H.B. Compliance Solutions

Intentional Radiator Test Report

For the

Alpine Electronics

Jeep Speaker Model # 6LQ27TRMXX

Tested under

The FCC Rules contained in Title 47 of the CFR, Part 15.247 for

Frequency Hopping Spread Spectrum

Prepared for:

Alpine Electronics.

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Auburn Hills, MI 48326

Prepared By:

H.B. Compliance Solutions

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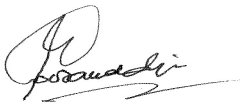
Reviewed By:



Hoosamuddin Bandukwala

Cert # ATL-0062-E

Engineering Statement: The measurements shown in this report were made in accordance with the procedure indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurement made, the equipment tested is capable of operation in accordance with the requirements of Part 15 of the FCC Rules under normal use and maintenance. All results contained herein relate only to the sample tested.

Report Status Sheet

Revision #	Report Date	Reason for Revision
Ø	October 26, 2018	Initial Issue

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EXECUTIVE SUMMARY

1. Testing Summary

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15.247. All tests were conducted using measurement procedure from ANSI C63.10-2013, FCC Public Notice DA 00-705 FHSS Guide March 30, 2000 as appropriate.

Test Name	Test Method/Standard	Result	Comments
Unintentional Radiated Emissions	15.109	Pass	
A/C Powerline Conducted Emissions	15.207	Pass	
Occupied Bandwidth	15.247(a)(2)	Pass	
Peak Output Power	15.247(b)	Pass	
Conducted Spurious Emissions	15.247(d)	Pass	
Radiated Spurious Emissions & Restricted Band	15.247(d), 15.209(a), 15.205	Pass	
Emissions at Band Edges	15.247(d), 15.209(a), 15.205	Pass	
Time of Occupancy (Dwell Time)	15.247(a)	Pass	
Number of Hopping Channels	15.247(a)	Pass	
Carrier Frequency Separation	15.247(a)	Pass	

EQUIPMENT CONFIGURATION

1. Overview

H.B Compliance Solutions was contracted by iCertifi to perform testing on the Alpine Jeep Speaker under the quotation number Q18021003.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Alpine Electronics, Jeep Speaker.

The tests were based on FCC Part 15 Rules. The tests described in this document were formal tests as described with the objective of the testing was to evaluate compliance of the Equipment Under Test (EUT) to the requirements of the aforementioned specifications. Alpine Electronics should retain a copy of this document and it should be kept on file for at least five years after the manufacturing of the EUT has been permanently discontinued. The results obtained relate only to the item(s) tested.

Product Name:	Jeep Speaker
Model(s) Tested:	6LQ27TRMXX
FCC ID:	2ARMV-6LQ27TRMXX
Supply Voltage Input:	Primary Power: +16V 2.7A (External AC/DC Adaptor)
Frequency Range:	2402-2480MHz
No. of Channels:	62 Channels
Necessary Bandwidth	N/A
Type(s) of Modulation:	GFSK π4-QPSK and 8-QPSK
Range of Operation Power:	0.0054W
Emission Designator:	N/A
Channel Spacing(s)	None
Test Item:	Pre-Production
Type of Equipment:	Portable
Antenna Requirement (§15.203) :	Type of Antenna: FPC (PCB) Gain of Antenna: 2.73dBi
Environmental Test Conditions:	Temperature: 15-35°C Humidity: 30-60% Barometric Pressure: 860-1060 mbar
Modification to the EUT:	None
Evaluated By:	Staff at H.B. Compliance Solutions
Test Date(s):	09/13/2018 till 10/19/2018

2. Test Facility

All testing was performed at H.B. Compliance Solutions. This facility is located at 5005 S. Ash Avenue, Suite # A-10, Tempe AZ-85282. All equipment used in making physical determination is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a GTEM chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at H.B. Compliance Solutions.

Test facility H.B. Compliance Solutions is an ANAB accredited test site. The ANAB certificate number is L2458. The scope of accreditation can be found on ANAB website www.anab.org

3. Description of Test Sample

The Alpine Electronics Jeep Speaker is a portable Bluetooth Speaker. The components are contained in a plastic enclosure. Device uses rechargeable batteries which can be charge by connecting to an AC/DC power adaptor

4. Equipment Configuration

Ref. ID	Name / Description	Model Number	Serial Number
# 1	Jeep Speaker (Sample # 1 with connector) – For Conducted test only	6LQ27TRMXX	S1807020044
# 2	Jeep Speaker (Sample # 2) – For Radiated test only	6LQ27TRMXX	S1807020044

Table 1. Equipment Configuration

5. Support Equipment

All support equipment supplied is listed in the following Support Equipment List.

Ref ID	Name / Description	Manufacturer	Model #	Serial #
# 3	Laptop Computer	Dell	Latitude E5450	CJNZK32
# 4	AC Power Supply	DYS	DYS650-165270W-K	DYS650-165270-14705A

Table 2. Support Equipment

6. Ports and Cabling Information

Ref ID	Port name on the EUT	Cable Description	Qty.	Length (m)	Shielded? (Y/N)	Termination Box ID & Port ID
# 5	Power	2 Wire	1	1	N	AC/DC Adaptor
# 6	Micro USB	USB	1	2	N	Laptop

Table 3. Ports and Cabling Information

7. Method of Monitoring EUT Operation

A test receiver will be used to monitor the data transmission from the EUT.

8. Mode of Operation

The EUT will be configured to transmit at maximum power level. The device was programmed with special test software that allowed to cycle through test modes. Test mode was provided to select the lower, middle and upper band of the transmitter. This software allowed the selection of the channel on the transmitter from three frequencies modulated and the other three in CW mode. These settings were created for testing purpose only.

9. Modifications

9.1 Modifications to EUT

No modifications were made to the EUT

9.2 Modifications to Test Standard

No Modifications were made to the test standard.

10. Disposition of EUT

The test sample including all support equipment submitted to H.B Compliance Solutions for testing will be returned to Alpine Electronics at the completion of testing & certification.

Criteria for Un-Intentional Radiators

1. Radiated Emissions

Test Requirement(s):	§15.109	**Test Engineer(s):**	Jerry Mejak
Test Results:	Pass	**Test Date(s):**	09/13/2018

Test Procedures:

The final radiated emissions test was performed using the parameters described above as worst case. That final test was conducted at a facility that meets the ANSI C63.4 NSA requirements. The frequency range noted in the data sheets was scanned/tested at that facility. Emissions were maximized as specified, by varying table azimuth, antenna height, and manipulating cables.

Using the mode of operation and configuration noted within this report, a final radiated emissions test was performed. The frequency range investigated (scanned), is also noted in this report. Radiated emissions measurements were made at the EUT azimuth and antenna height such that the maximum radiated emissions level will be detected. This requires the use of a turntable and an antenna positioner. The preferred method of a continuous azimuth search is utilized for frequency scans of the EUT field strength with both polarities of the measuring antenna. A calibrated, linearly polarized antenna was positioned at the specified distance from the periphery of the EUT.

> *Note: The specified distance is the horizontal separation between the closest periphery of the EUT and the center of the axis of the elements of the receiving antenna. However, if the receiving antenna is a log-periodic array, the specified distance shall be the distance between the closest periphery of the EUT and the front-to-back center of the array of elements.*

Tests were made with the antenna positioned in both the horizontal and vertical polarization planes. The measurement was varied in height above the conducting ground plane to obtain the maximum signal strength. Though specified in the report, the measurement distance shall be 3 meters. At any measurement distance, the antenna height was varied from 1 meter to 4 meters. These height scans apply for both horizontal and vertical polarization, except that for vertical polarization the minimum height of the center of the antenna shall be increased so that the lowest point of the bottom of the antenna clears the ground surface by at least 25 cm.

Frequency Range (MHz)	Peak Data (kHz)	Quasi-Peak Data (kHz)	Average Data (kHz)
30 MHz to 1 GHz	120 kHz	120 kHz	N/A
1 GHz to 11 GHz	1MHz	N/A	1MHz
Measurements were made using the bandwidths and detectors specified. The video filter was at least as wide as the IF bandwidth of the measuring receiver.			

Table 4. Radiated Emissions – Measurement Bandwidth

Emissions Tests Calculations

In the case of indoor measurements, radiated emissions measurements are made by the manipulation of correction factors using Rohde and Schwarz ES-K1 software. This is done automatically by the software during the final measurement process.

In both cases, the level of the Field Strength of the interfering signal is calculated by adding the Antenna Factor, Cable Factor and by subtracting the Amplifier Gain from the measured reading. The basic equation is as follows:

FS = RA + AF + (CF –AG)

Where: FS = Field Strength

RA = Receiver (indicated) Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

This laboratory uses an approach of combining the CF and AG using an end-to-end measurement of the entire cabling system, including the test cable, any in-line amplifiers, attenuators, or transient protection networks, all measured in-situ.

For a sample calculation, assume a receiver reading of 52.5 dBuV is obtained. With an antenna factor of 7.4 and a combined cable factor (CF + AG) of -27.9:

FS = 52.5 + 7.4 + (-27.9) = 32 dBuV/m

FS = 32 dBuV/m

If desired, this can be converted into its corresponding level in uV/m:

FS = 10^((32 dBuV/m)/20) = 39.8 uV/m

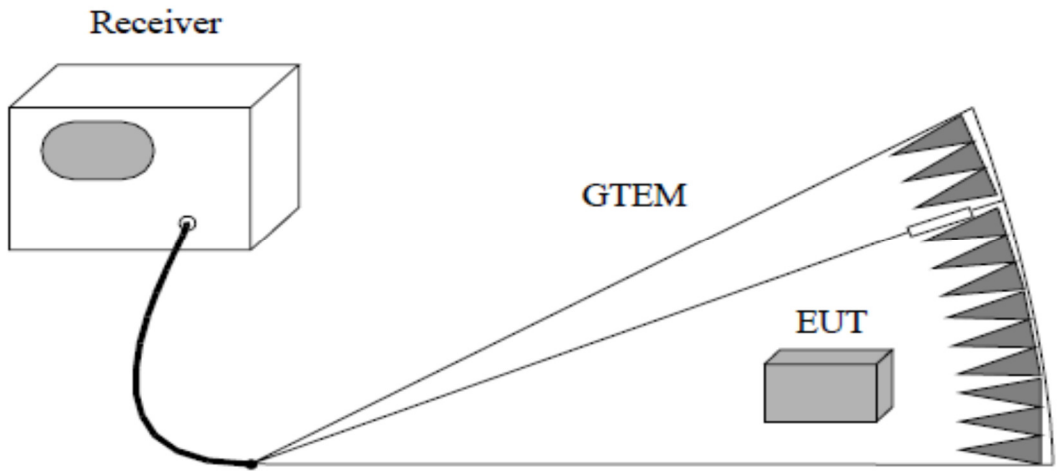
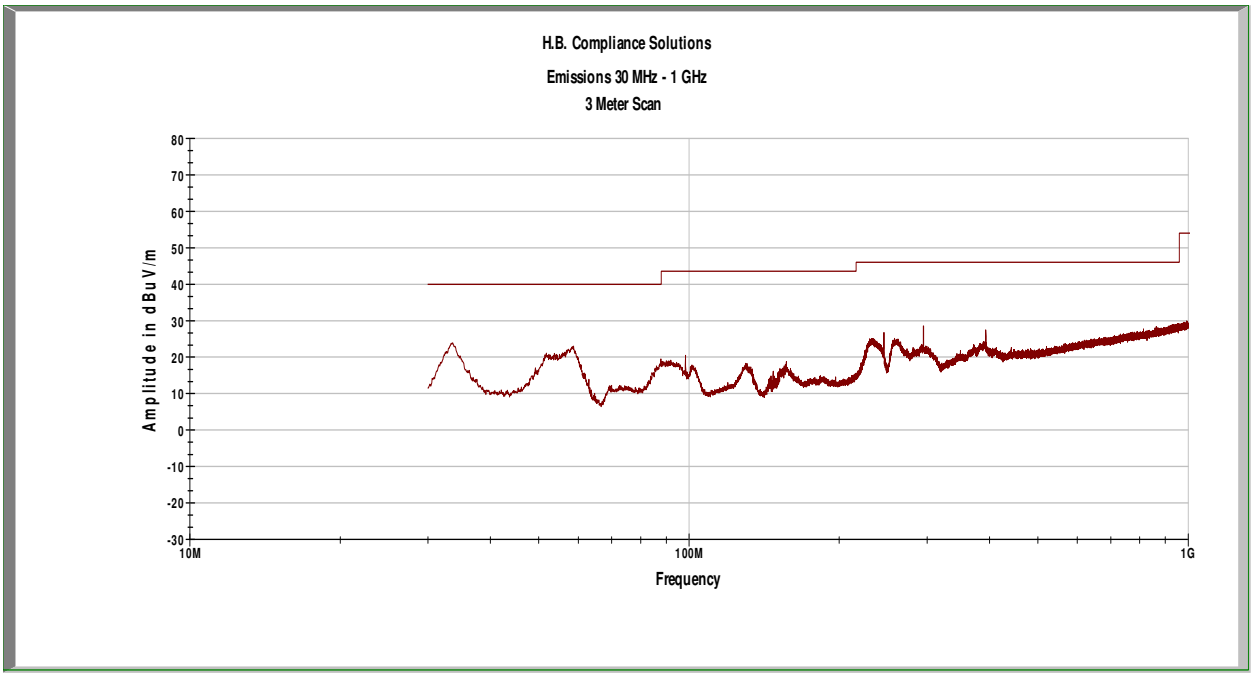
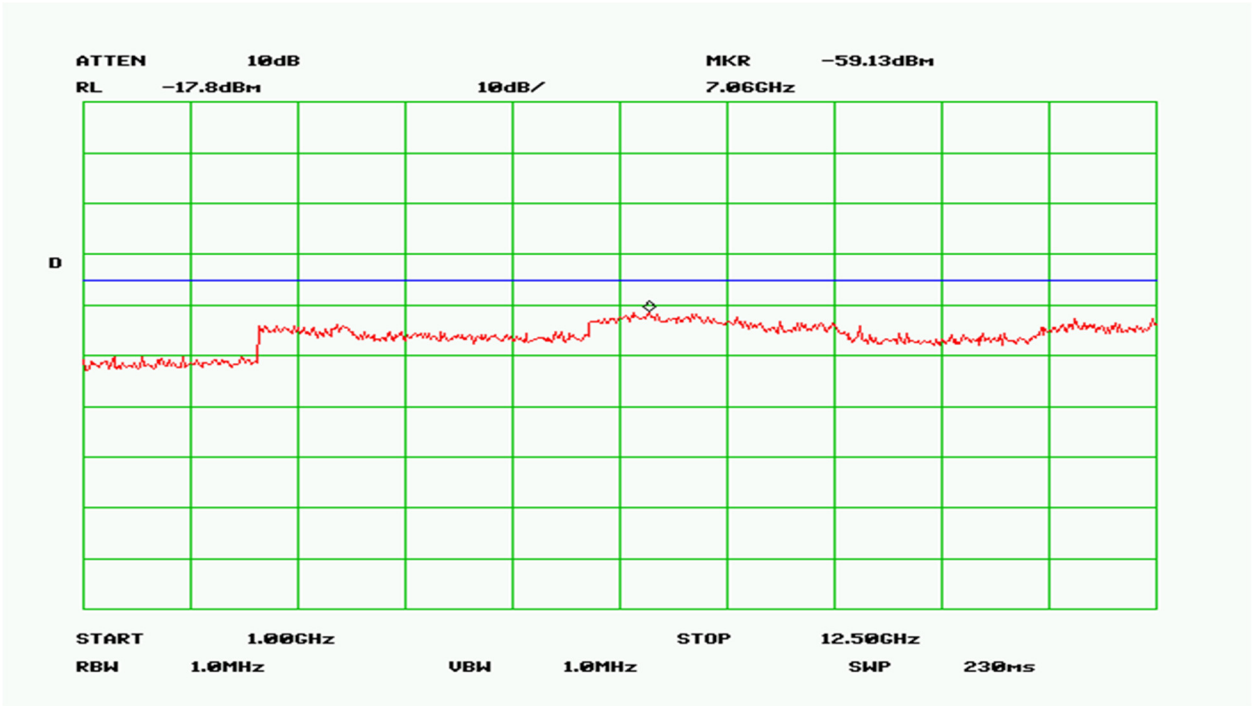


Figure 1. Radiated Emissions Test Setup (30MHz – 1GHz)



Plot 1 – Radiated Emissions – 30MHz to 1GHz



Plot 2 – Receiver Emissions (Conducted) – 1GHz to 12.5GHz (For Industry Canada RSS-GEN)

2. Conducted Emissions

Test Requirement(s):	§15.207	Test Engineer(s):	Frank Farrone
Test Results:	Pass	Test Date(s):	09/07/2018

Test Procedures: The EUT was placed on a non-metallic table, 80cm above the ground plane inside a shielded enclosure. The EUT was powered through a 50Ω/50µH LISN. The conducted emissions tests were performed using the mode of operation and configuration noted within this report. The frequency range investigated (scanned), is also noted in this report. Conducted power line measurements are made, unless otherwise specified, over the frequency range from 150 kHz to 30 MHz to determine the line-to-ground radio-noise voltage that is conducted from the EUT power-input terminals that are directly (or indirectly via separate transformer or power supplies) connected to a public power network. Equipment is tested with power cords that are the same as those cords normally used or that have electrical or shielding characteristics that are the same as those cords normally used. Typically, those measurements are made using a LISN (Line Impedance Stabilization Network). All 50 Ohm measuring ports of the LISN are terminated by 50 Ohms, either by the 50 Ohm EMI receiver or a 50 Ohm resistive load.

Refer to the Emissions Tests Calculations section in the Radiated Emissions section for sample calculations. For the purposes of the conducted emissions test, the Antenna Factor (AF) is replaced by the LISN correction factor.

Frequency Range (MHz)	Peak Data (kHz)	Quasi-Peak Data (kHz)	Average Data (kHz)
0.150 - 30	9.0	9.0	9.0
Measurements were made using the bandwidths and detectors specified. No video filter was used.			

Table 1. Conducted Emissions – Measurement Bandwidth

Frequency Range (MHz)	15.107(b), Class A Limits (dBuV)		15.107(a), Class B Limits (dBuV)	
	Quasi-Peak	Average	Quasi Peak	Average
0.15 – 0.5	79	66	66 - 56	56 - 46
0.5 – 5.0	73	60	56	46
5.0 – 30	73	60	60	50
Note 1 – The lower limit shall apply at the transition frequencies.				

Table 2. Conducted Emissions Limits – FCC Limits from Section 15.107(a)(b)

Test Setup:

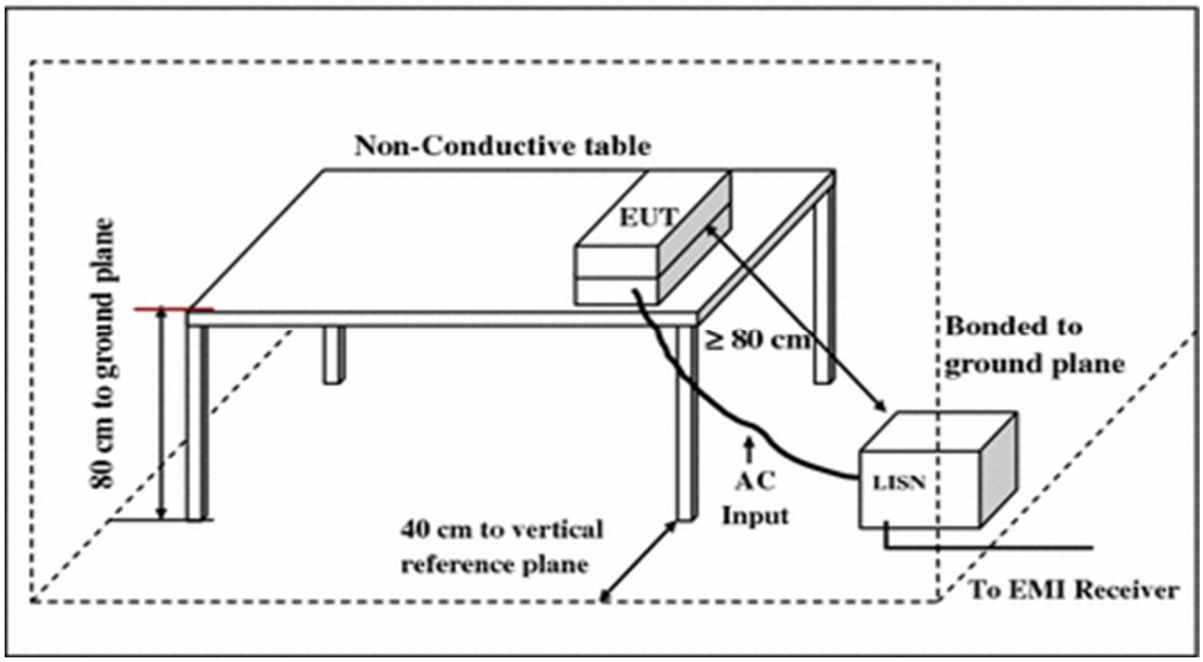
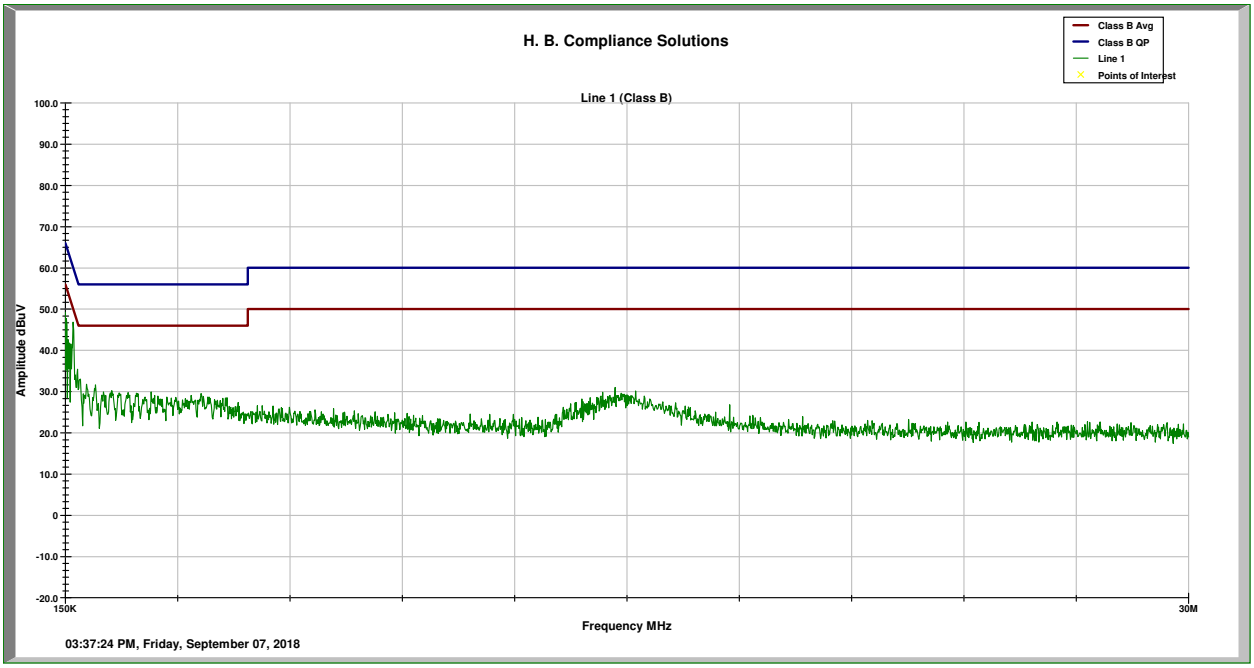


Figure 2. Conducted Emissions Test Setup



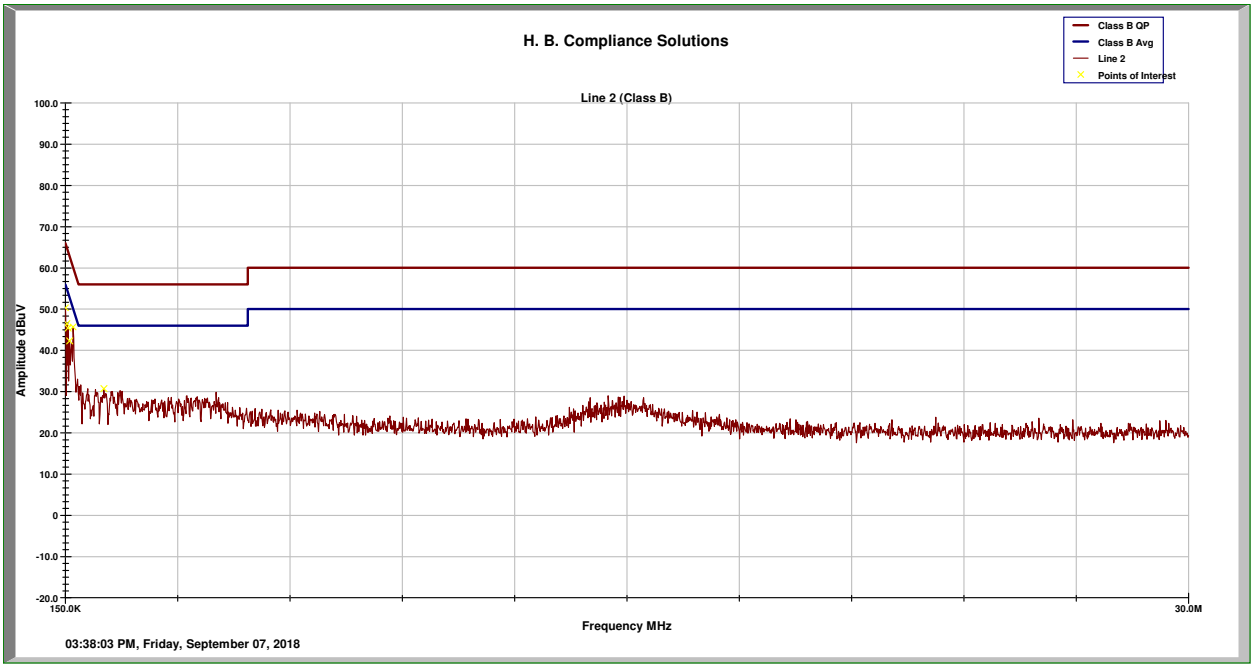
Plot 1 – Conducted Emission Plot – Positive Side

Frequency (MHz)	Measured Level (dBuV)	Limit	Margin
0.150	40.03	65.99	-25.96
0.378	41.5	59.47	-17.97
0.466	27.22	56.96	-29.74
0.790	23.9	56	-32.1
1.187	26.22	56	-29.78

Table 3. Measurement Results for QP

Frequency (MHz)	Measured Level (dBuV)	Limit	Margin
0.150	26.58	55.993	-29.413
0.378	33.2	49.479	-16.279
0.466	19.828	46.964	-27.137
0.790	18.015	46	-27.985
1.187	17.797	46	-28.203

Table 4. Measurement Results for Average



Plot 2 – Conducted Emissions – Ground Side

Frequency (MHz)	Measured Level (dBuV)	Limit	Margin
0.155	48.43	65.85	-17.42
0.183	44.43	65.043	-20.613
0.221	40.22	63.952	-23.732
0.250	38.26	63.117	-24.857
0.352	38.64	60.213	-21.573
1.196	27.55	56.0	-28.45

Table 5. Measurement Results for QP

Frequency (MHz)	Measured Level (dBuV)	Limit	Margin
0.155	35.05	55.85	-20.8
0.183	26.137	55.043	-28.906
0.221	17.407	53.952	-36.544
0.250	30.518	53.117	-22.6
0.352	33.233	50.213	-16.98
1.196	21.273	46.0	-24.727

Table 6. Measurement Results for Average

1. Occupied Bandwidth

Test Requirement(s):	15.247(a)(2), ANSI C63.10	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	10/10/2018

Test Procedure: As required by 47 CFR 15.247(a): For Frequency hopping systems operating in the 2400-2483.5 MHz band: measurements to be made with 20dB bandwidth for frequency hopping systems.

Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT was connected through an attenuator to a Spectrum Analyzer. The measured highest peak power was set relative to zero dB reference. The RBW of the Spectrum Analyzer was set to 100kHz and VBW>RBW. Measurements were carried out at the low, mid and high channels of the TX band at the output terminals of the EUT.

Frequency (MHz)	Recorded Measurement	Comments
2402	1.01 MHz	GFSK
2441	1.02 MHz	GFSK
2480	1.01 MHz	GFSK
2402	767.28 kHz	π/4-DQPSK
2441	765.44 kHz	π/4-DQPSK
2480	762.54 kHz	π/4-DQPSK
2402	1.13 MHz	8-DPSK
2441	1.13 MHz	8-DPSK
2480	1.13 MHz	8-DPSK

Table 7. Occupied Bandwidth Summary, Test Results

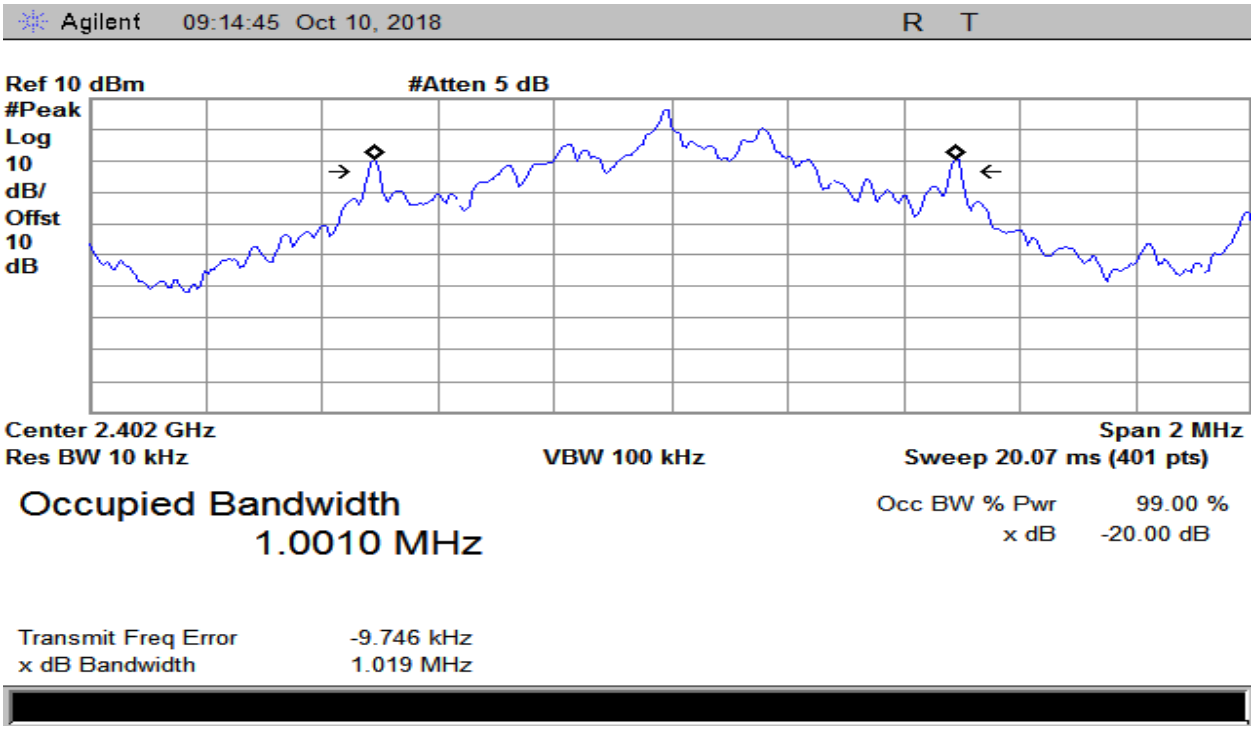
Frequency (MHz)	Recorded Measurement	Comments
2402	1.0 MHz	GFSK
2441	1.0 MHz	GFSK
2480	1.0 MHz	GFSK
2402	1.03 MHz	π/4-DQPSK
2441	1.03 MHz	π/4-DQPSK
2480	1.02 MHz	π/4-DQPSK
2402	1.09 MHz	8-DPSK
2441	1.09 MHz	8-DPSK
2480	1.09 MHz	8-DPSK

Table 8. 99% Bandwidth, Test Results

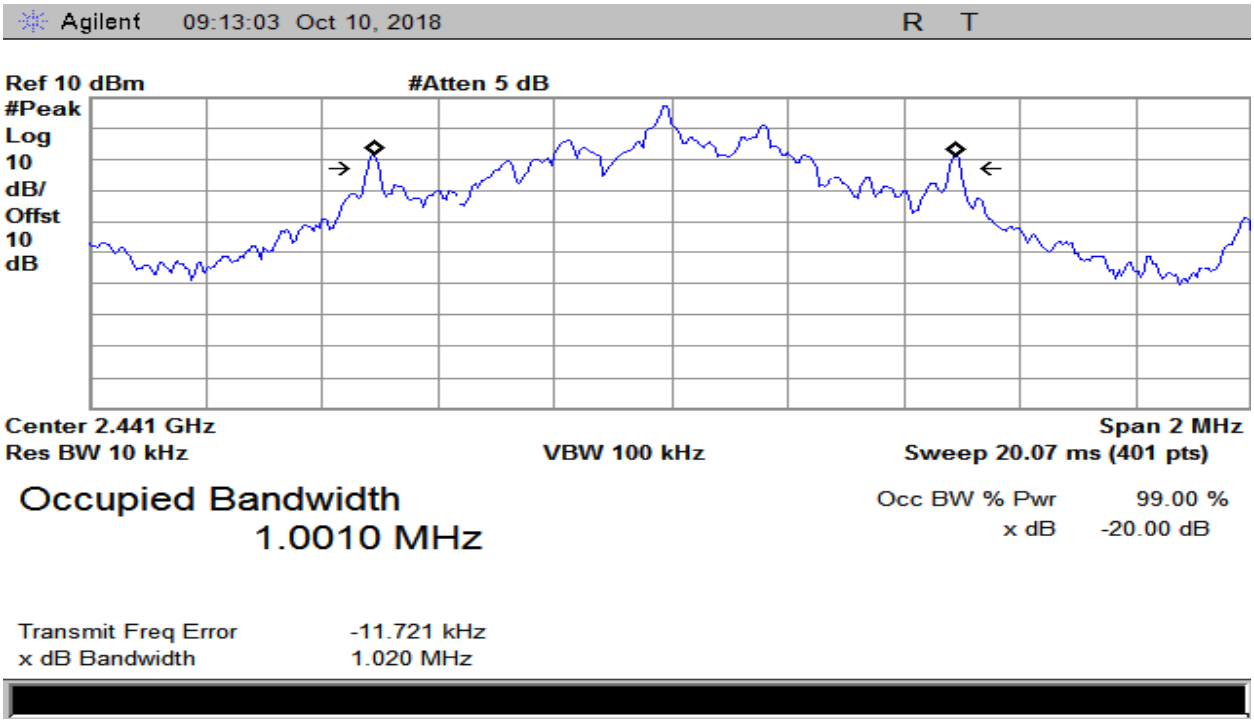
Test Setup:

Figure 3. Occupied Bandwidth Test Setup

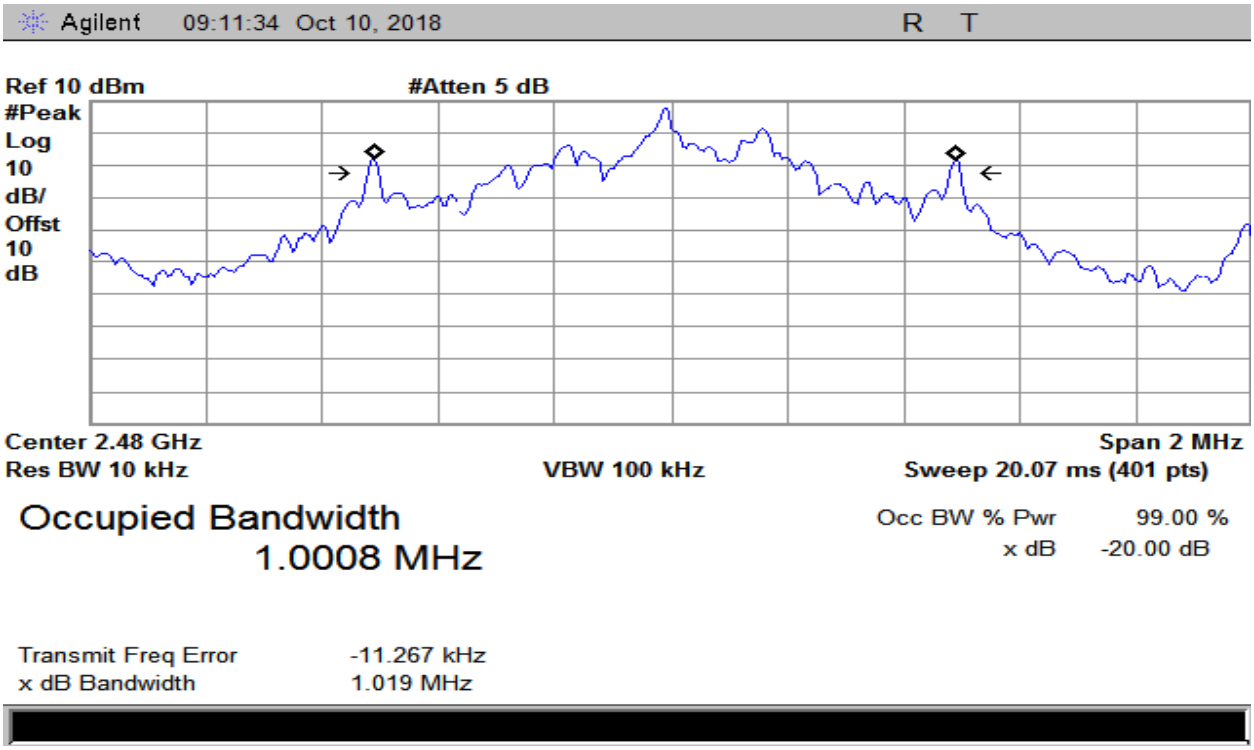
The following pages show measurements of Occupied Bandwidth plots:



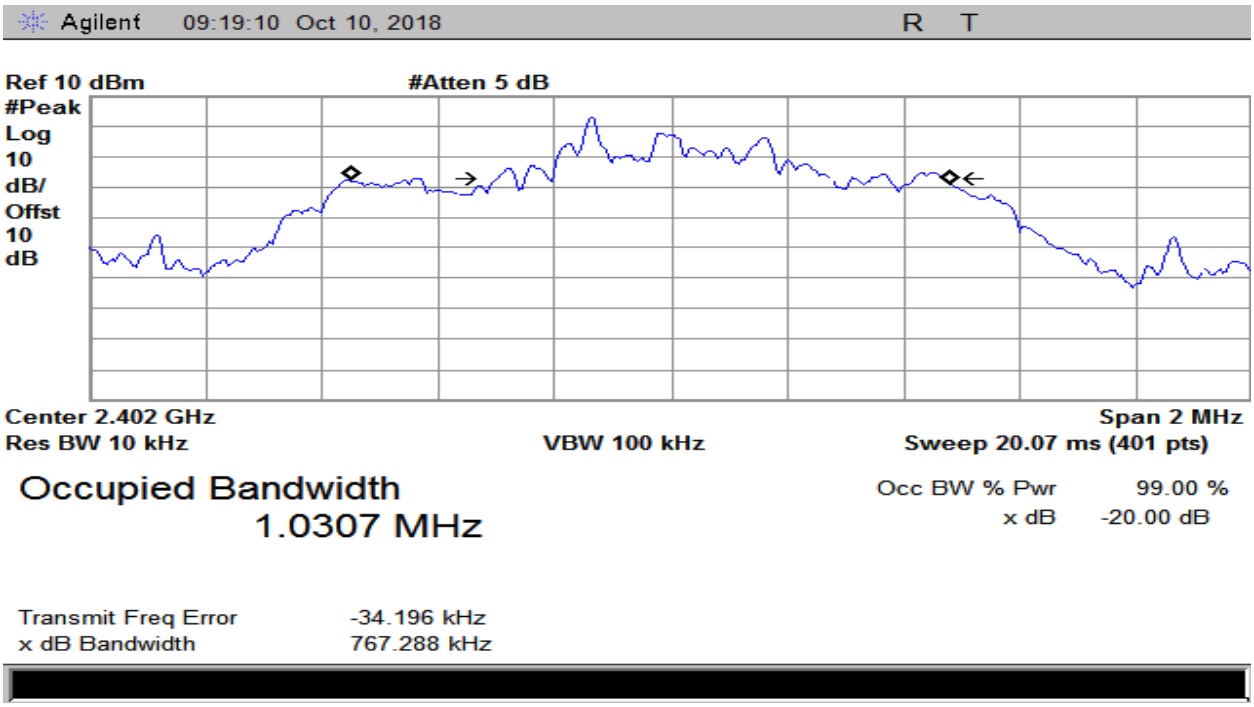
Plot 3 – Lowest Channel – 20dB BW (GFSK 1Mbps)



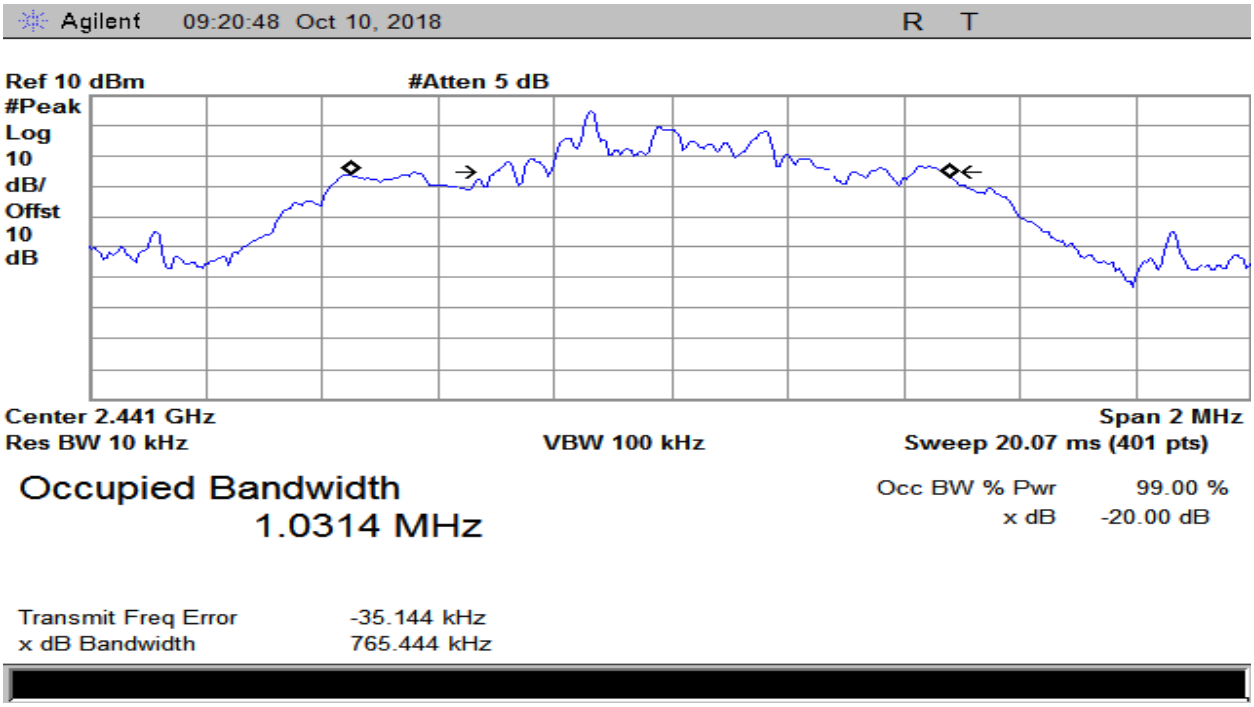
Plot 4 – Middle Channel – 20dB BW (GFSK 1Mbps)



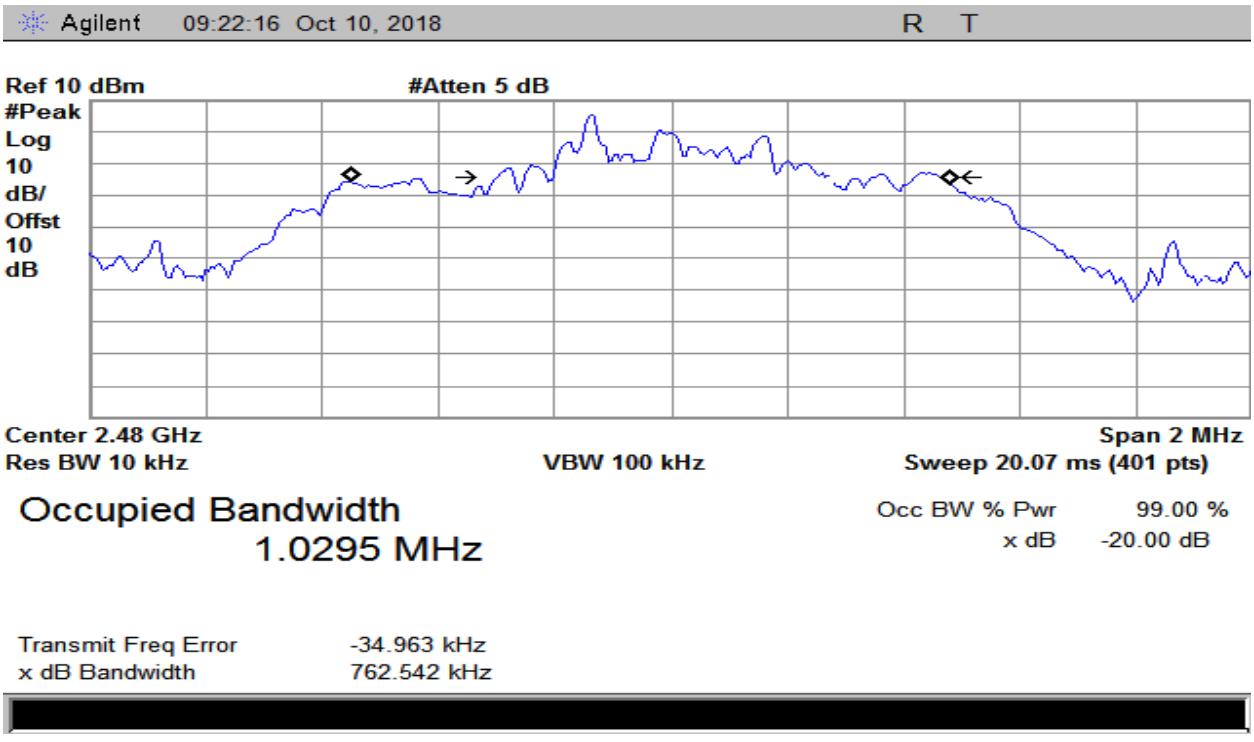
Plot 5 – Highest Channel – 20dB BW (GFSK 1Mbps)



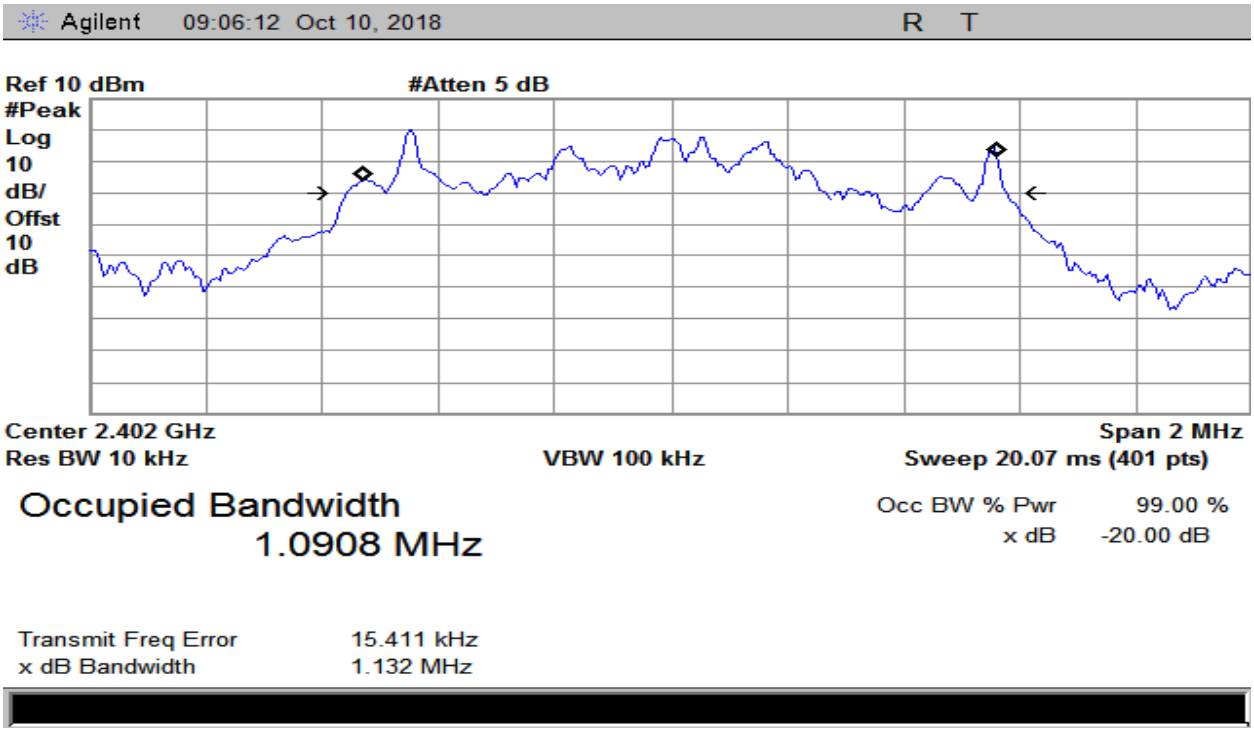
Plot 6 – Lowest Channel – 20dB BW (π/4-DQPSK 2Mbps)



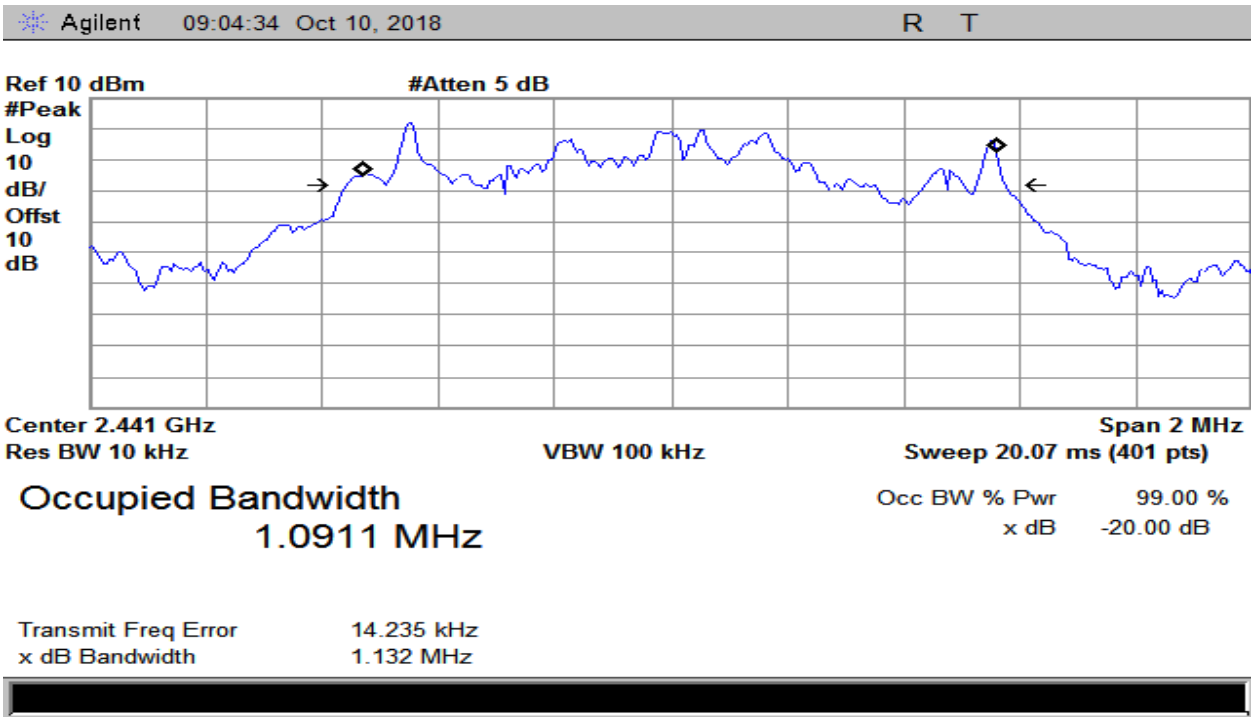
Plot 7 – Middle Channel – 20dB BW (π/4-DQPSK 2Mbps)



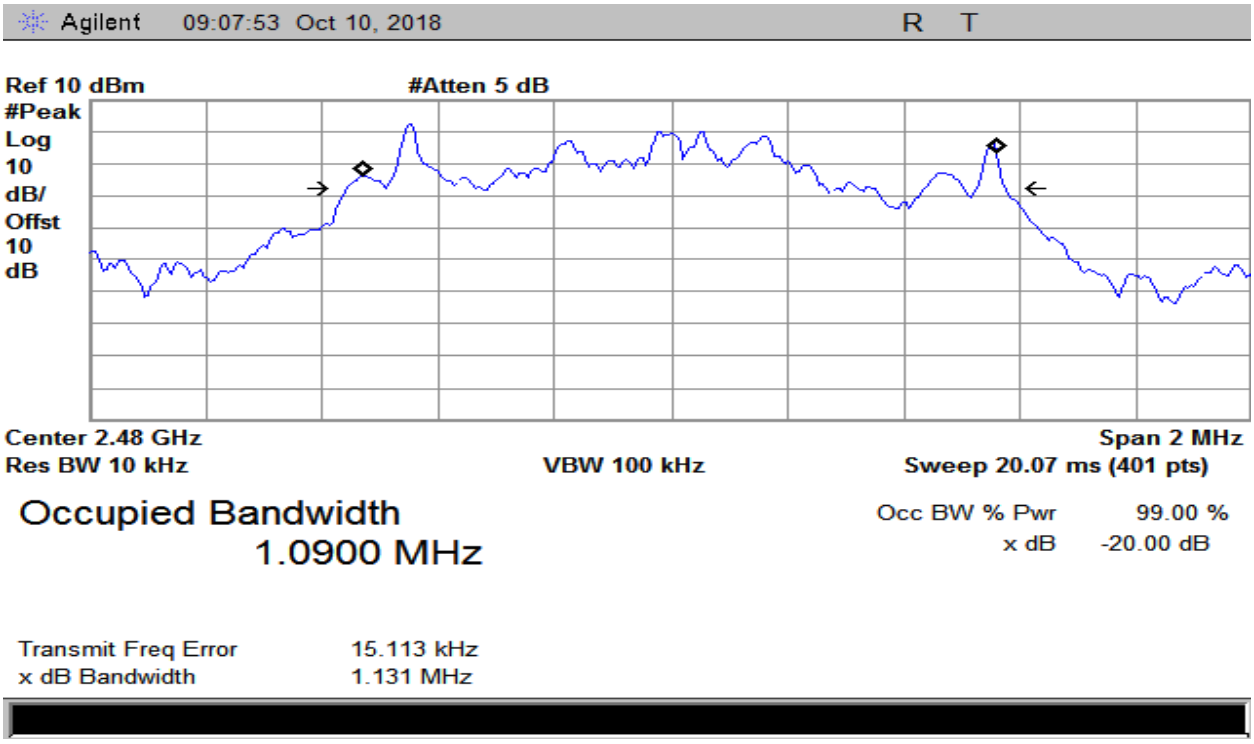
Plot 8 – Highest Channel – 20dB BW (π/4-DQPSK 2Mbps)



Plot 9 – Lowest – 20dB BW (8-DPSK 3Mbps)



Plot 10 – Middle Channel – 20dB BW (8-DPSK 3Mbps)



Plot 11 – Highest Channel – 20dB BW (8-DPSK 3Mbps)

2. RF Power Output

Test Requirement(s):	§15.247(b)(3)	Test Engineer(s):	Keith T.
Test Results:	Pass	Test Date(s):	09/18/2018

Test Procedures: As required by 47 CFR 15.247(b)(3), RF Power output measurements were made at the RF output terminals of the EUT

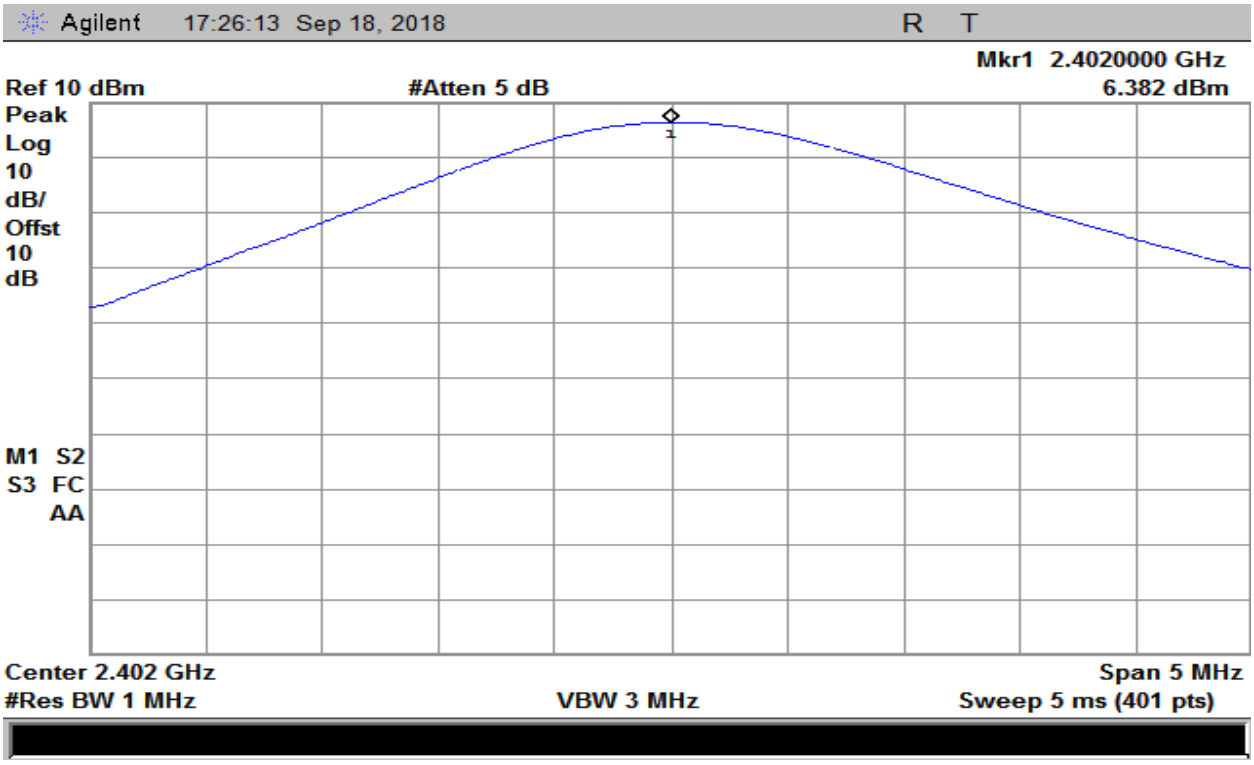
Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT was connected through an attenuator to a Spectrum Analyzer capable of making power measurements. Measurements were made at the low, mid, and high channels of the entire frequency band.

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (W)	Specification Limit
2402	6.38	0.0043	0.125W
2441	7.15	0.0051	0.125W
2480	7.39	0.0054	0.125W

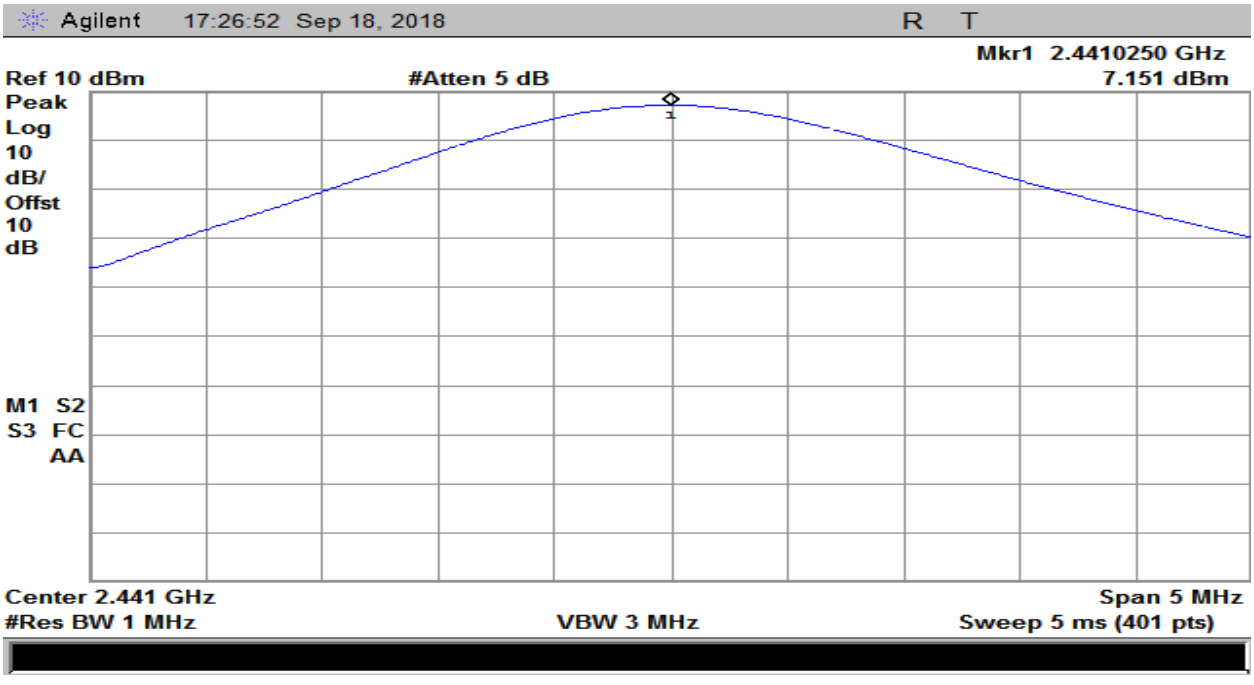
Table 9. RF Power Output, Test Results

Test Setup:

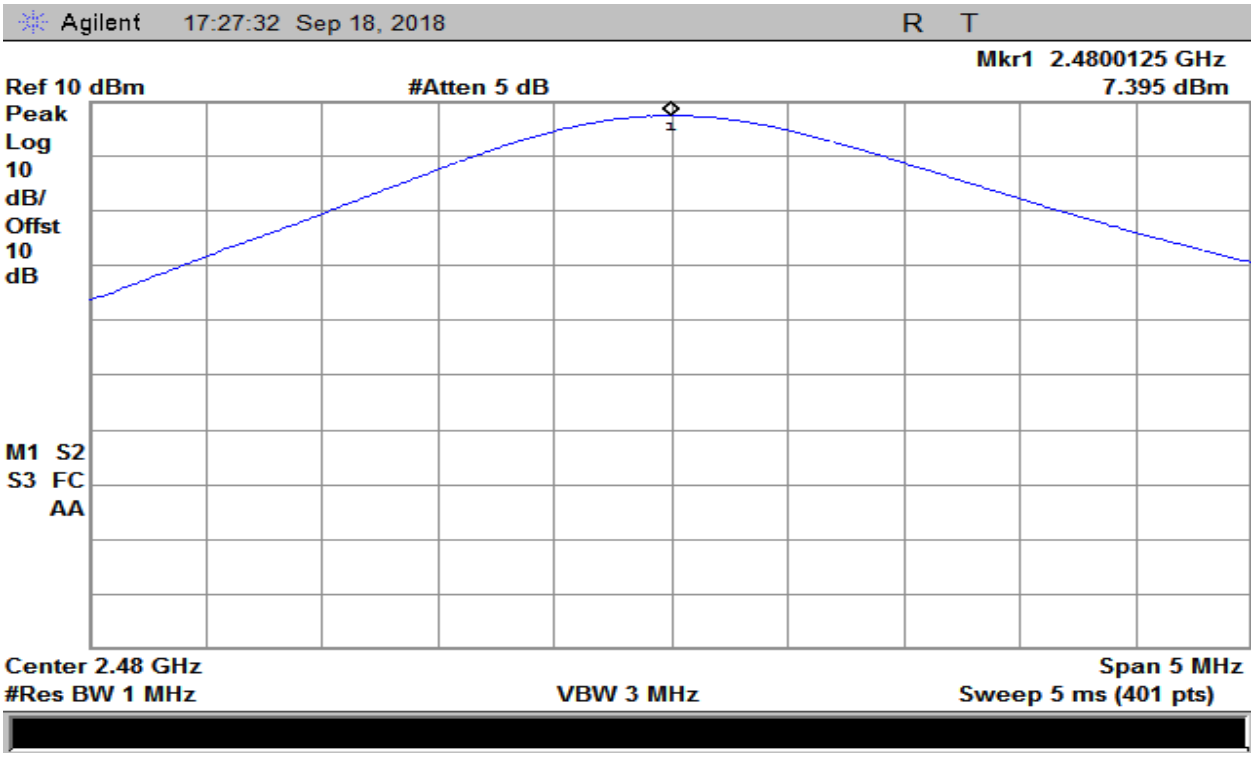
Figure 4. RF Power Test Setup



Plot 12 – Output Power – Lowest Channel



Plot 13 – Output Power – Middle Channel



Plot 14 – Output Power – Highest Channel

3. Conducted Spurious Emissions

Test Requirement(s):	§15.247(c)	**Test Engineer(s):**	Hoosam B.
Test Results:	Pass	**Test Date(s):**	03/20/17

Test Procedures:

As required by 47 CFR 15.247(c): In any 100kHz bandwidth the frequency band in which the spread spectrum or digitally modulation intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either and RF conducted or a radiated measurement. Conducted spurious emissions at antenna terminal measurements were made at the RF output antenna terminal of the EUT.

Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT was connected through an attenuator to a Spectrum Analyzer with RBW set to 100kHz and VBW ≥ RBW. The Spectrum Analyzer was set to sweep from 30MHz up to 10th harmonic of the fundamental or 40GHz whichever is the lesser. Measurements were made at the low, mid and high frequency of the transmit band.

Test Setup:

Figure 5. Conducted Spurious Emissions Test Setup

Test Data

Frequency (GHz)	Measured Level (dBm)	Limit (dBm)
2.465	-37.94	-12.6

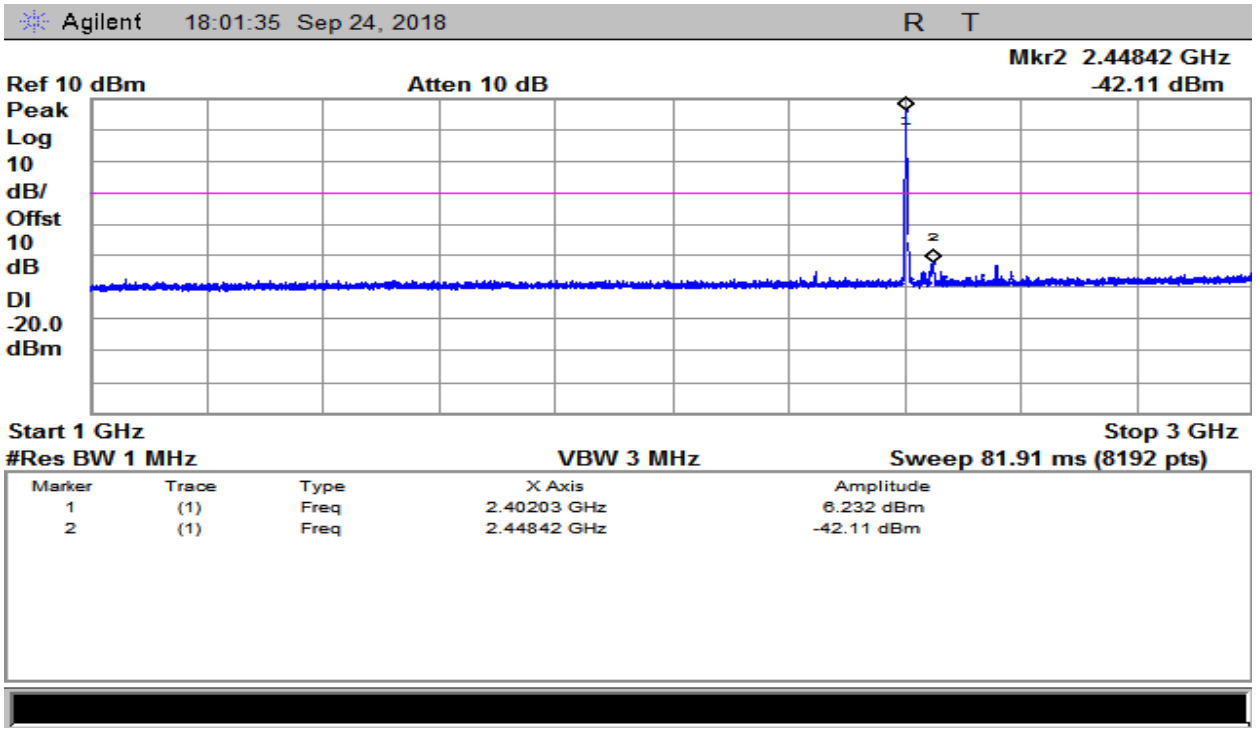
Table 10. Lowest Channel – Conducted Spurious Emissions, Test Results

Frequency (GHz)	Measured Level (dBm)	Limit (dBm)
21.51	-52.73	-10.6

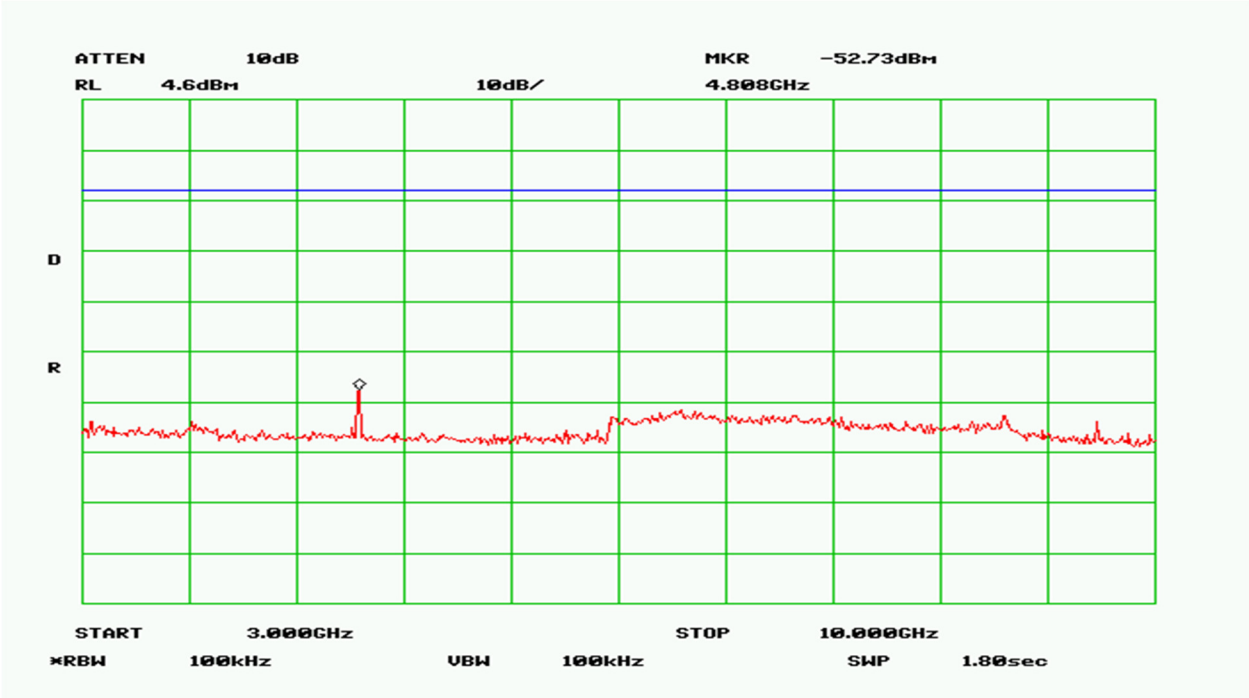
Table 11. Middle Channel – Conducted Spurious Emissions, Test Results

Frequency (GHz)	Measured Level (dBm)	Limit (dBm)
19.55	-50.63	-12.9

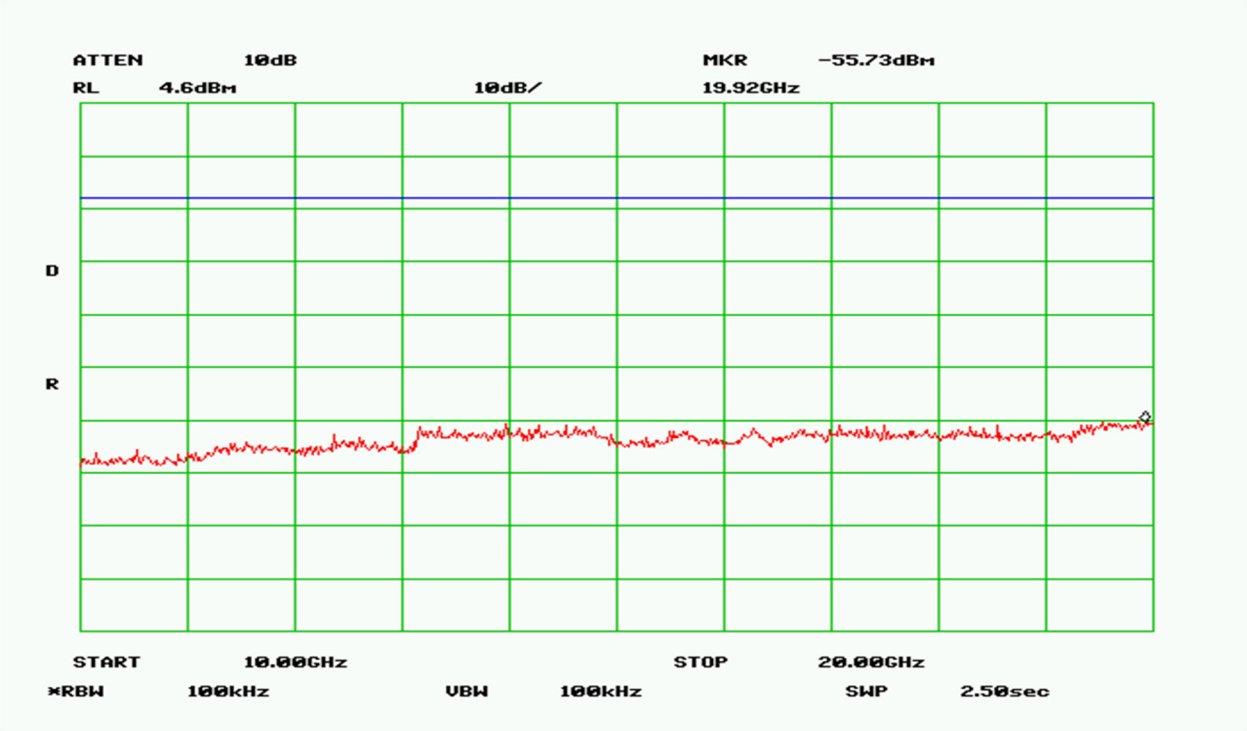
Table 12. Highest Channel – Conducted Spurious Emissions, Test Results



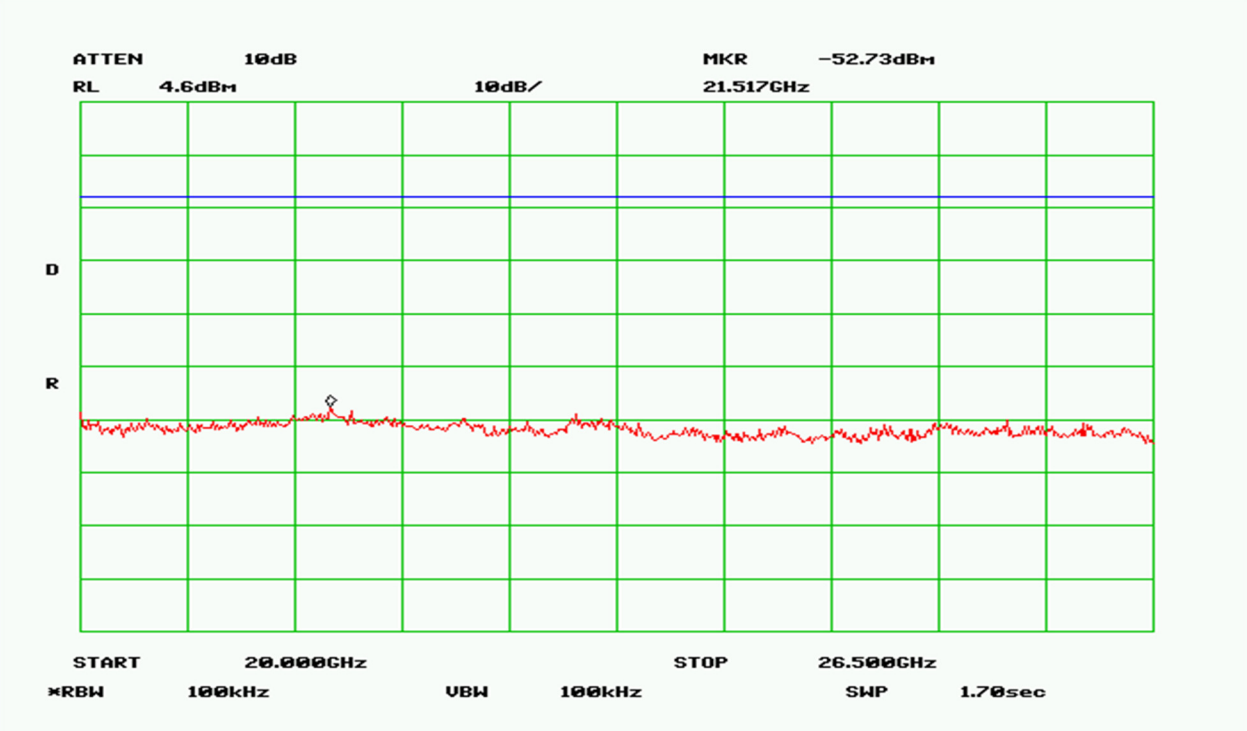
Plot 15 – Low Band – 30MHz to 3GHz



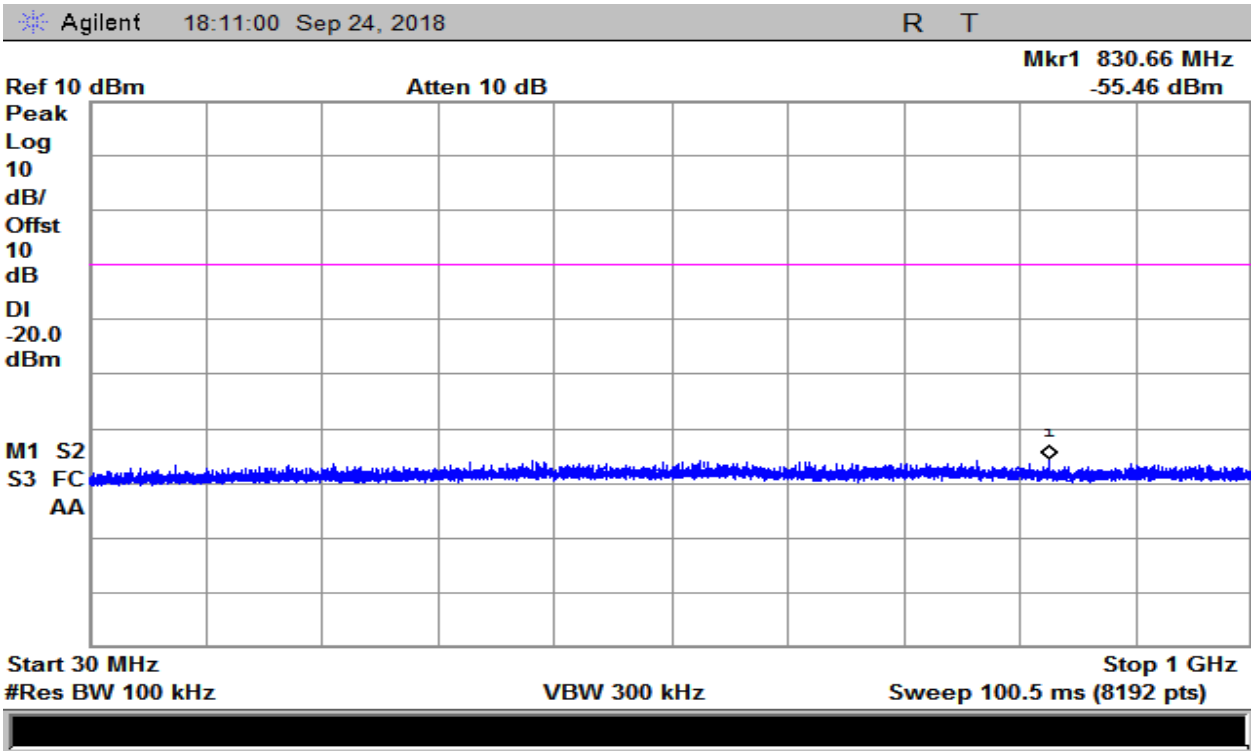
Plot 16 – Low Band – 3GHz to 10GHz



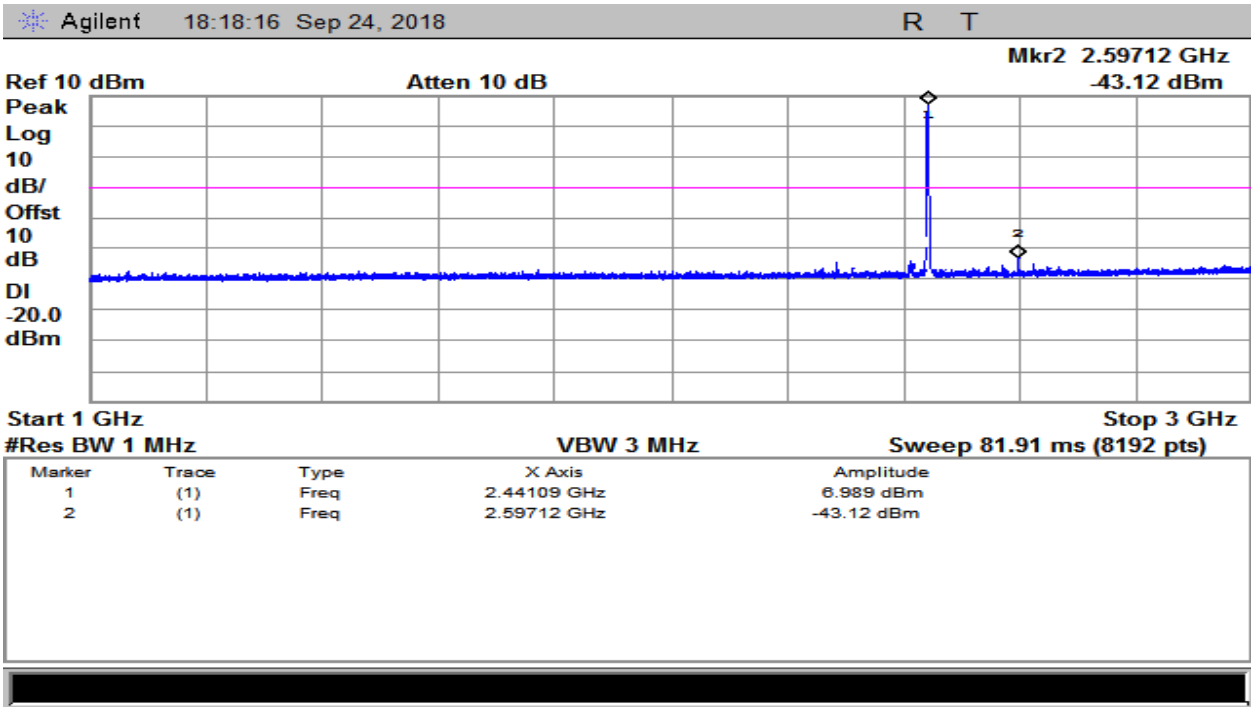
Plot 17 – Low Band – 10GHz to 20GHz



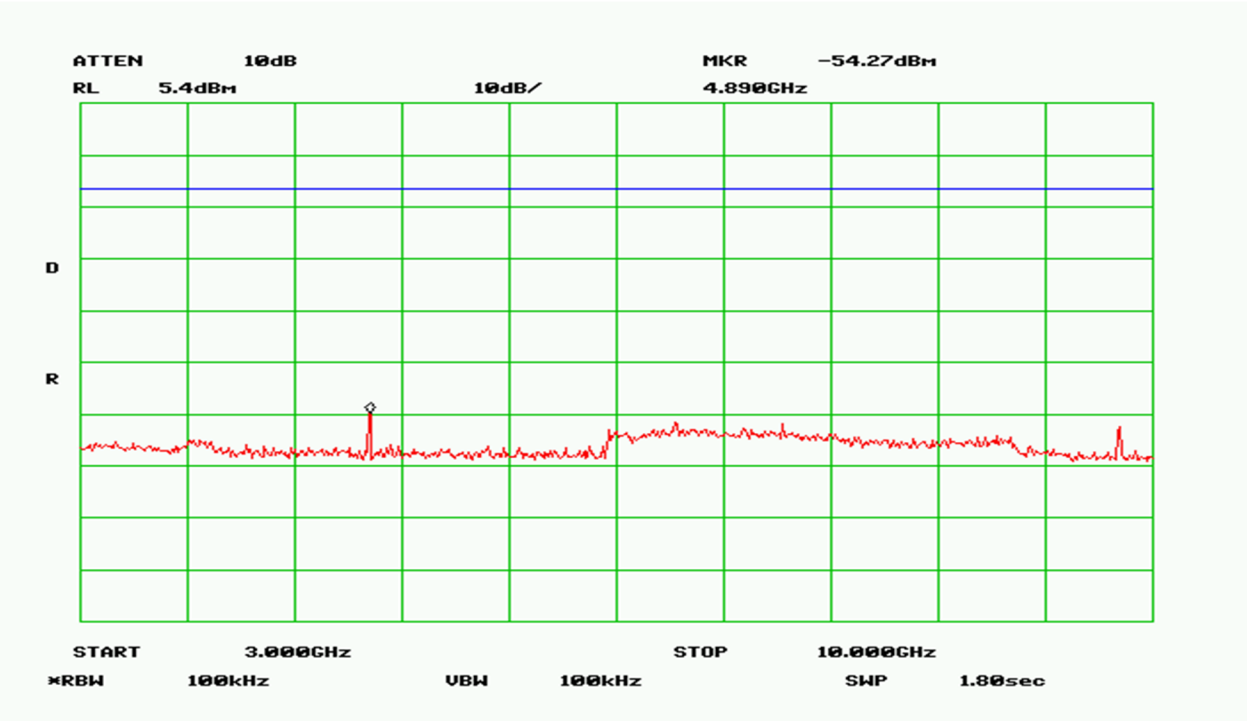
Plot 18 – Low Band – 20GHz to 26.5GHz



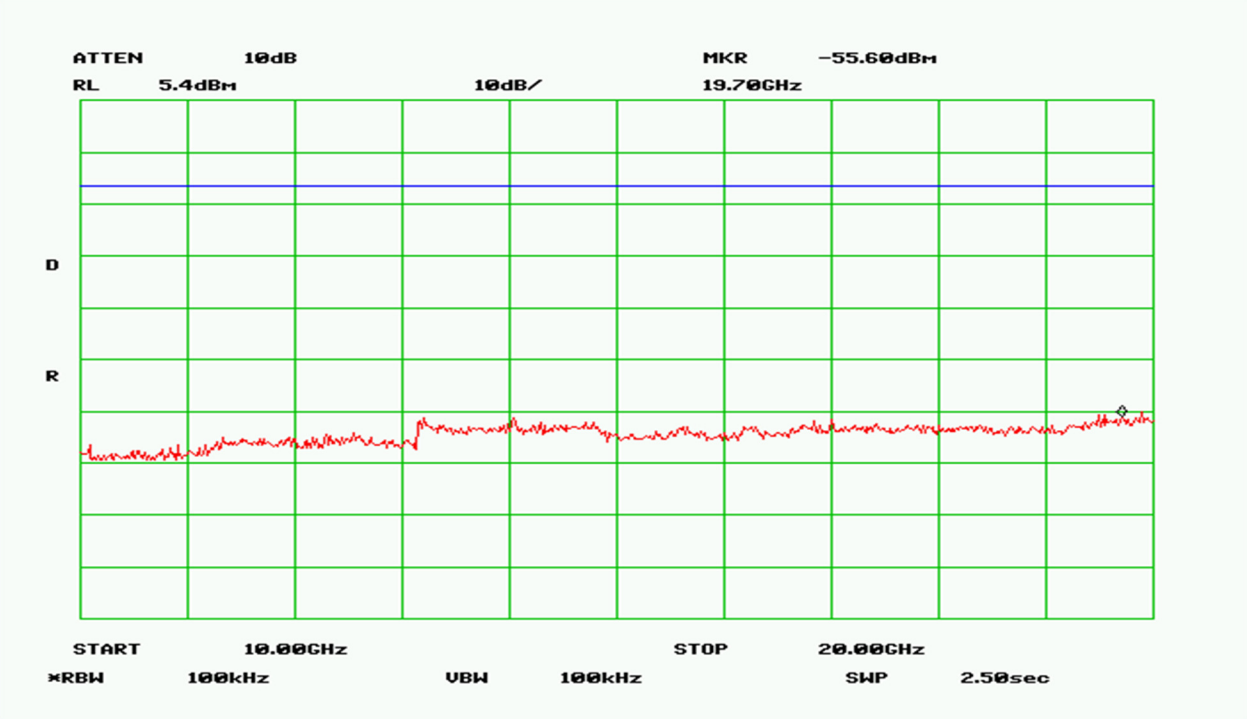
Plot 19 – Mid Band – 30MHz to 1GHz



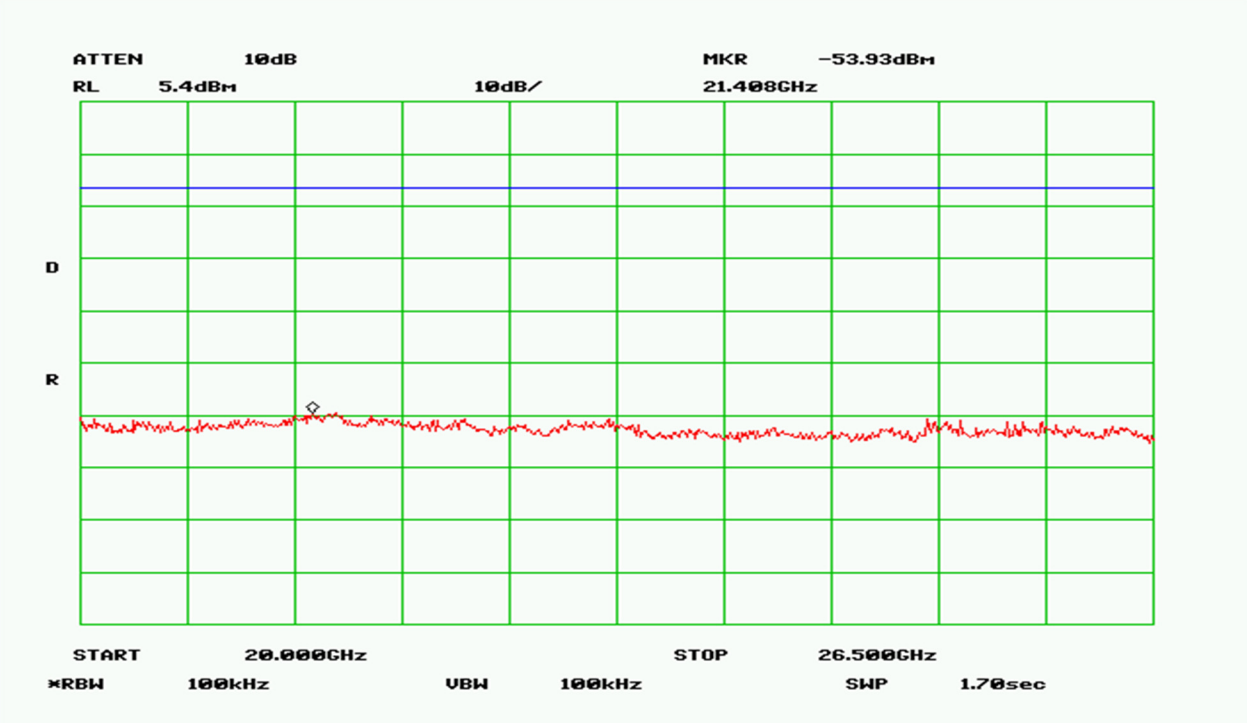
Plot 20 – Mid Band – 1GHz to 3GHz



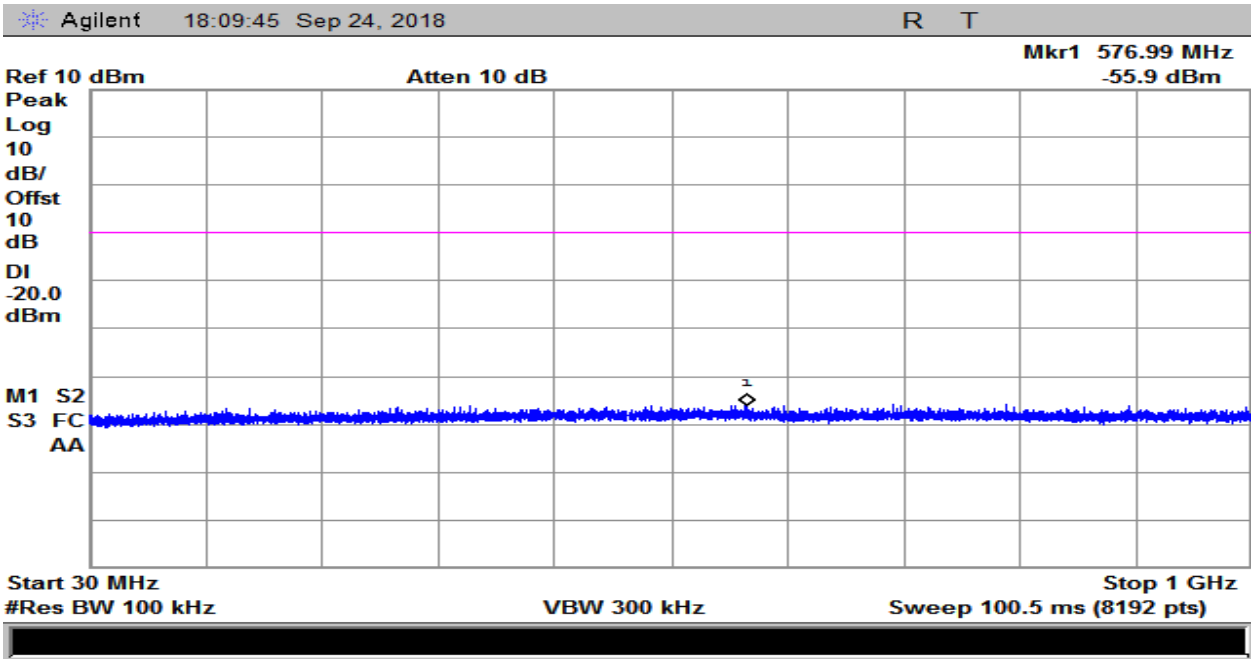
Plot 21 – Mid Band – 3GHz to 10GHz



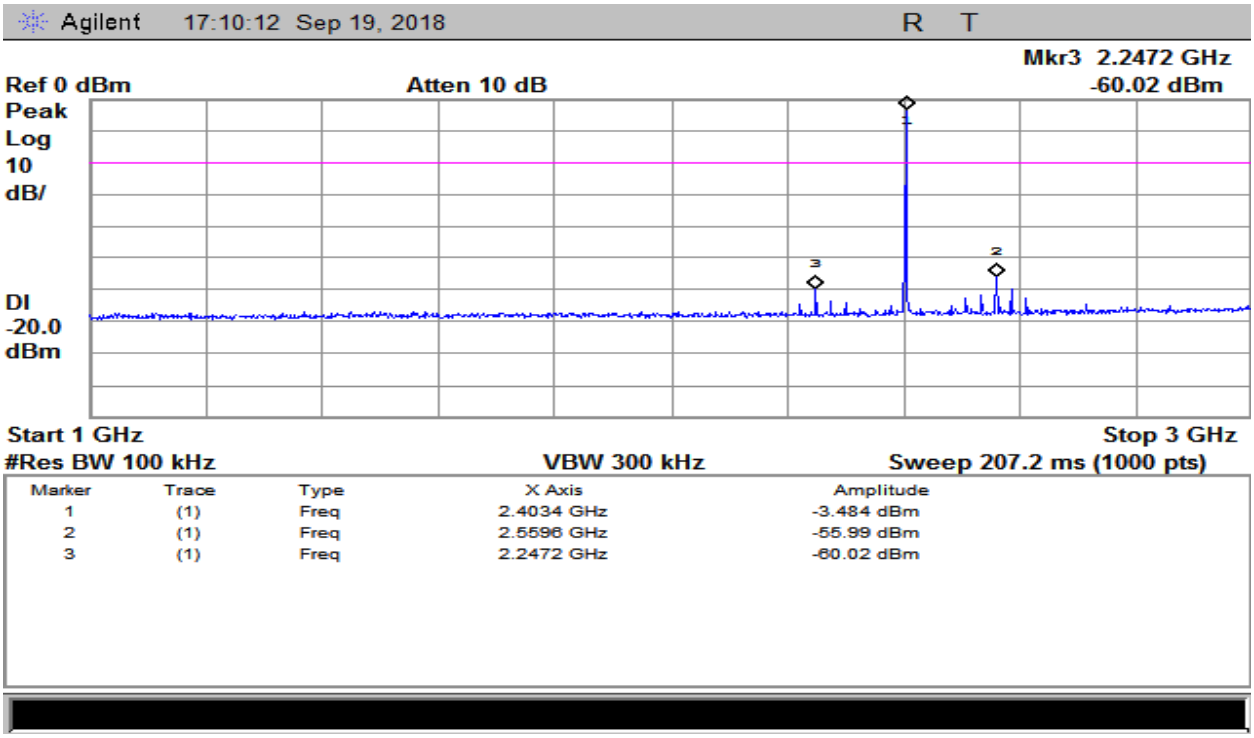
Plot 22 – Mid Band – 10GHz to 20GHz



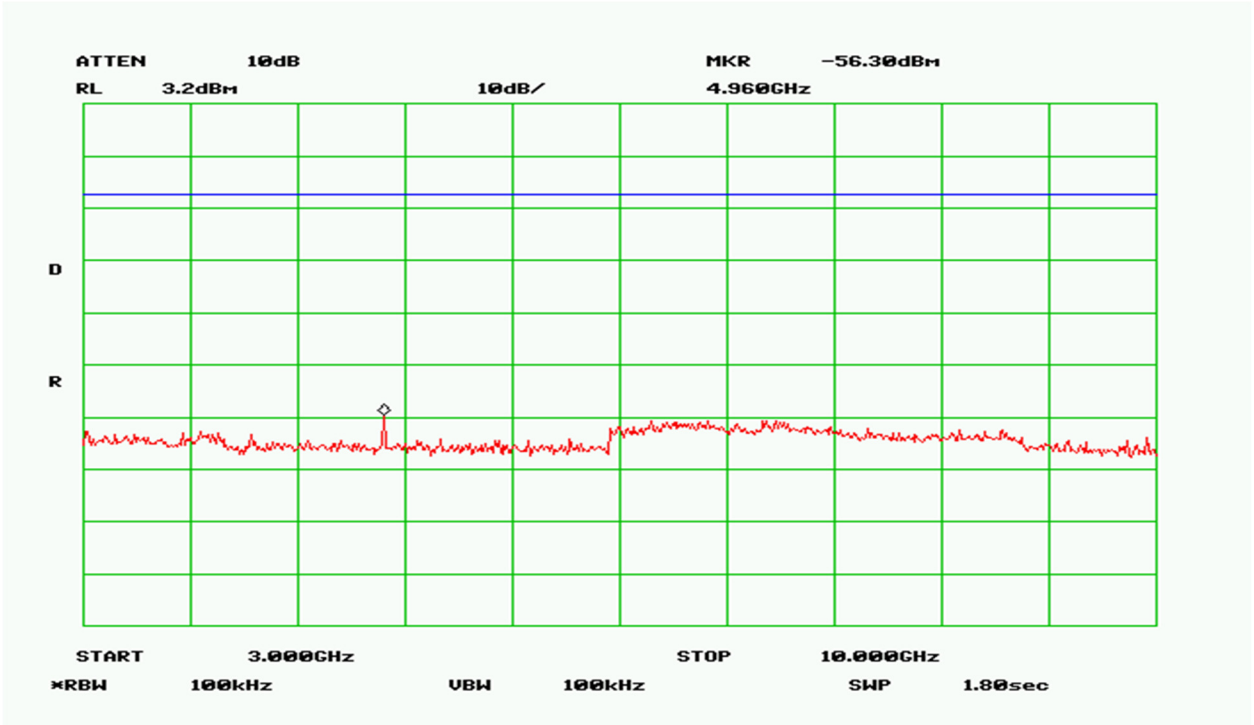
Plot 23 – Mid Band – 20GHz to 26.5GHz



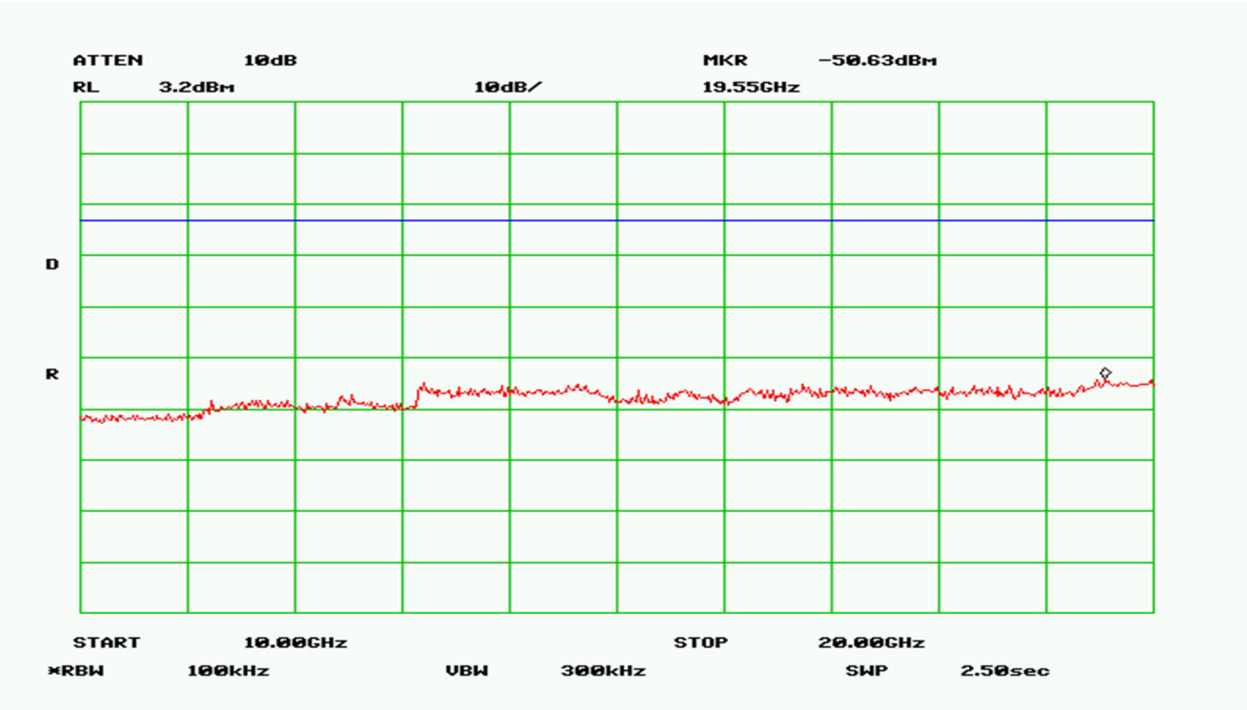
Plot 24 – High Band – 30MHz to 1GHz



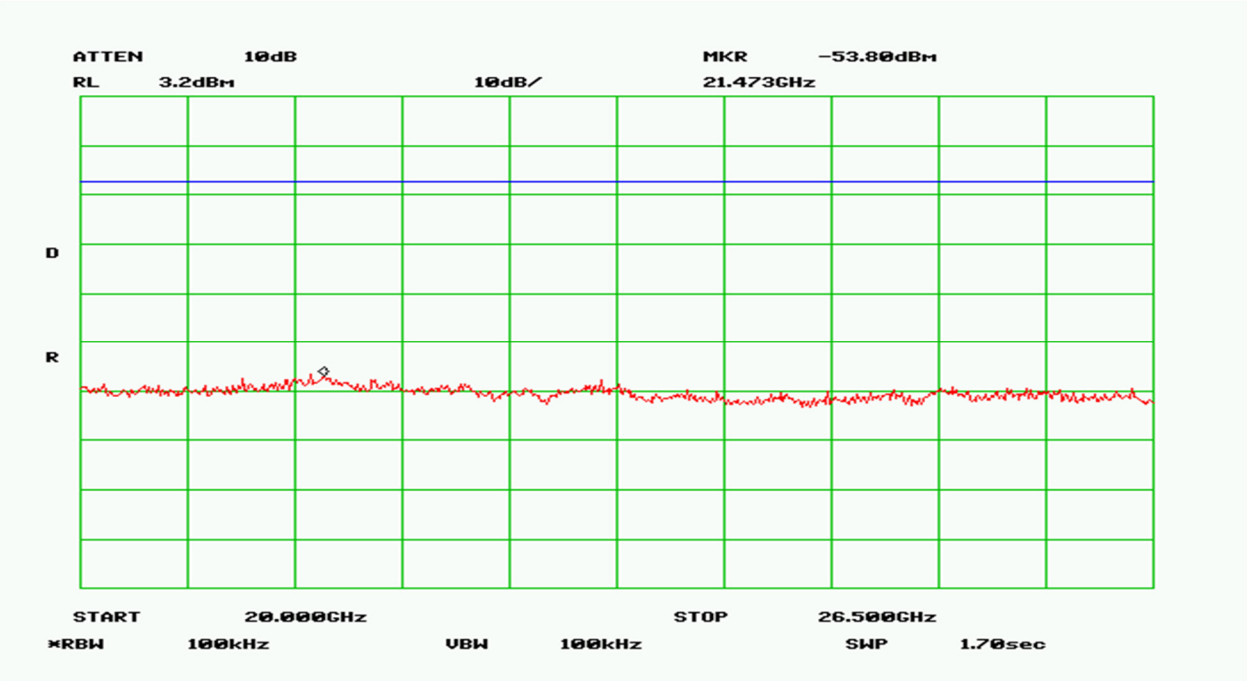
Plot 25 – High Band – 1GHz to 3GHz



Plot 26 – High Band – 3GHz to 10GHz



Plot 27 – High Band – 10GHz to 20GHz



Plot 28 – High Band – 20GHz to 26.5GHz

4. Radiated Spurious Emissions and Restricted Band

Test Requirement(s):	§15.247(d), 15.209(a), 15.205	**Test Engineer(s):**	Jerry M.
Test Results:	Pass	**Test Date(s):**	04/14/17

Test Procedures: As required by 47 CFR 15.247, Radiated spurious measurements were made in accordance with the procedures of the FCC Public Notice DA 00-705.

The EUT was placed on a non-reflective table inside a 3-meter semi-anechoic room. The EUT was set on continuous transmit.

The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT. The frequency range up to the 10^{th} harmonic was investigated.

To get a maximum emission level from the EUT, the EUT was rotated throughout the X-axis, Y-axis and Z-axis. Worst case is X-axis

Detector Setting	Resolution Bandwidth	Video Bandwidth	Span
Peak	1MHz	1MHz	As necessary
Average	1MHz	10Hz	0 Hz

Table 13. Analyzer Settings

Test Setup:

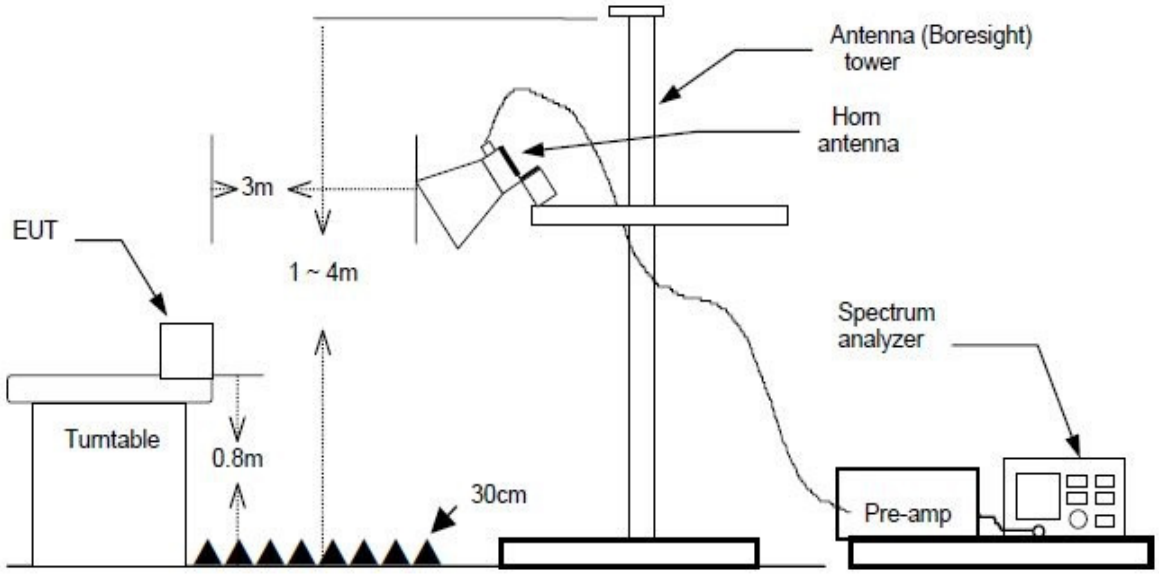


Figure 6. Radiated Emission Above 1GHz Test Setup

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peal Limit (dBuV/m)	Average Amplitude (dBuV/m))	Average Limit (dBuV/m)
4806	46.17	115.5	-	95.5
9612	45.0	115.5	-	95.5

Table 14 - Spurious Radiated Emission Data – Low Band –PCB Antenna

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
4883.4	45.5	115.5	-	95.5
9766.8	44.67	115.5	-	95.5

Table 15– Spurious Radiated Emission Data – Mid Band- PCB Antenna

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
4960	41.17	115.5	-	95.5
9921.2	45.33	115.5	-	95.5

Table 16- Spurious Radiated Emission Data – High Band - PCB Antenna

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peal Limit (dBuV/m)	Average Amplitude (dBuV/m))	Average Limit (dBuV/m)
4806	46.67	115.5	-	95.5
9612	43.33	115.5	-	95.5

Table 17 - Spurious Radiated Emission Data – Low Band –External Antenna

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
4883.4	44.43	115.5	-	95.5
9766.8	43.83	115.5	-	95.5

Table 18– Spurious Radiated Emission Data – Mid Band- External Antenna

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
4960	44.5	115.5	-	95.5
9921.2	45.83	115.5	-	95.5

Table 19- Spurious Radiated Emission Data – High Band – External Antenna

NOTE 1: There were no detectable emissions above the 2nd harmonic.

NOTE 2: Frequency marked with "*" falls under the restricted band

6. Emissions At Band Edges

Test Requirement(s):	§15.247(d)	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	10/09/2018

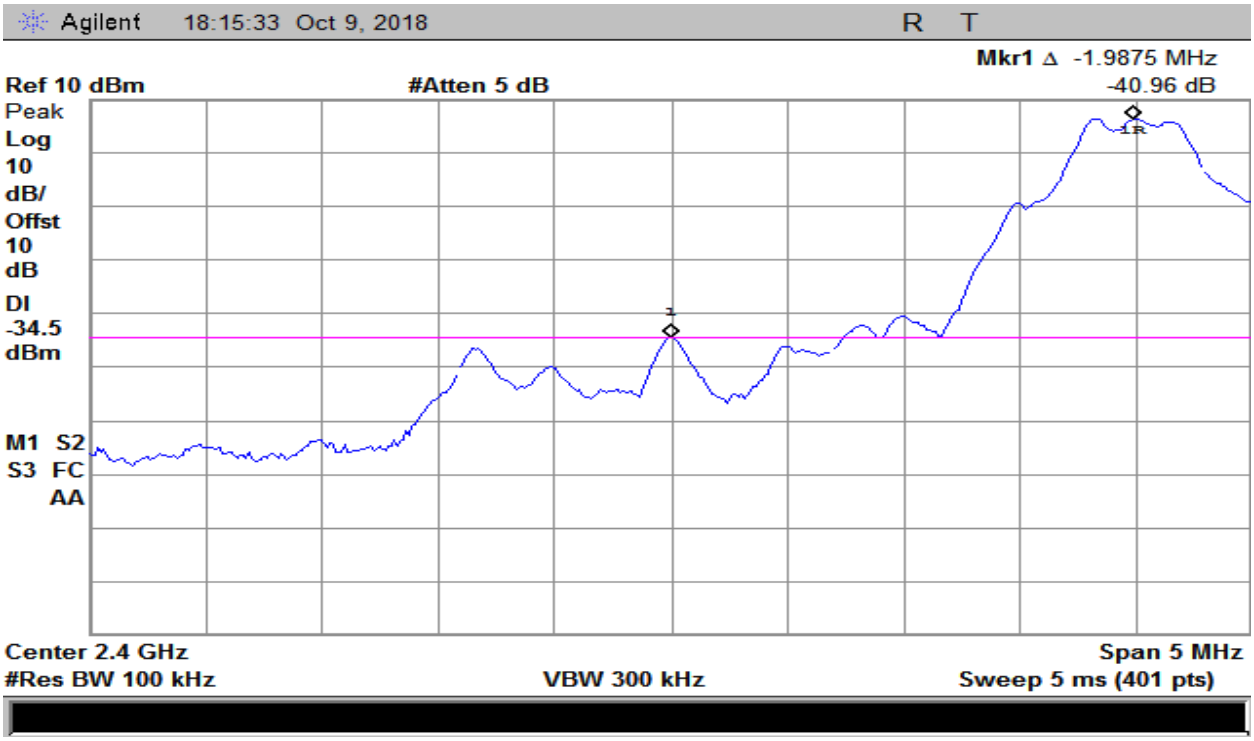
Test Procedures: As required by 47 CFR 15.247, Band edge radiated emissions measurements were made at the RF antenna output terminals of the EUT using the marker-delta method.

The EUT was placed on a wooden table inside a 3-meter semi-anechoic chamber. The EUT was set on continuous transmit.

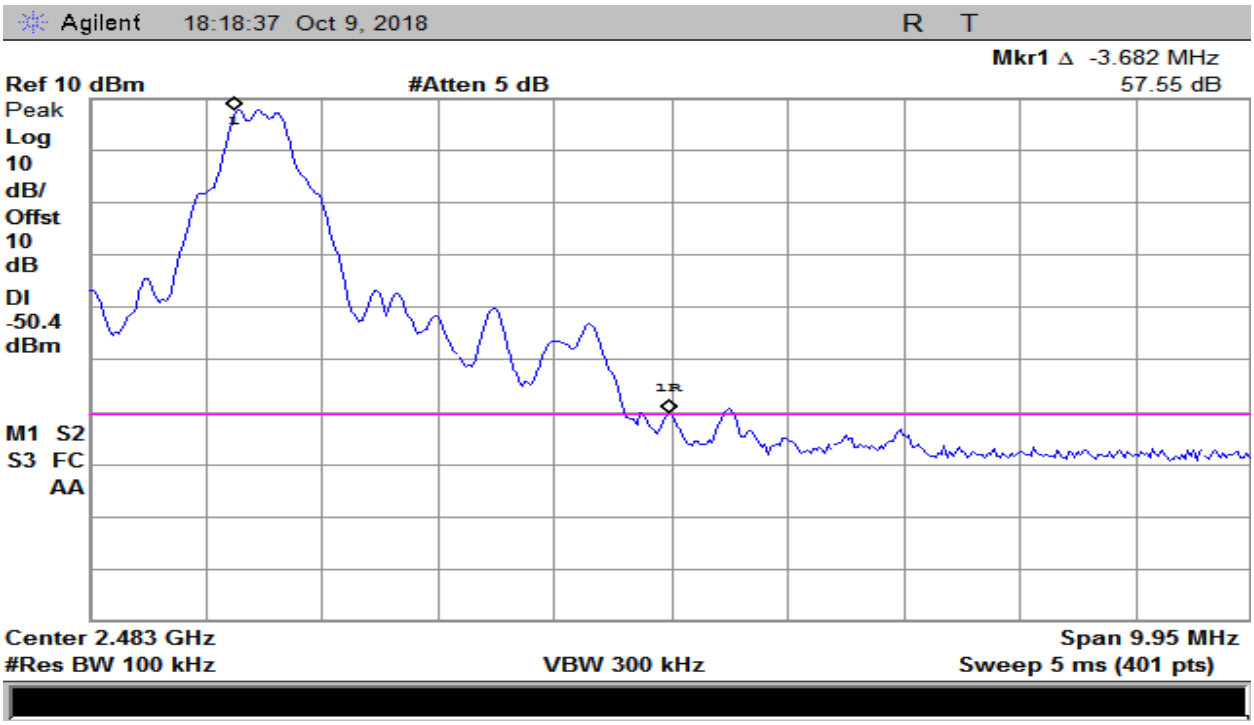
The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT. The EUT was set up at maximum power, first on the lowest operating channel, then on the highest operating channel of the transmit band.

Frequency (MHz)	Measured Level	Detector	Limit	Comments
2400	-40.96dB	Peak	-20dBc	GFSK
2483.5	-57.55dB	Peak	-20dBc	GFSK
2400	-36.74dB	Peak	-20dBc	π/4-DQPSK
2483.5	-56.47dB	Peak	-20dBc	π/4-DQPSK
2400	-36.87dB	Peak	-20dBc	8-DPSK
2483.5	-56.39dB	Peak	-20dBc	8-DPSK

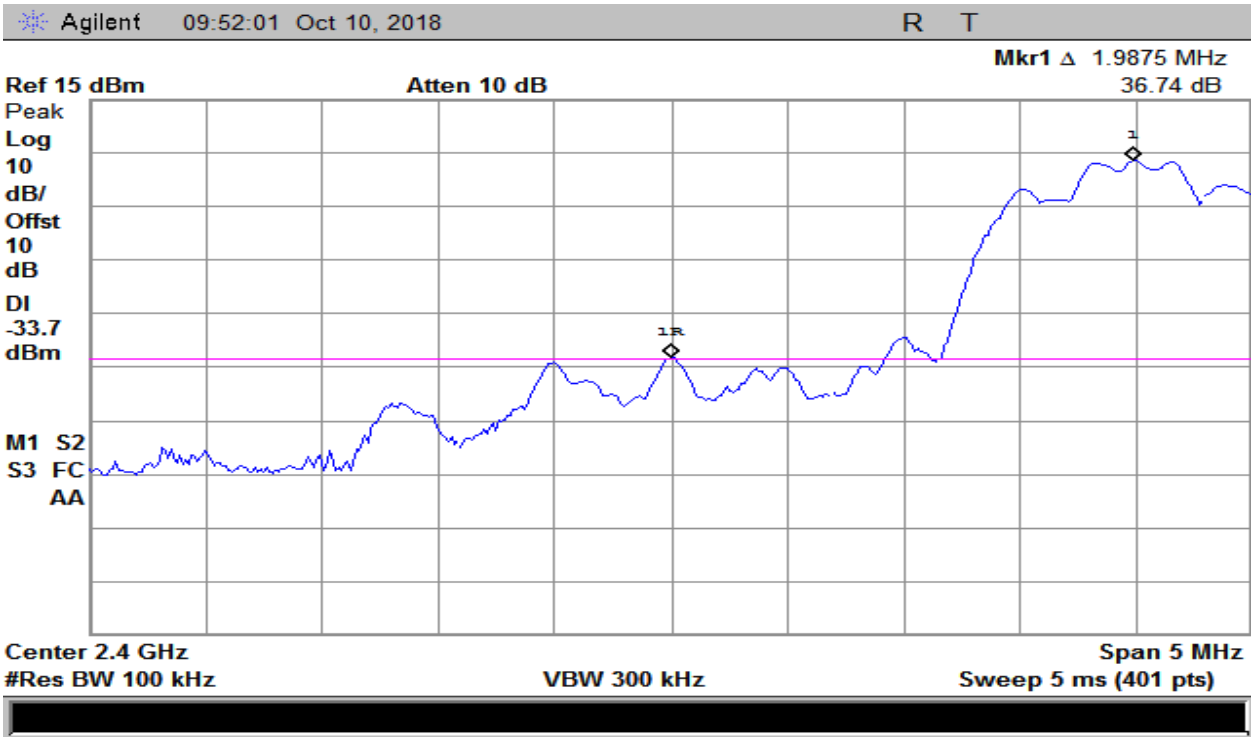
Table 20 – Band Edge Emissions Summary



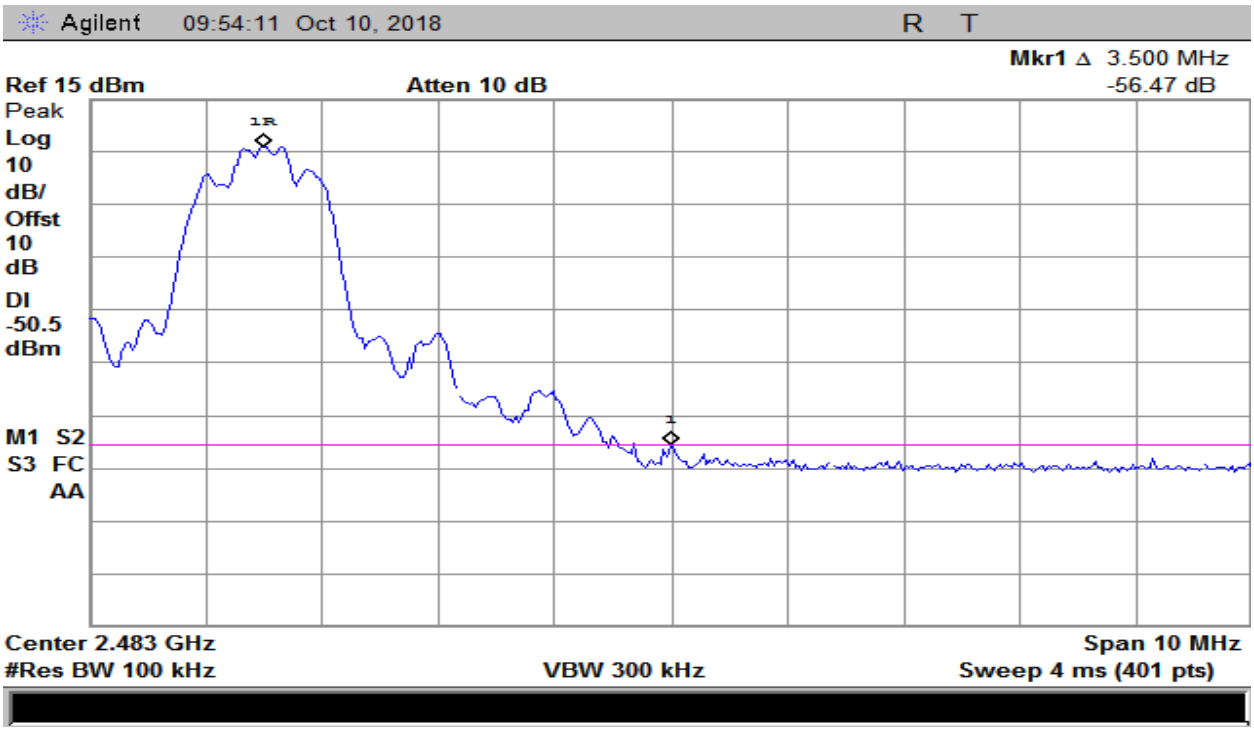
Plot 29 - Band Edge – Low Channel (GFSK)



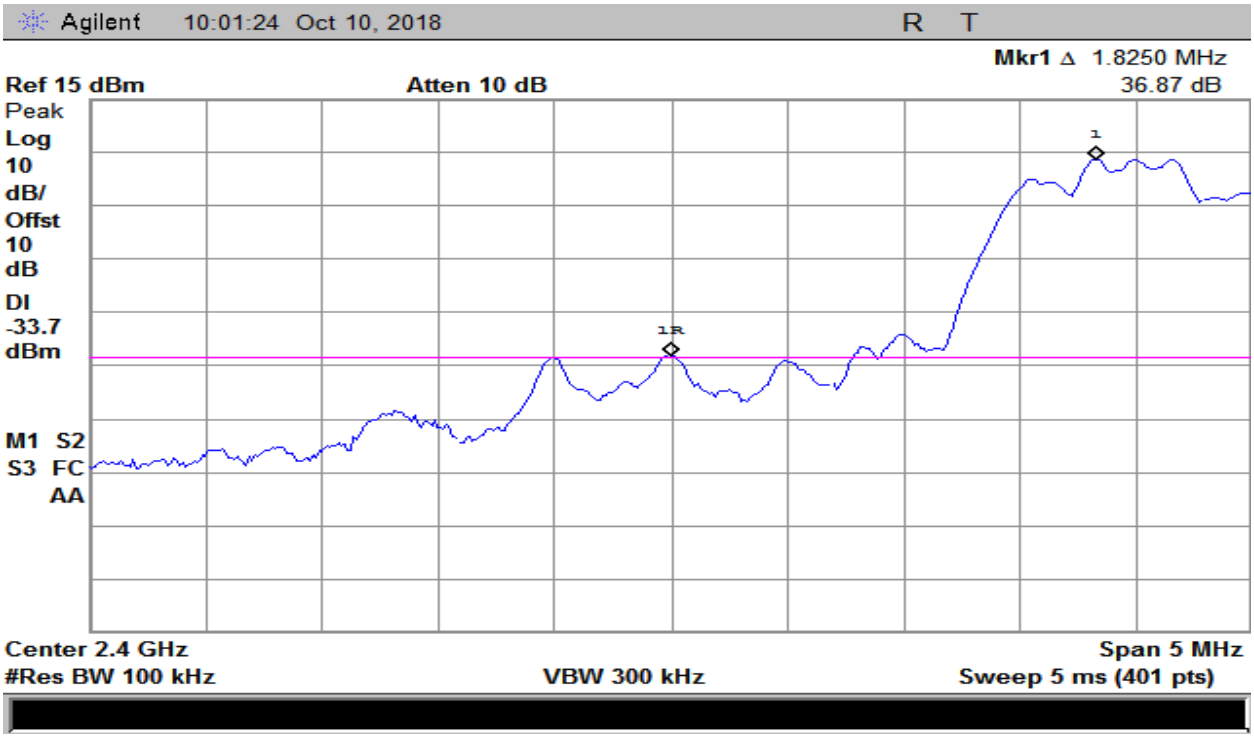
Plot 30 – Band Edge - High Channel (GFSK)



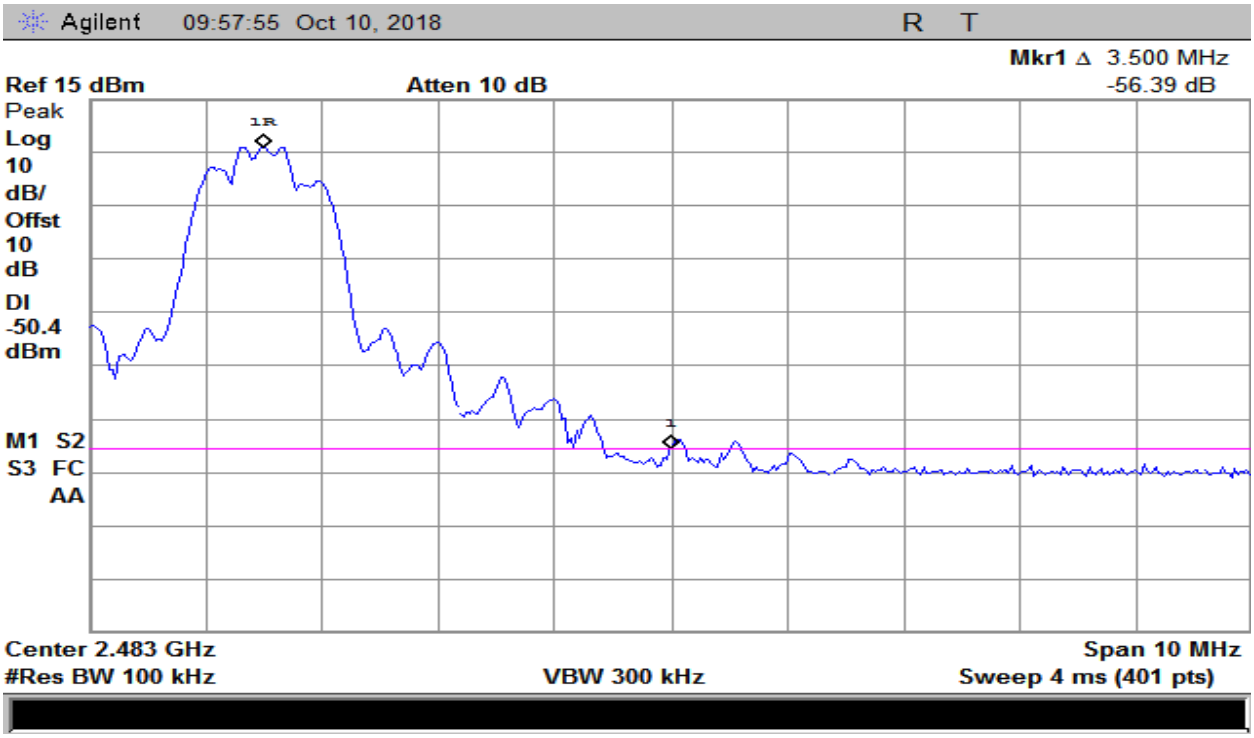
Plot 31 - Band Edge – Low Channel (π/4-DQPSK)



Plot 32 - Band Edge – High Channel (π/4-DQPSK)



Plot 33 - Band Edge – Low Channel (8-DPSK)



Plot 34 - Band Edge – High Channel (8-DPSK)

7. Time of Occupancy (Dwell Time)

Test Requirement(s):	§15.247(a)	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	10/19/2018

Test Procedures: As required by 47 CFR 15.247(a), for frequency hopping spread spectrum operating at 2400-2483.5 MHz band the average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Measurements were made with device hopping function enabled.

The EUT output was connected directly to the spectrum analyzer through an attenuator. The measurements were made at the RF antenna output terminals of the EUT.

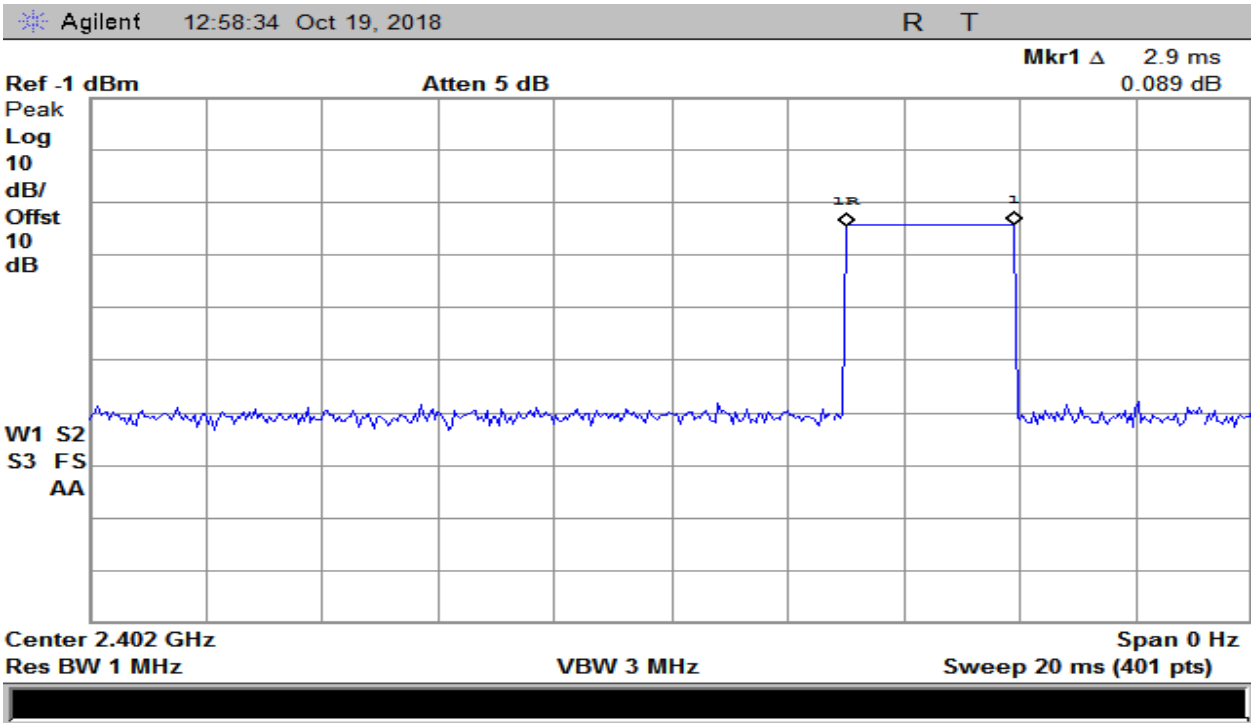
Detector Setting	Resolution Bandwidth	Video Bandwidth	Span
Peak	1MHz	1MHz	0

Table 21 – Analyzer settings

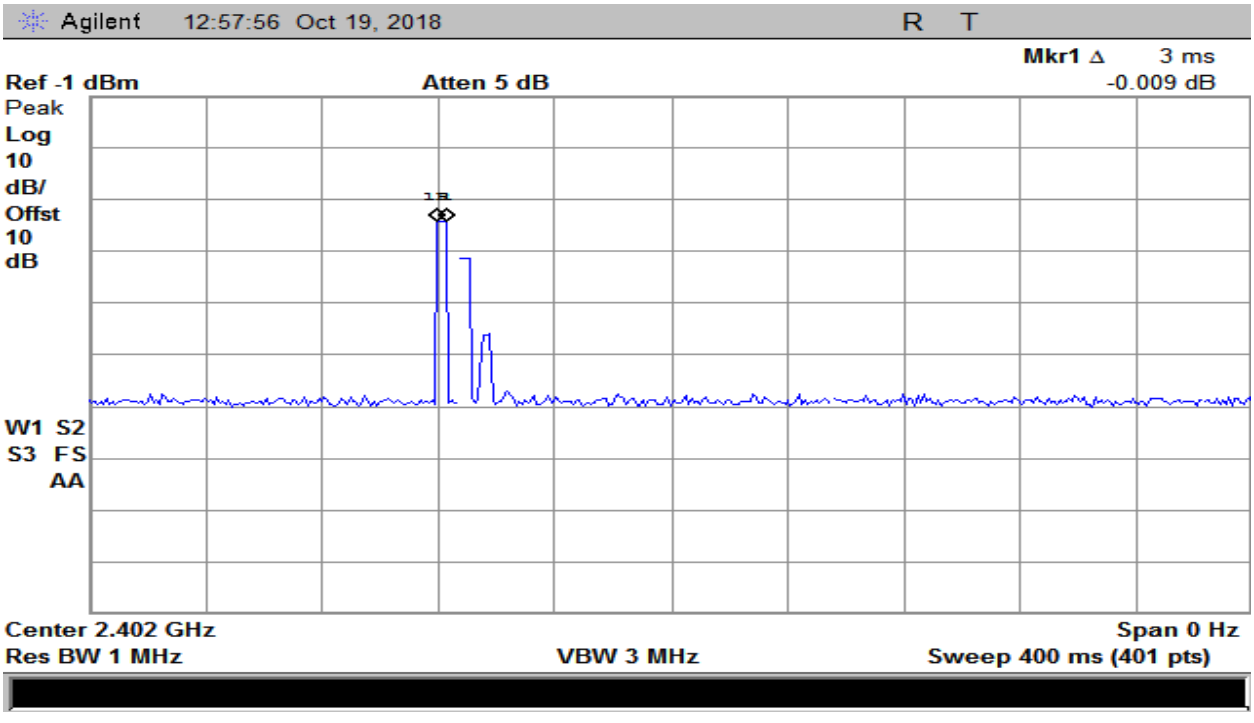
Calculation: At channel 2402MHz for GFSK Modulation, there is 1 burst in 0.4 seconds. Time period of each burst is 2.9msec. Therefore, device meets the 0.4 sec requirement.

At channel 2402MHz for π/4-DQPSK Modulation, there is 1 burst in 0.4 seconds. Time period of each burst is 2.9msec. Therefore, device meets the 0.4 sec requirement.

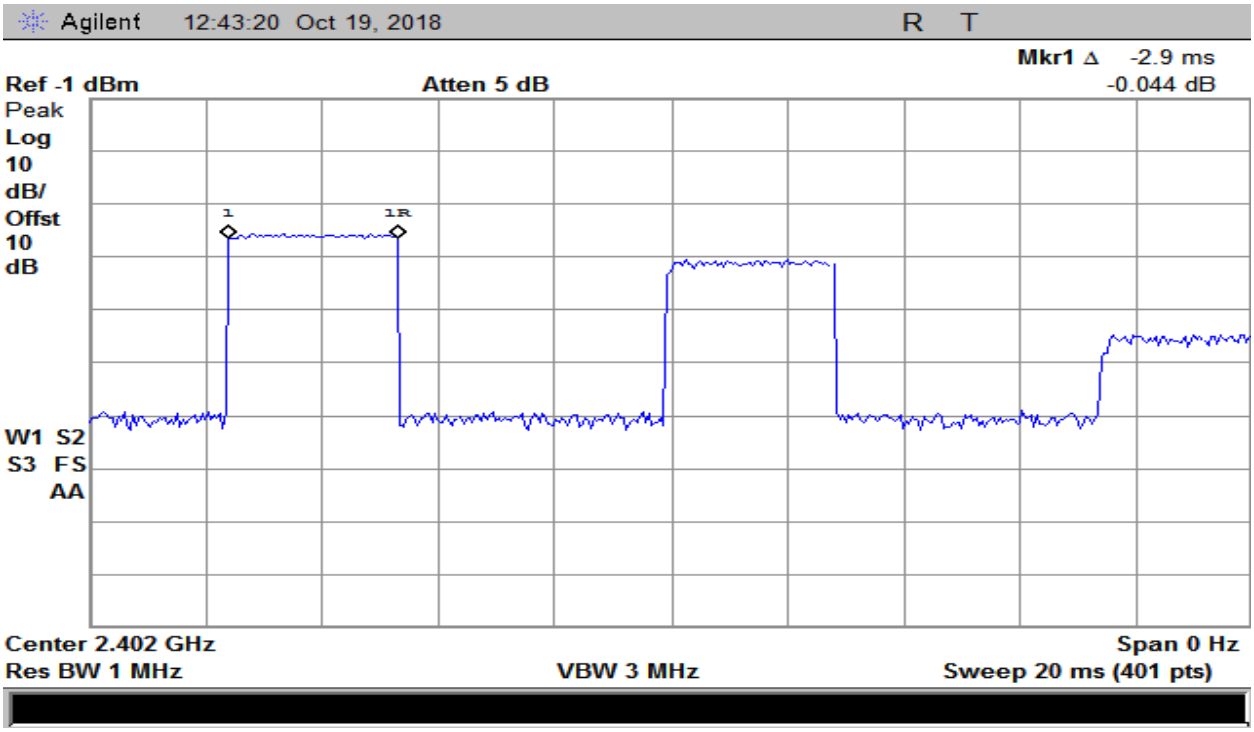
At channel 2402MHz for 8-DPSK Modulation, there is 1 burst in 0.4 seconds. Time period of each burst is 3msec. Therefore, device meets the 0.4 sec requirement.



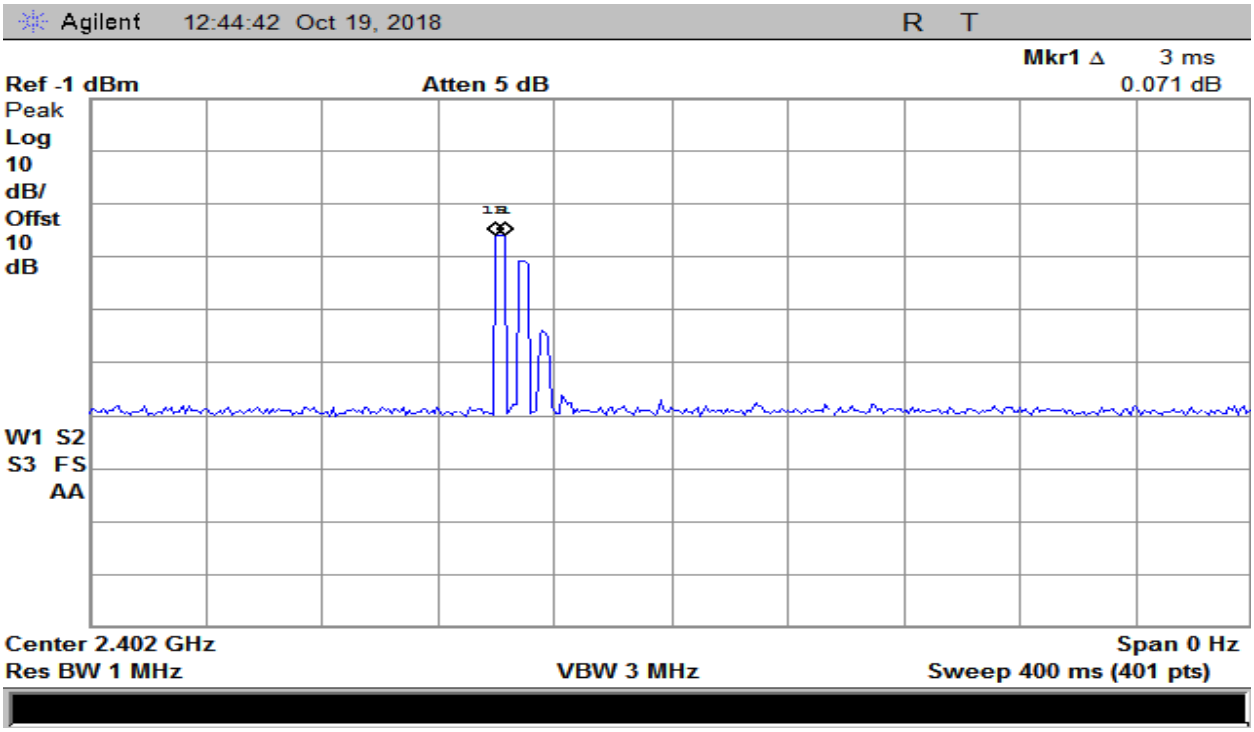
Plot 35 – Dwell Time (GFSK)



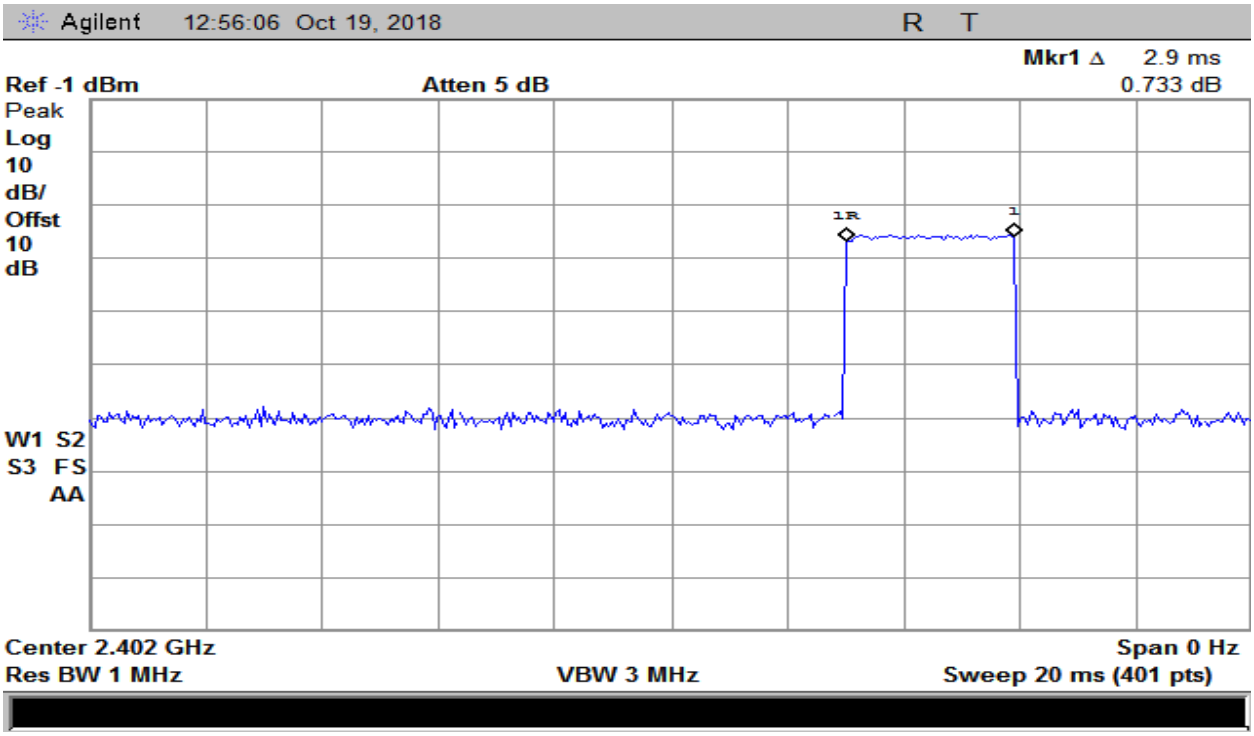
Plot 36 – # of Hops in 0.4 second period – GFSK



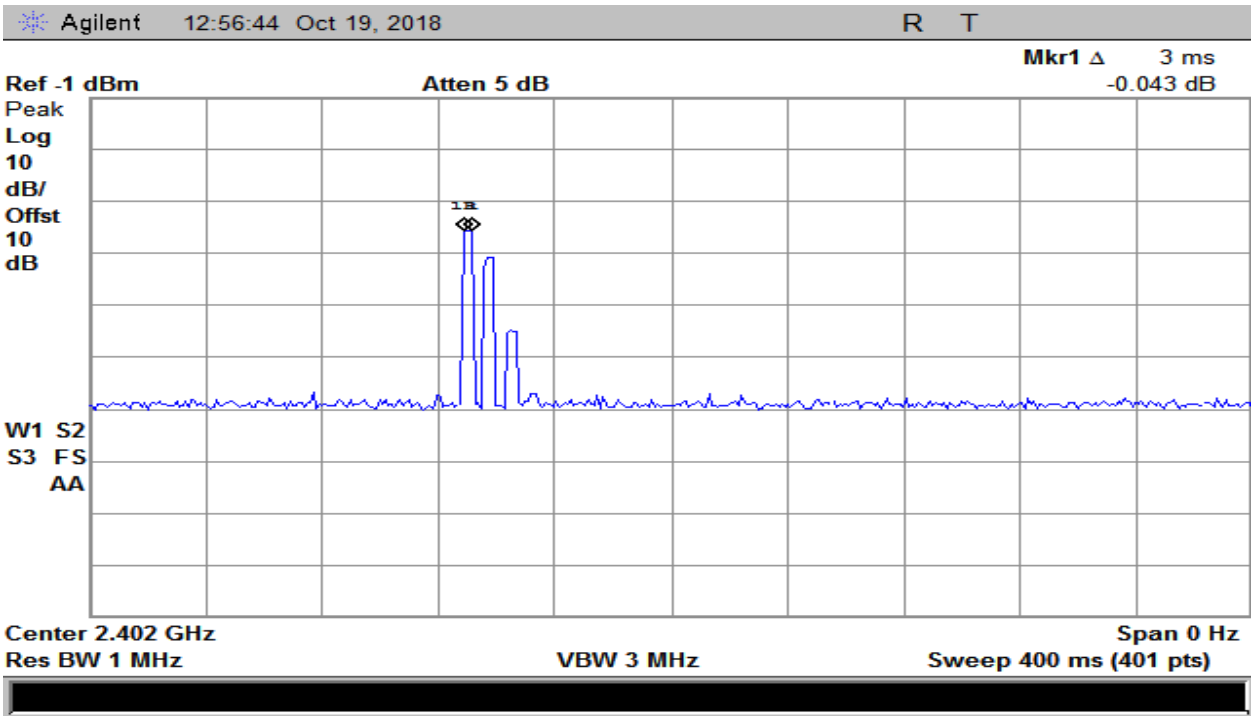
Plot 37 – Dwell Time (π/4-DQPSK)



Plot 38 – # of Hops in 0.4 second period – π/4-DQPSK



Plot 39 – Dwell Time (8-DPSK)



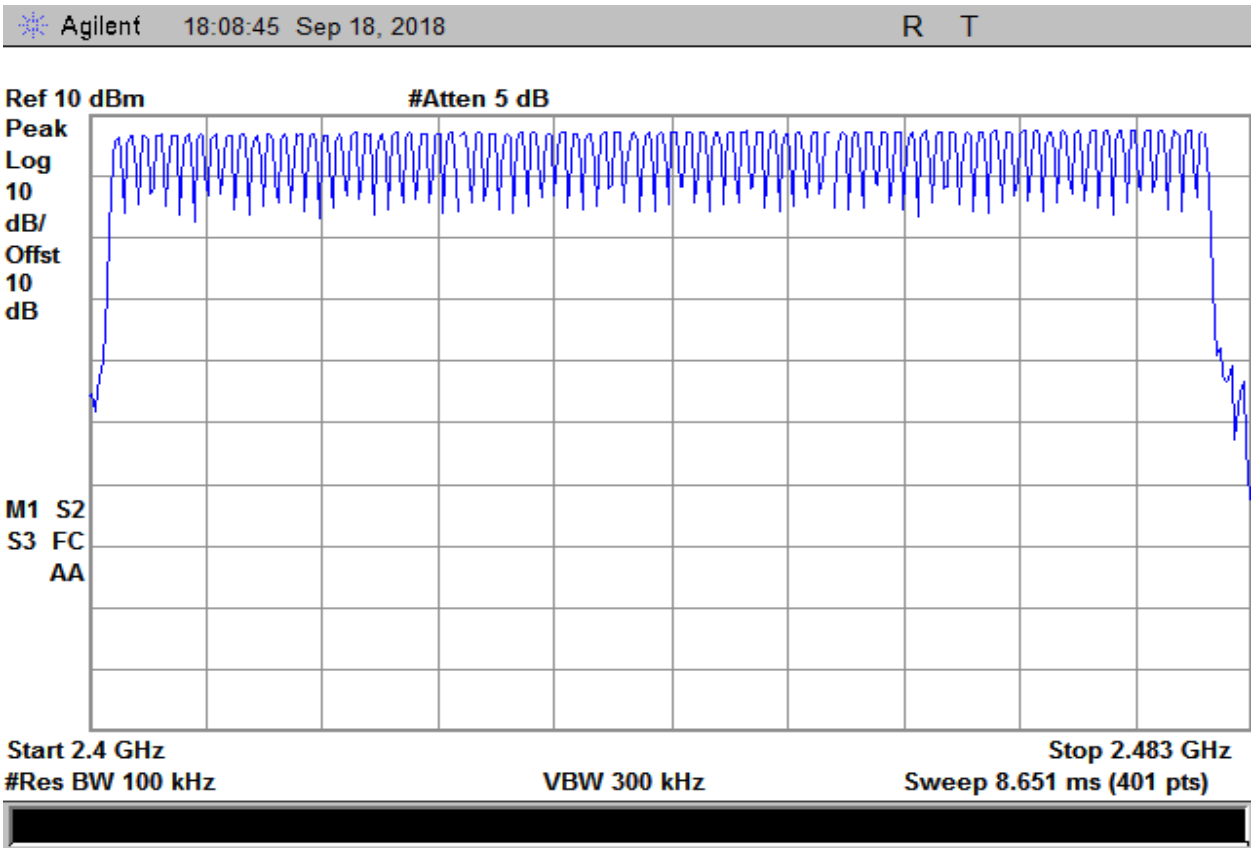
Plot 40 – # of Hops in 0.4 second period –8-DPSK

8. Number of Hopping Frequencies

Test Requirement(s):	§15.247(a)	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	09/18/2018

Test Procedures: As required by 47 CFR 15.247(a), for frequency hopping spread spectrum operating at 2400MHz-2483.5MHz band. Measurements were made with device hopping function enabled.

The EUT output was connected directly to the spectrum analyzer through an attenuator. The measurements were made at the RF antenna output terminals of the EUT. Peak detector was used, and trace was set to max hold



Plot 41 – Number of Frequency Hops – 2400MHz to 2483.5MHz (79Hops)

9. Carrier Frequency Separation

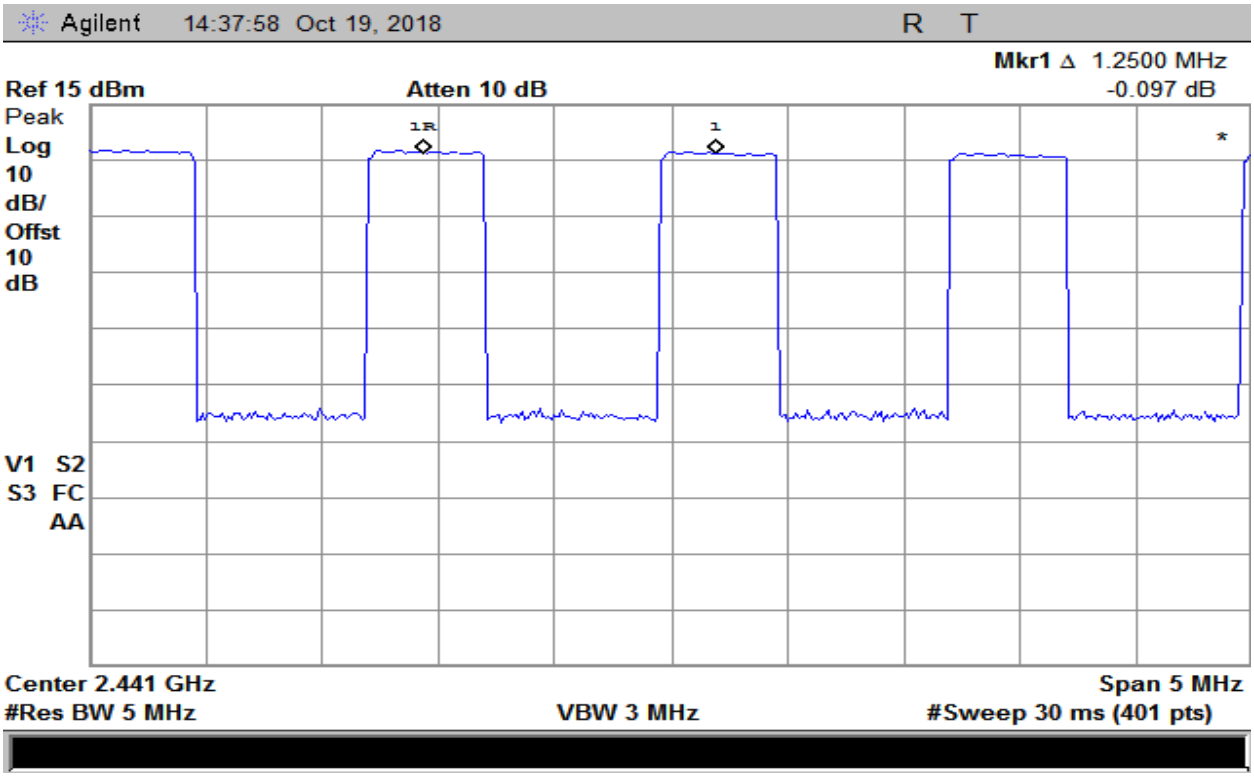
Test Requirement(s):	§15.247(a)(1)	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	04/12/17

Test Procedures: As required by 47 CFR 15.247(a), for frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater. Measurements were made with device hopping function enabled.

The EUT output was connected directly to the spectrum analyzer through an attenuator. The measurements were made at the RF antenna output terminals of the EUT. Peak detector was used, and trace was set to max hold.

Frequency Measured (MHz)	Frequency Separation (MHz)	Detector	Limit (20dB BW)
2441.0	1.25	Peak	1.13MHz

Table 22 – Carrier Frequency Separation - Summary



Plot 42 – Carrier Frequency Separation (Using Delta Marker Method)

10. Test Equipment

Equipment	Manufacturer	Model	Serial #	Last Cal Date	Cal Due Date
Spectrum Analyzer	Agilent	E4402B	US41192757	Mar/19/18	Mar/19/19
Spectrum Analyzer	Hewlett Packard	8563E	3821A09316	Jan/30/18	Jan/30/19
High Pass Filter	Mini-Circuits	VHF-3100+	1023	Verified	
LISN	Laplace Instruments	LISN 1600	152946	Mar-14-18	Mar-14-19
DMM	Fluke	77 III	72550270	Jan/30/18	Jan/30/20
Power Supply	Hewlett Packard	E3610A	KR83021468	Verified	
EMI Receiver	Hewlett Packard	8568B	2314A02642	Aug-08-18	Aug-08-19
Spectrum Analyzer	Hewlett Packard	8595EM	3801A00177	Mar-15-18	Mar-15-19
High Pass Filter	Mini-Circuits	VHF-1320+	1034	Verified	
Signal Generator	R&S	SMY02	1062.5502.12	Verified	
Attenuator 10dB	Huber+Suhner	6810.17.A	747300	Verified	
Horn Antenna	Com-Power	AHA-118	711150	May/10/16	May/10/19
Antenna	EMCO	GTEM 5417	1063	Verified	

Table 23 – Test Equipment List

***Statement of Traceability:** Test equipment is maintained and calibrated on a regular basis. All calibrations have been performed by a 17025 accredited test facility, traceable to National Institute of Standards and Technology (NIST)

11. Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The following measurement uncertainty values have been calculated as show in the table below:

Measured Parameter	Measurement Unit	Frequency Range	Expanded Uncertainty
Conducted Emissions (AC Power)	dBuV or dBuA	150kHz – 30MHz	± 4.3dB
Radiated Emission below 30MHz	dBuV/m	9kHz-30MHz	± 2.96dB
Radiated Emissions below 1GHz	dBuV/m	30 – 1000MHz	± 5.6dB
Radiated Emissions above 1GHz	dBuV/m	1 – 26.5GHz	± 4.1dB

The reported expanded uncertainty has been estimated at a 95% confidence level (k=2)

END OF TEST REPORT