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

For the

Asymmetric Technologies

Model: RFUGS MODEL B

FCC ID: 2AODE-RFUGSB

UST Project: 17-0454
Issue Date: February 26, 2018

Total Pages in This Report: 47

3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com

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: Alan Ghasiani

Title: Compliance Engineer – President

Date February 26, 2018

TESTING
NVLAP LAB CODE 200162-0

This report shall not be reproduced except in full. This report may be copied in part only with the prior written approval of US Tech. The results contained in this report are subject to the adequacy and representative character of the sample provided. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST or any agency of the Federal Government.

3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com

MEASUREMENT TECHNICAL REPORT

COMPANYS NAME: Asymmetric Technologies

MODEL: RFUGS MODEL B

FCC ID: 2AODE-RFUGSB

DATE: February 26, 2018

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:

US Tech
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
Fax Number: (770) 740-1508

Table of Contents

Paragraph Title Page

1 General Information 7

1.1 Purpose of this Report 7
1.2 Characterization of Test Sample 7
1.3 Product Description 7
1.4 Configuration of Tested System 8
1.5 Test Facility 8
1.6 Related Submittals 9

2 Tests and Measurements 11

2.1 Test Equipment 11
2.2 Modifications to EUT Hardware 12
2.3 Number of Measurements for Intentional Radiators (15.31(m)) 12
2.4 Frequency Range of Radiated Measurements (Part 15.33) 12
2.4.1 Intentional Radiator 12
2.4.2 Unintentional Radiator 13
2.5 Measurement Detector Function and Bandwidth (CFR 15.35) 13
2.5.1 Detector Function and Associated Bandwidth 13
2.5.2 Corresponding Peak and Average Requirements 13
2.5.3 Pulsed Transmitter Averaging (CFR 15.35(c)) 13
2.6 EUT Antenna Requirements (CFR 15.203) 14
2.7 Restricted Bands of Operation (Part 15.205) 14
2.8 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207) 14
2.9 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d)) (IC RSS 247 5.1 & 5.2) 15
2.10 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3)) 24
2.11 Power Spectral Density (CFR 15.247(e)) 28
2.12 Band Edge Measurements – (CFR 15.247 (d)) 32
2.13 Six (6) dB and Occupied Bandwidth per CFR 15.247(a)(2) Bandwidth 37
2.14 Unintentional Radiator and Intentional Radiator Power Lines Conducted Emissions (CFR 15.107, 15.207) 41
2.15 Unintentional Radiator and Intentional Radiator, Radiated Emissions (CFR 15.109 and 15.209) 43
2.16 Measurement Uncertainty 47
2.16.1 Conducted Emissions Measurement Uncertainty 47
2.16.2 Radiated Emissions Measurement Uncertainty 47

3 Conclusions 47

List of Figures

Figures **Title** **Page**

Figure 1. Block Diagram of Test Configuration 10
Figure 2. Antenna Conducted Emissions Low Channel, 30 MHz – 1 GHz..... 16
Figure 3. Antenna Conducted Emissions Low Channel, 1 GHz – 25 GHz..... 17
Figure 4. Antenna Conducted Emissions Mid Channel, 30 MHz – 1 GHz 18
Figure 5. Antenna Conducted Emissions Mid Channel, 1 GHz – 25 GHz..... 19
Figure 6. Antenna Conducted Emissions High Channel, 30 MHz – 1GHz..... 20
Figure 7. Antenna Conducted Emissions High Channel, 1 GHz – 25 GHz..... 21
Figure 8. Peak Antenna Conducted Output Power, Low Channel 25
Figure 9. Peak Antenna Conducted Output Power, Mid Channel 26
Figure 10. Peak Antenna Conducted Output Power, High Channel 27
Figure 11. Peak Power Spectral Density – Part 15.247 (e) – Low Channel..... 29
Figure 12. Power Spectral Density – Part 15.247 (e) – Mid Channel..... 30
Figure 13. Peak Power Spectral Density – Part 15.247 (e) – High Channel 31
Figure 14. Band Edge Compliance, Low Channel Delta - Peak..... 33
Figure 15. Conducted Restricted Band Measurements 2.31 GHz to 2.39 GHz 34
Figure 16. Band Edge Compliance, High Channel Delta – Peak 35
Figure 17. Conducted Restricted Band Measurements PK, 2.4835 GHz to 2.5 GHz 36
Figure 18. Six (6) dB Bandwidth– Low Channel 38
Figure 19. Six (6) dB Bandwidth – Mid Channel 39
Figure 20. Six (6) dB Bandwidth – High Channel..... 40

List of Tables

Table **Title** **Page**

Table 1. EUT and Peripherals 9
Table 2. Test Instruments 11
Table 3. Number of Test Frequencies for Intentional Radiators 12
Table 4. Allowed Antenna(s) 14
Table 5. Peak Radiated Fundamental & Harmonic Emissions 22
Table 6. Average Radiated Fundamental & Harmonic Emissions 23
Table 7. Peak Antenna Conducted Output Power per Part 15.247 (b) (3) 24
Table 8. Power Spectral Density for Low, Mid and High Bands 28
Table 9. Restricted Band 2310-2390 MHz 34
Table 10. Restrict Band 2483.5 - 2500 MHz PEAK 36
Table 11. Restrict Band 2483.5 - 2500 MHz AVERAGE 36
Table 12. 6 dB Bandwidth and 99% Occupied Bandwidth 37
Table 13. Transmitter Power Line Conducted Emissions Test Data, Part 15.107/15.207 42
Table 14. Spurious Radiated Emissions 150 kHz-30MHz (CFR 15.209) 44
Table 15. Unintentional Radiator, Peak Radiated Emissions (CFR 15.109/15.209), 30 MHz to 1000 MHz 45
Table 16. Unintentional Radiator, Peak Radiated Emissions (CFR 15.109/15.209) 1 GHz to 25 GHz 46

List of Attachments

Agency Agreement
Application Forms
Letter of Confidentiality
Equipment Label(s)
Block Diagram(s)
Schematic(s)
Test Configuration Photographs
Internal Photographs
External Photographs
Theory of Operation
RF Exposure
User's Manual

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.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on November 28, 2017 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Asymmetric Technologies model RFUGS MODEL B. The EUT is a beacon and sensor system. It contains 2.4 GHz and 900 MHz radios. The system includes an external battery which connects to the housing for the electronics. The antennas are above the electronics box enclosed inside of a fiberglass tube.

Both radios can join multi-system networks for communicating their data and routing data for other systems.

The radios are not designed to be operated simultaneously. The users are provided with either a 2.4 GHz radio option or 900 MHz radio option. The radio not being used is disabled by the manufacturer.

This report covers only the 2.4 GHz radio option. Below are some technical notes regarding this radio:

Modulation: OQPSK
Data rate: 250 kbps
Packet Type: IEEE 802.15.4
Operating frequency band: 2405-2475 MHz
Antenna: Dipole Antenna, +7.44 dBi Gain
Rated output: +22.0 dBm

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 Appendices.

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 MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/ IC ID	CABLES P/D
RFUGS System/ Asymmetric Technologies (EUT)	RFUGS MODEL B	Engineering Sample	2AODE-RFUGSB	1.5 m U D
PERIPHERAL MANUFACTURER	**MODEL NUMBER**	**SERIAL NUMBER**	**FCC/ IC ID**	**CABLES P/D**
Laptop/ Hewlett Packard	Various	Various	Various	1.5 m U P
Antenna See antenna details	--	--	--	--
Evaluation Board /Texas Instruments	CC2650	Engineering Sample	N/A	N/A

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

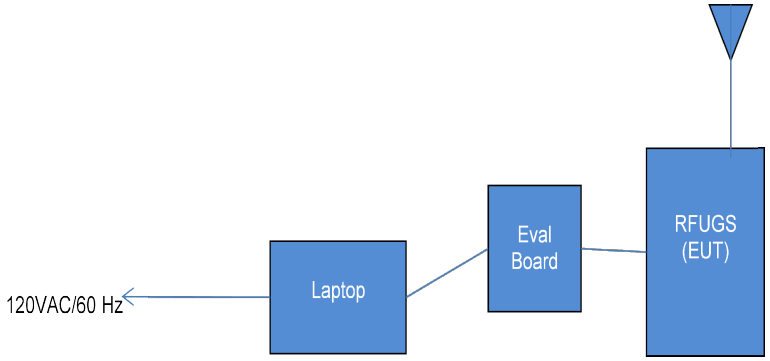


Figure 1. Block Diagram of Test Configuration

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	06/22/2018
SPECTRUM ANALYZER	8593E	HEWLETT-PACKARD	3205A00124	07/21/2018
RF PREAMP 100 kHz to 1.3 GHz	8447D	HEWLETT-PACKARD	1937A02980	03/07/2019
PREAMP 1.0 GHz to 26.0 GHz	8449B	HEWLETT-PACKARD	3008A00480	12/01/2018
LOOP ANTENNA	6502	EMCO	9810-3246	01/22/2020 2 yr
BICONICAL ANTENNA	3110B	EMCO	9307-1431	05/2/2019 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	05/1/2019 2 yr
HORN ANTENNA	3115	EMCO	9107-3723	09/22/2018 2 yr.

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

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 2405 MHz to 2475 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 10th 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 (CFR 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 3.9% intended for normal operation; therefore where applicable (when using AVG detection) the duty cycle factor based on a 3.9% DC was applied.

Duty Cycle factor = 20 log DC = 20 log (0.039) = -28.2 dB in this case the duty cycle applied is -20 dB

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	Ohio State University	2 Strip Transmission Line	2 Strip Transmission Line	+7.44	RP-SMA

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)

Power line conducted emissions testing was performed to ensure that with the EUT in operation (exercising all transmitter functions), the complete system continues to meet the applicable requirements for CFR 15.207. These measurements were completed and are displayed along with the 15.107 power line test data in the sections below.

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 KDB 558074 v04 and 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.

In this case the EUT was tested in the orientation of normal operation.

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 and KDB 558074 v04, clause 11 for conducted out of band emissions in non restricted bands 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.

Low Channel = 2405 MHz
Mid Channel = 2440 MHz
High Channel= 2475 MHz

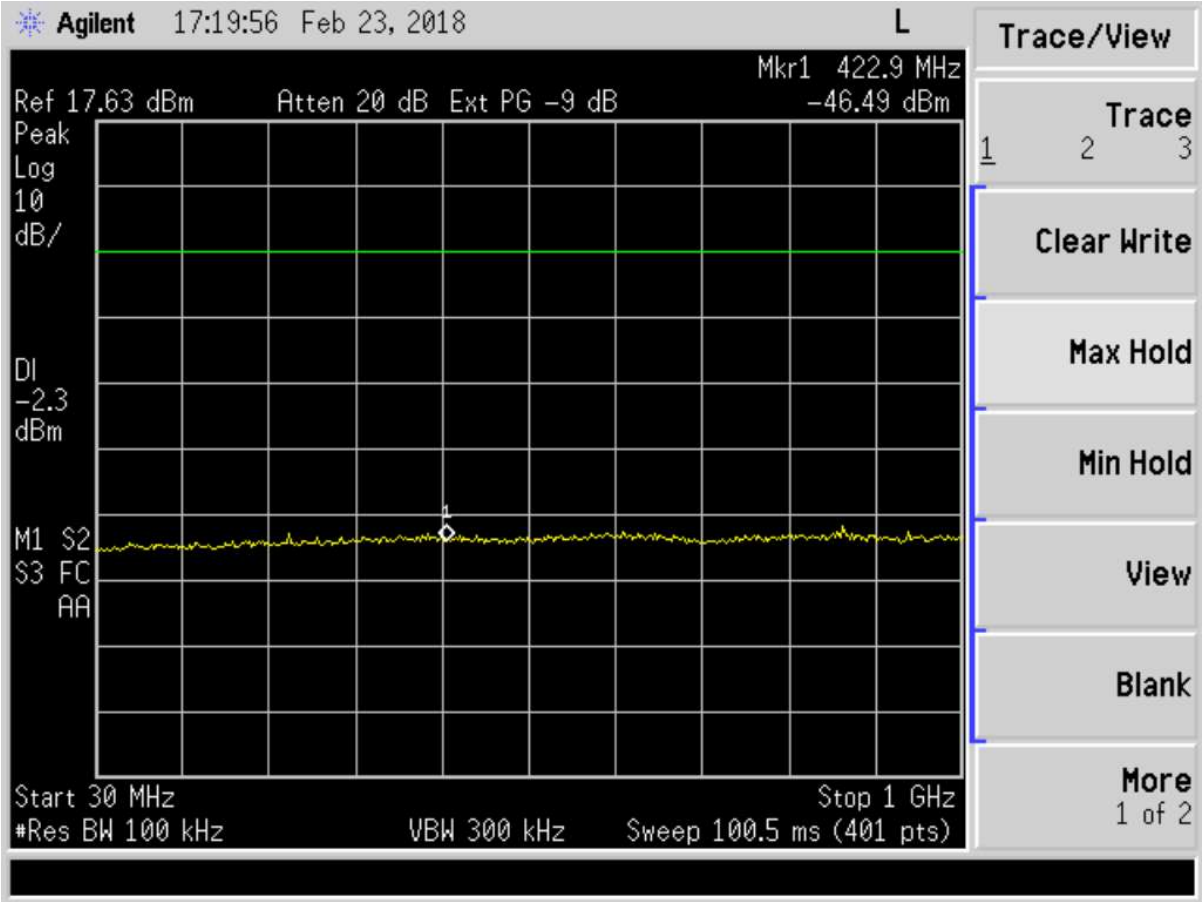


Figure 2. Antenna Conducted Emissions Low Channel, 30 MHz – 1 GHz
Green Line= Limit line

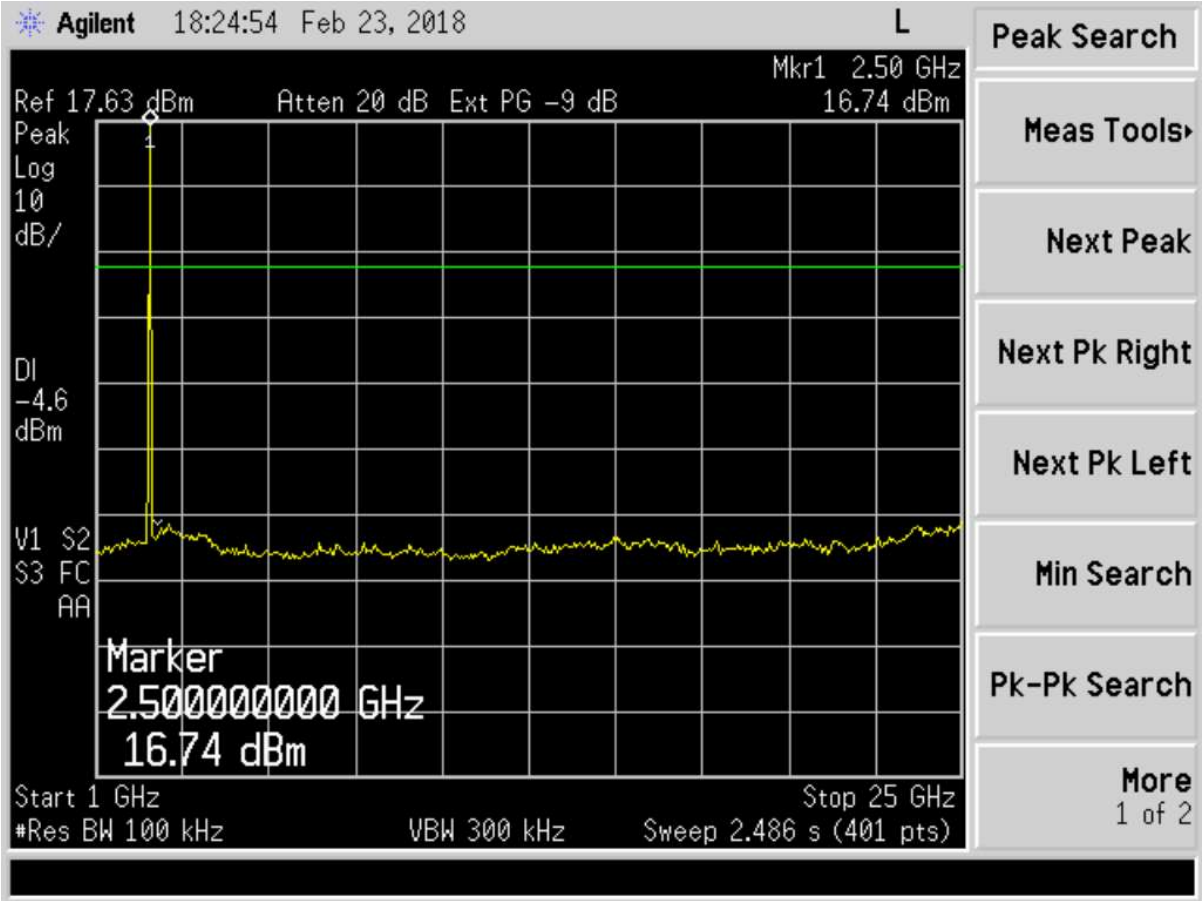


Figure 3. Antenna Conducted Emissions Low Channel, 1 GHz – 25 GHz
Green Line= Limit line

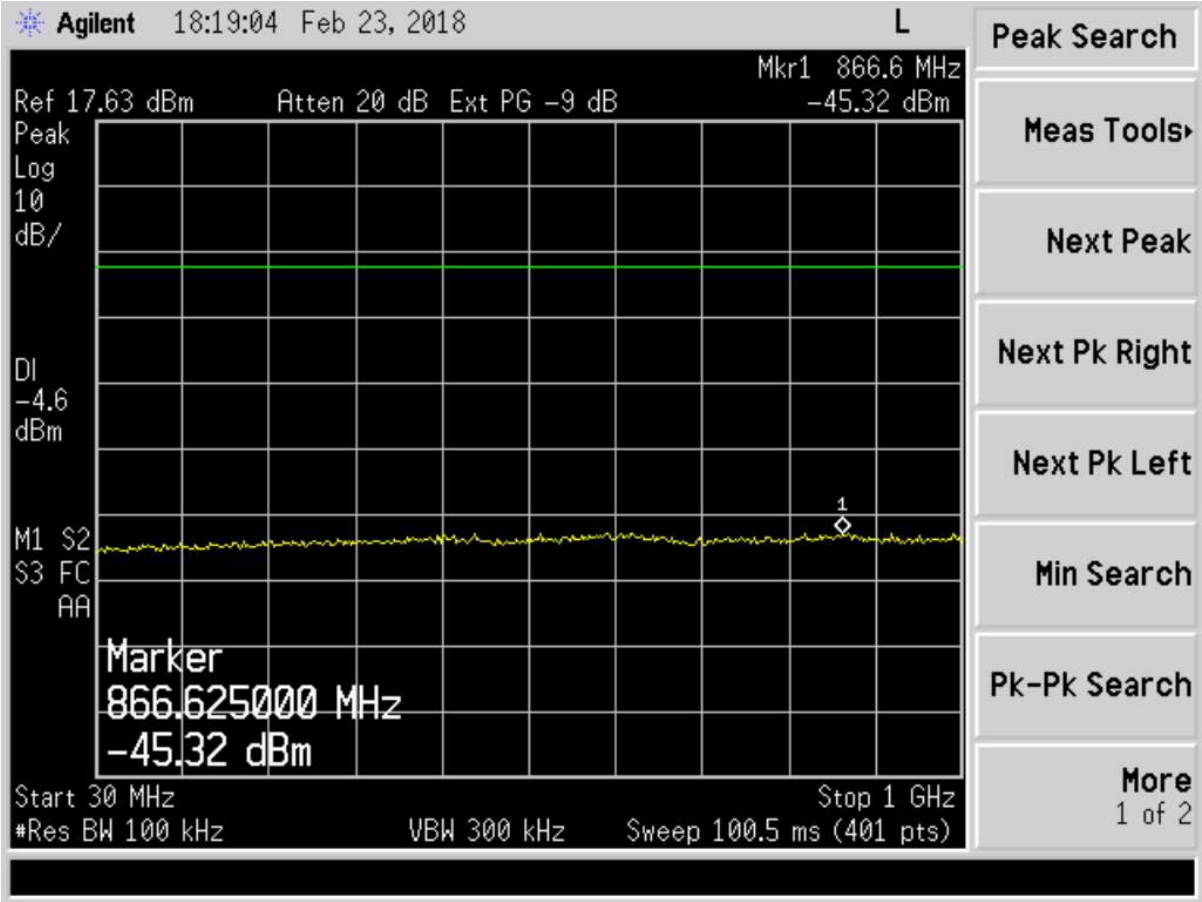


Figure 4. Antenna Conducted Emissions Mid Channel, 30 MHz – 1 GHz
Green Line= Limit line

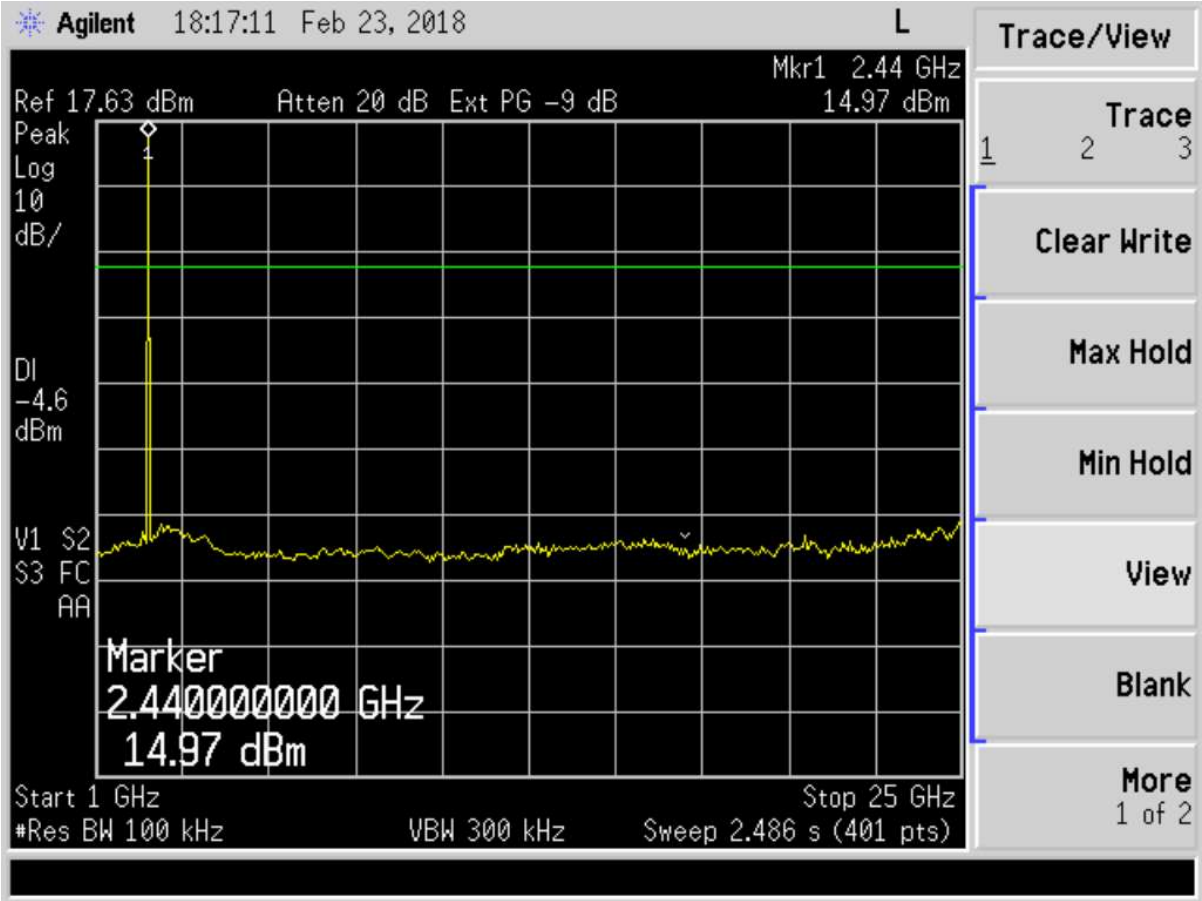


Figure 5. Antenna Conducted Emissions Mid Channel, 1 GHz – 25 GHz
Green Line= Limit line

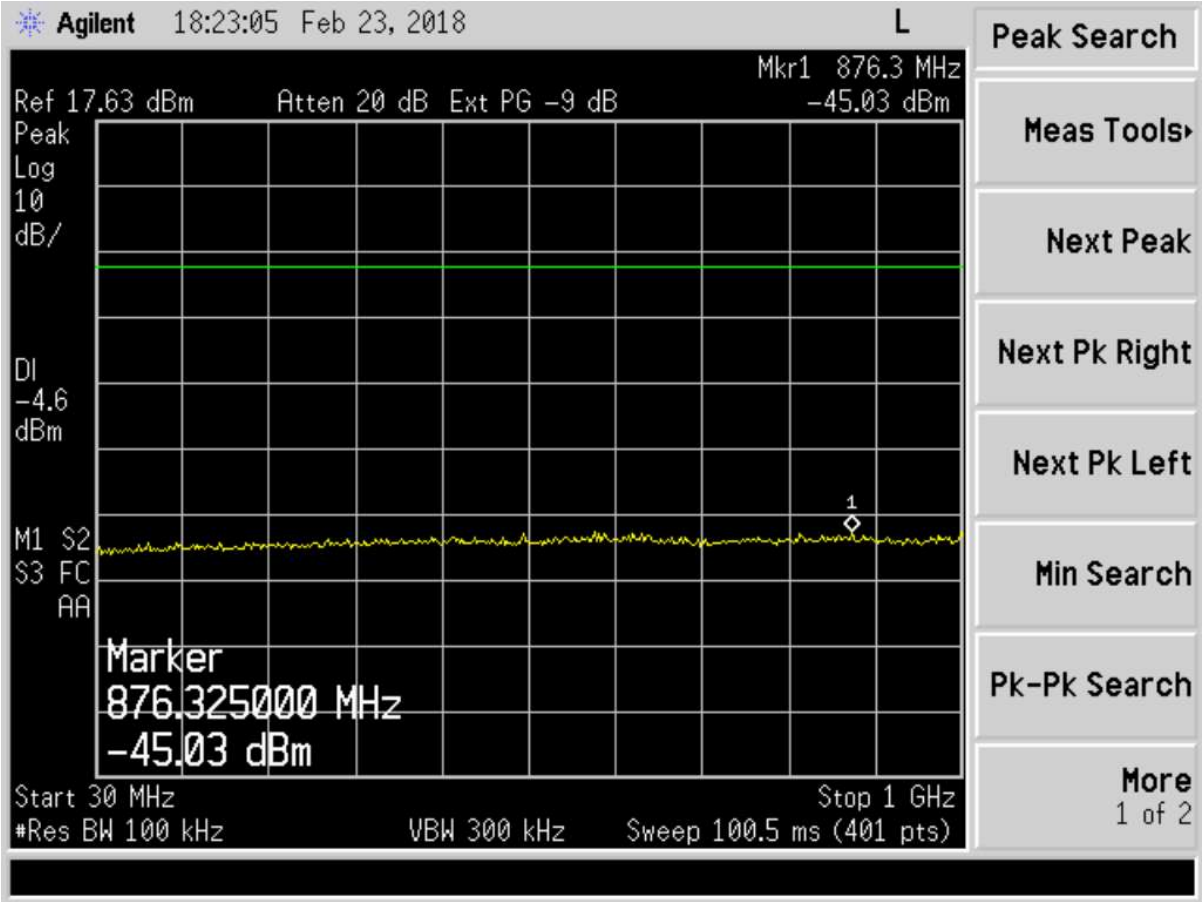


Figure 6. Antenna Conducted Emissions High Channel, 30 MHz – 1GHz
Green Line= Limit line

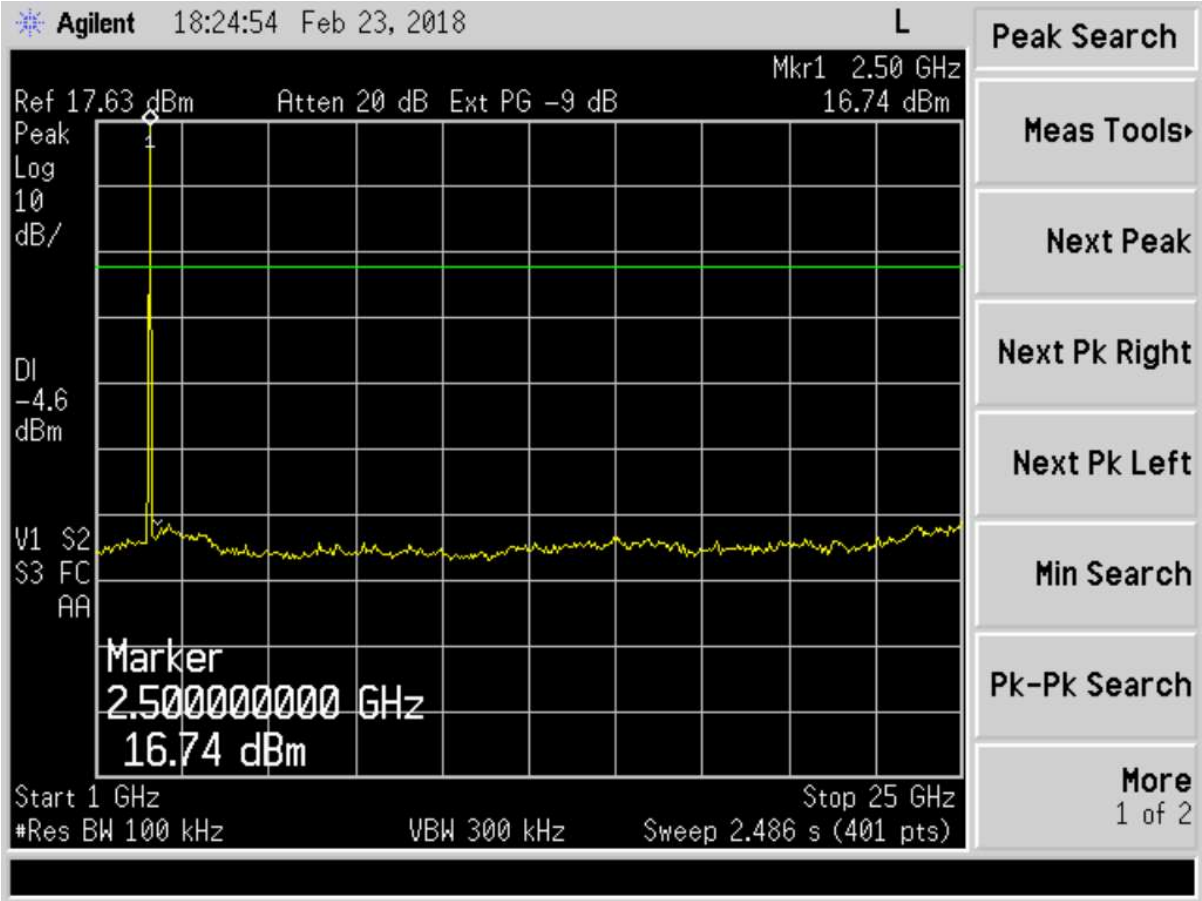


Figure 7. Antenna Conducted Emissions High Channel, 1 GHz – 25 GHz
Green Line= Limit line

Table 5. Peak Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)					**Client:** Asymmetric Technologies			
Project: 17-0454					**Model:** RFUGS MODEL B			
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)								
2404.38	88.88	--	32.09	120.97	--	3.0m./VERT	--	**PK**
*4810.39	64.41	--	5.47	69.88	74.0	3.0m./VERT	4.1	**PK**
*7212.93	52.97	-9.50	12.78	56.25	74.0	1.0m./VERT	17.8	**PK**
9617.15	59.62	-9.50	14.21	64.33	101.0	1.0m./VERT	36.6	**PK**
Mid Channel (Peak)								
2439.28	87.12	--	31.98	119.10	--	3.0m./VERT	--	**PK**
*4878.66	61.56	--	4.68	66.24	74.0	3.0m./VERT	7.8	**PK**
*7705.90	54.03	-9.50	12.63	57.16	74.0	1.0m./VERT	16.8	**PK**
9757.10	61.88	-9.50	14.28	66.66	99.1	1.0m./VERT	32.4	**PK**
High Channel (Peak)								
2475.25	86.05	--	32.13	118.18	--	3.0m./VERT	--	**PK**
*4950.49	62.89	--	6.08	68.97	74.0	3.0m./VERT	5.0	**PK**
*7691.30	52.63	-9.50	12.64	55.77	74.0	1.0m./VERT	18.2	**PK**
9897.15	67.84	-9.50	15.49	73.83	98.2	1.0m./VERT	24.3	**PK**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.
4. For measurement performed at 1 meter test distance an extrapolation factor of -9.5 dB was applied to correct back to 3 meter.
5. EUT programmed to transmit at > 98% duty cycle during testing.

Sample Calculation at: 2404.38 MHz

Magnitude of Measured Frequency	88.88	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	32.09	dB/m
Corrected Result	120.97	dBuV/m

Test Date: February 20, 2018
Tested By
Signature: _____ Name: John Freeman

Note: The transmitter was programmed to transmit at >98% during all testing.

Table 6. Average Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)					**Client:** Asymmetric Technologies			
Project: 17-0454					**Model:** RFUGS MODEL B			
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)								
2405.55	88.88	--	32.09	100.97	--	3.0m./VERT	--	**AVG**
*4810.39	64.41	-20.00	5.47	49.88	54.0	3.0m./VERT	4.1	**AVG**
*7212.93	52.97	-29.50	12.78	36.25	54.0	1.0m./VERT	17.8	**AVG**
9617.15	59.62	-29.50	14.21	44.33	54.0	1.0m./VERT	9.67	**AVG**
Mid Channel (Average)								
2439.55	87.12	--	31.98	99.10	--	3.0m./VERT	--	**AVG**
*4878.66	61.56	-20.00	4.68	46.24	54.0	3.0m./VERT	7.8	**AVG**
*7705.90	54.03	-29.50	12.63	37.16	54.0	1.0m./VERT	16.8	**AVG**
9757.10	61.88	-29.50	14.28	46.66	54.0	1.0m./VERT	7.34	**AVG**
High Channel (Average)								
2475.50	86.05	---	32.13	98.18	--	3.0m./VERT	--	**AVG**
*4950.49	62.89	-20.00	6.08	48.97	54.0	3.0m./VERT	5.0	**AVG**
*7691.30	52.63	-29.50	12.64	35.77	54.0	1.0m./VERT	18.2	**AVG**
9897.15	67.84	-29.50	15.49	53.83	54.0	1.0m./VERT	0.17	**AVG**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 15.247
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.
4. For measurement performed at 1 meter test distance an extrapolation factor of -9.5 dB was applied to correct back to 3 meter.
5. EUT programmed to transmit at > 98% duty cycle during testing. Duty Cycle correction factor of -20 dB have been applied.

Sample Calculation at: 2405.55 MHz

Magnitude of Measured Frequency	88.88	dBuV
+Additional Factor (duty cycle + extrapolation factor)	0.00	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	32.09	dB/m
Corrected Result	100.97	dBuV/m

Test Date: February 20, 2018
Tested By
Signature: _____ Name: John Freeman

Note: The transmitter was programmed to transmit at >98% during all testing.

2.10 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 7. 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	20.49	111.94	717.79
2440.00	20.25	105.92	717.79
2475.00	20.07	101.62	717.79

Note: Antenna gain exceeds 6.0 dBi by 1.44 dB, therefore the output power limit is reduced by 1.44 dB per Part 15.247(b)(4) & (e).

Test Date: February 23, 2018
Tested By
Signature: _____ Name: John Freeman

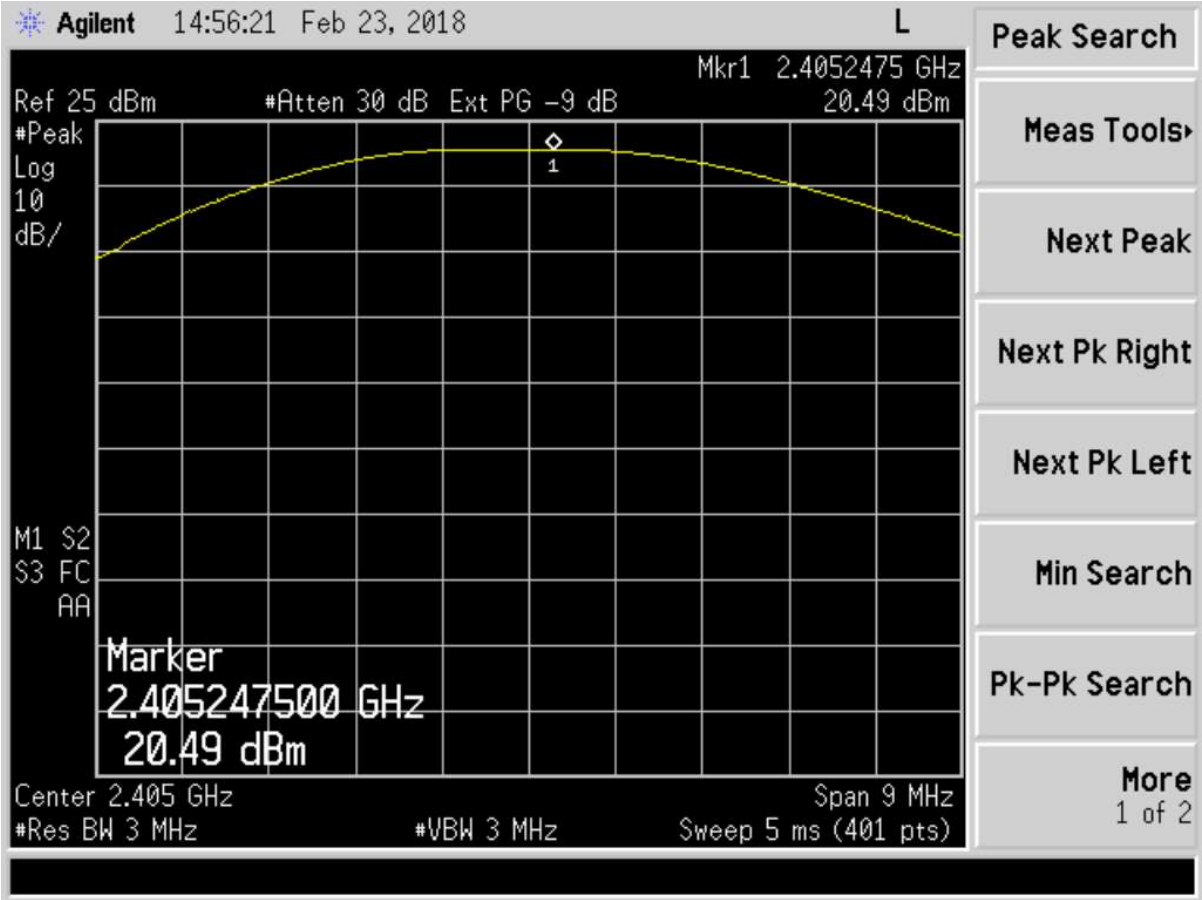


Figure 8. Peak Antenna Conducted Output Power, Low Channel

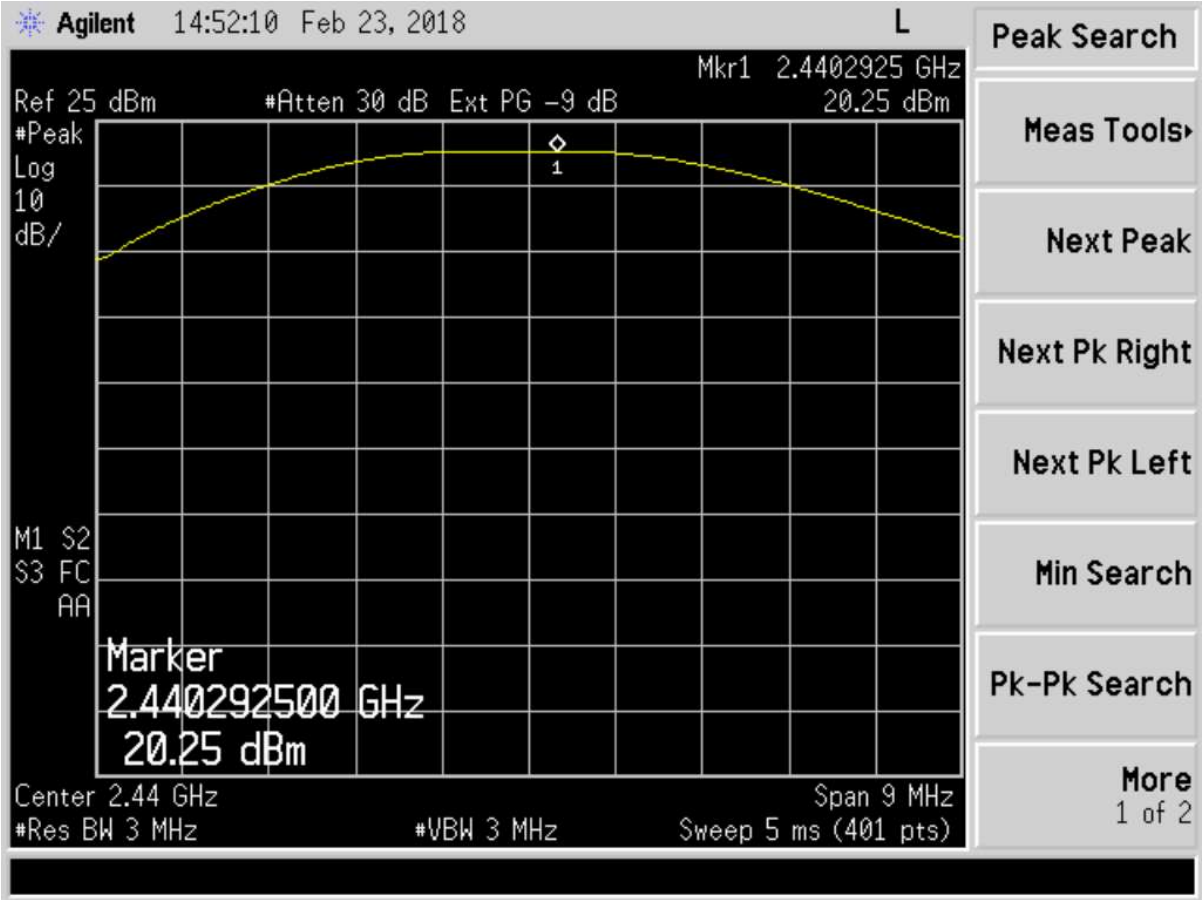


Figure 9. Peak Antenna Conducted Output Power, Mid Channel

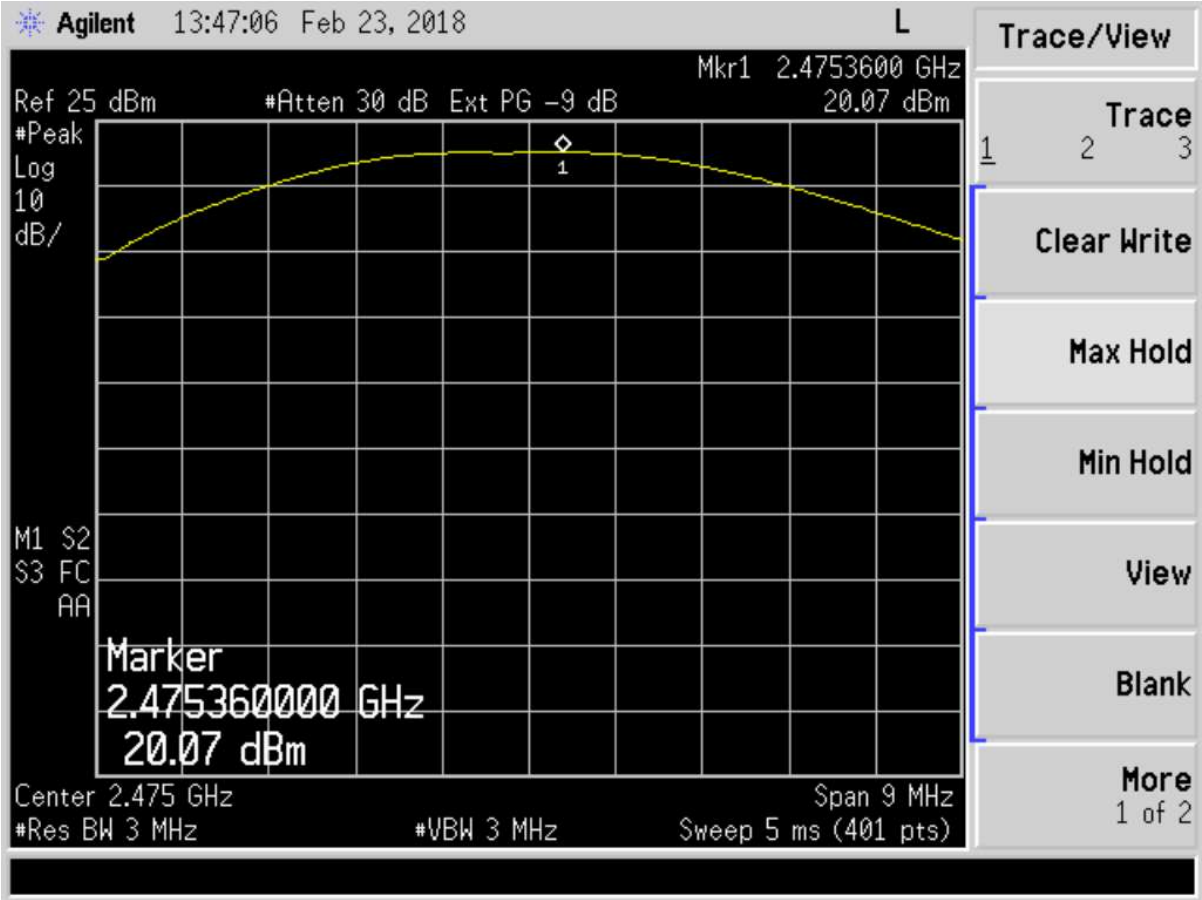


Figure 10. Peak Antenna Conducted Output Power, High Channel

2.11 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 8. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Results (dBm/3 kHz)	FCC Limit (dBm/3 kHz)
2405.00	6.24	6.56
2440.00	6.05	6.56
2475.00	5.64	6.56

Note: Antenna gain exceeds 6.0 dBi by 1.44 dB, therefore the output power limit is reduced by 1.44 dB per Part 15.247(b)(4) & (e).

Test Date: February 23, 2018
Tested By
Signature: _____ Name: John Freeman

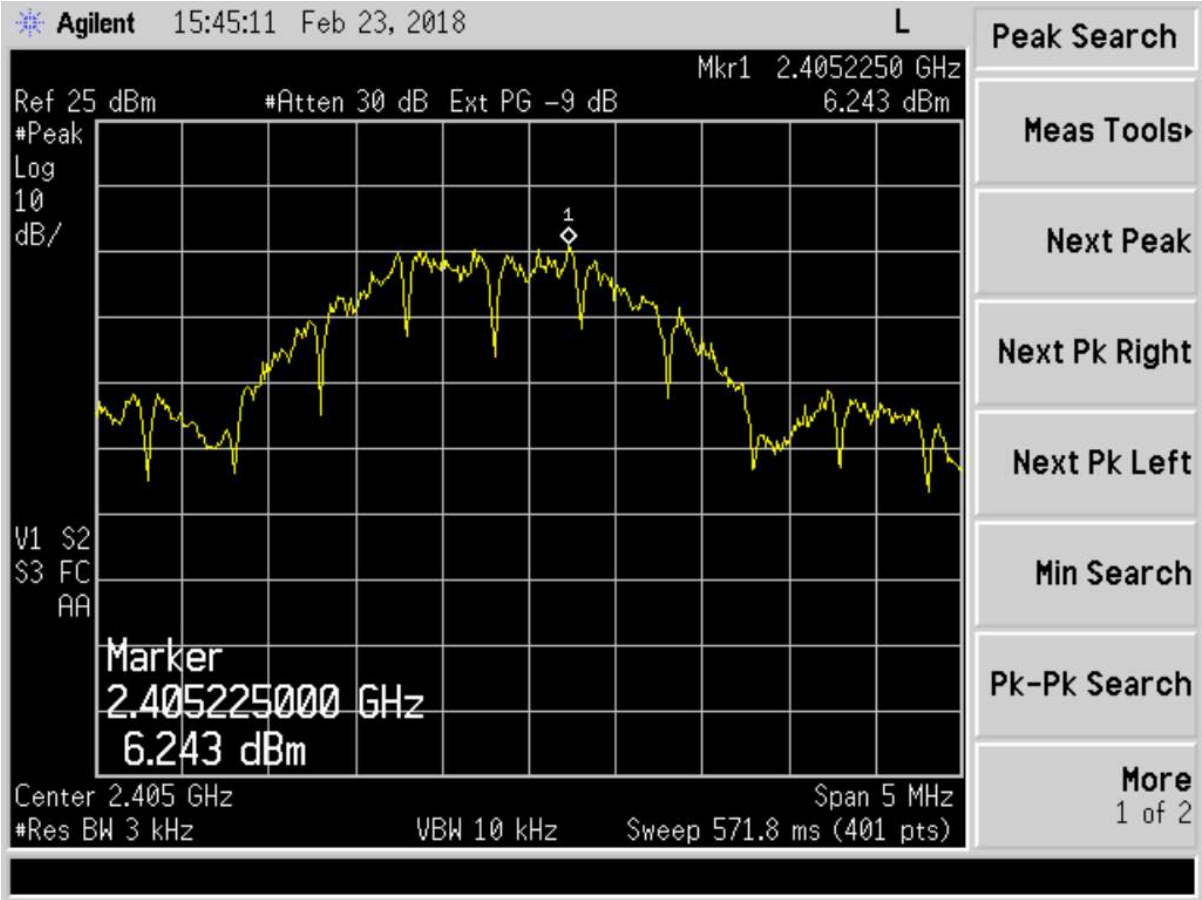


Figure 11. Peak Power Spectral Density – Part 15.247 (e) – Low Channel

Figure 12. Power Spectral Density – Part 15.247 (e) – Mid Channel

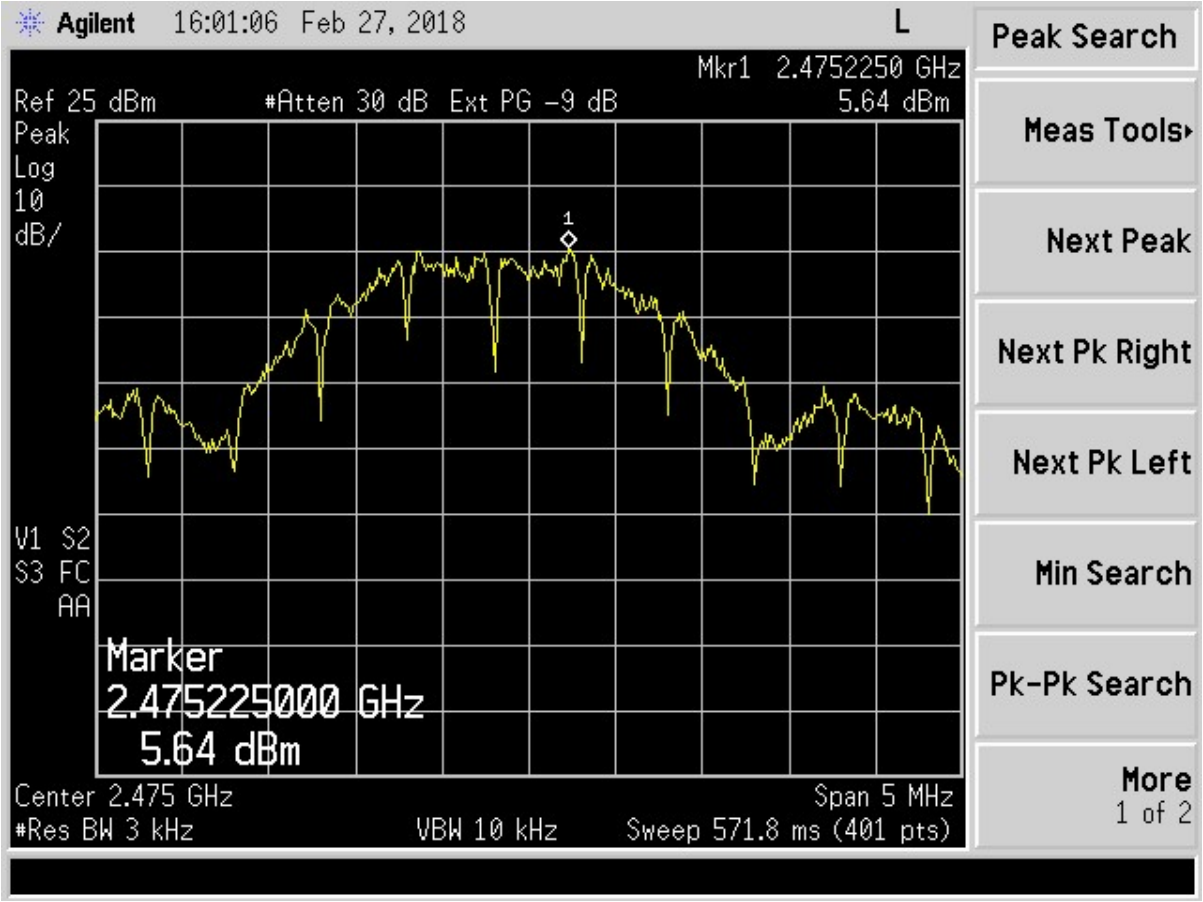


Figure 13. Peak Power Spectral Density – Part 15.247 (e) – High Channel

2.12 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.

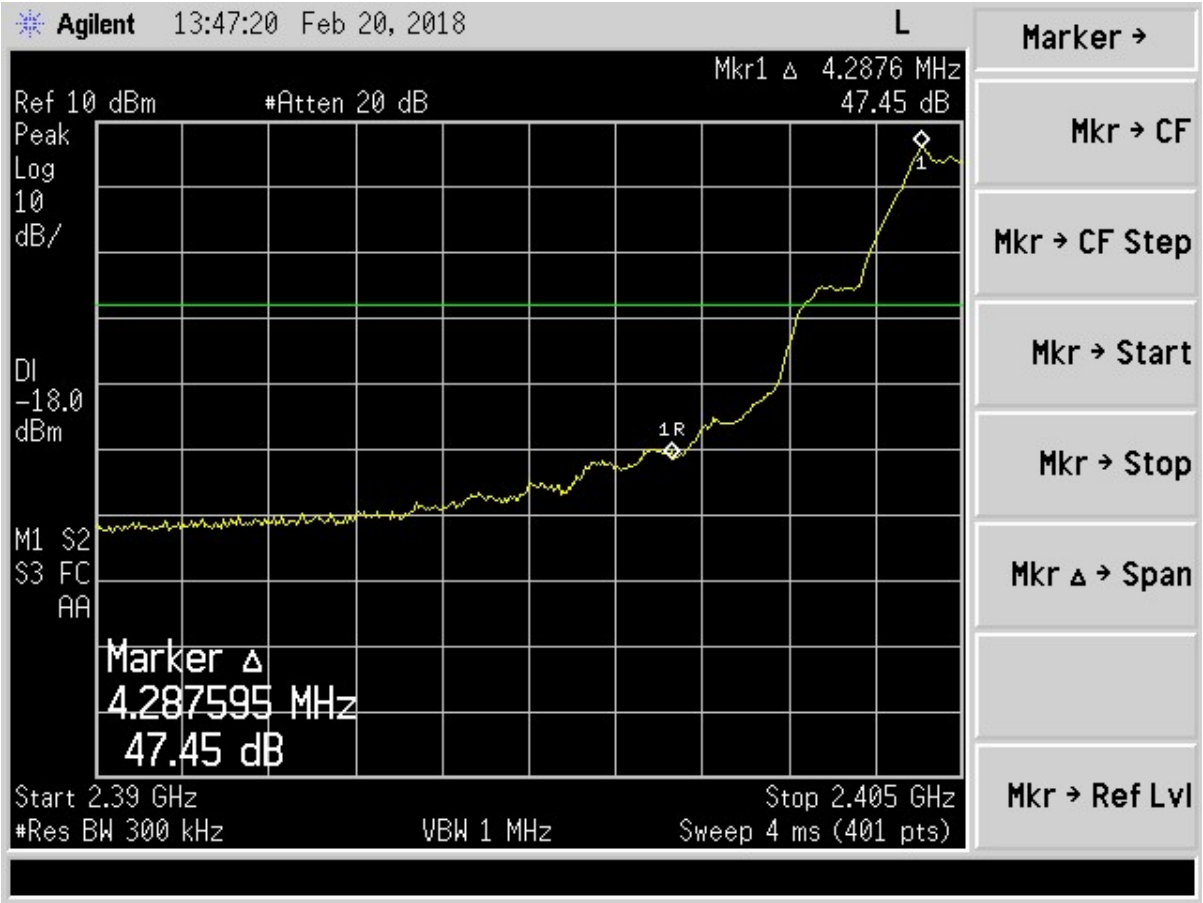


Figure 14. Band Edge Compliance, Low Channel Delta - Peak

Band edge must be 20 dB below the fundamental. An Average Measurement was not conducted since the peak measurement meets Average requirements.

Measured Result	47.45	dB
Band Edge Limit	20.00	dB
Band Edge Margin	27.45	dB

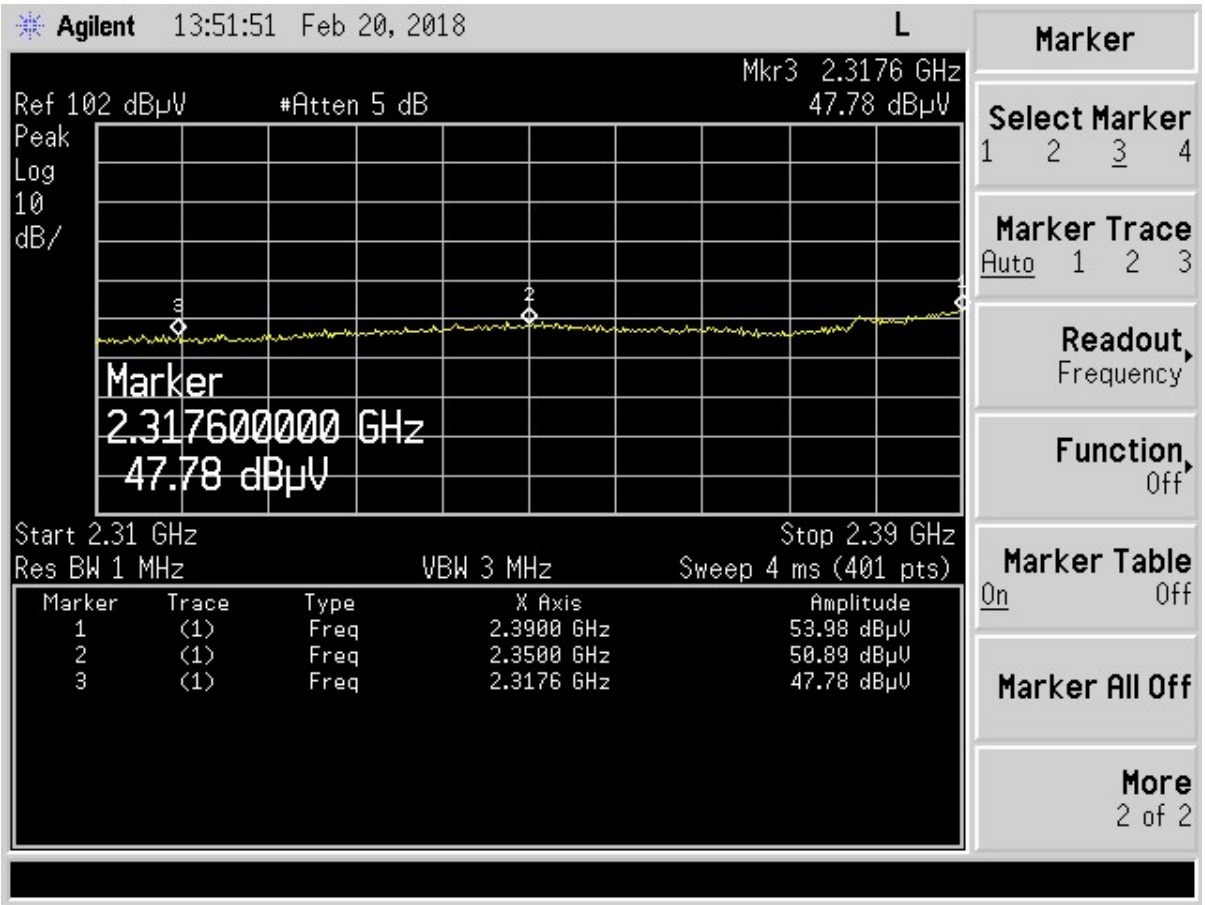


Figure 15. Conducted Restricted Band Measurements 2.31 GHz to 2.39 GHz

Table 9. Restricted Band 2310-2390 MHz

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2317.60	47.78	-3.33	44.45	54.0	3.0m./VERT	9.6	**PK**
2350.00	50.89	-3.32	47.57	54.0	3.0m./VERT	6.4	**PK**
2390.00	53.98	-4.14	49.84	54.0	3.0m./VERT	4.2	**PK**

Note: Peak value meets AVG limit.

Sample Calculation at: 2317.60 MHz

Magnitude of Measured Frequency	47.78	dBuV
+Additional Factor (duty cycle + extrapolation factor)	0.00	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	-3.33	dB/m
Corrected Result	44.45	dBuV/m

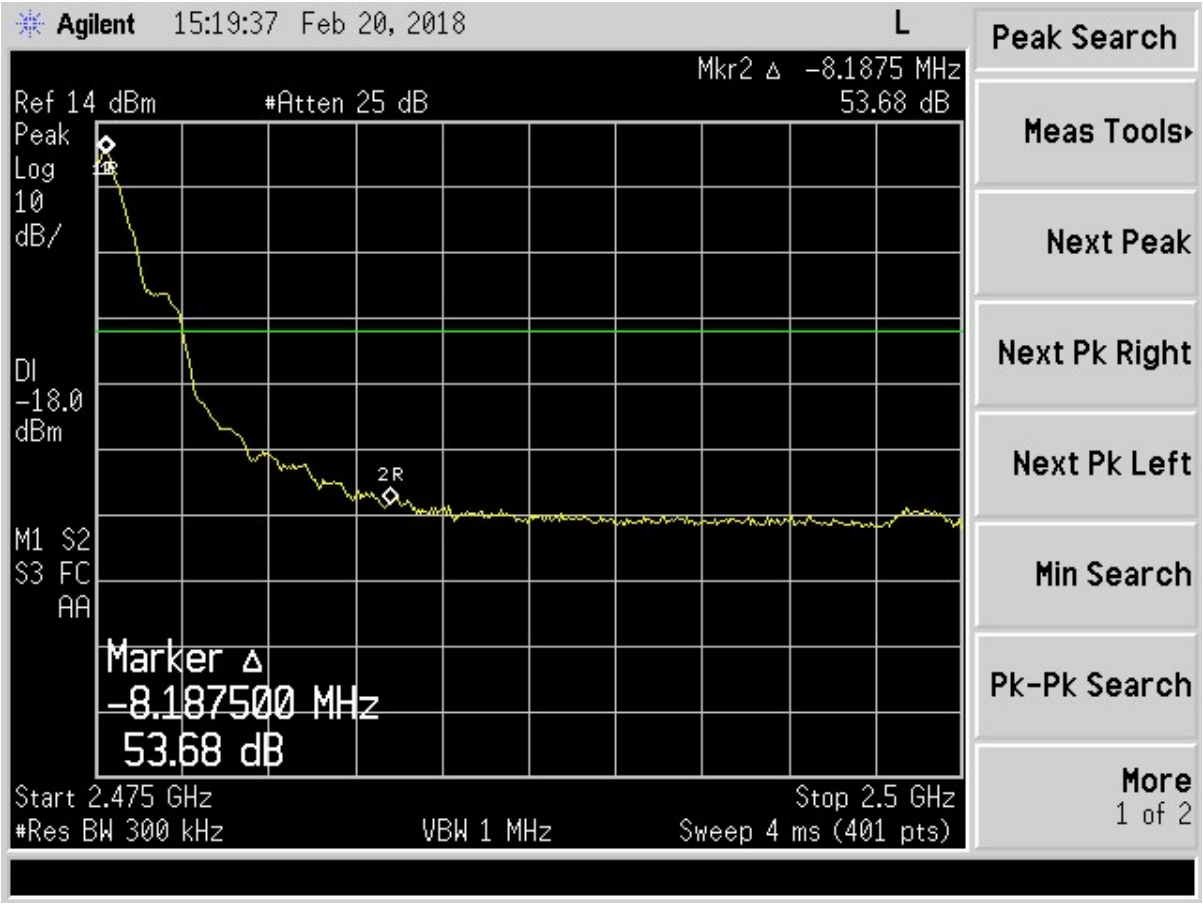


Figure 16. Band Edge Compliance, High Channel Delta – Peak

Band edge must be 20 dB below the fundamental. An Average Measurement was not conducted since the peak measurement meets Average requirements.

Measured Result	53.68	dB
Band Edge Limit	20.00	dB
Band Edge Margin	33.68	dB

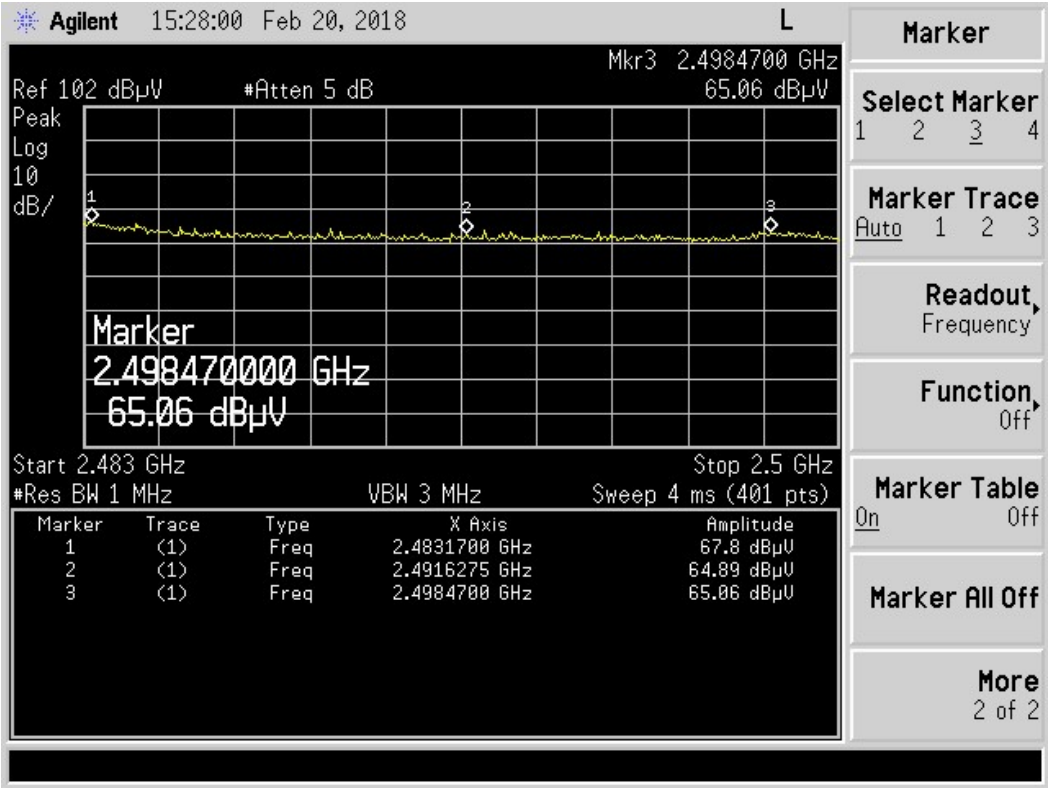


Figure 17. Conducted Restricted Band Measurements PK, 2.4835 GHz to 2.5 GHz

Table 10. Restrict Band 2483.5 - 2500 MHz PEAK

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2483.17	67.80	-2.44	65.36	74.0	3.0m./VERT	8.6	**PK**
2491.63	64.89	-2.44	62.45	74.0	3.0m./VERT	11.5	**PK**
2498.47	65.06	-2.44	62.62	74.0	3.0m./VERT	11.4	**PK**

Table 11. Restrict Band 2483.5 - 2500 MHz AVERAGE

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	(Duty Cycle) dB	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2483.17	67.80	-2.44	-20.0	45.36	54.0	3.0m./VERT	8.6	**AVG**
2491.63	64.89	-2.44	-20.0	42.45	54.0	3.0m./VERT	11.5	**AVG**
2498.47	65.06	-2.44	-20.0	42.62	54.0	3.0m./VERT	11.4	**AVG**

Sample Calculation at: 2483.17 MHz

Magnitude of Measured Frequency	67.80	dBuV
+Additional Factor (duty cycle + extrapolation factor)	-20.00	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	-2.44	dB/m
Corrected Result	45.36	dBuV/m

2.13 Six (6) dB and Occupied Bandwidth per CFR 15.247(a)(2) Bandwidth

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

Table 12. 6 dB Bandwidth and 99% Occupied Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
2405.00	1.635	2.7633	0.5
2440.00	1.633	2.7669	0.5
2475.00	1.643	2.7759	0.5

Test Date: February 22, 2018
Tested By
Signature: _____ Name: John Freeman

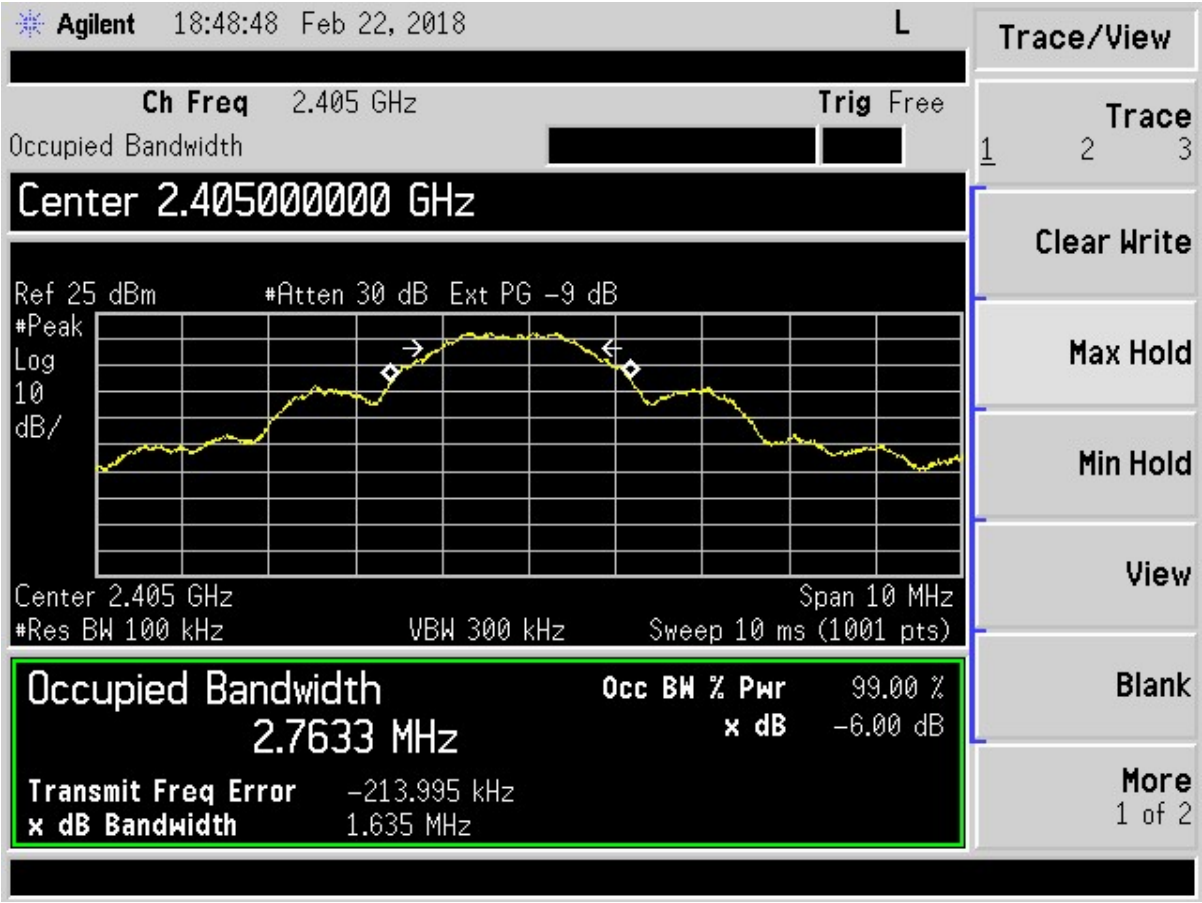


Figure 18. Six (6) dB Bandwidth– Low Channel

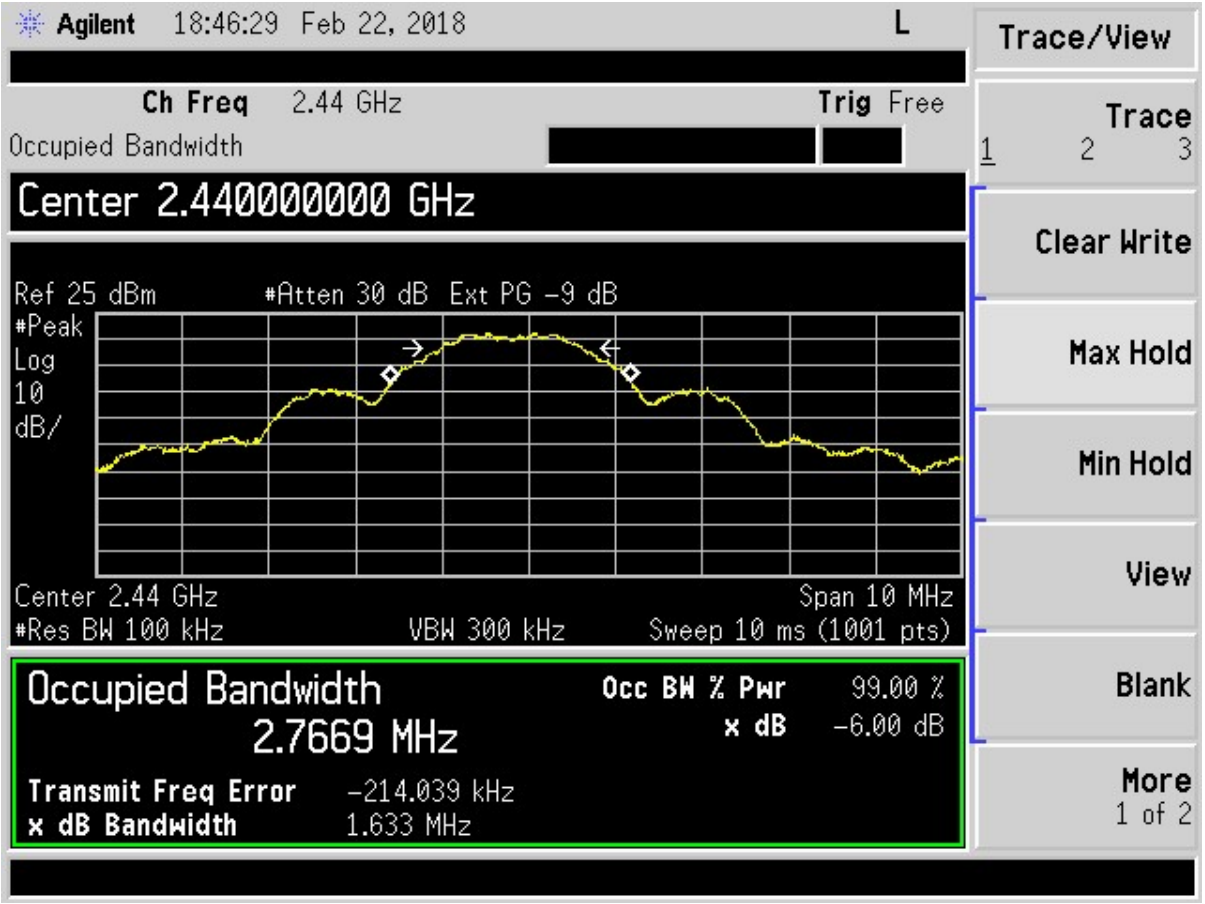


Figure 19. Six (6) dB Bandwidth – Mid Channel

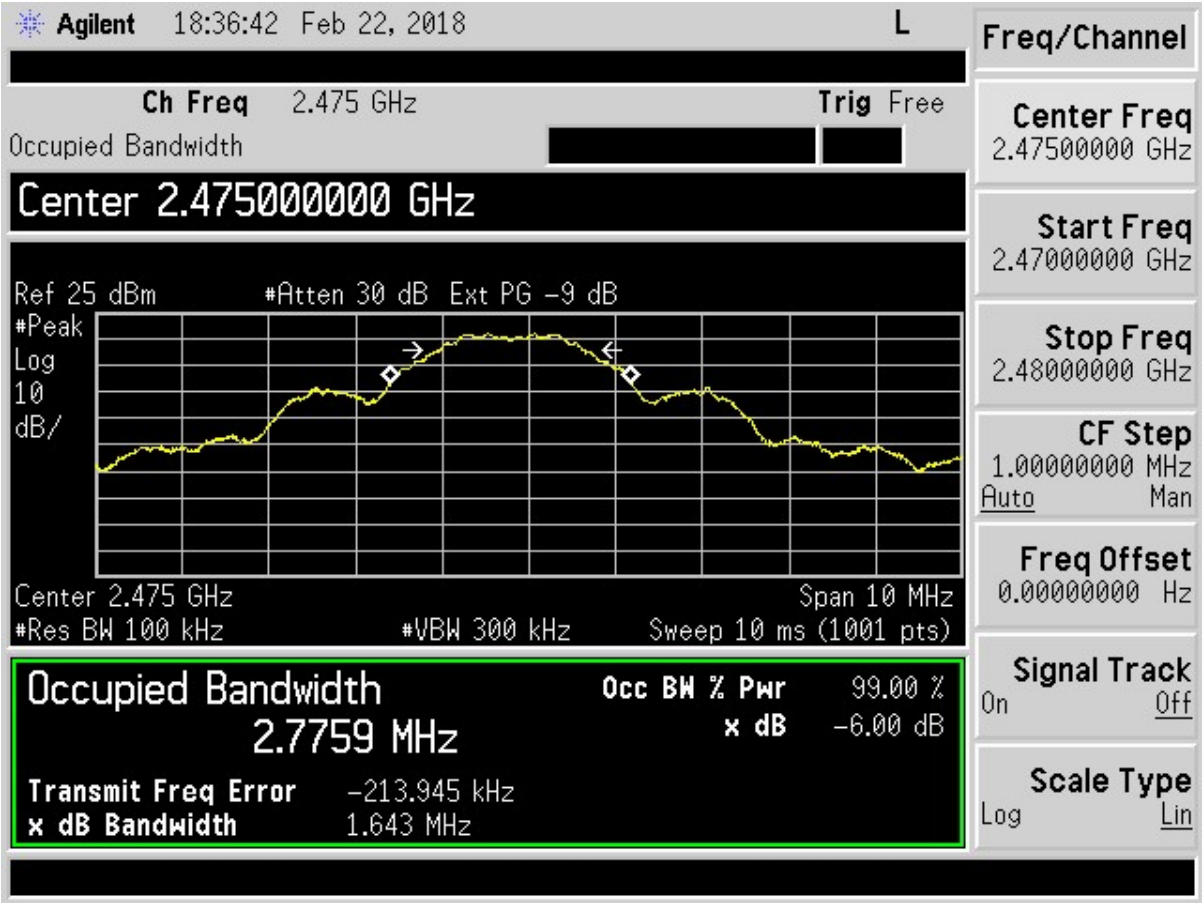


Figure 20. Six (6) dB Bandwidth – High Channel

2.14 Unintentional Radiator and Intentional Radiator Power Lines Conducted Emissions (CFR 15.107, 15.207)

The test data provided in this section is to support the Verification requirement for the digital apparatus. The power line conducted voltage measurements for Receiver and Digital Devices have been carried out in accordance with CFR 15.107 and ANSI C63.4:2014, Paragraph 7, with a spectrum analyzer connected to an LISN and the EUT placed into an idle condition or a continuous mode of receive (non-transmitting).

Additionally 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 EUT is Battery powered; therefore this test is not applicable.

Table 13. Transmitter Power Line Conducted Emissions Test Data, Part 15.107/15.207

150KHz to 30 MHz						
Test: Power Line Conducted Emissions				**Client:** Asymmetric Technologies		
Project: 17-0454				**Model:** RFUGS MODEL B		
Frequency (MHz)	**Test Data (dBuv)**	**LISN+CL-PA (dB)**	**Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector PK, QP, or AVG**
The EUT is battery powered; therefore this test is not applicable.						

SAMPLE CALCULATION at: N/A

Test Date: February 27, 2018

Tested By
Signature: _____ Name: John Freeman

2.15 Unintentional Radiator and Intentional Radiator, Radiated Emissions (CFR 15.109 and 15.209)

The test data provided herein is to support the verification requirement for digital devices. Radiated emissions coming from the EUT in a non-transmit state per 15.109 were evaluated from 30 MHz to 12.5 GHz as well as radiated emissions coming for the EUT in a transmitting state per 15.209 and were investigated from 9 kHz or the lowest operating clock frequency to 25 GHz and tested as detailed in ANSI C63.10:2013, Clause 6.4-6.6. Data is presented in the table below.

Radiated emissions within the band of 9 kHz to 30 MHz were investigated using a calibrated Loop Antenna and per the requirements of ANSI C63.10:2013.

Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turn-table through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure.

The data presented is with the EUT and 2.4 GHz radio ON and transmitting. This is considered the worst case operation and covers both the requirements for Part 15.109 and 15.209.

The worst-case radiated emission was 6.0 dB below the specification limit at 315.5 MHz. All other measured signals were at least 8.3 dB below the specification limit. The results are shown in the table below. These results are meant to show that this EUT has met the requirements for an unintentional radiator under CFR Part 15.109 as well as the intentional transmitter requirements of CFR Part 15.209.

Table 14. Spurious Radiated Emissions 150 kHz-30MHz (CFR 15.209)

Test By: BA	Test: FCC Part 15.209			Client: Asymmetric Technologies			
	Project: 17-0454			Model: RFUGS MODEL B			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
There were not emissions seen greater than 6 dB above the noise floor levels. The EUT was investigated from 9 kHz to 30 MHz. The limits applied were based on 3 meter test distance comparing to 15.209 limits. Peak detection was used for this investigation. Emissions levels were more than 20 dB below the applicable limits.							

SAMPLE CALCULATION: N/A

Test Date: November 29, 2017

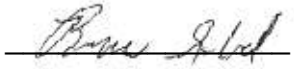
Tested By
Signature:  Name: Bruce Arnold

Table 15. Unintentional Radiator, Peak Radiated Emissions (CFR 15.109/15.209), 30 MHz to 1000 MHz

30 MHz to 1000 MHz								
Test: Radiated Emissions				**Client:** Asymmetric Technologies				
Project: 17-0454				**Model:** RFUGS MODEL B				
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**
80.03	38.28	--	-17.51	20.77	40.0	3m./HORZ	19.2	**PK**
80.03	37.90	--	-17.61	20.29	40.0	3m./VERT	19.7	**PK**
164.03	39.09	--	-12.41	26.68	43.5	3m./VERT	16.8	**QP**
315.50	50.74	--	-10.73	40.01	46.0	3m./VERT	6.0	**PK**
318.00	41.04	--	-10.33	30.71	46.0	3m./HORZ	15.3	**PK**

SAMPLE CALCULATION at: 80.03 MHz

Magnitude of Measured Frequency	38.28	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	-17.51	dB/m
Corrected Result	20.77	dBuV/m

Test Date: November 29, 2017
Tested By
Signature: _____ Name: Bruce Arnold

Table 16. 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:** Asymmetric Technologies			
Project: 17-0454				**Model:** RFUGS MODEL B			
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**
2977.50	50.89	-8.37	42.52	54.0	3m./VERT	11.5	**PK**
2996.25	53.51	-7.80	45.71	54.0	3m./HORZ	8.3	**AVG**
Notes: No other spurious emission seen except for Fundamental and harmonic emissions. Those emissions are presented in Table 5 & 6 above.							

SAMPLE CALCULATION at: 2977.50

Magnitude of Measured Frequency	50.89	dBuV
+Additional Factor (Distance Extrapolation)	0.0	dB
+Antenna Factor + Cable Loss+ Amplifier Gain	-8.37	dB/m
Corrected Result	42.52	dBuV/m

Test Date: February 28, 2018

Tested By
Signature: _____ Name: John Freeman

2.16 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%.

2.16.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.78 dB. This test was not applicable to this EUT.

2.16.2 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 have sufficient margin to negate the effects of uncertainty, therefore the EUT unconditionally meets and passes the requirements of the applicable standard when tested as presented in this test report.