Testing Tomorrow's Technology

Application

For

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, paragraphs 15.207, 15.209 and 15.247

And

Innovation, Science, and Economic Development Canada Certification Per IC RSS-Gen, Issue 4 General Requirements for Radio Apparatus And RSS-247, Issue 2 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and License-Exempt Local Area Network (LE-LAN) Devices

For the

Centero LLC

Model: CW24-012

FCC ID: 2ANDP-CW24-012
IC: 23069-CW24012

UST Project: 17-0343
Issue Date: November 10, 2017

Total Pages in This Report: 54

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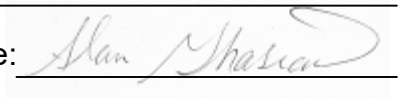
Testing Tomorrow's Technology

I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date November 10, 2017

TESTING
NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANYS NAME: Centero LLC

MODEL: CW24-012

FCC ID: 2ANDP-CW24-012

IC: 23069-CW24012

DATE: November 4, 2017

This report concerns (check one): Original grant [X]
Class II change

Equipment type: 2.4 GHz DTS Transmitter Module

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? Yes_____ No X

If Yes, defer until: _____N/A_____
date

agrees to notify the Commission by N/A
date

of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

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1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to the FCC Rules and Regulations Part 15, Section 247 and IC RSS Gen Issue 4 and RSS 247 Issue 2.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on 8/16/2017 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Centero LLC model CW24-012. The CW24-012 is an IEEE 802.15.4 compliant module that deploys QPSK modulation techniques. The module comes with one integral antenna. The chipset incorporates a complete low power 2.4 GHz radio frequency transceiver and a Kinetis family low power, mixed signal ARM© Cortex ™- M4 MCU into a single package. The EUT was designed to meet all the requirements needed to accommodate standards compliant industrial wireless applications based on the IEEE 802.15.4 physical layer such as ISA100.11a, Wireless HART and Thread. The EUT is offered in a surface mountable form factor, castellated PCB pins and the user interface provides various serial interfaces, MCU digital and analog I/Os and power. Firmware development and debugging are supported through the JTAG SWD port which is also exposed through the castellated PCB pins.

Modulation: Q-PSK
Data rate: 250 kbps
Operating frequency band: 2405-2475 MHz
Antenna: Omni Directional Antenna, +2.0 dBi Gain

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for the intentional radiator aspect of the device and *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)* for the unintentional radiator aspect of the device as well as FCC subpart B and C of Part 15 and per FCC KDB Publication number 558074 v04 for Digital Transmission Systems Operating Under section 15.247.

A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs are provided in separate exhibits.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is US5301. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittals

The EUT is subject to the following FCC authorizations:

a) Certification under section 15.247 as a transmitter.
b) Verification under 15.101 as a digital device and receiver.

The Verification requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the Verification authorization report (part 15.107 and 15.109) for the EUT is included herein.

Table 1. EUT and Peripherals

EUT/PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID IC ID	CABLES P/D
WISA/WEE Module (Centero LLC)	CW-24-012	2ANDP-CW24-012	FCC ID: 2ANDP-CW24-012 IC:23069-CW24-012	1.5 m U D
Hewlett-Packard (Laptop)	EliteBook 8530p	2CE010000TG	Various	-
Hewlett-Packard (Power Supply Adapter)	384020-001	PA-1900-08H2	Various	3.0 m UP
Antenna See antenna details	--	--	--	--

U= Unshielded S= Shielded
P= Power D= Data

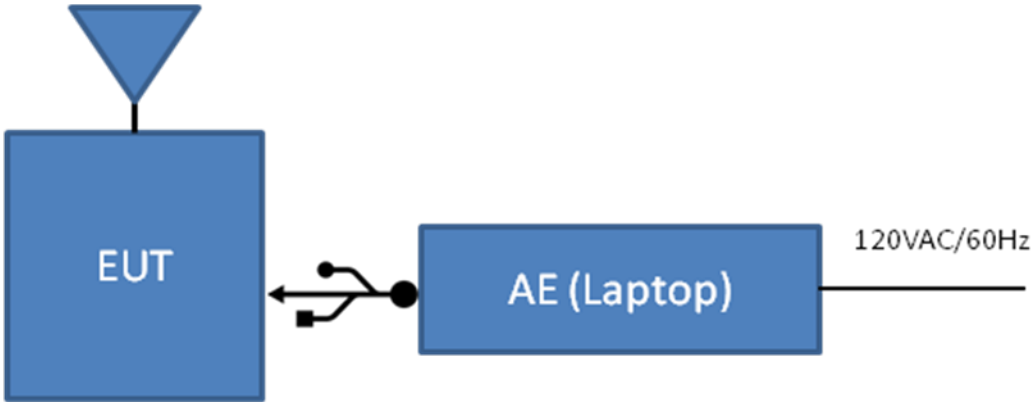


Figure 1. Test Configuration

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are indicated.

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	6/22/2019
SPECTRUM ANALYZER	DSA815	RIGOL	DSA8A1803001	10/11/2018*
RF PREAMP 100 kHz to 1.3 GHz	8447D	HEWLETT-PACKARD	1937A02980	3/7/2018
PREAMP 1.0 GHz to 26.0 GHz	8449B	HEWLETT-PACKARD	3008A00480	10/26/2017
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	12/28/2017 2 yr. extended
BICONICAL ANTENNA	3110B	EMCO	9307-1431	5/2/2019 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	5/1/2019 2 yr.
HORN ANTENNA	3115	EMCO	9107-3723	9/22/2018 2 yr.
LISN	9247-50-TS-50-N	SOLAR ELECTRONICS	955824 & 955826	2/28/2018
CALCULATION PROGRAM	N/A	N/A	Ver. 6.0	N/A

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.
(*)= Used for power line conducted emissions measurements

2.2 Modifications to EUT Hardware

No physical modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in Table 3 below.

Table 3. Number of Test Frequencies for Intentional Radiators

Frequency Range over which the device operates	Number of Frequencies	Location in the Range of operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

Because the EUT operates at 2400 MHz to 2483.5 MHz, 3 test frequencies were used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10^{th} harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz, or to 5 times the highest internal clock frequency.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the following:

2.5.1 Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR Quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the Quasi-peak device are used.

2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

2.5.3 Pulsed Transmitter Averaging (15.35 (c))

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may be expressed logarithmically in dB.

NOTE: The manufacturer has a declared a Duty Cycle of 41% intended for normal operation; therefore where applicable (when using AVG detection) the duty cycle factor based on a 41% DC was applied.

2.6 EUT Antenna Requirements (CFR 15.203)

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. Only the antenna(s) listed in Table 4 will be used with this module.

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
Antenna	Nearson	Omni Directional	S181FL-5-RMM-2450S	2.0	RA-MMCX

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious cannot exceed the limits of 15.209. Radiated harmonics and other spurious are examined for this requirement see paragraph 2.1

2.8 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

The power line conducted voltage emission measurements have been carried out in accordance with CFR 15.207, per ANSI C63.10:2013, Clause 6.2, with a spectrum analyzer connected to an LISN and the EUT placed into a continuous mode of transmission.

The worst-case results for conducted emissions were determined to be produced when the EUT was operating under continuous transmission. The worst case measurement was 8.3 dB from the applicable limit at 2.0667 MHz on the Phase line. All other emissions were at least 8.6 dB from the limit. Those results are given in the table below.

Table 5. Transmitter Power Line Conducted Emissions Test Data, Part 15.107

150KHz to 30 MHz with Class A Limits						
Test: Power Line Conducted Emissions				**Client:** Centero LLC		
Project: 17-0343				**Model:** CW24-012		
Frequency (MHz)	**Test Data (dBuv)**	**LISN+CL-PA (dB)**	**Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector PK, QP, or AVG**
Neutral						
0.1684	50.09	0.42	50.51	55.0	4.5	QP
0.6238	37.22	0.14	37.36	46.0	8.6	QP
1.1300	38.52	0.14	38.66	46.0	7.3	PK
9.7750	37.10	0.39	37.49	50.0	12.5	PK
10.2300	35.69	0.41	36.10	50.0	13.9	PK
20.3300	22.41	0.64	23.05	50.0	27.0	PK
Phase						
0.1640	47.51	0.54	48.05	55.3	7.2	QP
0.6400	36.04	0.29	36.33	46.0	9.7	QP
1.2900	30.64	0.29	30.93	46.0	15.1	QP
9.7870	37.29	0.52	37.81	50.0	12.2	PK
10.2000	36.00	0.53	36.53	50.0	13.5	PK
20.2000	24.23	0.72	24.95	50.0	25.0	PK

SAMPLE CALCULATION at: 0.1684 MHz:

Magnitude of Measured Frequency	50.09	dBuV
LISN+Antenna Factor + Cable Loss+ Amplifier Gain	.42	dB/m
Corrected Result	50.51	dBuV/m

Test Date: October 31, 2017
Tested By
Signature:  Name: Robert K. Mills

2.9 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d)) (IC RSS 247 5.1 & 5.2)

Radiated Spurious measurements: The EUT was placed into a continuous transmit mode of operation (>98%) duty cycle) and tested per ANSI C63.10:2013. A preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the device. A preliminary scan was performed on the EUT to find the worse case results the EUT was tested in X, Y, and Z axes or in the orientation of normal operation if the device is designed to operate in a fixed position.

Radiated measurements were then conducted between the frequency range of 9 kHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (no greater than 40 GHz). In the band below 30 MHz a resolution bandwidth (RBW) of 9 kHz was used, emissions below 1 GHz were tested with a RBW of 120 kHz and emissions above 1 GHz were tested with a RBW of 1 MHz. All video bandwidth settings were at least three times the RBW value.

The EUT was investigated to CFR 15.209, General requirements for unwanted spurious emissions. The conducted spurious method as described below was used to investigate all other emissions emanating from the antenna port.

Conducted Spurious measurements: The EUT was put into a continuous-transmit mode of operation and tested per ANSI C63.10:2013 for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to 25 GHz. A conducted scan was performed on the EUT to identify and record the spurious signals that were related to the transmitter to show that all spurious emissions were at least 20 dB below the fundamental frequency.

Table 6. Spurious Radiated Emissions 150 kHz-30MHz (CFR 15.209)

Test By: RKM	Test: FCC Part 15.209			Client: Centero LLC			
	Project: 17-0343			Model: CW24-012			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
All emissions were at least 20 dB below the applicable limit.							

SAMPLE CALCULATION: N/A

Test Date: August 28, 2017

Tested By
Signature:  Name: Robert K. Mills

Table 7. Unintentional Radiator, Peak Radiated Emissions (CFR 15.109/15.209), 30 MHz to 1000 MHz

30 MHz to 1000 MHz, 15.109/15.209 Limits								
Test: Radiated Emissions				**Client:** Centero LLC				
Project: 17-0343				**Model:** CW24-012				
Frequency (MHz)	**Test Data (dBuv)**	**Additional Factor (dB)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
48.13	52.36	--	-17.04	35.32	40.0	3m./VERT	4.7	PK
64.95	41.09	--	-17.20	23.89	40.0	3m./HORZ	16.1	PK
96.10	45.15	--	-16.66	28.49	43.5	3m./VERT	15.0	PK
135.90	46.86	--	-14.57	32.29	43.5	3m./HORZ	11.2	PK
201.16	40.49	--	-13.70	26.79	43.5	3m./HORZ	16.7	PK
215.96	40.28	--	-14.68	25.60	43.5	3m./VERT	17.9	PK
277.00	50.51	--	-12.19	38.32	46.0	3m./HORZ	7.7	PK
277.00	53.28	--	-12.59	40.69	46.0	3m./VERT	5.3	PK
461.30	46.65	--	-8.56	38.09	46.0	3m./HORZ	7.9	PK
608.80	43.76	--	-5.43	38.33	46.0	3m./VERT	7.7	PK
969.80	33.90	--	-0.49	33.41	54.0	3m./VERT	20.6	PK
993.30	33.83	--	0.78	34.61	54.0	3m./HORZ	19.4	PK

SAMPLE CALCULATION at: 48.13 MHz

Magnitude of Measured Frequency	52.36	dBuV
+Additional Factor	0	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	-17.04	dB/m
Corrected Result	35.32	dBuV/m

Test Date: August 28, 2017
Tested By
Signature:  Name: Robert K. Mills

Table 8. Unintentional Radiator, Peak Radiated Emissions (CFR 15.109/15.209) 1 GHz to 25 GHz

1 GHz to 25 GHz, Part 15.109/15.209 Limits							
Test: Radiated Emissions				**Client:** Centero LLC			
Project: 17-0343				**Model:** CW24-012			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
All emissions were at least 20 dB from the applicable limit.							

SAMPLE CALCULATION at: N/A

Test Date: August 28, 2017
Tested By
Signature:  Name: Robert K. Mills

Table 9. Peak Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)					**Client:** Centero LLC			
Project: 17-0343					**Model:** CW24-012			
Frequency (MHz)	**Test Data (dBuV)**	**Factor (dB)**	**AF+CA -AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel (Peak)								
2404.55	79.69	-	32.00	111.69		3.0m./HORZ		PK
4809.00*	48.41	-	7.68	56.09	74.0	3.0m./HORZ	17.9	PK
7216.55	47.82	-	18.34	66.16	91.7	3.0m./HORZ	25.5	PK
9618.25	47.73	-	19.28	67.01	91.7	3.0m./HORZ	24.7	PK
Mid Channel (Peak)								
2440.50	78.67	-	31.94	110.61		3.0m./HORZ		PK
4881.10*	48.25	-	7.64	55.89	74.0	3.0m./HORZ	18.1	PK
7318.10*	45.92	-	18.94	64.86	74.0	3.0m./HORZ	9.1	PK
9757.95	46.50	-	20.32	66.82	90.6	3.0m./HORZ	23.8	PK
High Channel (Peak)								
2474.45	74.48	-	31.96	106.44		3.0m./HORZ		PK
4950.95*	50.39	-	8.71	59.10	74.0	3.0m./HORZ	14.9	PK
7426.50*	45.20	-	19.01	64.21	74.0	3.0m./HORZ	9.8	PK
9890.65	43.06	-	20.18	63.24	86.4	3.0m./HORZ	23.2	PK

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at: 2404.55 MHz

Magnitude of Measured Frequency	79.69	dBuV
+Additional Factor (external)	0.00	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	32.00	dB/m
Corrected Result	111.69	dBuV/m

Test Date: August 23, 2017
Tested By
Signature:  Name: Robert K Mills

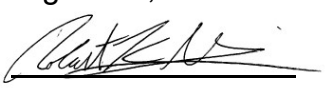
Table 10. Average Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)					**Client:** Centero LLC			
Project: 17-0343					**Model:** CW24-012			
Frequency (MHz)	**Test Data (dBuV)**	**Factor (dB)**	**AF+CA -AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel (Average)								
2404.55	78.06	-7.74	32.00	102.32		3.0m./HORZ		AVG
4809.00*	35.79		7.68	43.47	54.0	3.0m./HORZ	10.5	AVG
7216.55	34.78		18.34	53.12	71.7	3.0m./HORZ	18.6	AVG
9618.25	35.22		19.28	54.50	71.7	3.0m./HORZ	17.2	AVG
Mid Channel (Average)								
2440.50	75.81	-7.74	31.94	100.01		3.0m./HORZ		AVG
4881.10*	35.69		7.64	43.33	54.0	3.0m./HORZ	10.7	AVG
7318.10*	32.32	-7.74	18.94	43.52	54.0	3.0m./HORZ	10.5	AVG
9757.95	33.62		20.32	53.94	70.6	3.0m./HORZ	16.7	AVG
High Channel (Average)								
2474.45	71.46	-7.74	31.96	95.68		3.0m./HORZ		AVG
4950.95*	39.76	-7.74	8.71	40.73	54.0	3.0m./HORZ	13.3	AVG
7426.50*	31.62	-7.74	19.01	42.89	54.0	3.0m./HORZ	11.1	AVG
9890.65	29.34		20.18	49.52	66.4	3.0m./HORZ	16.9	AVG

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209
2. Additional factor of -7.74 dB (Duty Cycle factor) applied.
3. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic

Sample Calculation at: 2404.55 MHz

Magnitude of Measured Frequency	78.06	dBuV
+Additional Factor (filter + duty cycle)	-7.74	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	32.00	dB/m
Corrected Result	102.32	dBuV/m

Test Date: August 23, 2017
Tested By
Signature:  Name: Robert K. Mills

The following data is the conducted spurious emissions data measured for low, mid and high channels.

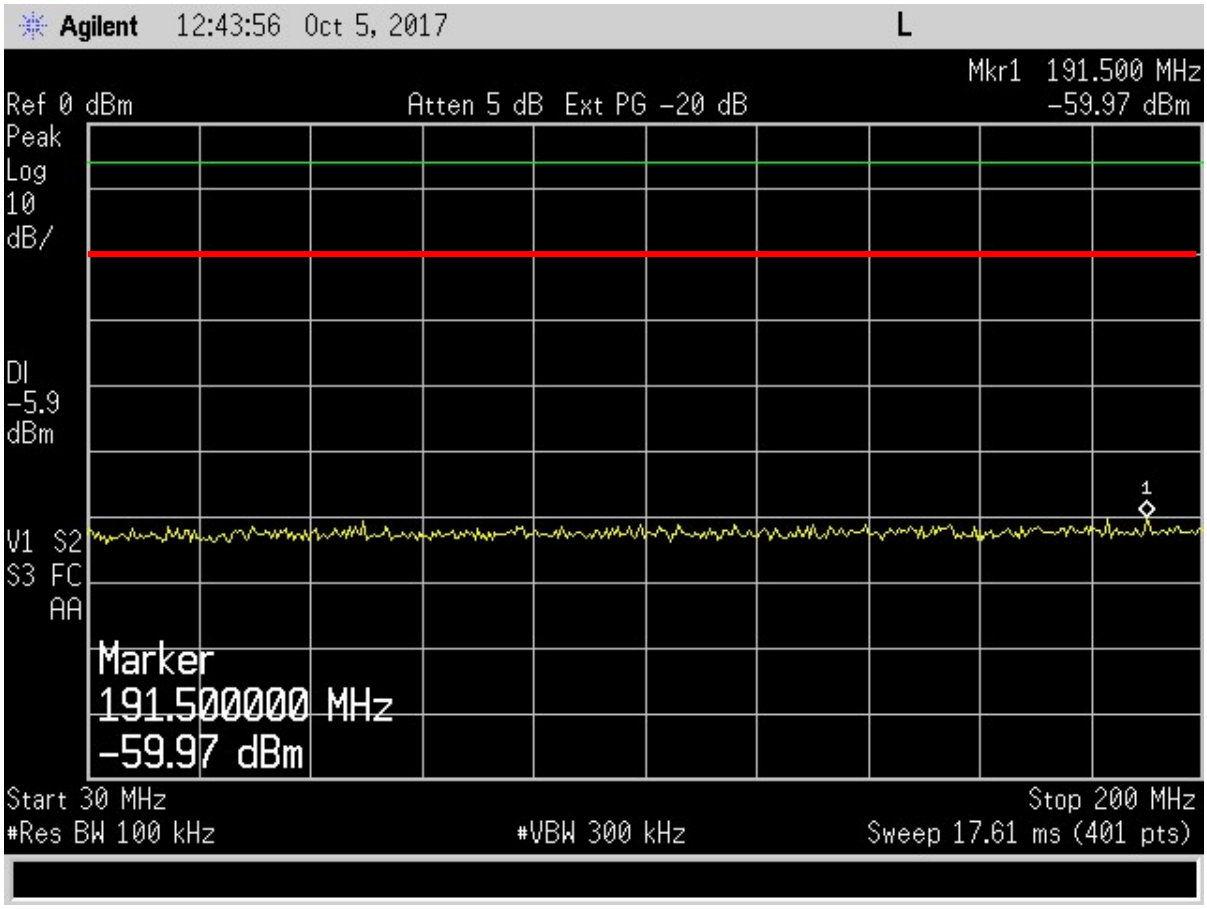


Figure 2. Antenna Conducted Emissions Low Channel, 30 – 200 MHz

RED= limit line

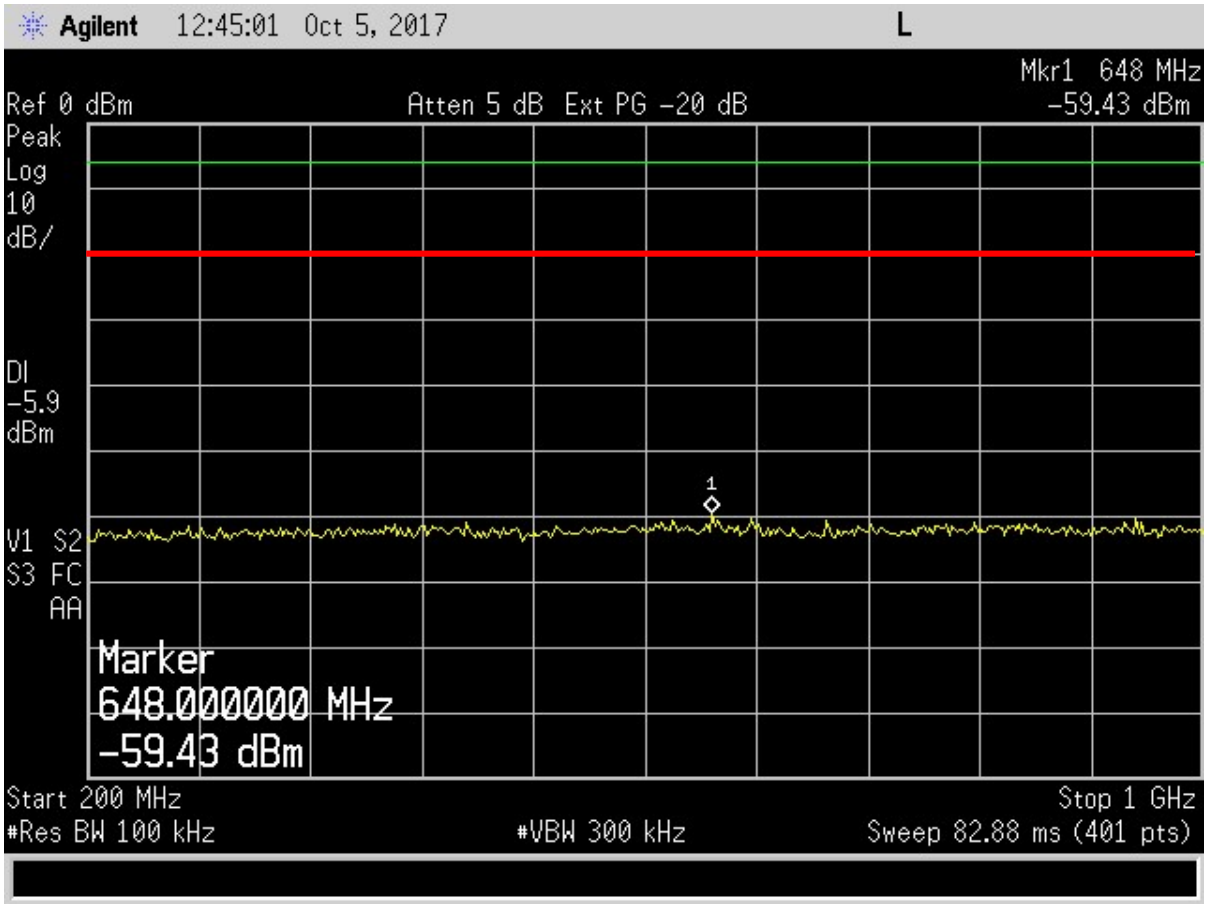


Figure 3. Antenna Conducted Emissions Low Channel, 200 – 1000 MHz

RED= limit line

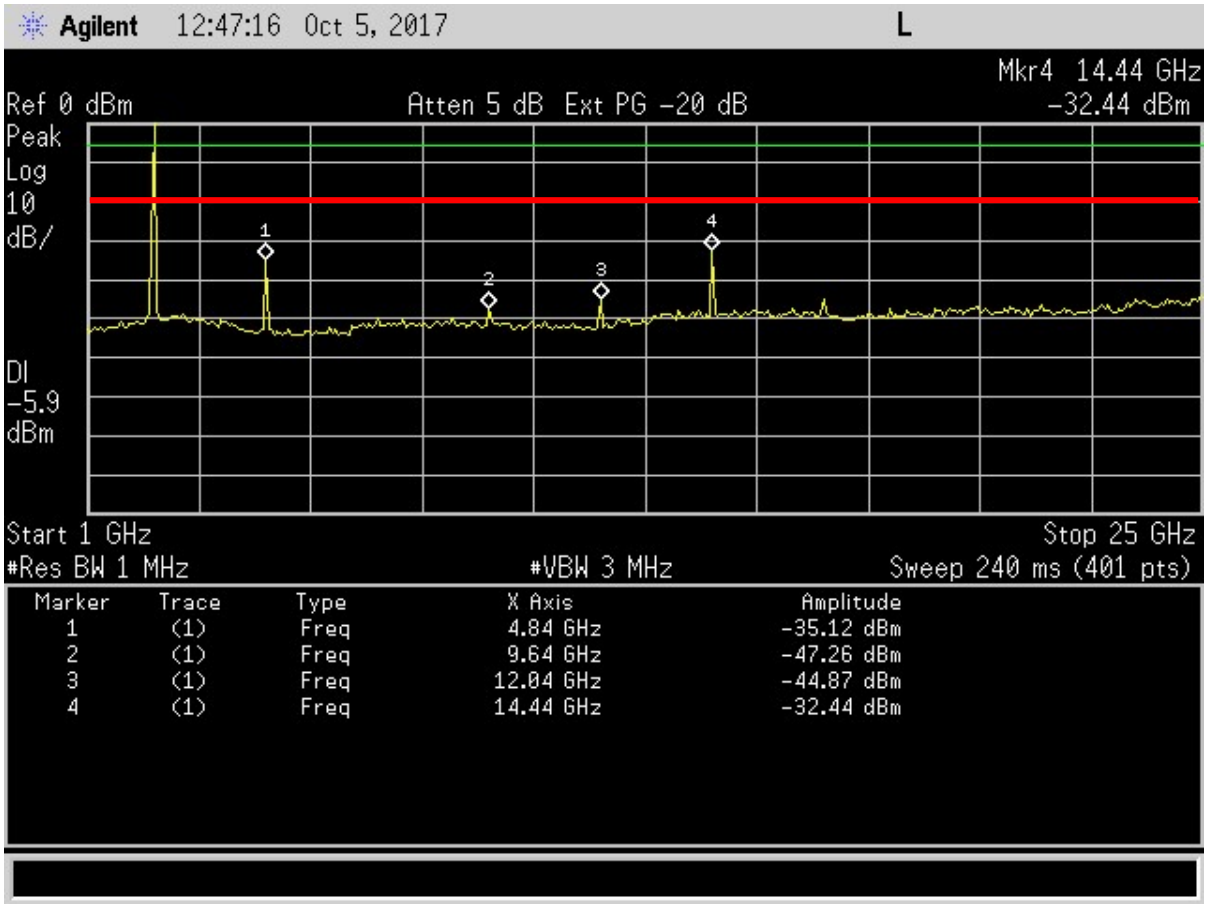


Figure 4. Antenna Conducted Emissions Low Channel, 1 GHz – 25 GHz

RED= limit line

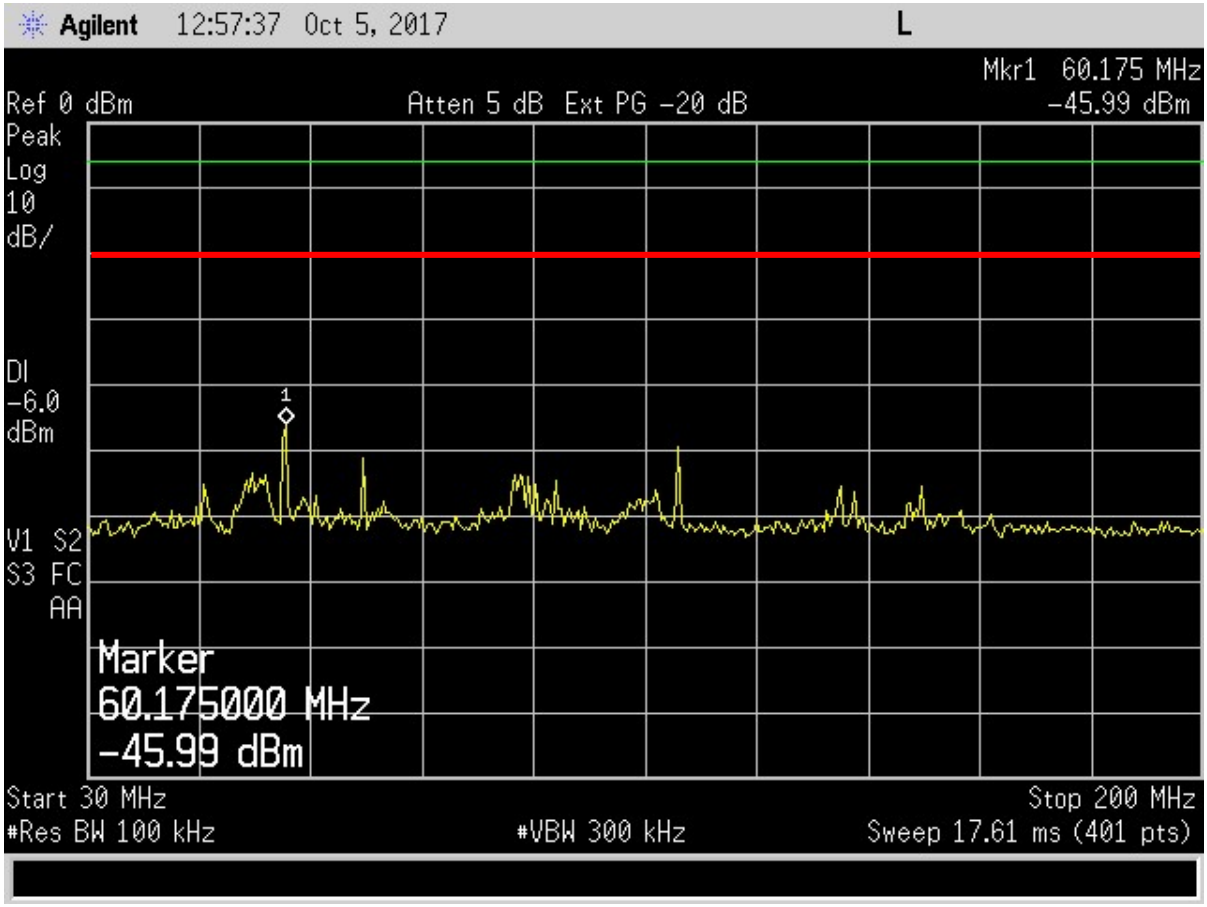


Figure 5. Antenna Conducted Emissions Mid Channel, 30 – 200 MHz

RED= limit line

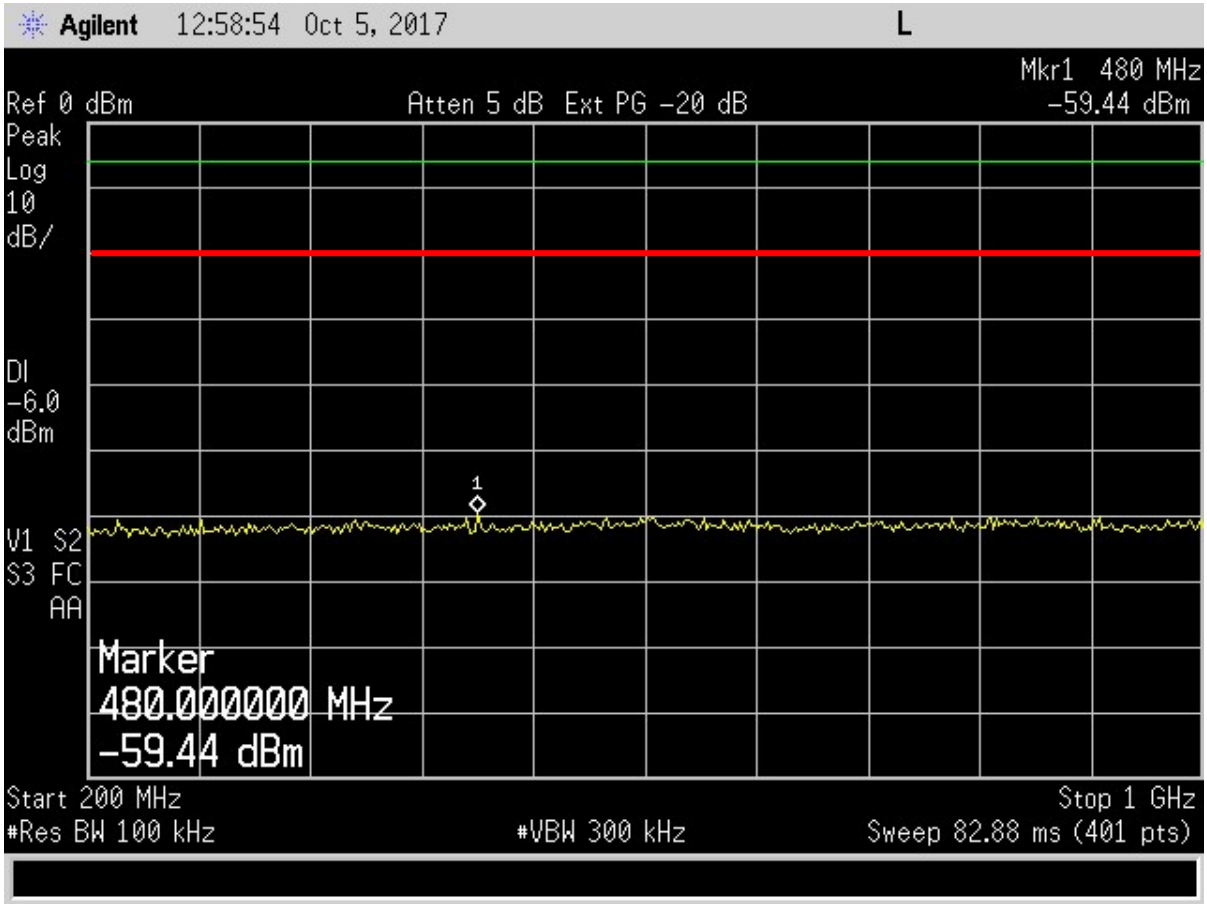


Figure 6. Antenna Conducted Emissions Mid Channel, 200 – 1000 MHz

RED= limit line

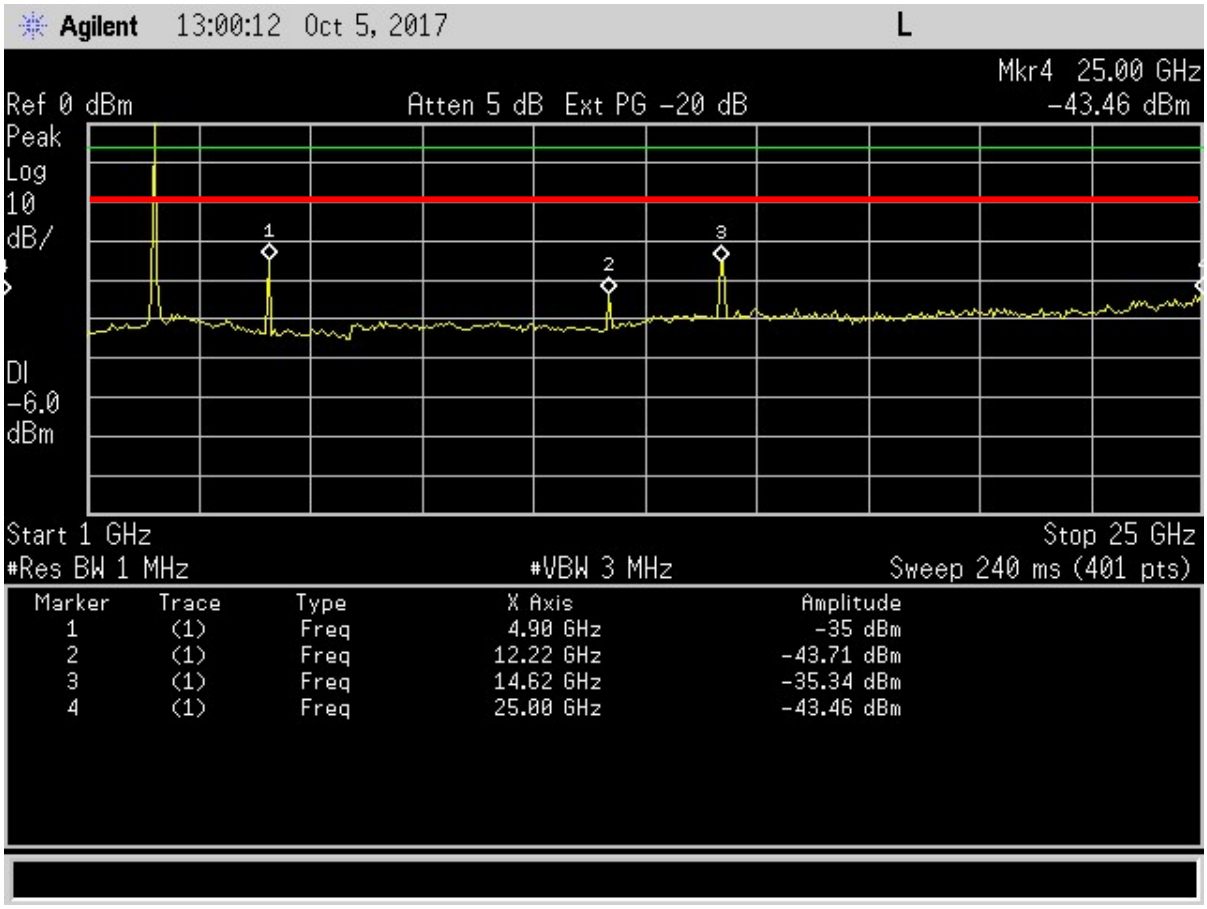


Figure 7. Antenna Conducted Emissions Mid Channel, 1 GHz – 25 GHz

RED= limit line

Figure 8. Antenna Conducted Emissions High Channel, 30 – 200 MHz

RED= limit line

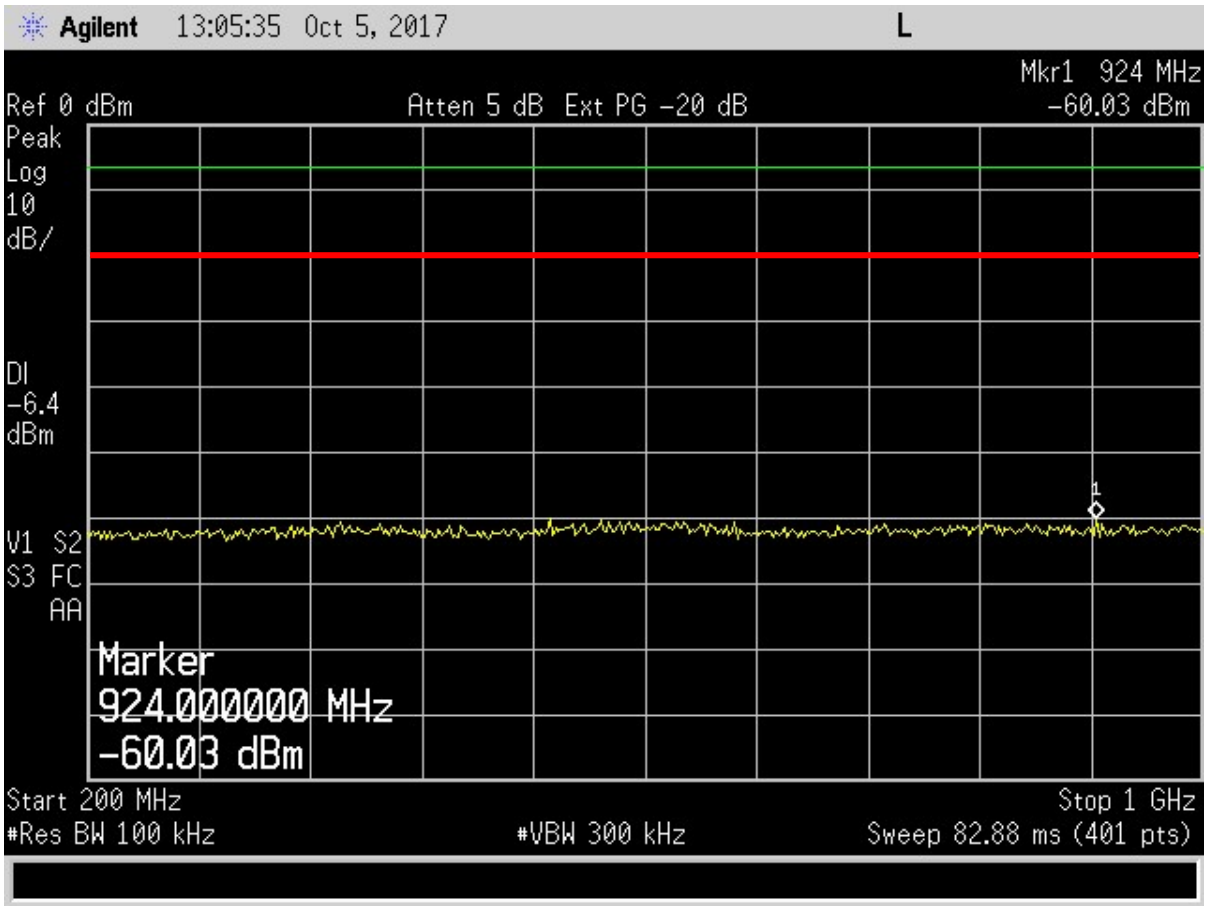


Figure 9. Antenna Conducted Emissions High Channel, 200 – 1000 MHz

RED= limit line

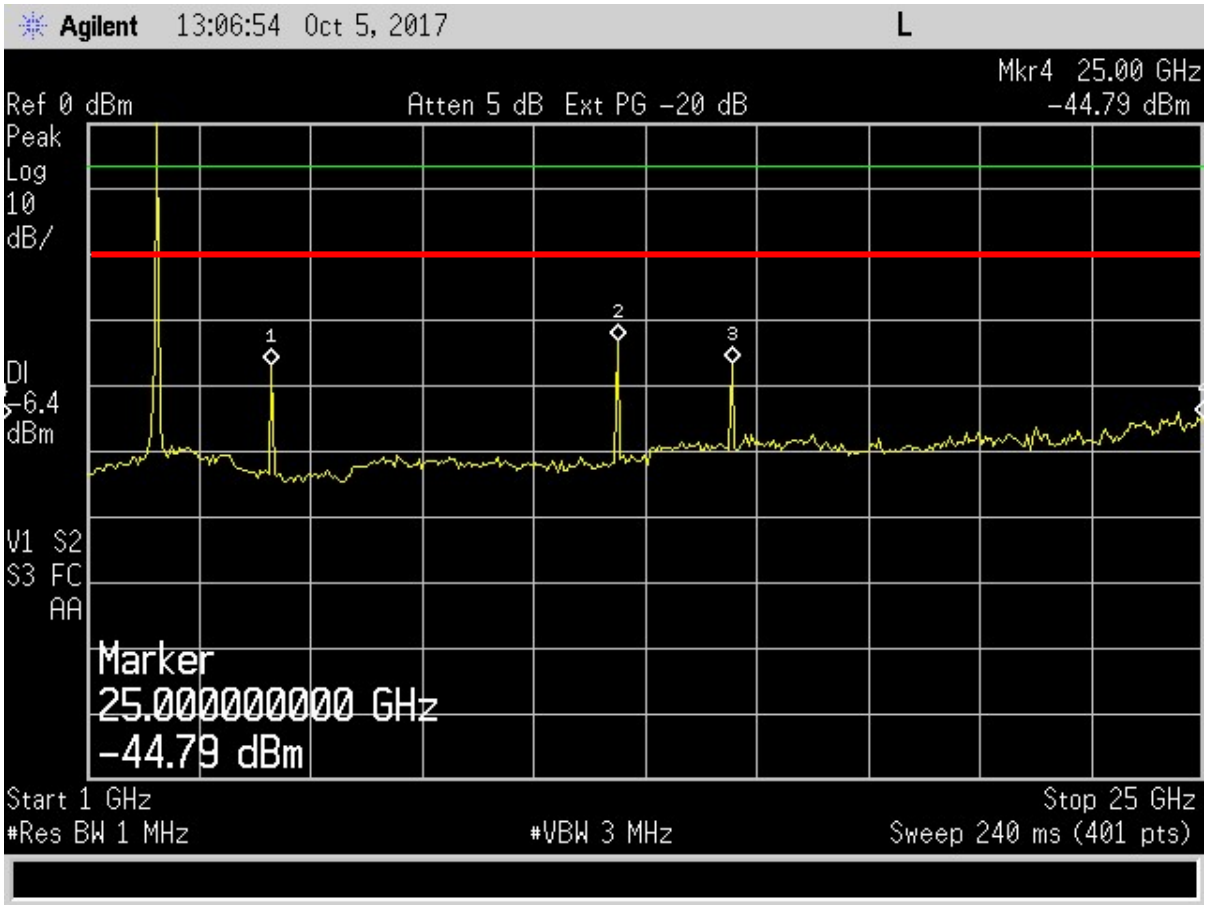


Figure 10. Antenna Conducted Emissions High Channel, 1 GHz – 25 GHz

RED= limit line

2.10 Band Edge Measurements – (CFR 15.247 (d))

Band Edge measurements are made following the guidelines in ANSI C63.10:2013 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Antenna port conducted measurements are performed to demonstrate compliance with the requirement of 15.247(d) that all emissions outside of the band edges be attenuated by at least 20 dB when compared to its highest in-band value (contained in a 100 kHz band).

To capture the band edge set the Spectrum Analyzer frequency span large enough (usually around 3 MHz) to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band of operation. Conducted measurements are performed with RBW ≥1% of the frequency span. In all cases, the VBW is set ≥ RBW. See figure and calculations below for more detail. This measurement was performed with the EUT continuously transmitting on the low and high channels as well as in normal use mode.

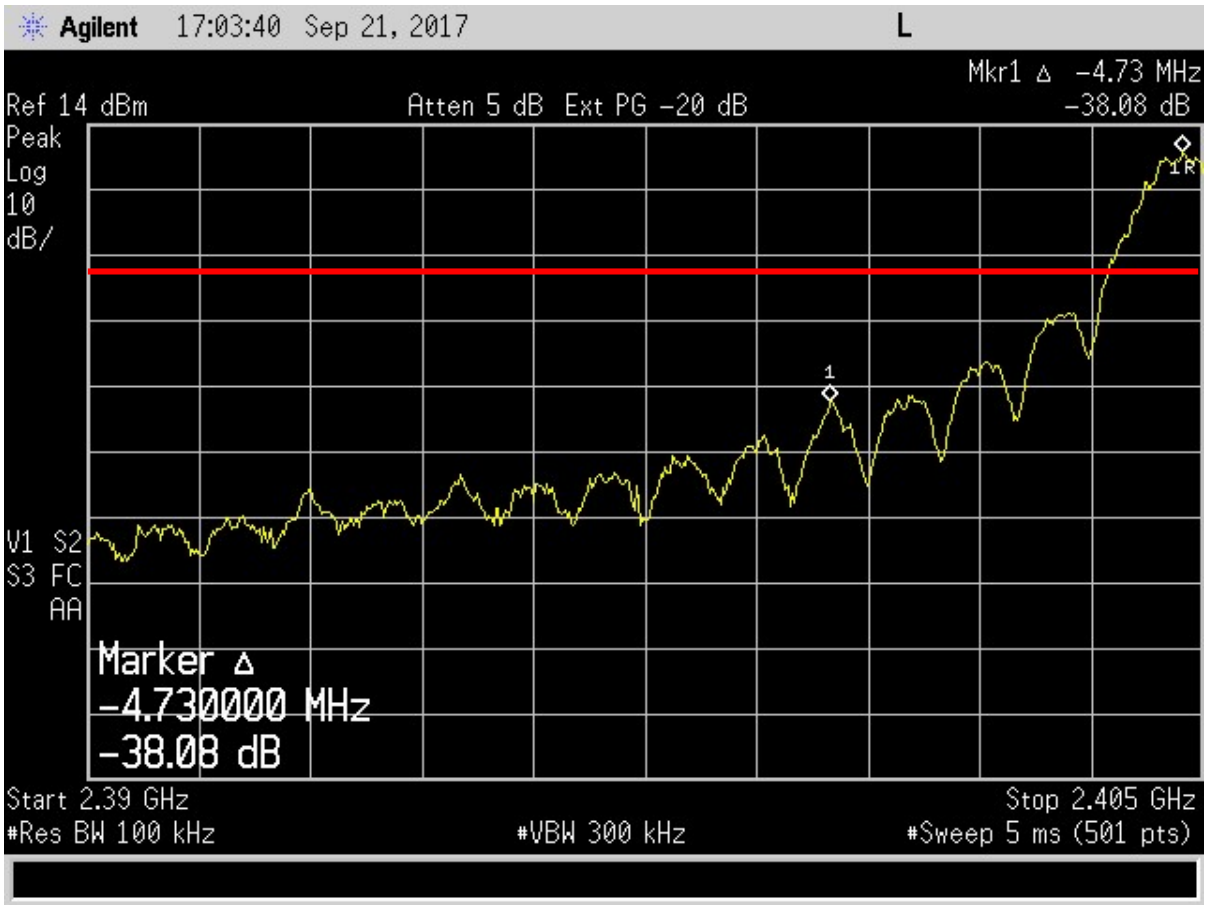


Figure 11. Band Edge Compliance, Low Channel Delta - Peak

Lower band edge must be 20 dB below the fundamental. The peak measurement meets Average requirements.

Measured Result	38.08	dB
Band Edge Limit	20.00	dB
Band Edge Margin	18.08	dB

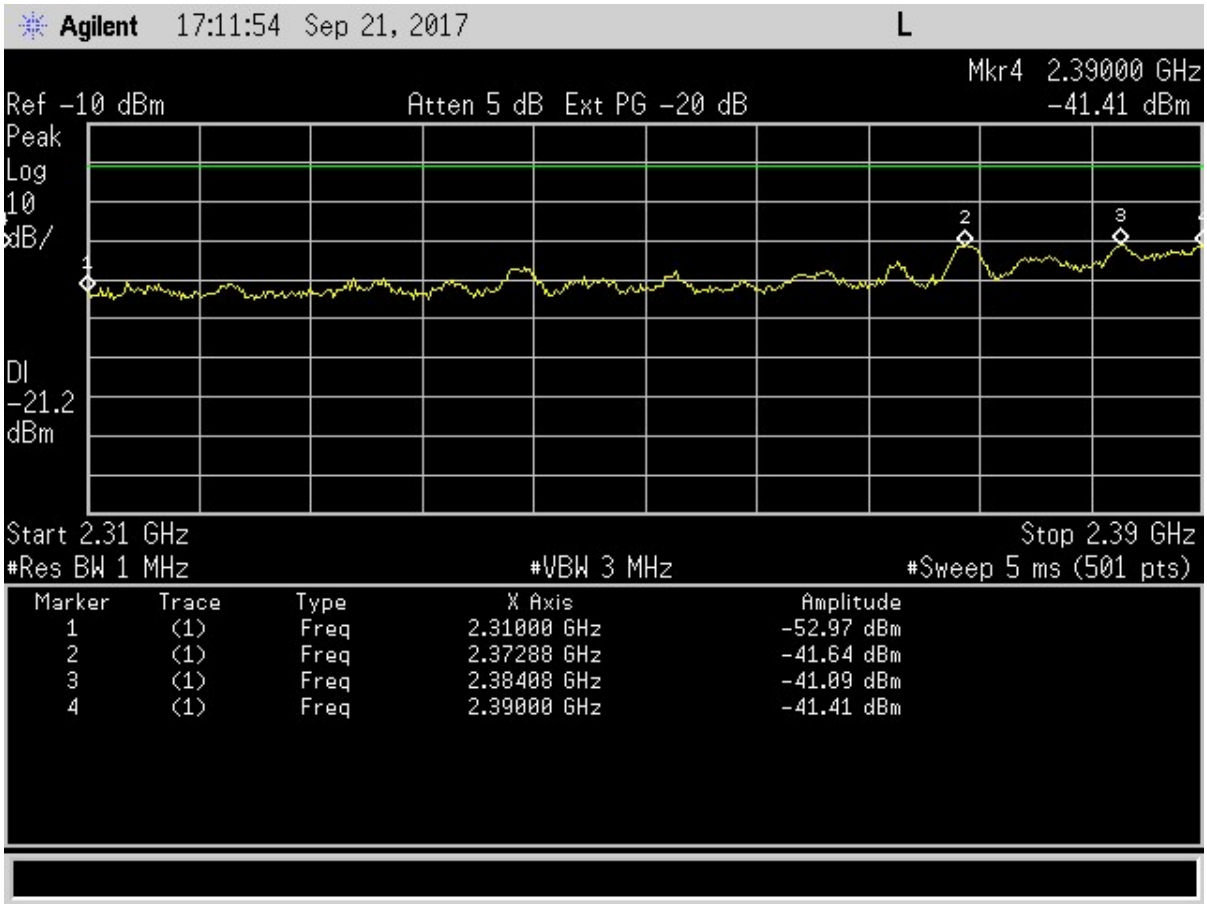


Figure 12. Conducted Restricted Band Measurements 2.31 GHz to 2.39 GHz

Calculation:

E= EIRP – 20 log (d) +104.8, where d is 3 meters
Limit PK = 74.0 dBuV/m

Frequency (MHz)	Test Data (dBm)	Corrected Measurement (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2310.00	-52.97	42.29	74.0	31.7
2372.88	-41.64	53.62	74.0	20.4
2384.08	-41.09	54.17	74.0	19.8
2390.00	-41.41	53.85	74.0	20.2

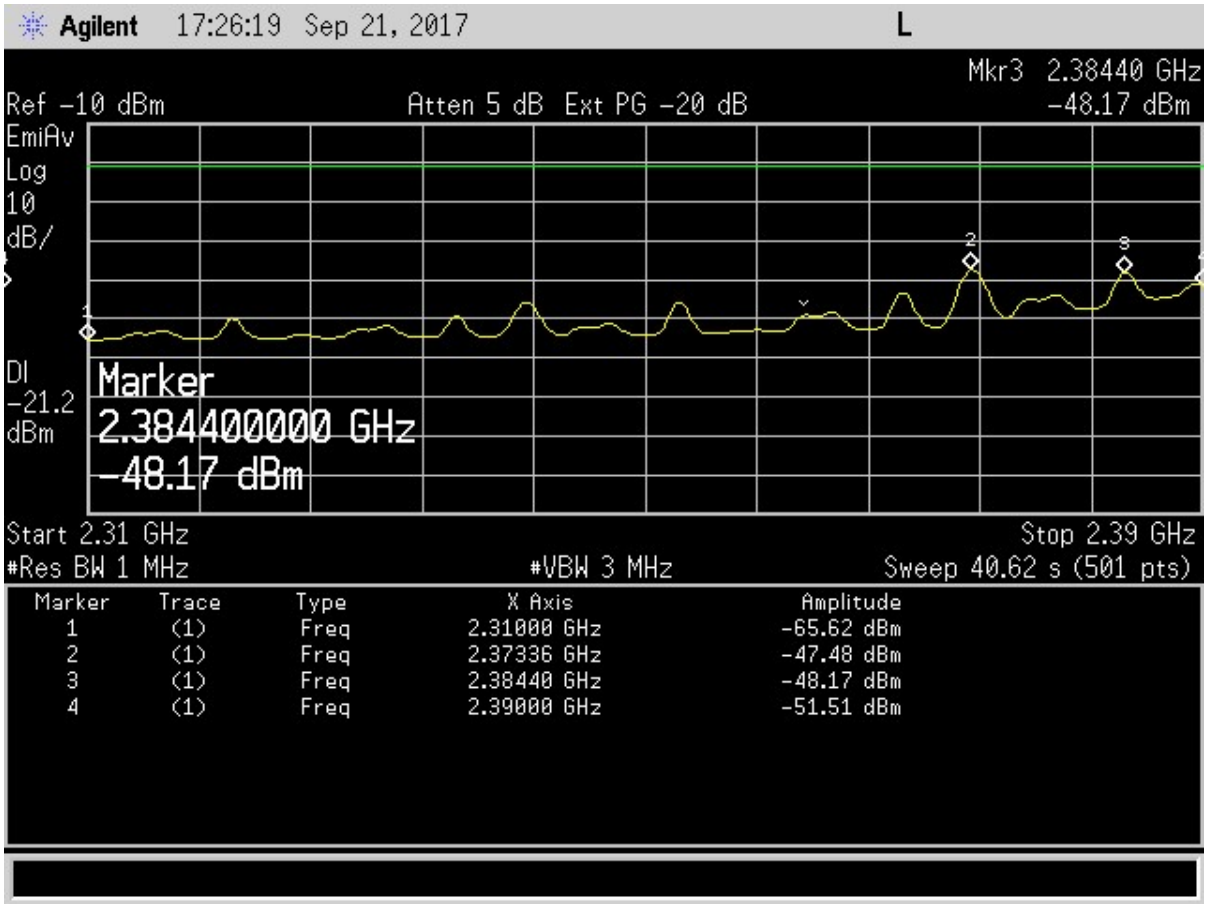


Figure 13. Radiated Restricted Band Measurements AVG, 2.31 GHz to 2.39 GHz

Calculation:

E= EIRP – 20 log (d) +104.8, where d is 3 meters
Limit PK = 54.0 dBuV/m

Frequency (MHz)	Test Data (dBm)	Corrected Measurement (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2310.00	-65.62	29.64	54.0	24.4
2373.36	-47.48	47.78	54.0	6.2
2384.4	-48.17	47.09	54.0	6.9
2390.00	-51.51	43.75	54.0	10.3

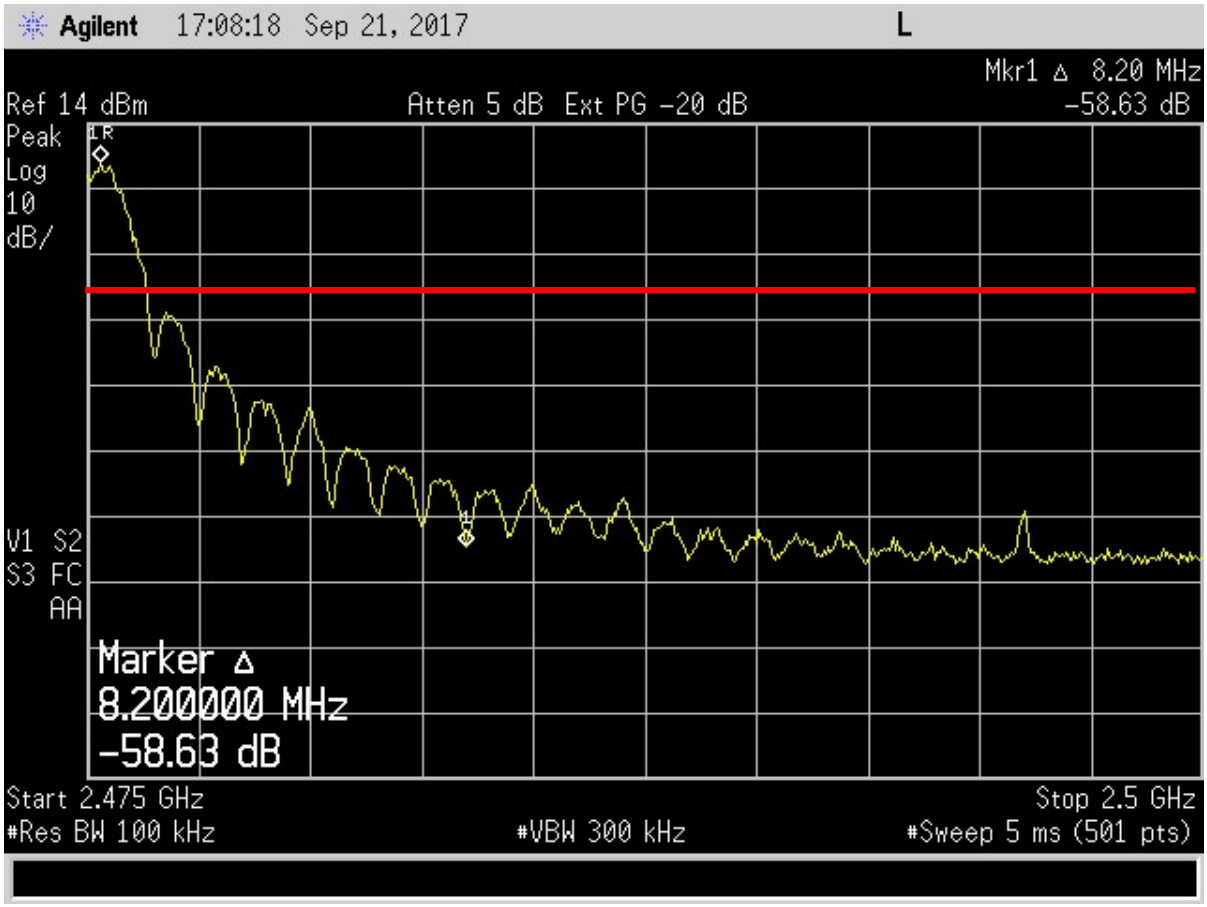


Figure 14. Band Edge Compliance, High Channel Delta – Peak

Upper band edge must be 20 dB below the fundamental. The peak measurement meets Average requirements.

Measured Result	58.63	dB
Band Edge Limit	20.00	dB
Band Edge Margin	38.63	dB

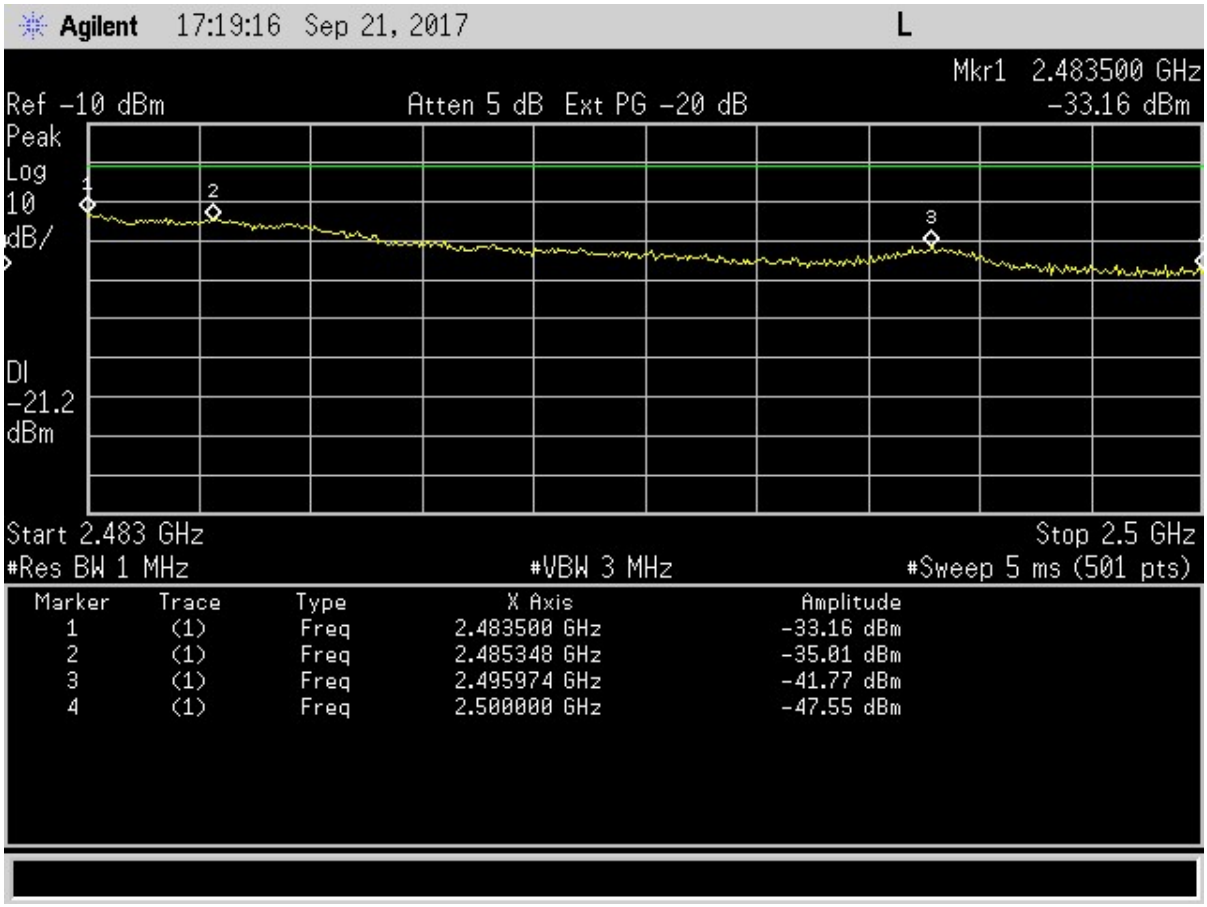


Figure 15. Conducted Restricted Band Measurements PK, 2.4835 GHz to 2.5 GHz

Calculation:

E= EIRP – 20 log (d) +104.8, where d is 3 meters
Limit PK = 74.0 dBuV/m

Frequency (MHz)	Test Data (dBm)	Corrected Measurement (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2483.50	-33.16	62.10	74.0	11.9
2485.35	-35.01	60.25	74.0	13.8
2495.97	-41.77	53.49	74.0	20.5
2500.00	-47.55	47.71	74.0	26.3

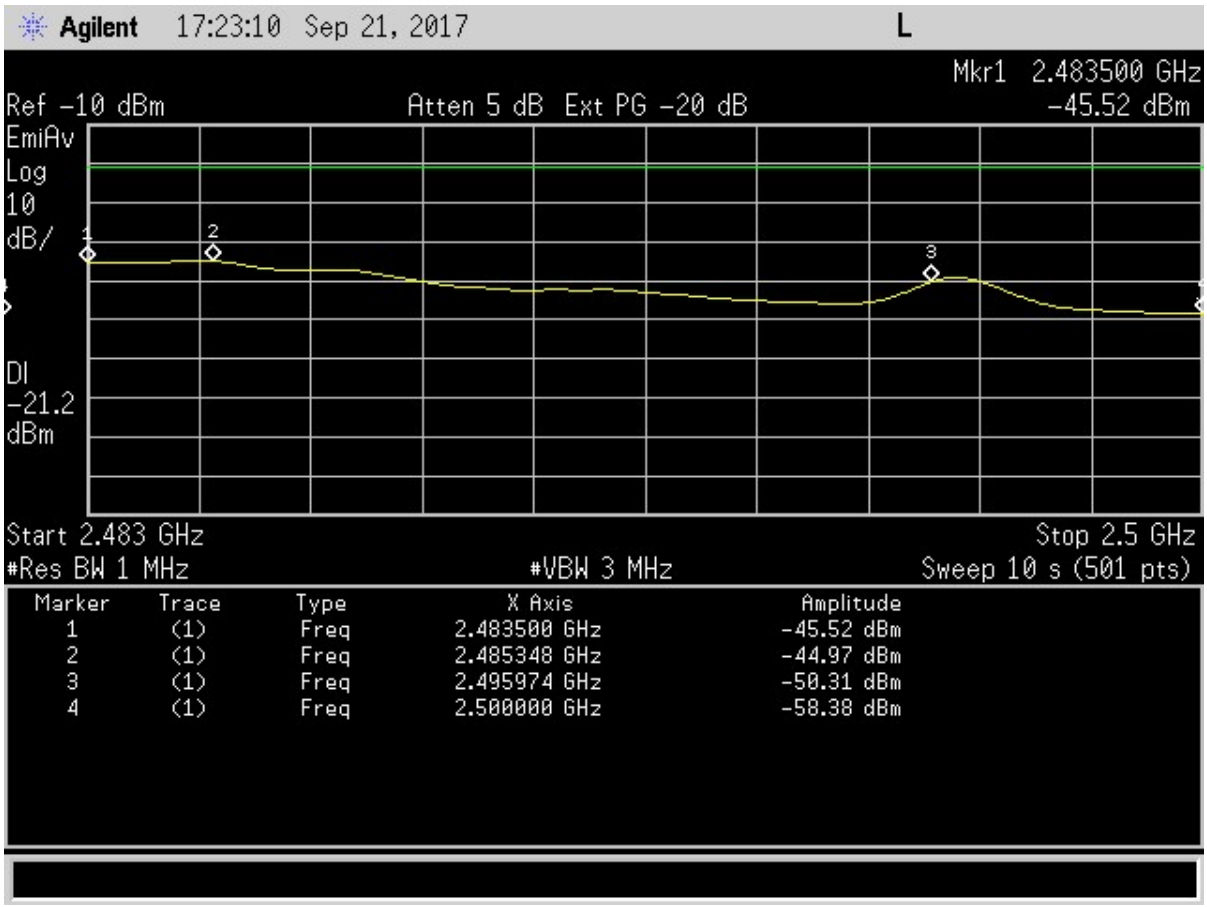


Figure 16. Conducted Restricted Measurements AVG, 2.4835 GHz to 2.5 GHz

Calculation:

E= EIRP – 20 log (d) +104.8, where d is 3 meters
Limit PK = 54.0 dBuV/m

Frequency (MHz)	Test Data (dBm)	Duty Cycle factor (dB)	Corrected Measurement (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2483.50	-45.52	-7.74	42.00	54.0	12.0
2485.35	-44.97	-7.74	42.55	54.0	11.5
2495.97	-50.31	-	44.95	54.0	9.1
2500.00	-58.38	-	36.88	54.0	17.1

Note: EUT transmitting at >98% duty cycle during testing therefore the duty cycle correction factor was added to adjust the reading.

2.11 Six (6) dB Bandwidth per CFR 15.247(a)(2)

The EUT antenna port was connected to a spectrum analyzer having a 50Ω input impedance. Measurements were performed following the guidelines of ANSI C63.10:2013.

Table 11. 6 dB Bandwidth Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
2405.00	1.56	0.5
2440.00	1.64	0.5
2475.00	1.65	0.5

Test Date: September 21, 2017
Tested By
Signature:  Name: Robert K. Mills

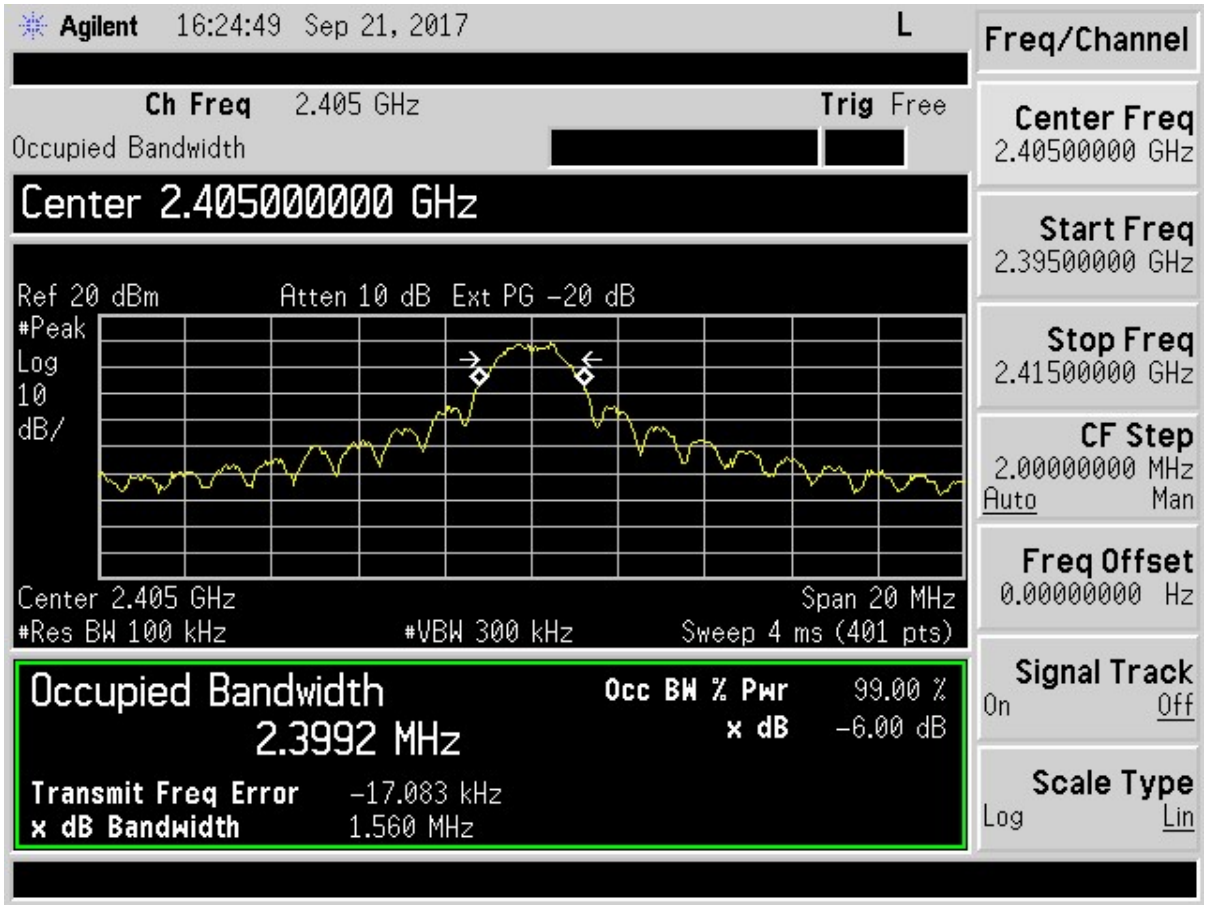


Figure 17. Six (6) dB Bandwidth– Low Channel

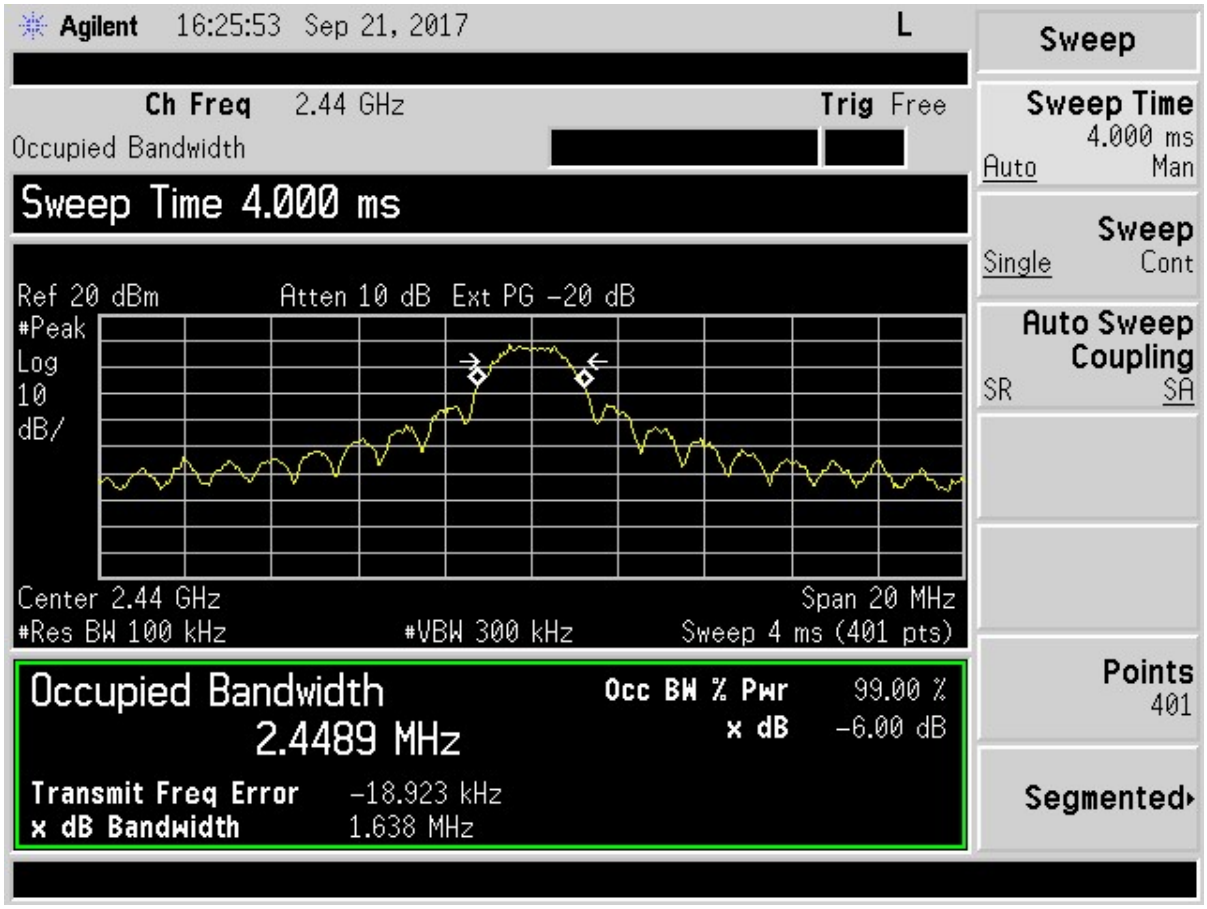


Figure 18. Six (6) dB Bandwidth – Mid Channel

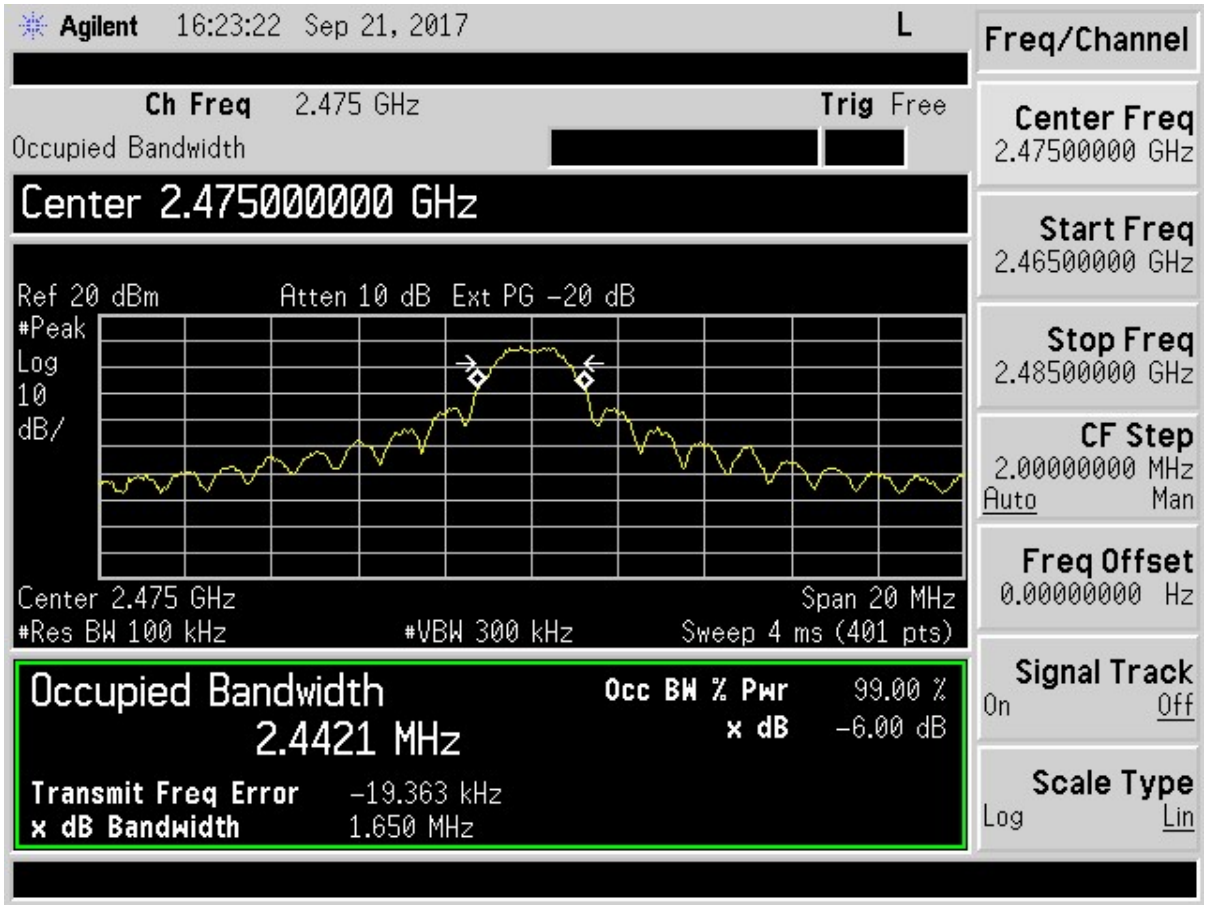


Figure 19. Six (6) dB Bandwidth – High Channel

2.12 Occupied bandwidth, 20 dB (99% Bandwidth) (RSS-GEN (6.6))

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed similar to the method of FCC, KDB Publication No. 558074 v04 for a bandwidth of 20 dB. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in Table 15 and Figures 32 through 34.

Table 12. 99% Occupied Bandwidth

Frequency (MHz)	99% Occupied Bandwidth (MHz)	20 dB Occupied Bandwidth (MHz)
2405	2.38	2.67
2440	2.45	2.68
2475	2.45	2.65

Test Date: September 14, 2017
Tested By
Signature:  Name: Robert K. Mills

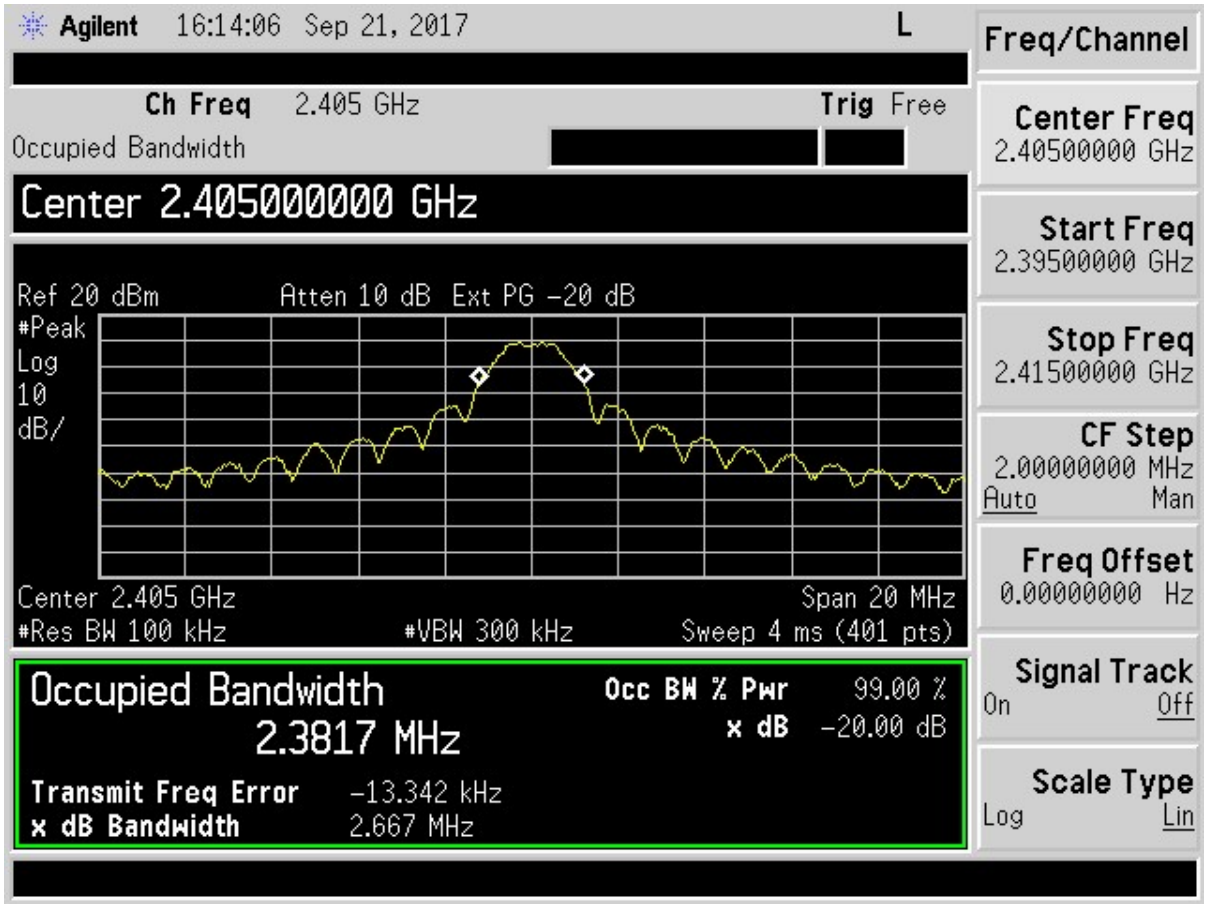


Figure 20. 20 dB Bandwidth – Low Channel

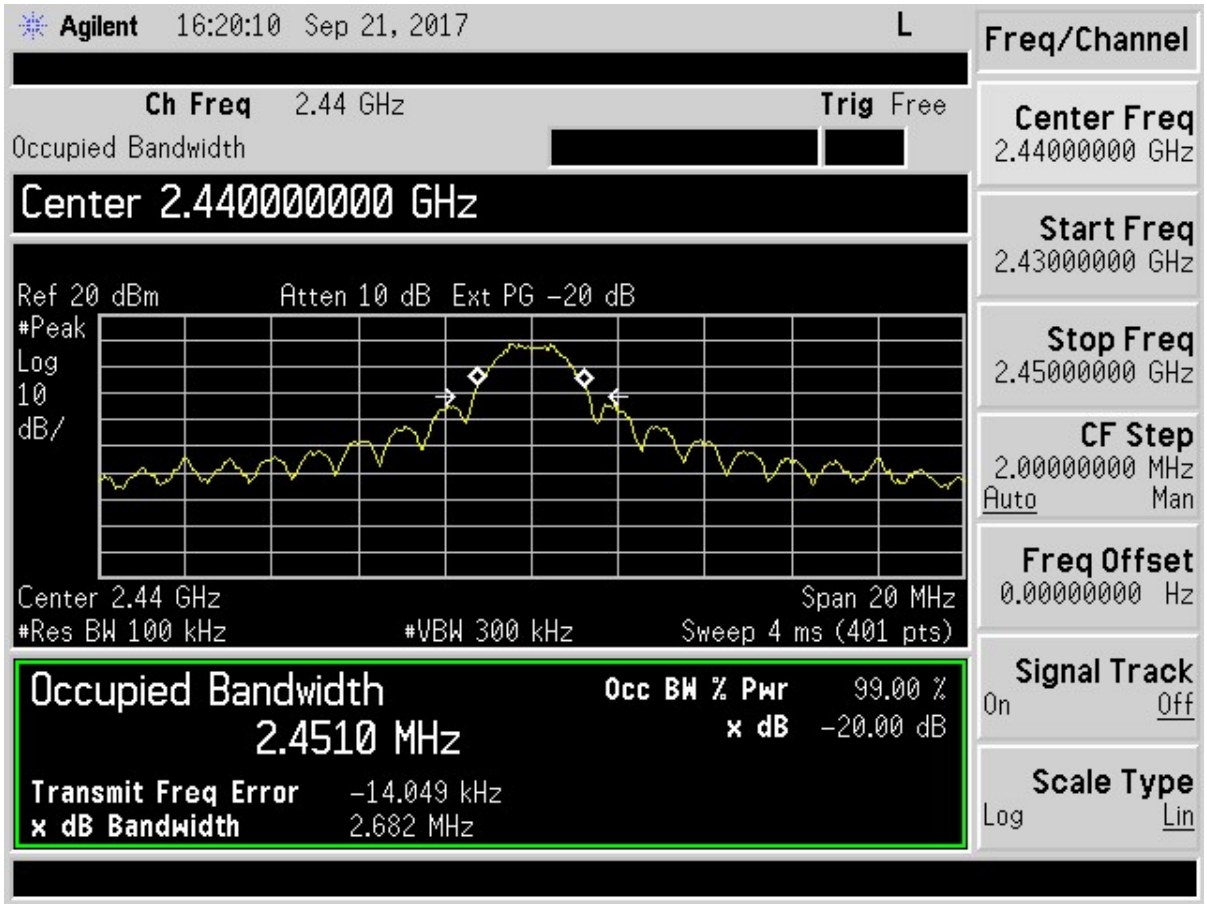


Figure 21.20 dB Bandwidth – Mid Channel

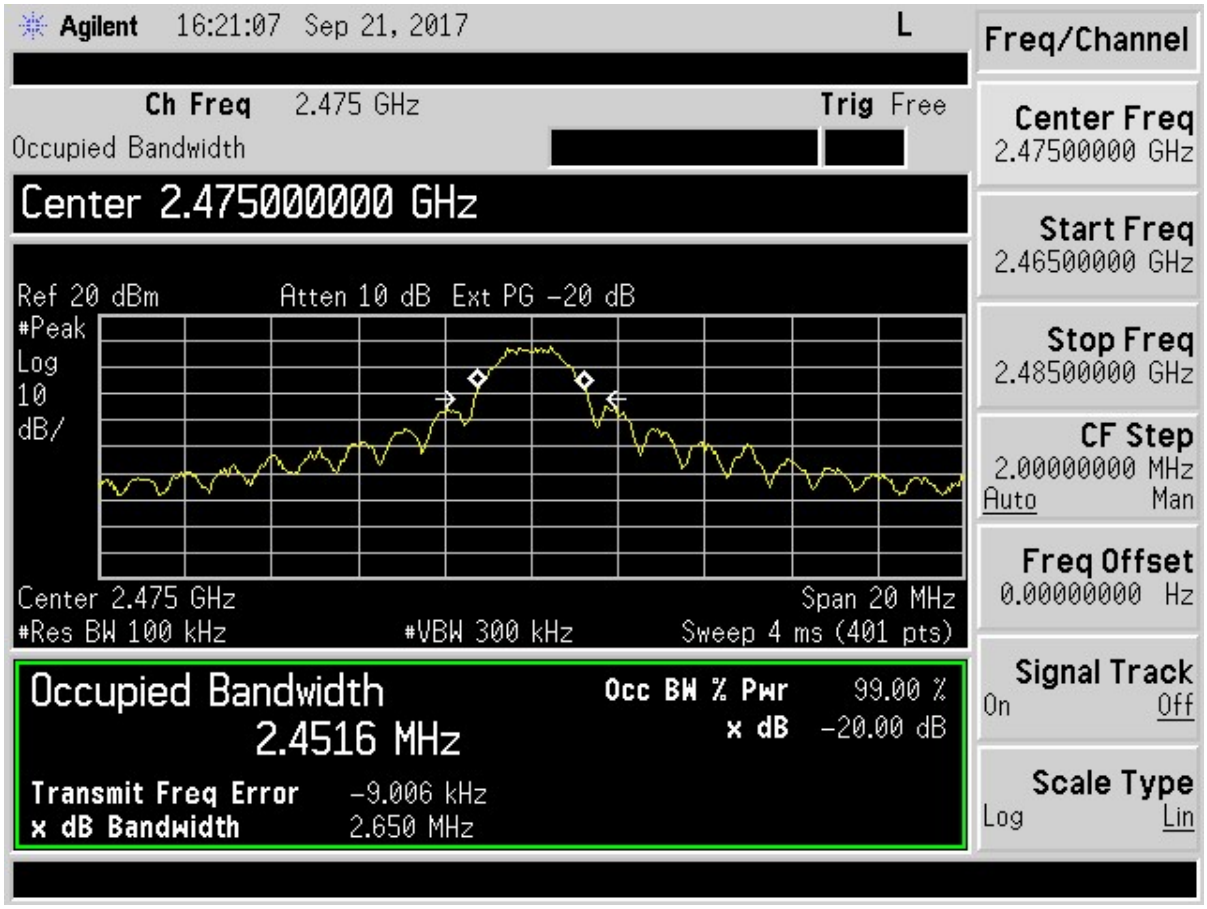


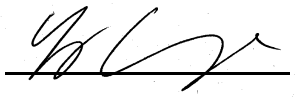
Figure 22. 20 dB Bandwidth – High Channel

2.13 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3))

Peak power within the band 2400 MHz to 2483.5 MHz was measured per FCC KDB Publication 558074 v04 and ANSI C63.10:2013 as an Antenna Conducted test with a spectrum analyzer by connecting the spectrum analyzer directly, via a short RF cable, and attenuators to the antenna output terminals on the EUT. The spectrum analyzer was set for an impedance of 50 Ω with the RBW set greater than the 6 dB bandwidth of the EUT, and the VBW ≥ RBW. Peak antenna conducted output power is tabulated in the table below.

Table 13. Peak Antenna Conducted Output Power per Part 15.247 (b) (3)

Frequency of Fundamental (MHz)	Measured Data dBm	Converted Data (mW)	FCC Limit (mW Maximum)
2405.00	14.36	0.027	1000
2440.00	14.07	0.025	1000
2475.00	13.96	0.025	1000

Test Date: November 8, 2017
Tested By
Signature:  Name: George Yang

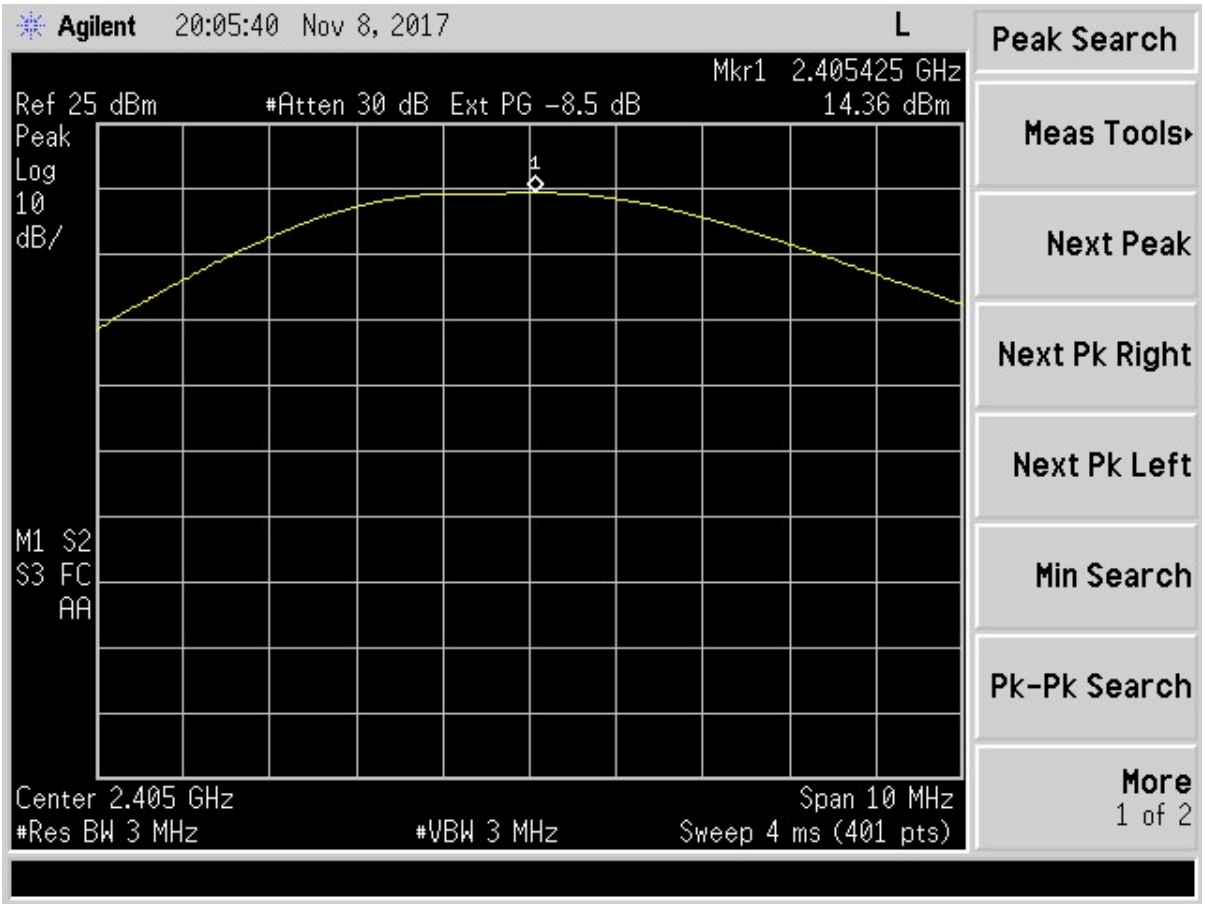


Figure 23. Peak Antenna Conducted Output Power, Low Channel

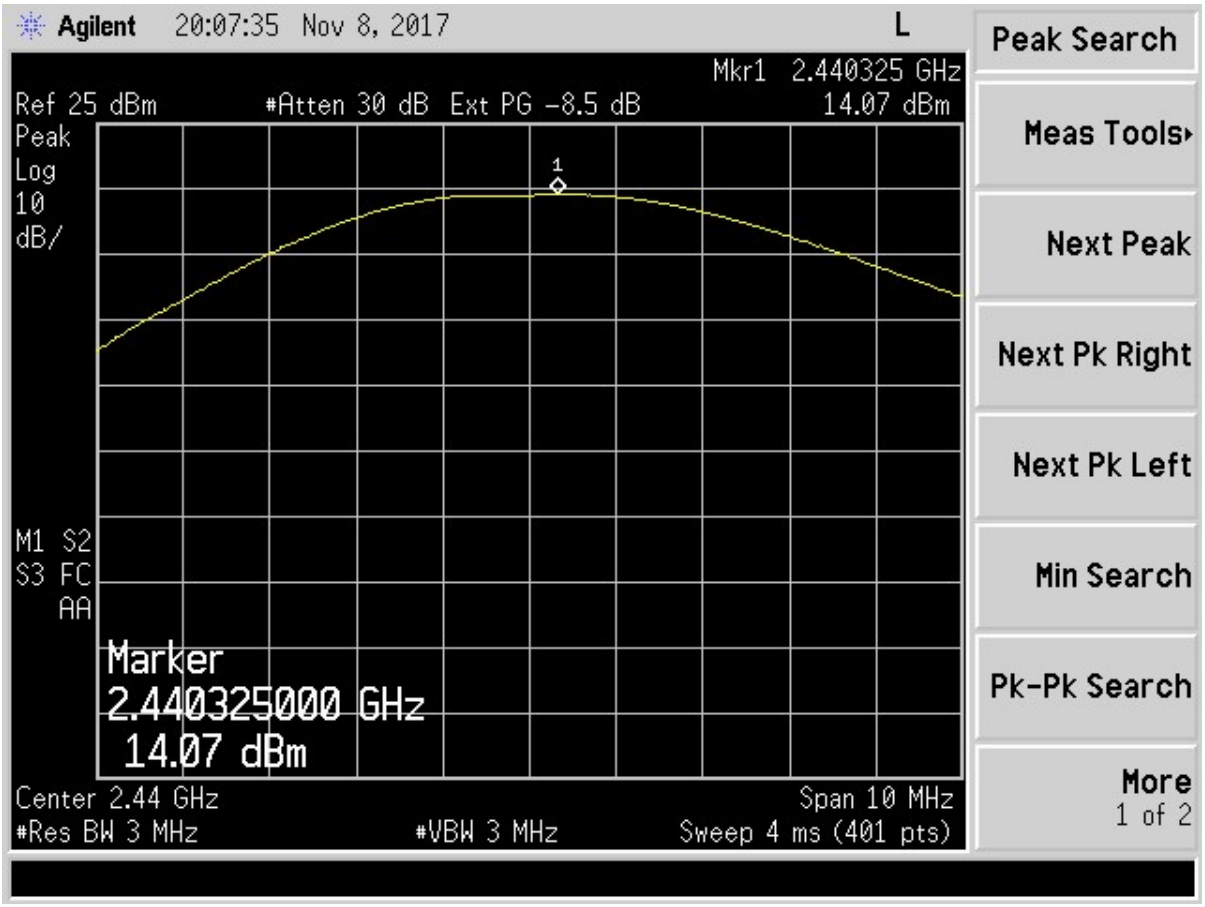


Figure 24. Peak Antenna Conducted Output Power, Mid Channel

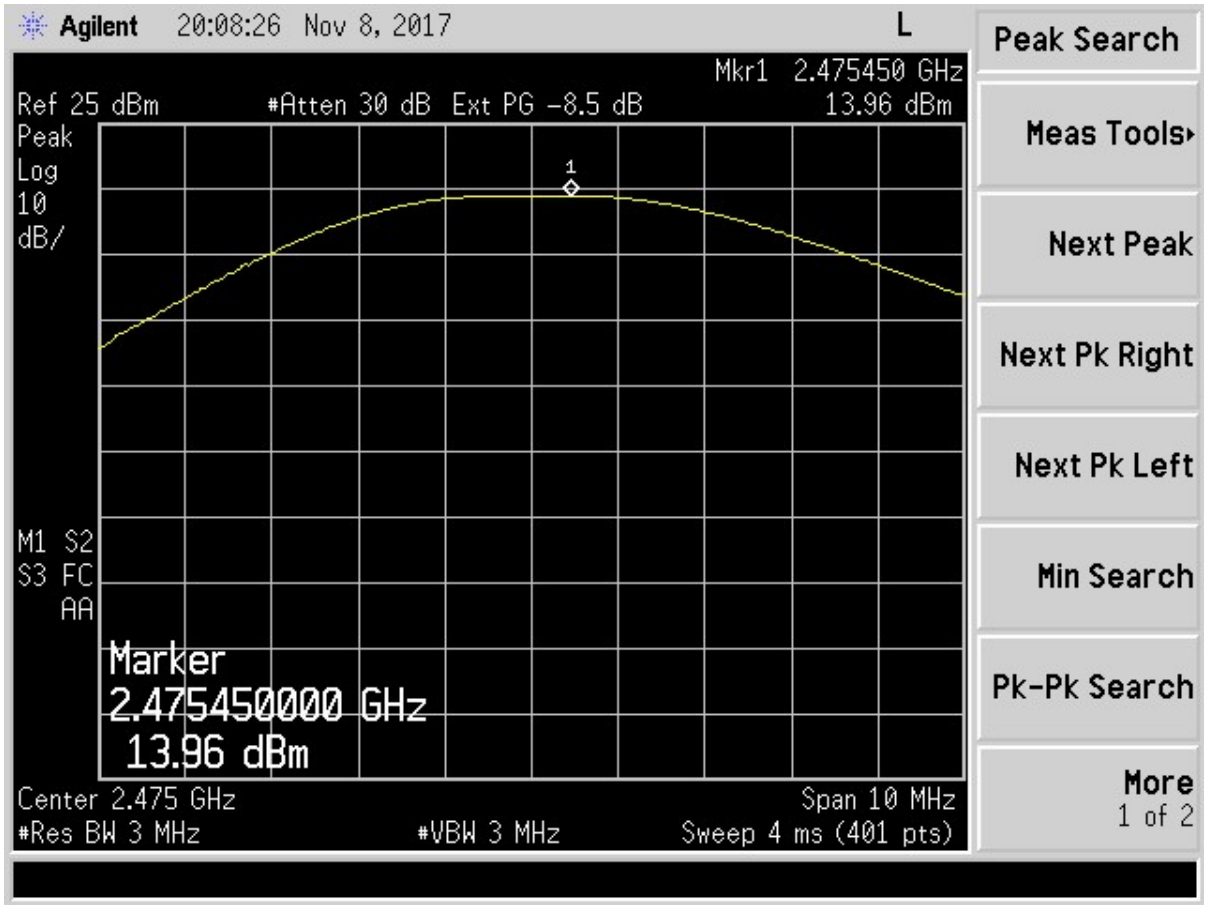


Figure 25. Peak Antenna Conducted Output Power, High Channel

2.14 Power Spectral Density (CFR 15.247(e))

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The measurements were performed per the procedures of FCC KDB Procedure 558074 v04 and ANSI C63.10:2013. The RBW was set to 3 kHz and the Video Bandwidth was set to ≥ RBW. The trace capture time was set to (Span/3 kHz).

In accordance with 15.247 (e), the power spectral density shall be no greater than +8 dBm per any 3 kHz band.

Results are shown in the table below and figures below. All are less than +8 dBm per 3 kHz band.

Table 14. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Results (dBm/10 kHz)	FCC Limit (dBm/3 kHz)
2405.00	2.20	8.0
2440.00	1.48	8.0
2475.00	0.75	8.0

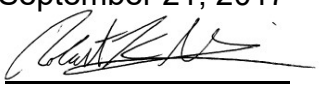
Test Date: September 21, 2017
Tested By
Signature:  Name: Robert K. Mills

Figure 26. Peak Power Spectral Density - Part 15.247 (e) - Low Channel

Figure 27. Power Spectral Density - Part 15.247 (e) - Mid Channel

Figure 28. Peak Power Spectral Density - Part 15.247 (e) - High Channel

2.15 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2:2011. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

2.15.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.78 dB.

2.15.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.39 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.18 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.21dB.

3 Conclusions

The data listed in this test report does not have sufficient margin to negate the effects of uncertainty, therefore the EUT conditionally meets and passes the requirements of the applicable standard when tested as presented in this test report.