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 LLC

Model: RFUGS MODEL B

FCC ID: 2AODE-RFUGSB

UST Project: 17-0455
Issue Date: March 14, 2018

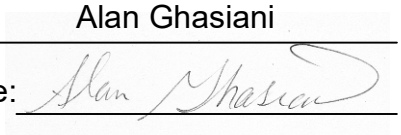
Total Pages in This Report: 57

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

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 March 14, 2018

TESTING
NVLAP LAB CODE 200162-0

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

Testing Tomorrow's Technology

MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Asymmetric Technologies

MODEL: RFUGS MODEL B

FCC ID: 2AODE-RFUGSB

DATE: March 14, 2018

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

Equipment type: 902-928 MHz ISM Radio

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

List of Figures

Figures **Title** **Page**

List of Tables

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
Antenna Photographs
Theory of Operation
RF Exposure
Installation 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 900 MHz radio option. Below are some technical notes regarding this radio:

Modulation: FSK (FHSS)
Data rate: 50 kbps
Packet Type: IEEE 802.15.4
Operating frequency band: 902 - 928 MHz
Antenna: Dipole Antenna, +1.2 dBi Gain
Rated output: +14.0 dBm

1.4 Configuration of Tested System

The Test Sample was tested per *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 FCC subpart A Digital equipment Verification requirements. Also, *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* was used as a test procedure guide.

A list of the 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 been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittals

The Equipment Under Test (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 for the EUT is included herein.

1.7 Test Results

In our opinion, and as indicated by the test results documented following, when tested in the configuration as described in this report, the EUT meets the applicable requirements of FCC including: FCC Parts 2.907, 15.101, 15.107, 15.109, 15.207, 15.209 and 15.247.

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

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	6/22/2018
SPECTRUM ANALYZER	8593E	HEWLETT-PACKARD	3205A00124	7/21/2018
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	1/22/2020 2 yr
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.

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 902.2 MHz to 927.8 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:

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.

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.

Pulsed Transmitter Averaging

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: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG) the duty cycle factor calculated will be applied.

2.6 EUT Antenna Requirements (CFR 15.203)

This equipment is not available to the general public and will only be installed by a professional installer working for an approved utility. The equipment therefore meets the intent of the above requirement. Only the antennas 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 1	Linx	Dipole	ANT-9160CW-HW	1.2	RP-SMA

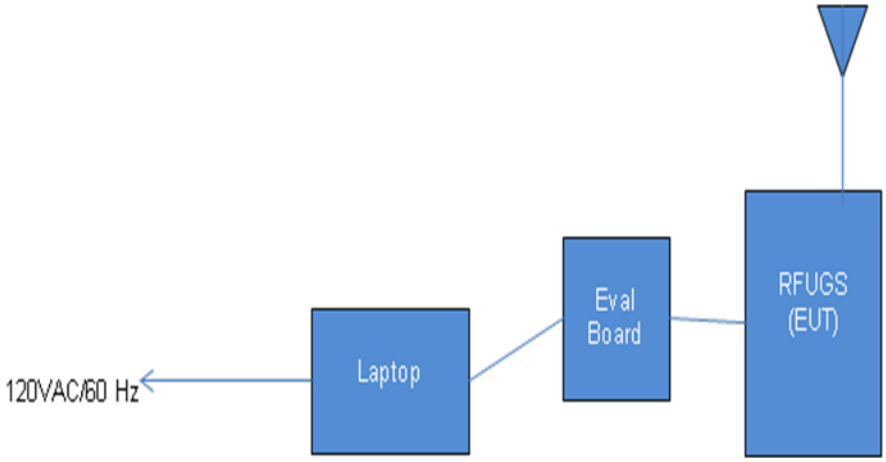


Figure 1. Block Diagram of Test Configuration

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 emissions are examined for this requirement. See paragraph 2.10 of the test report.

2.8 Transmitter Duty Cycle (CFR 15.35 (c))

When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification.

NOTE: The manufacturer has a declared a Duty Cycle of 2% intended for normal operation; therefore where applicable (when using AVG detection) the duty cycle factor based on a 2% DC was applied. See Theory of Operation for calucation.

Duty Cycle factor = 20 log DC = 20 log (0.02) = -33.9 dB in this case the duty cycle applied is -20 dB

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

The EUT is powered by two 3.6VDC Lithium battery**.** Since the EUT is battery powered, this test was not applicable. Due to the high duty cycles necessary for testing purposes battery life would be limited. Therefore the EUT was powered using alternative means, for example using a Laptop PC and evaluation board.

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d))

Radiated Spurious measurements: The EUT was placed into a continuous transmit mode of operation (>98%) duty cycle) and tested per FCC Public Notice DA 00-705 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 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 = 902.2 MHz
Mid Channel = 913.9 MHz
High Channel= 927.8 MHz

Table 5. Peak Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)					**Client:** Asymmetric Technologies			
Project: 17-0455					**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)								
902.10	76.34	-	25.19	101.53		3.0m./VERT		**PK**
1804.20	61.30	-	-6.47	54.83	74.0	3.0m./VERT	19.2	**PK**
2706.15	63.32	-	-2.11	61.21	74.0	3.0m./VERT	12.8	**PK**
3608.70	52.56	-	1.76	54.32	74.0	3.0m./VERT	19.7	**PK**
4510.50	55.55	-	4.49	60.04	74.0	3.0m./VERT	14.0	**PK**
Mid Channel (Peak)								
913.90	70.74	-	25.19	95.93		3.0m./VERT		**PK**
1827.76	57.46	-	-6.40	51.06	74.0	3.0m./VERT	22.9	**PK**
2741.67	61.20	-	-2.25	58.95	74.0	3.0m./VERT	15.1	**PK**
4569.16	59.04	-	4.44	63.48	74.0	3.0m./VERT	10.5	**PK**
High Channel (Peak)								
927.50	69.20	-	25.19	94.39		3.0m./VERT		**PK**
1855.00	59.46	-	-6.55	52.91	74.0	3.0m./VERT	21.1	**PK**
2782.50	60.53	-	-1.96	58.57	74.0	3.0m./VERT	15.4	**PK**
4637.70	60.15	-	4.37	64.52	74.0	3.0m./VERT	9.5	**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 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.
4. For measurement performed at 1 meter test distance an extrapolation factor of -9.5 dB was applied to correct back to 3 meter.

Sample Calculation at: 902.10 MHz

Magnitude of Measured Frequency	76.34	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	25.19	dB/m
Corrected Result	101.53	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: 17-0455					**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)								
902.10	69.15		25.79	94.94				
1804.20	61.30	-20.00	-5.42	35.88	54.0	3.0m./VERT	18.1	
2706.15	63.32	-20.00	-1.25	42.07	54.0	3.0m./VERT	11.9	**PK**
3608.70	52.56	-20.00	3.16	35.72	54.0	3.0m./VERT	18.3	
4510.50	55.55	-20.00	7.44	42.99	54.0	3.0m./VERT	11.0	**PK**
Mid Channel (Average)								
913.90	63.22		31.98	99.10		3.0m./VERT		AVG
1827.76	57.46	-20.00	-5.31	32.15	54.0	3.0m./VERT	21.9	AVG
2741.67	61.20	-20.00	-1.44	39.76	54.0	3.0m./VERT	14.2	AVG
4569.16	59.04	-20.00	5.82	44.86	54.0	3.0m./VERT	9.1	AVG
High Channel (Average)								
927.50	60.74	-	32.13	98.18		3.0m./VERT		AVG
1855.00	59.46	-20.00	-4.83	34.63	54.0	3.0m./VERT	19.4	AVG
2782.50	60.53	-20.00	-1.66	38.87	54.0	3.0m./VERT	15.1	AVG
4637.70	60.15	-20.00	4.25	44.40	54.0	3.0m./VERT	9.6	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 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.
4. For measurement performed at 1 meter test distance an extrapolation factor of -9.5 dB was applied to correct back to 3 meter.

Sample Calculation at: 1804.20 MHz

Magnitude of Measured Frequency	61.30	dBuV
+Additional Factor (filter + duty cycle)	-20.00	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	-5.42	dB/m
Corrected Result	35.88	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.

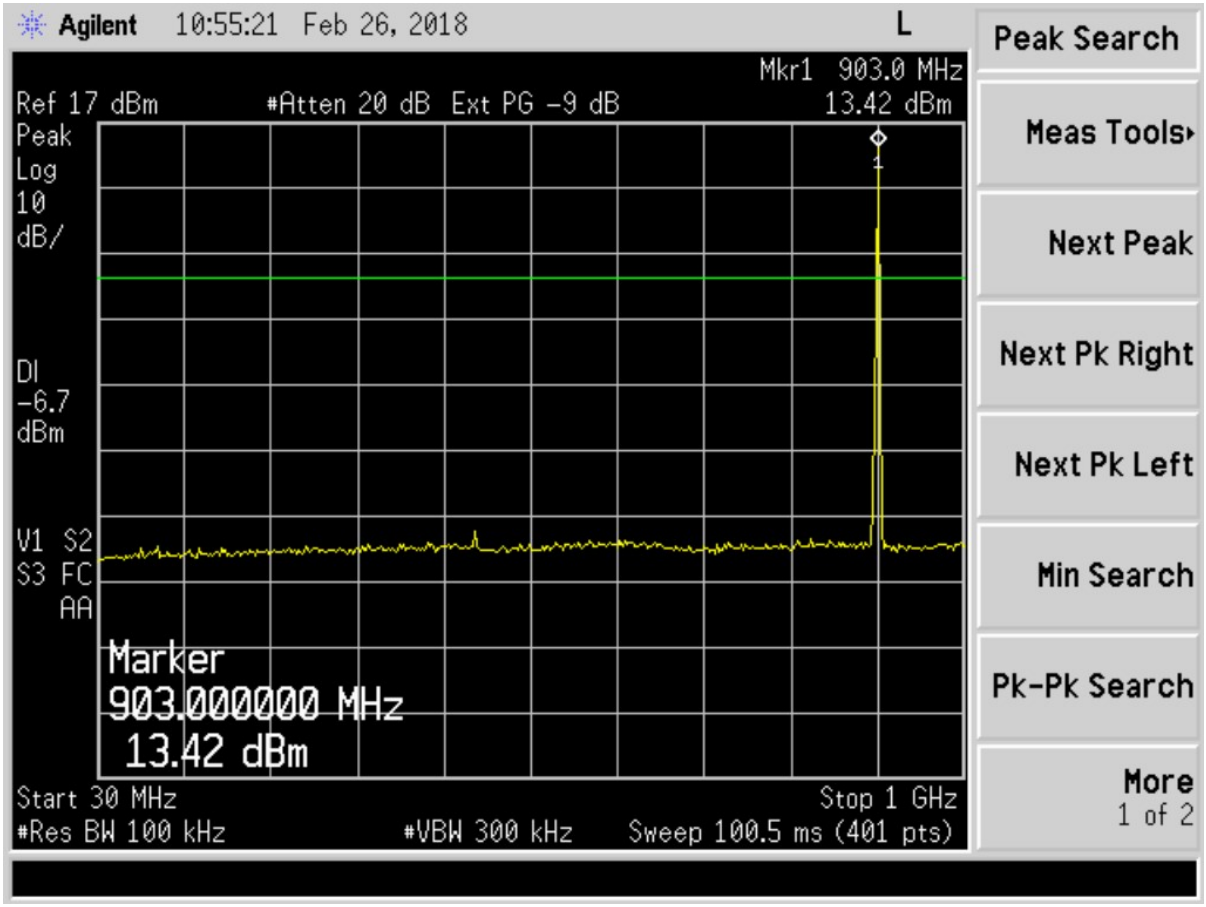


Figure 2. Antenna Conducted Emissions Low Channel, 30 MHz – 1 GHz
Green Line= Limit line

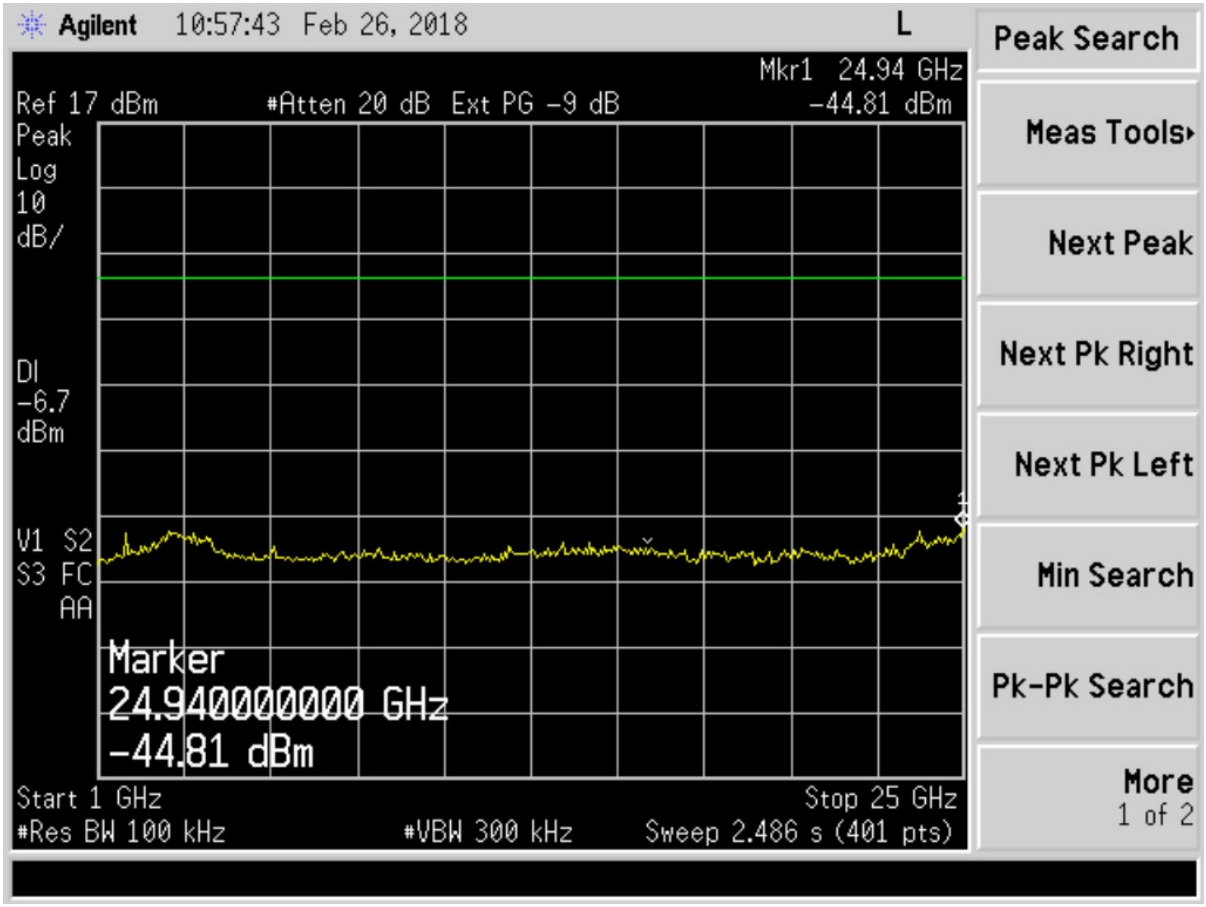


Figure 3. Antenna Conducted Emissions Low Channel, 1 GHz – 25 GHz
Green Line= Limit line

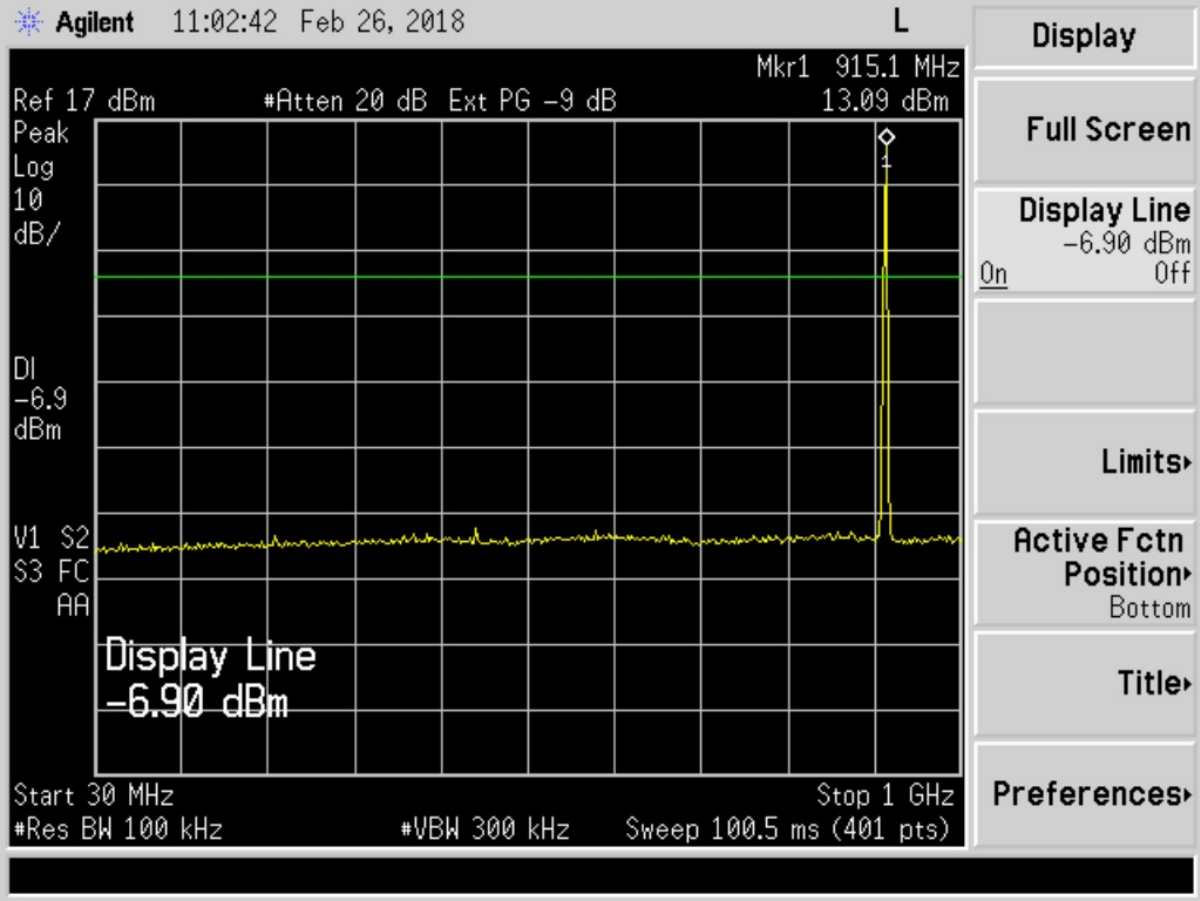


Figure 4. Antenna Conducted Emissions Mid Channel, 30 MHz – 1 GHz
Green Line= Limit line

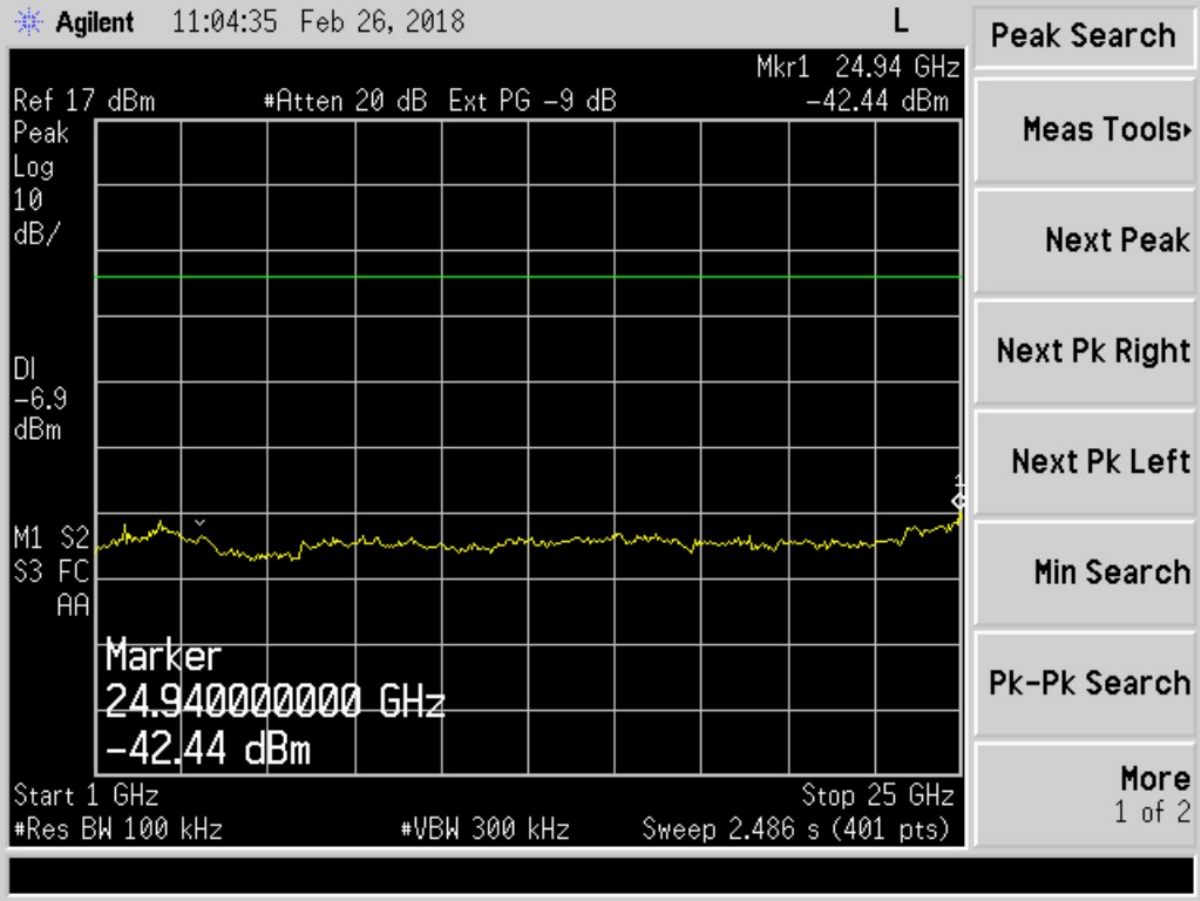


Figure 5. Antenna Conducted Emissions Mid Channel, 1 GHz – 25 GHz
Green Line= Limit line

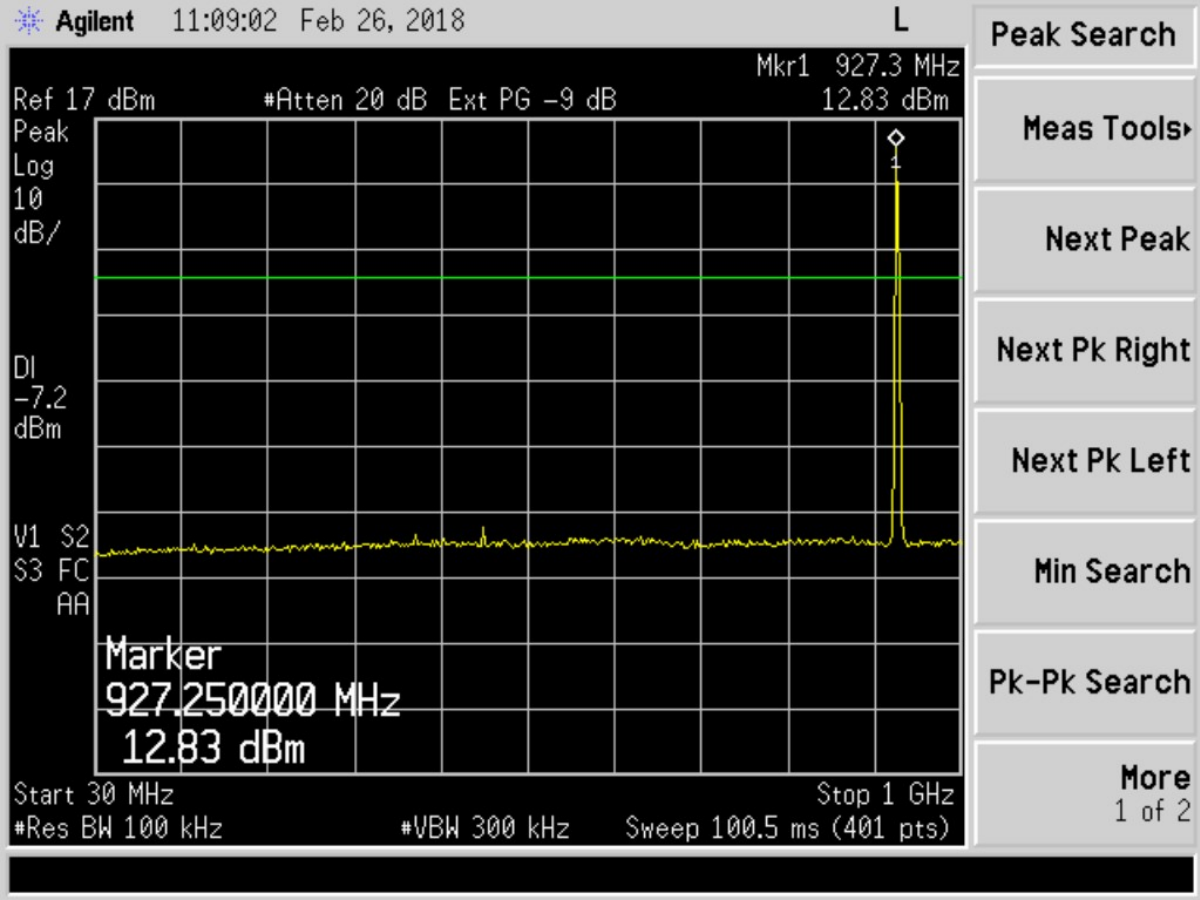


Figure 6. Antenna Conducted Emissions High Channel, 30 MHz – 1GHz
Green Line= Limit line

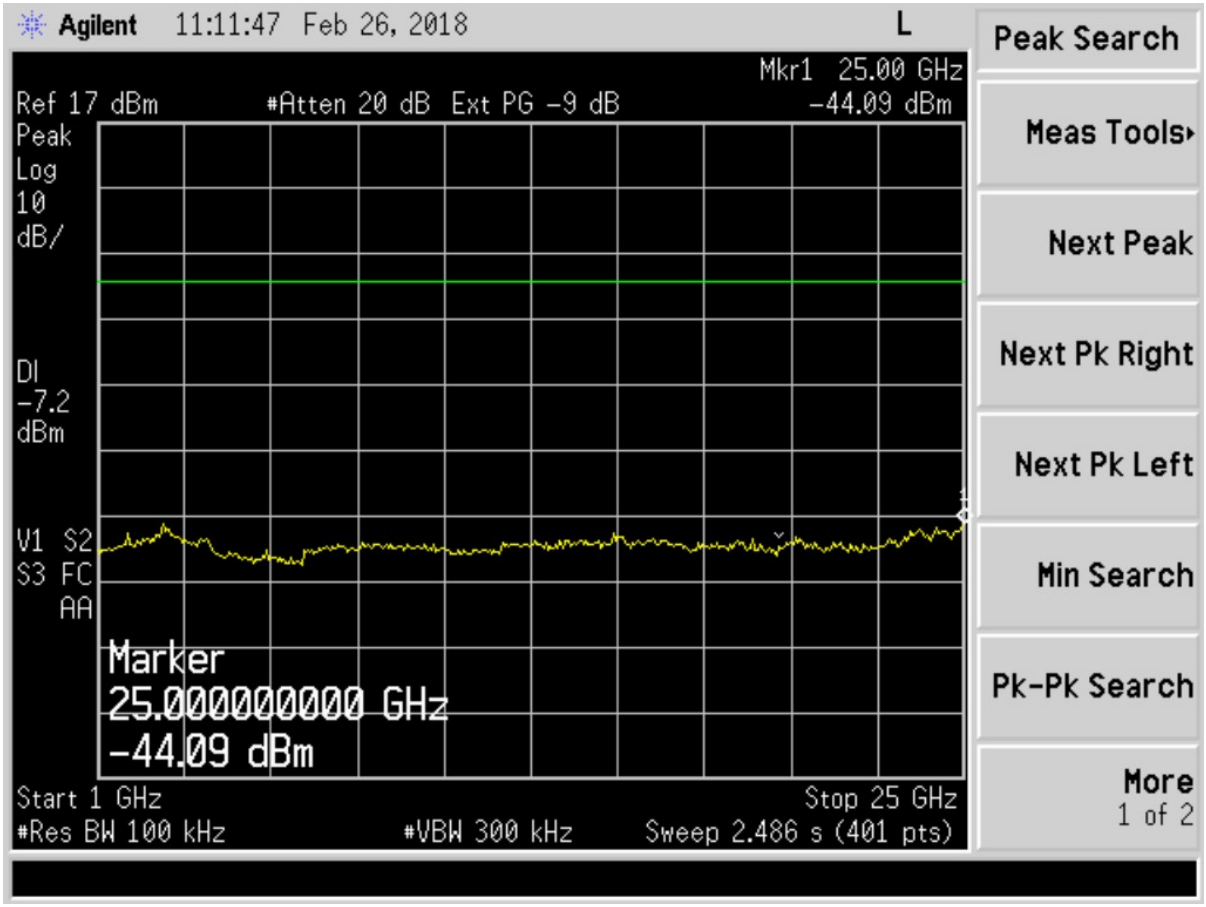


Figure 7. Antenna Conducted Emissions High Channel, 1 GHz – 25 GHz
Green Line= Limit line

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

Band Edge measurements are made, following the guidelines in ANSI 63.10-2013 for the FHSS modulation, with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Radiated measurements are performed for each antenna 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 2 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. Radiated measurements are performed with RBW = 100 kHz. The VBW is set ≥ RBW. See figure and calculations below for more detail.

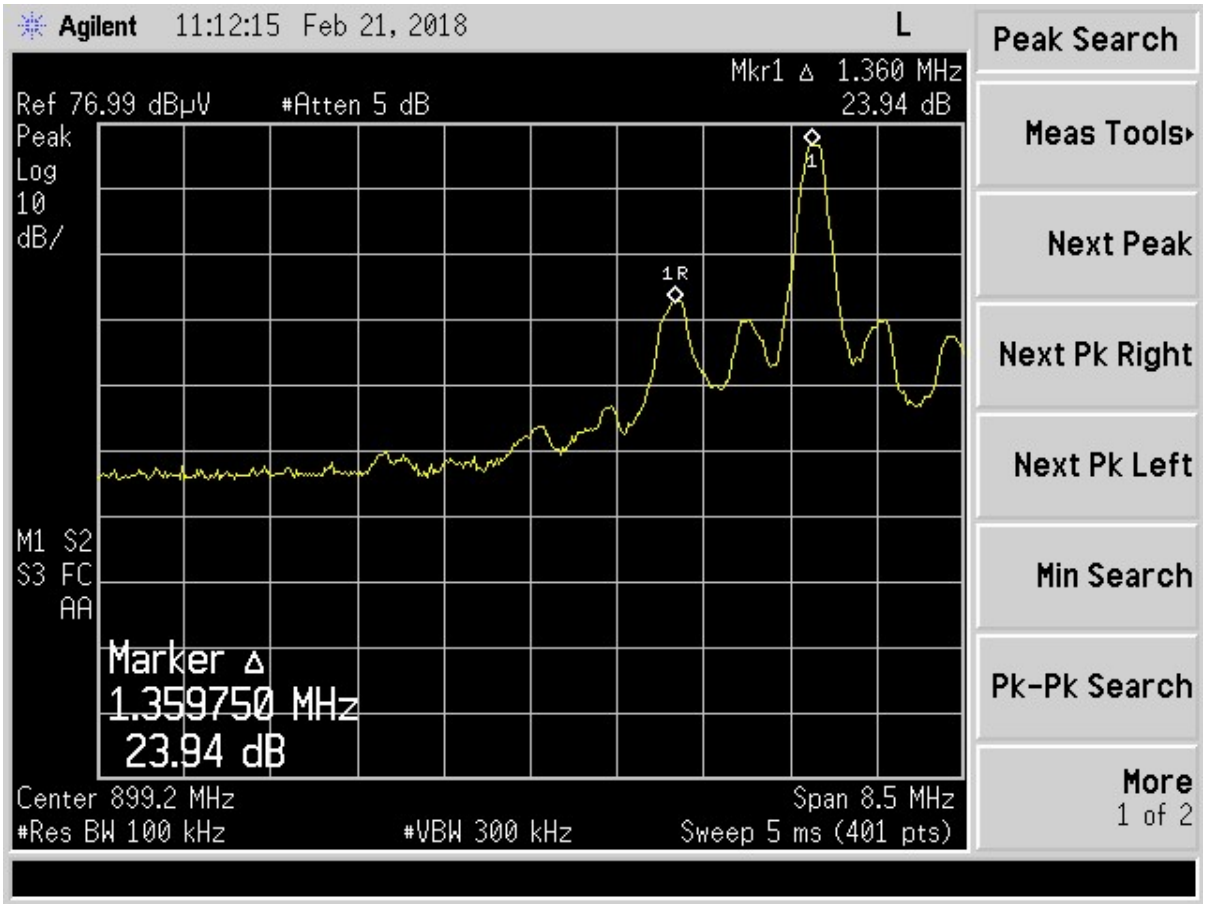


Figure 8. Band Edge Compliance, Low Channel Delta - Peak

Low band edge must be 20 dB below the fundamental.

Measured Result	23.94	dB
Band Edge Limit	20.00	dB
Band Edge Margin	3.94	dB

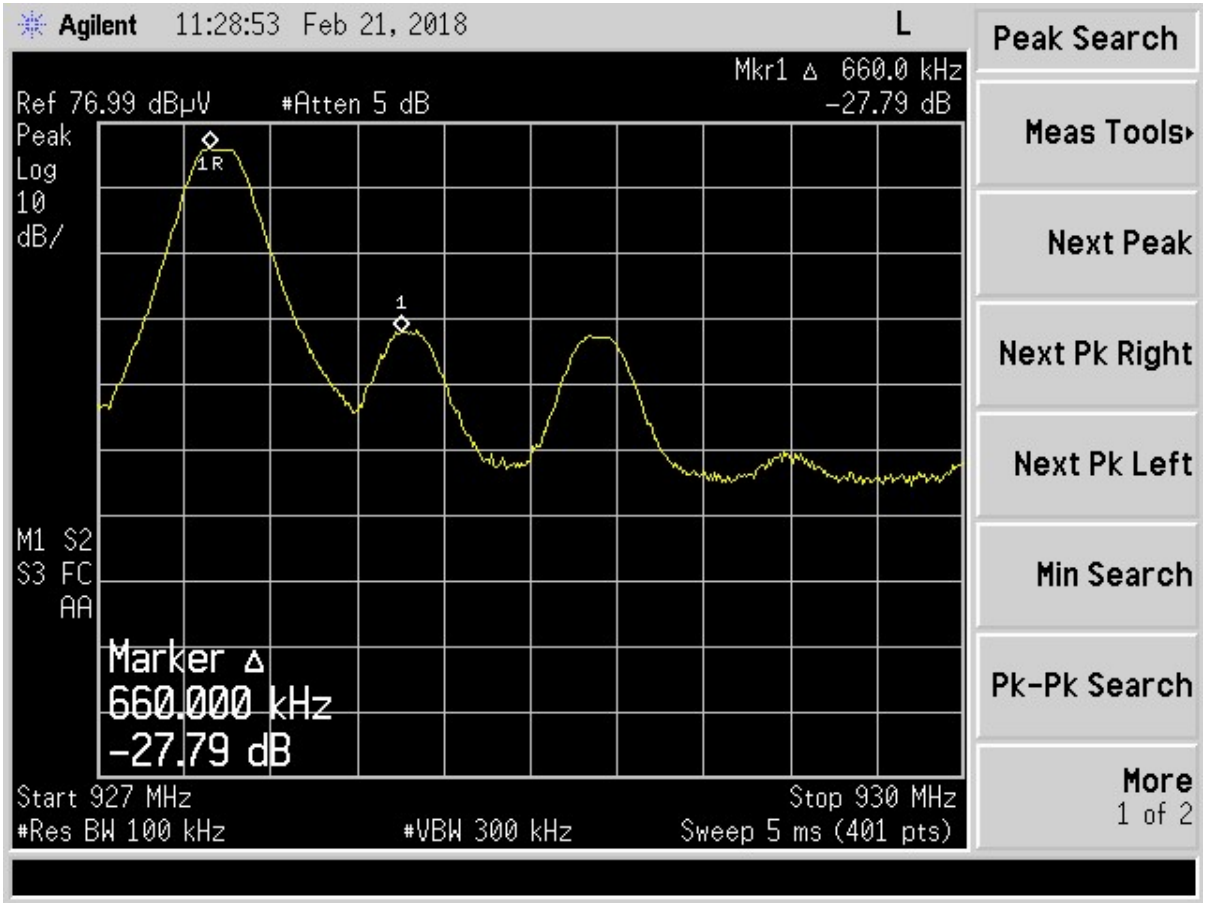


Figure 9. Band Edge Compliance, High Channel Delta – Peak

High band edge must be 20 dB below the fundamental.

Measured Result	27.79	dB
Band Edge Limit	20.00	dB
Band Edge Margin	7.79	dB

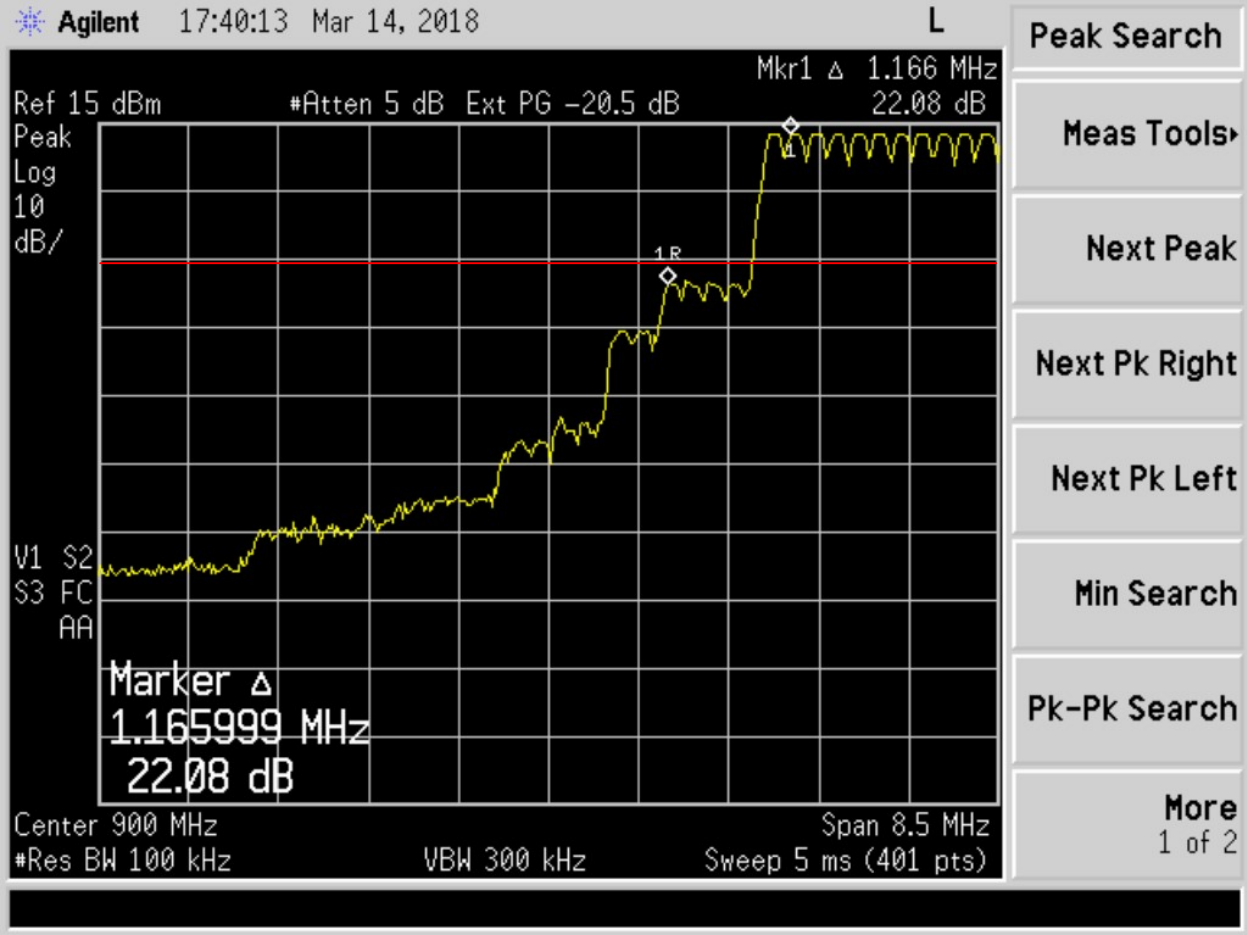


Figure 10. Band Edge Compliance, Low Channel Delta – Channel Hopping FHSS Modulation (Conducted)

Measured Delta (from Figure 14)	22.08	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	2.08	dB

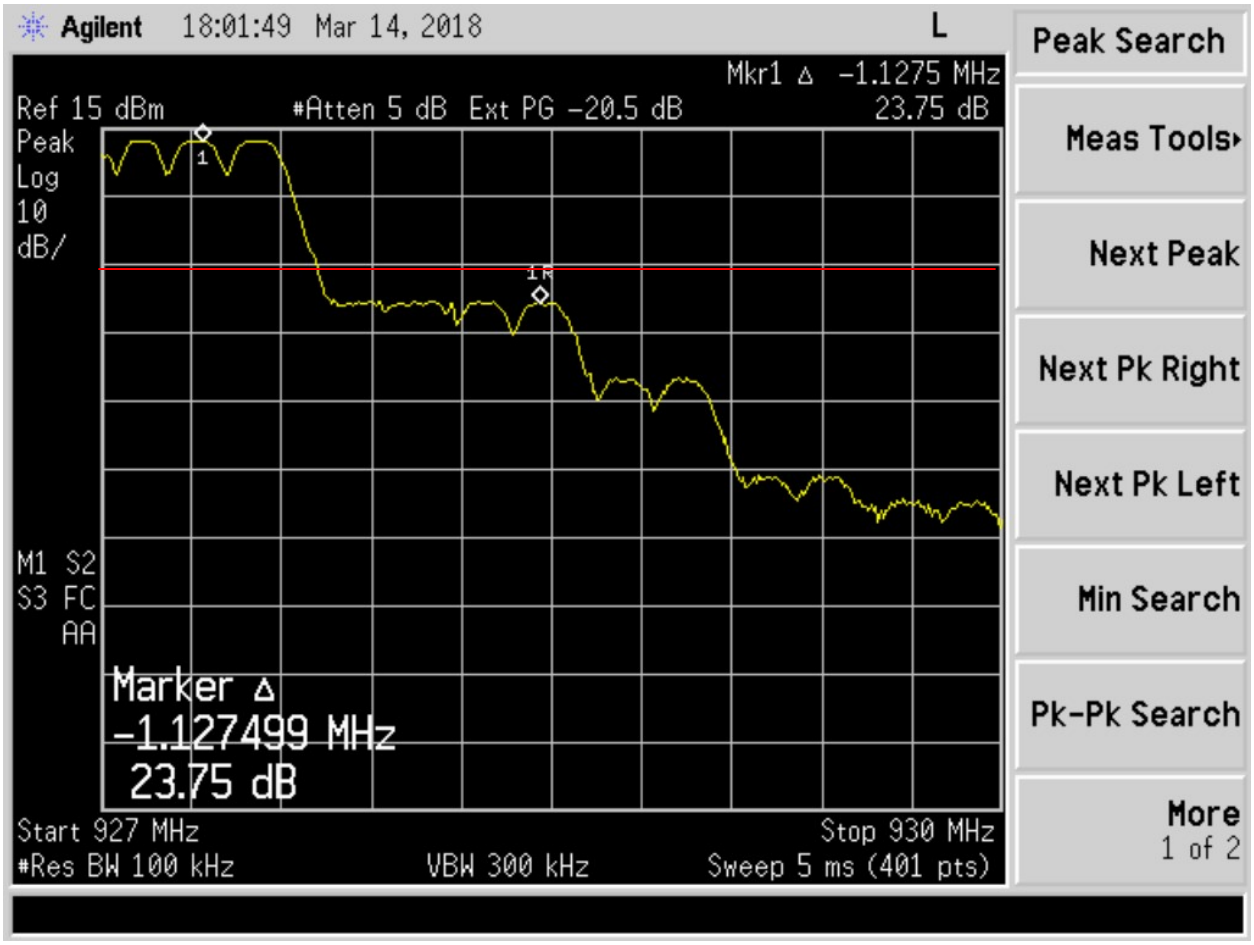


Figure 11. Band Edge Compliance, High Channel Delta – Channel Hopping FHSS Modulation (Conducted)

Measured Delta (from Figure 15)	23.75	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	3.75	dB

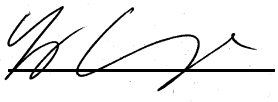
2.12 Twenty dB Bandwidth (CFR 15.247 (a) (1))

For frequency hopping systems operating in the 902-928 MHz band the maximum allowed 20 dB bandwidth is 500 kHz.

These measurements were performed while the EUT was in a constant transmit mode. A method similar to the marker delta method was used to capture the points. The RBW was set to 3 kHz and with the VBW ≥ RBW. The results of this test are given in Table and Figures following.

Table 7. Twenty (20) dB Bandwidth

Frequency (MHz)	20 dB Bandwidth (kHz)	Maximum Limit (kHz)	99% Occupied Bandwidth (kHz)
902.20	101.16	500.00	94.1
913.90	102.85	500.00	95.9
927.80	104.86	500.00	94.5

Test Date: March 14, 2018
Tested By
Signature:  Name: George Yang

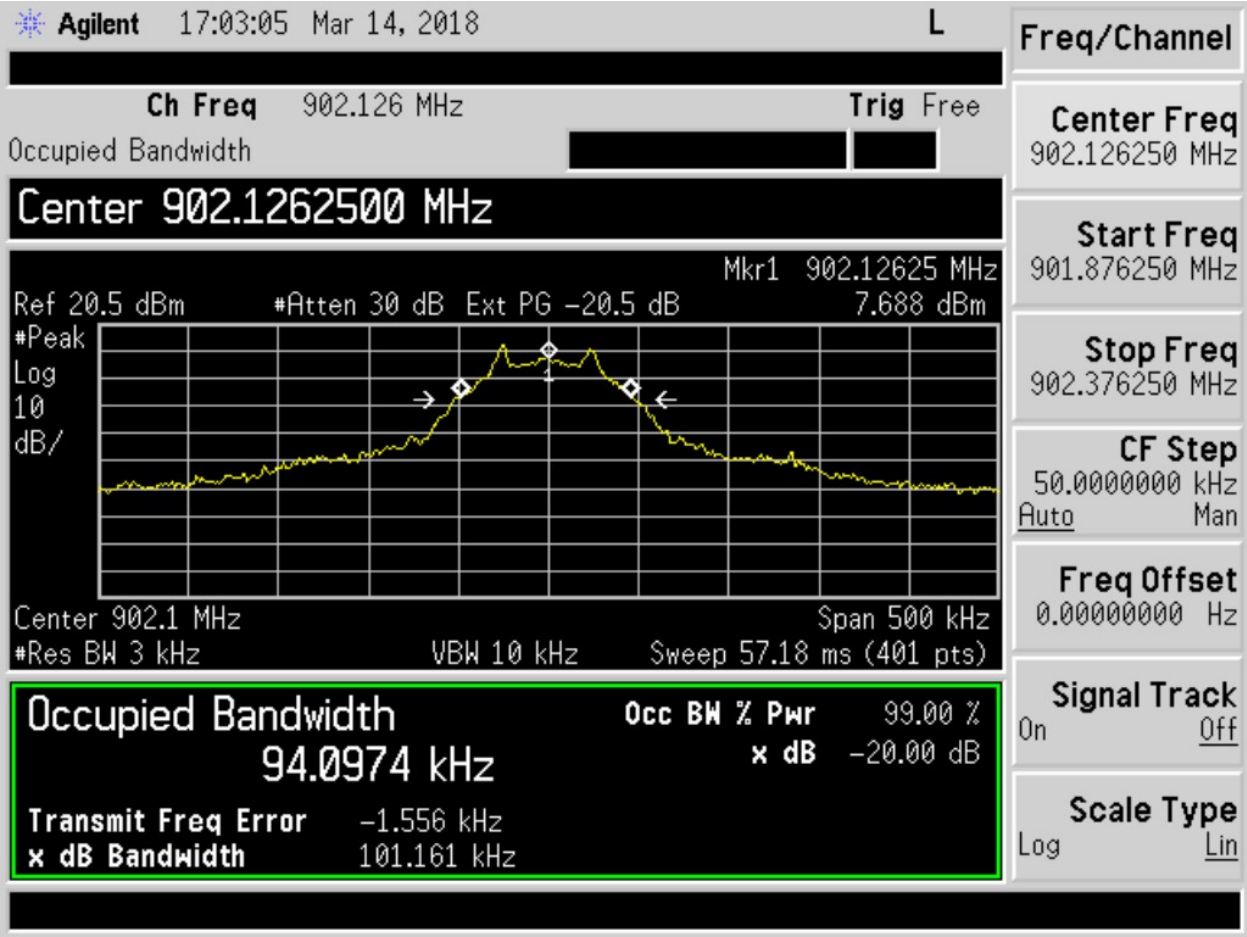


Figure 12. Twenty dB Bandwidth – Low Channel

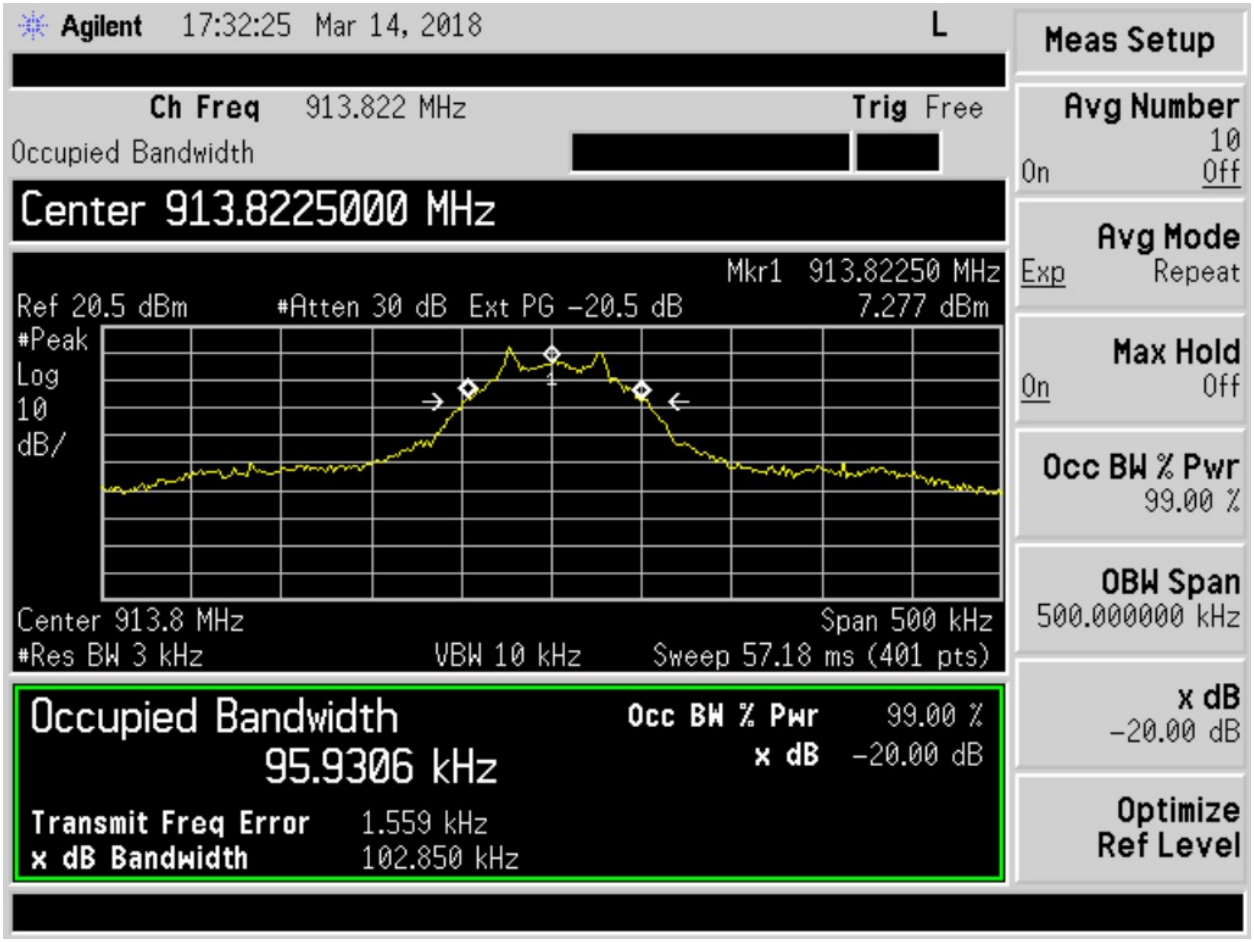


Figure 13. Twenty dB Bandwidth – Mid Channel

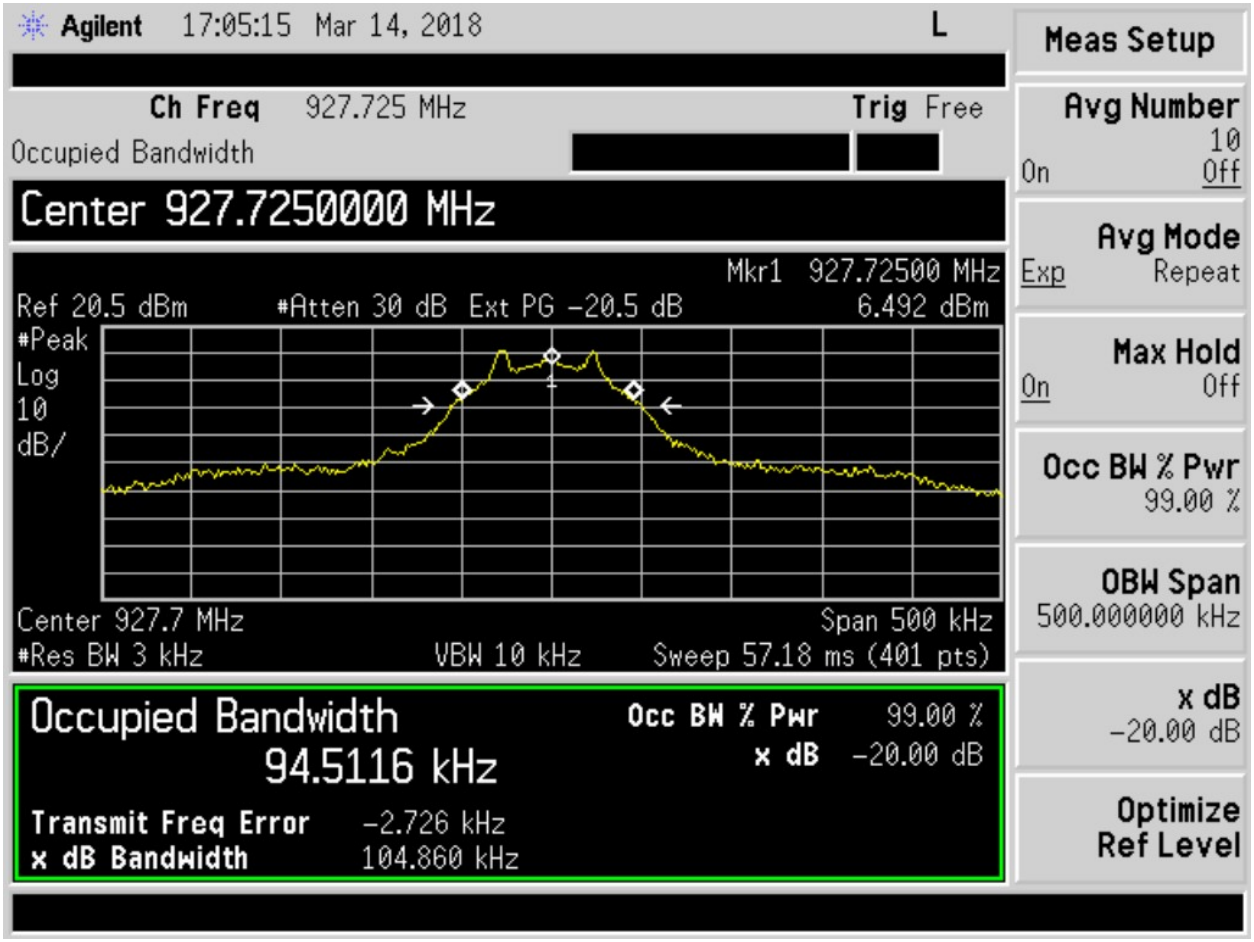


Figure 14. Twenty dB Bandwidth – High Channel

2.13 Maximum Peak Conducted Output Power (CFR 15.247 (b) (2))

For frequency hopping systems in the 902-928 MHz band with at least 50 hopping channels, the maximum peak conducted output power of the intentional radiator shall not exceed 1 watt. Since the EUT has 129 hopping channels, the maximum peak conducted output power shall not exceed 1 watt.

Peak power within the band 902.3 MHz to 914.9 MHz was measured per ANSI C63.10-20113 as an Antenna Conducted test with a spectrum analyzer. For these measurements the EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance using a 75 to 50 Ω adaptor. The setup losses were corrected by using a -6.4 dB offset in the analyzer measurements. Peak antenna conducted output power is tabulated in the table below.

Table 8. Peak Antenna Conducted Output Power per Part 15.247 (b) (2)

Frequency of Fundamental (MHz)	Raw Test Data dBm	Converted Data (mW)	FCC Limit (mW Maximum)
902.01	12.96	19.8	1000
913.72	13.17	20.7	1000
927.50	13.20	20.9	1000

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

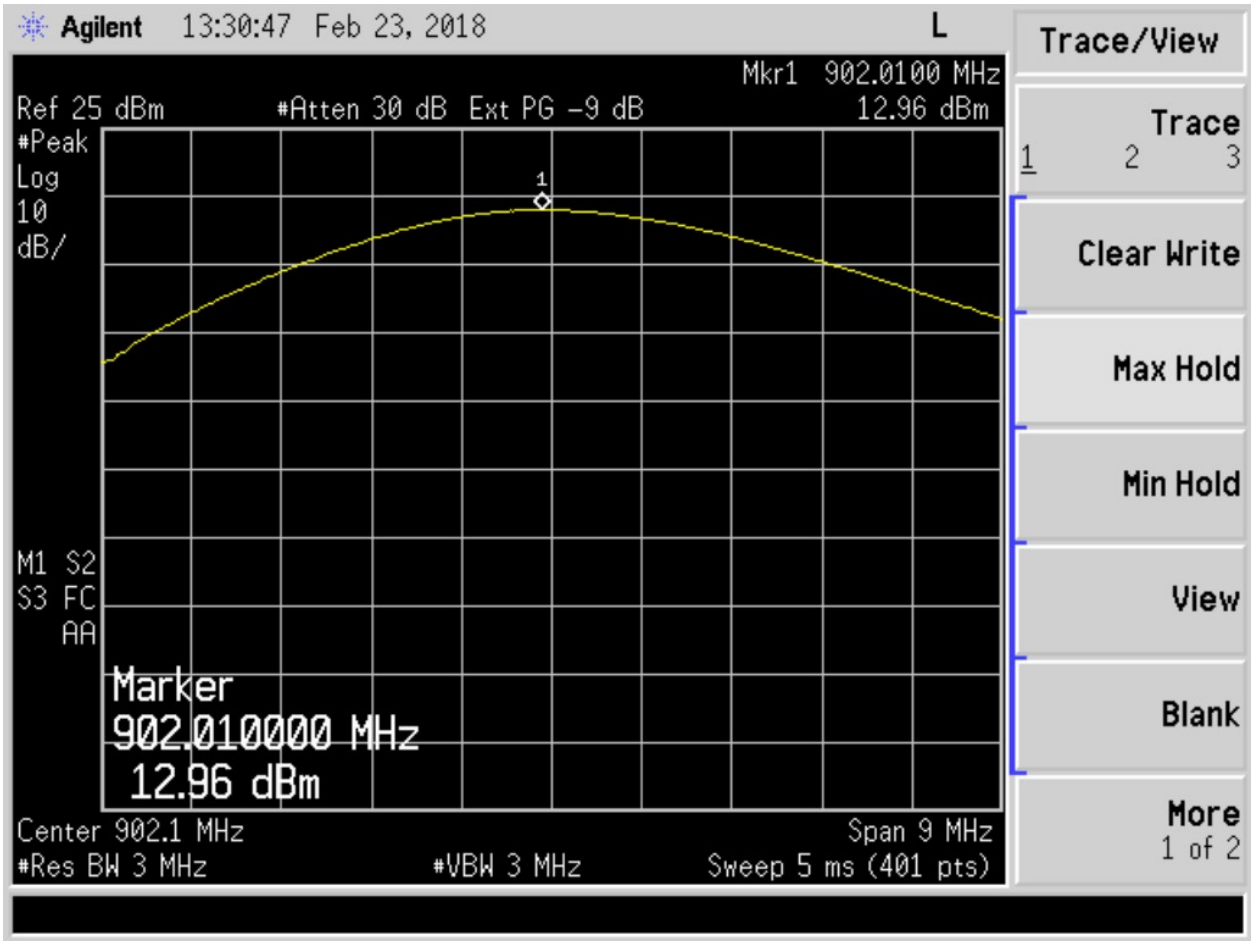


Figure 15. Peak Antenna Conducted Output Power, Low Channel

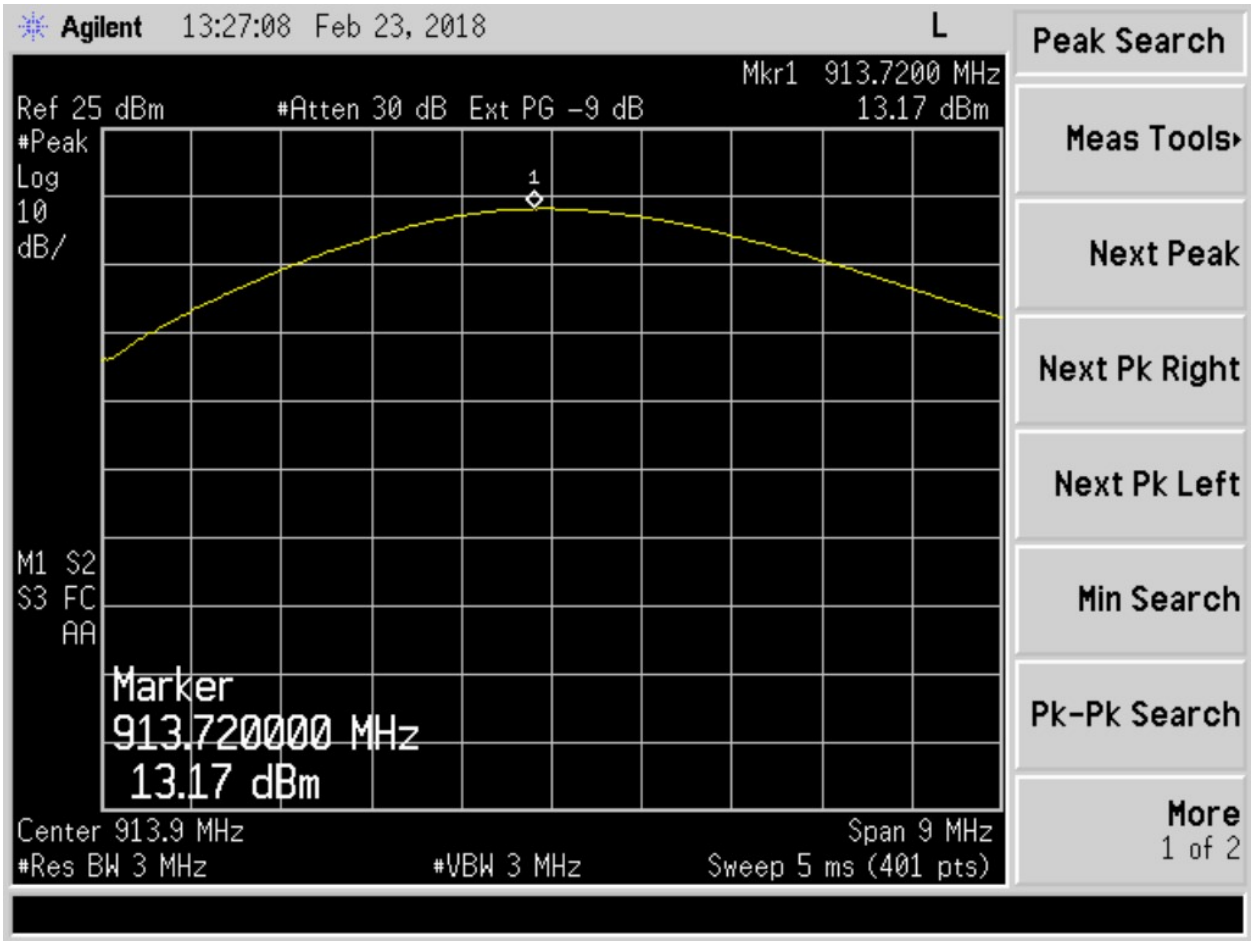


Figure 16. Peak Antenna Conducted Output Power, Mid Channel

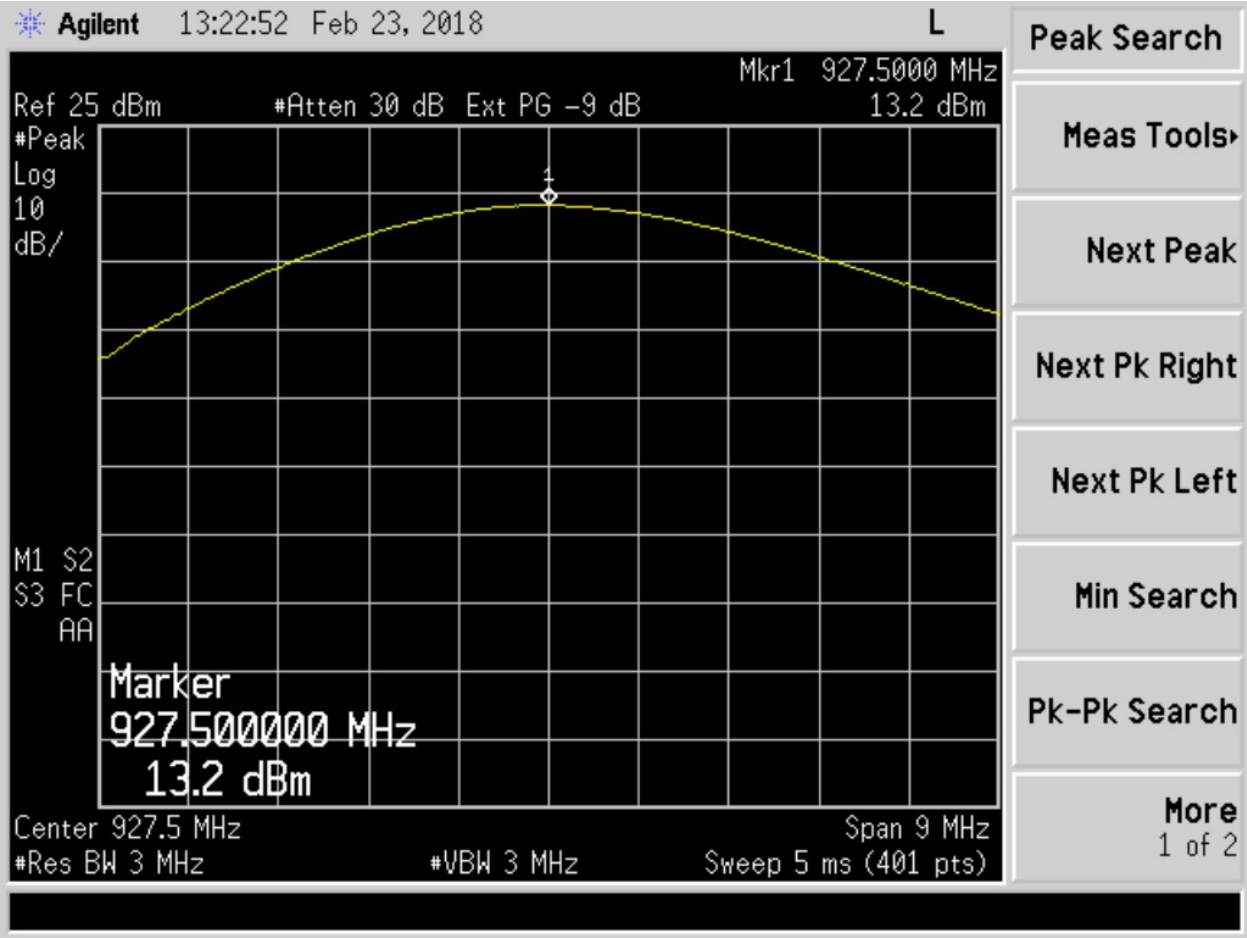


Figure 17. Peak Antenna Conducted Output Power, High Channel

2.14 Number of Hopping Frequencies (CFR 15.247 (a)(1))

Frequency hopping systems in the 902-928 MHz band shall have at least 50 hopping frequencies if the 20 dB bandwidth is less than 250 kHz. If the 20 dB bandwidth is 250 kHz or greater, then the system shall have at least 25 hopping frequencies. Since the EUT has a 20 dB bandwidth less than 250 kHz, then at least 50 hopping frequencies shall be used.

The plots provided below show that the EUT employs greater than 50 channels. The EUT employs 129 Channels starting at 902.2 Mhz and ending at 927.8 MHz with a step size of 0.2 MHz.

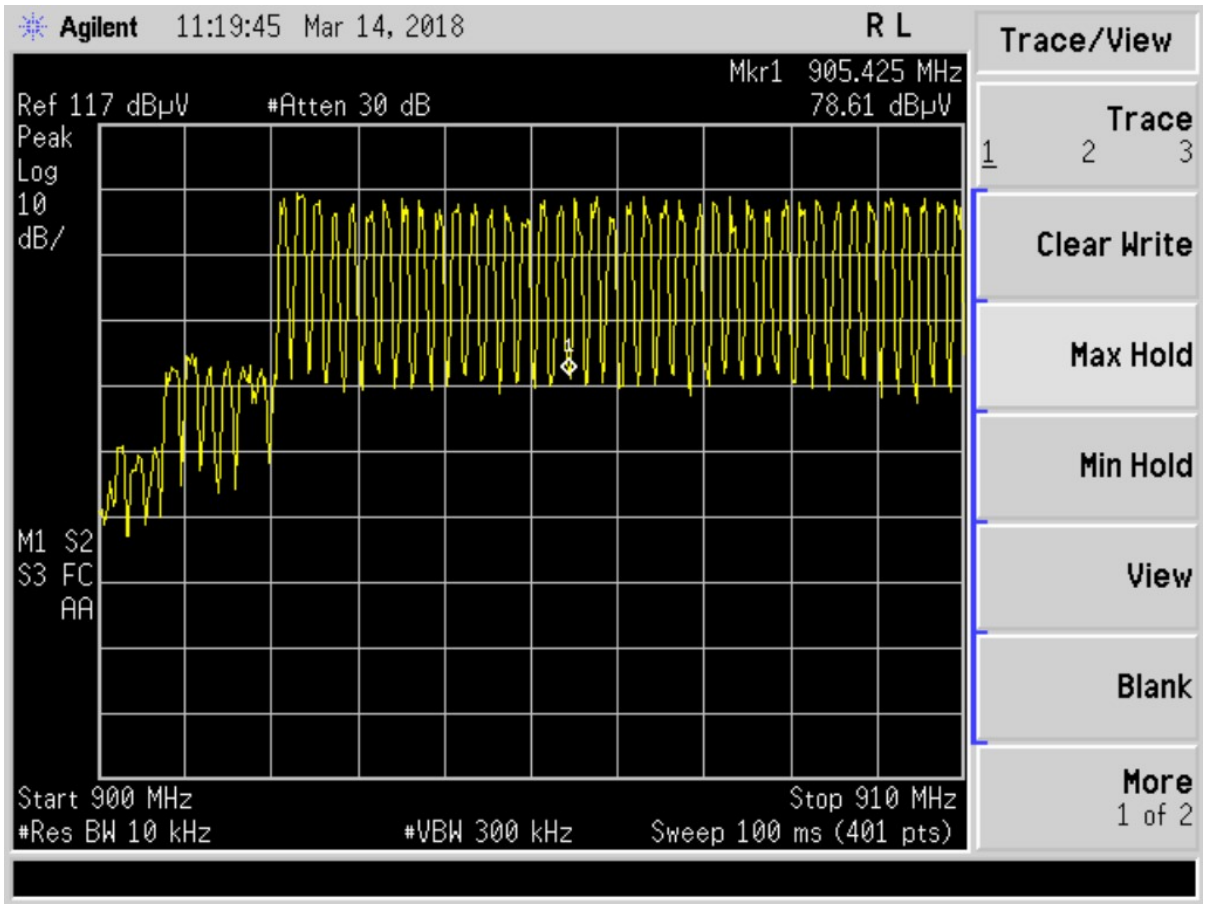


Figure 18. Hopping Channels 1 through 40

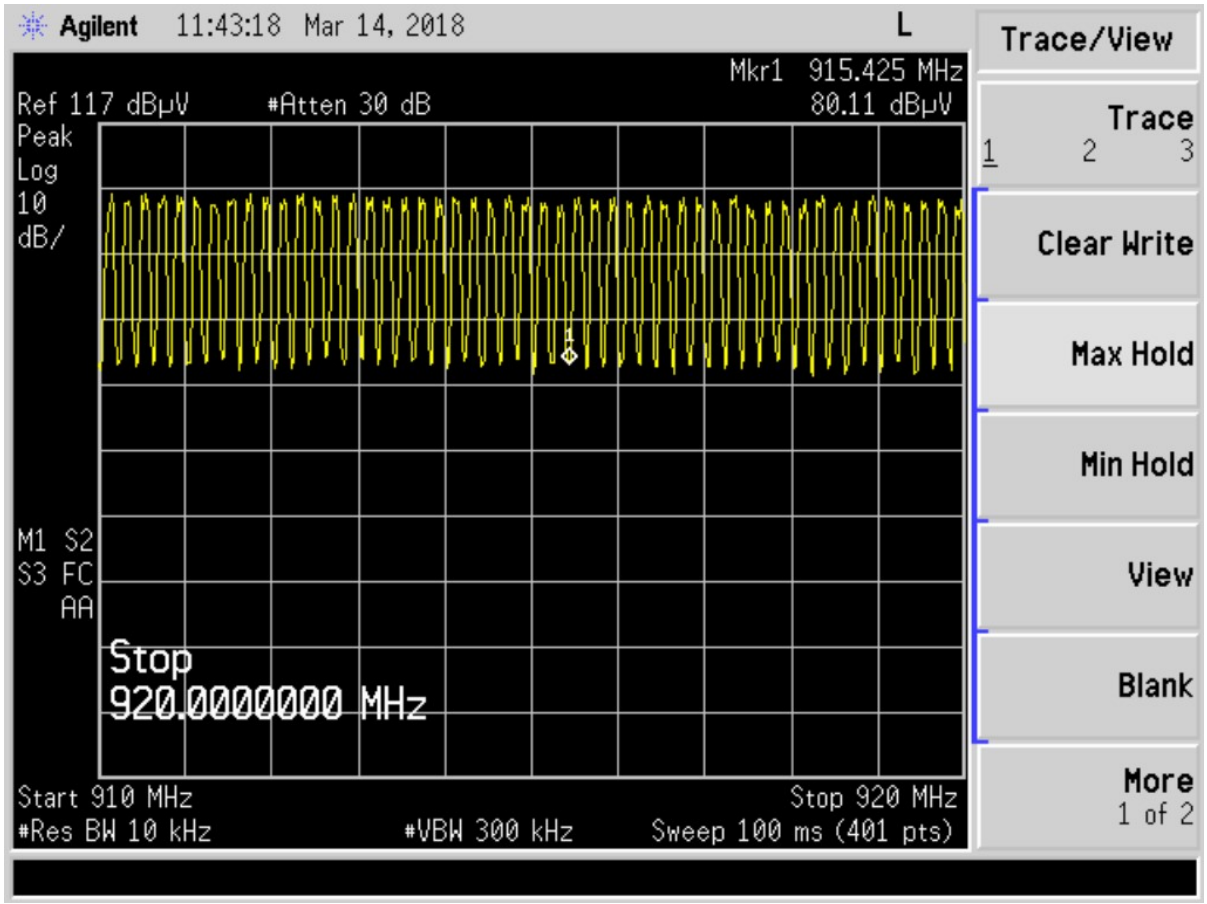


Figure 19. Hopping Channels 41 - 91

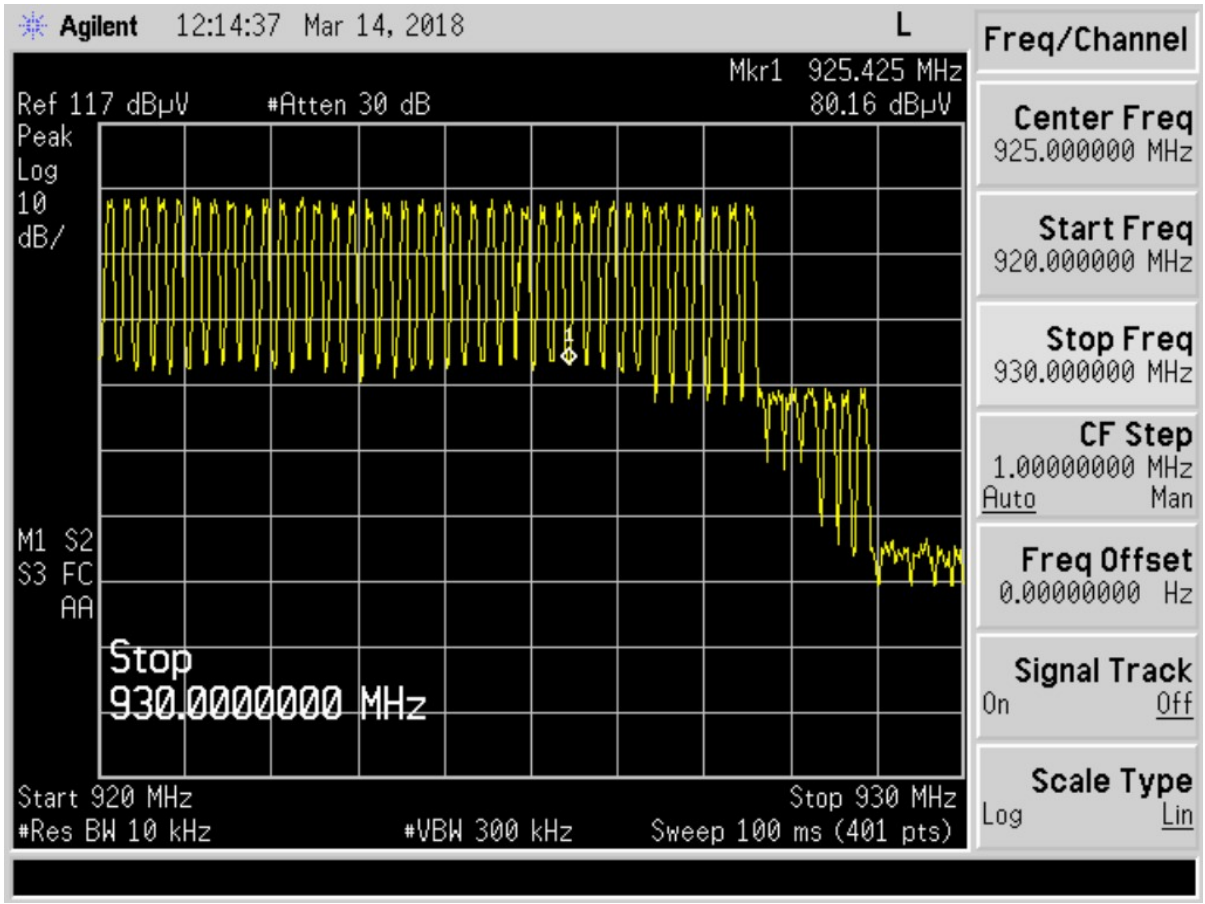


Figure 20. Hopping Channels 92 - 129

2.15 Frequency Separation (CRF 15.247(a)(1))

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. In this case, the 20 dB bandwidth of the Frequency hopping system is greater than 25 kHz, so the minimum requirement used was the 20 dB bandwidth. Therefore the frequency separation must be greater than 105.0 kHz.

The EUT does meet the frequency separation requirement.

The test procedure outlined in ANSI C63.10-2013 was used to conduct measurements.

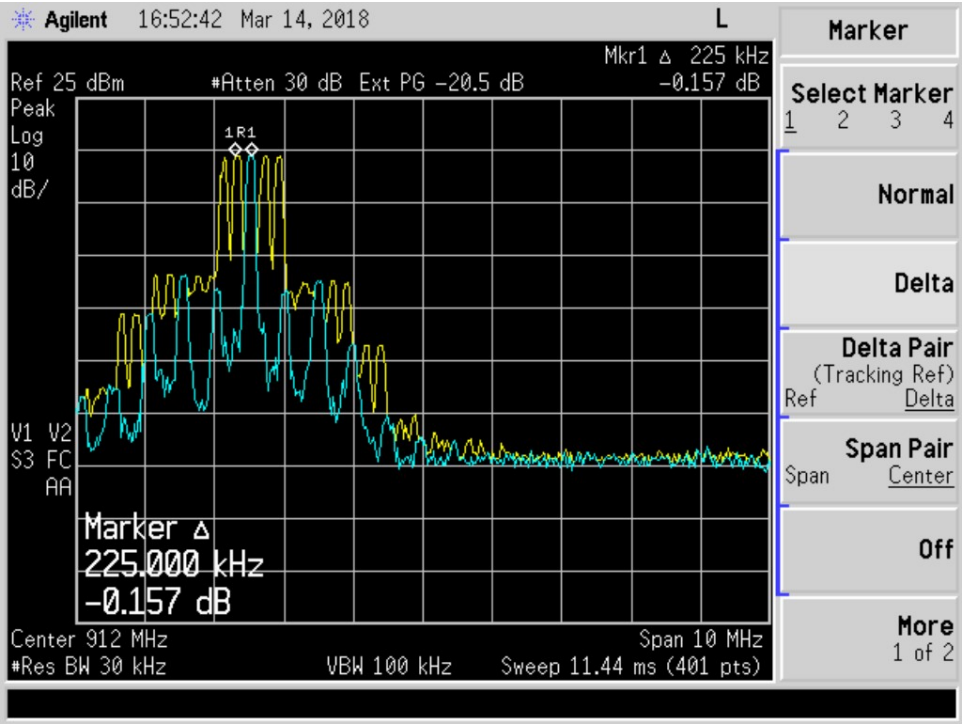


Figure 21. Channel Separation

Measured Delta (Figure above)	225.0 kHz
-Limit (20 dB Bandwidth)	105.0 kHz
Margin	20.0 kHz

2.16 Average Time of Occupancy (CFR 15.247(f))

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period

The maximum hop rate results in each channel being on (dwell) for no more than 400ms during a given 20s window, and is calculated as follows:

Frequency Hops (max) = (20s window)/(Transmission duration) = 20s/0.00675s = 2,963 frequency hops
Repetition on given channel (max) = 2963 / 129 channels= 22.9 hops per channel
Dwell time on each channel (max) = 22.9 * 6.75 ms = 155 ms total dwell time per channel < 400 ms

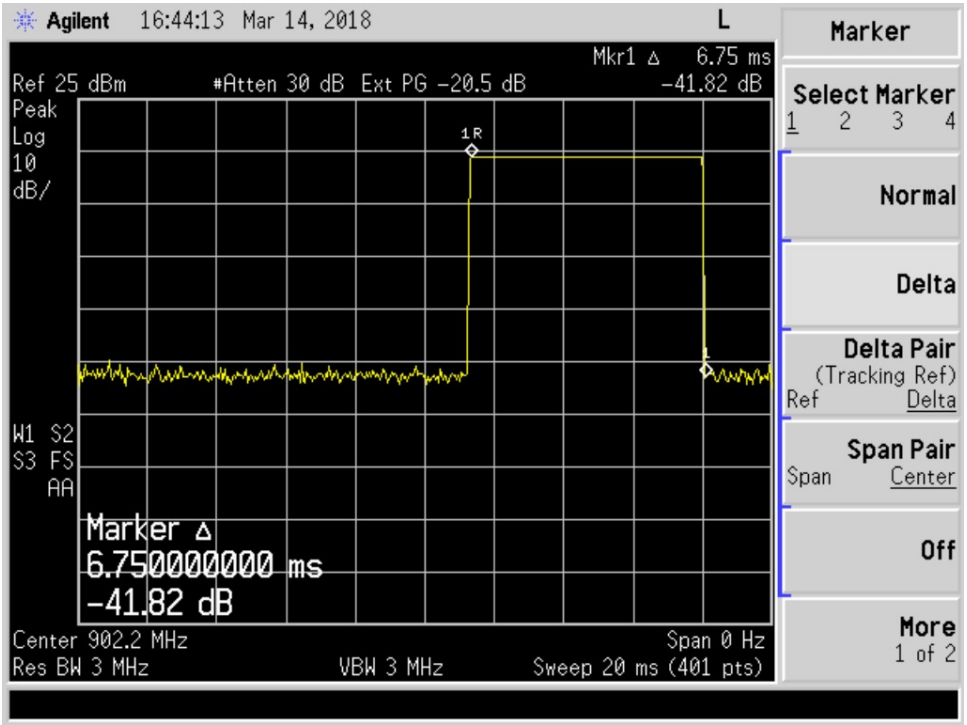


Figure 22. Maximum Dwell Time on a Single Channel

Note: EUT programmed in a test mode simulating extreme conditions. During normal operation packet lengths will be less than 6.75 ms

2.17 Unintentional and Intentional Radiator, Powerline Emissions (CFR 15.107/15.207)

The EUT was battery powered; therefore this test was not applicable.

2.18 Unintentional and Intentional Radiator, Radiated Emissions (CFR 15.109, 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. The data presented is with the EUT and all transmitters ON and transmitting. This is intended to satisfy the requirements for co-location transmitter testing.

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 worst-case radiated emission was 5.3 dB below the specification limit at 96.12 MHz. All other measured signals were at least 5.8 dB below the specification limit. The results are shown in the table below. These results are meant to show that this EUT's digital device portion has met the verification requirements for an unintentional radiator under CFR Part 15.109 as well as the intentional transmitter requirements of CFR Part 15.209.

Note: This testing covers co-location testing however the 2.4 GHz radio was disabled during testing because in normal operation only one of the two radios will be enabled. Both radios do not operate at the same time and will not be enabled at the same time.

Note: This test covers the EUT with the 900 MHz radio enabled and 2.4 GHz radio disabled.

Table 9. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209), 9 kHz to 30 MHz

Test By: JF	Test: FCC Part 15.209			Client: Asymmetric Technologies			
	Project: 17-0455			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 are deemed to be more than 20 dB below the applicable limits.							

SAMPLE CALCULATION: N/A

Test Date: February 21, 2018

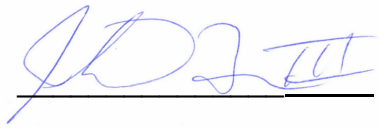
Tested By
Signature:  Name: John Freeman

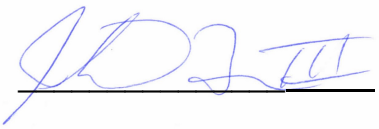
Table 10. Unintentional and Intentional Radiator, Spurious Radiated Emissions (CFR 15.109, 15.209) 30 MHz to 1000 MHz

30 MHz to 1000 MHz								
Test: Radiated Emissions			**Client:** Asymmetric Technologies					
Project: 17-0455			**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**
44.93	50.26	--	-16.05	34.21	40.0	3m./VERT	5.8	**QP**
72.05	44.32	--	-17.88	26.44	40.0	3m./HORZ	13.6	**PK**
96.12	55.23	--	-16.99	38.24	43.5	3m./VERT	5.3	**QP**
127.20	48.78	--	-15.26	33.52	43.5	3m./HORZ	10.0	**PK**
204.00	43.05	--	-14.20	28.85	43.5	3m./HORZ	14.6	**PK**
208.77	49.00	--	-15.11	33.89	43.5	3m./VERT	9.6	**PK**
456.92	48.63	--	-9.02	37.51	46.0	3m./VERT	8.5	**PK**
456.92	46.69	--	-8.82	37.87	46.0	3m./HORZ	8.1	**PK**

SAMPLE CALCULATION at: 44.93 MHz

Magnitude of Measured Frequency	50.35	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	-16.05	dB/m
Corrected Result	34.21	dBuV/m

Test Date: February 21,2018

Tested By
Signature: 

Name: John Freeman

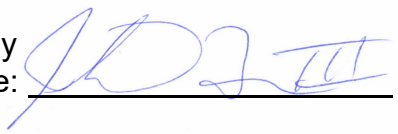
Table 11. Unintentional and Intentional Radiator, Spurious Radiated Emissions (CFR 15.109, 15.209) 1 GHz to 25 GHz

1 GHz to 25 GHz, Part 15.109/15.209 Limits							
Test: Radiated Emissions				**Client:** Asymmetric Technologies			
Project: 17-0455				**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**
1025.00	52.14	-9.80	42.34	54.0	3.0m./VERT	11.7	**PK**
1137.50	48.60	-8.49	40.11	54.0	3.0m./HORZ	13.9	**PK**
Notes: No other spurious emission seen except for Fundamental and harmonic emissions. Those emissions are presented in Table 5 & 6 above.							

SAMPLE CALCULATION at: 1025.00

Magnitude of Measured Frequency	52.14	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	-9.80	dB/m
Corrected Result	42.34	dBuV/m

Test Date: February 21, 2018

Tested By
Signature:  Name: John Freeman

2.19 Measurement Uncertainty

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

Conducted Emissions Measurement Uncertainty

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

This test was not performed. The EUT is battery operated.

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.