Testing Tomorrow's Technology

Application

For

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

And

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

For the

Matrix Design Group, LLC.

Model: MX3-IZ

FCC ID: USKCTRL-10000616

IC: 11898A-10000616

UST Project: 20-0146

Issue Date: July 31, 2020

Total Pages in This Report: 45

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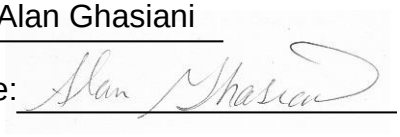
I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date: July 31, 2020

TESTING
NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Matrix Design Group, LLC.

MODEL: MX3-IZ

FCC ID: USKCTRL-10000616

IC: 11898A-10000616

DATE: July 31, 2020

This report concerns (check one): Original grant ☒
Class II change ☐

Equipment type: 2.4 GHz Transmitter Module

Technical:
IEEE 802.15.4
Operating Freq: 2405-2470 MHz
Type of Modulation: O-QPSK
Data/Bit Rate: 250 kbps
Antenna Gain: +1.8 dBi
Maximum Output Power: +18.8 dBm (77mW)
EUT firmware number: 5.6.5.1
Power setting:18
Software used to program EUT: fcc_controller_v3200.mx

Report prepared by:

US Tech
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1 General Information

1.1 Purpose of this Report

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

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on March 25, 2020 in good operating condition.

1.3 Product Description

The Matrix Design Group, LLC, Model MX3-IZ is the main device of the MX3 Proximity Detection system that will be used in mines to meet the MSHA proximity detection role. The purpose of the EUT is to provide a practical, mine-duty system that will automatically warn personnel when they are entering a potentially hazardous area around a machine. The system must be able to disable some or all machine functions if a particular zone is breached. The proximity detection system detects when a person enters a dangerous area around a given machine and changes machine operation accordingly.

Radio: 2.4 GHz ZigBee (IEEE 802.15.4)
Range: 2405 – 2470 MHz ISM band
Modulation: O-QPSK
RF Output Power: 18.84 dBm
Data Rate (Max): 250 kbps

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 under designation number 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/IC authorizations:

a) Certification under section 15.247/IC RSS-247 as a transmitter.

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 and IC, including: FCC Parts 2.902, 15.207, 15.209, 15.247, RSS GEN, and RSS-247.

Table 1. EUT and Peripherals

EUT MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID:	CABLES P/D
Controller Matrix Design Group, LLC	MX3-IZ	001A57-0062CA	FCC ID: USKCTRL-10000616 IC ID:11898A-10000616	P/U
PERIPHERAL MANUFACTURER	**MODEL NUMBER**	**SERIAL NUMBER**	**FCC/IC ID:**	**CABLES P/D**
Antenna See antenna details	--	--	--	--

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	8/17/2020 2 yr.
SPECTRUM ANALYZER	DSA815	RIGOL	DSA8A18030 0138	12/10/2021 2 yr.
LOOP ANTENNA	6502	EMCO	9810-3246	4/06/2022 2 yr
BICONICAL ANTENNA	3110B	EMCO	9306-1708	6/27/2021 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	2/01/2021 2 yr
HORN ANTENNA	3115	EMCO	9107-3723	11/28/2020 2 yr
RF PREAMP 100 kHz to 1.3 GHz	8447D	HEWLETT-PACKARD	1937A02980	5/13/2021
PREAMP 1.0 GHz to 26.0 GHz	8449B	HEWLETT-PACKARD	3008A00480	5/13/2021
HIGH PASS FILTER	H3R020G2	Mini-circuits Inc	001DC9528	5/11/2021
8 dB ATTENUATOR	VAT-8 15542	Mini-circuits Inc	3 0519	6/30/2021
LISN x2	9247-50-TS-50-N	Solar Electronics	955824 and 955825	5/11/2021

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

For compliance to CFR 15.207, Conducted Limits, US Tech made the following modifications:

- Added a Schaffner, Model FN2030, AC/DC line filter to the 24 VDC input power rail at the connector side of EUT.

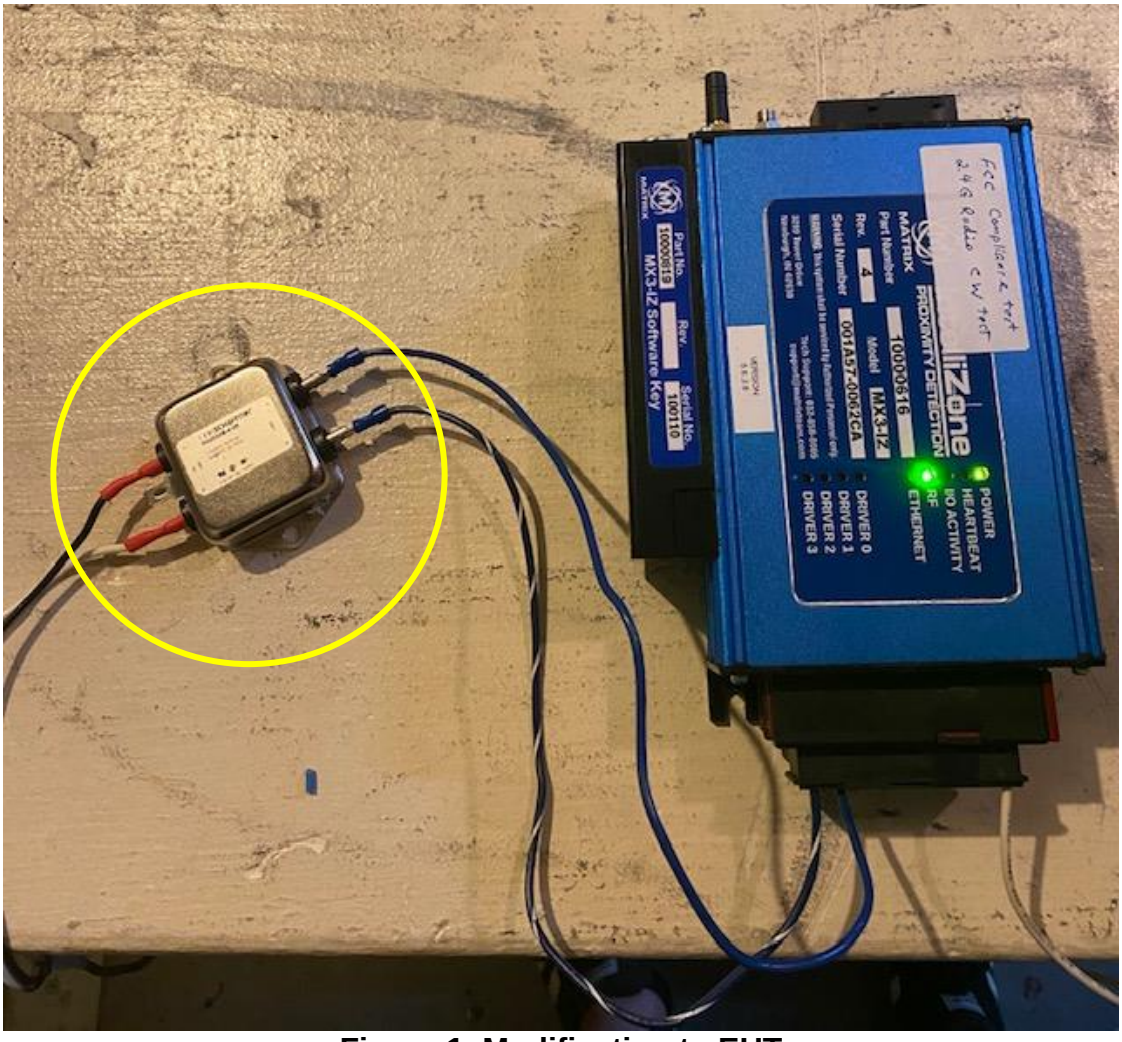


Figure 1. Modification to EUT

2.3 Number of Measurements for Intentional Radiators (CFR 15.31(m),RSS-Gen 6.8)

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

Table 3. Number of Test Frequencies for Intentional Radiators

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

Because the EUT operates at 2405 to 2470 MHz, 3 test frequencies were used.

2.4 Frequency Range of Radiated Measurements (CFR 15.33, RSS-Gen 6.13)

2.4.1 Intentional Radiator

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

2.4.2 Unintentional Radiator

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

2.5 Measurement Detector Function and Bandwidth (CFR 15.35, RSS-Gen 6.9)

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

2.5.1 Detector Function and Associated Bandwidth

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

2.5.2 Corresponding Peak and Average Requirements

For frequencies above 1000 MHz, radiated limits are based upon measuring instruments employing an average detector function. When average radiated emissions are specified there is also a corresponding peak limit requirement of 20 dB greater than the average limit. Peak measurements shall be made using the peak detector function of the measuring instrument. For all measurements above 1000 MHz, the resolution bandwidth shall be at least 1 MHz.

2.5.3 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, RSS-Gen 6.7)

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	Taoglas	Monopole	GW.26.0111	1.8	SMA(M)

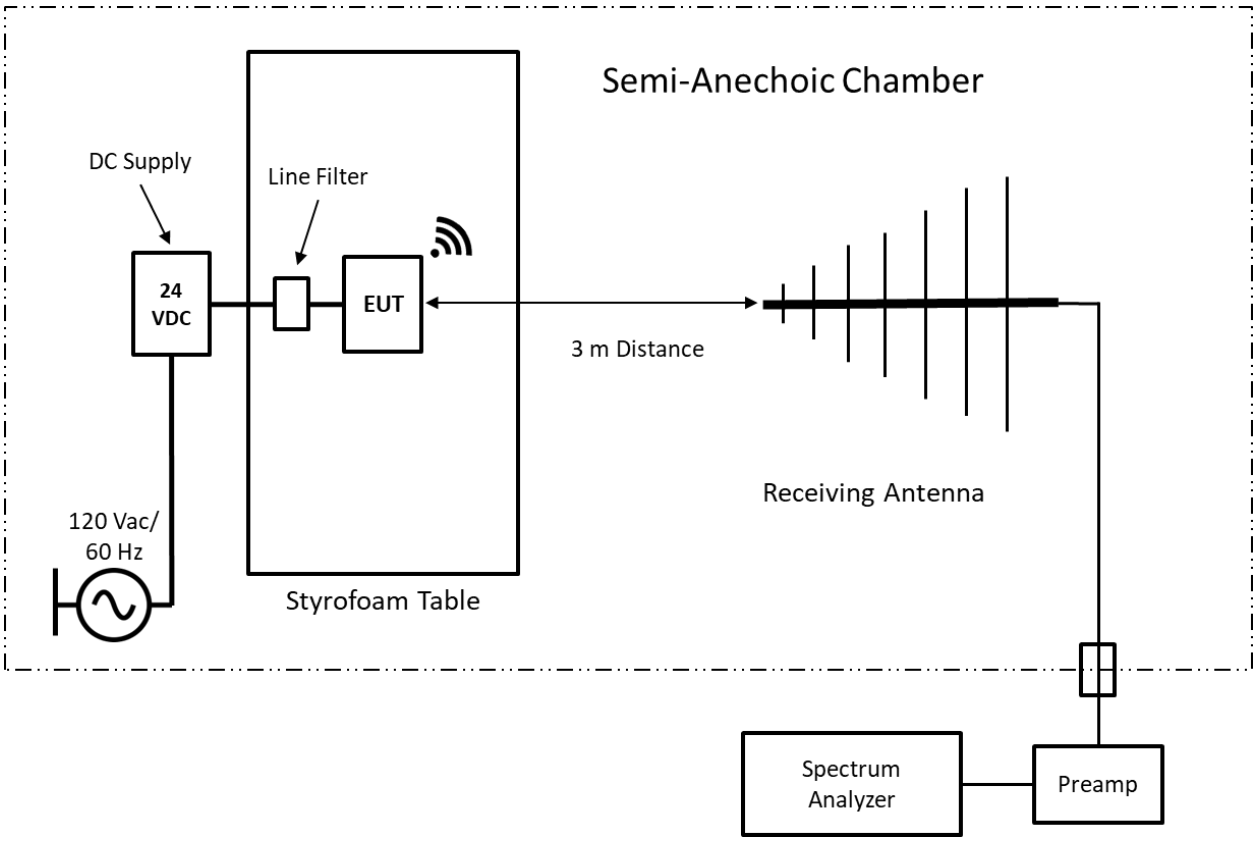


Figure 2. Block Diagram of Test Configuration

2.7 Restricted Bands of Operation (CFR 15.205, RSS-Gen 8.10)

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), RSS-Gen 6.10)

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.

In this case, no duty cycle correction factor was used.

2.9 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207, RSS-Gen 8.8)

Table 5. Transmitter Power Line Conducted Emissions Test Data, Part 15.207

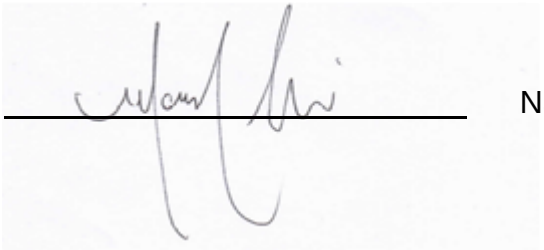
150 kHz to 30 MHz						
Test: FCC Part 15, Para 15.207				**Client:** Matrix Design Group, LLC.		
Project: 20-0146				**Model:** MX3-IZ		
Frequency (MHz)	**Test Data (dBuv)**	**LISN+CL (dB)**	**Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector PK, QP, or AVG**
120 Vac / 60 Hz, Phase						
0.1523	32.12	0.08	32.20	55.9	23.7	**PK**
0.7525	29.68	0.23	29.91	46.0	16.1	**PK**
1.9066	29.47	0.29	29.76	46.0	16.2	**PK**
5.7166	29.98	0.31	30.29	50.0	19.7	**PK**
12.0830	38.39	0.67	39.06	50.0	10.9	**PK**
18.1330	37.80	0.95	38.75	50.0	11.3	**PK**
24.1830	37.14	1.19	38.33	50.0	11.7	**PK**
120 Vac / 60 Hz, Neutral						
0.1815	30.19	0.13	30.32	54.4	24.1	**PK**
0.7983	31.00	0.08	31.08	46.0	14.9	**PK**
1.1333	29.80	0.51	30.31	46.0	15.7	**PK**
6.6666	30.39	0.47	30.86	50.0	19.1	**PK**
18.0830	35.23	1.31	36.54	50.0	13.5	**PK**
20.0000	33.21	1.45	34.66	50.0	15.3	**PK**

Sample Calculation at: 0.1523 MHz

Magnitude of Measured Frequency	32.12	dBuV
+Antenna Factor + Cable Loss	0.08	dB
Corrected Result	32.20	dBuV/m

Test Date: July 20, 2020

Tested By

Signature:  Name: Mark Afroozi

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d), RSS-247, 5.1,5.5)

For measurements of radiated spurious emissions, the EUT was placed into a continuous transmit mode of operation (>98% or max level possible duty cycle) and tested per ANSI C63.10:2013. The EUT was tested in three orthogonal positions to find the maximum emission position.

Radiated emissions were evaluated between the frequency range of 9 kHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (not greater than 40 GHz). In the band below 150 kHz, a resolution bandwidth (RBW) of 200 Hz was used. In the band from 150 kHz to 30 MHz, a 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 per CFR 15.209, general requirements for unwanted spurious emissions. The conducted spurious method as described below was used to investigate all other emissions radiating from the antenna port.

2.10.1 Fundamental and Harmonic Emissions

Table 6. Average Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Matrix Design Group, LLC.			
Project: 20-0146				**Model:** MX3-IZ			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Ch 0 – Low							
2405	69.52	31.31	100.83	--	3.0m/HORZ	--	**AVG**
4810	41.67	4.03	45.70	54.0	3.0m/HORZ	8.3	**AVG**
7215	51.58	10.41	* 52.49	54.0	1.0m/HORZ	1.5	**AVG**
9620	47.35	9.67	* 47.52	54.0	1.0m/HORZ	6.5	**AVG**
Ch 9 – Mid							
2450	66.56	31.35	97.91	--	3.0m/HORZ	--	**AVG**
4900	42.25	4.34	46.59	54.0	3.0m/HORZ	7.4	**AVG**
7350	53.06	9.48	* 53.04	54.0	3.0m/HORZ	1.0	**AVG**
9800	50.84	9.88	* 51.22	54.0	3.0m/HORZ	2.8	**AVG**
Ch 13 – High							
2470	72.10	31.26	103.36	--	3.0m/HORZ	--	**AVG**
4940	42.54	5.91	48.45	54.0	3.0m./HORZ	5.6	**AVG**
7410	47.77	11.83	50.10	54.0	1.0m./HORZ	3.9	**AVG**
9880	51.98	10.95	53.43	54.0	1.0m./HORZ	0.6	**AVG**
12350	40.09	12.25	42.84	54.0	1.0m./HORZ	11.2	**AVG**

*Measurements taken above 6 GHz are performed at a distance of 1m (vs. 3m). This correction includes an additional factor of -9.5 dB to account for this change.

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
2. The EUT was placed in its normal operating position and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98% or max level possible. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the table above represents worst case emissions.

Sample Calculation at 2405 MHz:

Magnitude of Measured Frequency	69.52	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	31.31	dB/m
Corrected Result	100.83	dBuV/m

Test Date: March 25, 2020

Tested By
Signature:  Name: Afzal Fazal

Table 7. Peak Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Matrix Design Group, LLC.			
Project: 20-0146				**Model:** MX3-IZ			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Ch 0 – Low							
2405	79.53	31.31	110.84	--	3.0m./HORZ	--	**PK**
4810	55.03	4.03	59.06	74.0	3.0m./HORZ	14.9	**PK**
7215	67.14	10.41	* 68.05	74.0	3.0m./HORZ	6.0	**PK**
9620	64.17	9.67	* 64.34	74.0	1.0m./HORZ	9.7	**PK**
Ch 9 – Mid							
2450	77.42	31.35	108.77	--	3.0m./HORZ	--	**PK**
4900	56.25	4.34	60.59	74.0	3.0m./HORZ	13.4	**PK**
7350	68.55	9.48	* 68.53	74.0	3.0m./HORZ	5.5	**PK**
9800	66.81	9.88	* 67.19	74.0	1.0m./HORZ	6.8	**PK**
Ch 13 – High							
2470	82.47	31.26	113.73	--	3.0m./HORZ	--	**PK**
4940	55.89	5.91	61.80	74.0	3.0m./HORZ	12.2	**PK**
7410	63.44	11.83	65.77	74.0	1.0m./HORZ	8.2	**PK**
9880	68.58	10.95	70.03	74.0	1.0m./HORZ	4.0	**PK**
12350	55.82	12.25	42.84	54.0	1.0m./HORZ	11.2	**AVG**

*Measurements taken above 6 GHz are performed at a distance of 1m (vs. 3m). This correction includes an additional factor of -9.5 dB to account for this change.

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
2. The EUT was placed in its normal operating position and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98% or max level possible. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 2405 MHz:

Magnitude of Measured Frequency	79.53	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	31.31	dB/m
Corrected Result	110.84	dBuV/m

Test Date: March 25, 2020

Tested By
Signature: Afzal Fazal Name: Afzal Fazal

2.10.2 Spurious Emissions other than Fundamental and Harmonics

The EUT was placed into a mode representative of normal operation and spurious emissions measurements were performed. The antenna port was terminated with a 50 ohm load during testing.

Table 8. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209), 9 kHz to 30 MHz

9 kHz to 30 MHz							
Test: FCC Part 15, Para 15.209				**Client:** Matrix Design Group, LLC.			
Project: 20-0146				**Model:** MX3-IZ			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
15.75	49.87	5.22	55.09	69.5	3.0 m	14.5	**PK**
24.27	42.23	1.96	44.19	69.5	3.0 m	25.4	**PK**
All other emissions detected were attenuated more than 20 dB below the applicable limits.							

SAMPLE CALCULATION at 15.75 MHz:

Magnitude of Measured Frequency	49.87	dBuV
+ Cable Loss+Antenna Factor - Amp Gain	5.22	dB
Corrected Result	55.09	dBuV

Test Date: July 9, 2020

Tested By

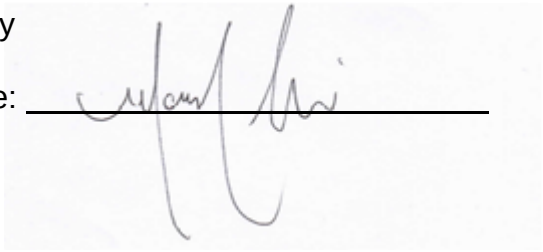
Signature:  Name: Mark Afroozi

Table 9. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209), 30 MHz to 1000 MHz

30 MHz to 1000 MHz with Class B Limits							
Test: FCC Part 15, Para 15.209				**Client:** Matrix Design Group, LLC.			
Project: 20-0146				**Model:** MX3-IZ			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
97.25	45.88	-16.14	29.74	43.5	3m./HORZ	13.8	**PK**
97.14	51.10	-15.04	36.06	43.5	3m./VERT	7.4	**PK**
132.75	46.19	-13.62	32.57	43.5	3m./HORZ	10.9	**PK**
196.48	47.67	-10.13	37.54	43.5	3m./HORZ	6.0	**PK**
266.75	55.44	-12.47	42.97	46.0	3m./HORZ	3.0	**QP**
392.83	47.90	-9.18	38.72	46.0	3m./HORZ	7.3	**QP**
700.02	42.74	-2.06	40.68	46.0	3m./HORZ	5.3	**QP**
799.86	44.33	-1.76	42.57	46.0	3m./HORZ	3.4	**QP**

SAMPLE CALCULATION at 97.25 MHz:

Magnitude of Measured Frequency	45.88	dBuV
+ Cable Loss+Antenna Factor - Amp Gain	-16.14	dB
Corrected Result	29.74	dBuV

Test Date: July 29, 2020

Tested By

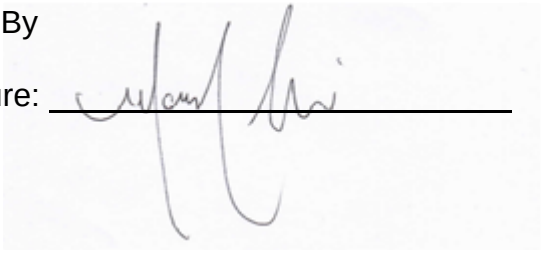
Signature:  Name: Mark Afroozi

Table 10. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209), 1 GHz to 12.5 GHz

1 GHz to 12.5 GHz with Class B Limits							
Test: FCC Part 15, Para 15.209				**Client:** Matrix Design Group, LLC.			
Project: 20-0146				**Model:** MX3-IZ			
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**
1067.03	57.05	-10.94	46.11	54.0	3.0m./HORZ	7.9	**PK**
1333.17	54.92	-9.89	45.03	54.0	3.0m./HORZ	9.0	**PK**
2330.67	32.75	-6.10	26.65	54.0	3.0m./HORZ	27.3	**AVG**
3514.00	45.65	-0.93	44.72	54.0	3.0m./HORZ	9.3	**PK**
All other emissions detected were more than 20 dB below the applicable limits.							

SAMPLE CALCULATION at 1067.03 MHz:

Magnitude of Measured Frequency	57.05	dBuV
+ Cable Loss+Antenna Factor - Amp Gain	-10.94	dB
Corrected Result	46.11	dBuV

Test Date: March 25, 2020

Tested By

Signature: Afzal Fazal Name: Afzal Fazal

2.10.3 Conducted Spurious Emissions

Conducted Spurious measurements: The EUT was put into a continuous-transmit mode of operation (>98% or max level possible duty cycle) and tested per ANSI C63.10-2013 for conducted out of band emissions emanating from the antenna port over the frequency range of 9 kHz or lowest operating clock frequency to ten times the highest operating clock frequency. A conducted scan was performed on the EUT to identify and record the spurious signals that were related to the transmitter.

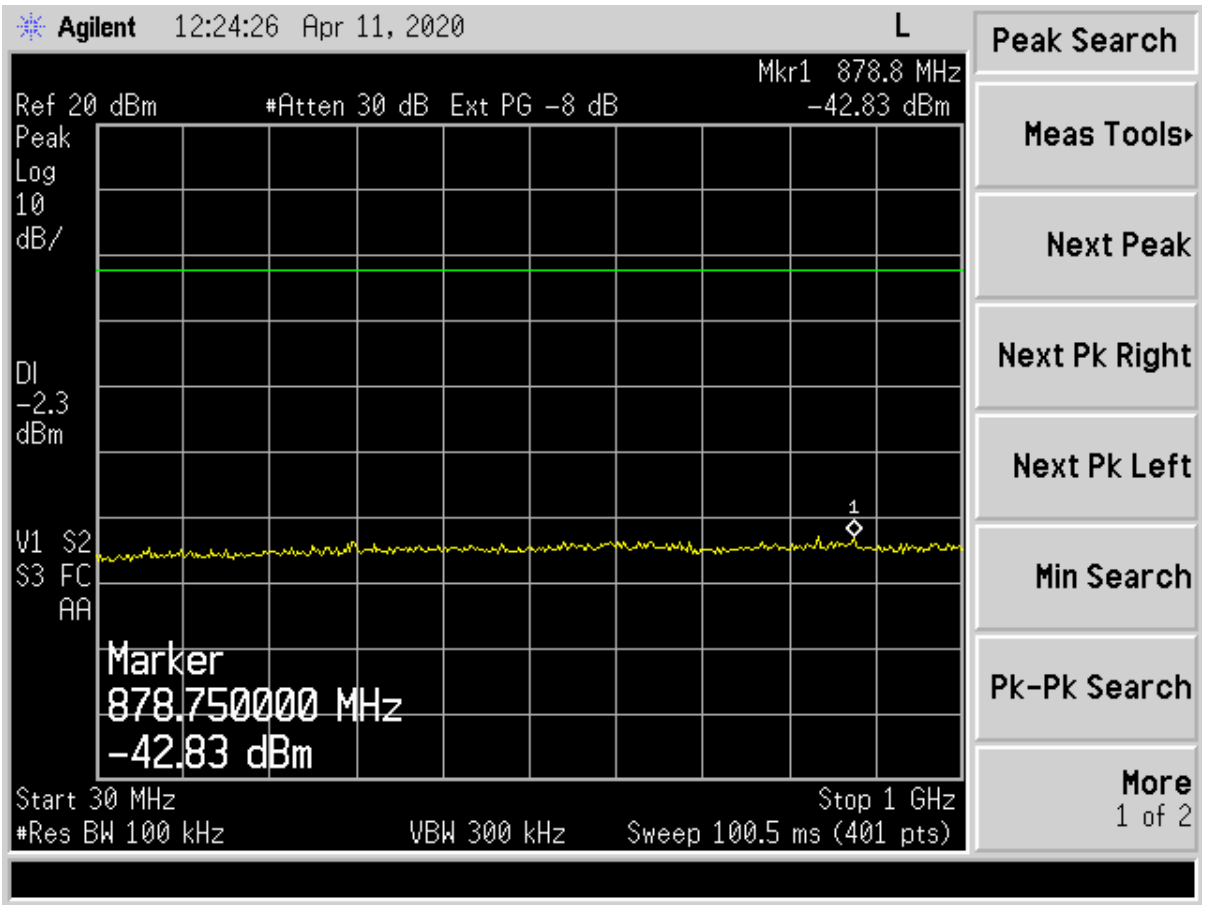


Figure 3. Conducted Spurious Emissions, Low Channel, 30 MHz – 1 GHz

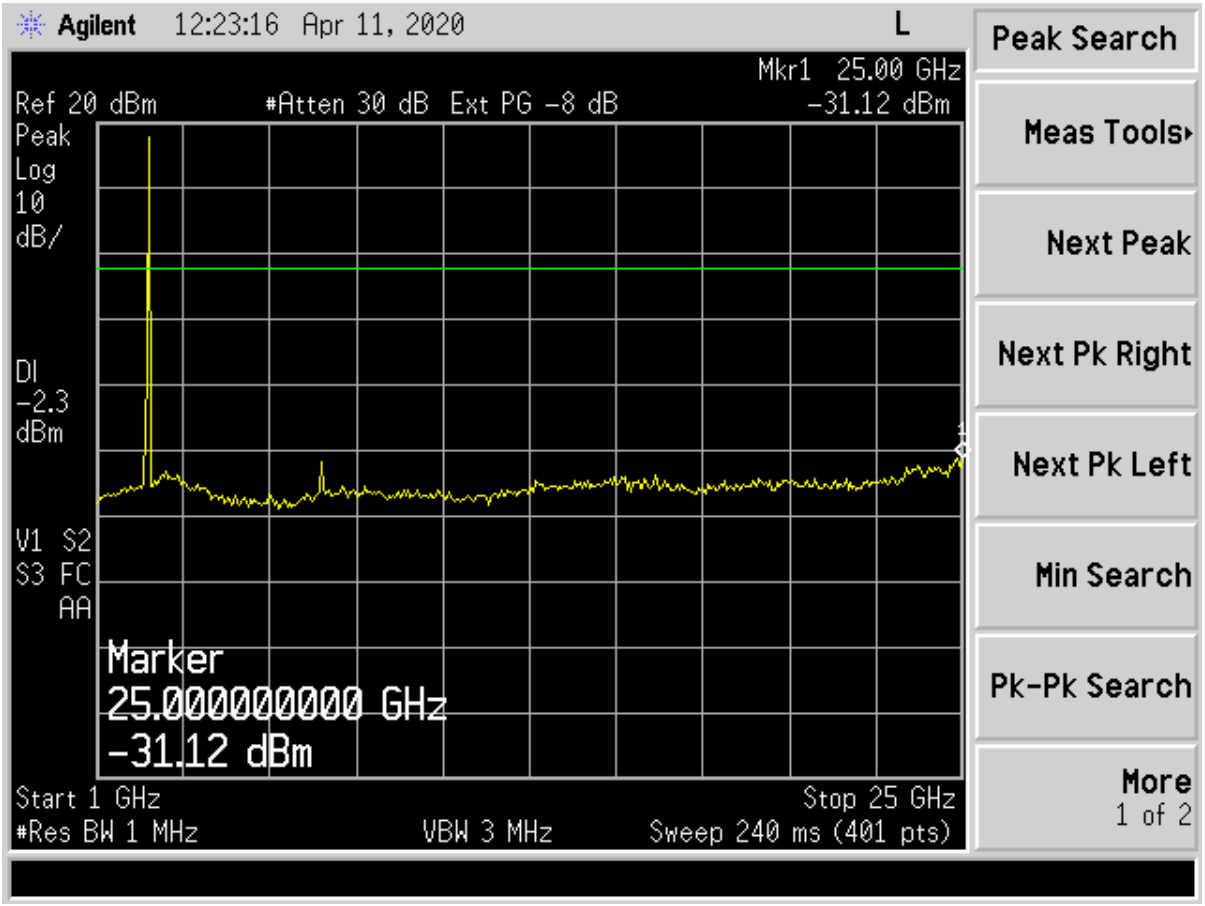


Figure 4. Conducted Spurious Emissions, Low Channel, 1 – 25 GHz

Note: Large emission seen is the fundamental frequency.

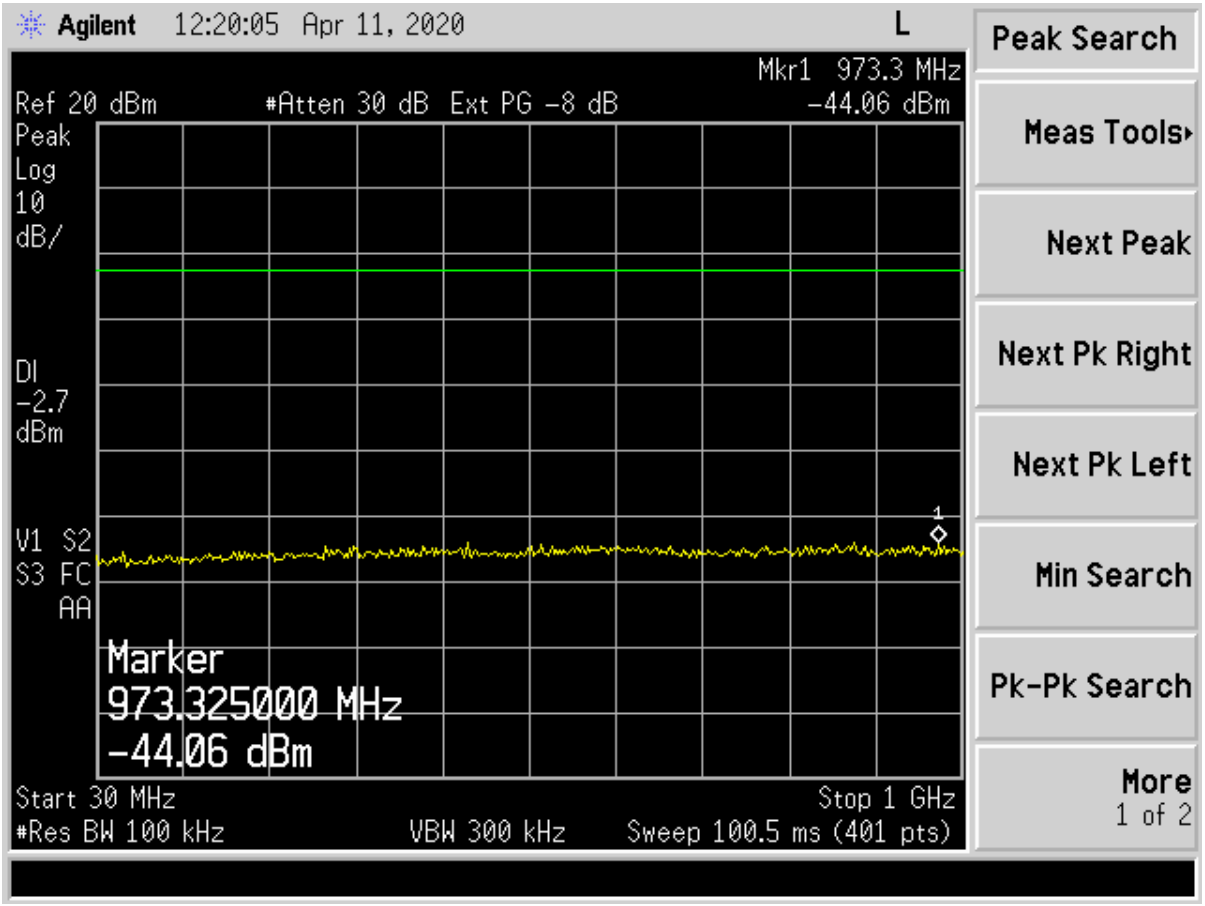


Figure 5. Conducted Spurious Emissions Mid Channel, 30 MHz – 1 GHz

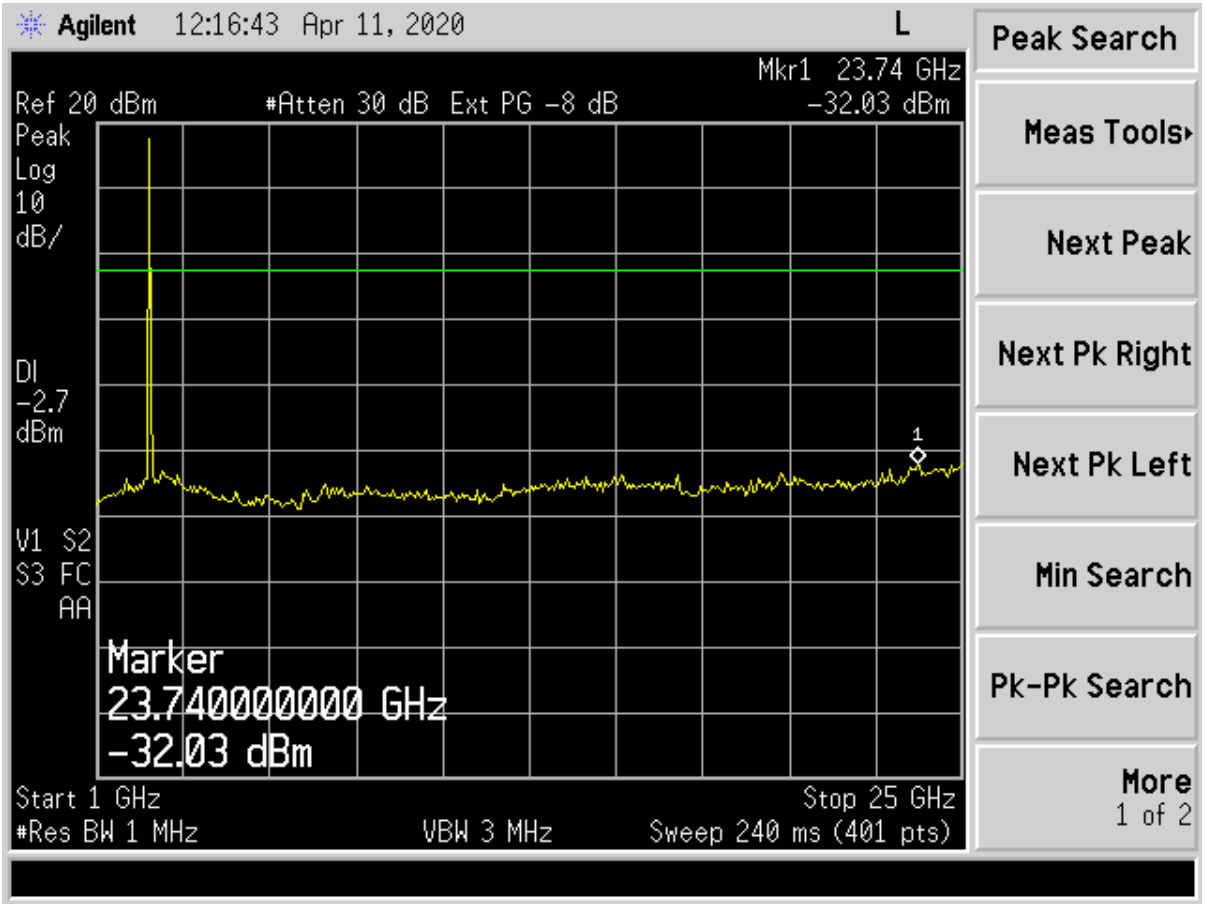


Figure 6. Conducted Spurious Emissions Mid Channel, 1 – 25 GHz

Note: Large emission seen is the fundamental frequency.

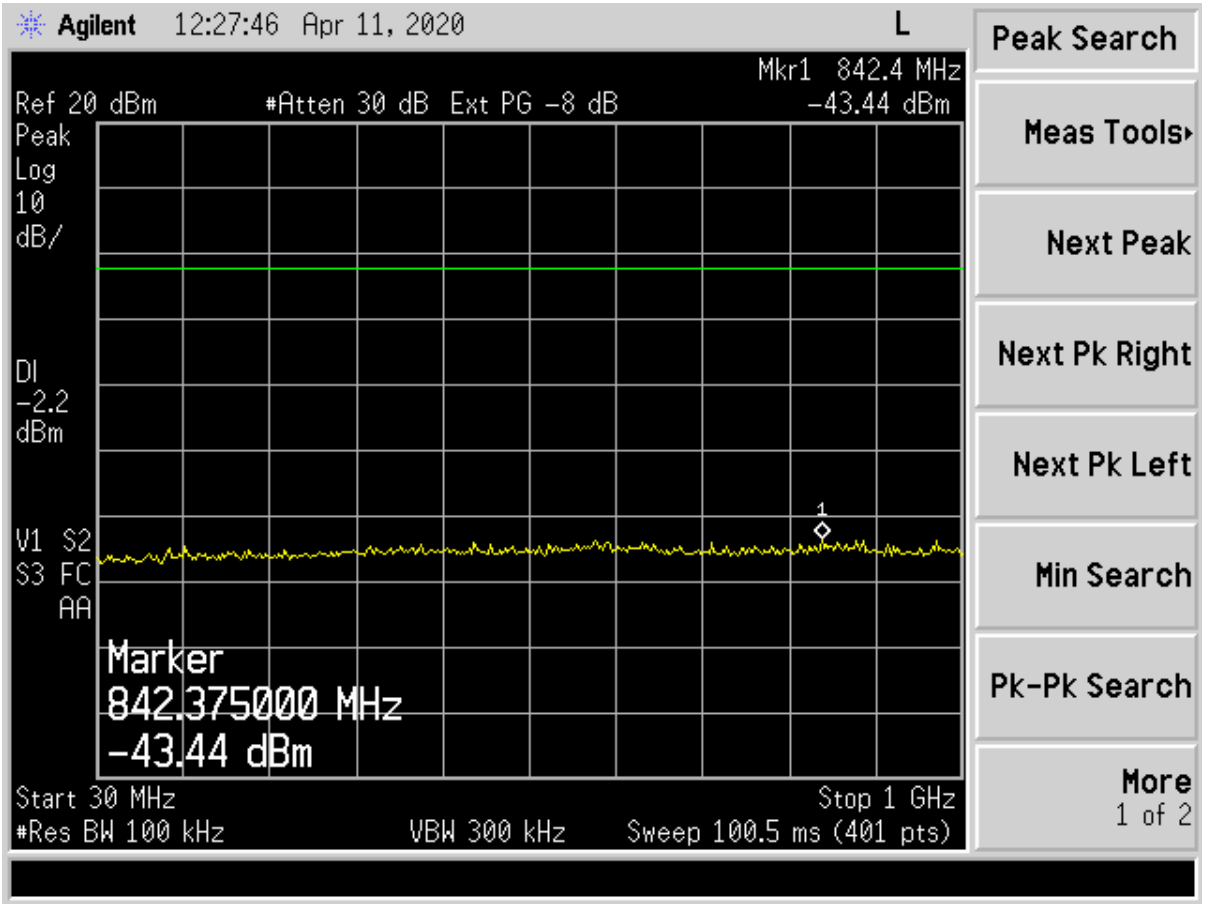


Figure 7. Conducted Spurious Emissions High Channel, 30 MHz – 1 GHz

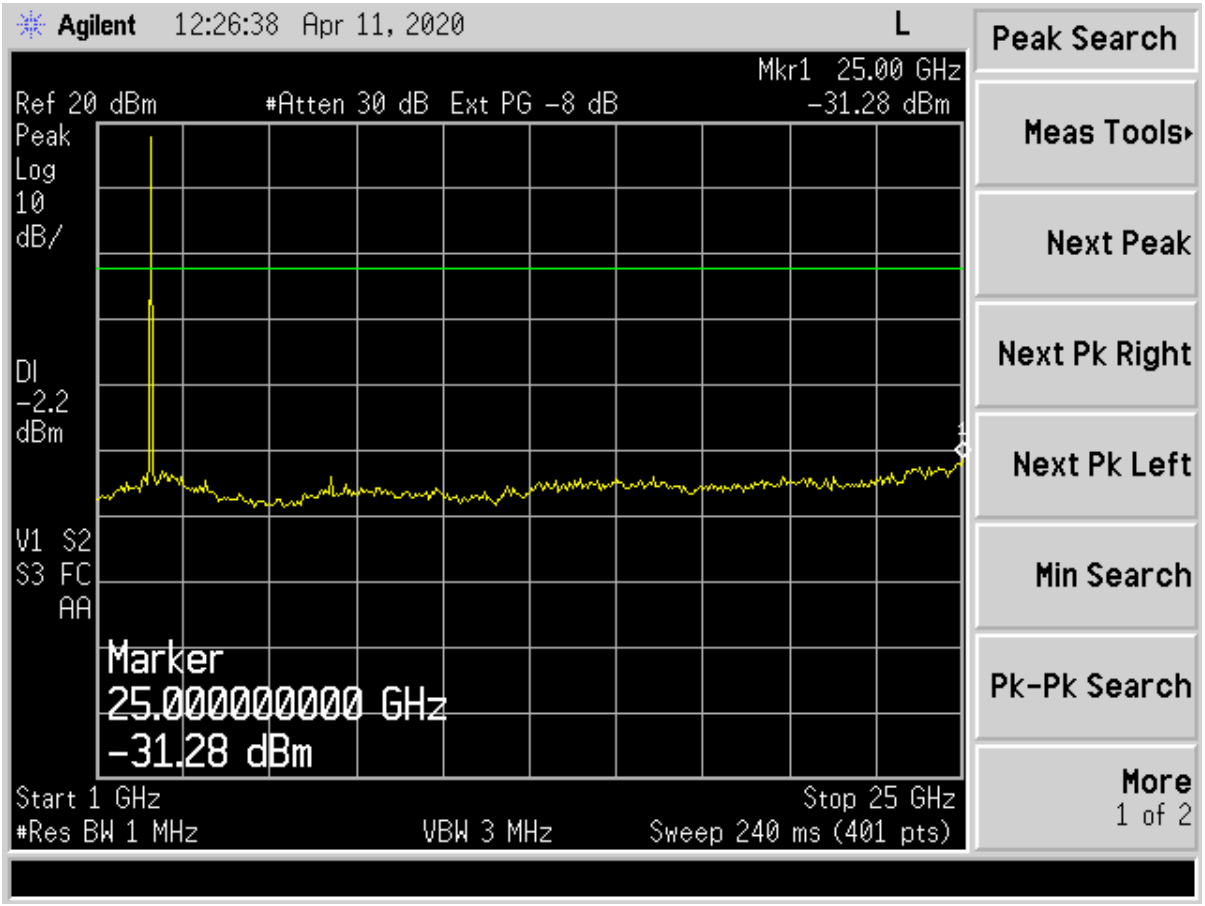


Figure 8. Conducted Spurious Emissions High Channel, 1 – 25 GHz

Note: Large emission seen is the fundamental frequency.

2.11 Band Edge Measurements (CFR 15.247(d), RSS-247, 5.5)

Band edge measurements were made following the guidelines in ANSI 63.10-2013 for the DTS device 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.

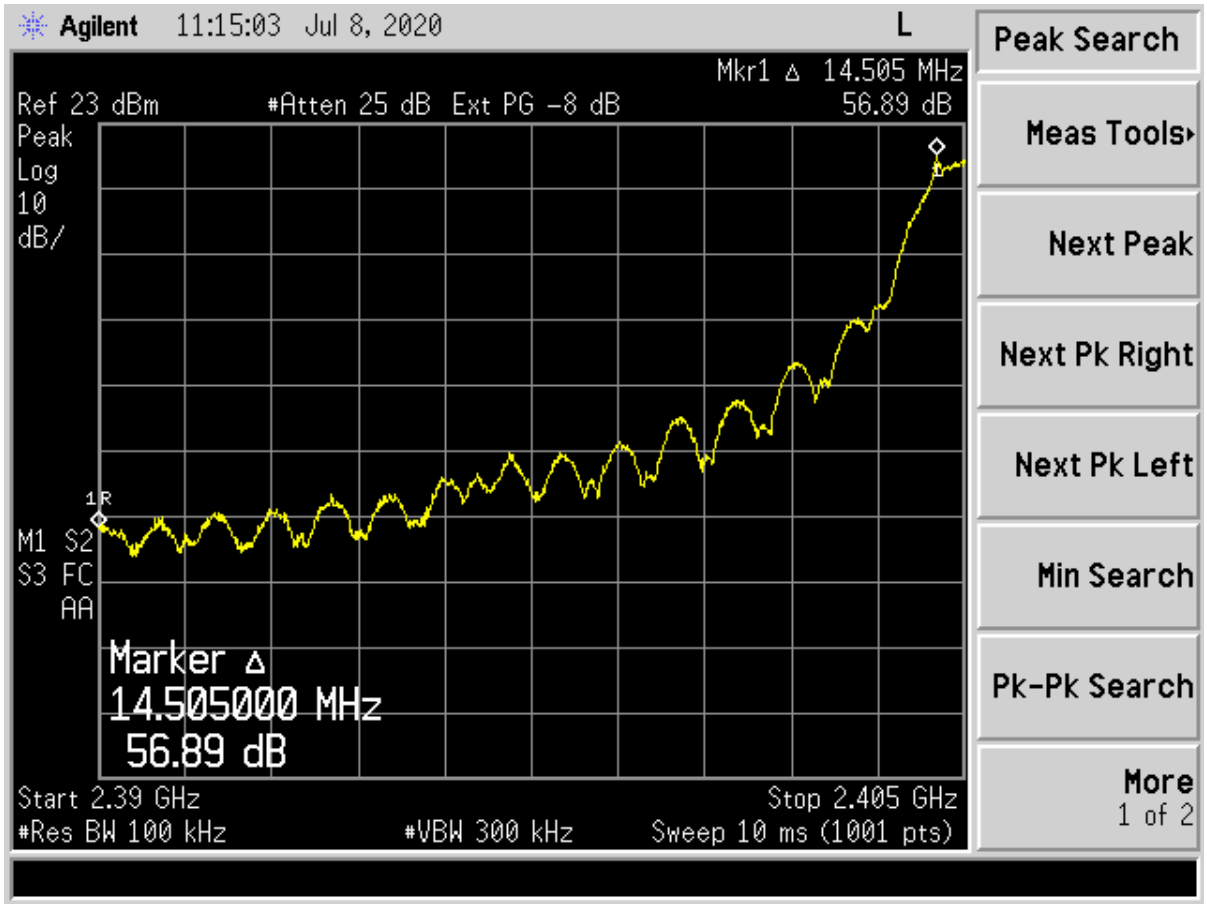


Figure 9. Band Edge Compliance, Low Channel Marker-Delta Method

Measured Delta (from Figure 11)	56.89	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	36.89	dB

Test Date: July 8, 2020

Tested by:

Signature: _____ Name: Mark Afroozi

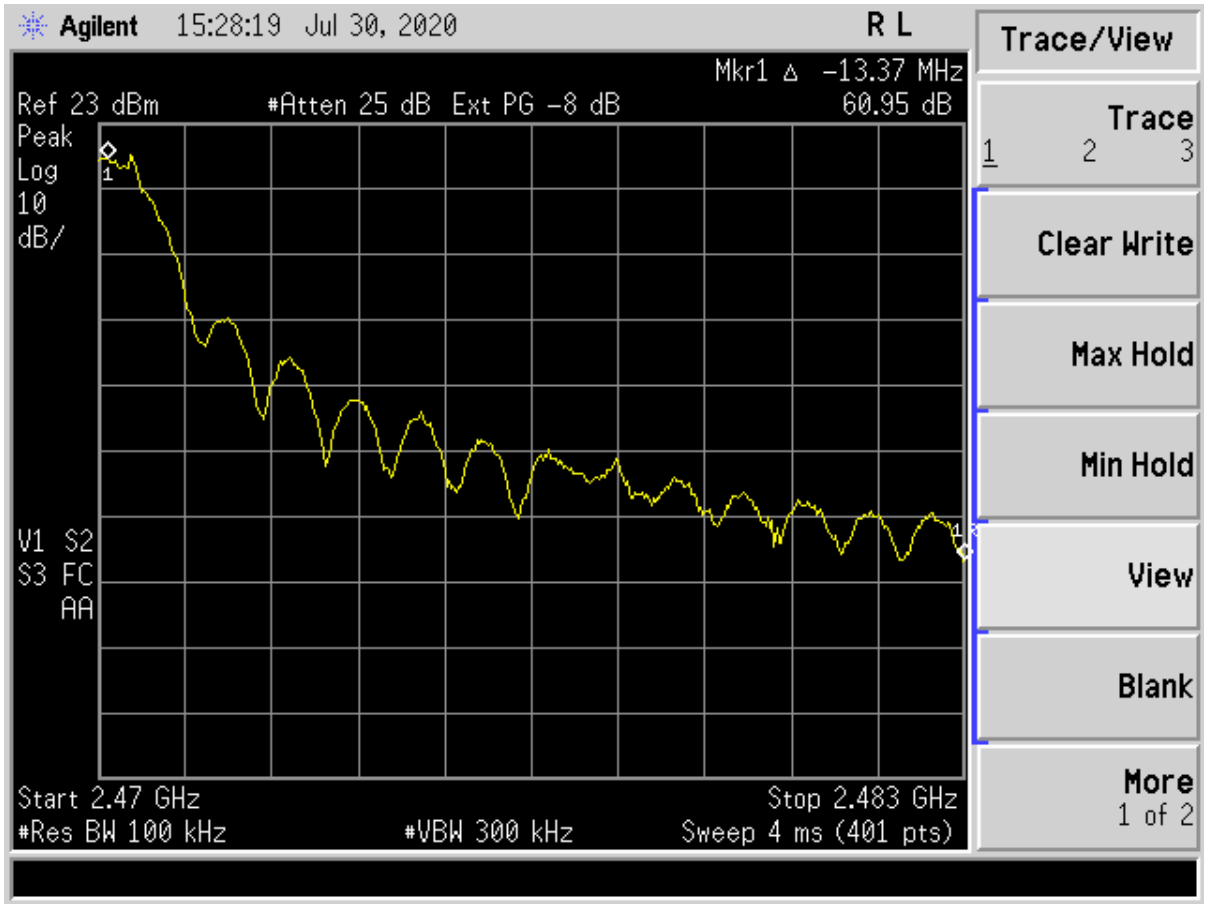


Figure 10. Band Edge Compliance, High Channel Marker-Delta Method

Measured Delta (from Figure 13)	60.95	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	40.95	dB

Test Date: July 30, 2020

Tested by:

Signature: _____ Name: Mark Afroozi

2.12 99% and 20 dB Bandwidth (CFR 15.247(a)(1)(i), RSS-Gen 6.6)

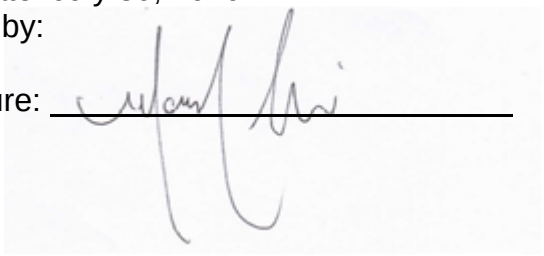
These measurements were performed while the EUT was in a constant transmit mode. The RBW was set to 100 kHz and with the VBW ≥ RBW. The results of this test are given in Table and Figures following.

The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

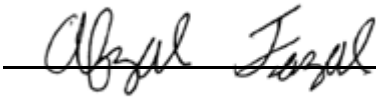
Table 11. Occupied Bandwidth (99% & 20 dB)

Frequency (MHz)	6 dB Bandwidth (MHz)	CFR 15.247(a)(1)(i) Minimum Limit (MHz)	99% Occupied Bandwidth (MHz)
2405	1.642	0.500	2.758
2450	1.633	0.500	3.114
2470	1.678	0.500	3.301

Test Date: July 30, 2020
Tested by:

Signature:  Name: Mark Afroozi

Test Date: April 11, 2020
Tested by:

Signature:  Name: Afzal Fazal

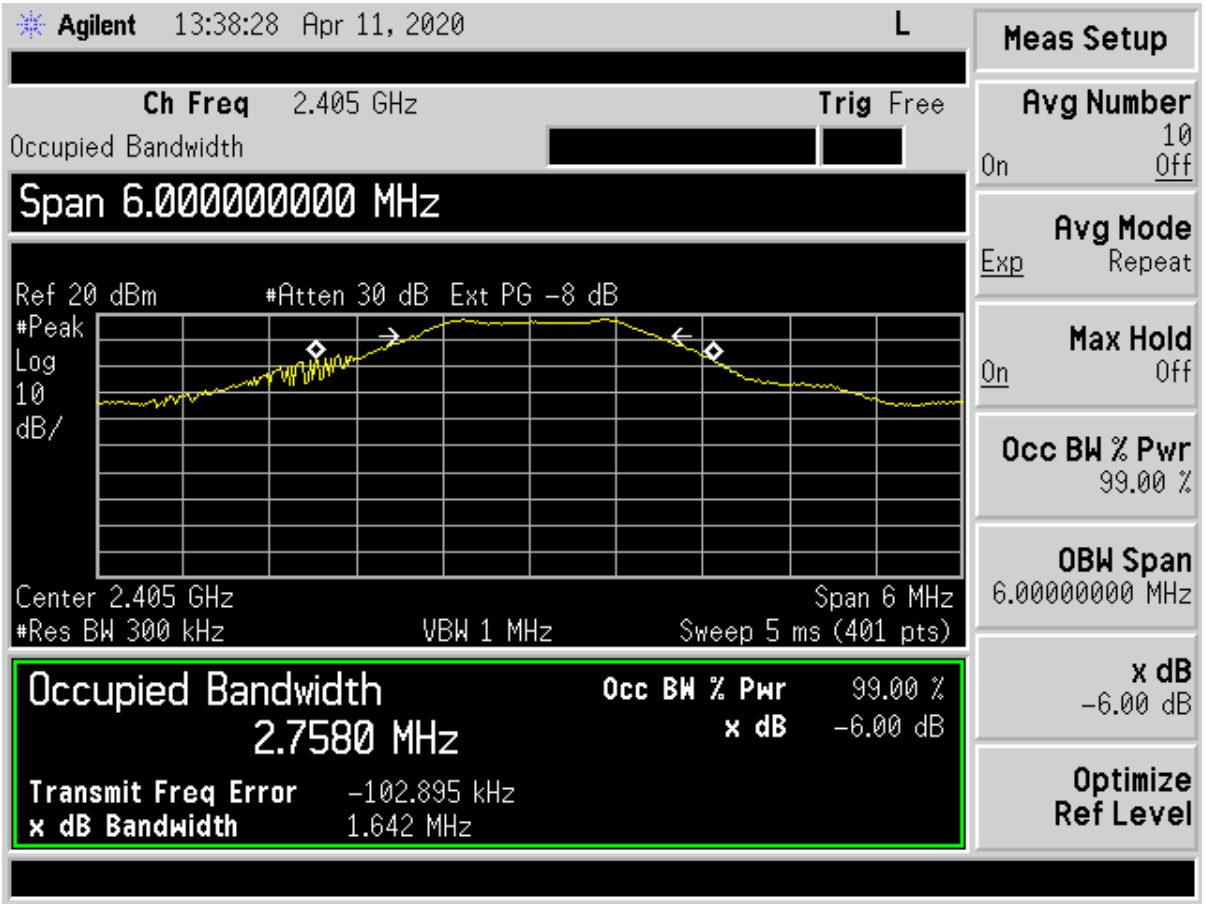


Figure 11. 99% & 6 dB Bandwidth – Low Channel

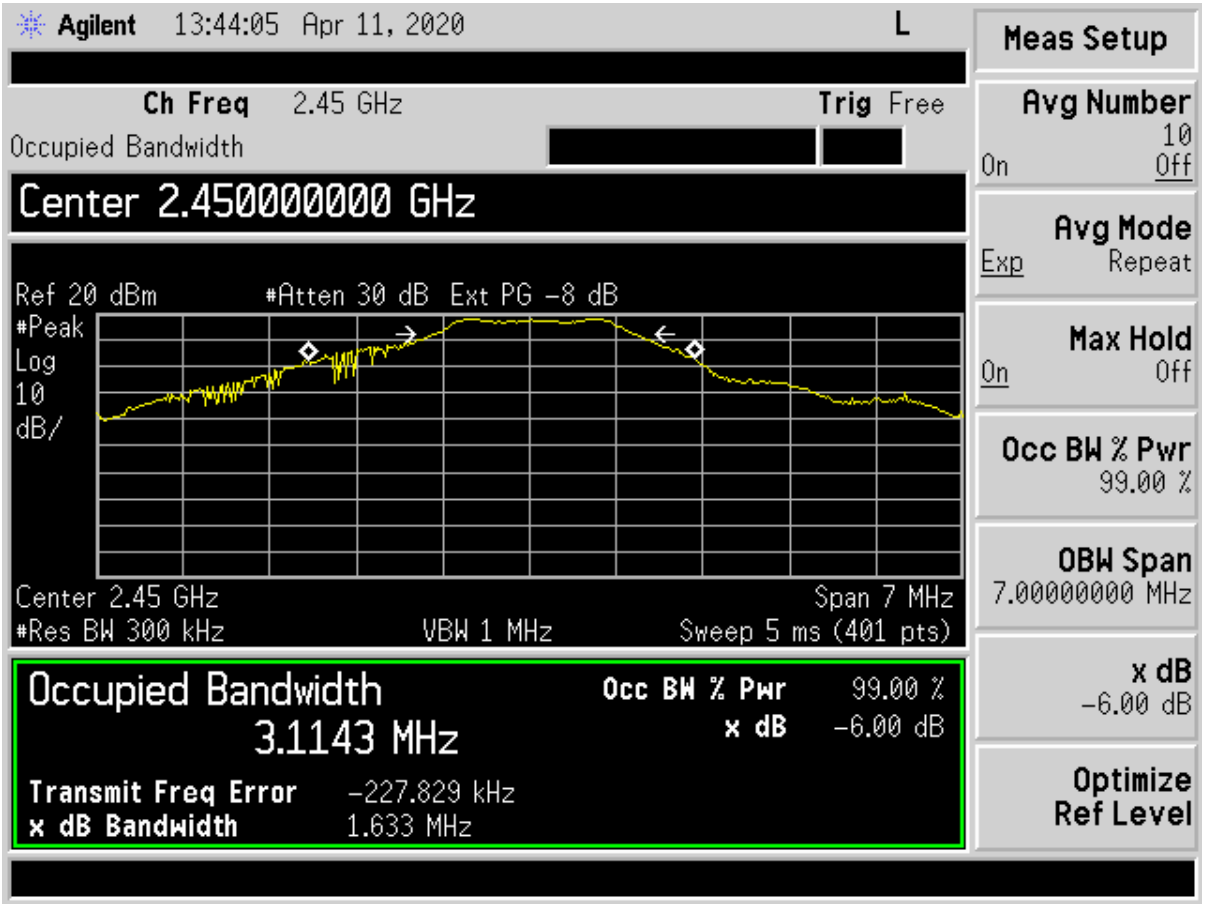


Figure 12. 99% & 6 dB Bandwidth – Mid Channel

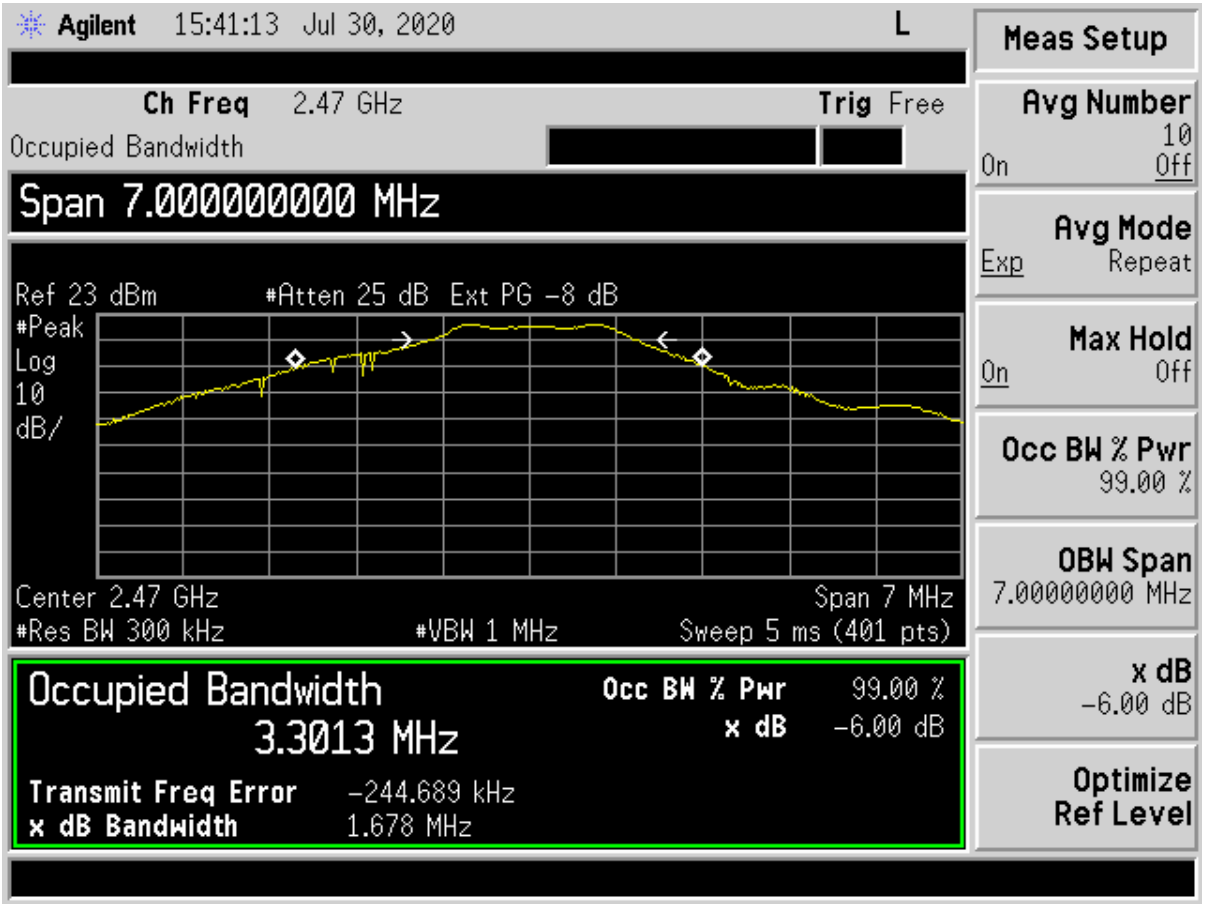


Figure 13. 99% & 6 dB Bandwidth – High Channel

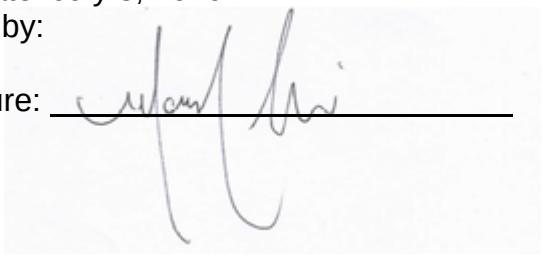
2.13 Maximum Peak Conducted Output Power (CFR 15.247(b)(1), RSS-247 5.1)

Peak power within the band 902 – 928 MHz was measured per ANSI C63.10-2013 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. An 8 dB attenuator was used at the RF input port of the spectrum analyzer and attenuator loss was accounted for. Peak antenna conducted output power is tabulated in the table below.

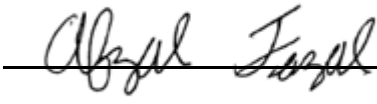
Table 12. Peak Antenna Conducted Output Power per Part 15.247 (b) (2)

Frequency of Fundamental (MHz)	Raw Test Data dBm	Converted Data (mW)	FCC Limit (mW Maximum)
2405	17.86	61.094	1000
2450	17.96	62.517	1000
2470	18.84	76.560	1000

Test Date: July 8, 2020
Tested by:

Signature:  Name: Mark Afroozi

Test Date: April 11, 2020
Tested by:

Signature:  Name: Afzal Fazal

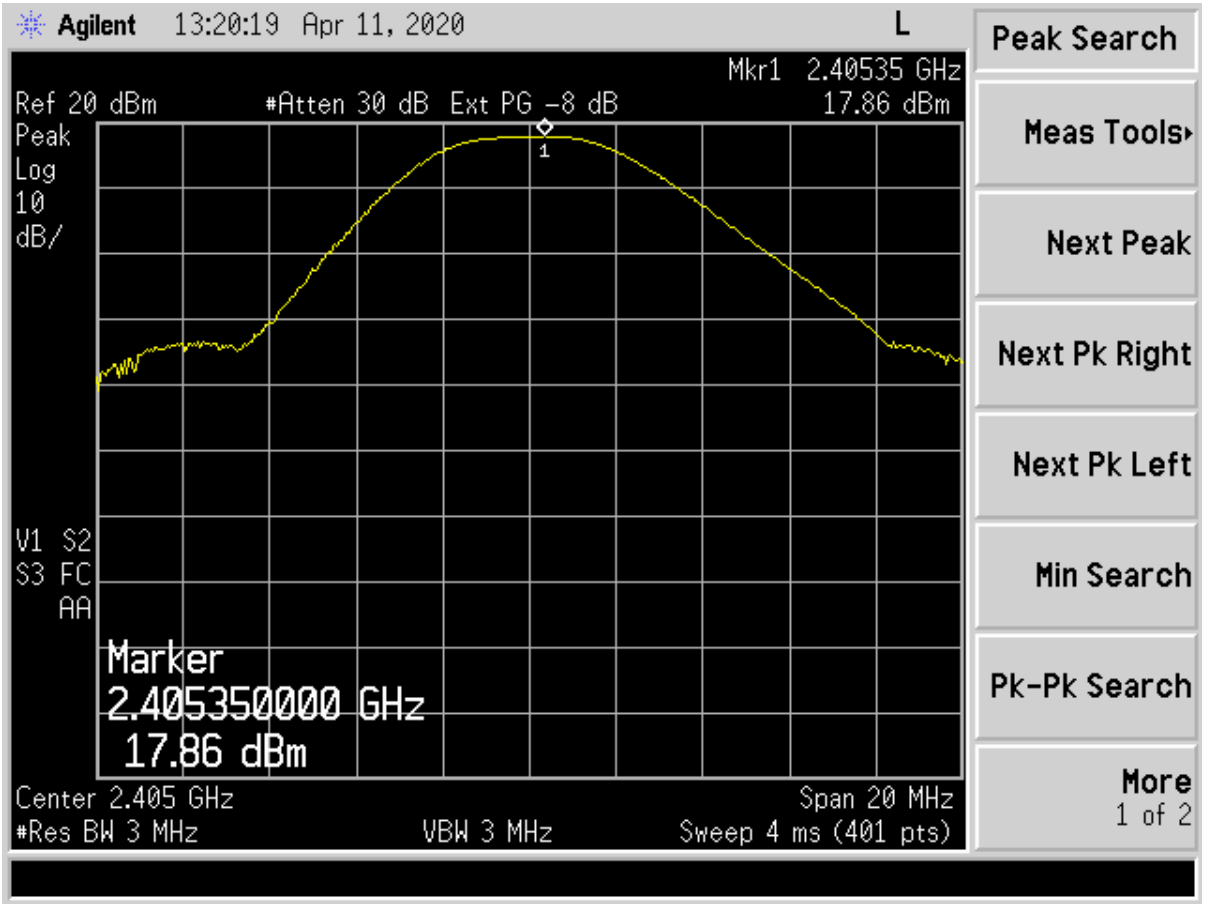


Figure 14. Peak Antenna Conducted Output Power, Low Channel

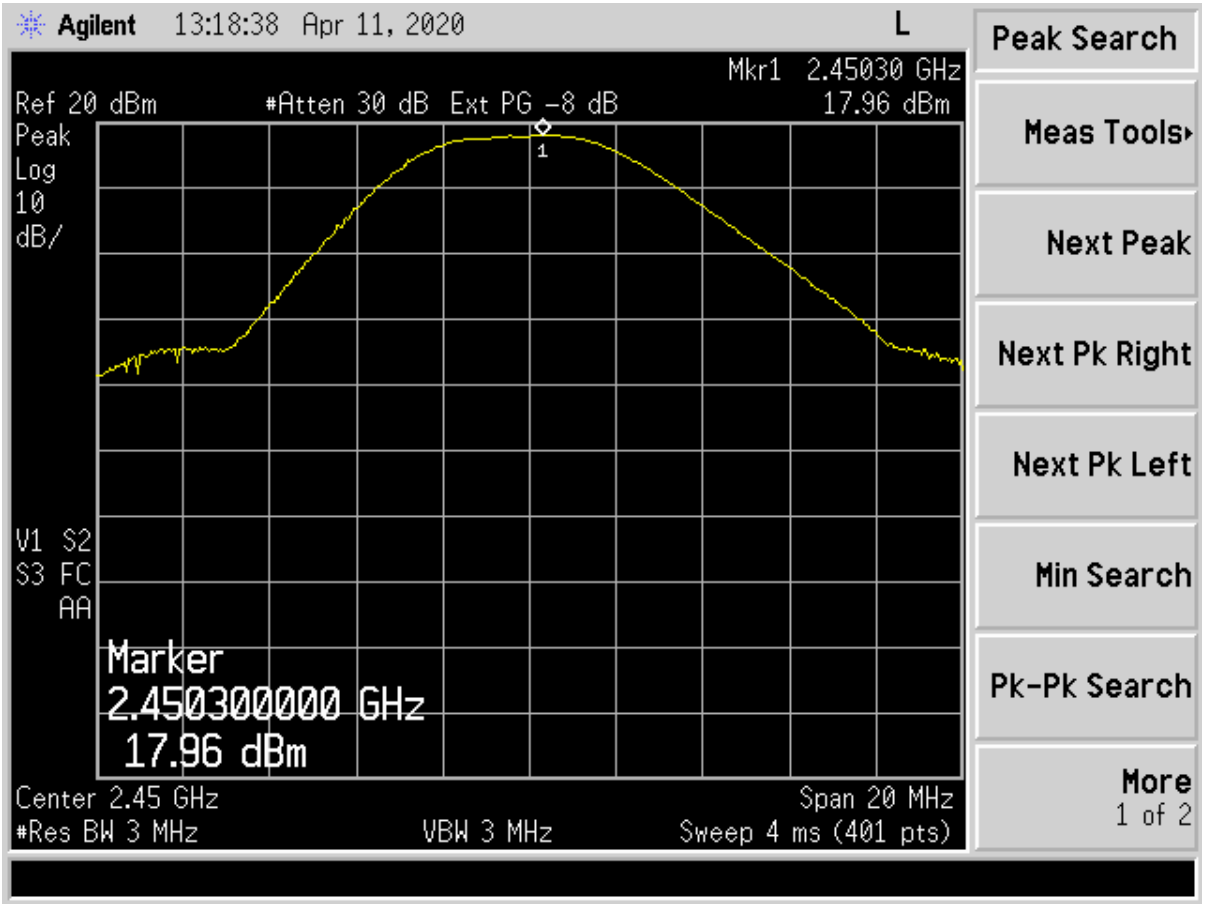


Figure 15. Peak Antenna Conducted Output Power, Mid Channel

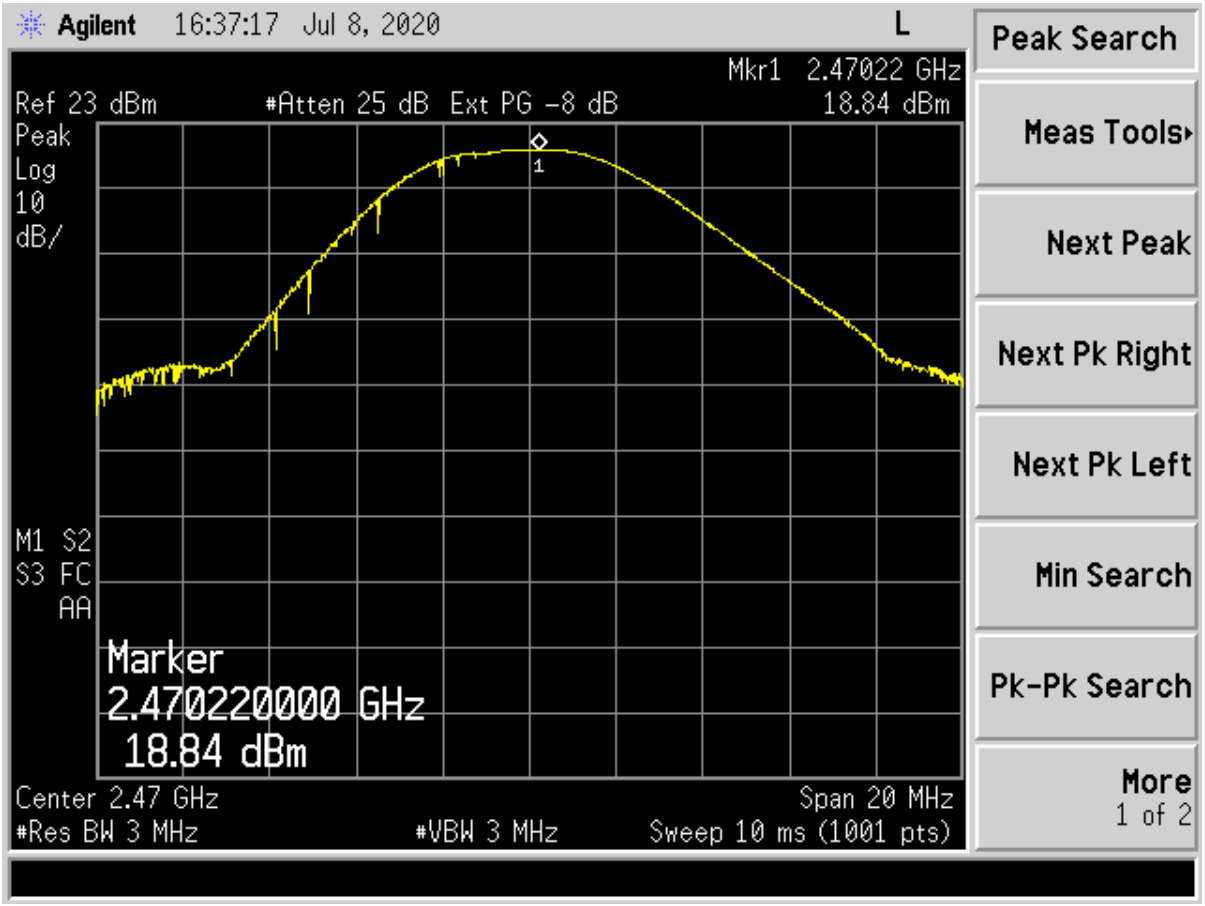


Figure 16. Peak Antenna Conducted Output Power, High Channel

2.14 Power Spectral Density (CFR 15.247(e))

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

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

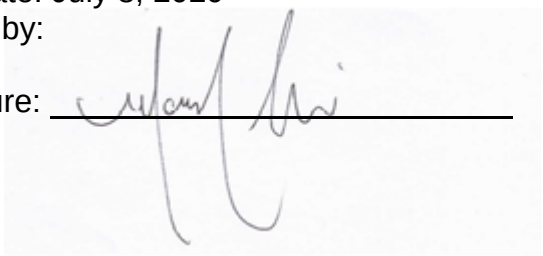
Results are shown in the table and figures below. All are less than +8 dBm per 3 kHz band.

Note: dBm/Hz correct to dBm/kHz using the following formula, 10 log $RBW_{ref}/RBW_{measured}$.

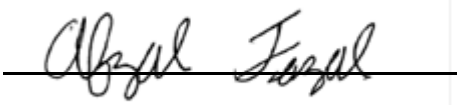
Table 13. Power Spectral Density (CFR 15.247(e))

Frequency (MHz)	Results (dBm/3 kHz)	FCC Limit (dBm/3 kHz)
2405	4.77	8.00
2450	5.89	8.00
2470	6.12	8.00

Test Date: July 8, 2020
Tested by:

Signature:  Name: Mark Afroozi

Test Date: April 11, 2020
Tested by:

Signature:  Name: Afzal Fazal

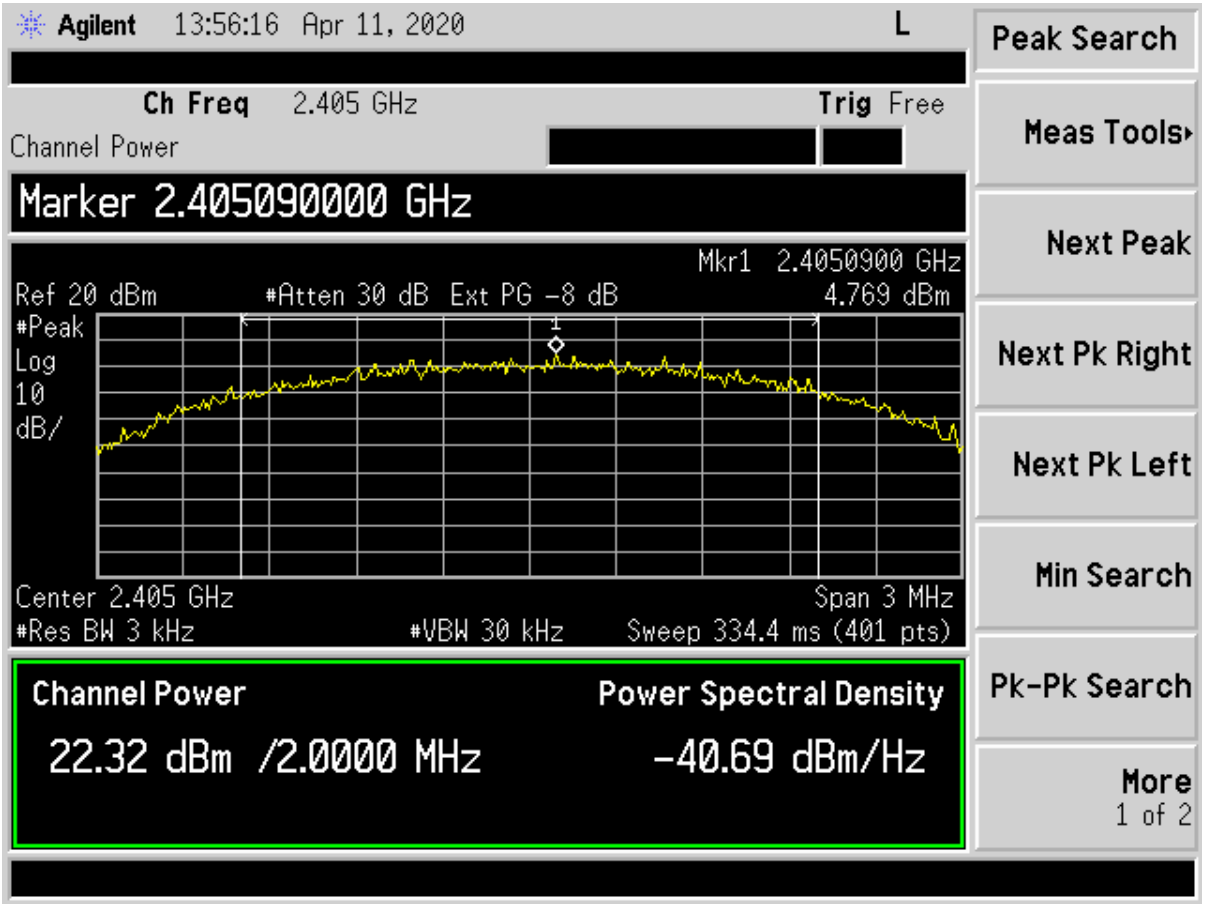


Figure 17. Power Spectral Density - Low Channel

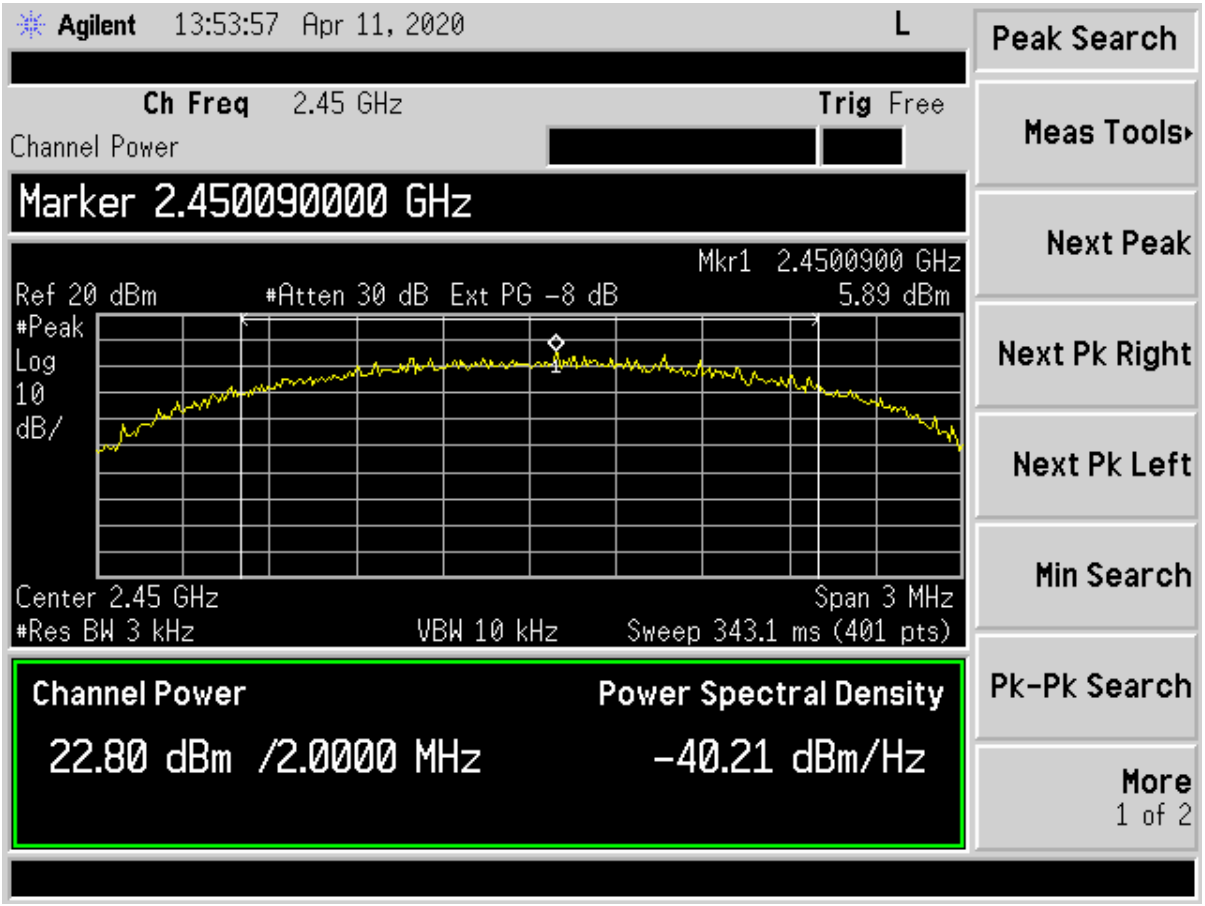


Figure 18. Power Spectral Density - Mid Channel

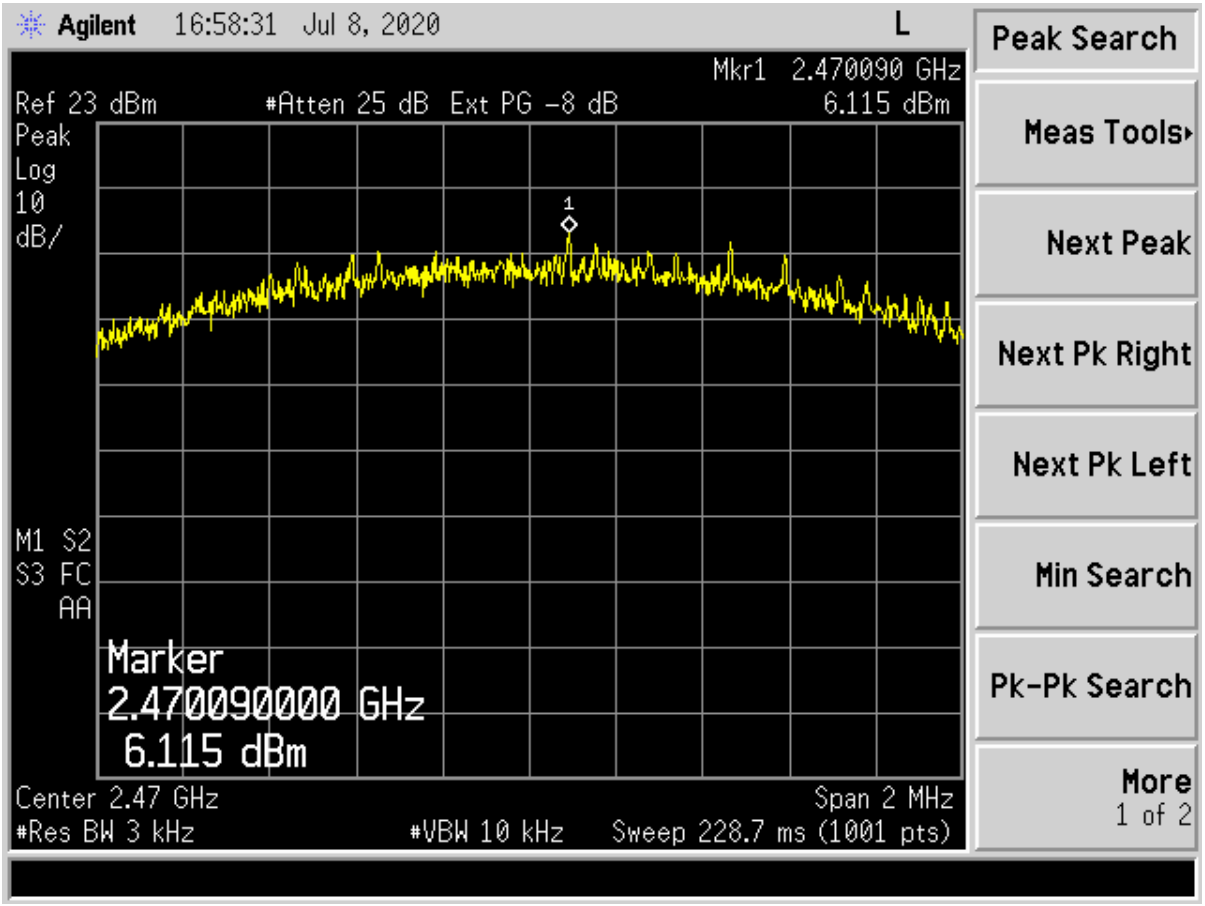


Figure 19. Power Spectral Density - High Channel

2.15 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%. This value includes all elements of measurement.

2.15.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.85 dB.

2.15.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.40 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.19 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.08 dB.

3 Conclusions

The EUT meets the requirements of Part 15.247 and RSS-247 based on the test results presented in this test report.