5.84 %.
The estimated combined standard uncertainty for voltage variation and interruption measurements is ± 3.48%.

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.

Measurement Uncertainty – Radio Testing

The estimated combined standard uncertainty for frequency error measurements is ± 3.88 Hz
The estimated combined standard uncertainty for carrier power measurements is ± 1.59 dB.
The estimated combined standard uncertainty for adjacent channel power measurements is ± 1.47 dB.
The estimated combined standard uncertainty for modulation frequency response measurements is ± 0.46 dB.
The estimated combined standard uncertainty for transmitter conducted emission measurements is ± 4.01 dB

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

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005.

3 Product Information

3.1 Product Description

The SU-4E 6-wire BLE Compact Sensor SU-4E-01 is deployed at every fixture throughout a building, working with all types of lamps–fluorescent, LED and others.

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 a 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.

3.2 Operating Mode

A description of the operation mode is given in the Test Plan Section. In the case of a 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 and to place the EUT in the most susceptible state for immunity testing.

3.3 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.

3.3.1 Results

The SU-4E uses the permanently attached PCB trace antennas inside the device. Refer to EUT Photo for details. There is no external antenna connection available.

4 Emission Requirements – 2400 MHz to 2483.5 MHz Band

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.

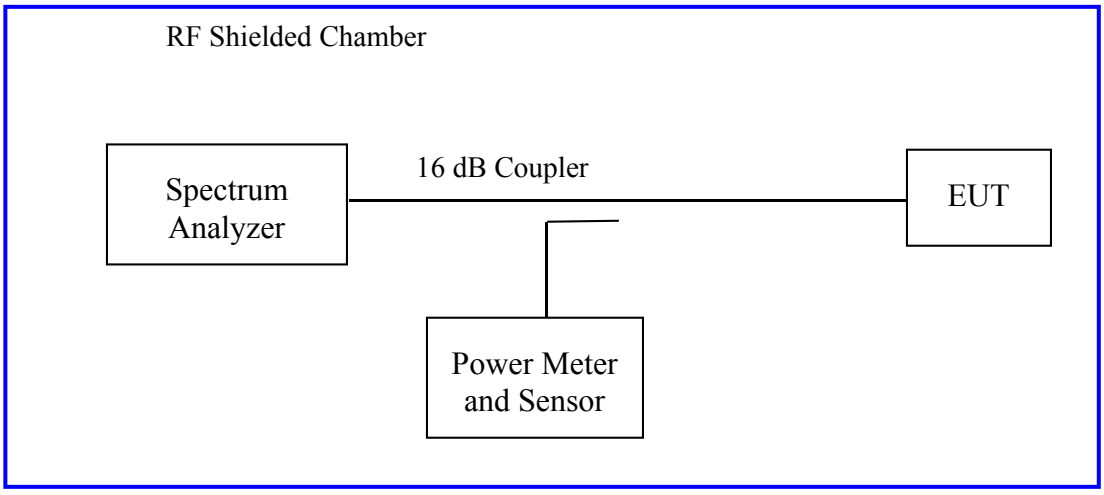
The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b1) and RSS 247 Sect. 5.4.4: 2015

Frequency hopping systems in the 2400-2483.5 MHz band: 1 watts.

4.1.1 Test Method

The conducted method was used to measure the channel power output according to ANSI C63.10:2013 Section 11.9.2.2.2. The measurement was performed with modulation per CFR47 Part 15.247 (b 1):2015 and RSS-247 Sect. 5.4.2. This test was conducted on 3 channels on SU-4E. The worst mode results are 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).

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

Test Conditions: Conducted Measurement		**Date**: March 28, 2016	
Antenna Type: Integrated		**Power Setting:** Default	
Max. Antenna Gain: 0 dBi		**Signal State:** Modulated	
Duty Cycle: 100 %		**Data Rate:** Default	
Ambient Temp.: 23º C		**Relative Humidity:** 33 %RH	
802.15.1 Mode			
Operating Channel	**Limit [dBm]**	**Power [dBm]**	**Margin [dB]**
2402 MHz	+30.00	-20.52	-50.52
2440 MHz	+30.00	-21.88	-51.88
2480 MHz	+30.00	-23.81	-53.81
Note:			

Test Conditions: Conducted Measurement		**Date**: March 28, 2016	
Antenna Type: Integrated		**Power Setting:** Default	
Max. Antenna Gain: 0 dBi		**Signal State:** Modulated	
Duty Cycle: 100 %		**Data Rate:** Default	
Ambient Temp.: 23º C		**Relative Humidity:** 33 %RH	
802.15.4 Mode			
Operating Channel	**Limit [dBm]**	**Power [dBm]**	**Margin [dB]**
2405 MHz	+30.00	2.40	-27.60
2440 MHz	+30.00	2.73	-27.27
2480 MHz	+30.00	2.89	-.27.11
Note:			

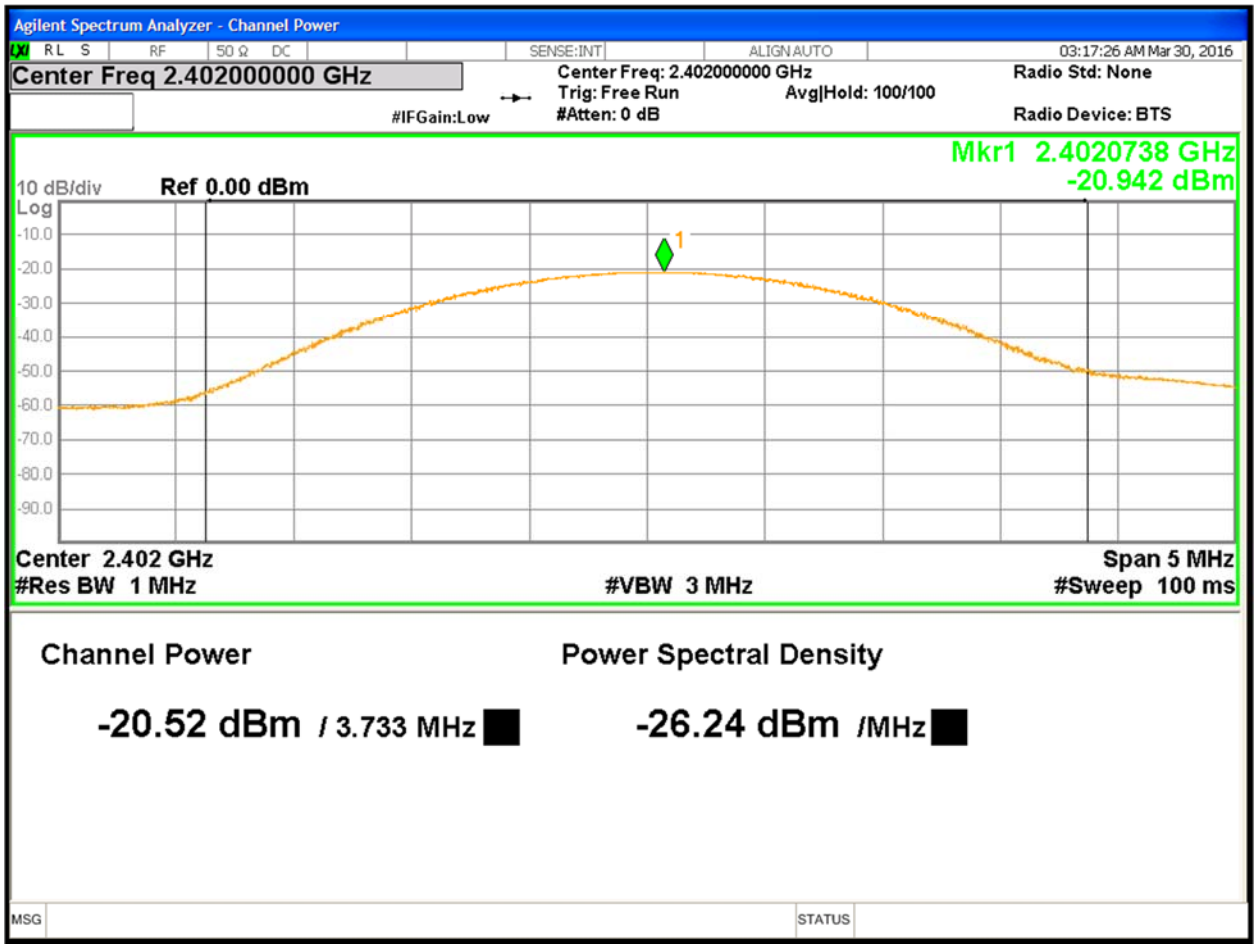


Figure 1: Maximum Transmitted Power, 2402 MHz

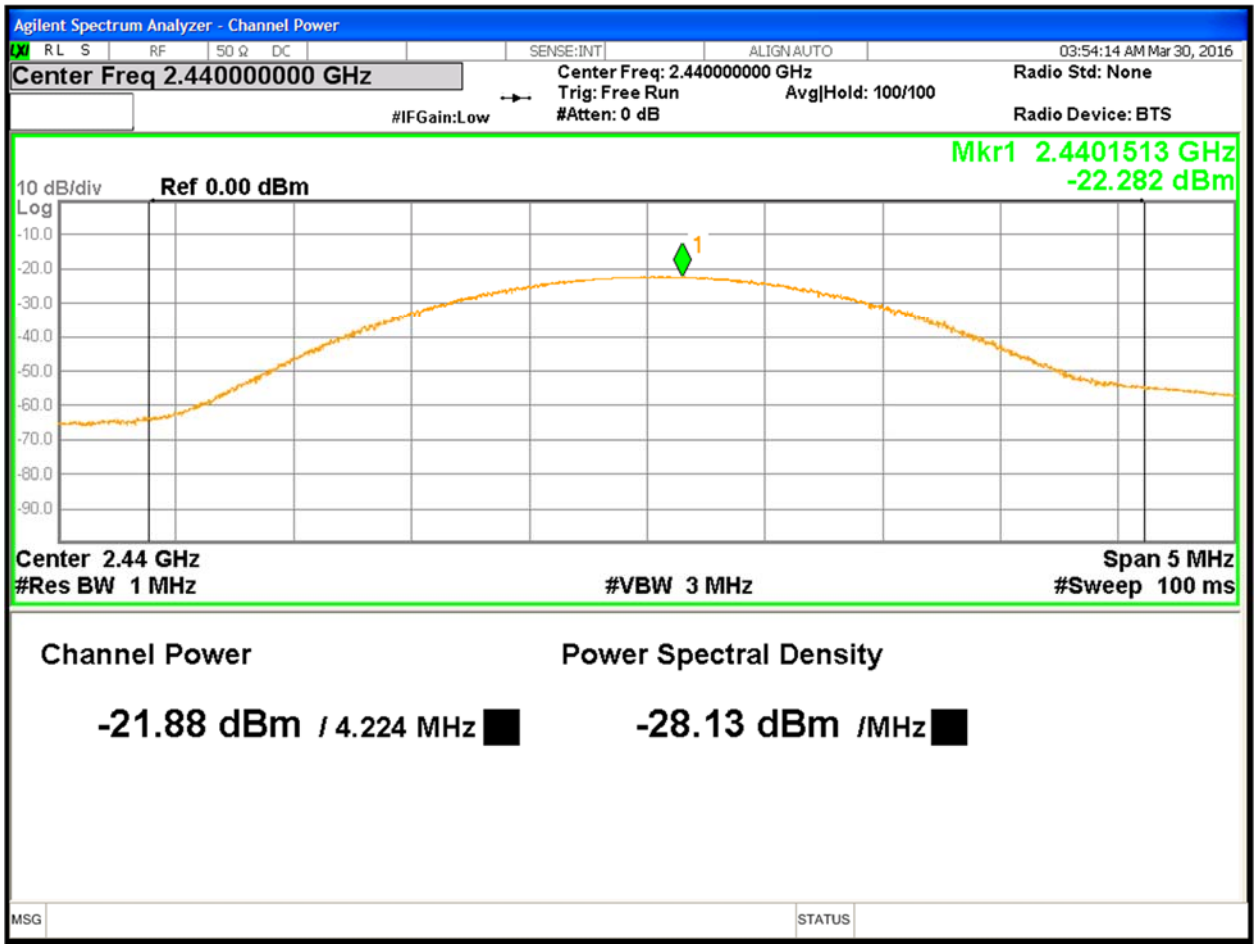


Figure 2: Maximum Transmitted Power, 2440 MHz

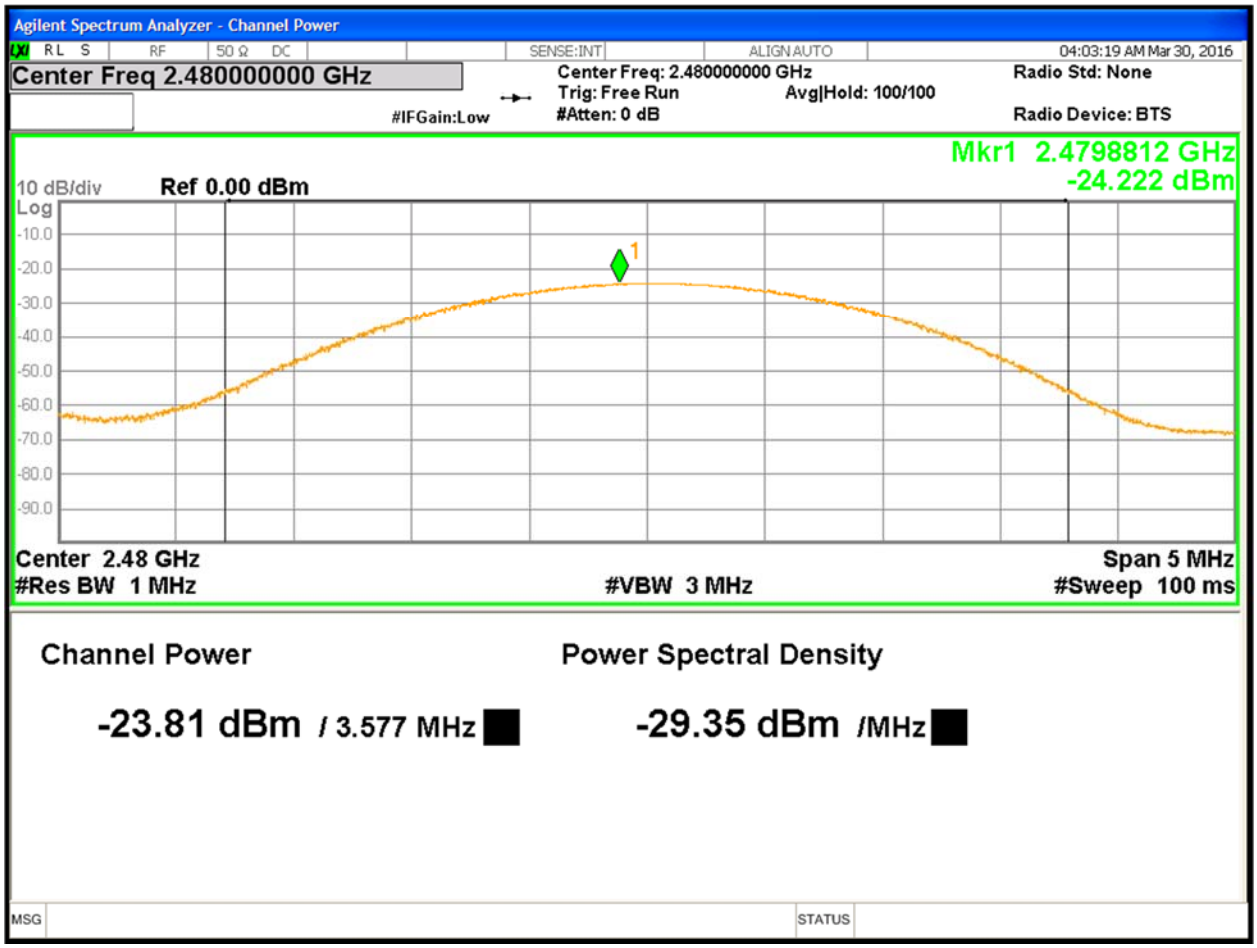


Figure 3: Maximum Transmitted Power, 2480 MHz

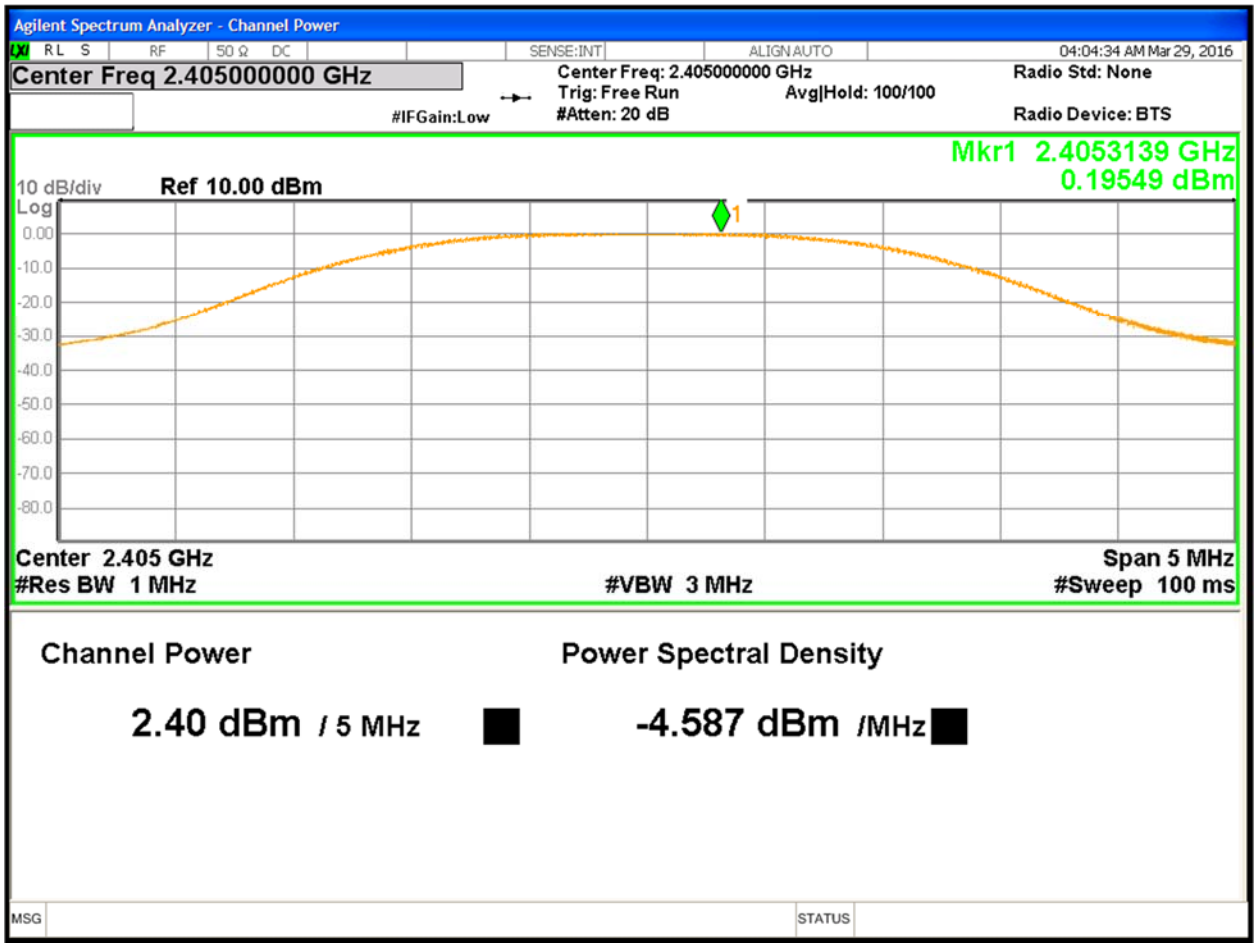


Figure 4: Maximum Transmitted Power, 2405 MHz ZigBee

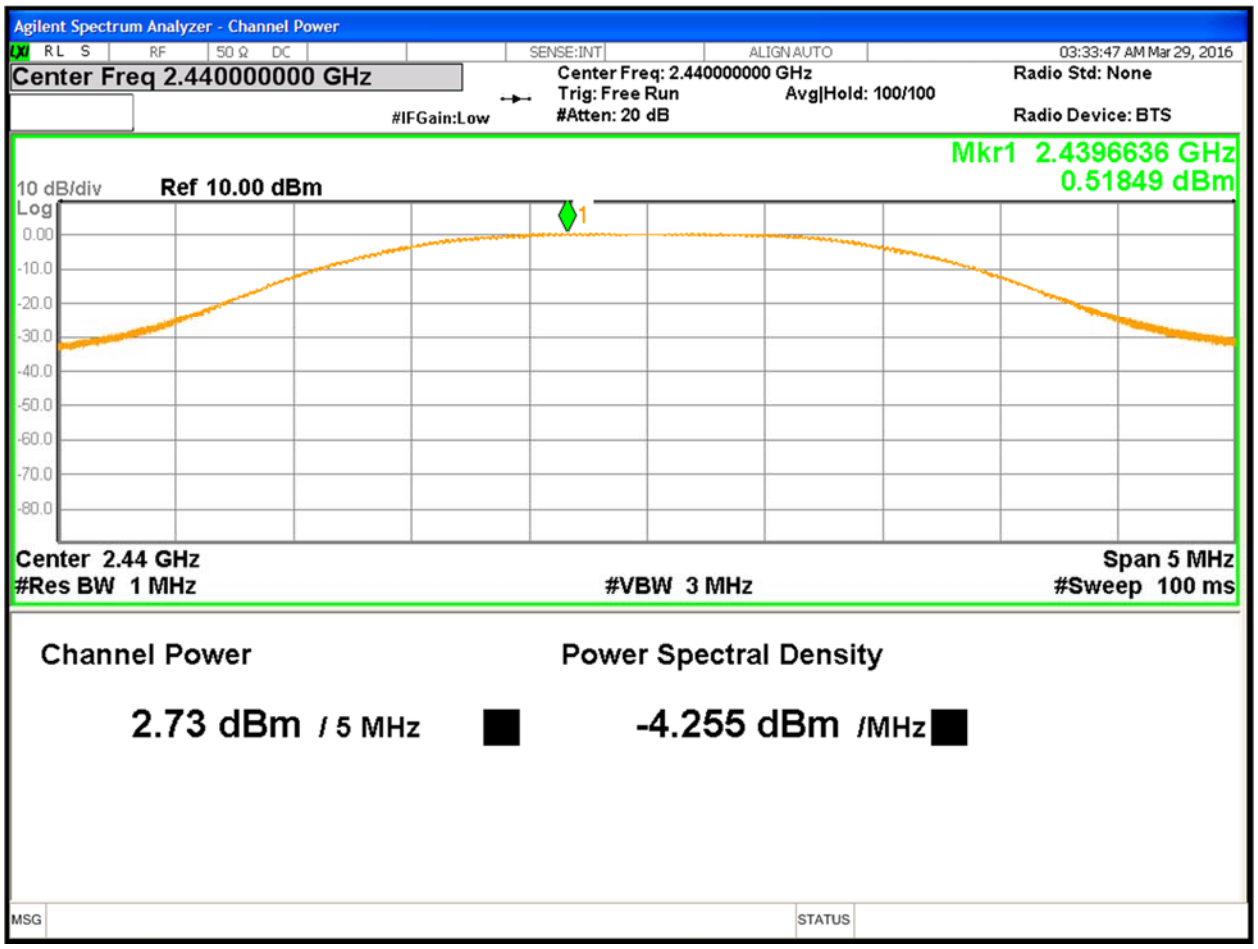


Figure 5: Maximum Transmitted Power, 2440 MHz ZigBee

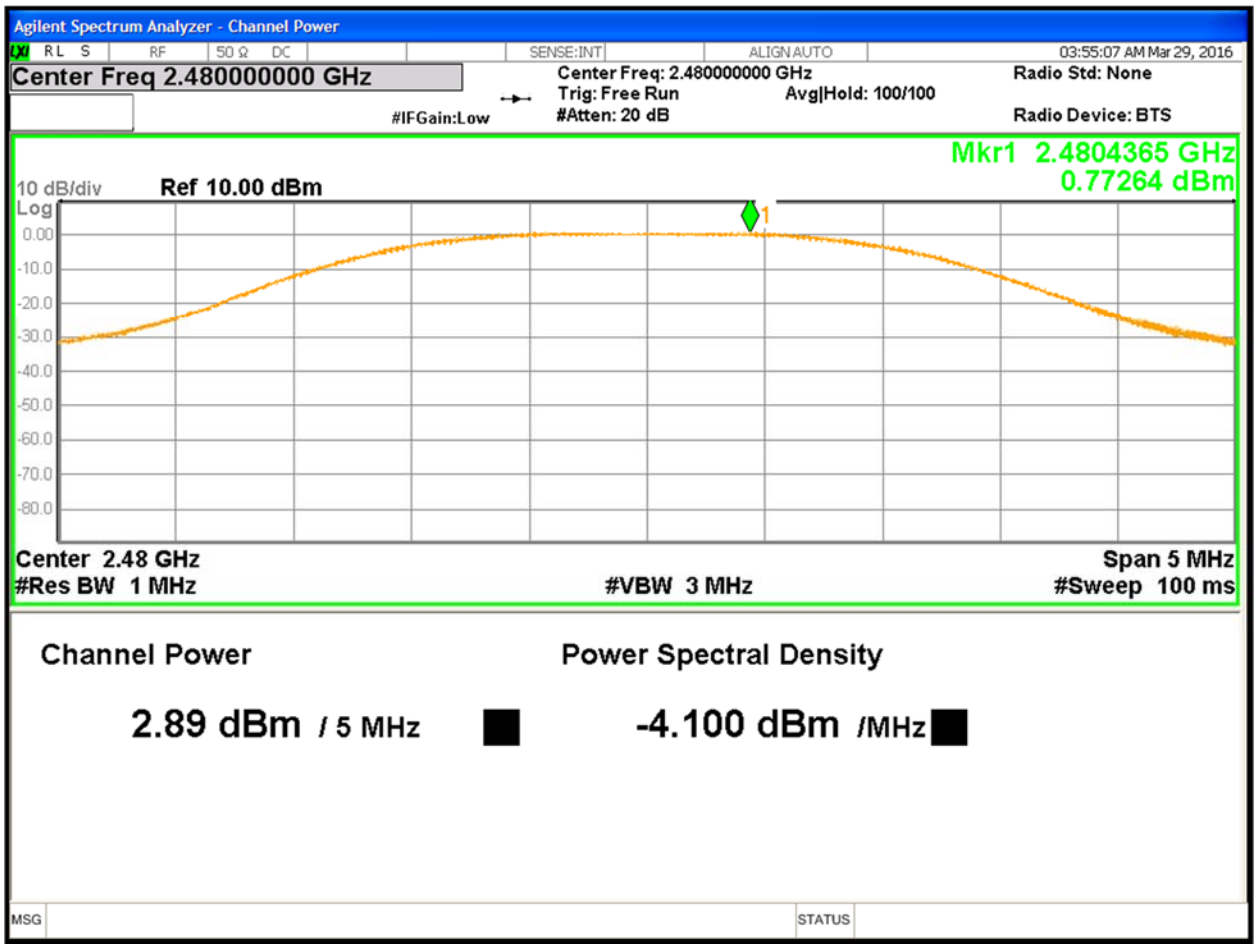


Figure 6: Maximum Transmitted Power, 2480 MHz ZigBee

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.

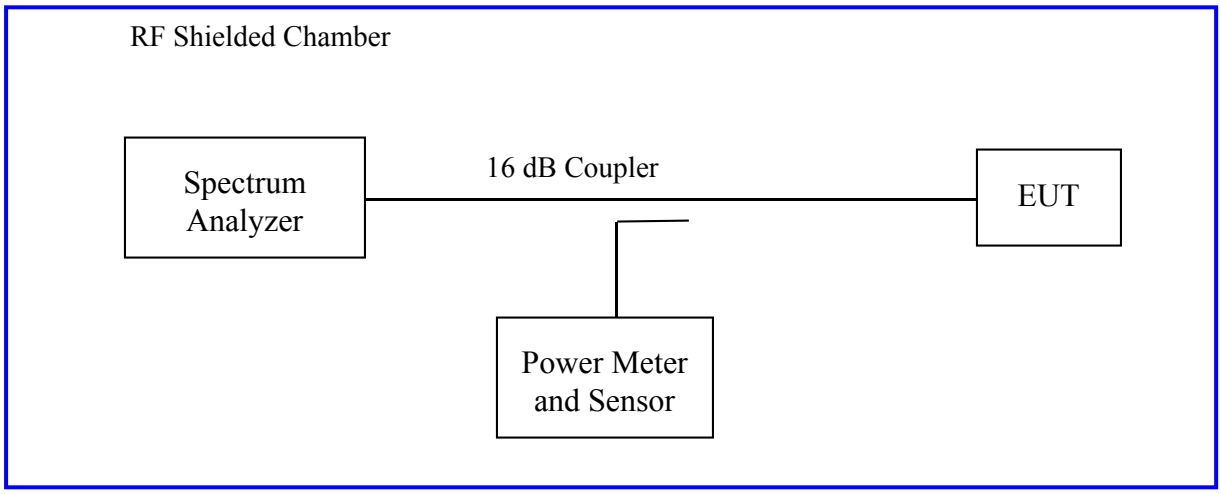
The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

20 dB bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer.

4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth. The measurement was performed with modulation per CFR47 15.247(a) (1) 2015 and RSS 247 Sect. 5.2.1. This test was conducted on 3 channels on SU-4E The worst sample result indicated below.

Test Setup:



4.2.2 Results

These measurements were used for information only

Table 3: Occupied Bandwidth – Test Results BLE

Test Conditions: Conducted Measurement	**Date:** March 28, 2016	
Antenna Type: Integrated	**Power Setting:** Fixed.	
Max. Antenna Gain: +0 dBi	**Signal State:** Modulated	
Duty Cycle: 100 %	**Data Rate:** Fixed	
Ambient Temp.: 23º C	**Relative Humidity:** 33 %RH	
Bandwidth (MHz)		
Freq. (MHz)	**6dB Bandwidth MHz**	**99% Bandwidth MHz**
2402	0.673	1.092
2440	0.660	1.087
2480	0.675	1.080
Note: Worst case for frequency range is plotted below.		

Table 4: Occupied Bandwidth – Test Results **ZigBee**

Test Conditions: Conducted Measurement	**Date:** March 28, 2016	
Antenna Type: Integrated	**Power Setting:** Fixed.	
Max. Antenna Gain: +0 dBi	**Signal State:** Modulated	
Duty Cycle: 100 %	**Data Rate:** Fixed	
Ambient Temp.: 23º C	**Relative Humidity:** 33 %RH	
Bandwidth (MHz)		
Freq. (MHz)	**6dB Bandwidth MHz**	**99% Bandwidth MHz**
2405	1.331	1.895
2440	1.333	1.920
2480	1.318	2.054
Note: Worst case for frequency range is plotted below.		

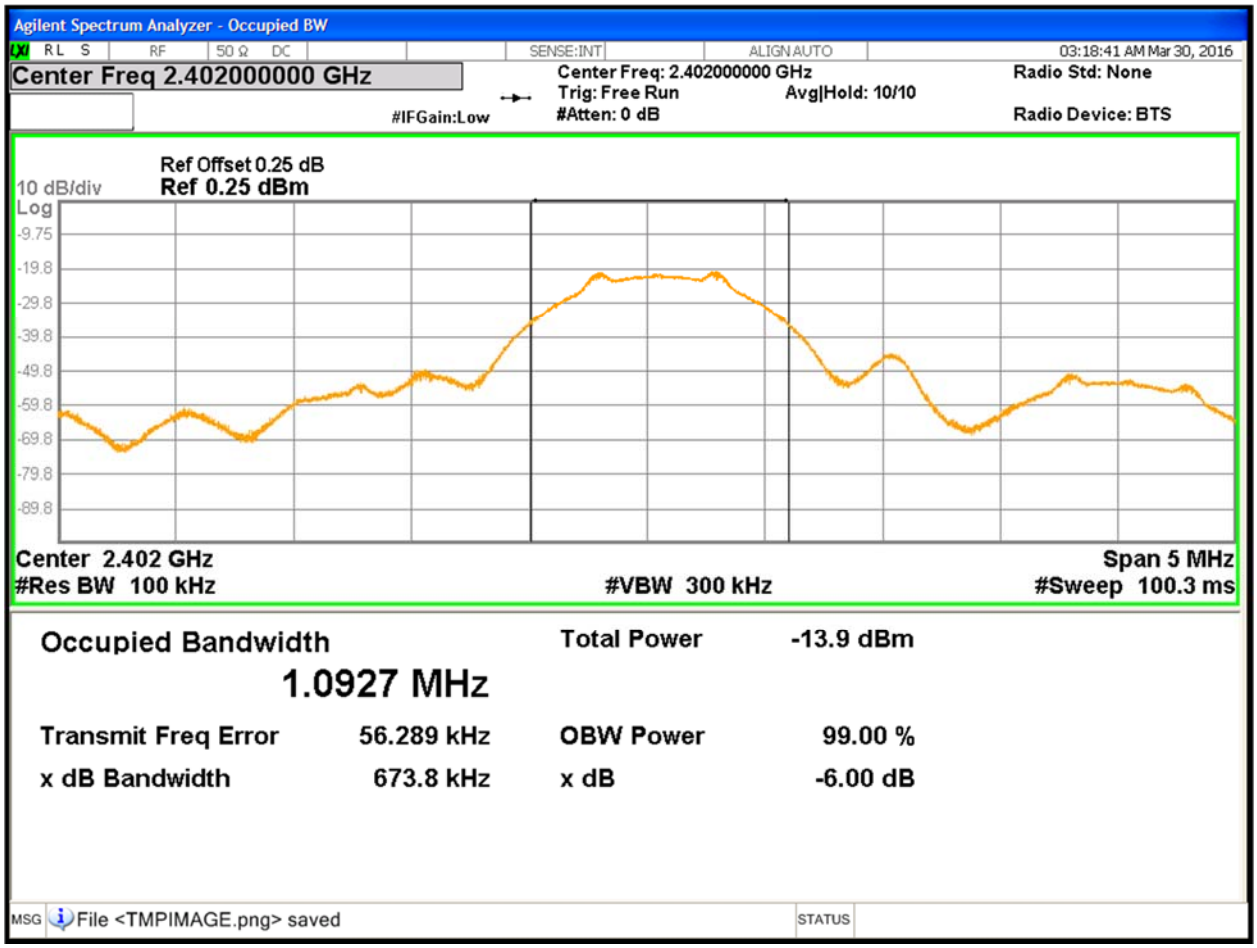


Figure 7: Occupied Bandwidth at 2402 MHz

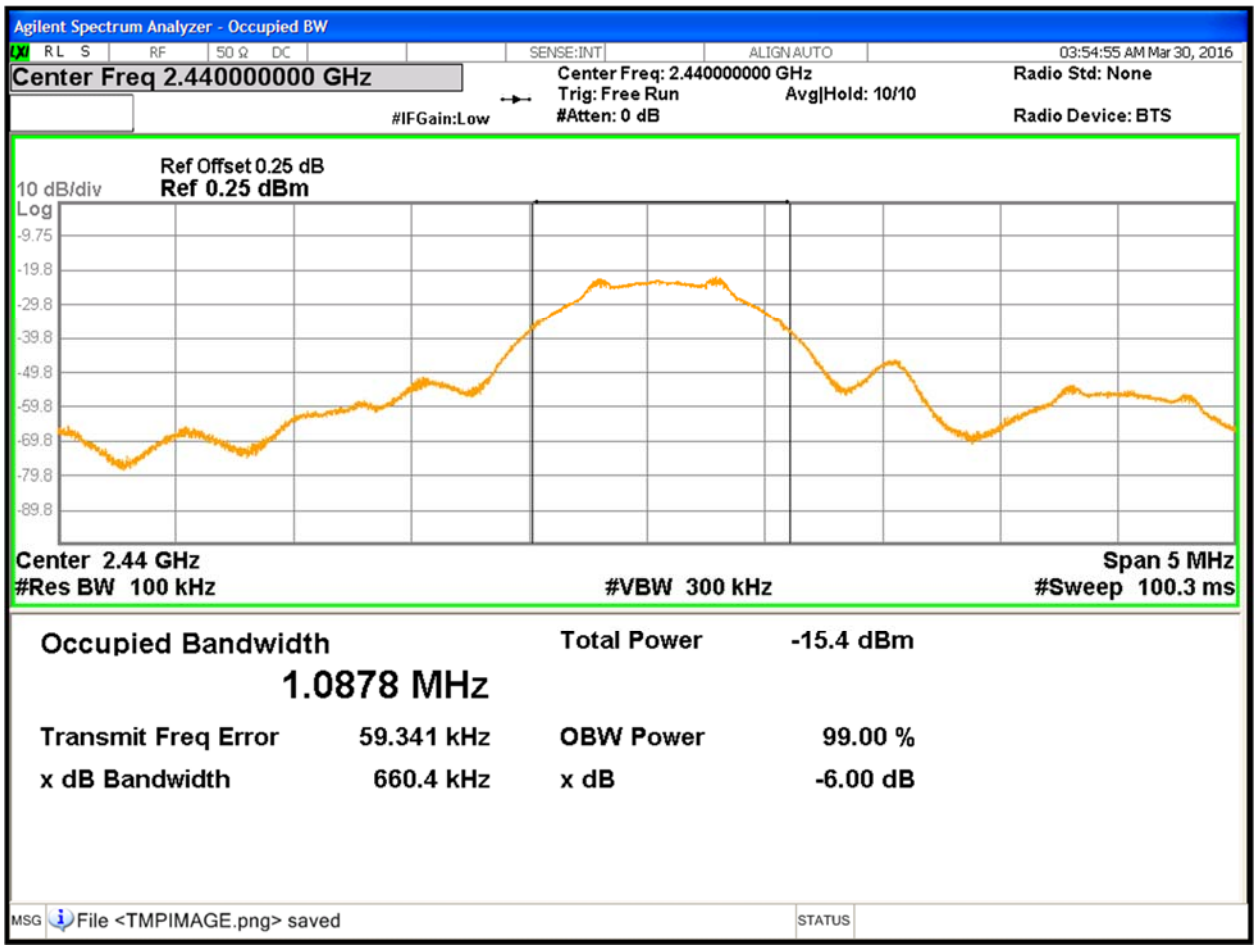


Figure 8: Occupied Bandwidth at 2440 MHz

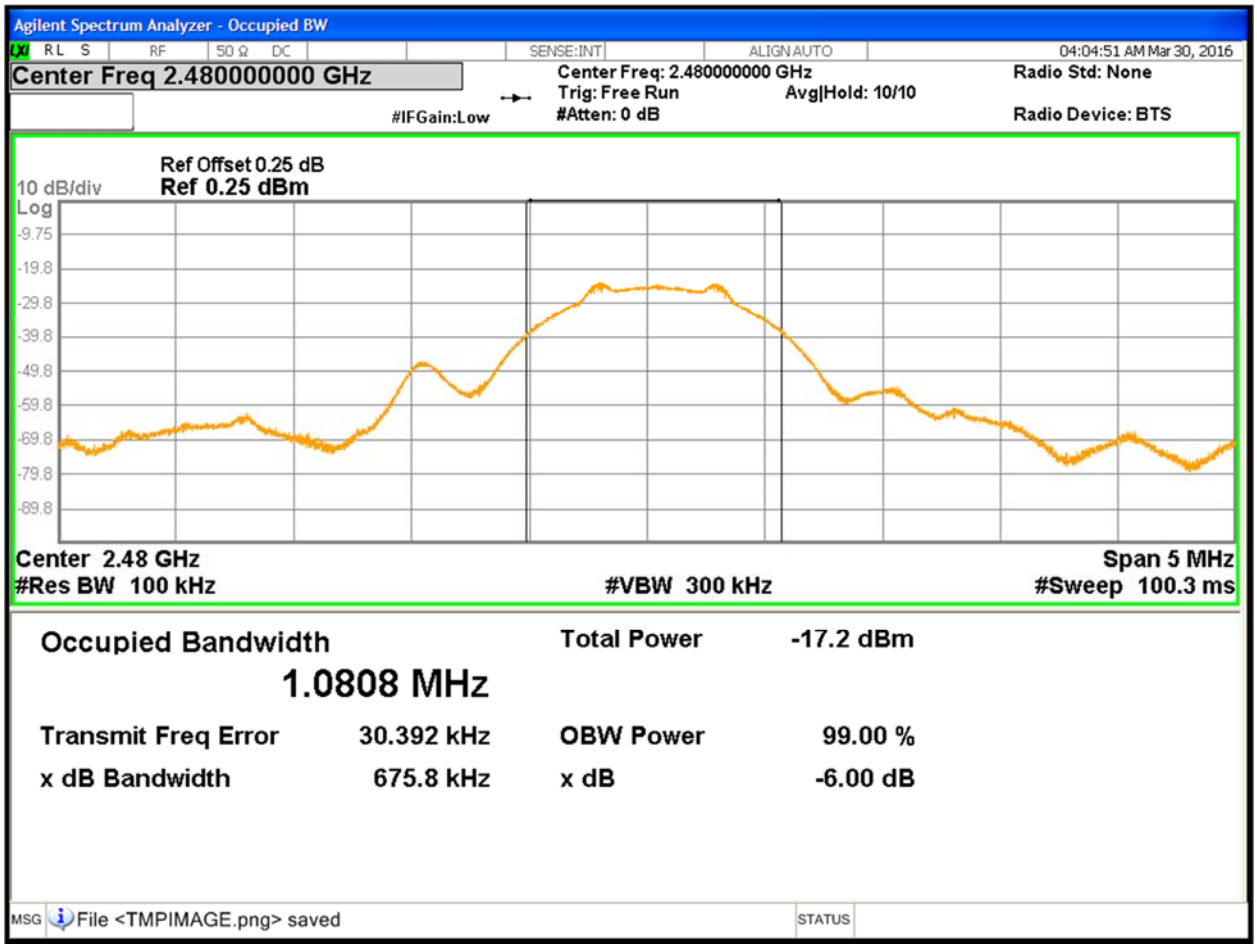


Figure 9: Occupied Bandwidth at 2480 MHz BLE

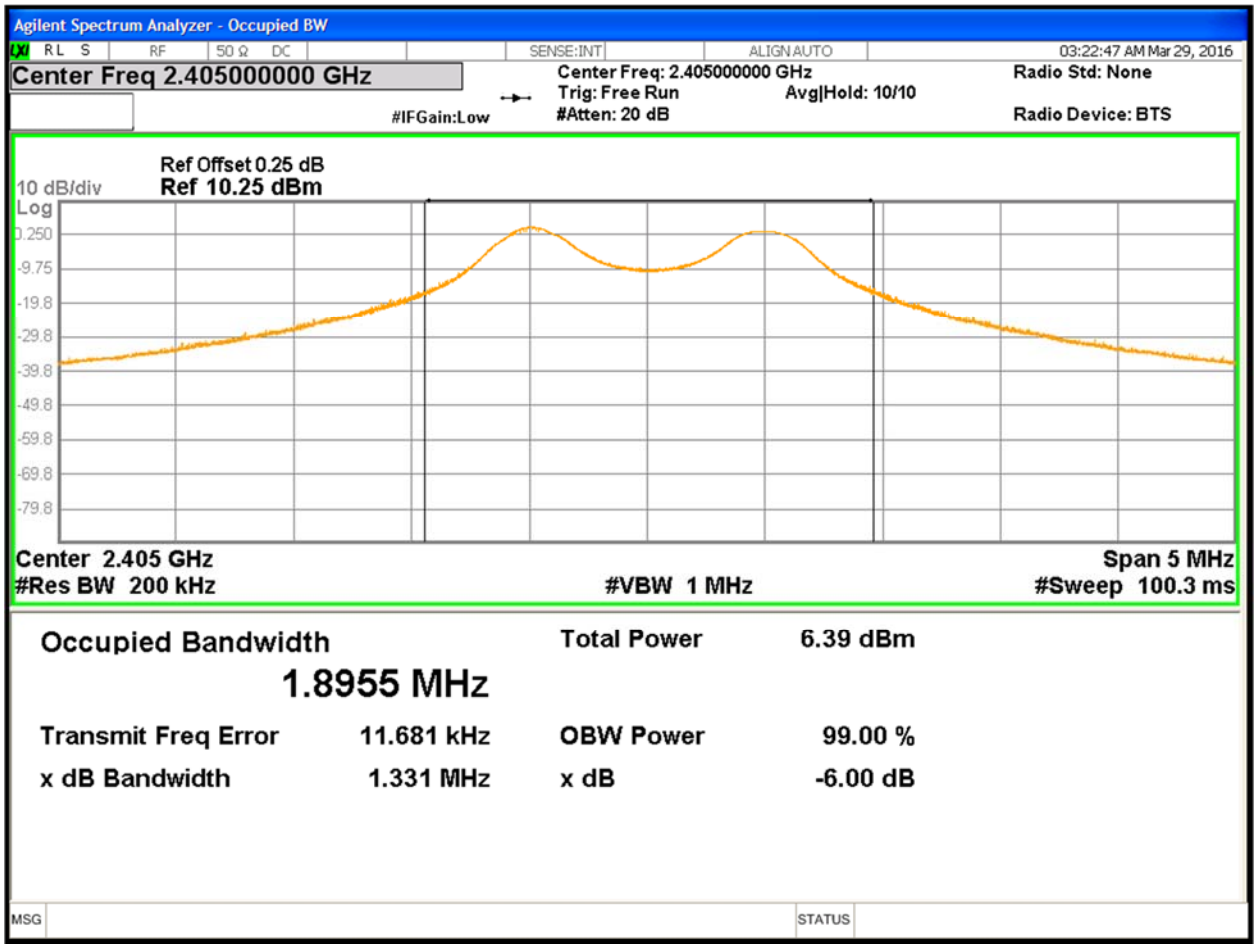


Figure 10: Occupied Bandwidth at 2405 MHz ZigBee

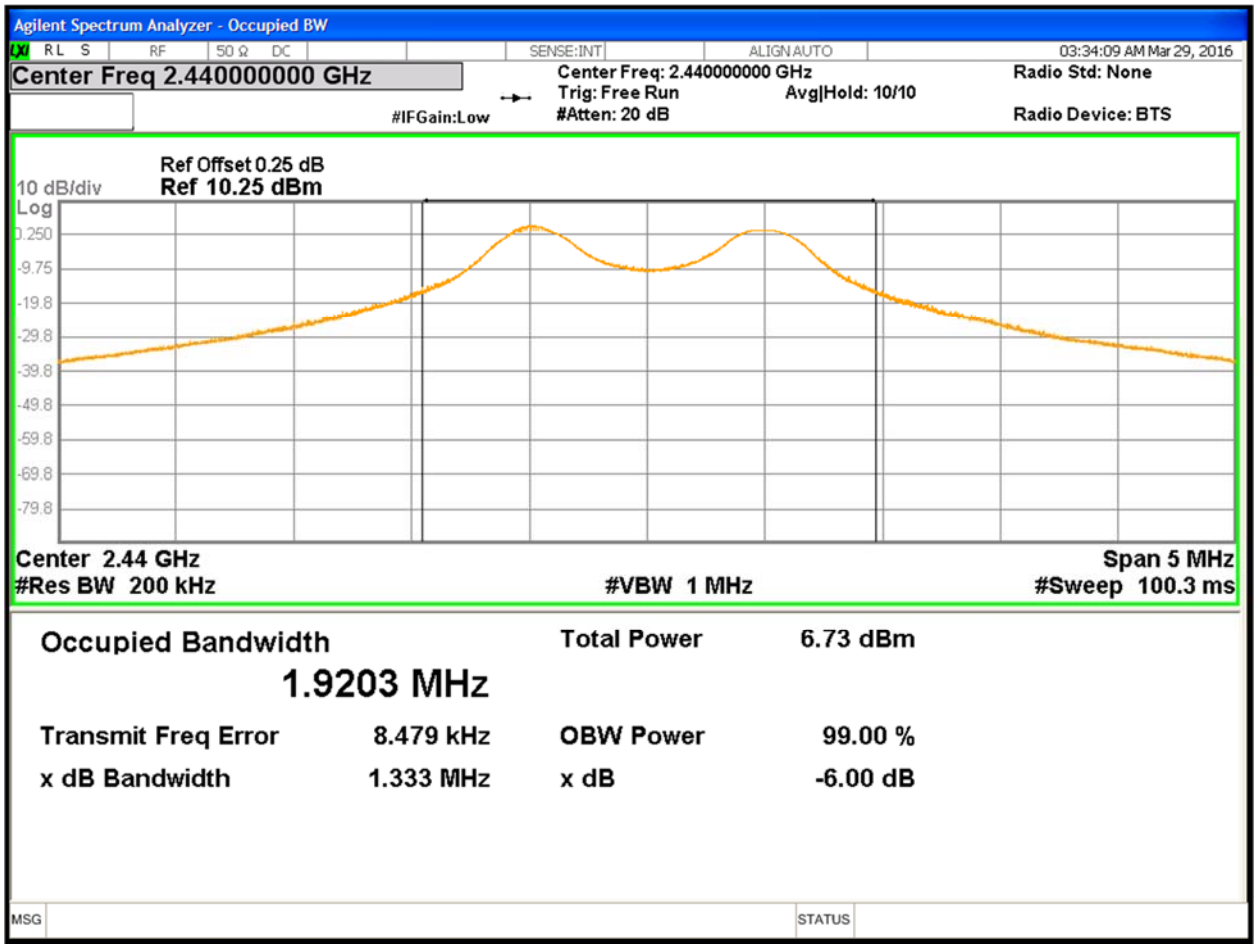


Figure 11: Occupied Bandwidth at 2440 MHz ZigBee

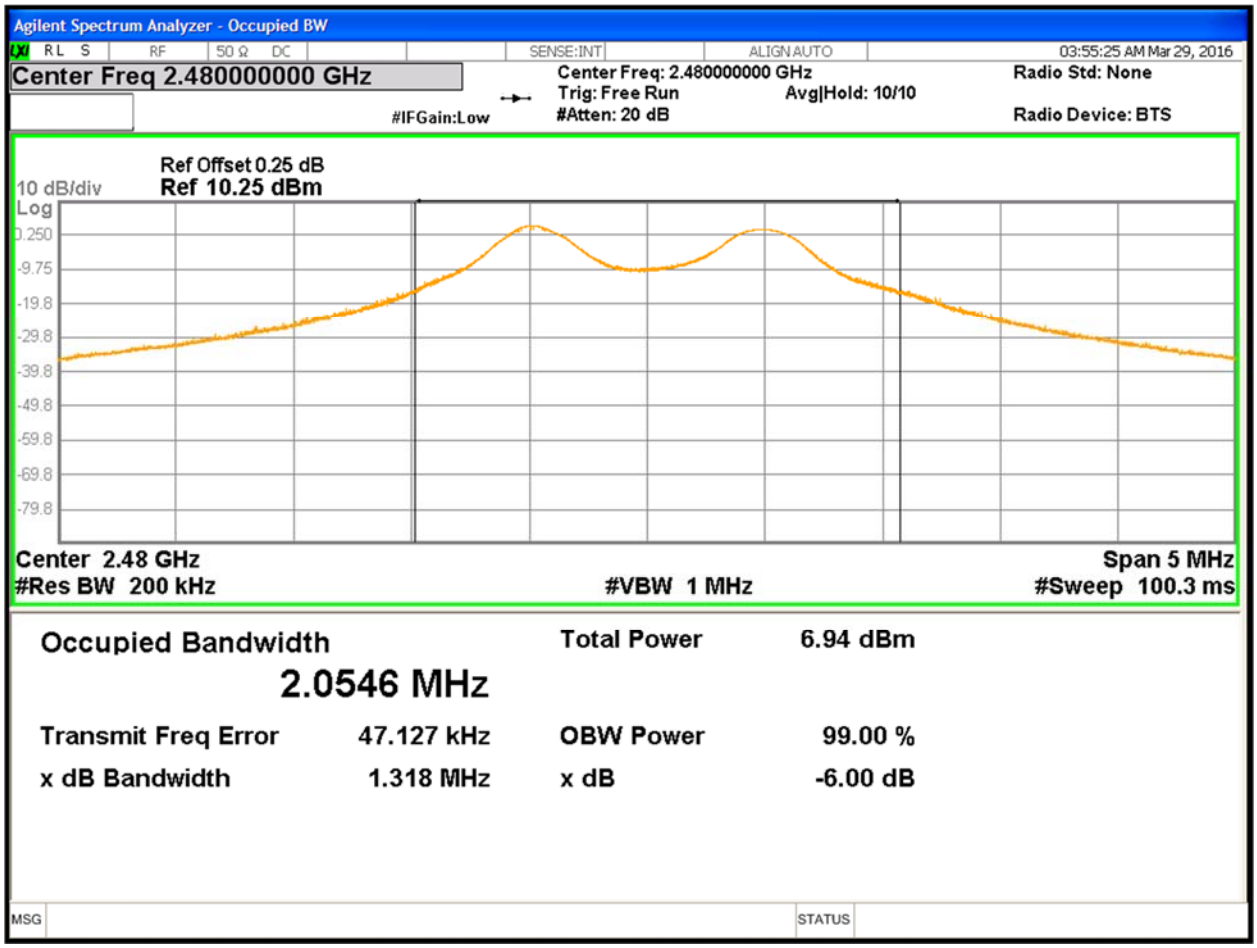


Figure 12: Occupied Bandwidth at 2480 MHz ZigBee

4.3 Power Spectral Density Requirements

According to the CFR47 Part 15.247 (e) and RSS-210 (A8.2), the spectral power density output of the antenna port shall be less than 8dBm in any 3kHz band during any time interval of continuous transmission.

4.1.1 Test Method

The conducted method was used to measure the channel power output per ANSI C63.10:2009 Section 6.11.2. The measurement was performed with modulation per CFR47 Part 15.247 (e) and RSS-247 (5.2.2). This test was conducted on 3 channels of Sample SN 003. The worst sample result indicated below.

The setup was identical to RF output power measurement.

4.3.2 Results

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

Table 5: BLE mode

Test Conditions: Conducted Measurement		**Date**: March 28, 2016	
Antenna Type: Integrated		**Power Setting:**	
Max. Antenna Gain: 0 dBi		**Signal State:** Modulated	
Duty Cycle: 100 %		**Data Rate:**	
Ambient Temp.: 23º C		**Relative Humidity:** 33 %RH	
802.15.4 Mode			
Operating Channel	**Limit [dBm]**	**PSD [dBm]**	**Margin [dB]**
2402 MHz	+8.00	-40.92	-48.92
2440 MHz	+8.00	-42.36	-50.36
2480 MHz	+8.00	-44.06	-52.06
Note:			

ZigBee Mode

Test Conditions: Conducted Measurement	**Date**: March 28, 2016
Antenna Type: Integrated	**Power Setting:**
Max. Antenna Gain: 0 dBi	**Signal State:** Modulated
Duty Cycle: 100 %	**Data Rate:**
Ambient Temp.: 23º C	**Relative Humidity:** 33 %RH

802.15.4 Mode			
Operating Channel	**Limit [dBm]**	**PSD [dBm]**	**Margin [dB]**
2405 MHz	+8.00	-3.59	-11.59
2440 MHz	+8.00	-3.22	-11.22
2480 MHz	+8.00	-3.05	-11.05
Note:			

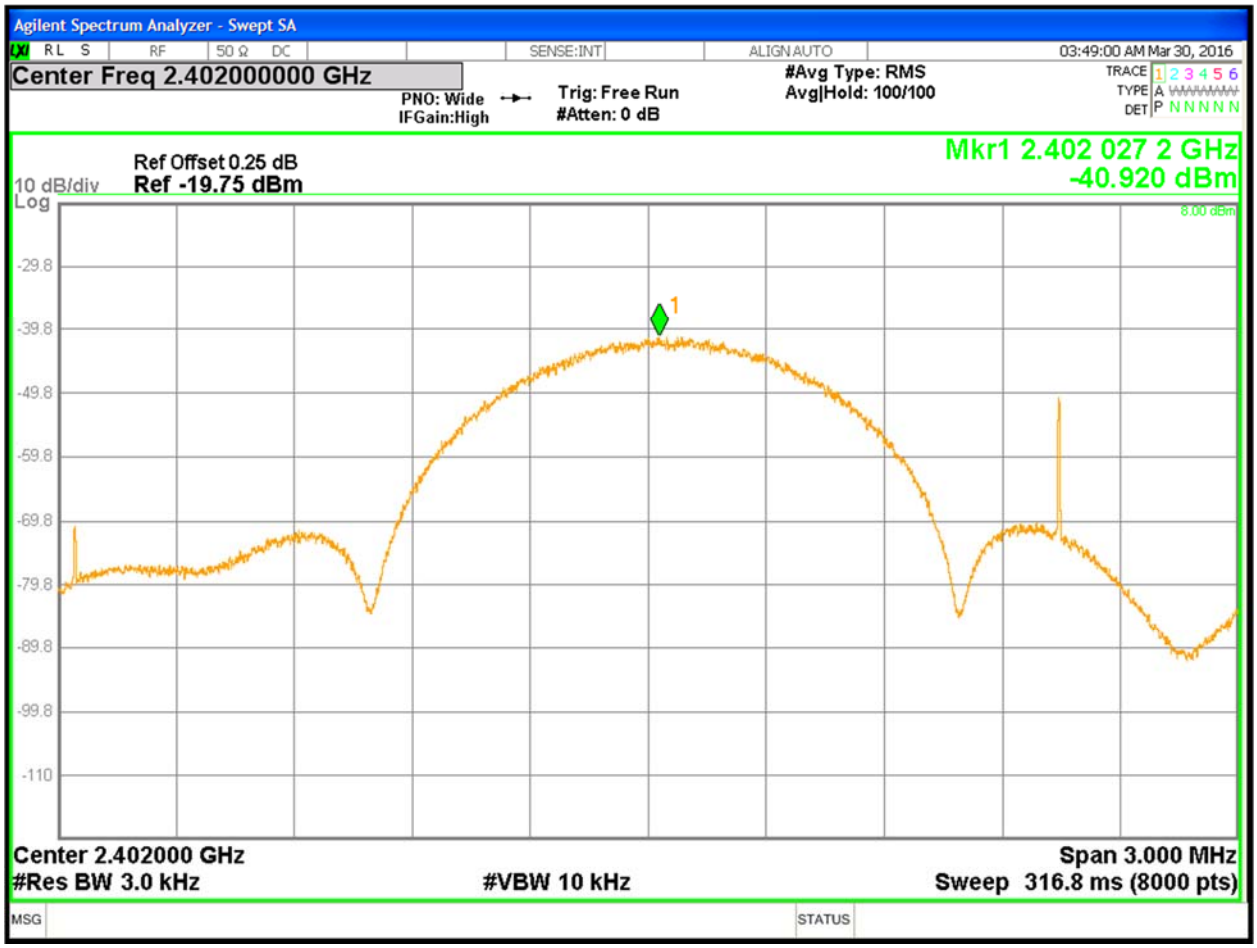


Figure 13: Power Spectral Density 2402 BLE mode

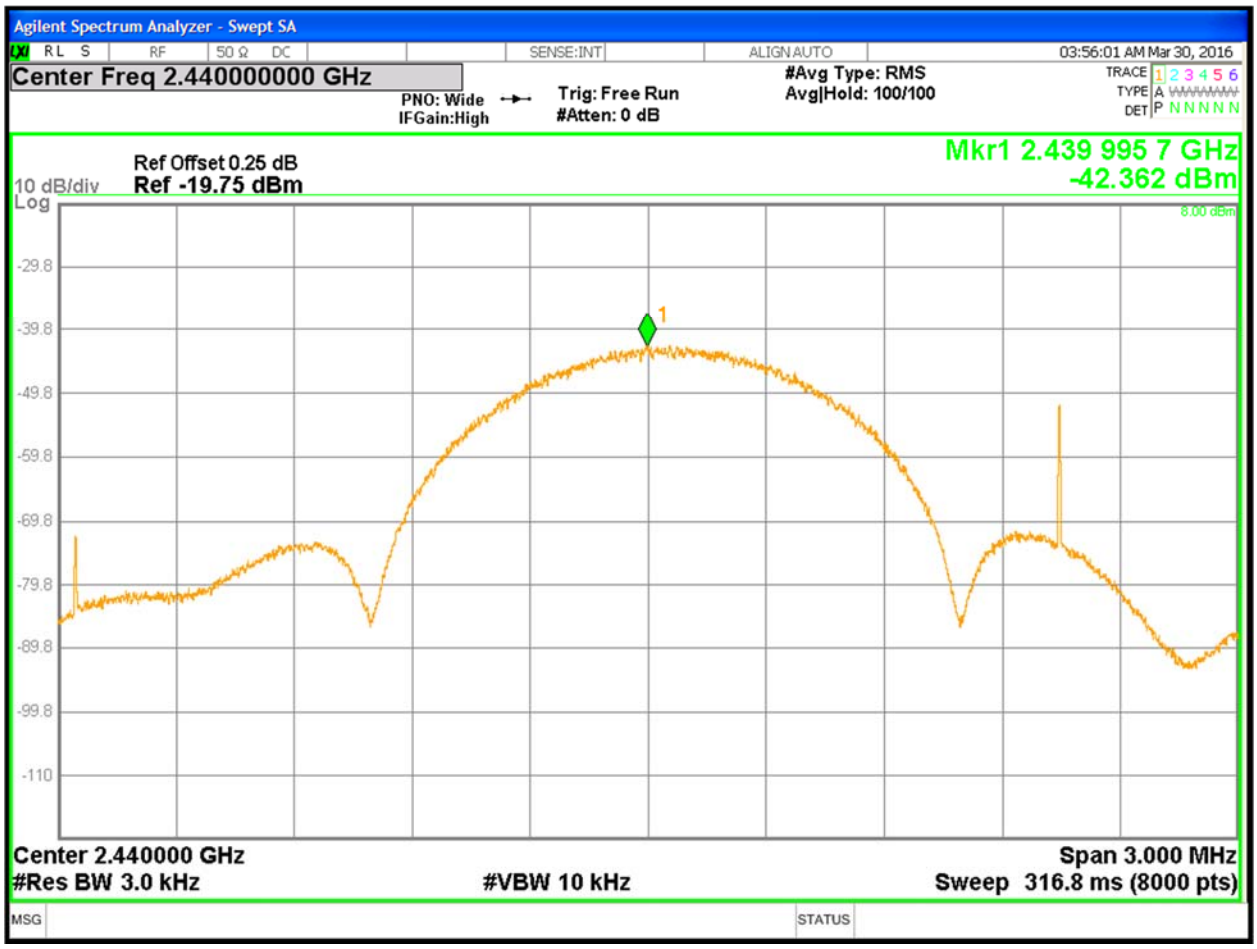


Figure 14: Power Spectral Density 2440 BLE mode

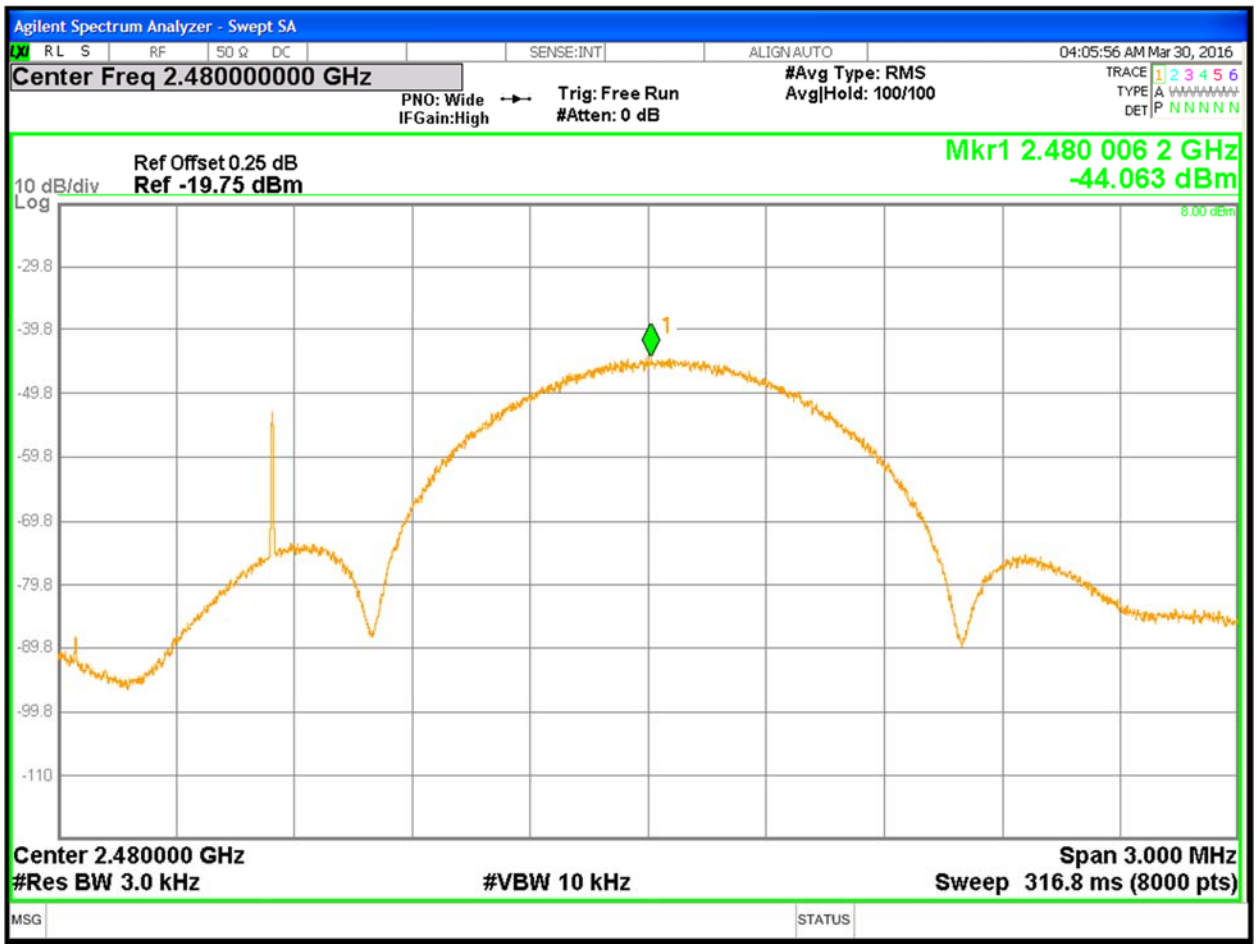


Figure 15: Power Spectral Density 2480 BLE mode

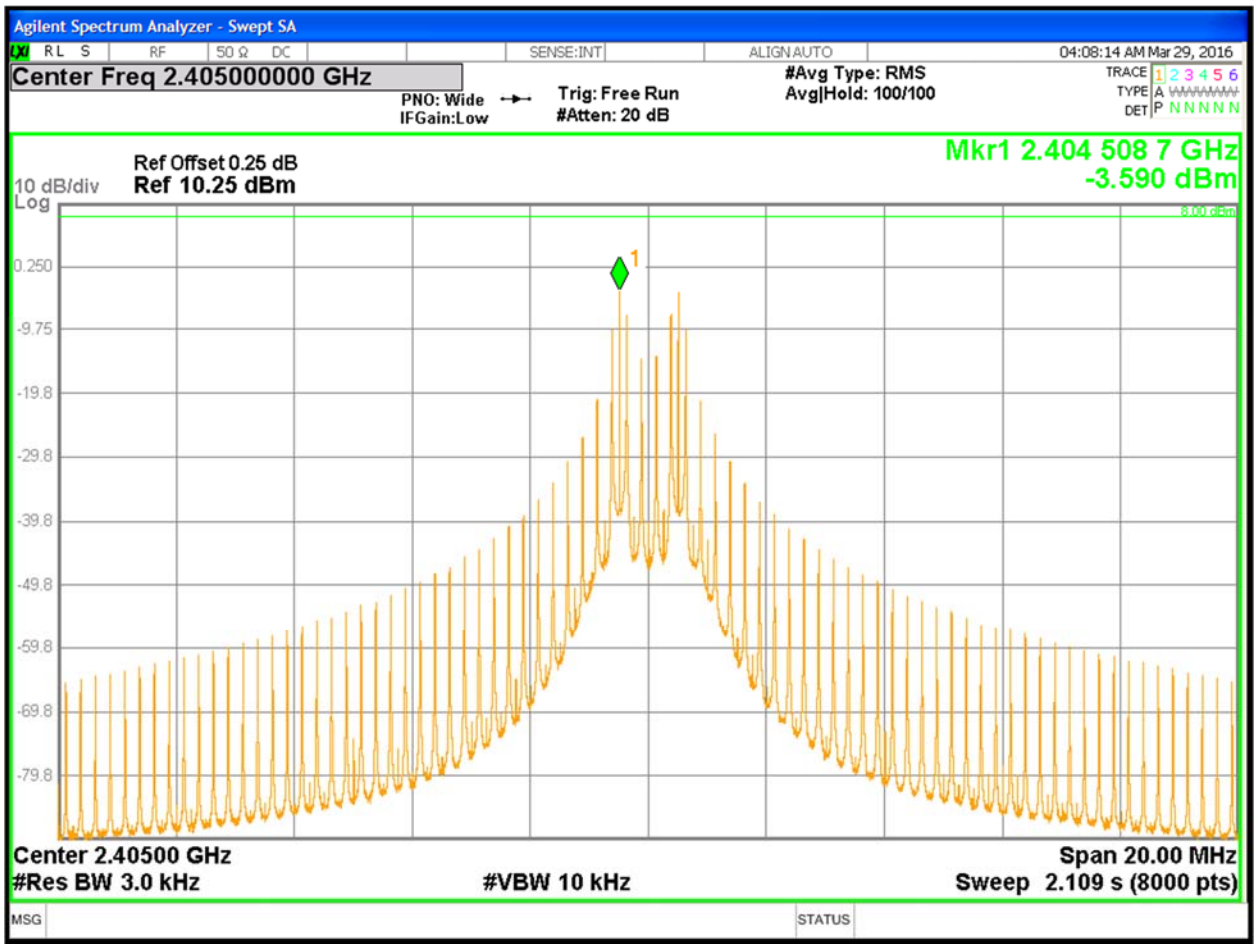


Figure 16: Power Spectral Density 2405 ZigBee mode

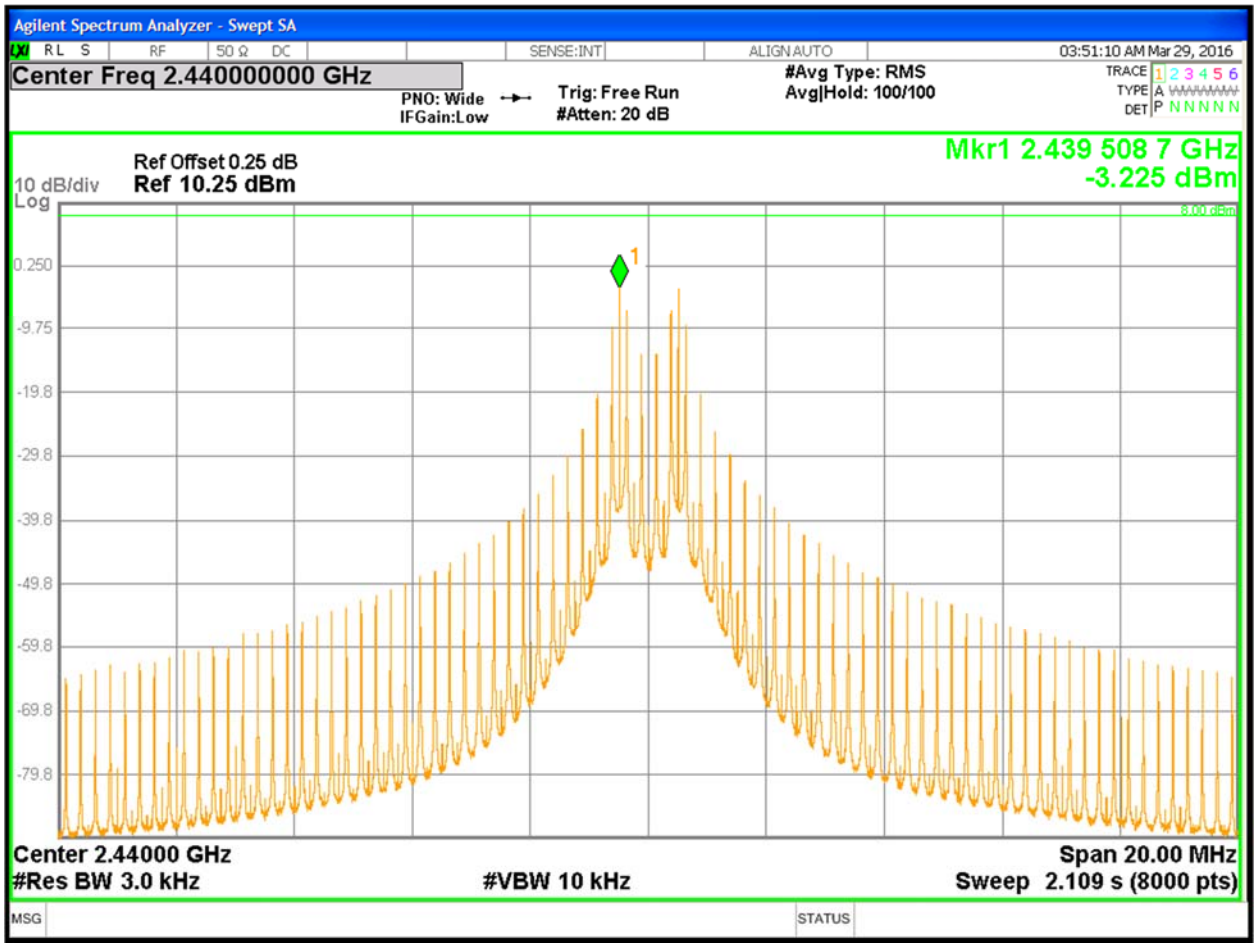


Figure 18: Power Spectral Density 2405 ZigBee mode

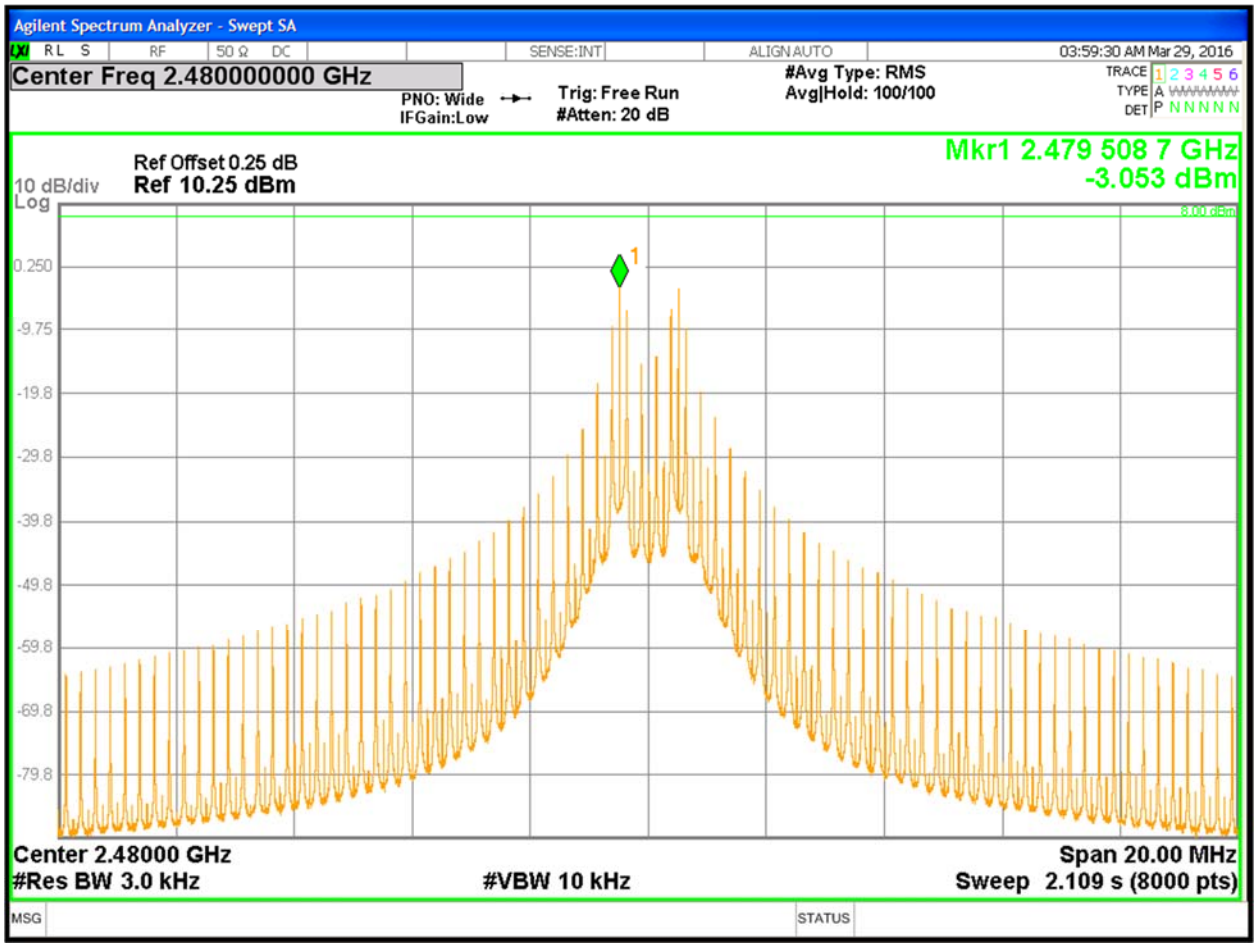


Figure 19: Power Spectral Density 2480 ZigBee mode

4.4 Out of Band Emission requirements

The setup was identical to RF output power measurement. Intentional radiators operating under the alternative provisions to the general emission limits, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If the frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Since the transmitter complies with the conducted power limits base on the use of RMS averaging per CFR47 Part 15.247(b)(3), any frequency outside the band of 2400MHz to 2483.5 MHz, the power output level must be below 30 dB from the in-band transmitting signal; CFR 47 Part 15.215, 15.247(d) and.RSS 247 Sect. 5.5: 2015.

The setup was identical to RF output power measurement.

This test was conducted on 3 channels on SU-4E

4.1.2 Results

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

Table 6: Band Edge Requirements – Test Results BLE

Test Conditions: Conducted Measurement		**Date:**	
Antenna Type: Integrated Antenna		**Power Setting:**	
Max. Antenna Gain: +0 dBi		**Signal State:** Modulated	
Duty Cycle: 100 %		**Data Rate:** see below	
Ambient Temp.: 23º C		**Relative Humidity:** 33 %RH	
-30 dBr Band Edge Results			
Operating Freq.	**Limit (dBm)**	**Measured Value (dBm)**	**Result**
2402 MHz	-51.14	-51.73	Pass
2440 MHz	-52.16	-53.60	Pass
2480 MHz	-53.20	-53.84	Pass
Note: The stated limits for 20 dBr are relative to each individual output per KDB 662911 Method. The worst case of each data rate is recorded.			

Out of Band Emission			
Operating Freq.	**Limit (dBm)**	**Measured Value (dBm)**	**Result**
2402 MHz	-51.14	-59.40	Pass
2440 MHz	-52.16	-61.90	Pass
2480 MHz	-53.20	-61.17	Pass
Note: The stated limits are relative to each individual output per KDB 662911 Method.			

ZigBee mode

Test Conditions: Conducted Measurement	**Date:**
Antenna Type: Integrated Antenna	**Power Setting:**
Max. Antenna Gain: +0 dBi	**Signal State:** Modulated
Duty Cycle: 100 %	**Data Rate:** see below
Ambient Temp.: 23º C	**Relative Humidity:** 33 %RH

-30dBr Band Edge Results			
Operating Freq.	**Limit (dBm)**	**Measured Value (dBm)**	**Result**
2405 MHz	-28.28	-31.51	Pass
2440 MHz	-26.33	-30.39	Pass
2480 MHz	-26.21	-29.50	Pass

Note: The stated limits for 30dBr are relative to each individual output per KDB 662911 Method. The worst case of each data rate is recorded.

Out of Band Emission			
Operating Freq.	**Limit (dBm)**	**Measured Value (dBm)**	**Result**
2405 MHz	-28.28	-51.11	Pass
2440 MHz	-26.33	-49.37	Pass
2480 MHz	-26.21	-50.41	Pass

Note: The stated limits are relative to each individual output per KDB 662911 Method.

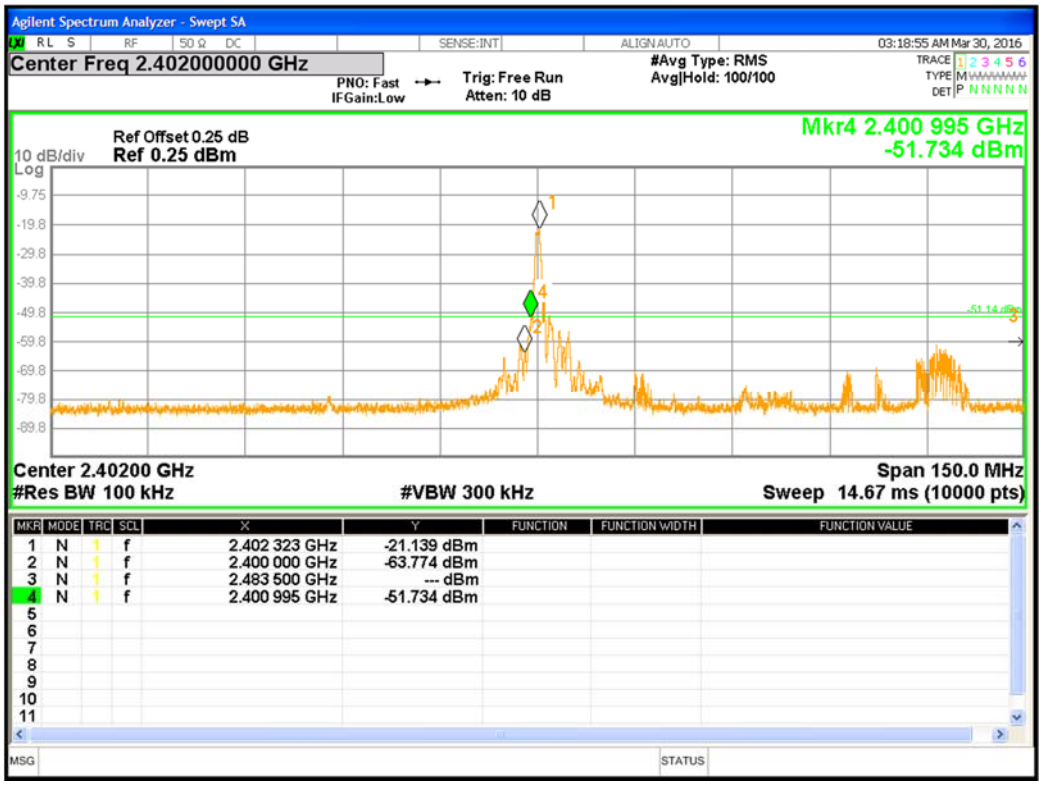


Figure 20: Band Edge Requirements at 2402 MHz

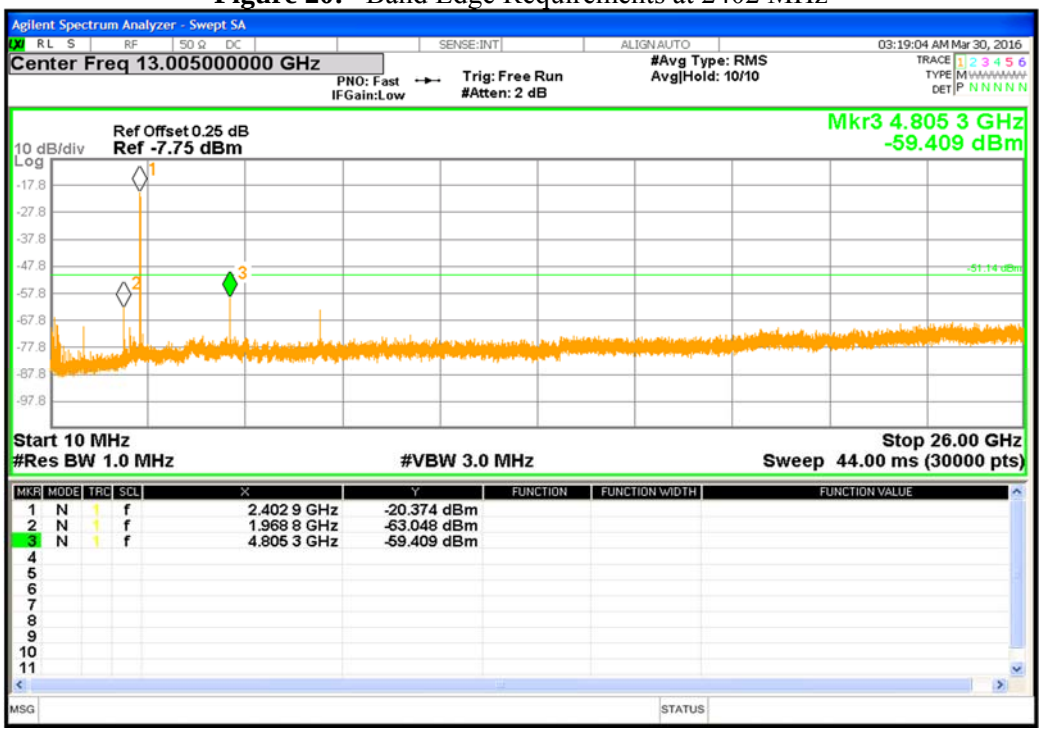


Figure 21: Out of Band Emission Requirements at 2402 MHz

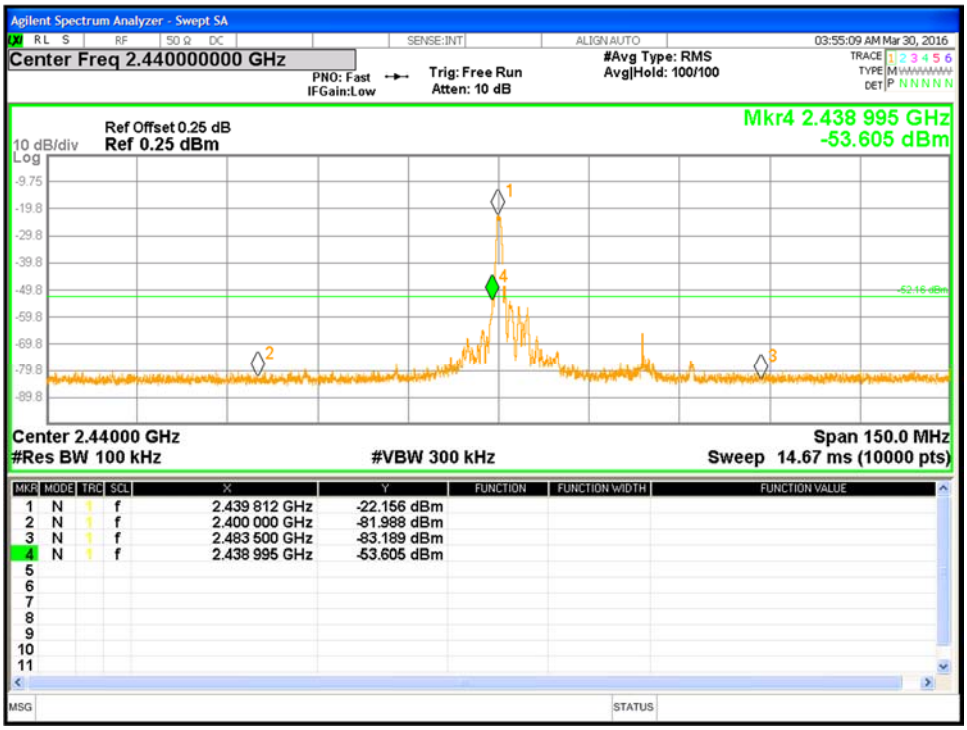


Figure 22: Band Edge Requirements at 2440 MHz

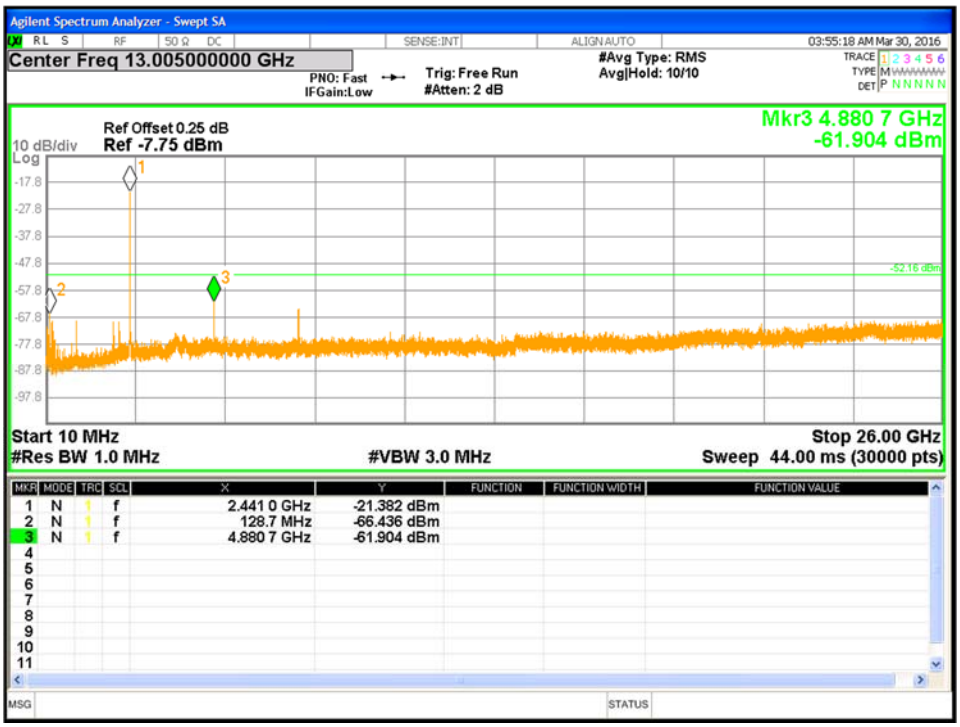


Figure 23: Out of Band Emission Requirements at 2440 MHz

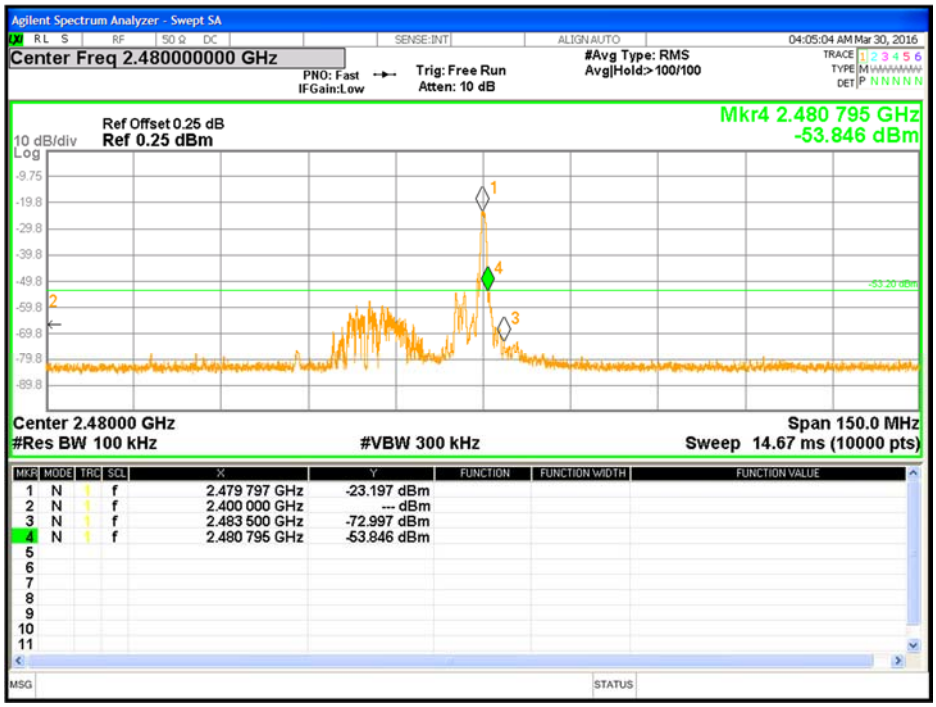


Figure 24: Band Edge Requirements at 2480 MHz

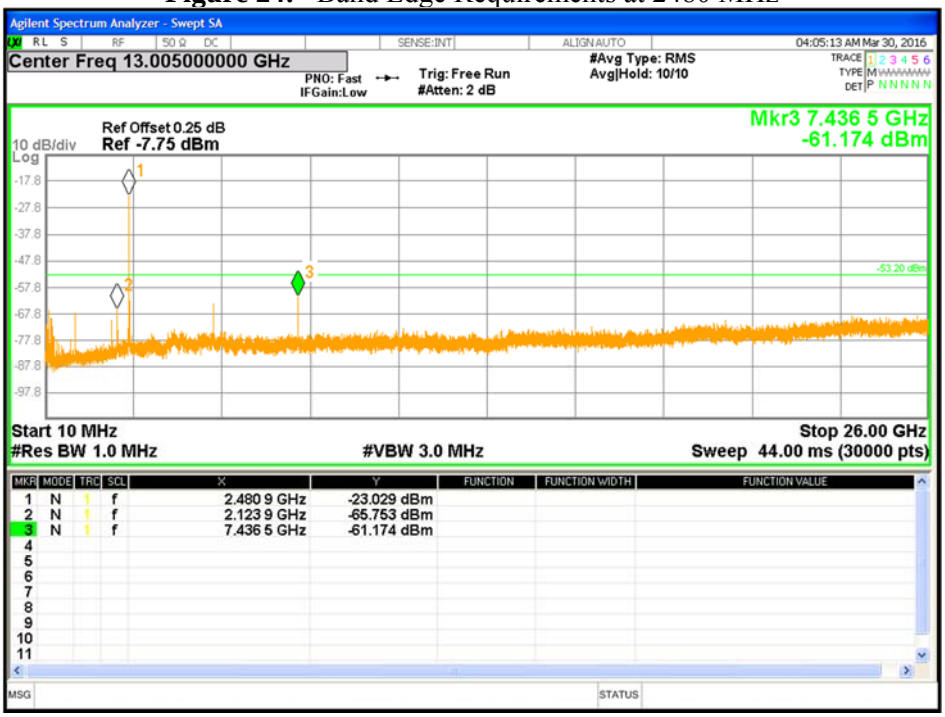


Figure 25: Out of Band Emission Requirements at 2480 MHz

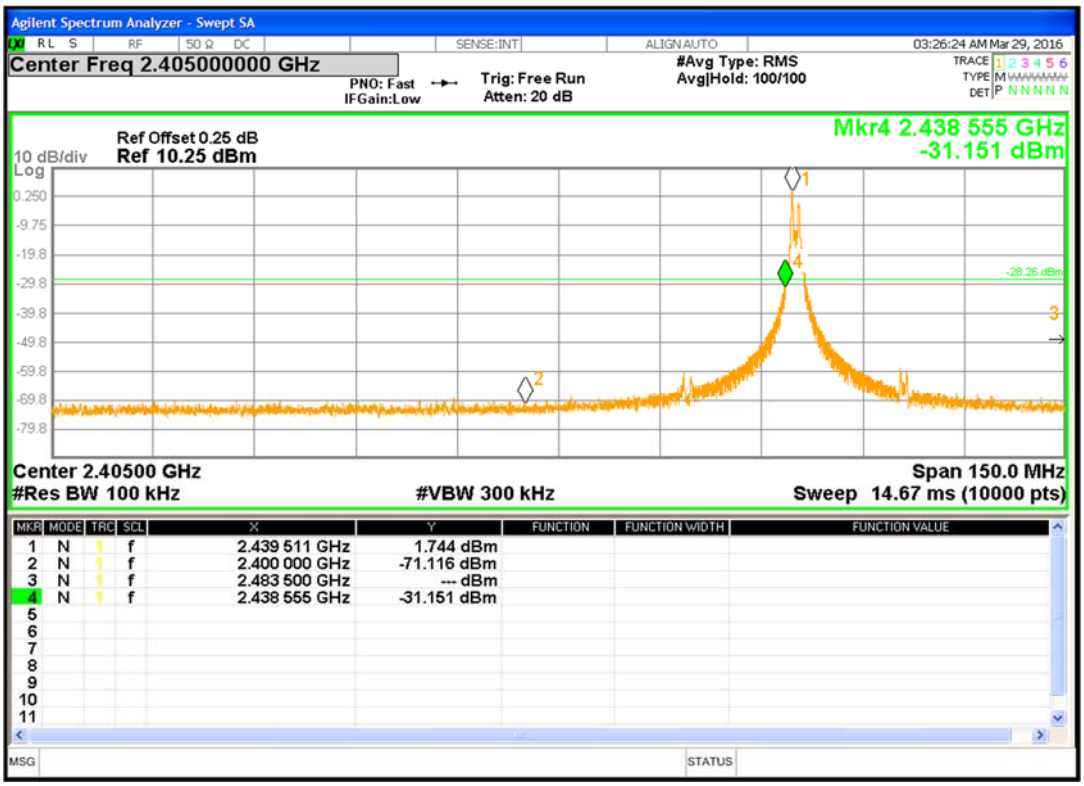


Figure 26: Band Edge Requirements at 2405 MHz ZigBee

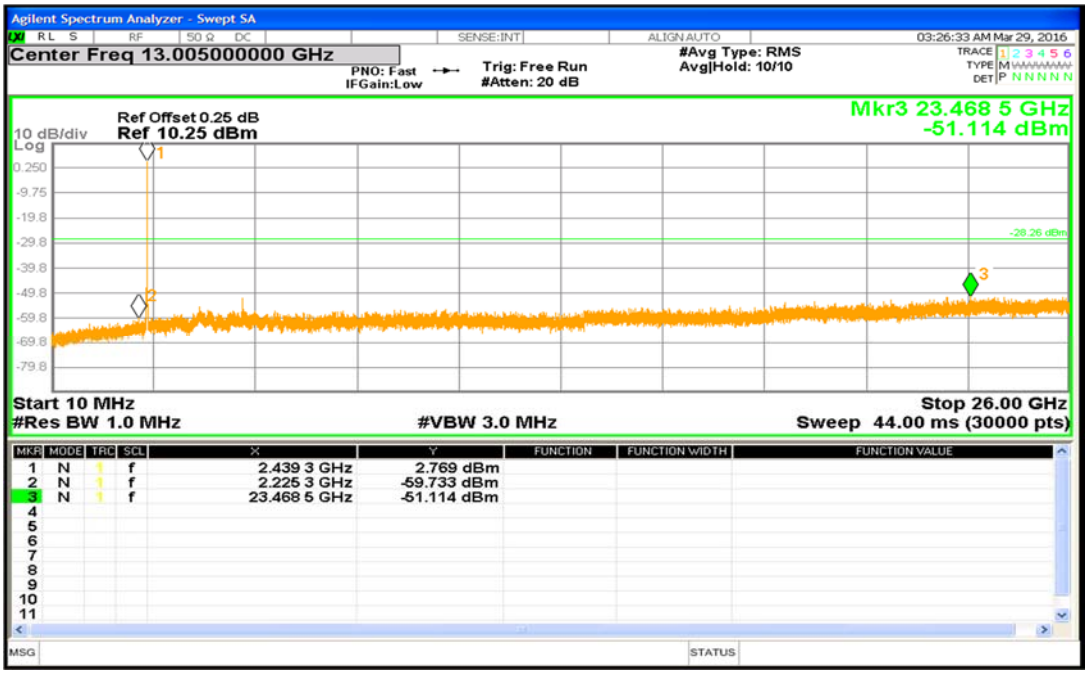


Figure 27: Out of Band Emission Requirements at 2405 MHz ZigBee

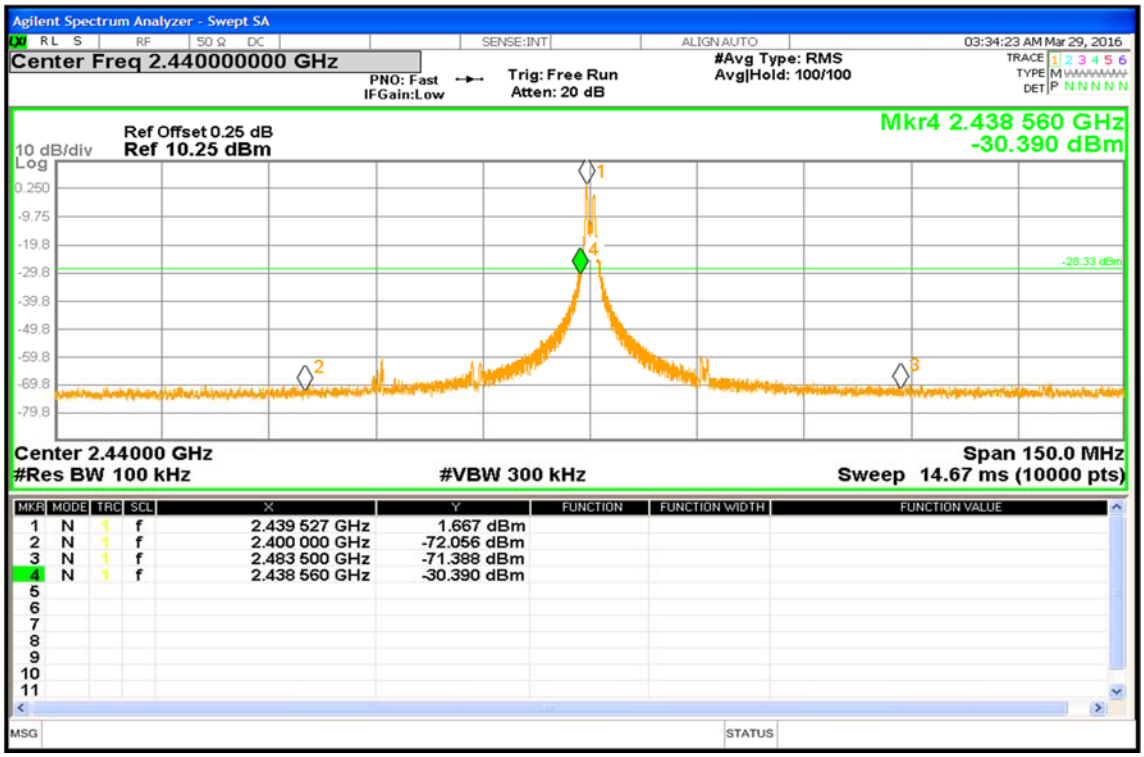


Figure 28: Band Edge Requirements at 2440 MHz ZigBee

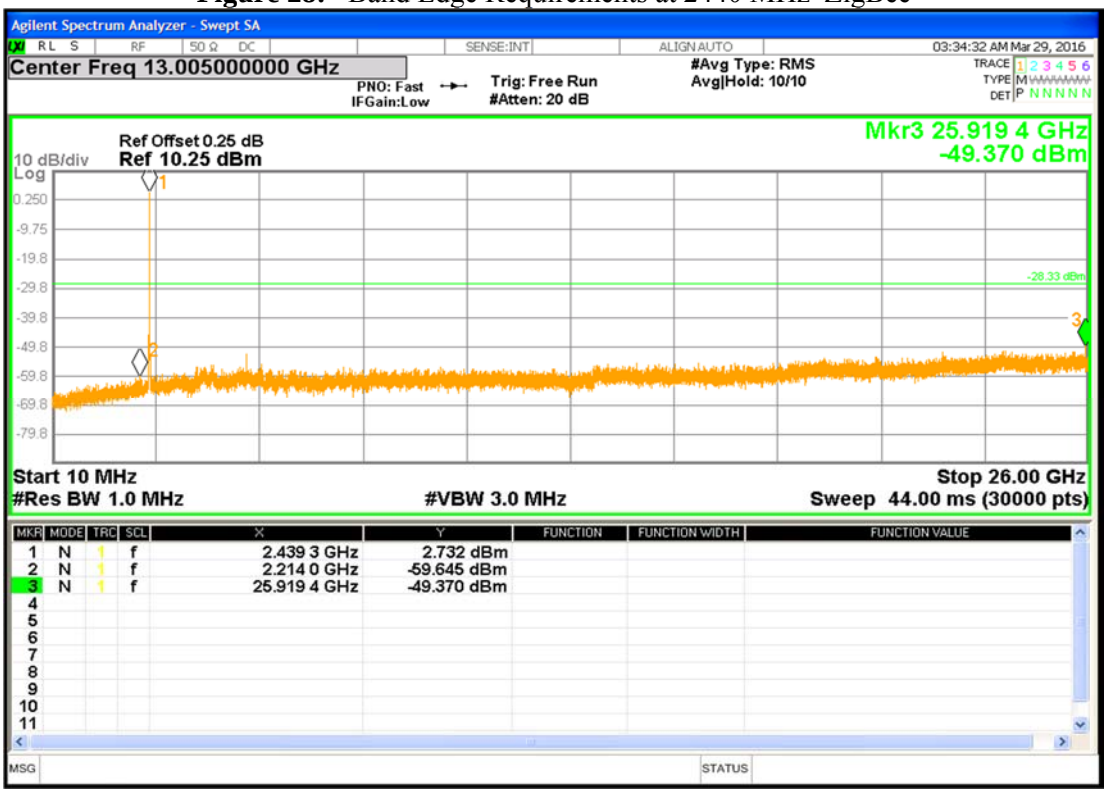


Figure 29: Out of Band Emission Requirements at 2440MHz ZigBee

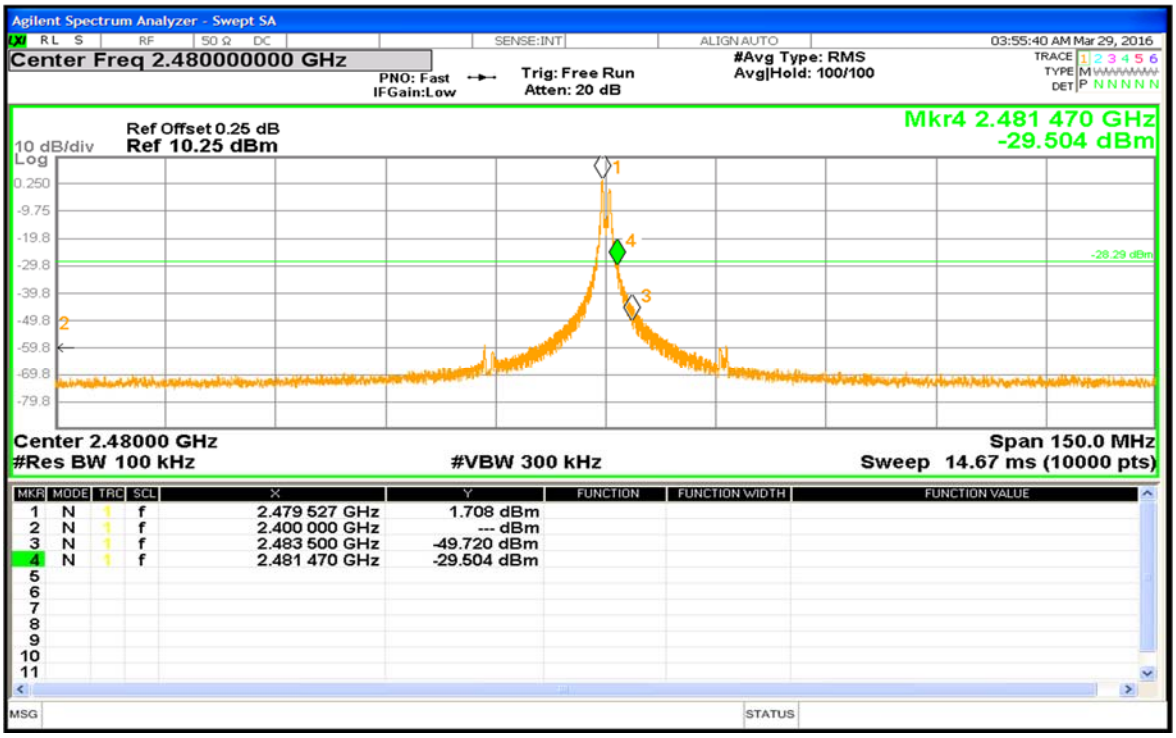


Figure 30: Band Edge Requirements at 2480 MHz ZigBee

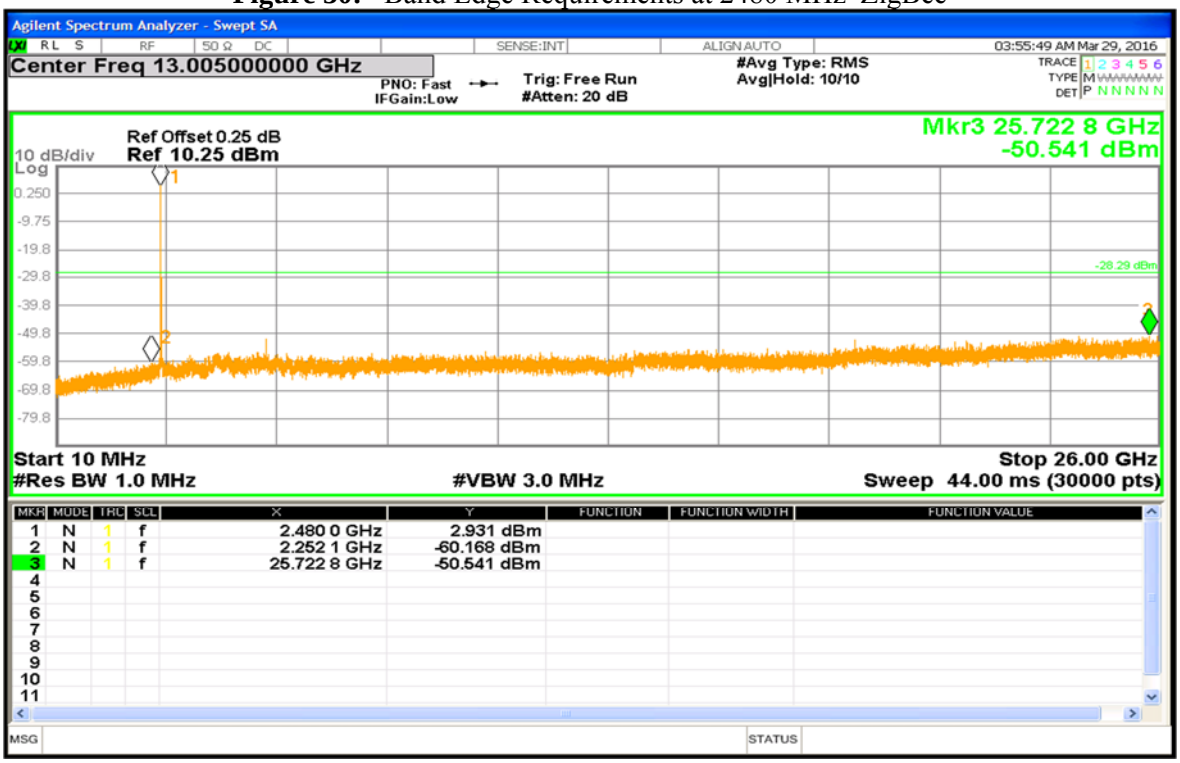


Figure 31: Out of Band Emission Requirements at 2480 MHz ZigBee

4.5 Transmitter Spurious 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.

4.6.1 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.

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.

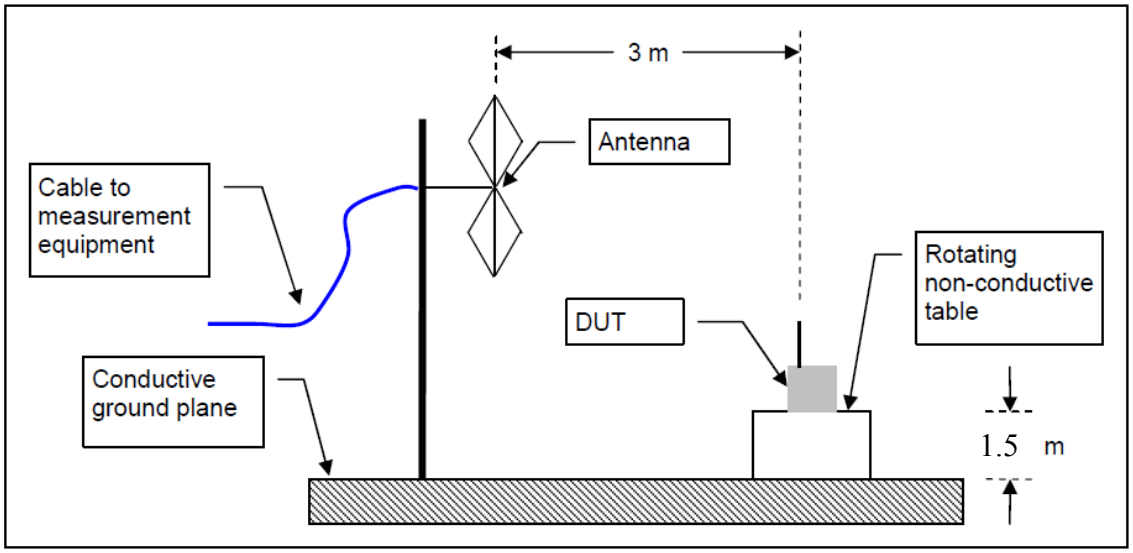
Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The final scans performed on the worst axis, Y-Axis, for three operating channels: 2402 MHz, 2440 MHz, and 2480 MHz for BLE mode and 2405MHz, 2440MHz and 2480 for ZigBee mode .

4.6.1.3 Deviations

None.

Test Setup:



4.6.2 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. 8.9: 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 20 dB below the in-band emission.

4.6.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. 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 7: Transmit Spurious Emission at Restricted Band Edge Requirements

Test Conditions: Radiated Measurement at 3 meters	**Date:** March 30, 2016
Antenna Type: Integrated	**Power Setting:** Fixed.
Max. Antenna Gain: +0 dBi	**Signal State:** Modulated
Duty Cycle: 100 %	**Data Rate:** see below
Ambient Temp.: 23º C	**Relative Humidity:** 37 %RH

Band Edge Results BLE

Freq. MHz	Level dBuV/m	Pol. V/H	15.209/15.247 Limit	Margin	Detector Pk/Avg	Azimuth degrees	Height meters	Comments
2390.0	34.58	H	74	-39.42	Pk	0	1.52	TX at 2402 MHz,
2390.0	22.70	H	54	-31.30	Avg	0	1.52	TX at 2402 MHz,
2390.0	33.84	V	74	-40.16	Pk	298	168	TX at 2402 MHz,
2390.0	22.72	V	54	-31.28	Avg	298	168	TX at 2402 MHz,
2483.5	32.50	V	74	-41.50	Pk	246	140	TX at 2480 MHz,
2483.5	23.21	V	54	-30.79	Avg	246	140	TX at 2480 MHz,
2483.5	34.43	H	74	-39.57	Pk	88	162	TX at 2480 MHz,
2483.5	23.31	H	54	-30.69	Avg	88	162	TX at 2480 MHz,

ZigBee Mode

Test Conditions: Radiated Measurement at 3 meters	**Date:** March 30, 2016
Antenna Type: Integrated	**Power Setting:** Fixed.
Max. Antenna Gain: +0 dBi	**Signal State:** Modulated
Duty Cycle: 100 %	**Data Rate:** see below
Ambient Temp.: 23º C	**Relative Humidity:** 37 %RH

Band Edge Results ZigBee

Freq. MHz	Level dBuV/m	Pol. V/H	15.209/15.247 Limit	Margin	Detector Pk/Avg	Azimuth degrees	Height meters	Comments
2390.0	34.92	H	74	-39.08	Pk	0	142	TX at 2405 MHz,
2390.0	23.34	H	54	-30.66	Avg	0	142	TX at 2405 MHz,
2390.0	33.34	V	74	-40.66	Pk	210	161	TX at 2405 MHz,
2390.0	23.39	V	54	-30.61	Avg	210	161	TX at 2405 MHz,
2483.5	49.23	H	74	-24.77	Pk	202	183	TX at 2480 MHz,
2483.5	37.27	H	54	-16.73	Avg	202	183	TX at 2480 MHz,
2483.5	43.82	V	74	-30.18	Pk	137	135	TX at 2480 MHz,
2483.5	32.09	V	54	-21.91	Avg	137	135	TX at 2480 MHz,

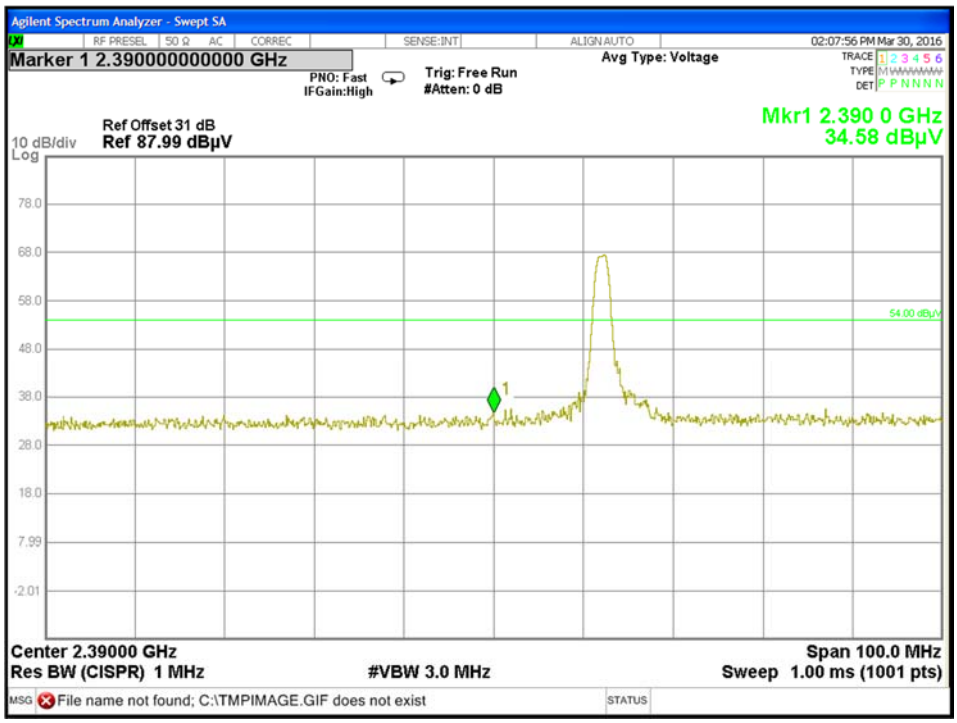


Figure 32: Radiated Emission at the 2390MHz Edge for Channel 2402 MHz Horizontal (Pk)

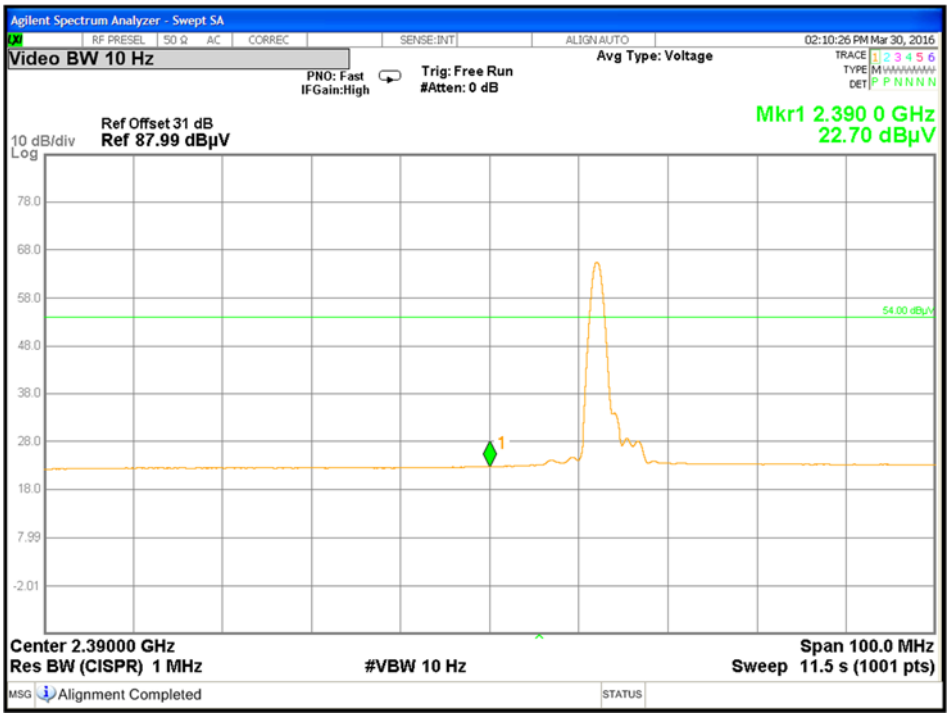


Figure 33: Radiated Emission at the 2390MHz Edge for Channel 2402 MHz Horizontal (Avg)

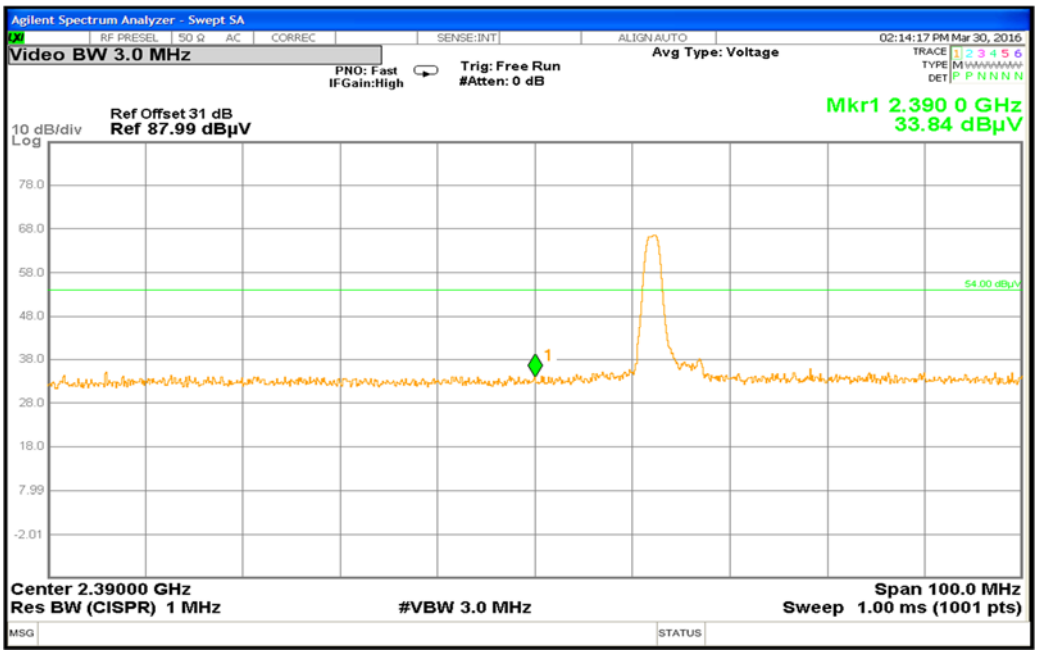


Figure 34: Radiated Emission at the 2390MHz Edge for Channel 2402 MHz Vertical (Pk)

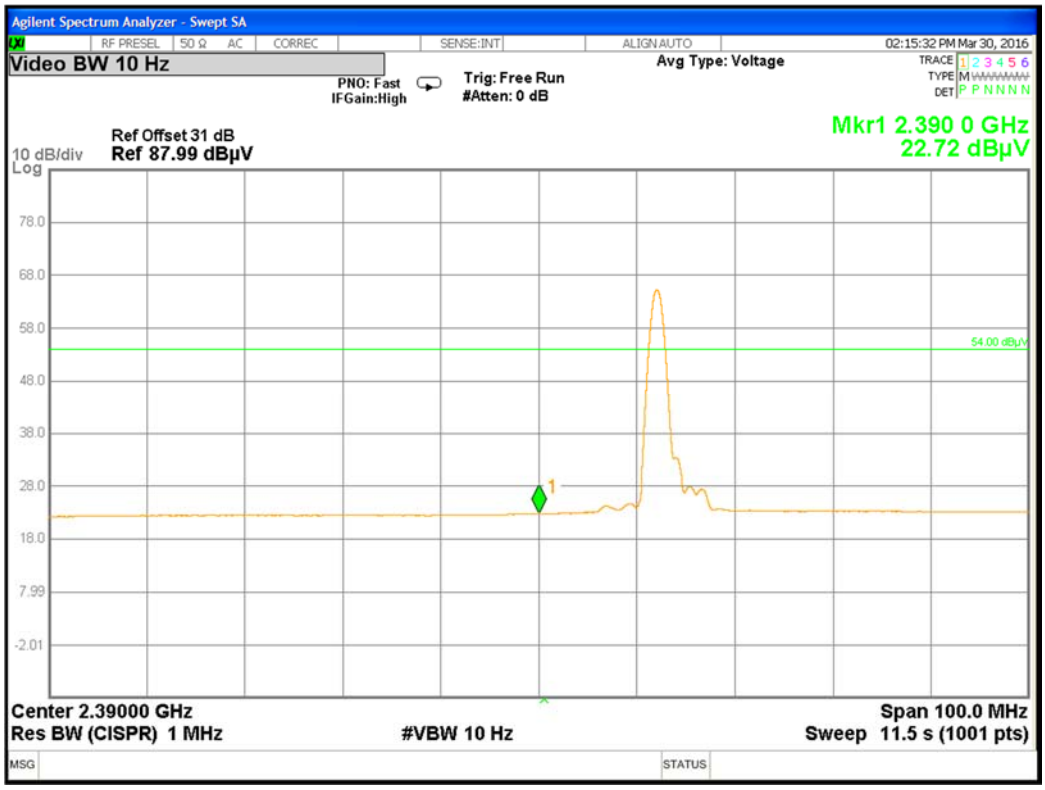


Figure 35: Radiated Emission at the 2390MHz Edge for Channel 2402 MHz– Vertical (Avg)

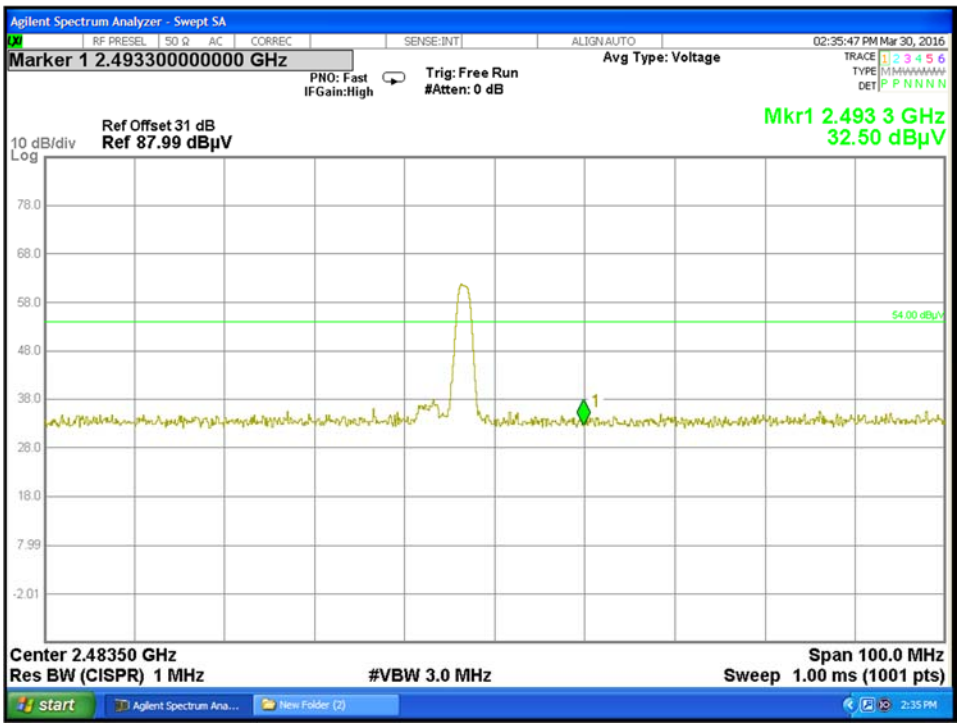


Figure 36: Radiated Emission at the 2483.5MHz Edge for Channel 2480 MHz– Vertical (Pk)

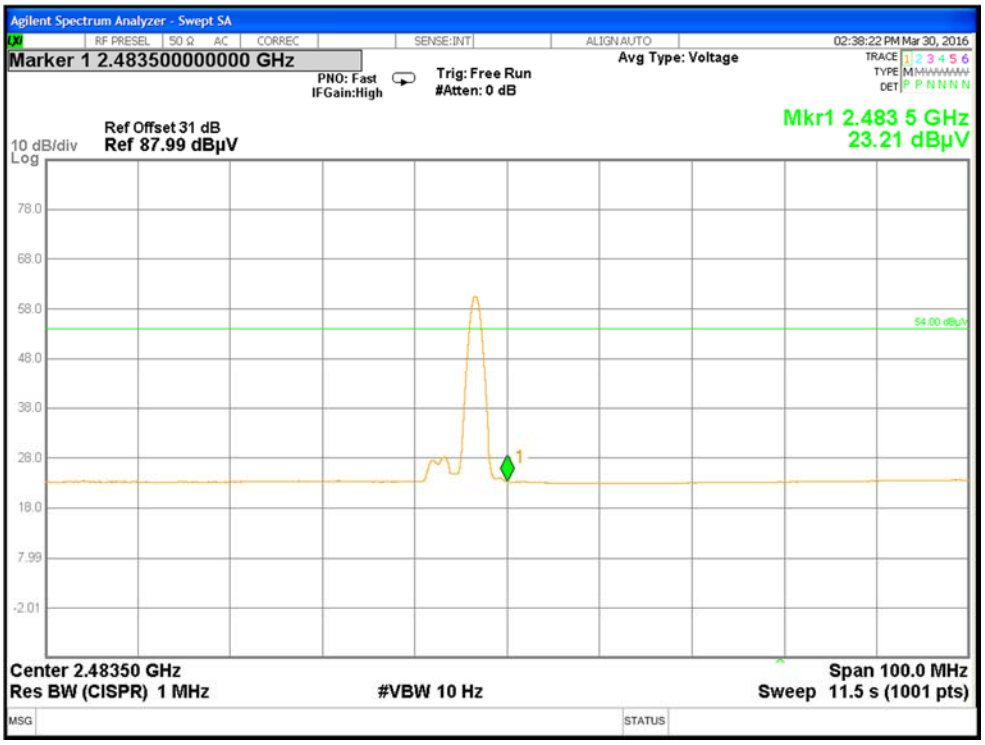


Figure 37: Radiated Emission at the 2483.5MHz Edge for Channel 2480 MHz– Vertical (Avg)

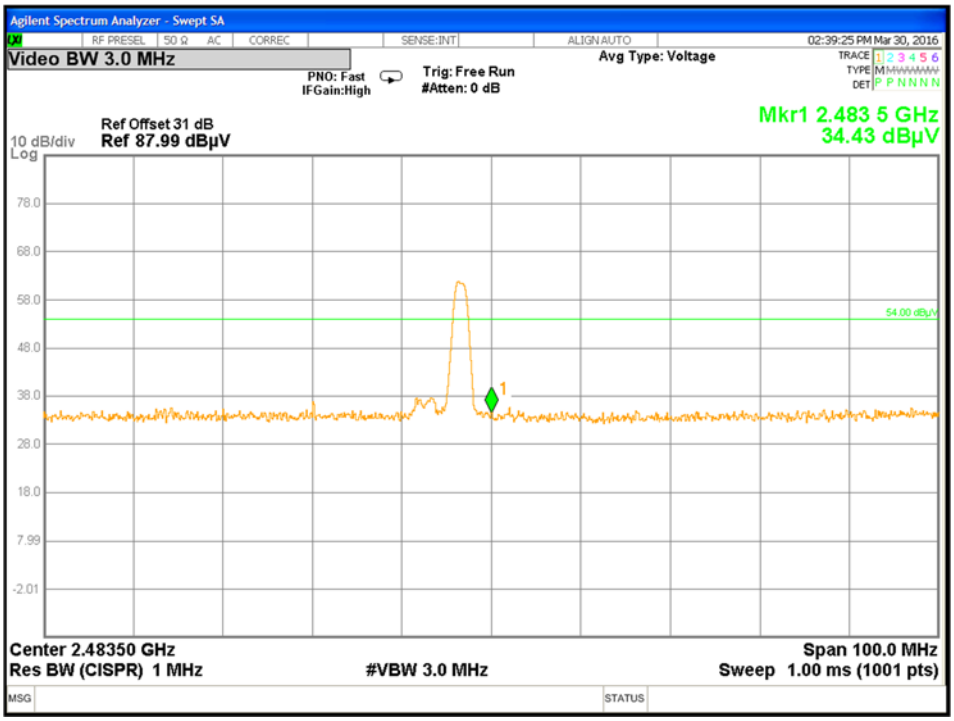


Figure 38: Radiated Emission at the 2483.5MHz Edge for Channel 2480 MHz at – Horizontal (Pk)

Figure 39: Radiated Emission at the 2483.5MHz Edge for Channel 2480 MHz– Horizontal (Avg)

ZigBee mode

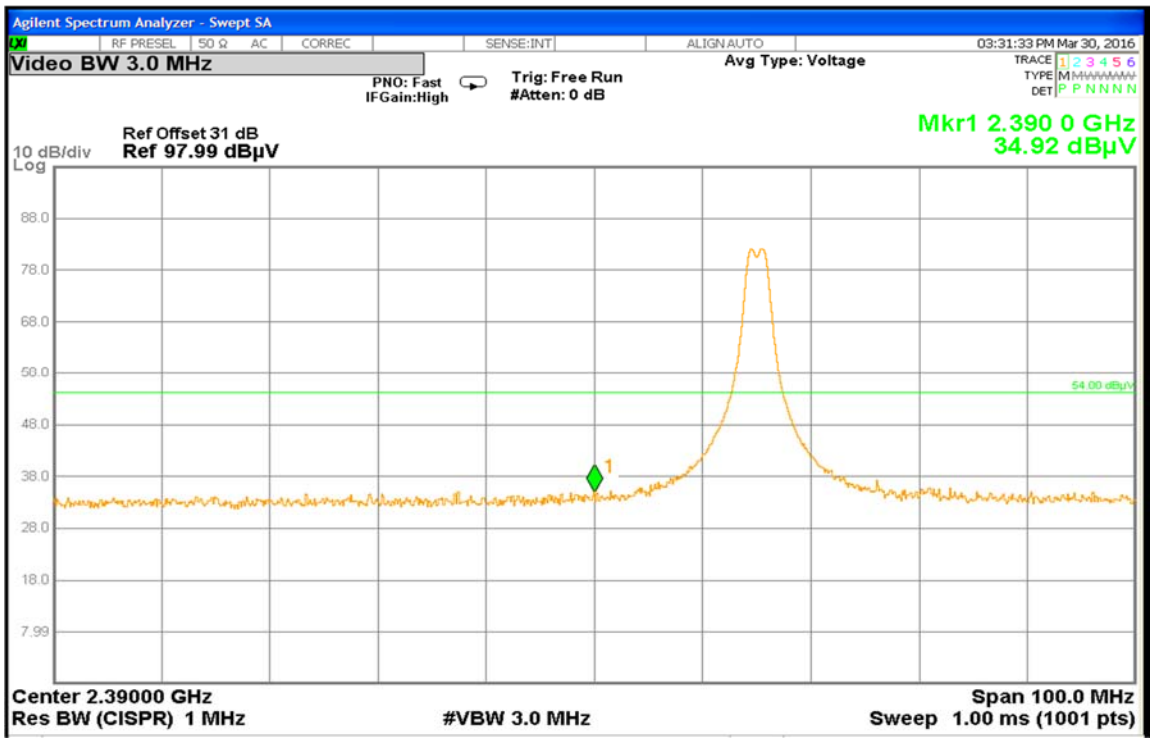


Figure 40: Radiated Emission at the 2390MHz Channel 2405 MHz at – Horizontal (Pk)

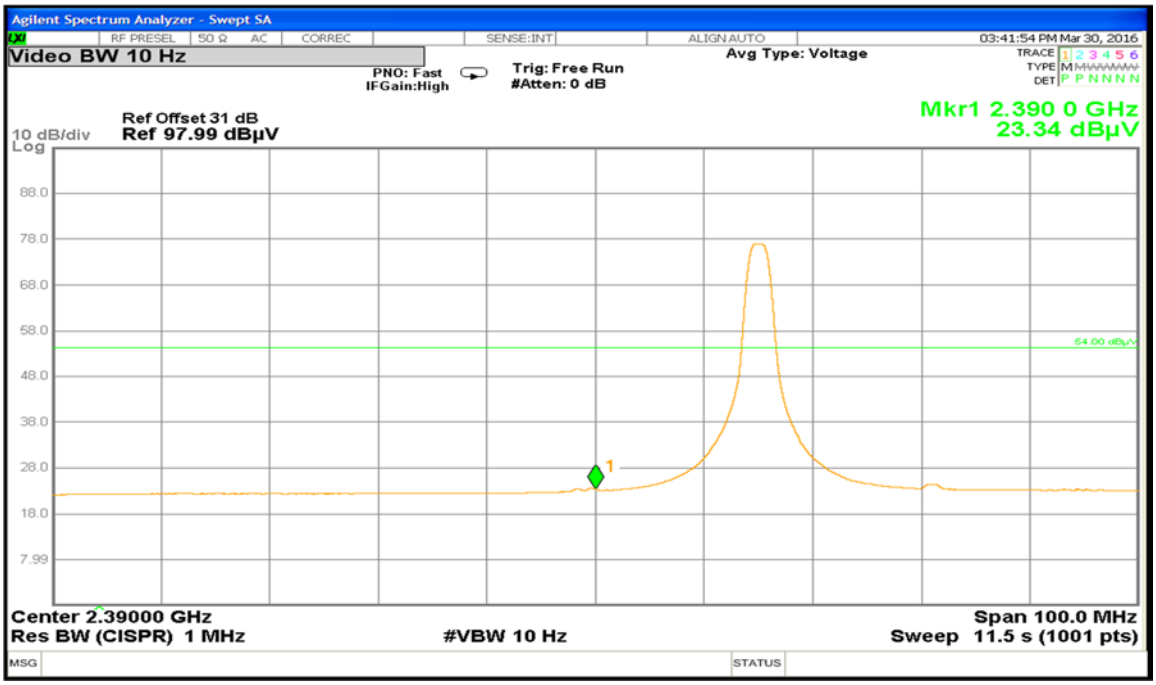


Figure 41: Radiated Emission at the 2390MHz Channel 2405 MHz at – Horizontal (Avg)

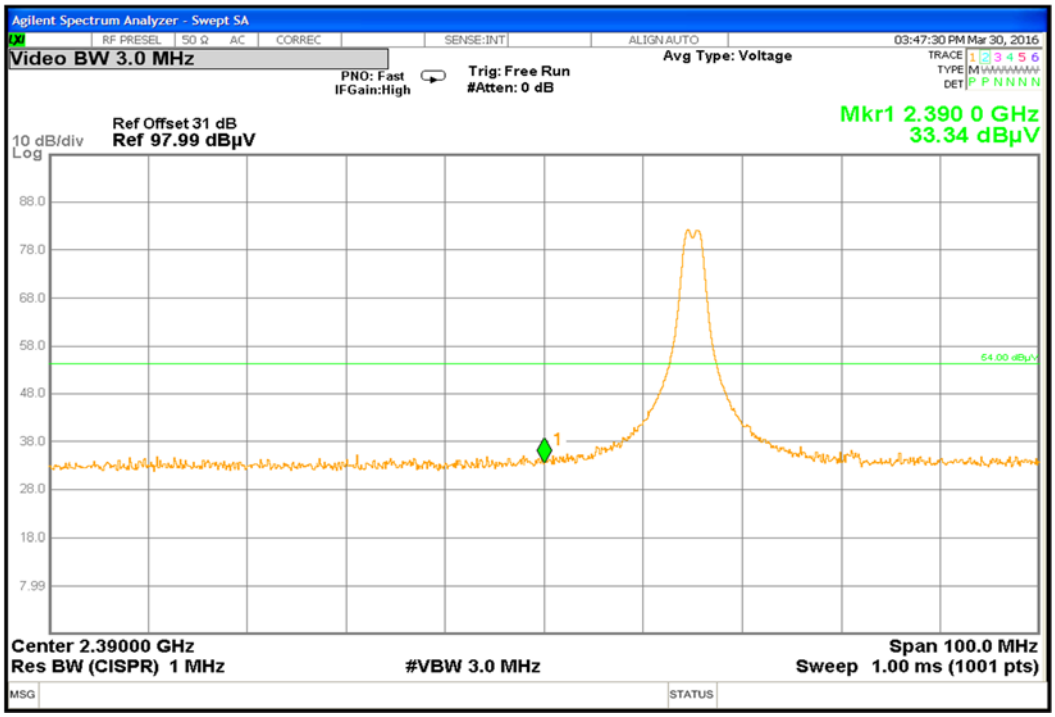


Figure 42: Radiated Emission at the 2390MHz Channel 2405 MHz at – Vertical (Pk)

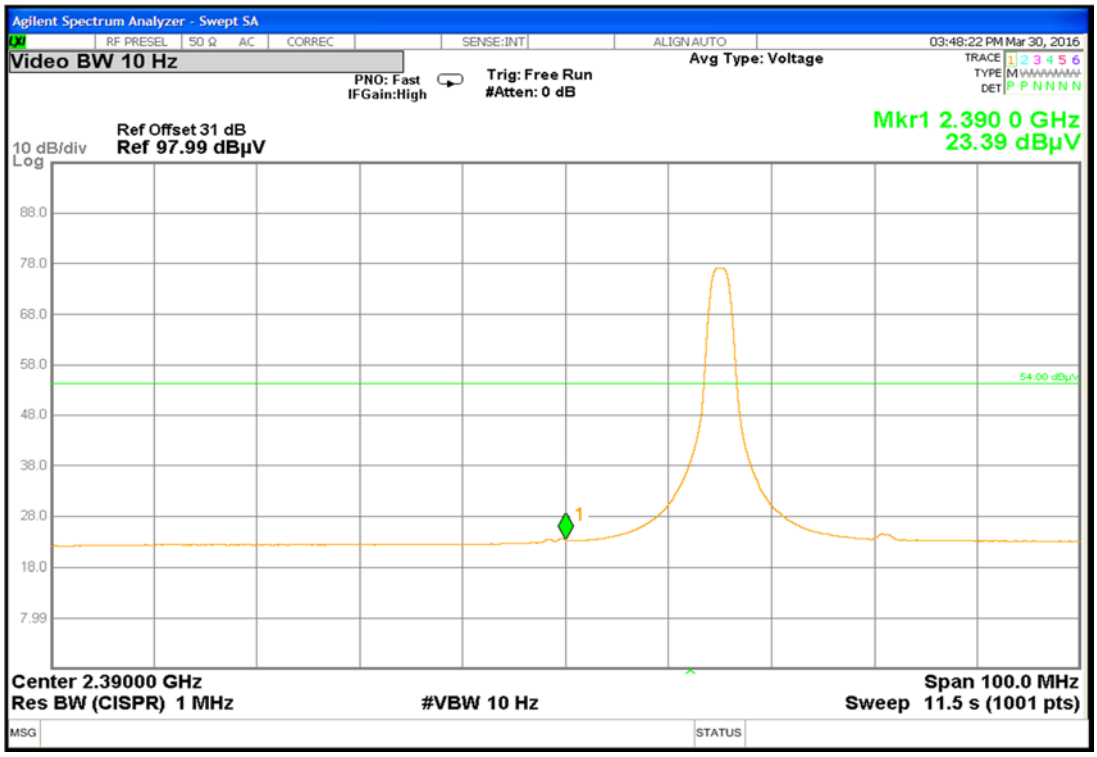


Figure 43: Radiated Emission at the 2390MHz Channel 2405 MHz at – Vertical (Avg)

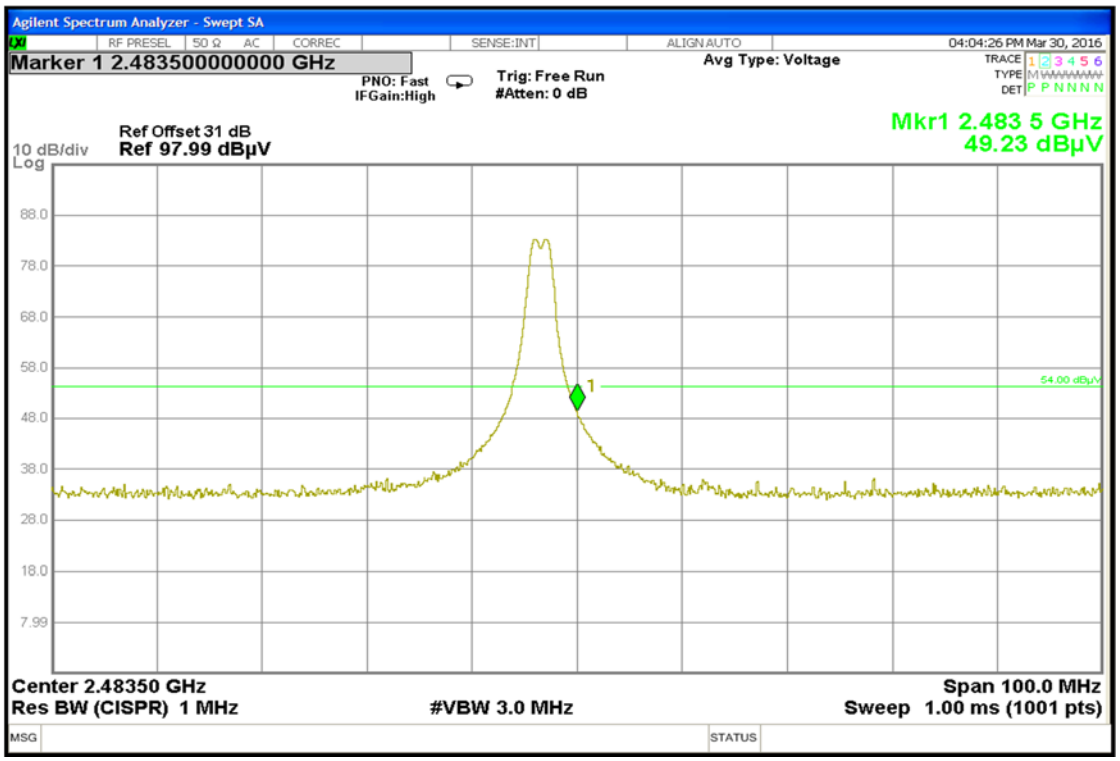


Figure 44: Radiated Emission at the 24843.5MHz Channel 2480 MHz at – Horizontal (Pk)

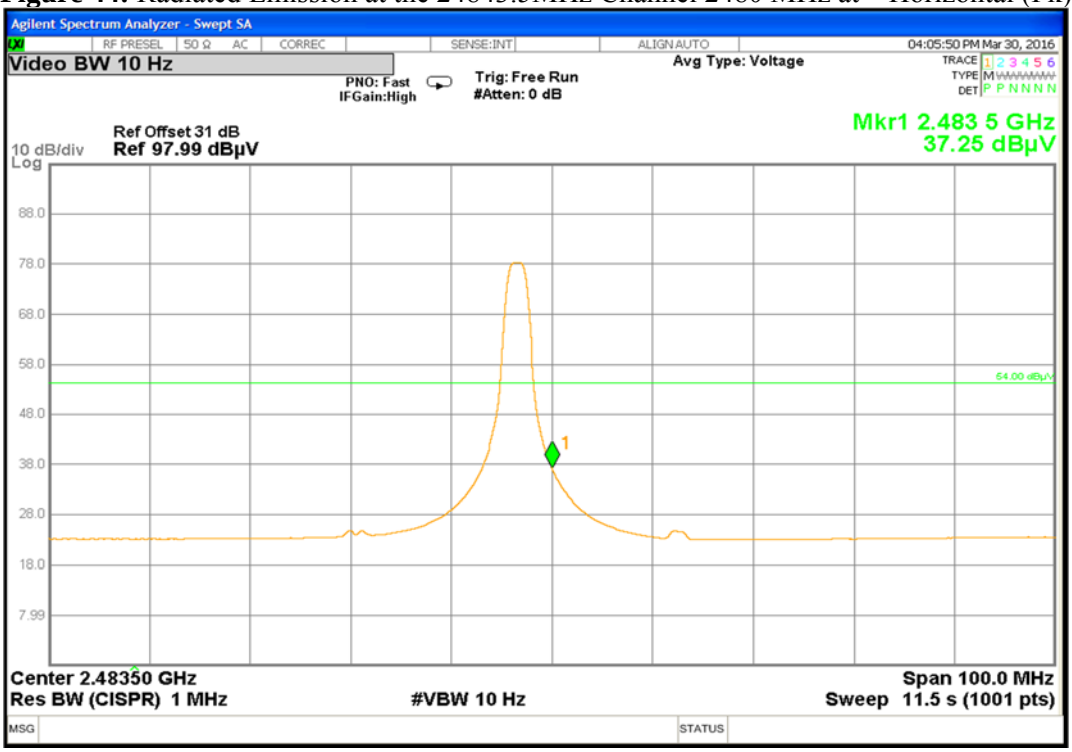


Figure 45: Radiated Emission at the 24843.5MHz Channel 2480 MHz at – Horizontal (Avg)

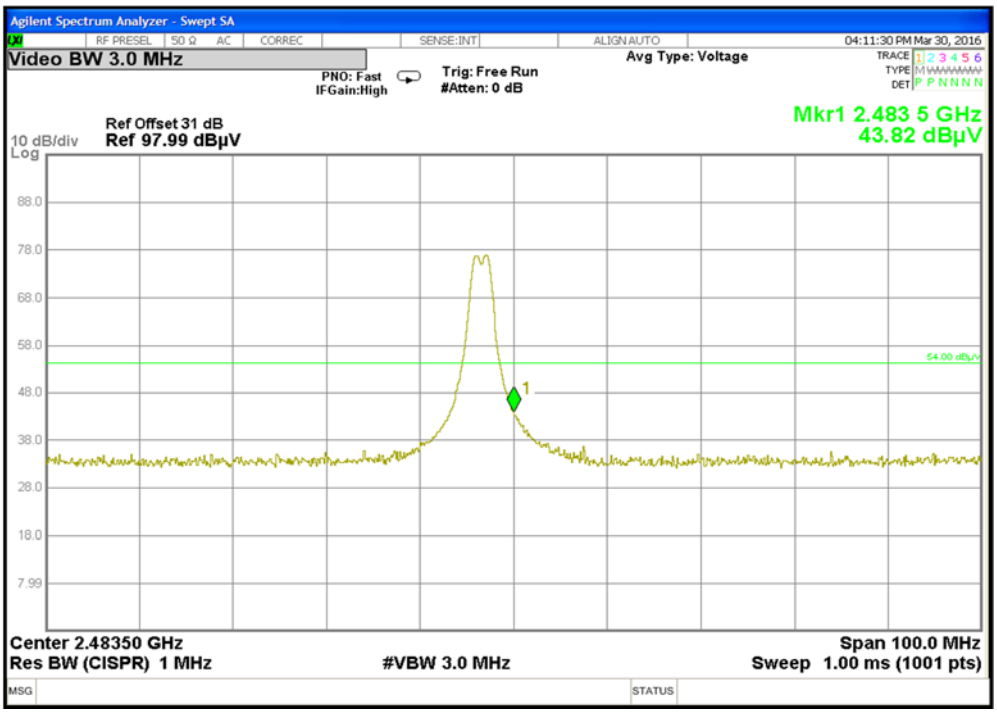


Figure 46: Radiated Emission at the 2483.5MHz Channel 2480 MHz at – Vertical (PK)

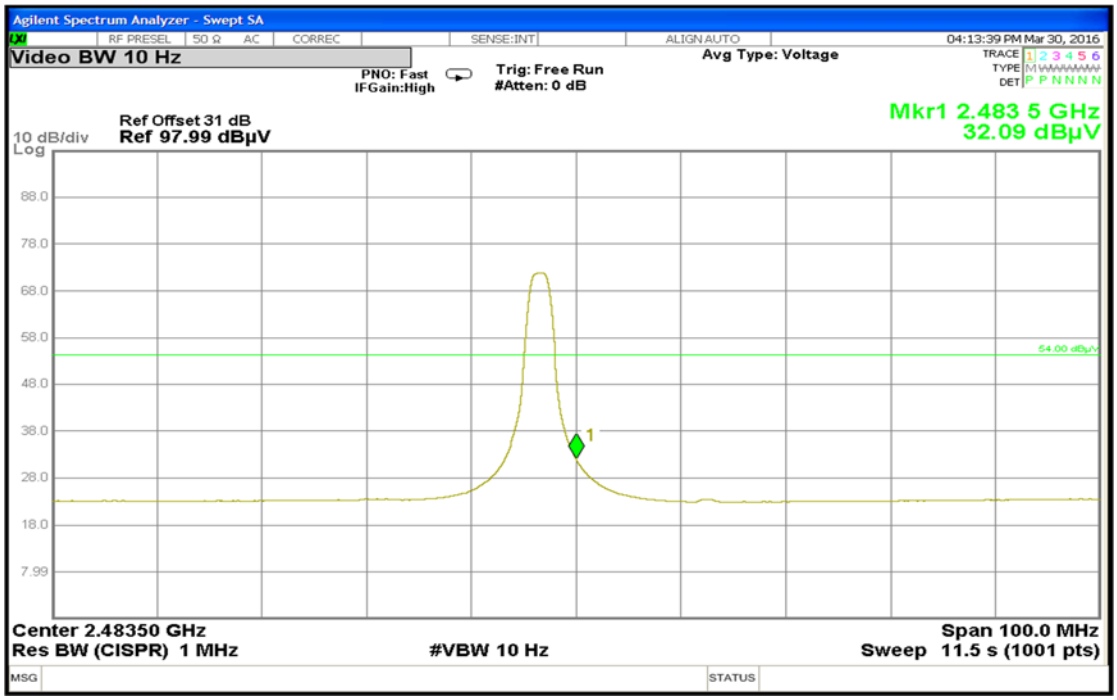


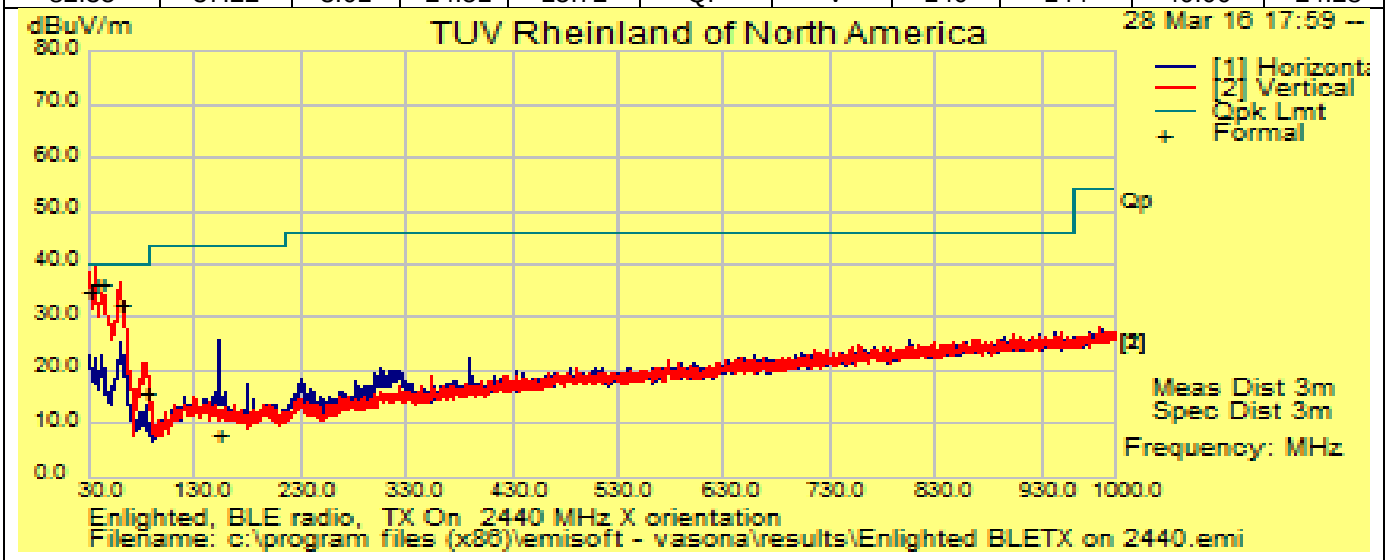
Figure 47: Radiated Emission at the 24843.5MHz Channel 2480 MHz at – Vertical (Avg)

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 1 of 7

EUT Name	Compact Sensor	**Date**	March 28, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	BLE on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / JB3	**Performed by**	Suresh K

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
152.24	23.70	3.40	-19.36	7.74	QP	H	327	240	43.50	-35.76
30.01	42.22	2.60	-10.13	34.69	QP	V	151	-2	40.00	-5.31
36.13	48.69	2.66	-14.91	36.44	QP	V	116	92	40.00	-3.56
42.04	53.05	2.71	-19.34	36.42	QP	V	104	-2	40.00	-3.58
60.22	54.04	2.85	-24.60	32.29	QP	V	116	-2	40.00	-7.71
82.35	37.22	3.01	-24.51	15.72	QP	V	140	144	40.00	-24.28



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

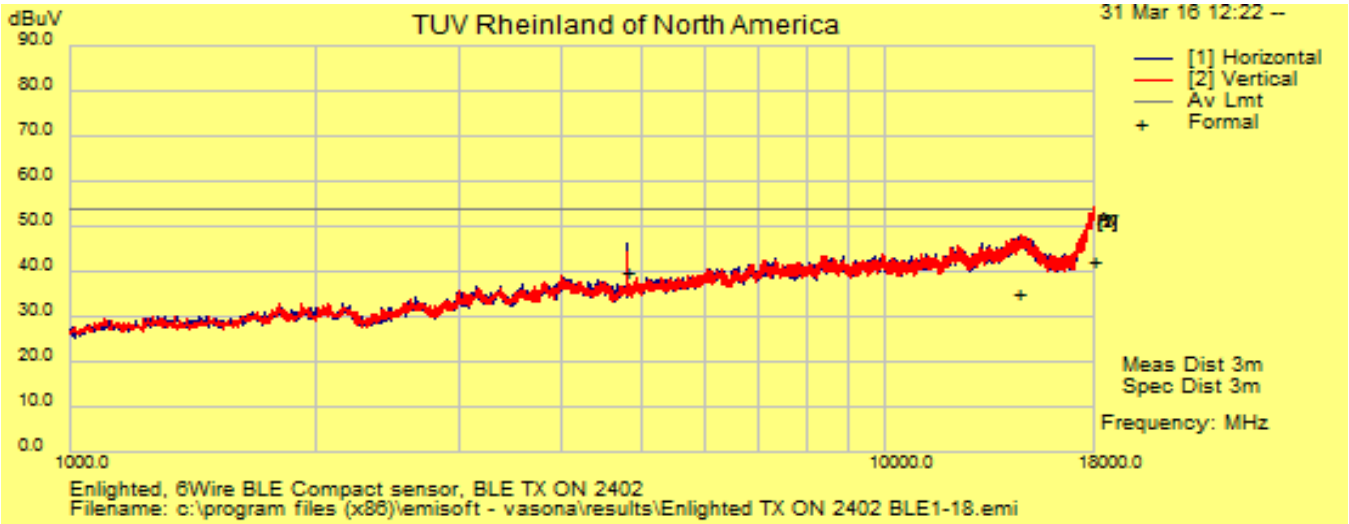
Note: The worst case was observed at mid channel.
All other emissions passed Class B limit.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 2 of 7

EUT Name	Compact Sensor	**Date**	March 28, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	BLE on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

1 – 18 GHz Transmit at 2402 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
4804.53	55.22	1.87	-17.12	39.98	Avg	H	206	22	54.00	-14.02
14614.07	38.23	3.43	-6.81	34.85	Avg	H	205	146	54.00	-19.15
17993.68	36.03	4.04	2.32	42.40	Avg	V	104	256	54.00	-11.60



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 3 of 7

EUT Name	Compact Sensor	**Date**	March 28, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	BLE on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

18 – 25 GHz Transmit at 2402 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
22040.08	43.93	5.45	-10.20	39.18	Pk	H	160	0	54.00	-14.82

Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

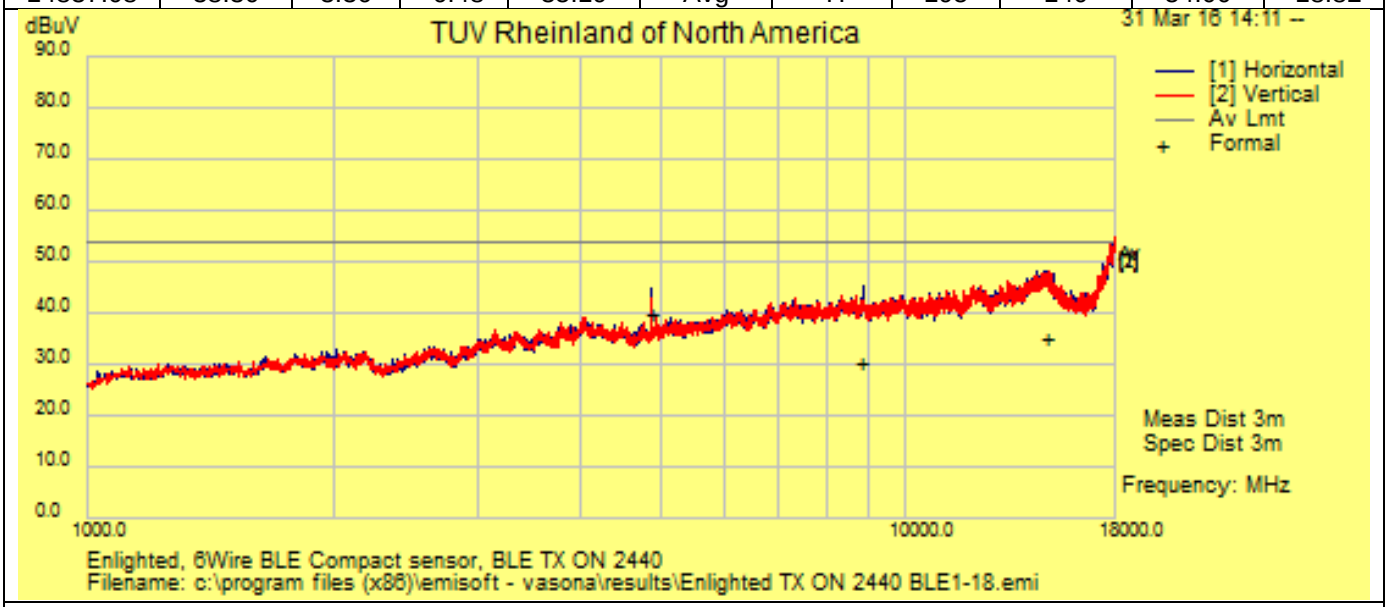
Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 4 of 7

EUT Name	Compact Sensor	**Date**	March 31, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	DH5 on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

1 – 18 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
4882.01	54.55	1.88	-16.73	39.71	Avg	H	100	40	54.00	-14.29
8846.91	35.97	2.46	-8.30	30.14	Avg	H	244	118	54.00	-23.86
14837.08	38.30	3.36	-6.48	35.19	Avg	H	195	140	54.00	-18.82



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

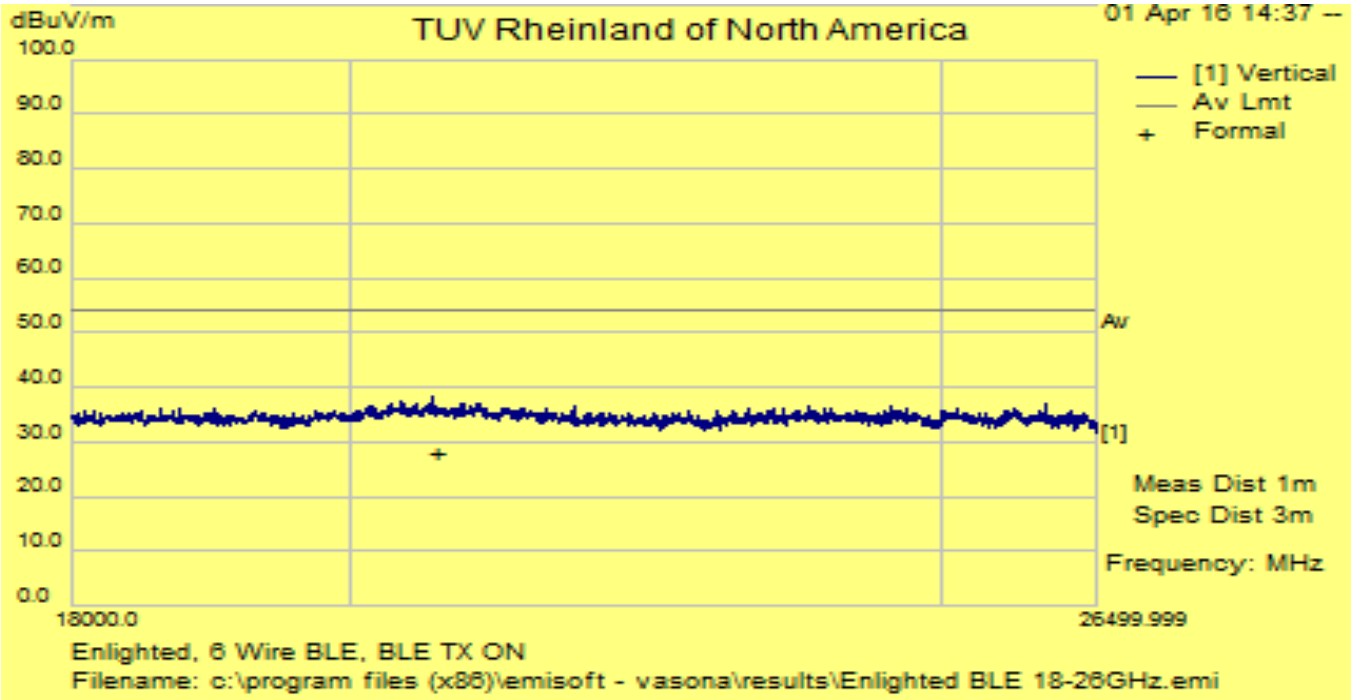
Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 5 of 7

EUT Name	Compact Sensor	**Date**	March 31, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	DH5 on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

18 – 25 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
20635.12	31.75	5.28	-8.92	28.12	Avg	H	107	70	54.00	-25.88
26500.92	34.50	6.12	-13.45	27.17	Avg	H	111	302	54.00	-26.83



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

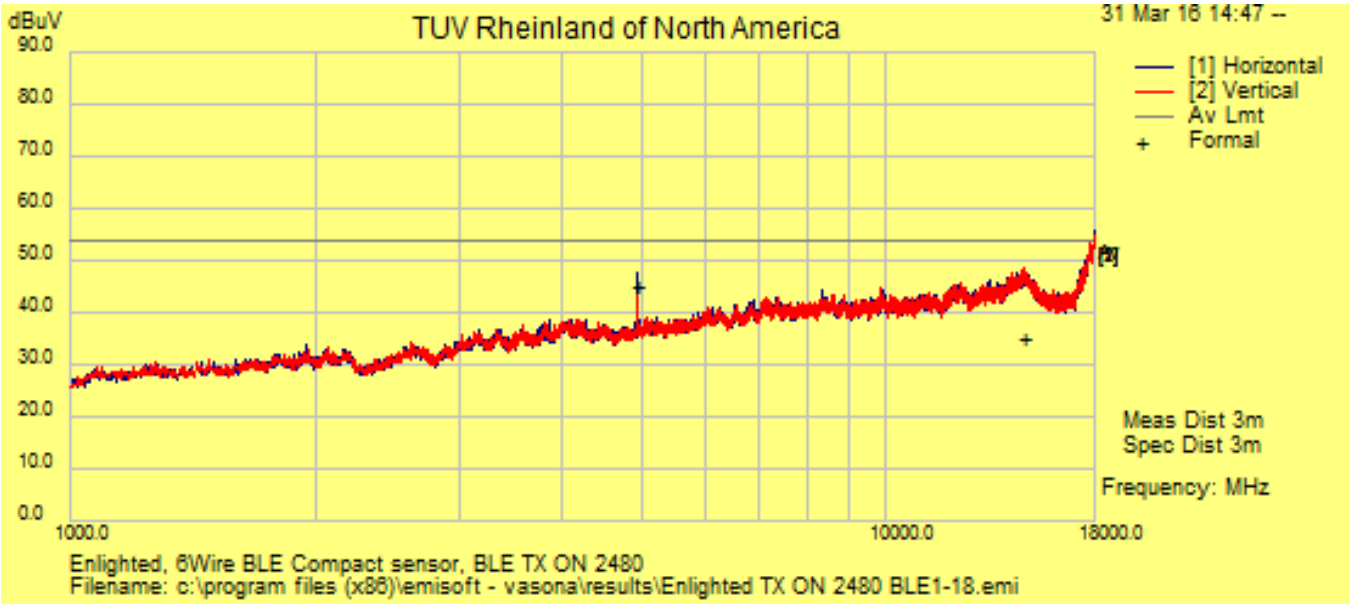
Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 6 of 7

EUT Name	Compact Sensor	**Date**	March 31, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	BLE on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

1 – 18 GHz Transmit at 2480 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
4958.23	59.88	1.87	-16.47	45.29	Avg	H	142	34	54.00	-8.72
14759.28	38.00	3.39	-6.38	35.01	Avg	V	239	138	54.00	-18.99



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 7 of 7

EUT Name	Compact Sensor	**Date**	March 31, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	BLE on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

18 – 25 GHz Transmit at 2480 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
21661.32	44.80	5.40	-9.76	40.44	Pk	V	160	0	54.00	-13.56

Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

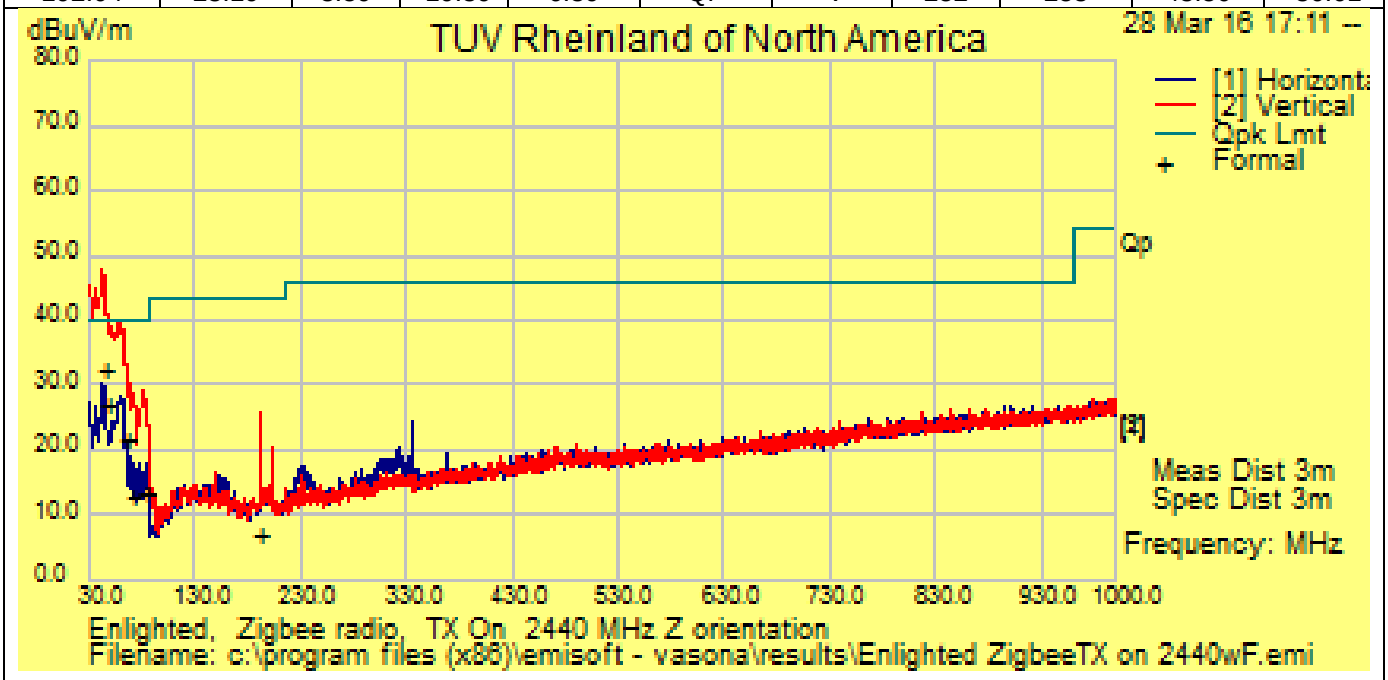
Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 1 of 7

EUT Name	Compact Sensor	**Date**	March 28, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	ZigBee on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / JB3	**Performed by**	Suresh K

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
43.03	49.90	2.72	-20.03	32.59	QP	V	115	275	40.00	-7.41
48.06	47.06	2.76	-22.83	26.99	QP	V	135	22	40.00	-13.01
65.30	42.74	2.89	-24.17	21.47	QP	V	168	24	40.00	-18.53
69.77	33.97	2.93	-23.89	13.01	QP	V	195	124	40.00	-26.99
82.25	34.97	3.01	-24.51	13.47	QP	V	207	282	40.00	-26.53
192.04	23.19	3.59	-19.89	6.89	QP	V	252	258	43.50	-36.61



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

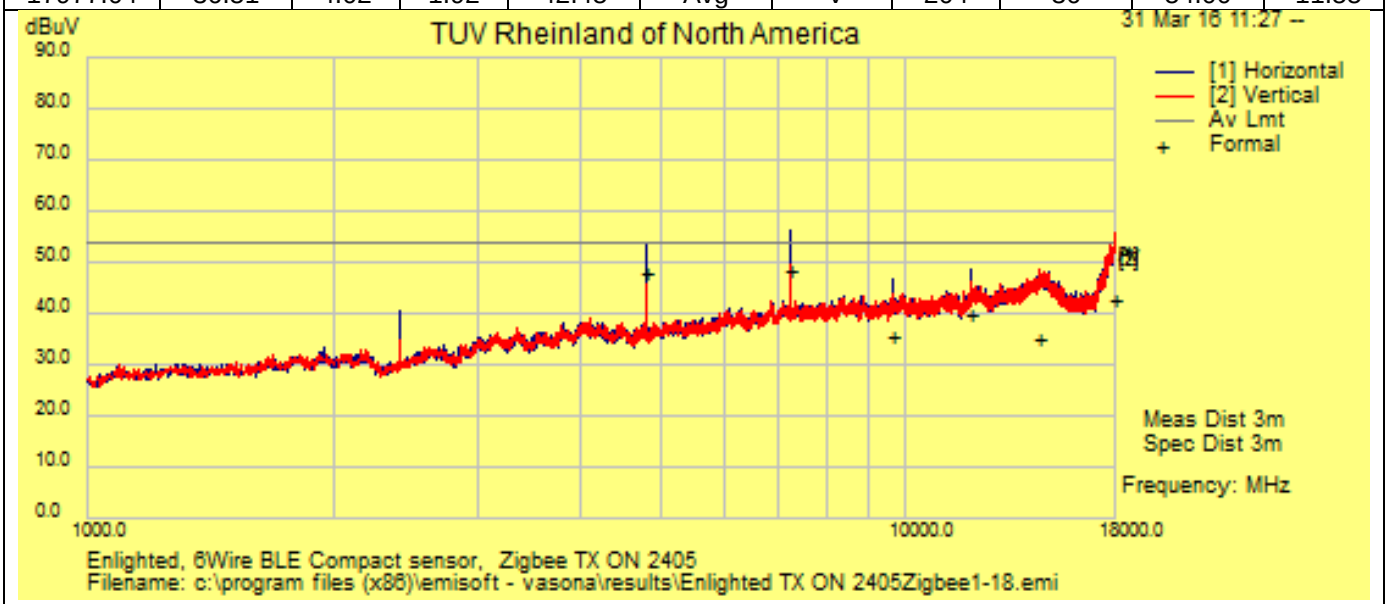
Note: The worst case was observed at mid channel.
All other emissions passed Class B limit.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 2 of 7

EUT Name	Compact Sensor	**Date**	March 31, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	ZigBee on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

1 – 18 GHz Transmit at 2405 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
4808.96	62.91	1.88	-17.11	47.68	Avg	H	228	40	54.00	-6.32
7216.57	57.32	2.28	-11.03	48.57	Avg	H	162	126	54.00	-5.43
9622.17	41.14	2.67	-8.10	35.72	Avg	H	106	110	54.00	-18.28
12022.84	47.99	2.95	-11.17	39.77	Avg	H	150	54	54.00	-14.23
14609.86	38.41	3.44	-6.83	35.02	Avg	V	241	40	54.00	-18.98
17977.04	36.51	4.02	1.92	42.45	Avg	V	204	36	54.00	-11.55



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

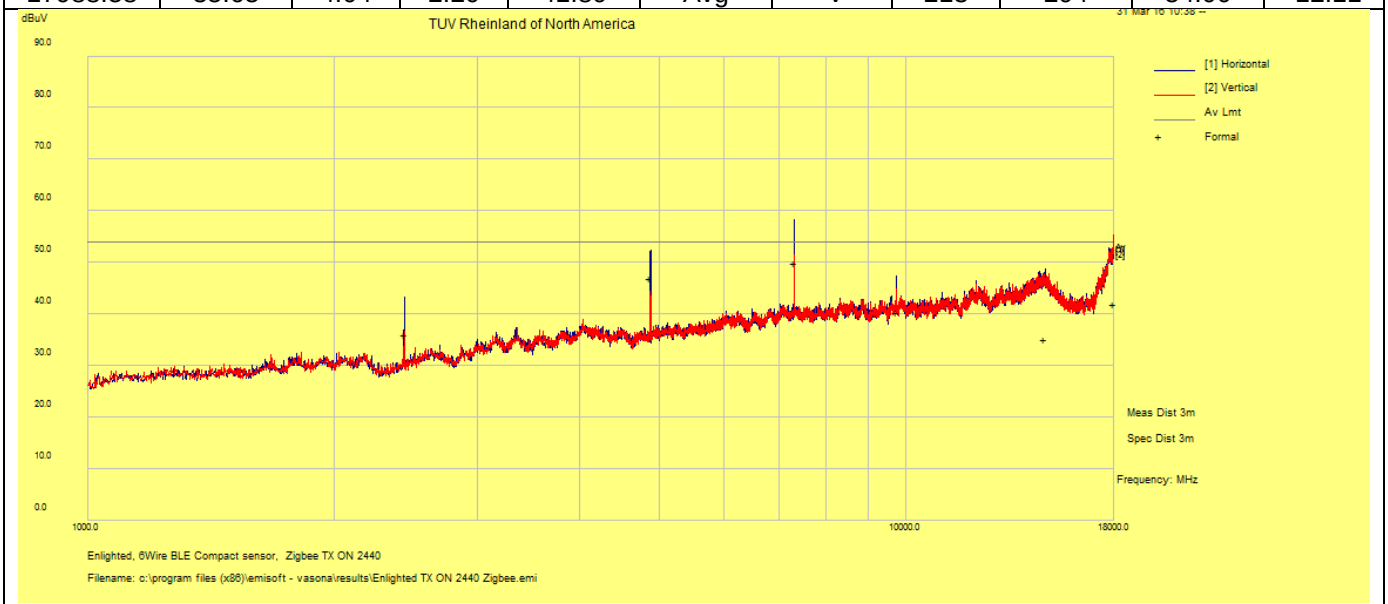
Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 2 of 7

EUT Name	Compact Sensor	**Date**	March 31, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	ZigBee on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

1 – 18 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
4879.09	61.85	1.88	-16.74	46.99	Avg	H	219	40	54.00	-7.01
7318.55	58.54	2.29	-10.91	49.93	Avg	H	179	132	54.00	-4.07
9758.16	46.26	2.70	-8.65	40.31	Avg	H	175	132	54.00	-13.69
14819.14	38.30	3.36	-6.46	35.20	Avg	H	211	162	54.00	-18.80
17988.58	35.65	4.04	2.20	41.89	Avg	V	213	294	54.00	-12.11



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

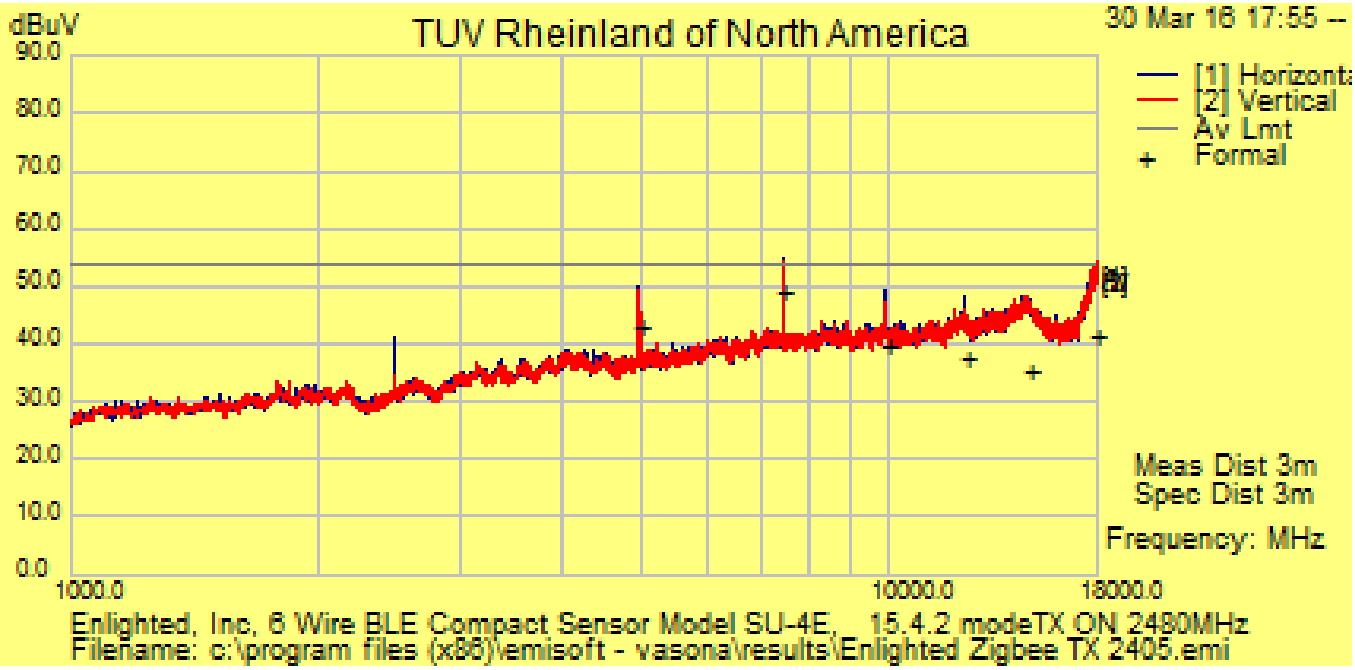
Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 2 of 7

EUT Name	Compact Sensor	**Date**	March 31, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	ZigBee on Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

1 – 18 GHz Transmit at 2480 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
4959.12	57.83	1.87	-16.47	43.23	Avg	H	125	124	54.00	-10.77
7438.41	57.24	2.31	-10.67	48.89	Avg	H	234	100	54.00	-5.11
9921.99	45.25	2.70	-8.25	39.69	Avg	H	214	139	54.00	-14.31
12402.45	45.97	3.03	-11.56	37.44	Avg	H	225	331	54.00	-16.56
14826.17	38.46	3.36	-6.46	35.36	Avg	V	195	50	54.00	-18.64



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

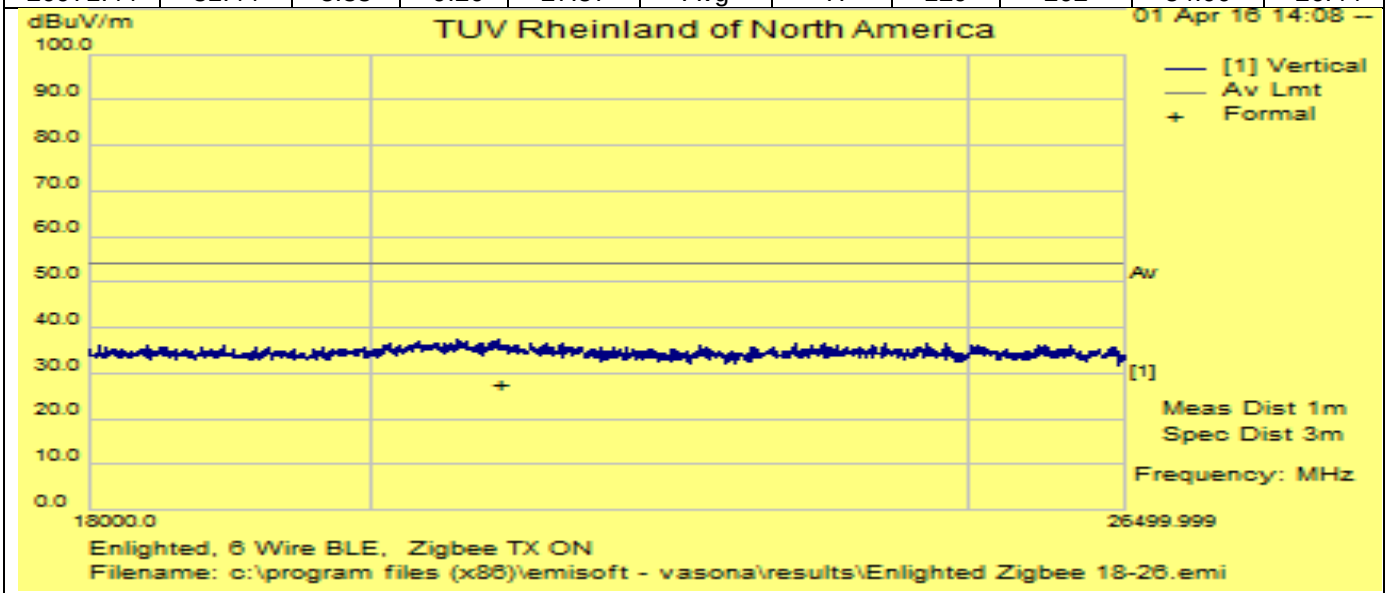
Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

SOP 1 Radiated Emissions — Tracking # 31563521.001 Page 7 of 7

EUT Name	Compact Sensor	**Date**	April 01, 2016
EUT Model	SU-4E	**Temp / Hum in**	23° C / 35%rh
EUT Serial	002	**Temp / Hum out**	N/A
EUT Config.	ZigBeeon Y-Axis	**Line AC / Freq**	16VDC
Standard	CFR47 Part 15 Subpart C, RSS-247, RSS-GEN	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / DRH-118 & 1m / AHA-840	**Performed by**	Suresh K

18 – 25 GHz Transmit at 2480 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
20971.44	31.44	5.33	-9.20	27.57	Avg	H	129	202	54.00	-26.44



Spec Margin = Level - Limit, Level = Raw+ Cbl+ CF ± Uncertainty
CF= Amp Gain + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 4.52 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note: All emissions passed the spurious emission limit. No significant emission was observed from 1GHz to 25GHz.

4.6.4 Sample Calculation

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) = FIM - AMP + CBL + ACF

Where:

FIM = Field Intensity Meter (dBμV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

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

4.3 Maximum Permissible Exposure

4.3.1 Test Methodology

In this document, we try to prove the safety of radiation harmfulness to the human body for our product. The limit for Maximum Permissible Exposure (MPE) specified in FCC 1.1310 is followed. The Gain of the antenna used in this product is measured in a Semi-Anechoic Chamber, and also the maximum total power input to the antenna is measured. Through the Friis transmission formula and the maximum gain of the antenna, we can calculate the distance, away from the product, where the limit of MPE is reached.

Although the Friis transmission formula is a far field assumption, the calculated result of that is an over-prediction for near field power density. We will take that as the worst case to specify the safety range.

4.3.2 RF Exposure Limit

According to FCC 1.1310 table 1: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b). RSS-102 Section 2.5.2 and IEEE C95.3 are also applicable

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm2)	Average Time (minutes)
(A)Limits For Occupational / Control Exposures				
300 - 1500	…	…	F/300	6
1500 - 100,000	…	…	5	6
(B)Limits For General Population / Uncontrolled Exposure				
300 - 1500	…	…	F/1500	6
1500 - 100,000	…	…	1.0	30

F = Frequency in MHz

4.3.3 EUT Operating Condition

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

4.3.4 Classification

The antenna of the product, under normal use condition, is at least 20cm away from the body of the user. Warning statement to the user for keeping at least 20cm or more separation distance with the antenna should be included in user's manual. So, this device is classified as a **Mobile Device**.

4.3.5 Test Results

4.3.5.1 Antenna Gain

The transmitting antenna was integrated. The antenna gain was +0.0 dBi or 1.68 (numeric).

4.3.5.2 Output Power into Antenna & RF Exposure value at distance 20cm:

Calculations for this report are based on highest power measurement.

Limit for MPE (from FCC part 1.1310 table1) is 1.0 mW/cm^2

The highest Zigbee +BLE measured power is +2.89 dBm or 1.94mW; average power.

Using the Friss transmission formula, the EIRP is Pout*G, and R is 20cm.

Pd = (1.94*1.68) / (1600π) = 0.000648 mW/cm2, which is 0.9993 mW/cm2 below to the limit.

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

4.3.6 Sample Calculation

The Friss transmission formula: $Pd = (Pout*G) / (4*\pi*R^2)$

Where;

Pd = power density in mW/cm2
Pout = output power to antenna in mW
G = gain of antenna in linear scale
$\pi \approx 3.1416$
R = distance between observation point and center of the radiator in cm

Ref. : David K. Cheng, Field and Wave Electromagnetics, Second Edition, Page 640, Eq. (11-133).

5 Test Equipment Use 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	07/08/2014	07/08/2016
Bilog Antenna	Sunol Sciences	JB3	A020502	04/30/2015	04/30/2017
Horn Antenna	EMCO	3115	9710-5301	07/03/2015	07/03/2017
Horn Antenna	Sunol Science	DRH118	A040806	02/10/2015	02/10/2017
Horn Antenna	AH Systems	SAS-571	752	01/28/2016	01/28/2017
Spectrum Analyzer	Agilent	N9038A	MY51210195	01/26/2016	01/26/2017
Spectrum Analyzer	Agilent	N9030A	MY51380689	01/19/2015	01/19/2017
Amplifier	Sonoma Instruments	310	213221	01/18/2016	01/18/2017
Amplifier	Miteq	TTA1800-30-4G	1842452	01/20/2016	01/20/2017
Power Meter	Agilent	E3634A	MY400004331	01/19/2016	01/19/2017
Power Sensor	Hewlett Packard	8482A	US37295801	01/19/2016	01/19/2017
DC Power Supply	Agilent	E3634A	MY400004331	01/19/2016	01/19/2017
Notch Filter	Micro-Tronics	BRM50702	003	01/30/2016	01/30/2017
Signal Generator	Anritsu	MG3694A	42803	01/19/2016	01/19/2017

* Calibration of equipment past due for re-calibration will be performed expeditiously. If any equipment is found to be out of tolerance at that time, affected customers will be notified accordingly.

6 EMC Test Plan

6.1 Introduction

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

6.2 Customer

Table 8: Customer Information

Company Name	Enlighted , Inc.
Address	930 Benecia Avenue
City, State, Zip	Sunnyvale
Country	U.S.A.

Table 9: Technical Contact Information

Name	Deepak Kumar
E-mail	deepak.kumar@enlightedinc.com
Phone	+1-650-964-1094

6.3 Equipment Under Test (EUT)

Table 10: EUT Specifications

EUT Specifications	
Package Dimensions	47.5mm height x 20.8mm width (32mm wide faceplate)
Input Voltage	Input Voltage: 16 Vdc
Environment	Indoor
Operating Temperature Range:	-20 to 55 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No
Hardware Version	1.0
RF Software Version	3.0
Bluetooth Radio	
Operating Mode	BLE
Transmitter Frequency Band	2402 MHz to 2480 MHz
Operating Bandwidth	1 MHz
Max. Power Output	-20 dBm
Antenna Type	1 integrated PCB antenna
Antenna Gain	0.0 dBi
Modulation Type	GFSK, π/4-DQPSK and 8DPSK
Data Rate	1Mbps
Note: This report only documents the radio characteristics for 2402 - 2480 MHz bands.	
802.15.4 Radio	
Operating Mode	Modified ZigBee
Transmitter Frequency Band	2405 MHz to 2480 MHz
Operating Bandwidth	1 MHz
Max. Power Output	3dBm
Power Setting @ Operating Channel	Default
Antenna Type	1 integrated PCB antenna
Antenna Gain	0.0 dBi
Modulation Type	BPSK, ASK and O-QPSK
Data Rate	1 Mbps
Note: This report only documents the radio characteristics for 2405- 2480 MHz bands.	

Table 11: 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?
6 wire	Custom Connector	☒ No	☒ Metric: 1 m	☒ M

Table 12: Supported Equipment

Equipment	Manufacturer	Model	Serial	Used for
Laptop	Lenovo	Think Pad T420	417786VU	Setup EUT operating channel
Interface Board	Texas Instruments	CC Debugger	NA	Access BLE radio chipset
Interface Board	Atmel	Zigzag Mirage	396744-1Q-1	Access Atmel ZigBee radio chipset
Note: None.				

Table 13: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.247
SU-4E	1	Integrated Antenna	Radiated Emissions, Radiated band Edge
	3	Direct via SMA Connection	Transmit Power, Occupied Bandwidth, Out of Band Emission, PSD

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

Device	Antenna	Mode	Setup Photo (X-Axis)	Setup Photo (Y-Axis)	Setup Photo (Z-Axis)
SU-4E	Integrated	Transmit BLE mode	Flat on the table	Vertical	Parallel to Table
Note: The SU-4E is designed and intended to be mounted in ceiling light fixtures in vertical mode. Preliminary tests showed that Highest emissions were found in X axis for BLE mode and Highest emissions were found in Z axis for ZigBee mode.					

Table 15: Final Test Mode for 2402 MHz to 2480MHz Channels

Test	802.11 BLE Mode	802.15.2 Modified ZigBee Mode
Occupied Bandwidth CFR 47 15.247(a1), RSS Gen Sect. 6.6.	2402, 2440, 2480 MHz	2405, 2440, 2480 MHz
Output Power CFR47 15.247 (b1), RSS 247 Sect. 5.4.2	2402, 2440, 2480 MHz	2405, 2440, 2480 MHz
Out of Band Emission CFR47 15.247 (d), RSS 247 Sect. 6.2.1.2	2402, 2440, 2480 MHz	2405, 2440, 2480 MHz
Hopping Requirements CFR47 15.247 (a1), RSS 247 Sect. 5.1.4	2402, 2440, 2480 MHz	2405, 2440, 2480 MHz
Band-Edge (Radiated) FCC Part 15.205, 15.209, RSS 247 Sect. 5.5	2402, 2480 MHz	2405, 2480 MHz
Transmitted Spurious Emission (30 MHz – 1GHz) FCC Part 15.205, 15.209, RSS 247 Sect. 5.5	2440 MHz	2440 MHz
Transmitted Spurious Emission (Above 1GHz) FCC Part 15.205, 15.209, RSS 247 Sect. 5.5	2402, 2440, 2480 MHz	2405, 2440, 2480 MHz
AC Conducted Emission FCC Part 15.207, RSS GEN Sect. 8.8	Test Not Applicable	Test Not Applicable

Note: 1. All radiated emission performed on X-Axis.
3. All tests were pre-scanned for worst case before final testing.

6.4 Test Specifications

Testing requirements

Table 16: Test Specifications

Emissions and Immunity	
Standard	Requirement
CFR 47 Part 15.247: 2014	All
RSS-247 Issue 1, 2015	All

END OF REPORT