H.B. Compliance Solutions

Intentional Radiator Test Report

For the

CoreKinect

BLELRA1 (Beacon and Sensor)

Tested under

The FCC Rules contained in Title 47 of the CFR, Part 15.247 and ISED RSS-247 Issue 2 for

Hybrid System

Prepared for:

CoreKinect

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Tempe, Arizona 85282

Prepared By:

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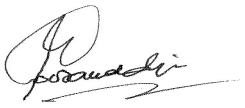
Reviewed By:



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	February 16, 2022	Initial Issue
1	March 3, 2022	Added further details for dwell time

Table of Contents

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 and RSS-247. All tests were conducted using measurement procedure from ANSI C63.10-2013, FCC Guidance document 558074 D01 v05r02 April 02, 2019 as appropriate.

Test Name	Test Method/Standard	ISED Standard	Result	Comments
Unintentional Radiated Emissions	15.109	RSS Gen 7.0	Pass	
A/C Powerline Conducted Emissions	15.207	RSS Gen 8.8	N/A	Battery Powered Device
Occupied Bandwidth	15.247(a)(2)	RSS 247 5.1(a)	Pass	
Peak Output Power	15.247(b)	RSS 247 5.4	Pass	
Conducted Spurious Emissions	15.247(d)	RSS 247 5.5	Pass	
Radiated Spurious Emissions & Restricted Band	15.247(d), 15.209(a), 15.205	RSS 247 5.5	Pass	
Emissions at Band Edges	15.247(d), 15.209(a), 15.205	RSS Gen 8.10	Pass	
Power Spectral Density	15.247(e)	RSS 247 5.2(b)	Pass	
Time of Occupancy (Dwell Time)	15.247(a)	RSS 247 5.1(c)	Pass	
Number of Hopping Channels	15.247(a)	RSS 247 5.1(c)	Pass	
Carrier Frequency Separation	15.247(a)	RSS 247 5.1(c)	Pass	

EQUIPMENT CONFIGURATION

1. Overview

H.B Compliance Solutions was contracted by CoreKinect to perform testing on the LoRa based Vehicle Asset Tracker under the purchase order number 24983.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the CoreKinect, LoRa Based Vehicle Asset Tracker.

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. CoreKinect 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:	LoRa Based Vehicle Asset Tracker
Model(s) Tested:	BLELRA1
FCC ID:	2ARKMBLELRA1
IC ID:	24436-BLELRA1
Supply Voltage Input:	Primary Power: +3.6 VDC
Frequency Range:	902.3-914.9MHz (125kHz BW) and 903-914.2MHz (500kHz BW)
No. of Channels:	64 Channels (125kHz BW) and 8 Channels (500kHz BW)
Necessary Bandwidth	N/A
Type(s) of Modulation:	CSS (Chirp Spread Spectrum)
Range of Operation Power:	0.065W
Emission Designator:	N/A
Channel Spacing(s)	None
Test Item:	Pre-Production
Type of Equipment:	Portable
Antenna Requirement (§15.203) :	Type of Antenna: PCB Trace Gain of Antenna: 0 dBi
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):	01/20/2022 till 02/03/2022

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 CoreKinect's, LoRa Vehicle Asset Tracker is a high efficiency, high precision GPS system built for ruggedized environment. It runs on a single D size cell

4. Equipment Configuration

Ref. ID	Name / Description	Model Number	Serial Number
# 1	(Sample # 1 with connector) – For Conducted test only	-	-
# 2	(Sample # 2) – For Radiated test only - Beacon	BLELRA1	-
# 3	(Sample # 2) – For Radiated test only - Sensor	BLELRA1	-

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	DC Power Supply	Hewlett Packard	E3611A	KR23003803

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
-	-	-	-	-	-	-

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. Customer supplied test tool software that allowed program the EUT. Test mode was provided to select the lower, middle and upper band of the transmitter. This software allowed the selection of all the channels and both the bandwidths to operate in CW and with modulation on. These settings were created for testing purpose only. For 125kHz BW Spreading Factor SF9 was used for channels (0-63). For 500kHz BW spreading factor SF9 was used for channels (64-71). For Transmit power "PA_Boost +20dbm setting level was selected for highest power level

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 CoreKinect at the completion of testing & certification.

Criteria for Un-Intentional Radiators

1. Radiated Emissions

Test Requirement(s):	§15.109 and RSS Gen 7.0	**Test Engineer(s):**	Frank F.
Test Results:	Pass	**Test Date(s):**	02/03/2022

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 TILE4 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

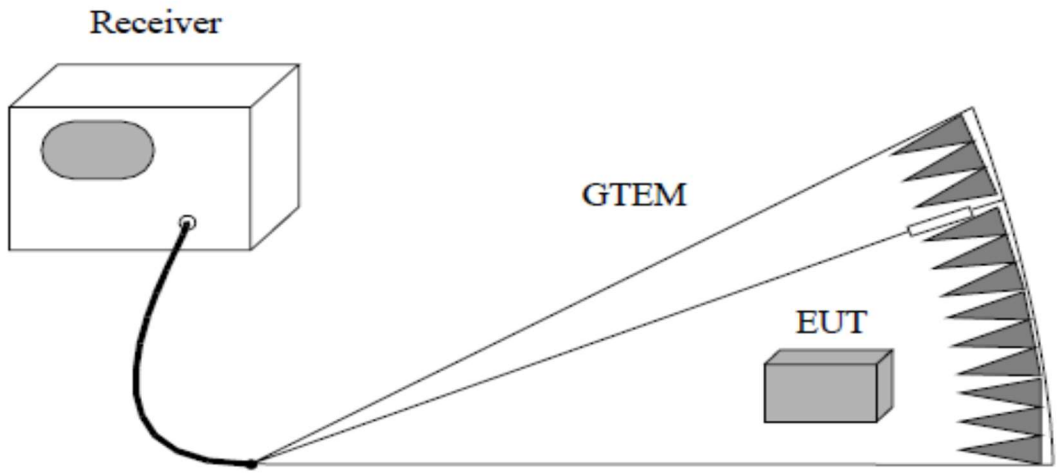
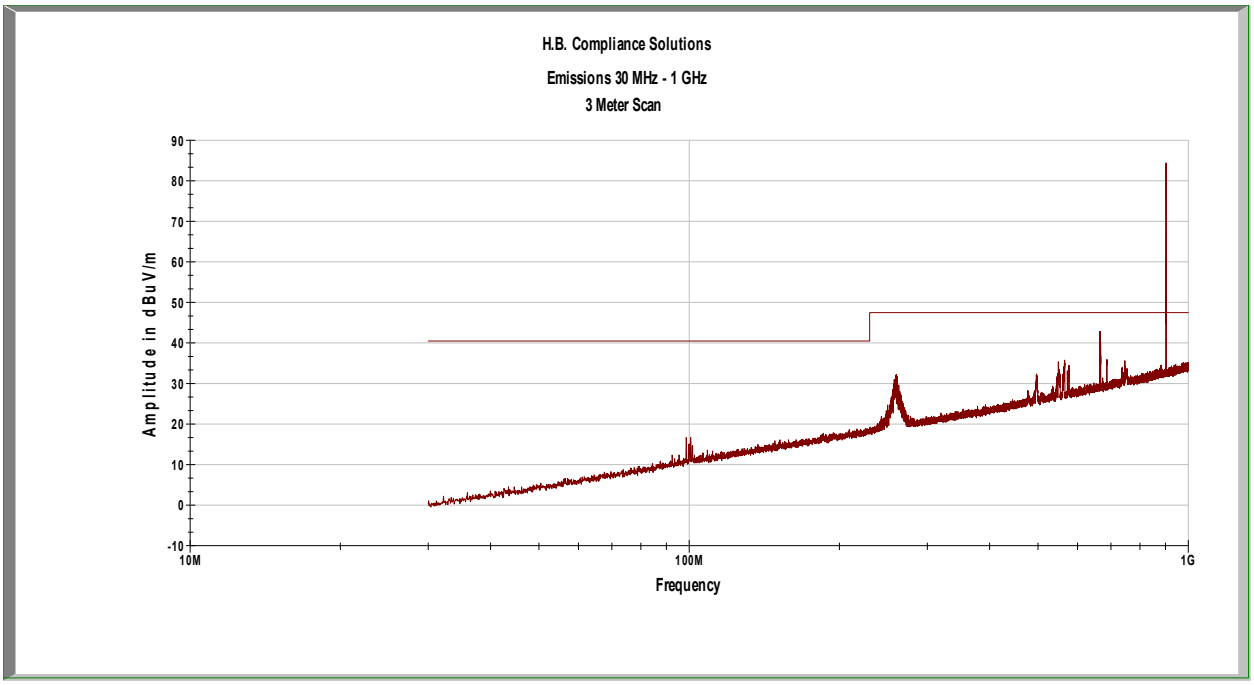
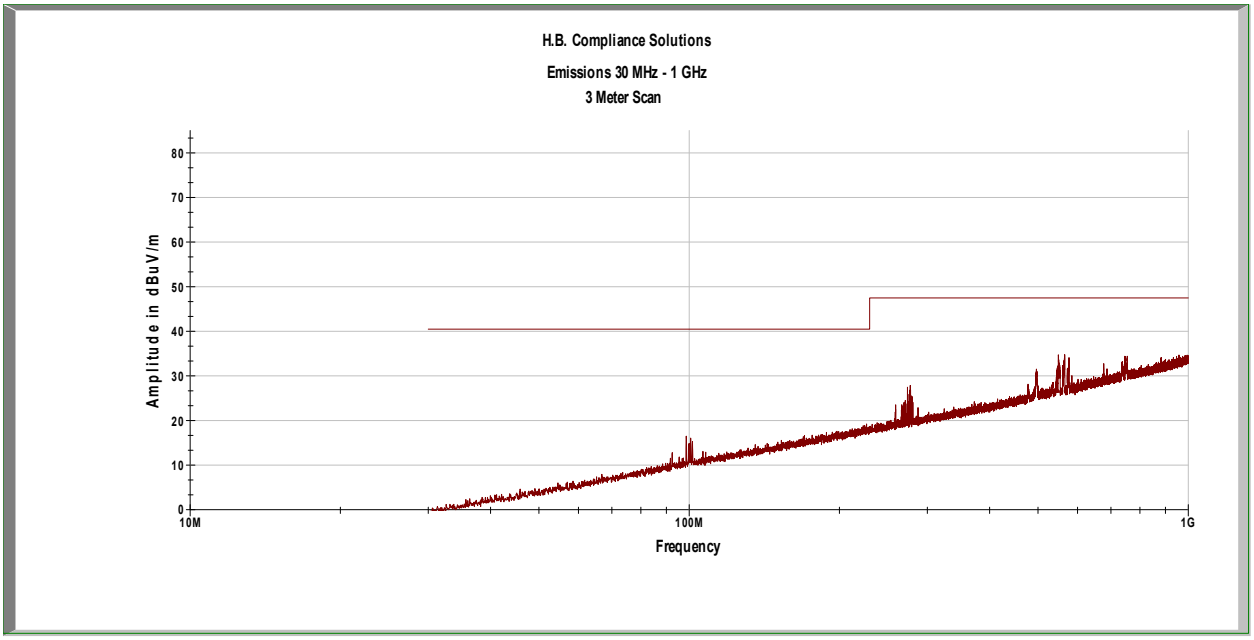


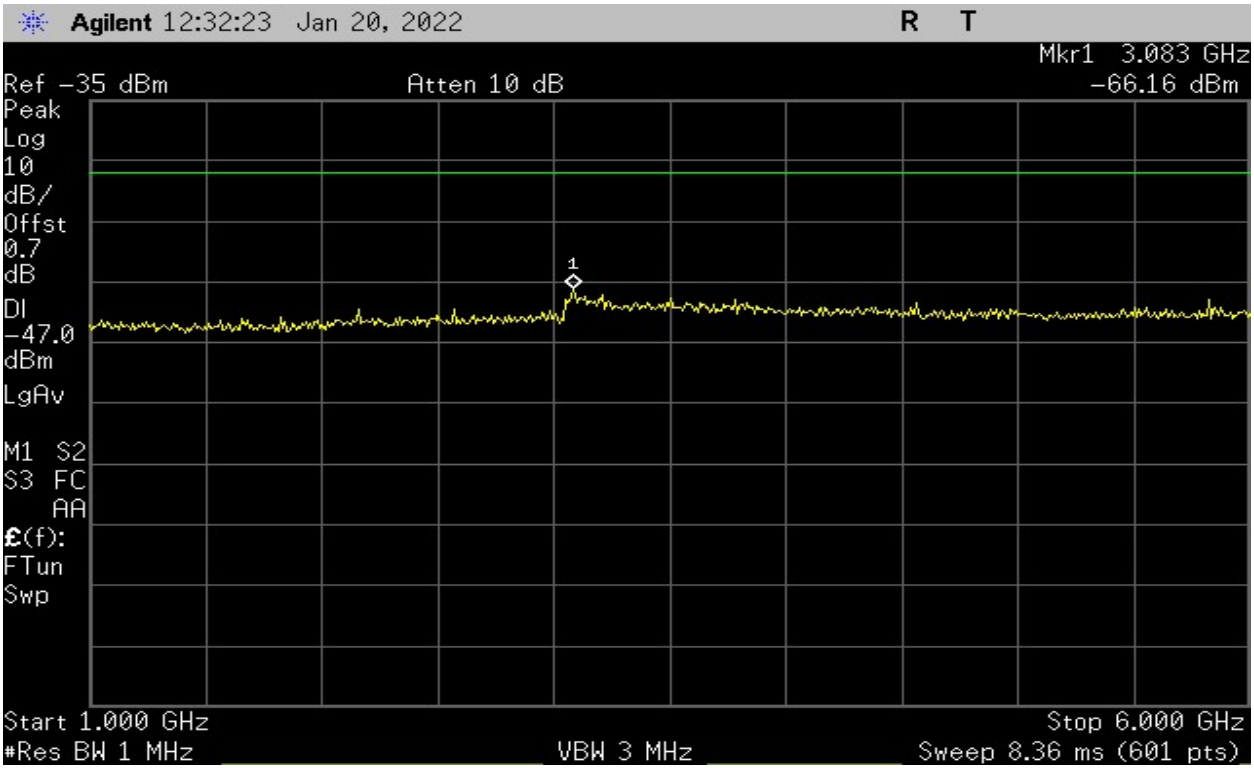
Figure 1. Radiated Emissions Test Setup (30MHz – 1GHz)



Plot 1 – Radiated Emissions – 30MHz to 1GHz (Beacon)



Plot 2 – Radiated Emissions – 30MHz to 1GHz (Sensor)



Plot 3 – Receiver Emissions (Conducted) – 1GHz to 6GHz (For Industry Canada RSS-GEN)

Criteria for Intentional Radiators

1. Occupied Bandwidth

Test Requirement(s):	15.247(a)(2), ANSI C63.10 and RSS-247 5.1(a)(b)	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	01/20/2022

Test Procedure: As required by 47 CFR 15.247(a): For Frequency hopping systems operating in the 902-928 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.

Test Setup:

Figure 2. Occupied Bandwidth Test Setup

Test Result:

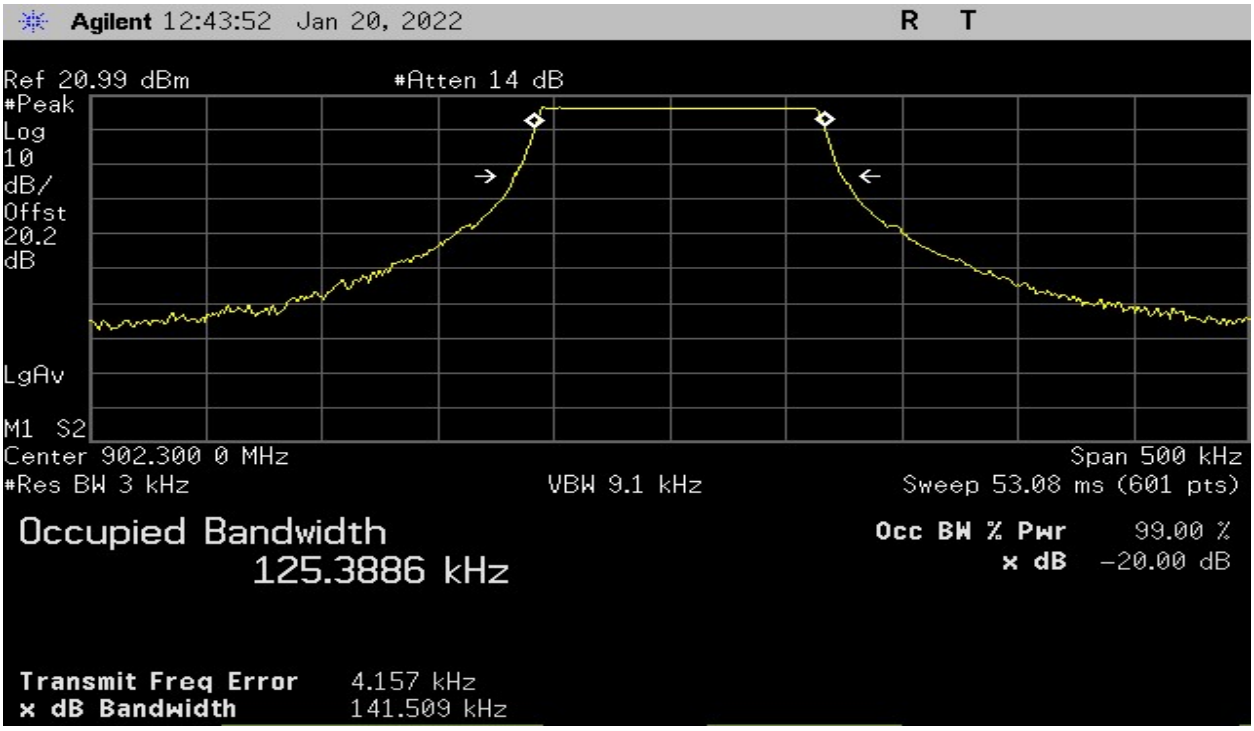
Frequency (MHz)	Recorded Measurement (kHz)	Comments
902.3	141.51	125kHz BW
908.7	139.90	125kHz BW
914.9	140.35	125kHz BW
903.0	606.86	500 kHz BW
907.8	604.65	500 kHz BW
914.2	607.21	500 kHz BW

Table 5. Occupied Bandwidth Summary, Test Results

Frequency (MHz)	Recorded Measurement (kHz)	Comments
902.3	125.39	125kHz BW
908.7	125.44	125kHz BW
914.9	125.51	125kHz BW
903.0	653.15	500 kHz BW
907.8	655.29	500 kHz BW
914.2	650.75	500 kHz BW

Table 6. 99% Bandwidth, Test Results

The following pages show measurements of Occupied Bandwidth plots:

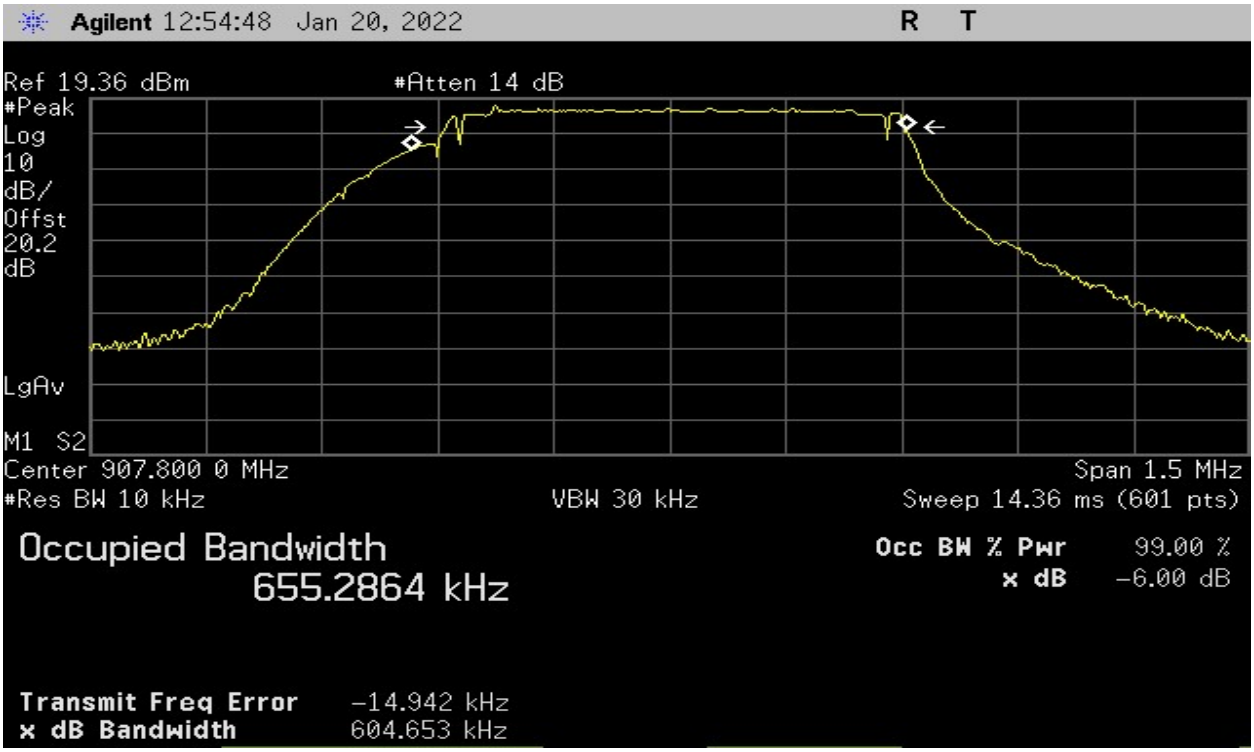


Plot 4 – Lowest Channel – 20dB BW (125kHz BW)

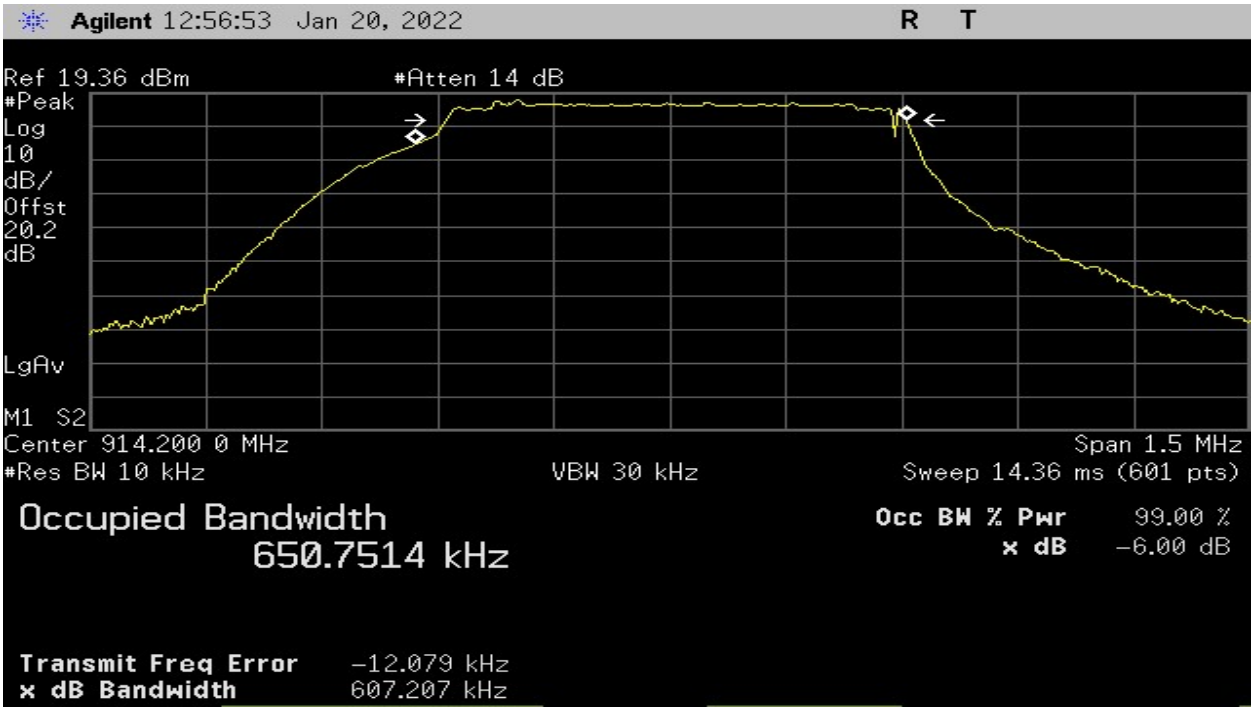
Plot 5 – Middle Channel – 20dB BW (125kHz BW)

Plot 6 – Highest Channel – 20dB BW (125kHz BW)

Plot 7 – Lowest Channel – 6dB BW (500kHz BW)



Plot 8 – Middle Channel – 6dB BW (500kHz BW)



Plot 9 – Highest Channel – 6dB BW (500 kHz BW)

2. RF Power Output

Test Requirement(s):	§15.247(b)(3) and RSS-247 5.4(1)	Test Engineer(s):	Sean E.
Test Results:	Pass	Test Date(s):	01/20/2022

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 using the Method AVGSA-1 as per ANSI C63.10-2013

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.

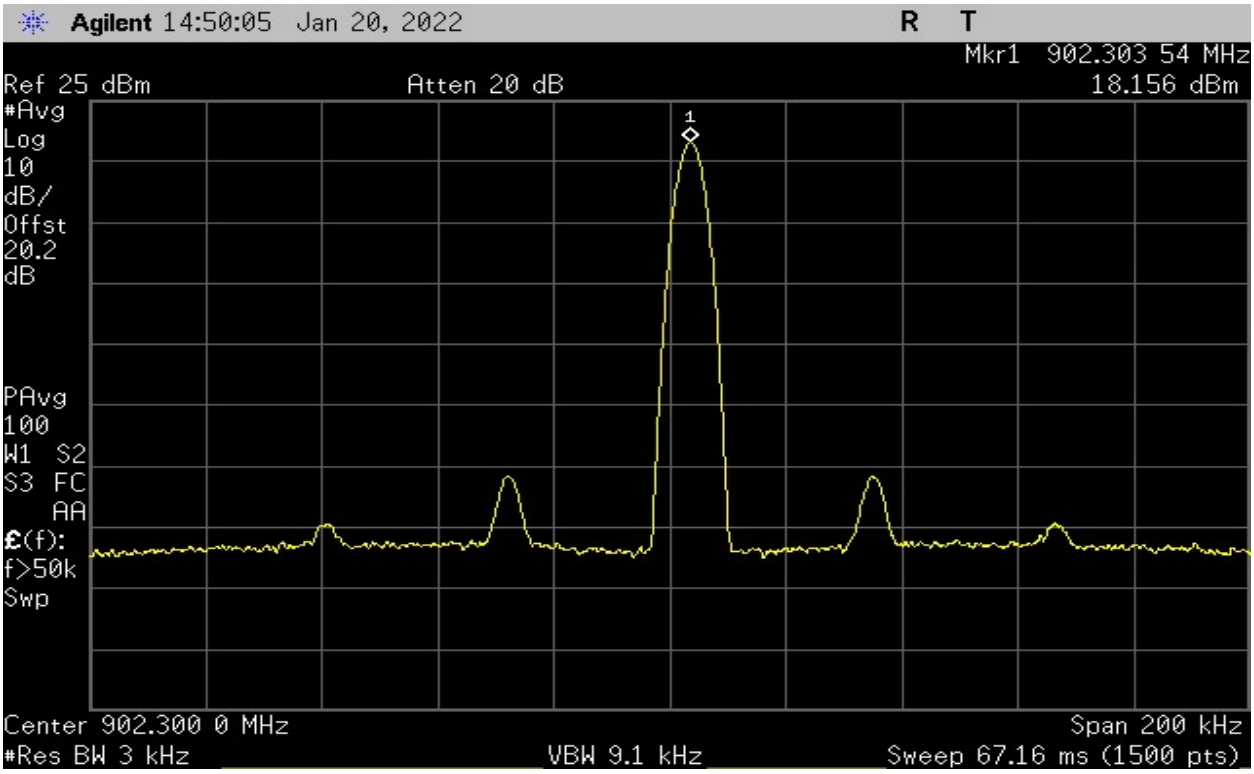
Test Setup:

Figure 3. RF Power Test Setup

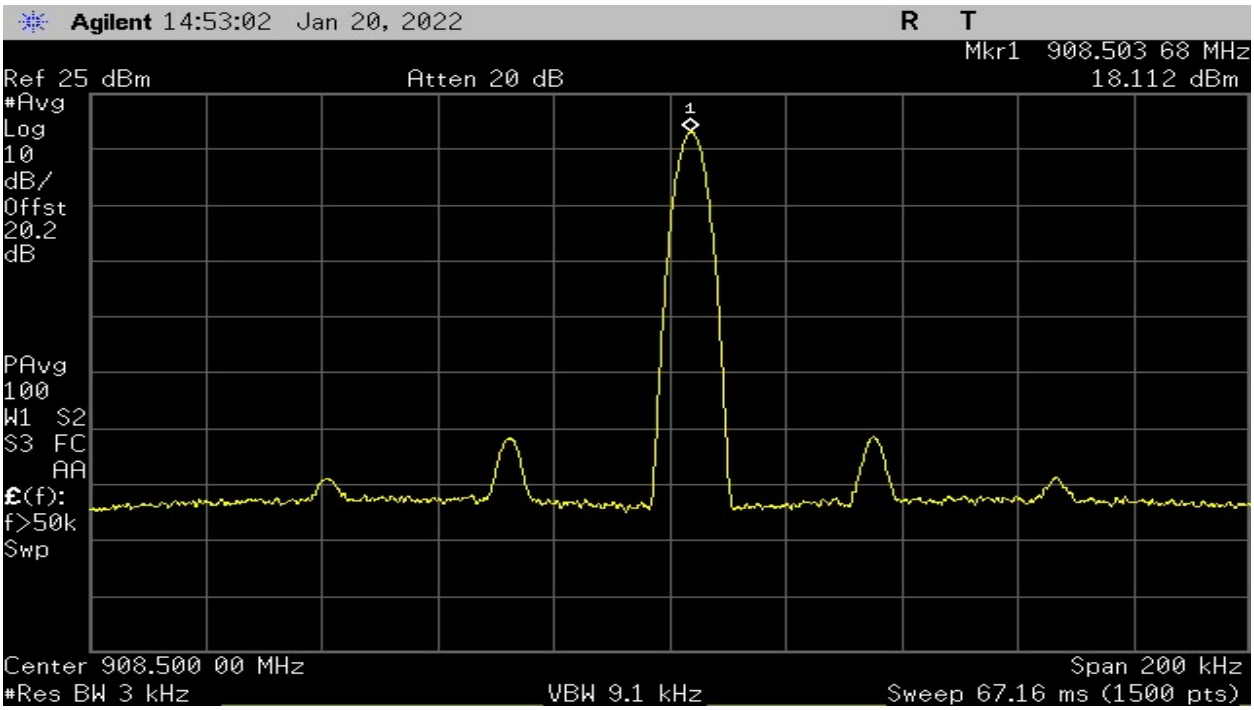
Test Result:

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (Watts)	Specification Limit
902.3	18.16	0.065	1W
908.7	18.11	0.065	1W
914.9	18.06	0.064	1W
903.0	18.16	0.065	1W
907.8	18.13	0.065	1W
914.2	17.93	0.062	1W

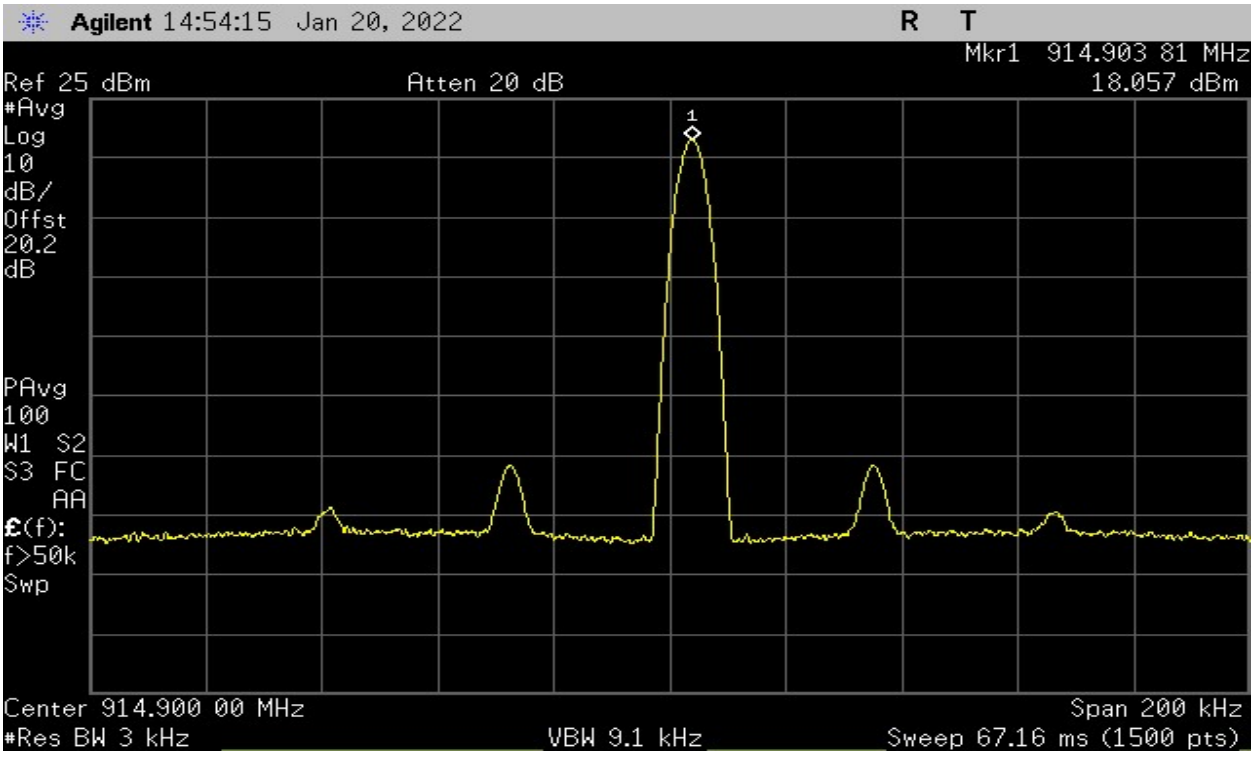
Table 7. RF Power Output, Test Results



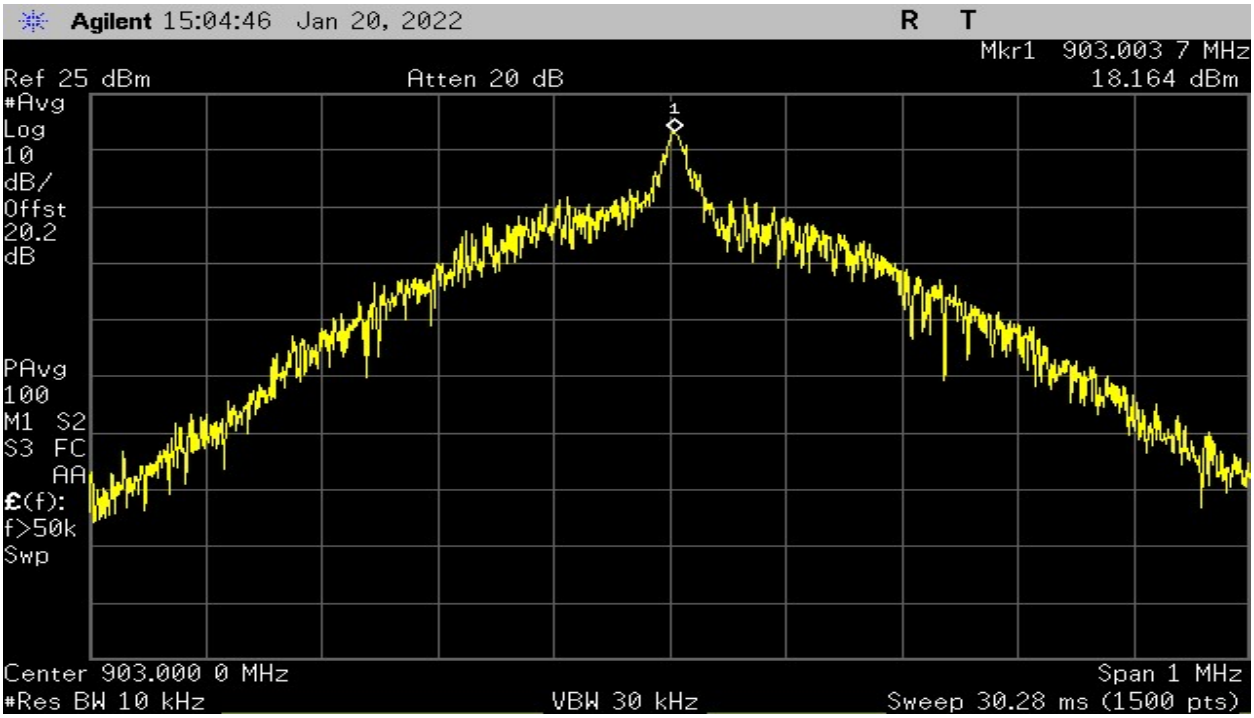
Plot 10 – Output Power – Lowest Channel



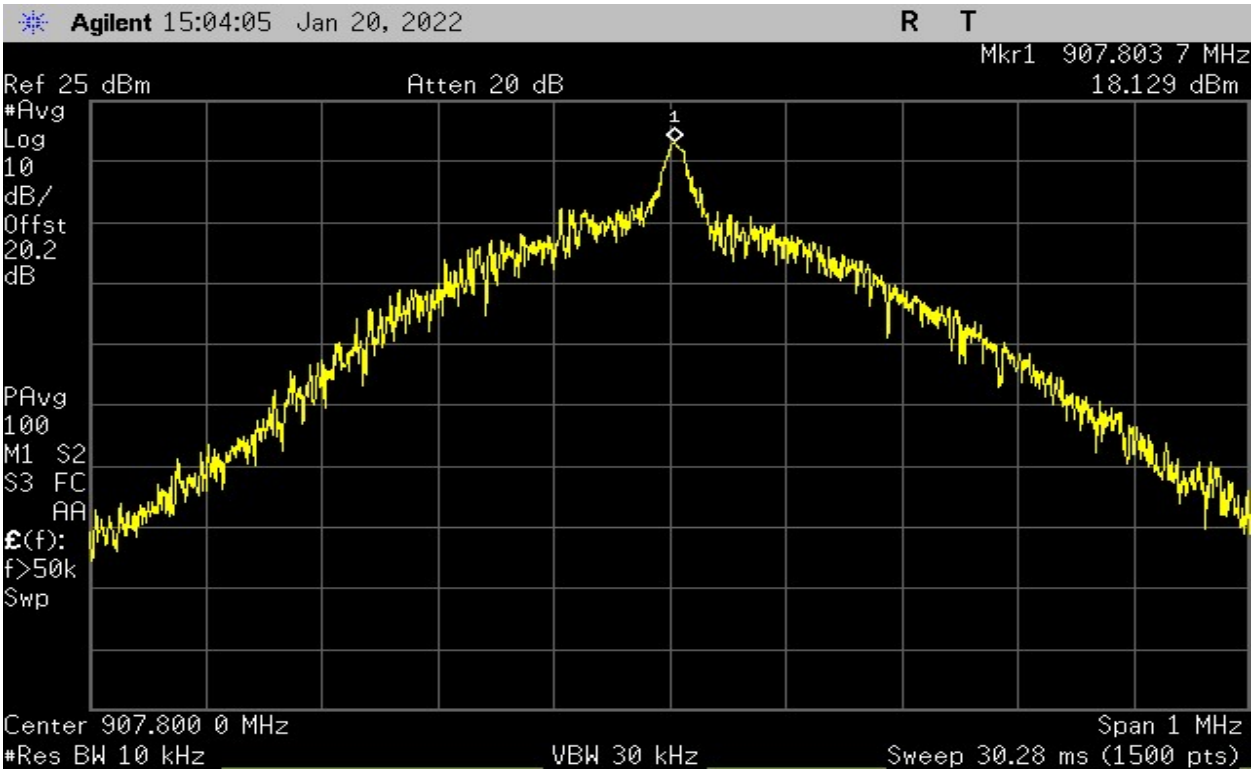
Plot 11 – Output Power – Middle Channel



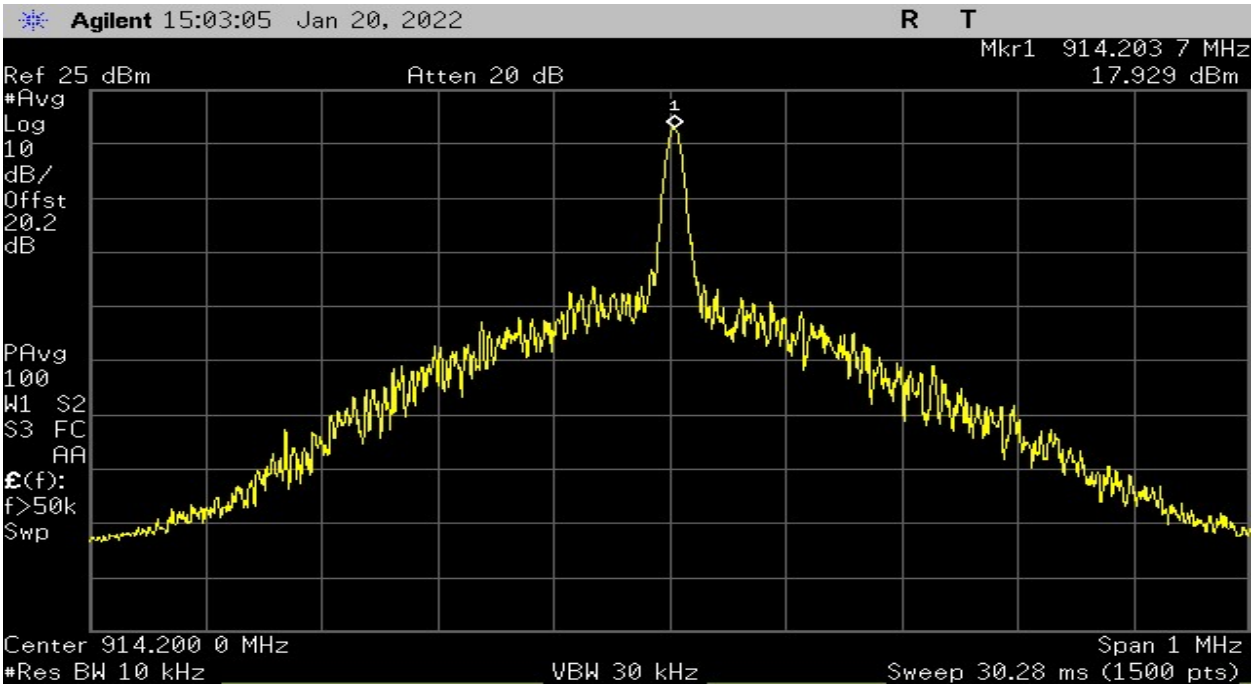
Plot 12 – Output Power – Highest Channel



Plot 13 – Output Power – Lowest Channel (500kHz BW)



Plot 14 – Output Power – Middle Channel (500khz BW)



Plot 15 – Output Power – Highest Channel (500kHz)

3. Conducted Spurious Emissions

Test Requirement(s):	§15.247(c) and RSS-247 5.5	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	01/20/2022

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 4. Conducted Spurious Emissions Test Setup

Test Result:

Frequency (GHz)	Measured Level (dBm)	Limit (dBm)
1.80	-45.3	-1.8

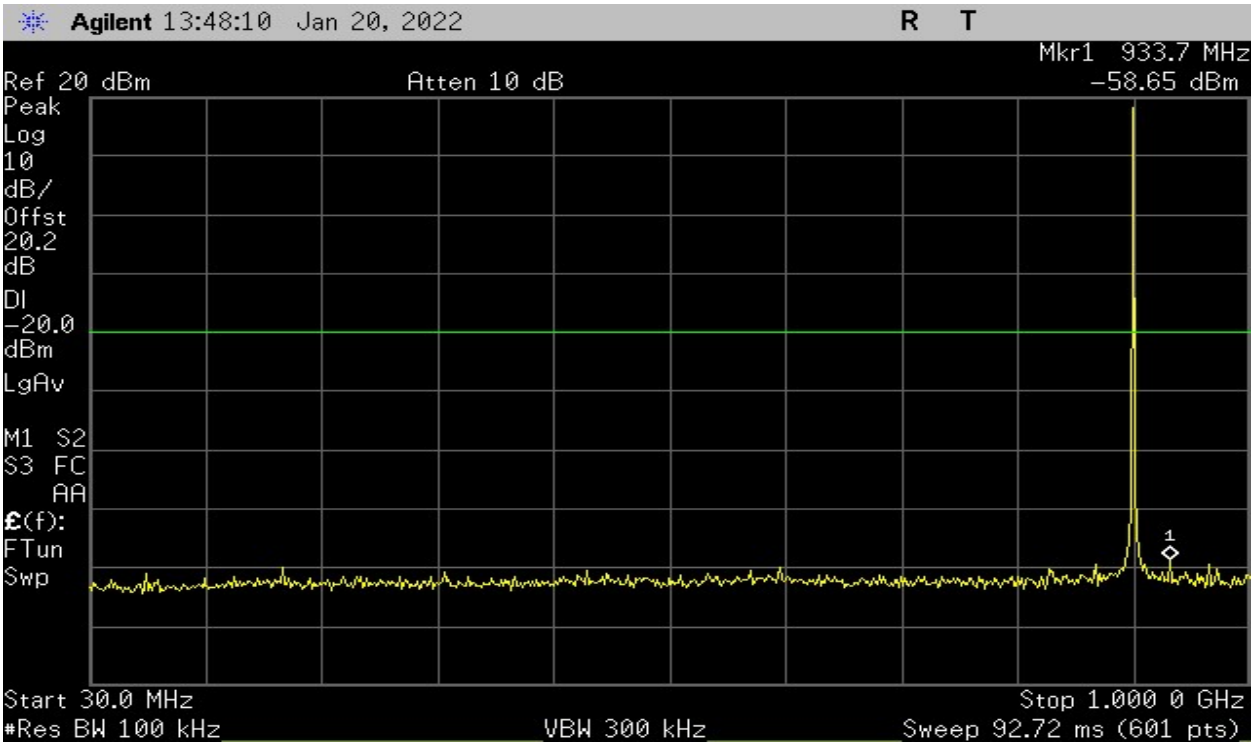
Table 8. Lowest Channel – Conducted Spurious Emissions, Test Results

Frequency (GHz)	Measured Level (dBm)	Limit (dBm)
1.81	-45.13	-1.8

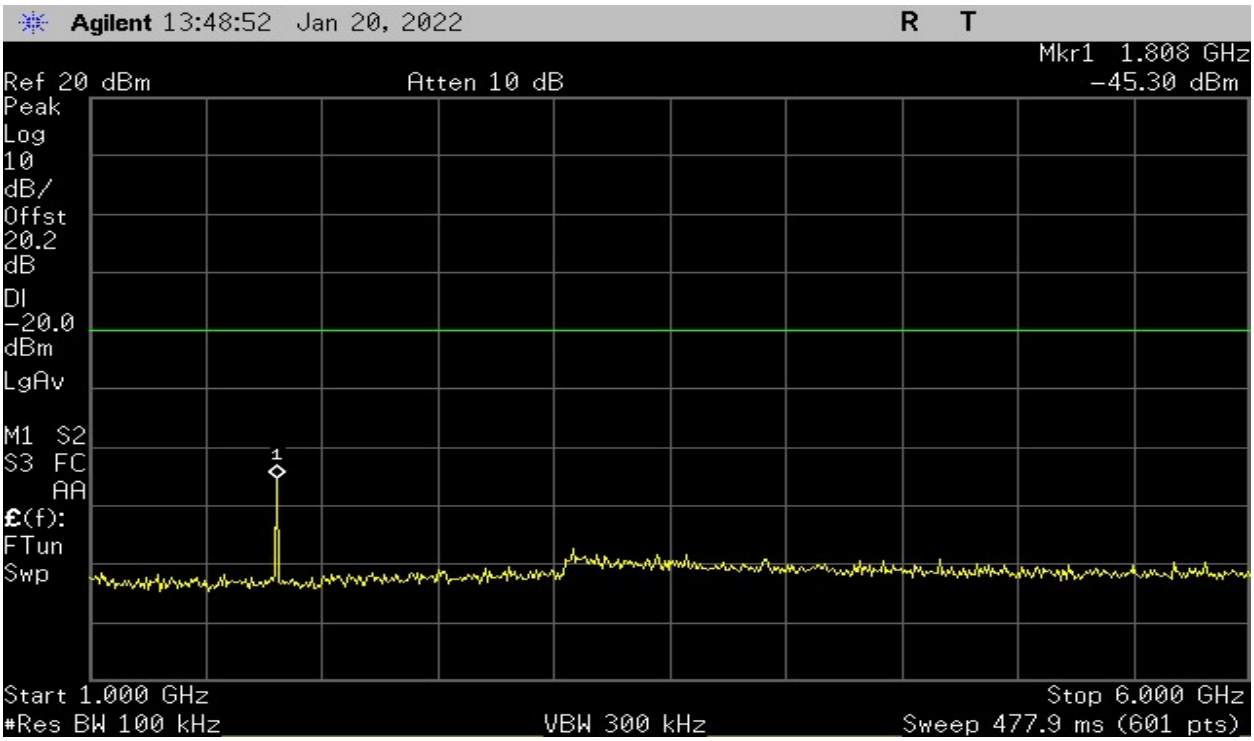
Table 9. Middle Channel – Conducted Spurious Emissions, Test Results

Frequency (GHz)	Measured Level (dBm)	Limit (dBm)
1.83	-45.23	-1.8

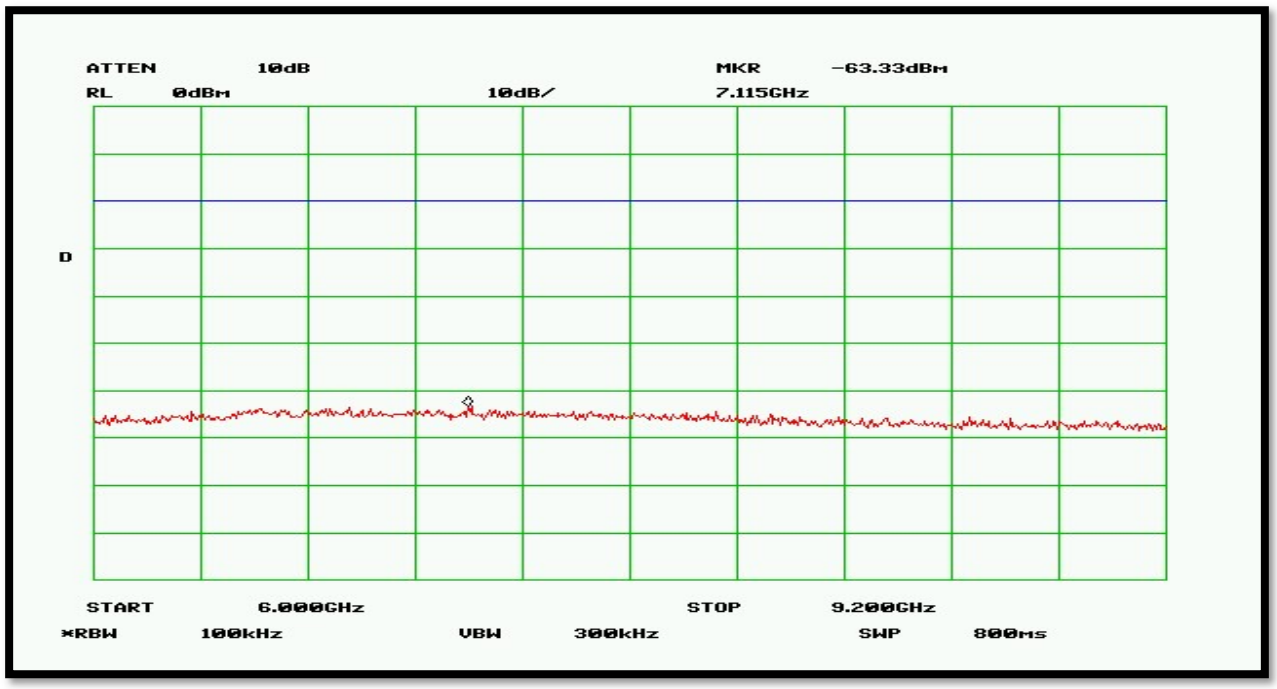
Table 10. Highest Channel – Conducted Spurious Emissions, Test Results



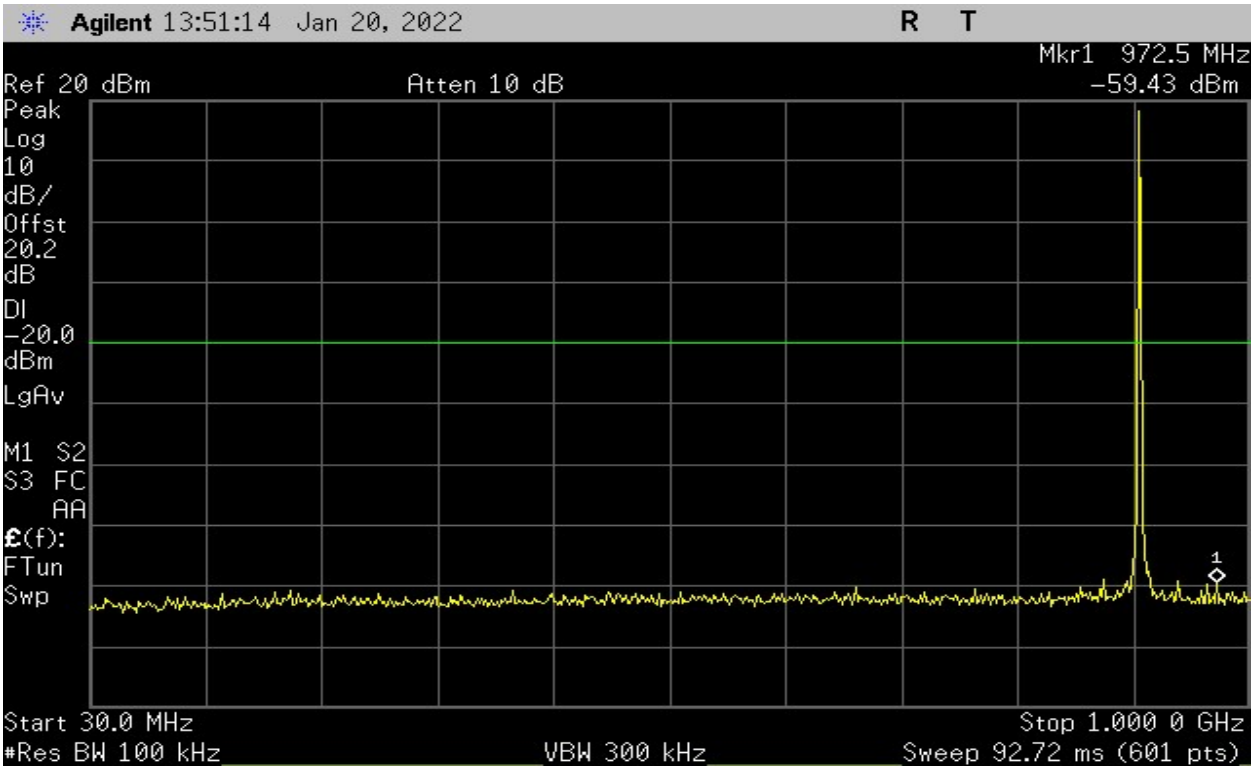
Plot 16 – Low Band – 30MHz to 1GHz (Channel 0)



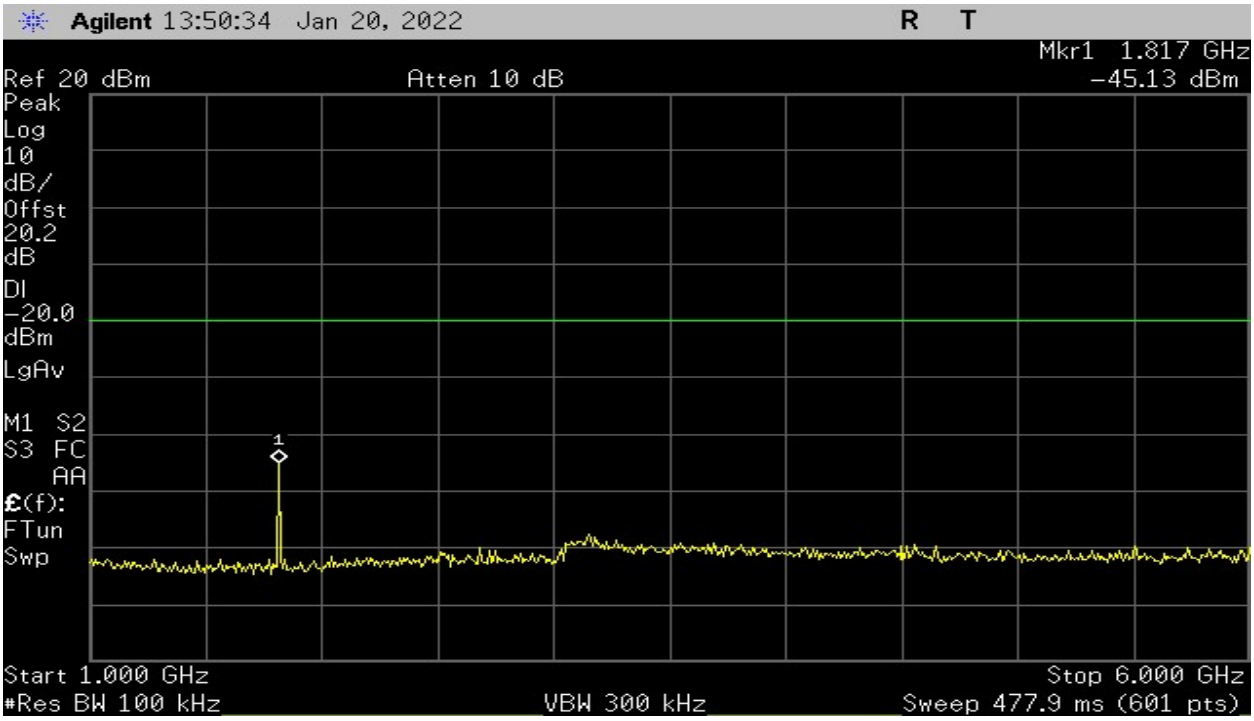
Plot 17 – Low Band – 1GHz to 6GHz (Channel 0)



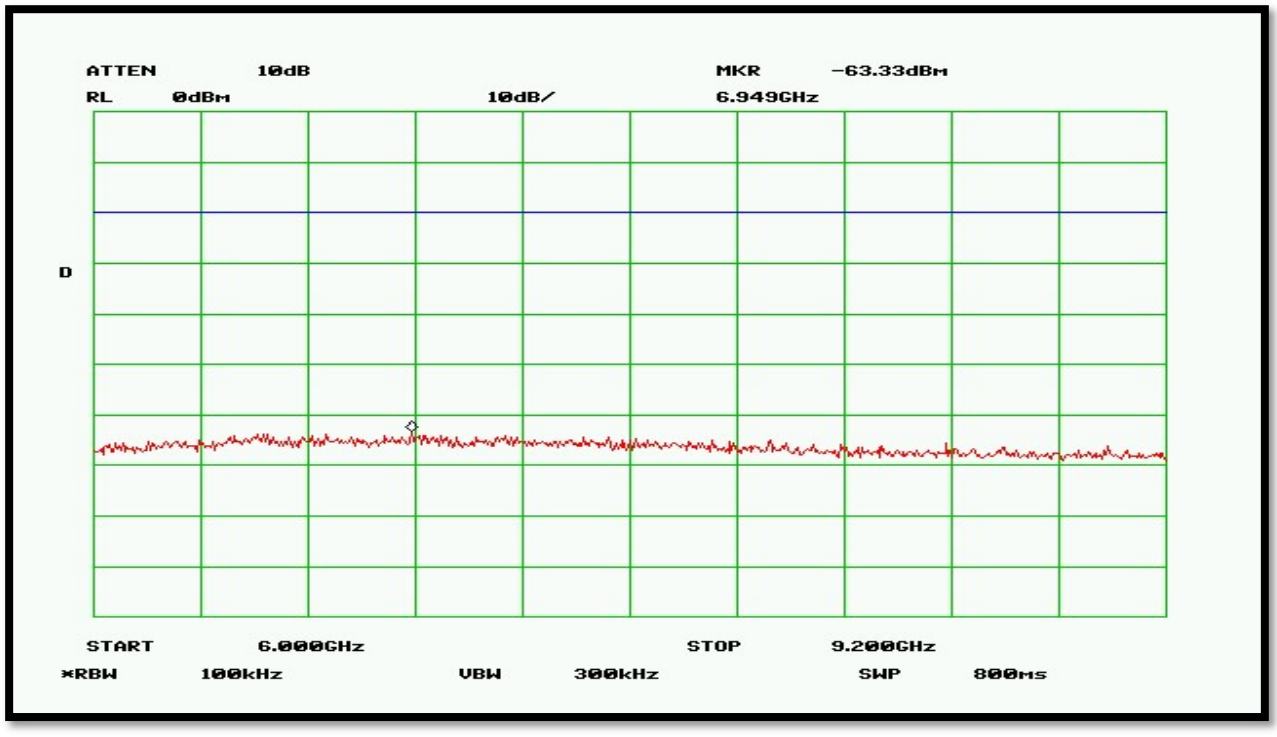
Plot 18 – Low Band – 6GHz to 9.2GHz (Channel 0)



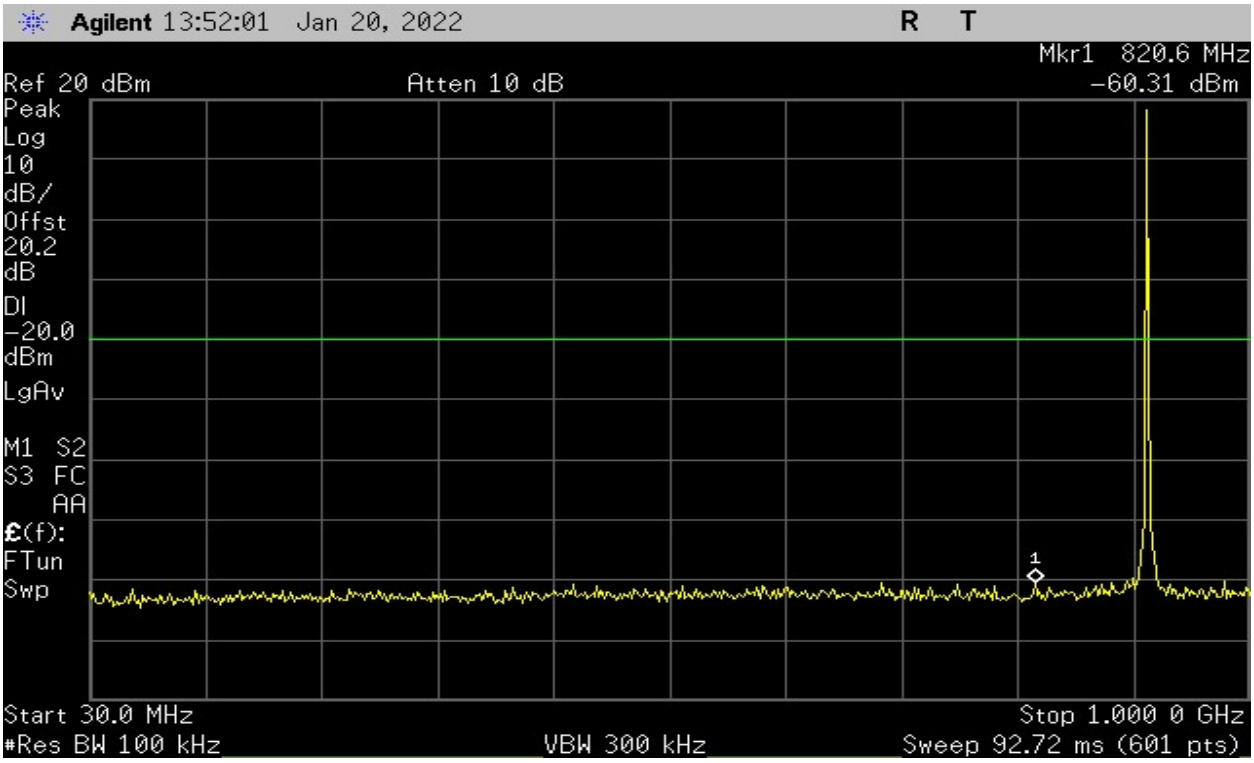
Plot 19 – Mid Band – 30MHz to 1GHz (Channel 32)



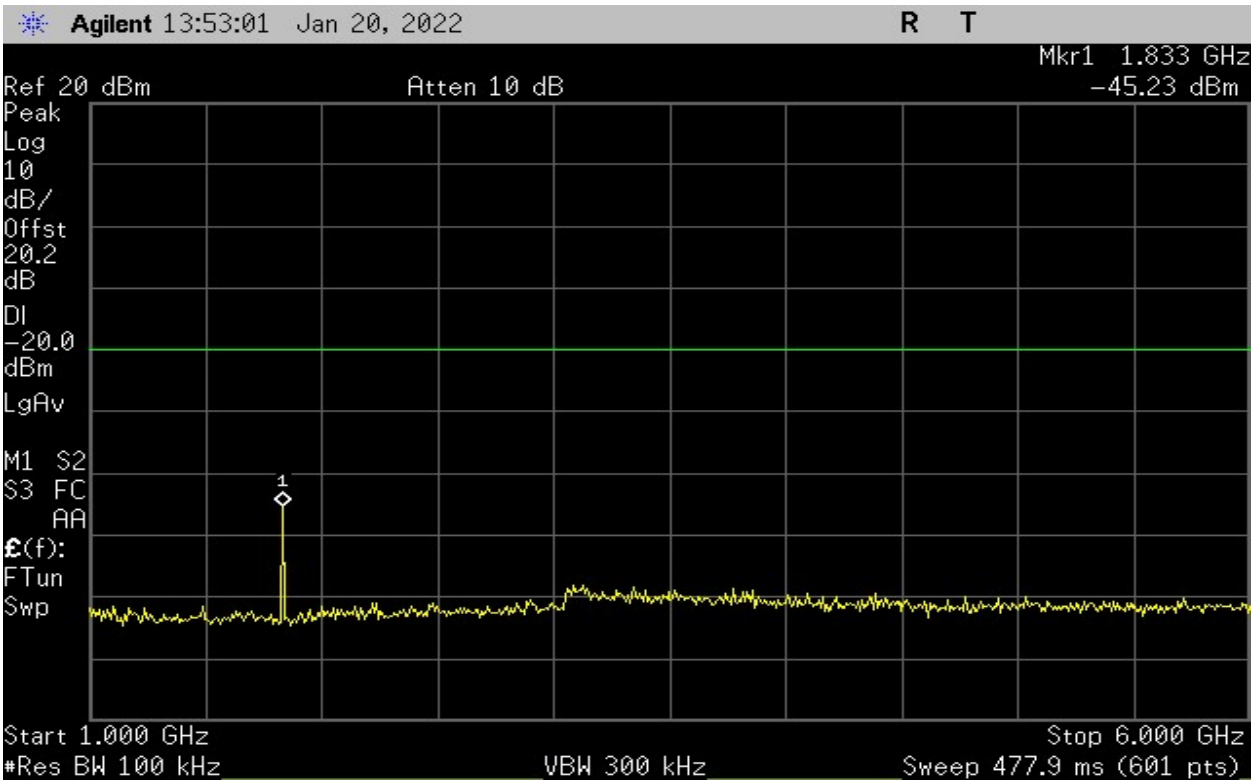
Plot 20 – Mid Band – 1GHz to 6GHz (Channel 32)



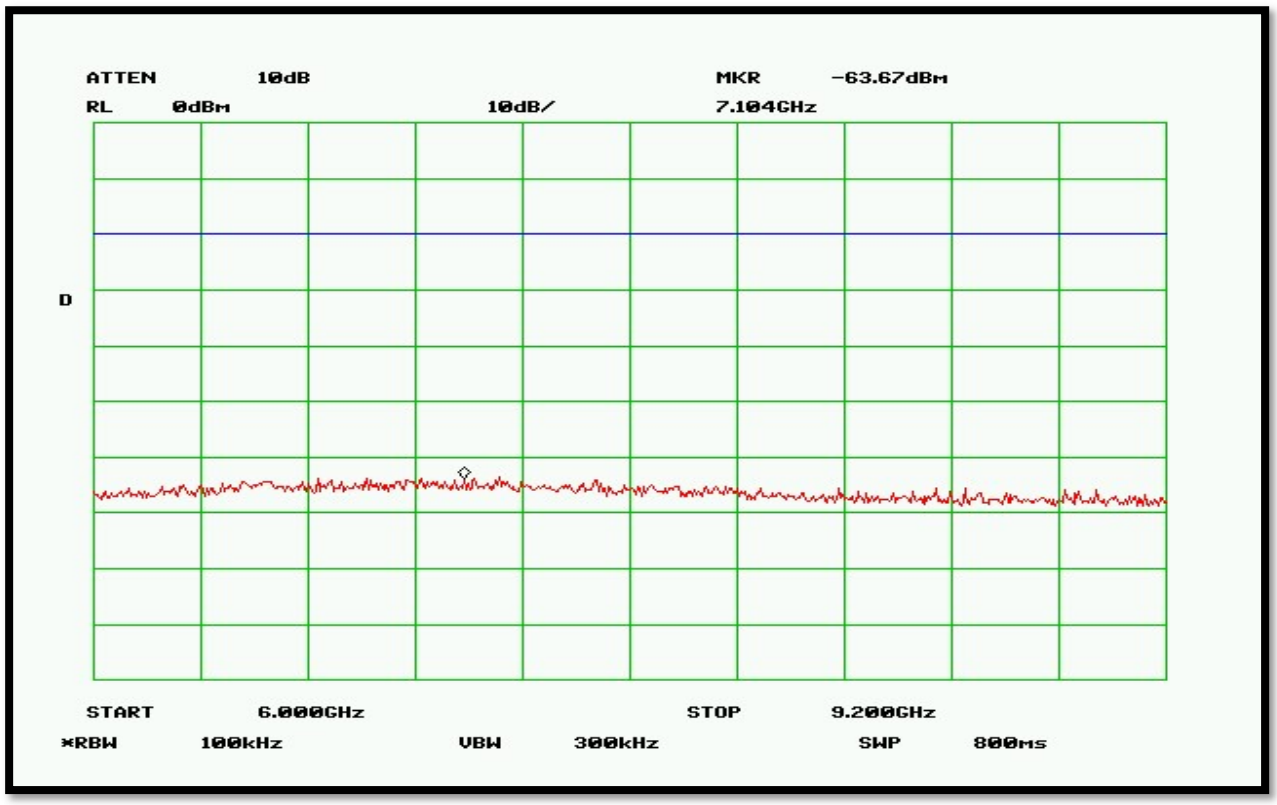
Plot 21 – Mid Band – 6GHz to 9.2GHz (Channel 32)



Plot 22 – High Band – 30MHz to 1GHz (Channel 71)



Plot 23 – High Band – 1GHz to 6GHz (Channel 71)



Plot 24 – High Band – 6GHz to 9.2GHz (Channel 71)

4. Radiated Spurious Emissions and Restricted Band

Test Requirement(s):	§15.247(d), 15.209(a), 15.205 and RSS Gen 8.0	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	02/02/2022

Test Procedures: As required by 47 CFR 15.247, Radiated spurious measurements were made in accordance with the procedures of the FCC Guidance Document 558074 D01.

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 11. Analyzer Settings

Test Setup:

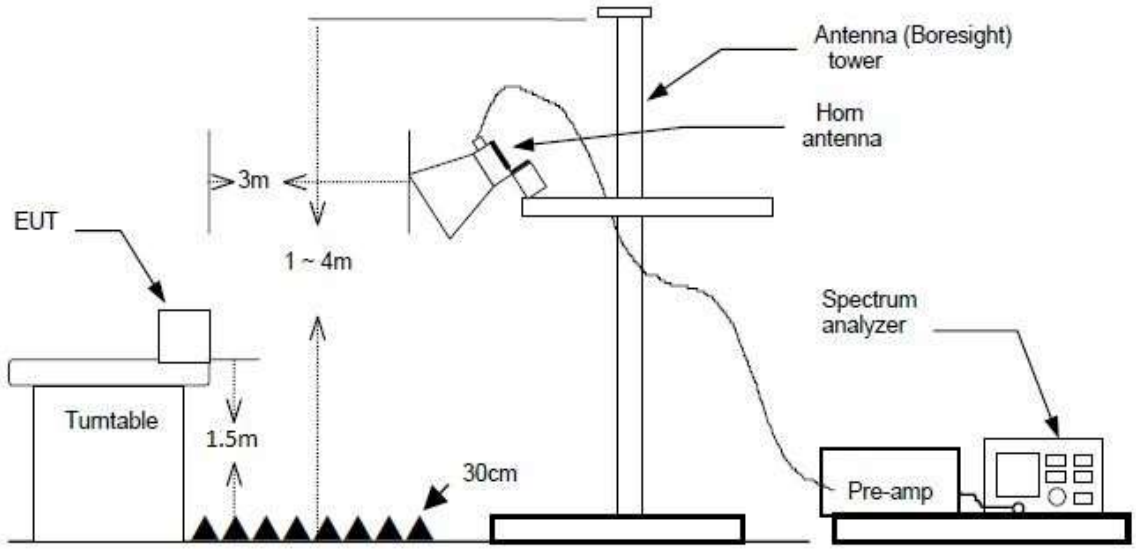


Figure 5. Radiated Emission Above 1GHz Test Setup

Test Result:

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m))	Average Limit (dBuV/m)
1804.6	49.309	113.4	-	95.6
2706.9*	40.16	74.0	-	54.0
3609.2*	-	74.0	-	54.0

Table 12 - Spurious Radiated Emission Data – Low Band – (125kHz BW) – Beacon

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1817.4	48.0	113.3	-	91.8
2726.1*	37.57	74.0	-	54.0
3634.8*	-	74.0	-	54.0

Table 13– Spurious Radiated Emission Data – Mid Band- (125kHz BW) – Beacon

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1829.8	45.92	113.3	-	93.4
2744.7*	38.46	74.0	-	54.0
3659.6*	-	74.0	-	54.0

Table 14- Spurious Radiated Emission Data – High Band – (125khz BW) – Beacon

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m))	Average Limit (dBuV/m)
1806	48.98	113.4	-	94.4
2709*	39.66	74.0	-	54.0
3612*	-	74.0	-	54.0

Table 15 - Spurious Radiated Emission Data – Low Band – (500kHz BW) – Beacon

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1815.6	48.0	113.3	-	92.0
2723.4*	38.4	74.0	-	54.0
3631.2*	-	74.0	-	54.0

Table 16– Spurious Radiated Emission Data – Mid Band- (500kHz BW) – Beacon

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1828.4	46.78	113.1	-	94.0
2742.6*	39.49	74.0	-	54.0
3656.8*	-	74.0	-	54.0

Table 17- Spurious Radiated Emission Data – High Band – (500kHz BW) – Beacon

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

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

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m))	Average Limit (dBuV/m)
1804.6	33.79	113.4	-	95.6
2706.9*	43.47	74.0	-	54.0
3609.2*	34.21	74.0	-	54.0

Table 12 - Spurious Radiated Emission Data – Low Band – (125kHz BW) – Sensor

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1817.4	29.50	113.3	-	91.8
2726.1*	39.73	74.0	-	54.0
3634.8*	-	74.0	-	54.0

Table 13– Spurious Radiated Emission Data – Mid Band- (125kHz BW) – Sensor

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1829.8	29.74	113.3	-	93.4
2744.7*	41.13	74.0	-	54.0
3659.6*	-	74.0	-	54.0

Table 14- Spurious Radiated Emission Data – High Band – (125khz BW) – Sensor

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m))	Average Limit (dBuV/m)
1806	29.64	113.4	-	94.4
2709*	42.16	74.0	-	54.0
3612*	-	74.0	-	54.0

Table 15 - Spurious Radiated Emission Data – Low Band – (500kHz BW) – Sensor

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1815.6	30.67	113.3	-	92.0
2723.4*	40.39	74.0	-	54.0
3631.2*	-	74.0	-	54.0

Table 16– Spurious Radiated Emission Data – Mid Band- (500kHz BW) – Sensor

Frequency (MHz)	Peak Amplitude (dbuV/m)	Peak Limit (dBuV/m)	Average Amplitude (dBuV/m)	Average Limit (dBuV/m)
1828.4	32.27	113.1	-	94.0
2742.6*	41.83	74.0	-	54.0
3656.8*	-	74.0	-	54.0

Table 17- Spurious Radiated Emission Data – High Band – (500kHz BW) – Sensor

6. Emissions At Band Edges

Test Requirement(s):	§15.247(d) and RSS Gen 8.0	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	01/27/2022

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.

Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT output was connected directly to the spectrum analyzer through an attenuator. The EUT was set up at maximum power, first on the lowest operating channel, then on the highest operating channel of the transmit band.

Detector Setting	Resolution Bandwidth	Video Bandwidth	Sweep Time
Peak	100 kHz	300 kHz	Auto

Table 18 – Analyzer settings

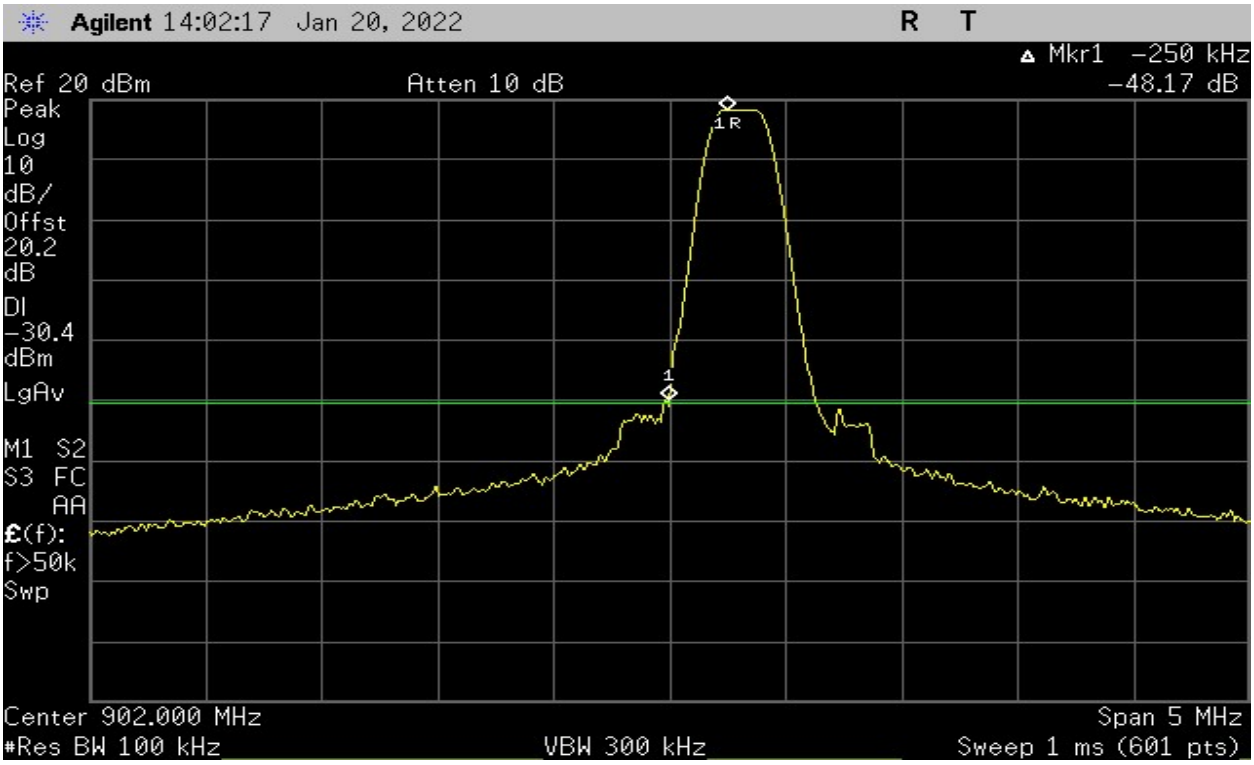
Test Result:

Frequency (MHz)	Measured Level	Detector	Limit	Comments
902.0	-48.17dB	Peak	-20dBc	125kHz BW
928.0	-78.67dB	Peak	-20dBc	125kHz BW
902.0	-62.00dB	Peak	-20dBc	500 kHz BW
928.0	-78.09dB	Peak	-20dBc	500 kHz BW

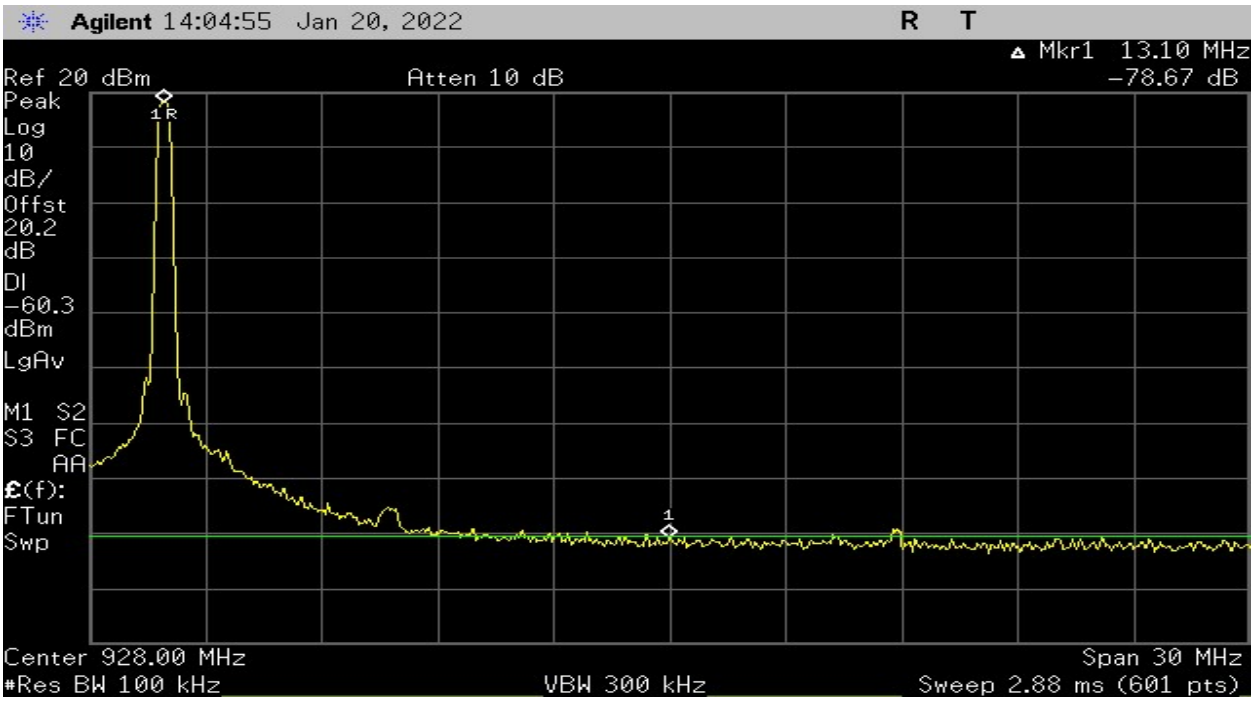
Table 19 – Band Edge Emissions Summary

Test Setup:

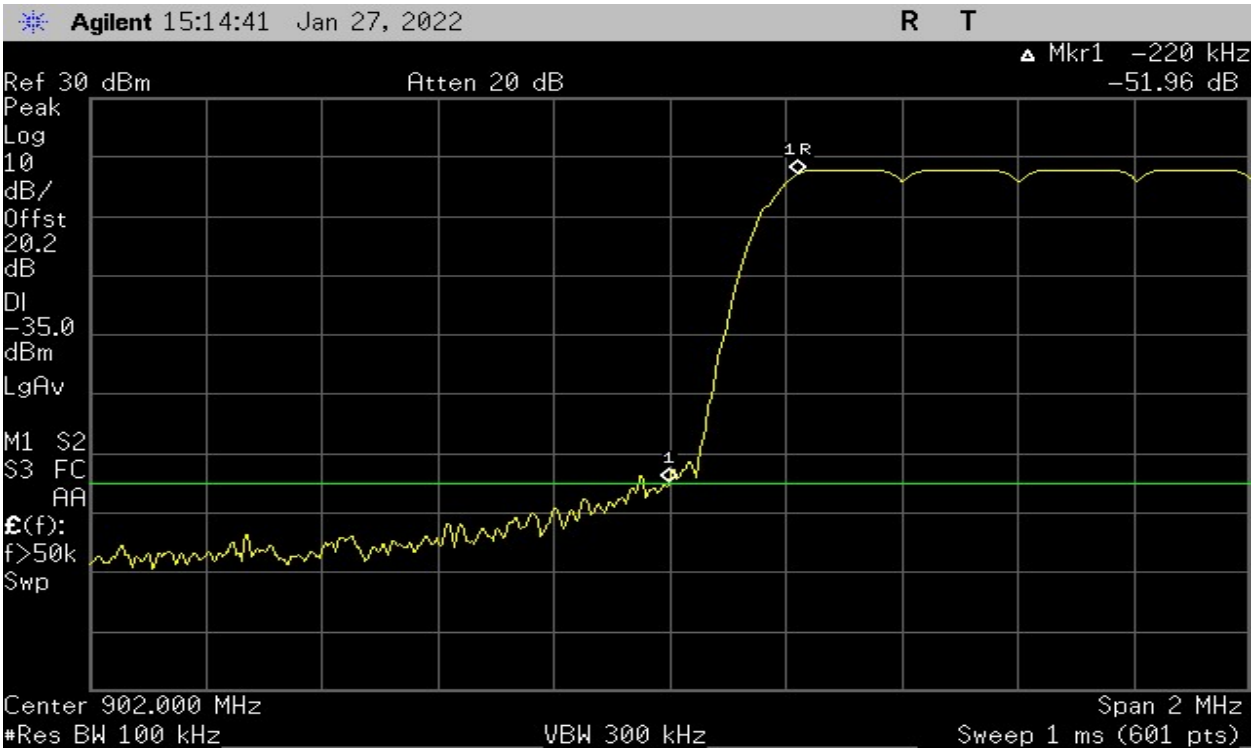
Figure 6. Band Edge Test Setup



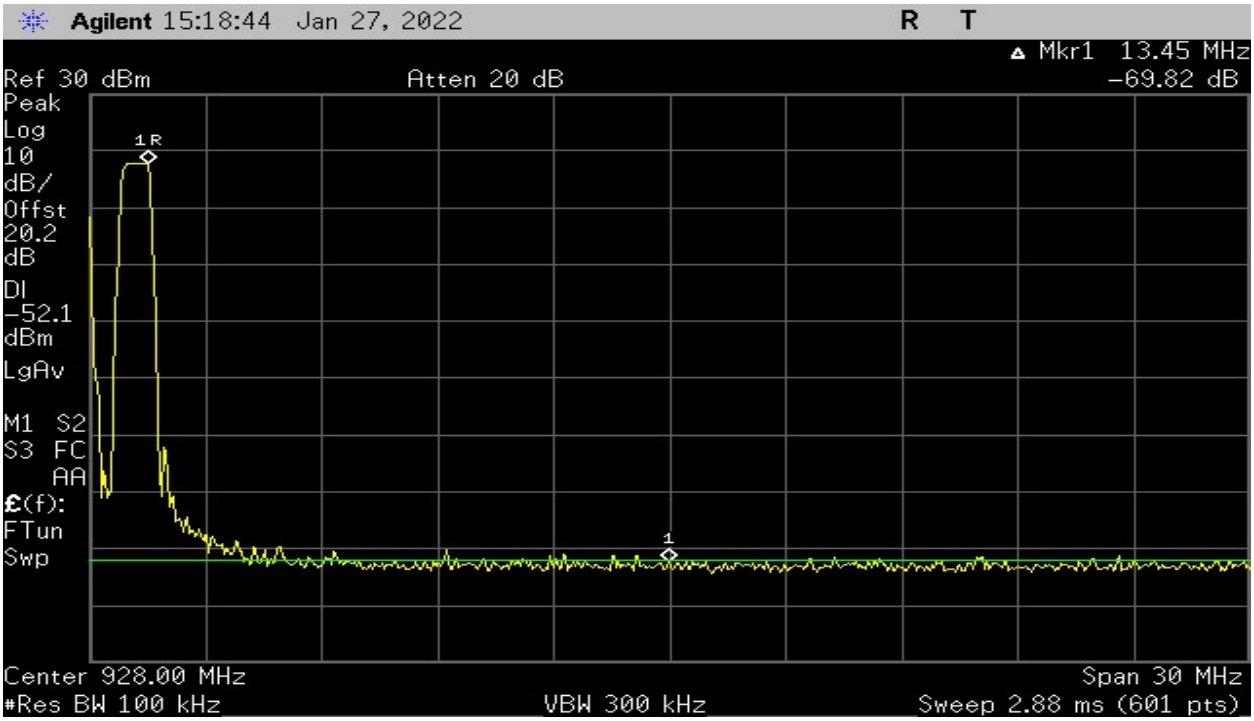
Plot 25 - Band Edge – Low Channel (125kHz BW) – Hopping Off



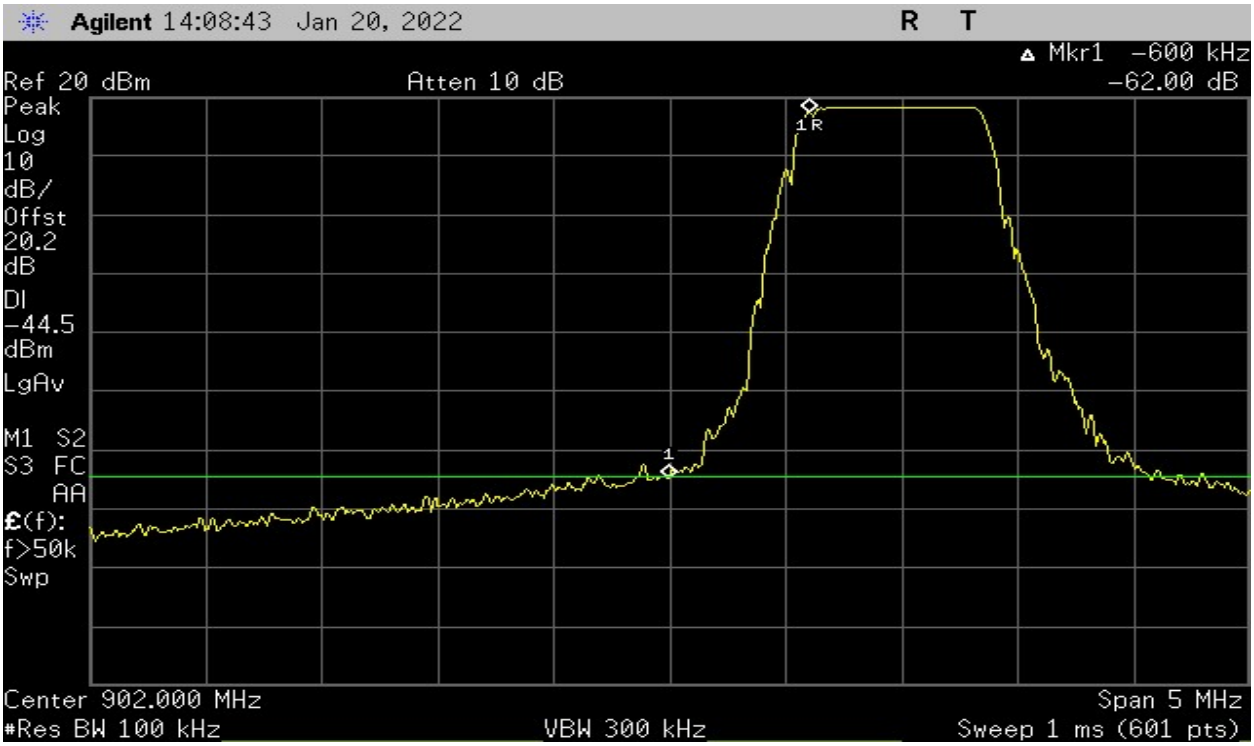
Plot 26 – Band Edge - High Channel (125kHz BW) – Hopping Off



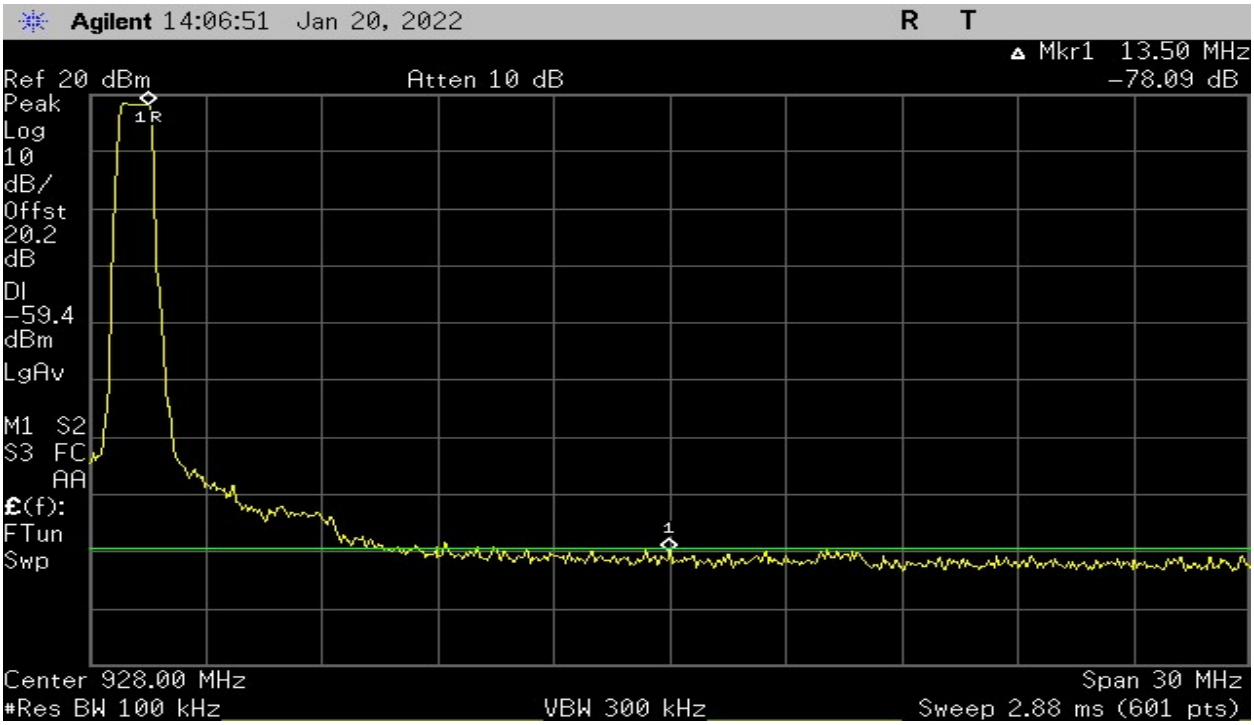
Plot 27 - Band Edge – Low Channel (125kHz BW) – Hopping On



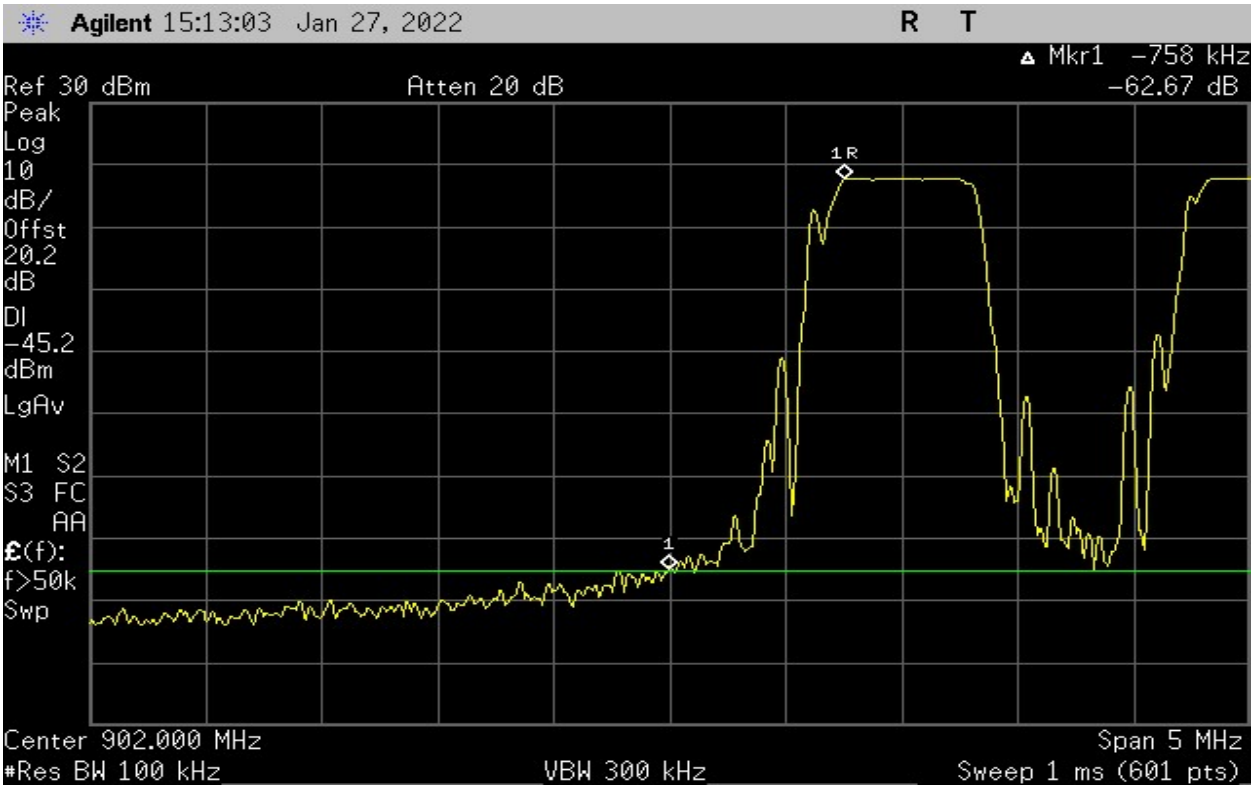
Plot 28 – Band Edge - High Channel (125kHz BW) – Hopping On



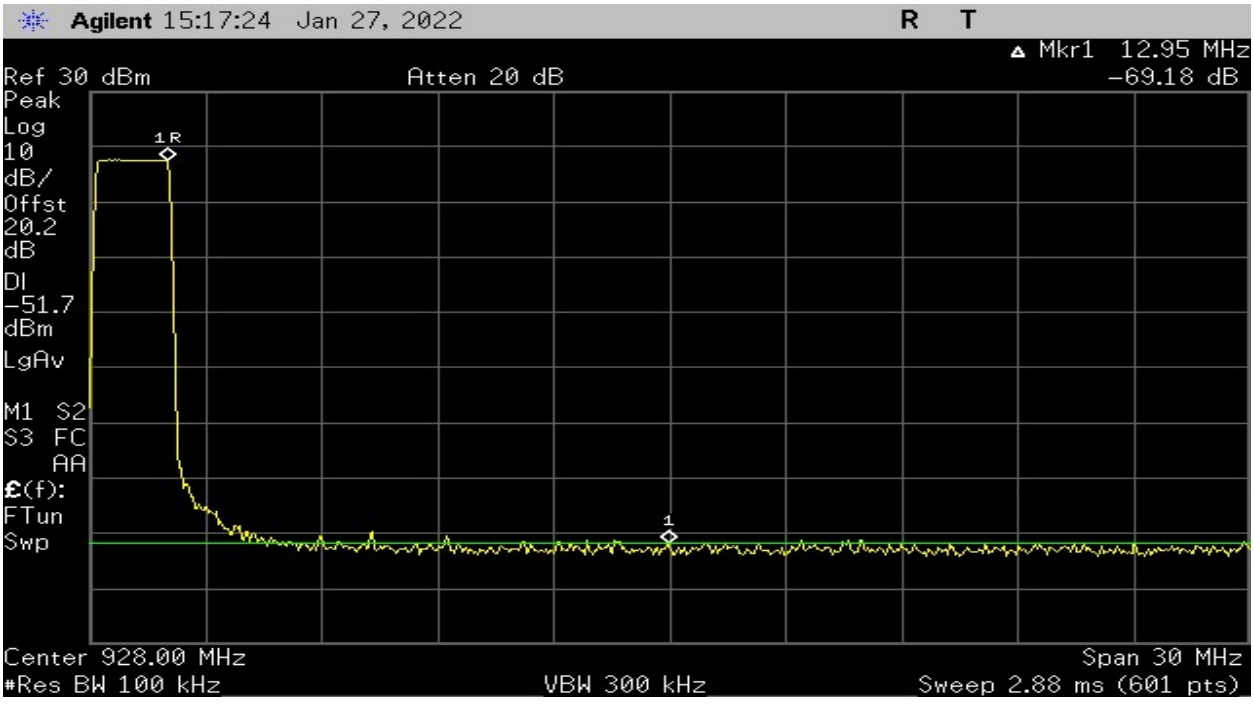
Plot 29 - Band Edge – Low Channel (500kHz BW) – Hopping Off



Plot 30 - Band Edge – High Channel (500 kHz BW) – Hopping Off



Plot 31 - Band Edge – Low Channel (500kHz BW) – Hopping On



Plot 32 - Band Edge – High Channel (500 kHz BW) – Hopping On

7. Power Spectral Density

Test Requirement(s):	§15.247(f), ANSI C63.10 and RSS-247 5.2(b)	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	01/20/2022

Test Procedures: As required by 47 CFR 15.247(f), For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3kHz band during any time interval of continuous transmission. Power spectral density measurements were made at the RF antenna output terminals of the EUT using the DTS methods section 8.4 was used for DTS mode and section 10 was used for Hybrid mode.

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	Sweep Time	Span
Peak	3KHz	Auto	2 MHz

Table 20 – Analyzer settings

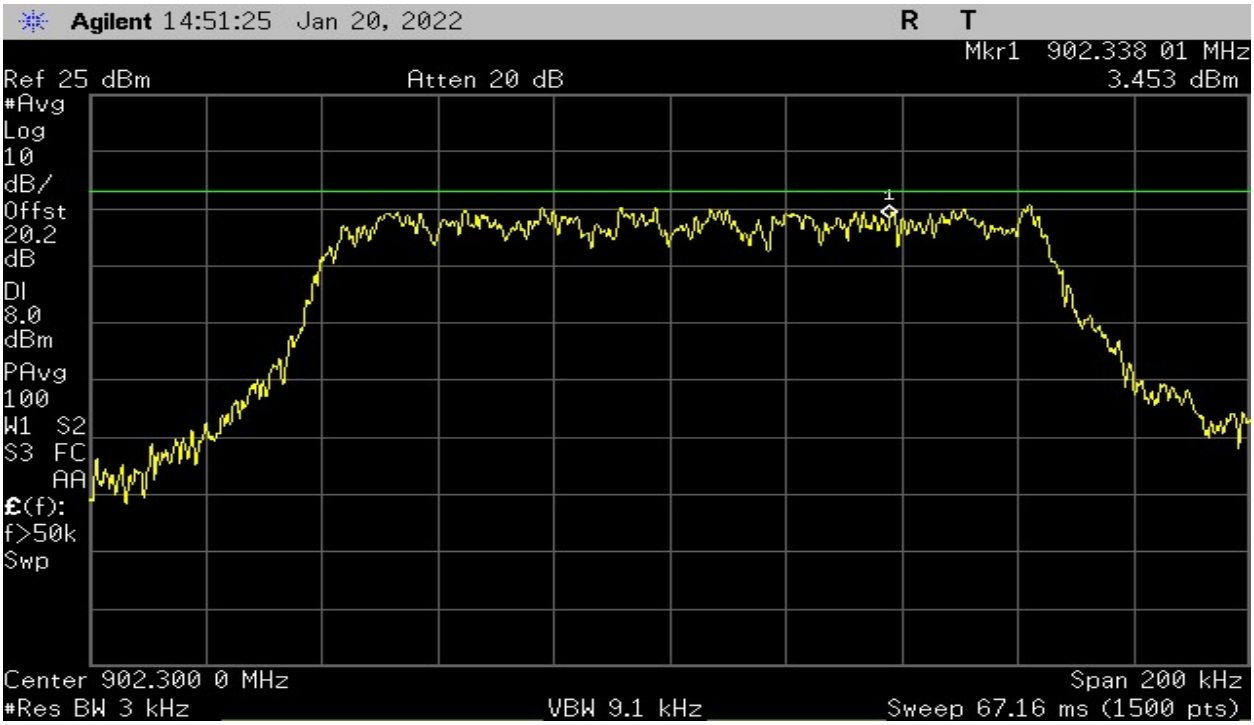
Test Result:

Frequency (MHz)	Measured Level (dBm)	Limit
902.3	3.45	8 dBm
908.5	4.55	8 dBm
914.9	4.64	8 dBm

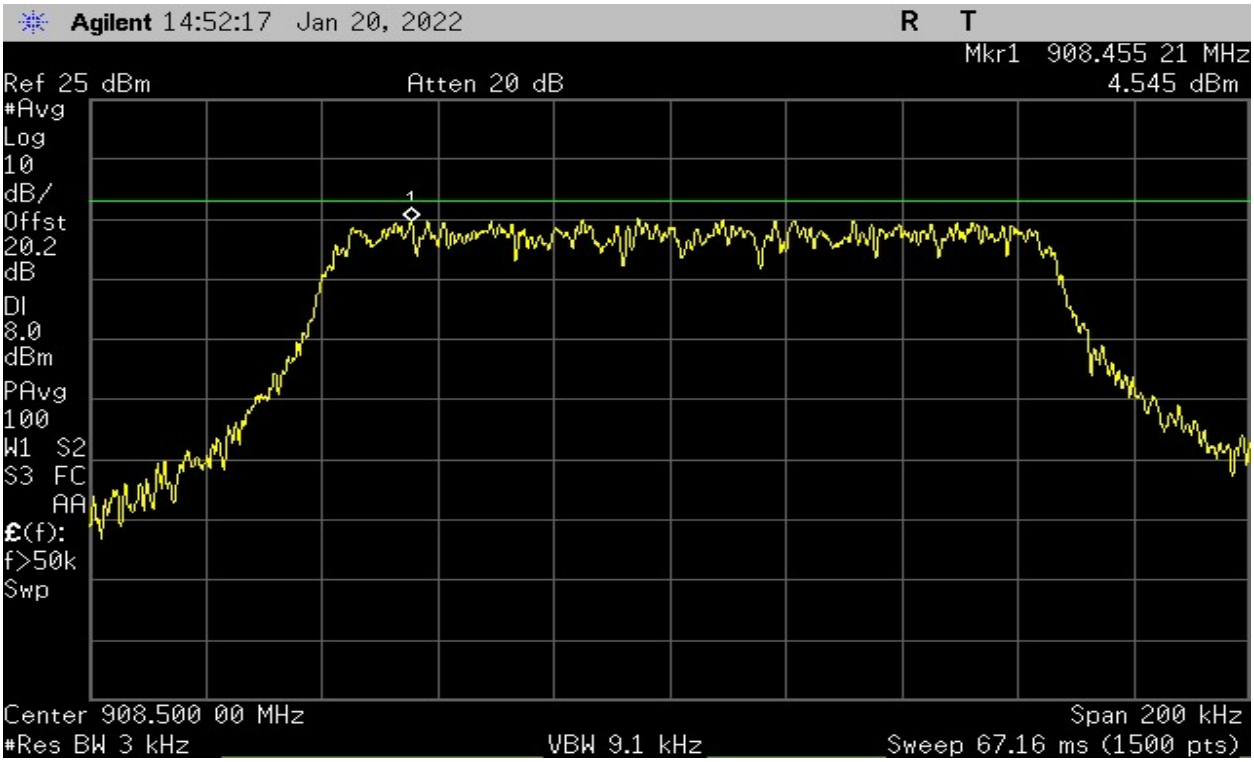
Table 21 - PSD Summary Test Result- 125kHz BW

Frequency (MHz)	Measured Level (dBm)	Limit
903.0	-1.59	8 dBm
907.8	-1.31	8 dBm
914.2	-0.92	8 dBm

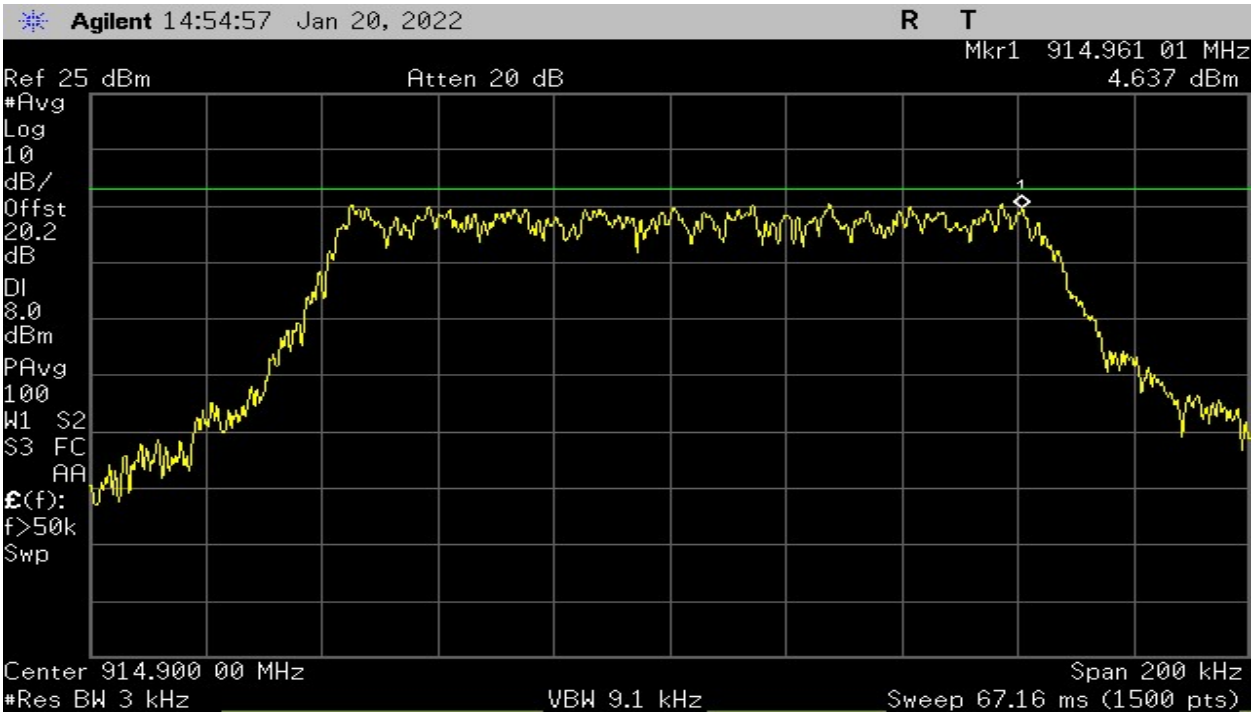
Table 22 - PSD Summary Test Result- 500kHz BW



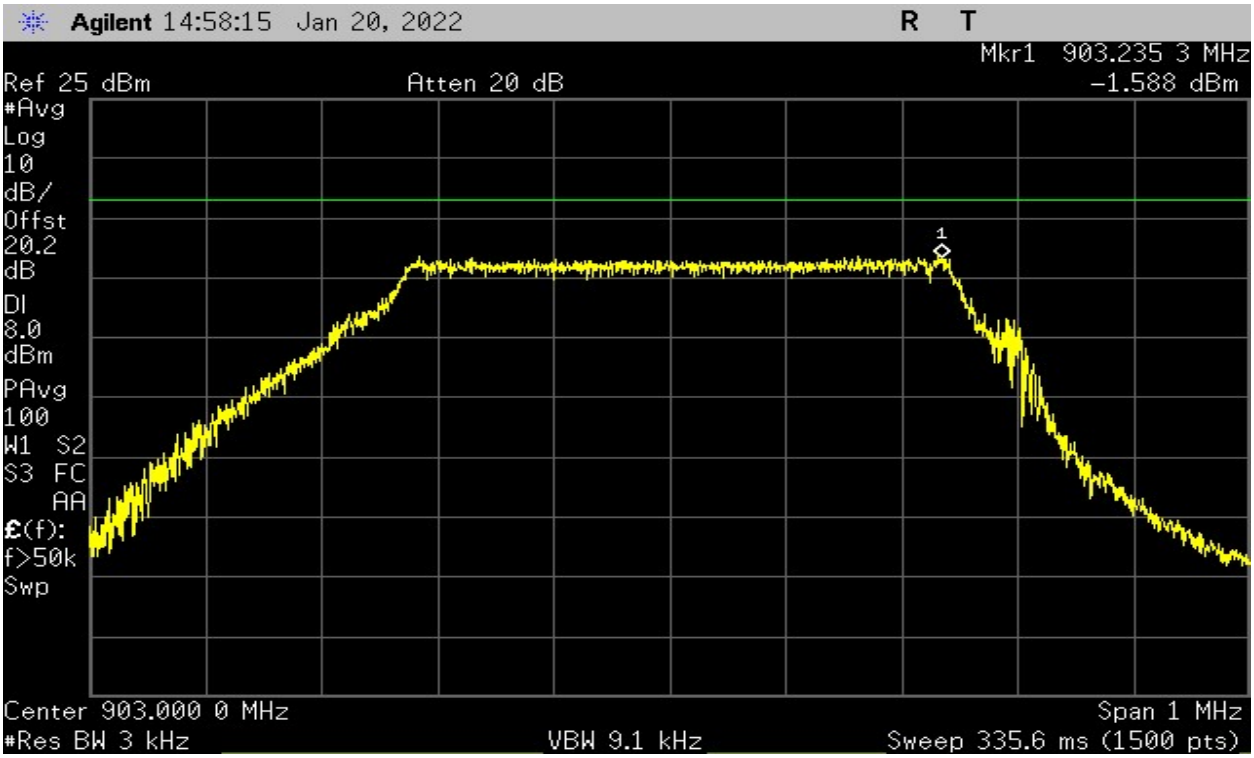
Plot 33 – Power Spectral Density – Lowest Channel – 125kHz BW



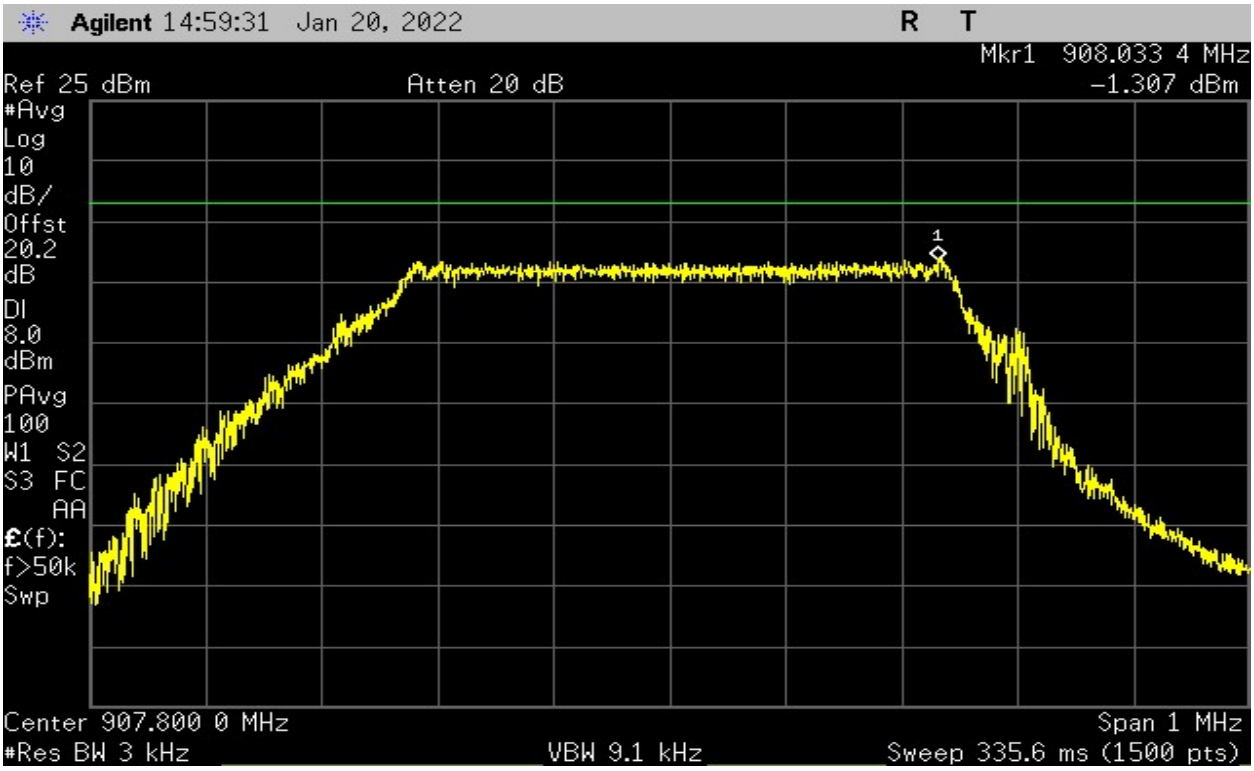
Plot 34 – Power Spectral Density – Middle Channel – 125kHz BW



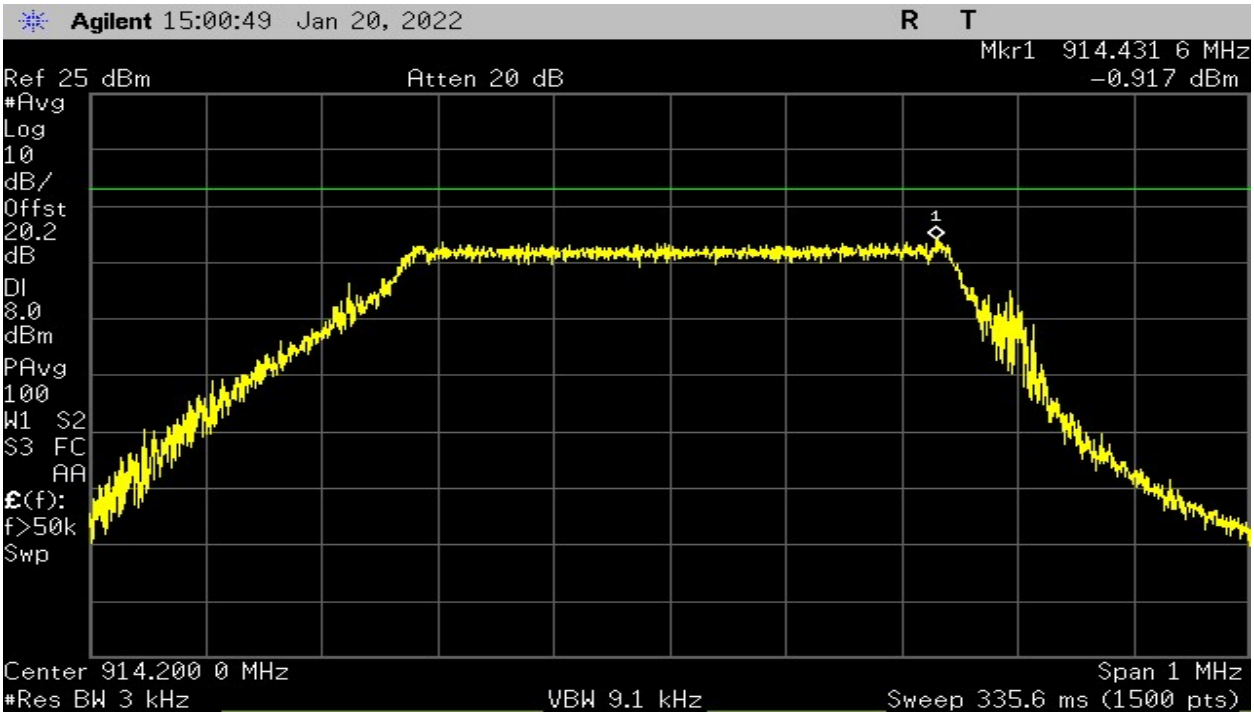
Plot 35 – Power Spectral Density – Highest Channel – 125kHz BW



Plot 36 – Power Spectral Density – Lowest Channel – 500kHz BW



Plot 37 – Power Spectral Density – Middle Channel – 500kHz BW



Plot 38 – Power Spectral Density – Highest Channel – 500kHz BW

8. Time of Occupancy (Dwell Time)

Test Requirement(s):	§15.247(a) and RSS 247 5.1(c)	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	01/27/2022

Test Procedures: As required by 47 CFR 15.247(a), for frequency hopping spread spectrum operating at 902-928 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 23 – Analyzer settings

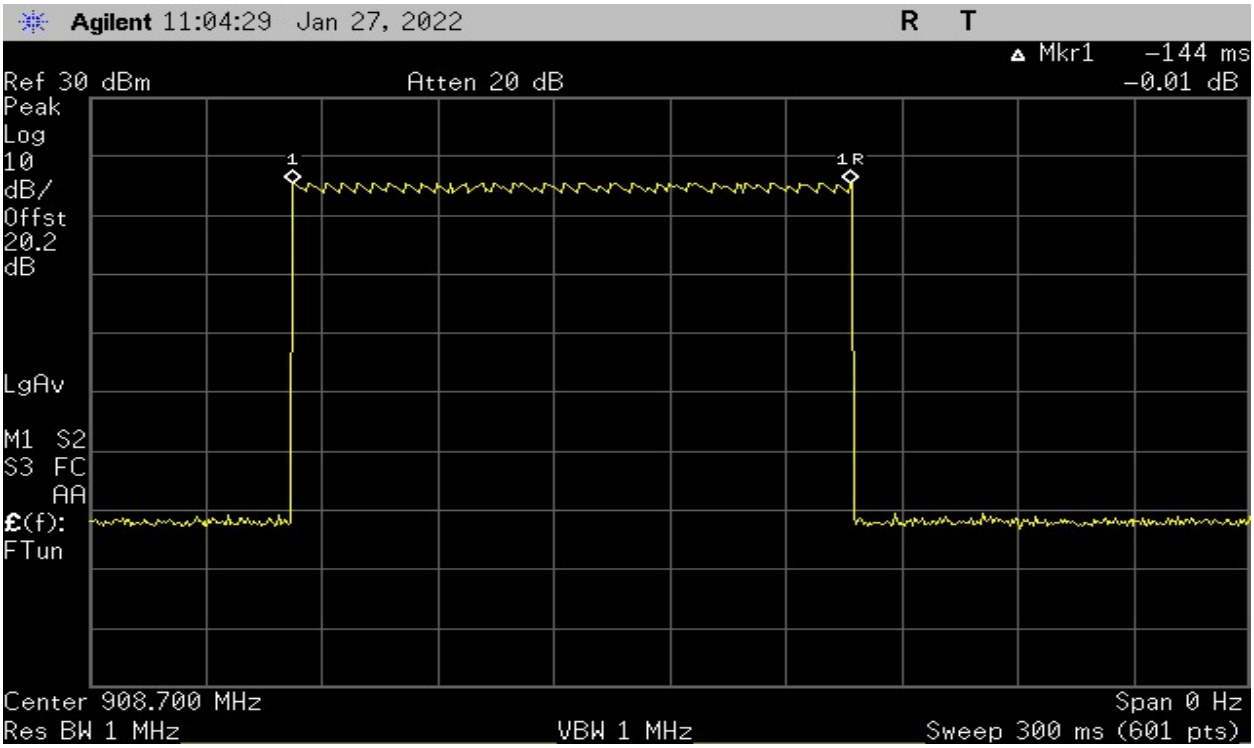
Test Result:

Calculation:

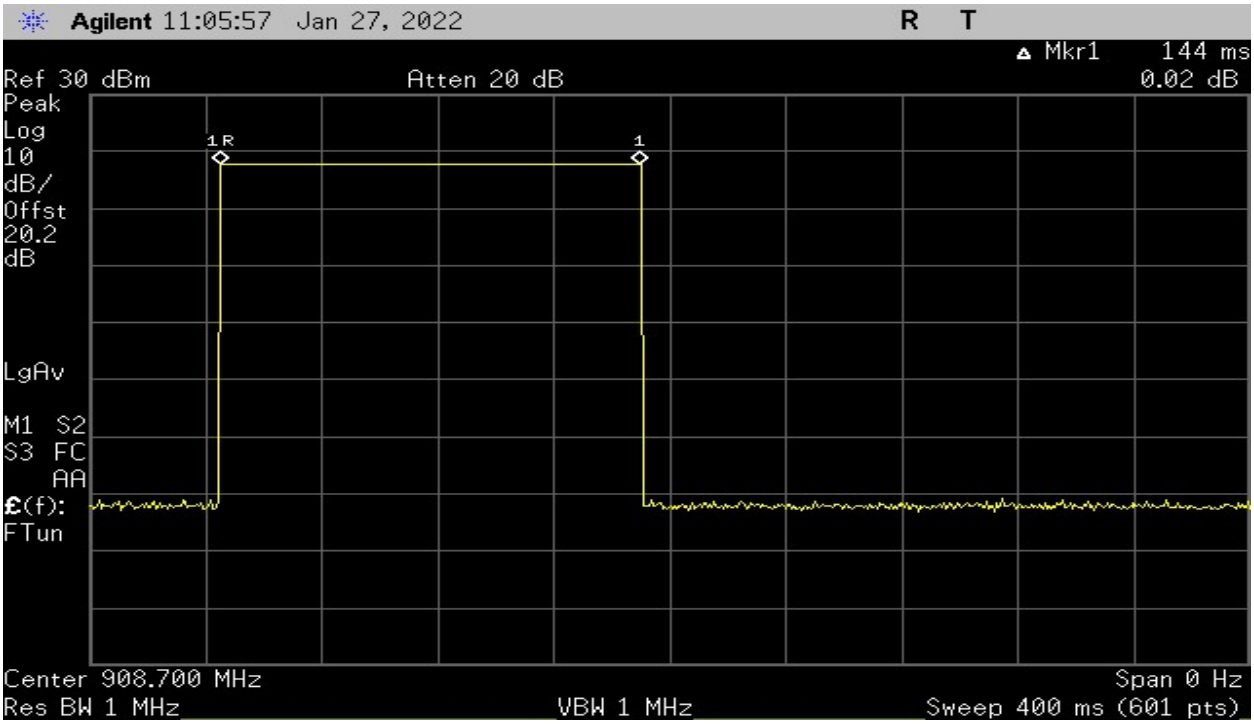
The device operates across 72 channels making the requirement for channel occupancy less than 0.4 seconds in any 28.8 second duration.

At channel 908.7MHz for 125kHz BW, there is 1 burst in 0.4 seconds. Time period of each burst is 144.0msec. As the device will not transmit again for a minimum of 20 seconds, and will not transmit on the same channel consecutively, the minimum possible time before returning to the same channel is 40.248 seconds. Therefore, device meets the 0.4 sec requirement.

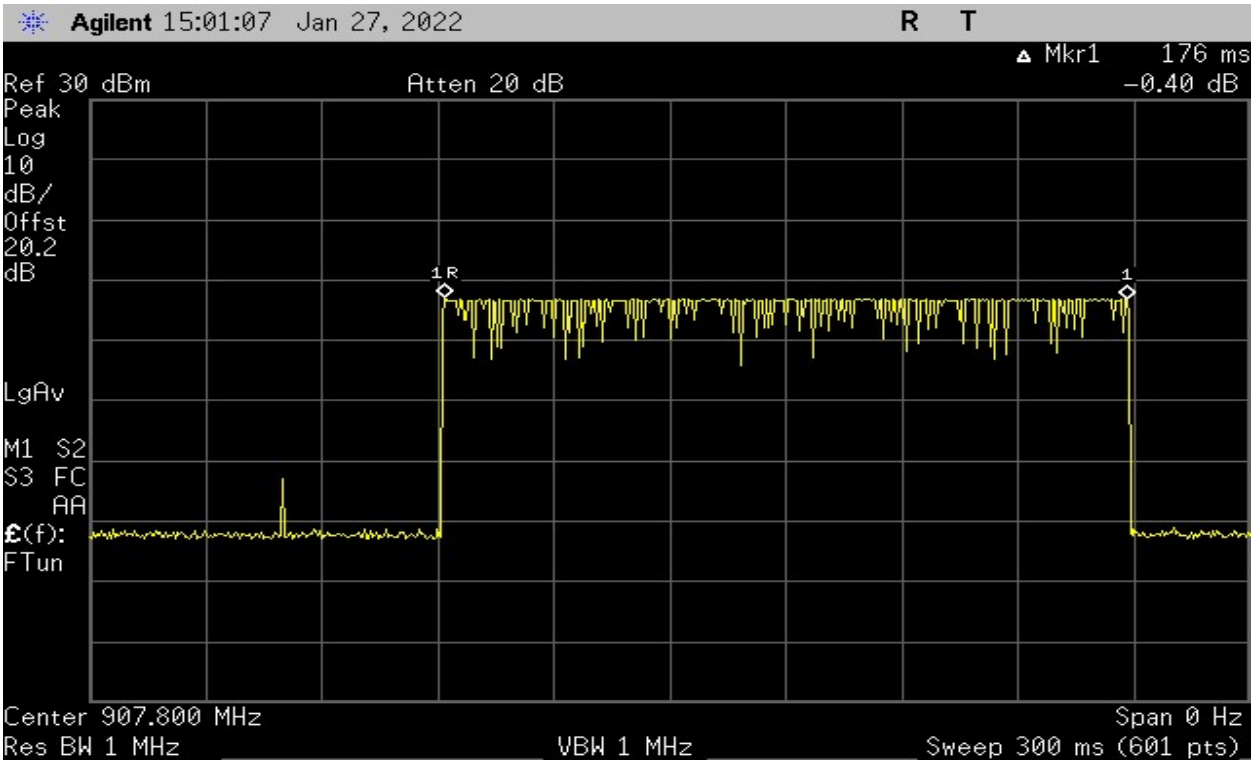
At channel 907.8MHz for 500kHz BW, there is 1 burst in 0.4 seconds. Time period of each burst is 176msec. As the device will not transmit again for a minimum of 20 seconds, and will not transmit on the same channel consecutively, the minimum possible time before returning to the same channel is 40.352 seconds. Therefore, device meets the 0.4 sec requirement.



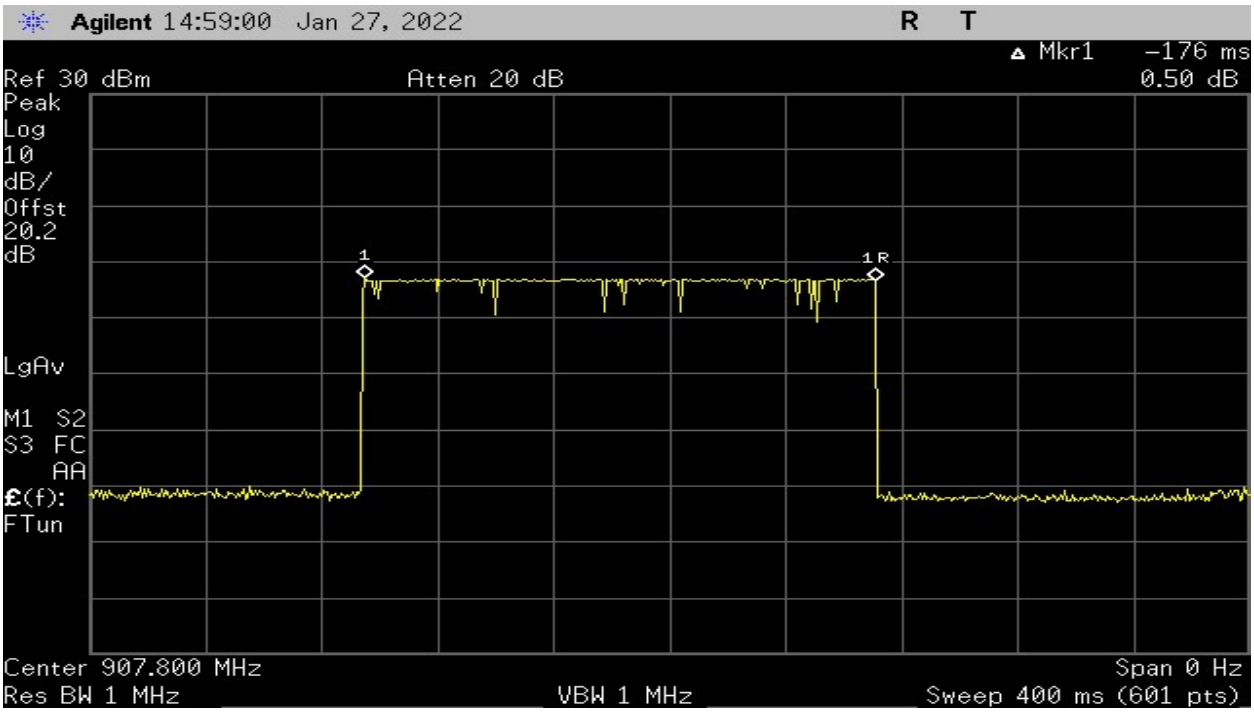
Plot 39 – Dwell Time (125kHZ BW)



Plot 40 – # of Hops in 0.4 second period – 125kHz BW



Plot 41 – Dwell Time (500kHz BW)



Plot 42 – # of Hops in 0.4 second period – 500kHz BW

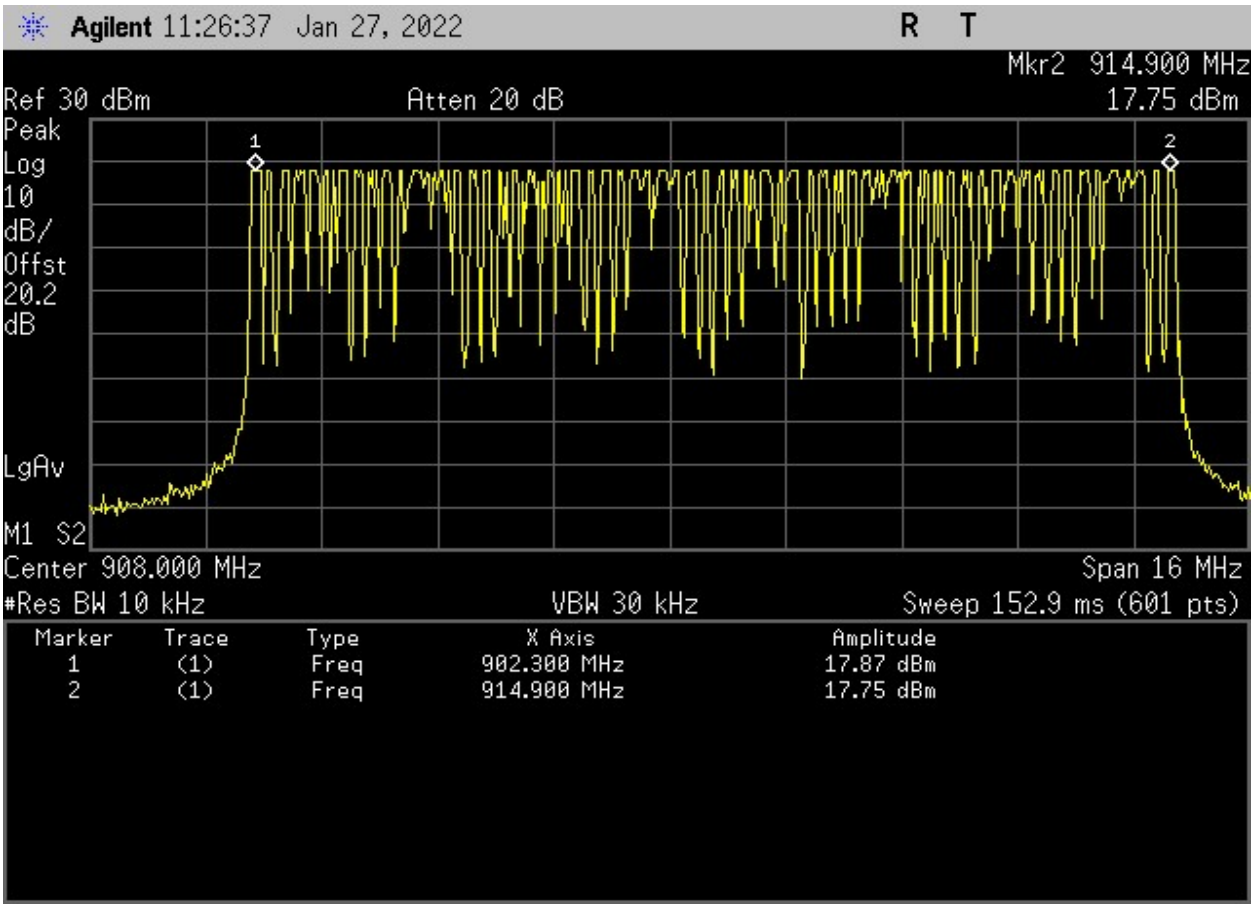
9. Number of Hopping Frequencies

Test Requirement(s):	§15.247(a) and RSS 247 5.1(c)	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	01/27/2022

Test Procedures: As required by 47 CFR 15.247(a), for frequency hopping spread spectrum operating at 902MHz-928MHz 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

Test Result:



Plot 43 – Number of Frequency Hops – 902.3MHz to 914.9MHz (72Hops)

10. Carrier Frequency Separation

Test Requirement(s):	§15.247(a)(1) and RSS 247 5.1(c)	**Test Engineer(s):**	Sean E.
Test Results:	Pass	**Test Date(s):**	01/27/2022

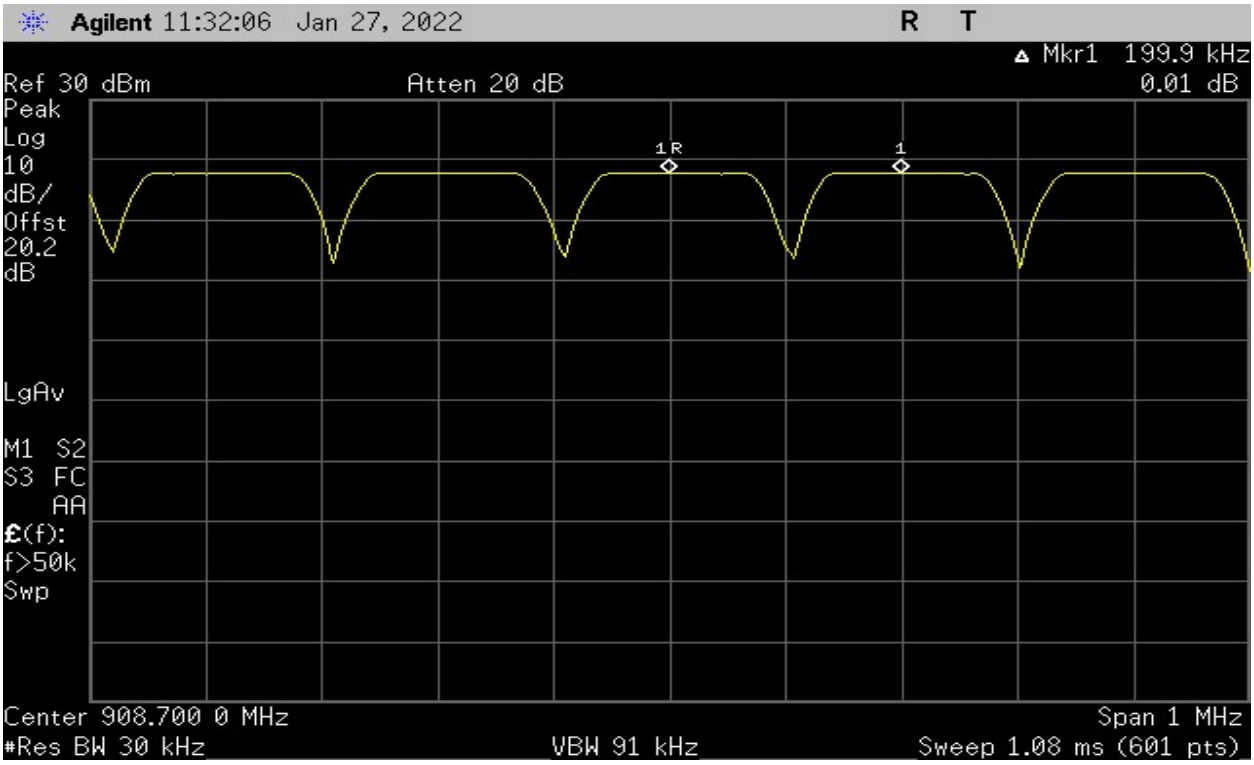
Test Procedures: As required by 47 CFR 15.247(a), for frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater. Measurements were made with device hopping function enabled.

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.

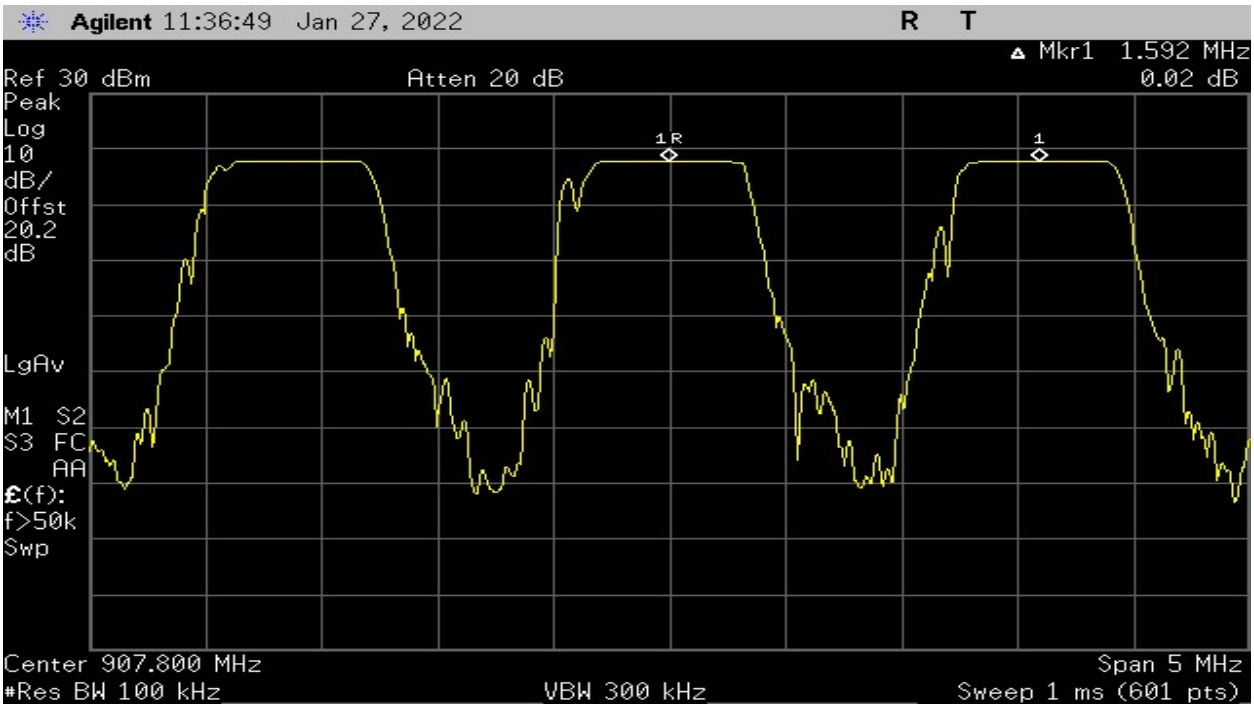
Test Result:

Frequency Measured (MHz)	Frequency Separation	Detector	Limit (20dB BW)	Comment
908.7	200kHz	Peak	147.3kHz	125kHz BW
907.8	1.6MHz	Peak	604.7kHz	500kHz BW

Table 24 – Carrier Frequency Separation - Summary



Plot 44 – Carrier Frequency Separation (Using Delta Marker Method) – 125khz BW



Plot 45 – Carrier Frequency Separation (Using Delta Marker Method) – 500khz BW

11. Test Equipment

Equipment	Manufacturer	Model	Serial #	Last Cal Date	Cal Due Date
Spectrum Analyzer	Agilent	E4443A	US41420164	Jan-28-21	Jan-28-22
Spectrum Analyzer	Hewlett Packard	8563E	3821A09316	Apr-28-21	Apr-28-22
High Pass Filter	Mini-Circuits	VHF-3100+	1023	Verified	
Power Supply	Hewlett Packard	E3610A	KR83021468	Verified	
EMI Receiver	Hewlett Packard	8666B	2747A05264	Dec-7-21	Dec-7-22
Power Supply	Hewlett Packard	Lambda	LA2-AA20-143 3535	NCR	None
High Pass Filter	Mini-Circuits	VHF-1320+	1034	Verified	
Attenuator 20dB	Weinschel	41-20-12	86332	Apr-27-21	Apr-27-23
Horn Antenna	Com-Power	AHA-118	711150	Dec-17-20	Dec-17-22
Antenna	EMCO	GTEM 5417	1063	Verified	

Table 25 – 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)

12. Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. These measurements figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2. Instrumentation measurement uncertainty has **not** been taken into account to determine compliance.

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