Testing Tomorrow's Technology

Application

For

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

And

Verification
Per
Part 15, Subpart B, for Unintentional Radiators, section 15.101, 15.107 and 15.109

And

Industry Canada RSS-Gen, Issue 5 and RSS-247, Issue 2

For the

Neptune Technology Group Inc.

Model: MRX920v4e

FCC ID: P2SMRXV4E
IC: 4171B-MRXV4E

UST Project: 23-0044
Issue Date: March 30, 2023

Total Pages in This Report: 54

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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 March 30, 2023

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

Company Name:	Neptune Technology Group Inc
Address:	1600 Alabama Hwy 229 Tallassee, AL 36078 USA
Model:	MRX920v4e
FCC ID:	P2SMRXV4E
IC ID:	4171B-MRXV4E
Date:	March 30, 2023

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

Equipment type: 902-928 MHz ISM Radio

Technical Information:

Radio Technology:	FHSS
Frequency of Operation (MHz):	911.08 – 919.08
Output Power (dBm):	21.5 dBm (141 mW)
Type of Modulation:	OOK
Data/Bit Rate (M)bps:	1200 Baud
Antenna Gain (dBi):	Refer to Table 5
Software used to program EUT:	ETi 81-00 Client/TSW-1024 v.1.0.0 R900 Test v.2.0.2023.0209
EUT firmware:	Pilot Release Candidate, v.50.1.230327.3584
Power setting:	"39*" (*)Power is adjusted at the manufacturing facility to match measured/granted output power for every unit.

Report prepared by:
US Tech
3505 Francis Circle
Alpharetta, GA30004

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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 28, 2023 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Neptune Technology Group Inc. Model MRX920v4e. The EUT is a transceiver that is used in a motor vehicle to read wireless water meters. It operates within the 902 - 928 MHz ISM band. The equipment also contains a low-power Bluetooth Transceiver with modular certification, the Laird BL653U. The EUT is powered from the vehicle “cigarette lighter” or other indirect or direct connection to the 12V or 24V starting/charging/battery system in the motor vehicle in which it is operated.

The EUT employs a frequency hopping spread spectrum (FHSS) type of modulation and has 3 operating modes:

1. Unattended receive mode
2. Bluetooth-controlled mode
3. USB-controlled mode

Antenna: Laird 915 MHz monopole
Maximum Output Power: 21 dBm (Rated)

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. Block diagrams of the tested system are shown in Figures 1 and 2. Test configuration photographs are provided in separate Appendices.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is US5301. Additionally, this site has been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittals

The Equipment under Test (EUT) is subject to the following FCC/IC authorizations:

a) Certification under section 15.247/IC RSS-247 as a transmitter.
b) Verification under 15.101/ICES-003 as a digital device and receiver.

The Verification requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the Verification authorization report for the EUT is included herein.

1.7 Test Results

In our opinion, and as indicated by the test results documented following, when tested in the configuration as described in this report, the EUT meets the applicable requirements of FCC and IC, including: FCC Parts 2.902, 15.101, 15.107, 15.109, 15.207, 15.209, 15.247, RSS GEN, and RSS-247.

Table 1. EUT and Peripherals

EUT MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC and IC ID	CABLES P/D
Neptune Technology Group, Inc.	MRX920v4e		FCC ID: P2SMRXV4 IC: 4171B-MRXV4 Contains: FCCID: SQGBL653U IC: 3147A-BL653U	None

PERIPHERAL and MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC and IC ID	CABLES P/D
Laird 915 MHz Antenna	B8965C	3	--	12 ft S D
Dell Laptop Computer (Used only for receive mode unintentional emissions testing)	Various	Various	Various	15 ft D
Optima Deep Cycle and Starting Battery	D34	--	--	8 ft U P

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

Table 2. Details of I/O Cables Attached to EUT

DESCRIPTION OF CABLE	DETAILS OF CABLE			CABLE LENGTH
Power Cable	**Manufacturer and Part Number**			8 ft
	Various			
	Shield Type	**Shield Termination**	**Type of Backshell**	
	N/A	N/A	N/A	
Antenna Cable (Reverse TNC)	**Manufacturer and Part Number**			12 ft
	Various			
	Shield Type	**Shield Termination**	**Type of Backshell**	
	CND	360	MS	
USB (Receive mode testing only)	**Manufacturer and Part Number**			15 ft
	Various			
	Shield Type	**Shield Termination**	**Type of Backshell**	
	CND	CND	PU	

Shield Type
N/A = None
F = Foil
B = Braided
2B = Double Braided
CND = Could Not Determine

Shield Termination
N/A = None
360 = 360 Degrees
P = Pigtail/Drain Wire
CND = Could Not Determine
MU = Metal Unshielded

Type of Backshell
N/A = Not Applicable
PS = Plastic Shielded
PU = Plastic Unshielded
MS = Metal Shielded

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 3. Test Instruments

TEST INSTRUMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CALIBRATION DUE DATE
Spectrum Analyzer	Advantest	U3772	1806001039	1/25/2025 2 yr.
Spectrum Analyzer	Hewlett-Packard	8593E	3205A00124	2/28/2024 2 yr.
Preamp	Hewlett-Packard	8449B	3008A00480	3/3/2024
Preamp	Hewlett-Packard	8447D	1937A02980	6/9/2023
Loop Antenna	EMCO	6502	9810-3246	12/7/2024 2 yr
Biconical Antenna	EMCO	3110B	9306-1708	8/17/2023 2 yr
Log Periodic Antenna	EMCO	3146	9110-3236	12/13/2023 2 yr
Horn Antenna	A.H. Systems	SAS-571	605	4/28/2024 2 yr
Attenuator 8 dB	Mini-Circuits Inc.	VAT-8 15542	3 0519	9/1/2023

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

2.2 Modifications to EUT Hardware

No physical modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

2.3 Number of Measurements for Intentional Radiators (Part 15.31(m))

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

Table 4. 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 over a range of 8 MHz, 2 test frequencies were used 911.08 MHz and 919.08 MHz.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

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

2.4.2 Unintentional Radiator

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

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

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

Detector Function and Associated Bandwidth

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

Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may be expressed logarithmically in dB.

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

2.6 EUT Antenna Requirements (CFR 15.203)

This equipment is not available to the general public and will only be installed by a professional installer working for an approved utility. The equipment therefore meets the intent of the above requirement. Only the antennas listed in Table 4 will be used with this module.

Table 5. Allowed Antenna

MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
Laird	Monopole	B8965C	5.1	Reverse TNC

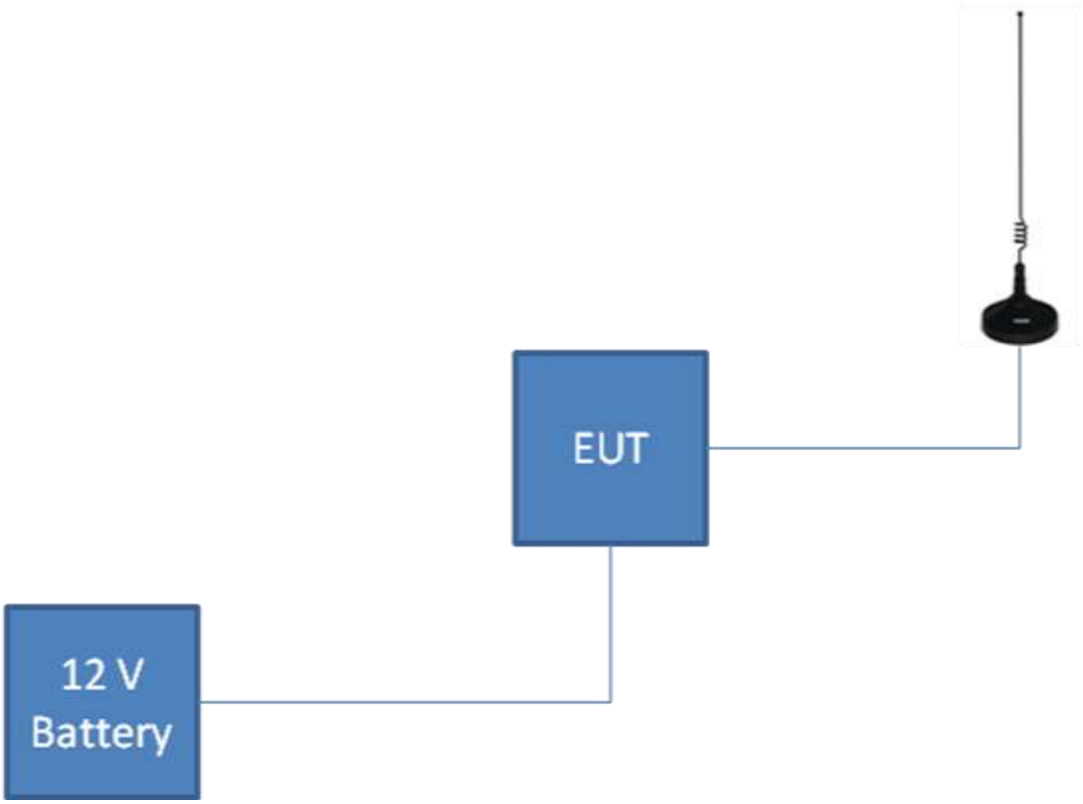


Figure 1. Block Diagram of Transmit Mode Test Configuration

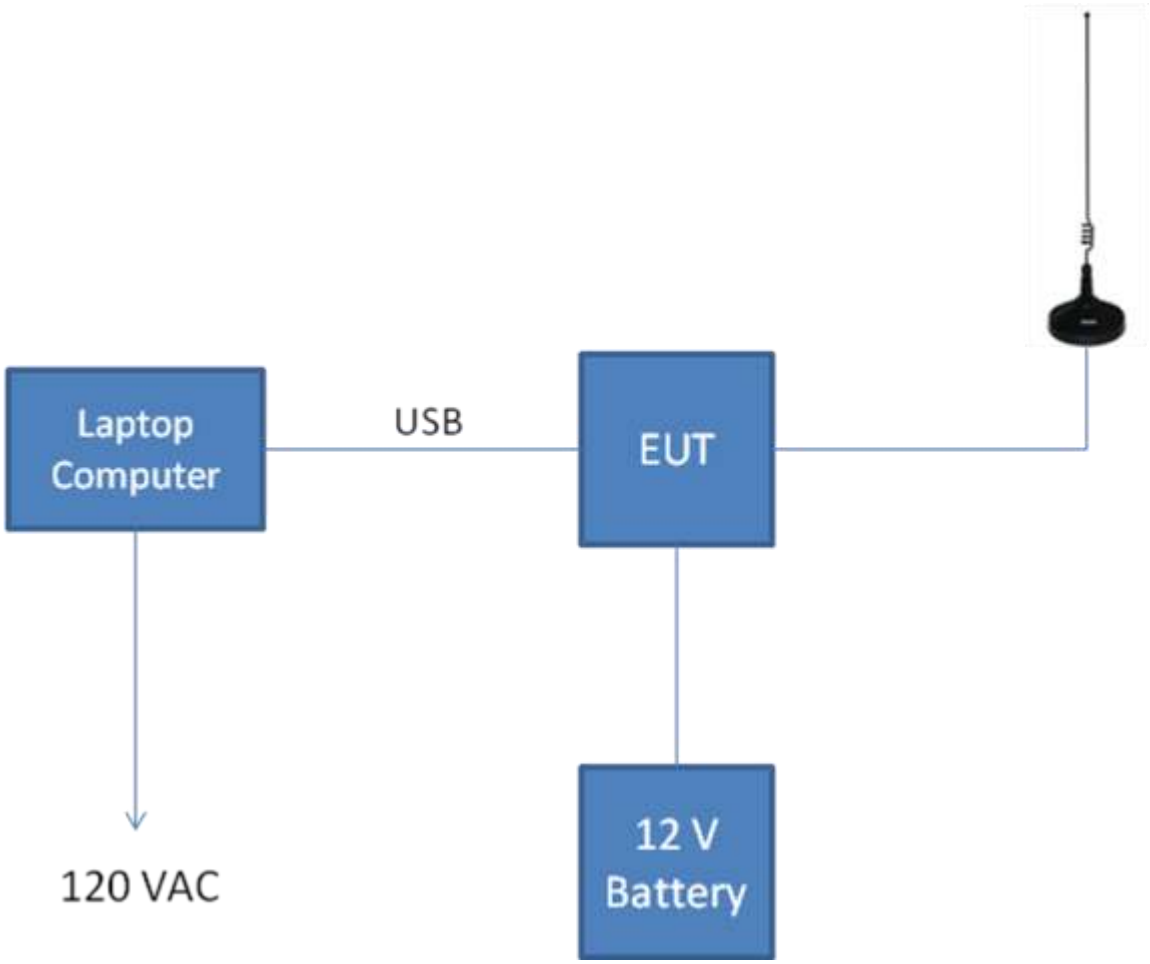


Figure 2. Block Diagram of Receive Mode Test Configuration

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious cannot exceed the limits of 15.209. Radiated harmonics and other spurious emissions are examined for this requirement. See paragraph 2.10 of the test report.

2.8 Transmitter Duty Cycle (CFR 15.35 (c))

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

In this case the EUT pulse train does not exceed 0.1 seconds; plots of the pulse train are provided below.

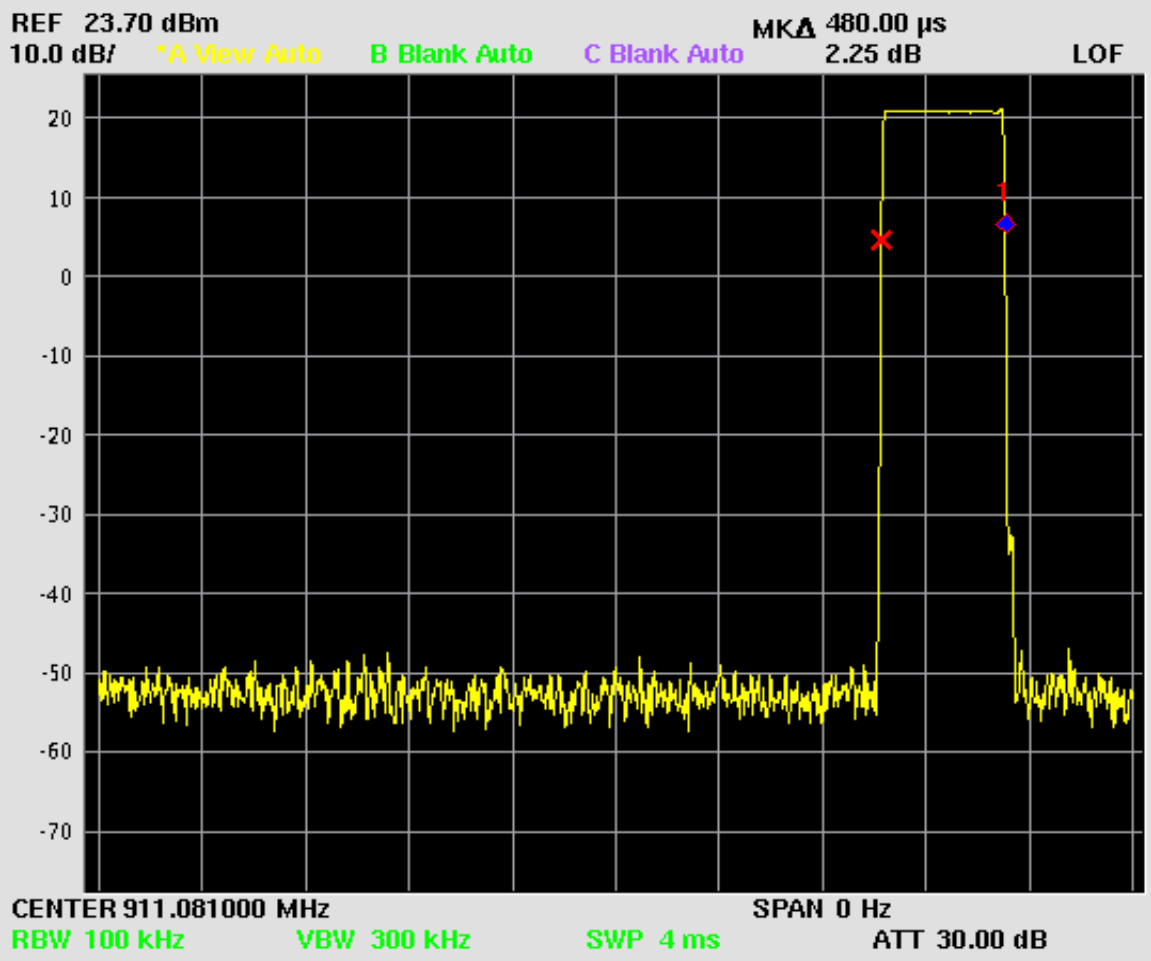


Figure 3. Pulse Width

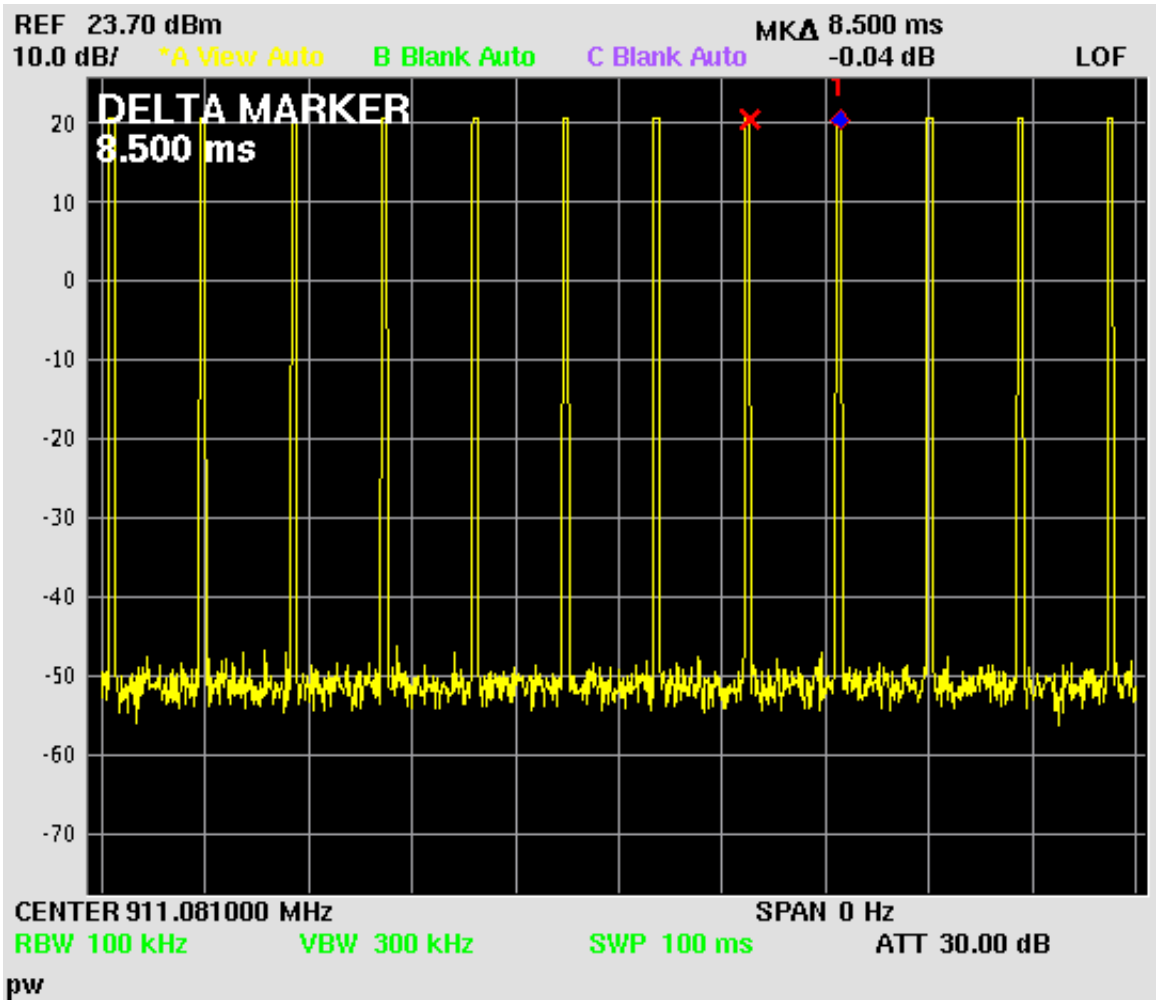


Figure 4. Pulse Train (Duty Cycle)

TX On time = 12 x 0.48 ms = 5.76 ms
Duty cycle = 20 log (5.76 ms/100 ms) = -24.79 dB = duty cycle correction factor
Note: Duty cycle correction greater than -20 dB therefore -20 dB was used as the correction factor in this report.

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

The EUT is intended to be powered by an automotive electrical system**.** Since the EUT is not powered from a public utility source, this test was not applicable. A 12 VDC deep cycle lead acid battery was used to power the EUT during testing.

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

Radiated Spurious measurements: The EUT was placed into a continuous transmit mode of operation (>98% duty cycle) and tested per ANSI C63.10-2013. The EUT was tested in 3 orthogonal positions because the device is considered portable.

Radiated measurements were conducted 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 125 kHz, a resolution bandwidth (RBW) of 200 Hz was used. In the band from 125 kHz to 30 MHz, a RBW of 9 kHz was used; emissions below 1 GHz were tested with a RBW of 100/120 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 emanating from the antenna port.

Conducted Spurious measurements: The EUT was put into a continuous-transmit mode of operation (>98% 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 30 MHz 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.

Table 6. Average Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Neptune Technology Group Inc.			
Project: 23-0044				**Model:** MRX920v4e			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel – AVERAGE							
911.09	97.56	22.62	120.18	--	3.0m./VERT	--	**QP**
1822.00	35.59	-9.42	26.17	54.0	3.0m./VERT	27.8	**AVG**
2731.00	36.08	-5.15	30.93	54.0	3.0m./VERT	23.1	**AVG**
High Channel – AVERAGE							
919.09	98.71	22.62	121.33	--	3.0m./VERT	--	**QP**
1838.00	45.10	-9.32	35.78	54.0	3.0m./VERT	18.2	**AVG**
2753.00	35.97	-5.28	30.69	54.0	3.0m./VERT	23.3	**AVG**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic.
3. (~) Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. 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%. 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 911.09 MHz:

Magnitude of Measured Frequency	97.56	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	22.62	dB/m
Corrected Result	120.18	dBuV/m

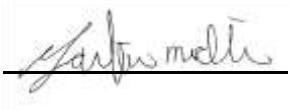
Test Date: March 28, 2023
Tested By
Signature:  Name: Gabriel Medina

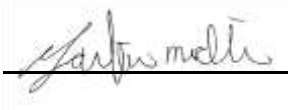
Table 7. Peak Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Neptune Technology Group Inc.			
Project: 23-0044				**Model:** MRX920v4e			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel – PK							
911.09	98.67	22.62	121.29	--	3.0m./VERT	--	**PK**
1822.00	52.47	-9.42	43.05	74.0	3.0m./VERT	30.9	**PK**
2731.00	50.33	-5.15	45.18	74.0	3.0m./VERT	28.8	**PK**
High Channel – PK							
919.09	99.23	22.62	121.85	--	3.0m./VERT	--	**PK**
1838.00	53.95	-9.32	44.63	74.0	3.0m./VERT	29.4	**PK**
2753.00	50.57	-5.28	45.29	74.0	3.0m./VERT	28.7	**PK**

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic.
3. (~) Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. 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%. 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 911.09 MHz:

Magnitude of Measured Frequency	98.67	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	22.62	dB/m
Corrected Result	121.29	dBuV/m

Test Date: March 28, 2023
Tested By
Signature:  Name: Gabriel Medina

Conducted Spurious Emissions:

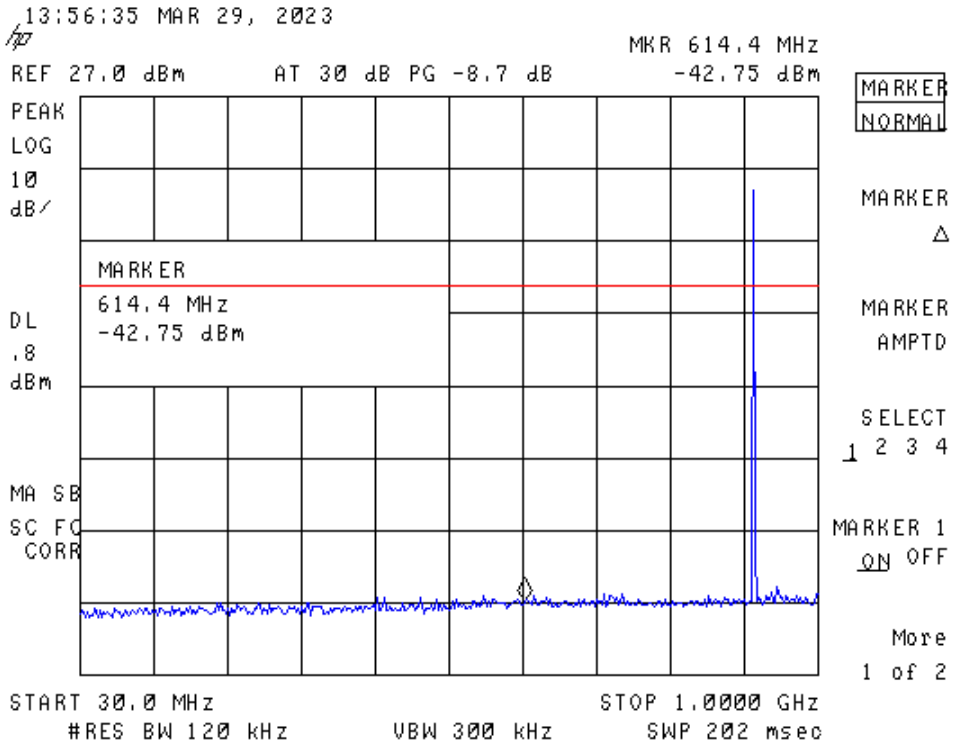


Figure 5. Antenna Conducted Emissions Low Channel, 30 MHz to 1 GHz

Note: Large emission seen is the fundamental emission.

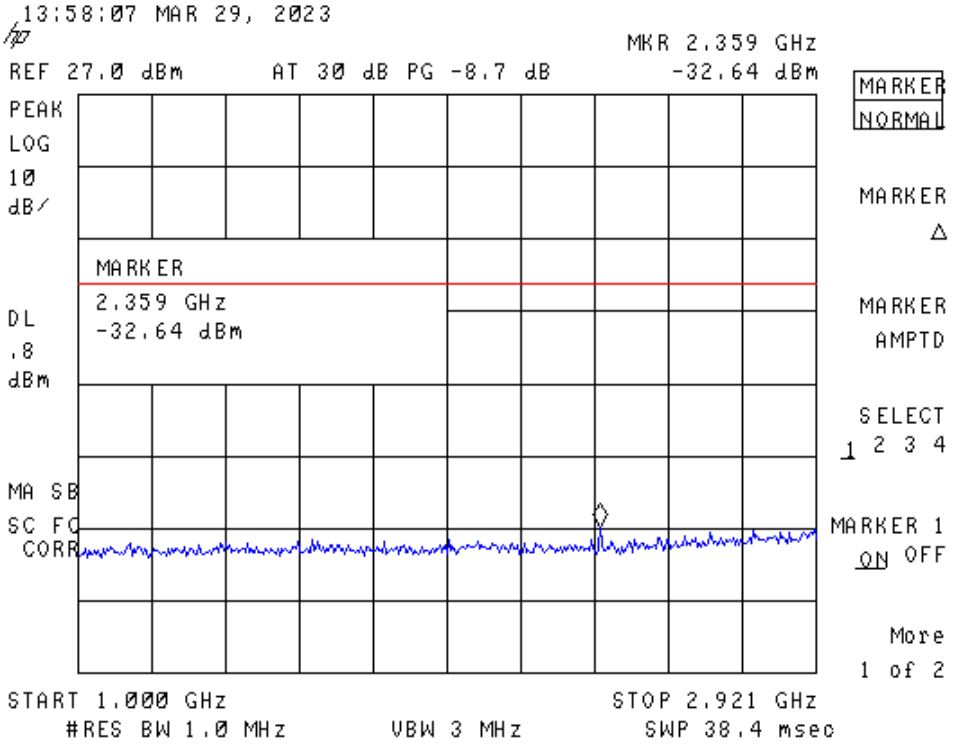


Figure 6. Antenna Conducted Emissions Low Channel, 1 to 2.9 GHz

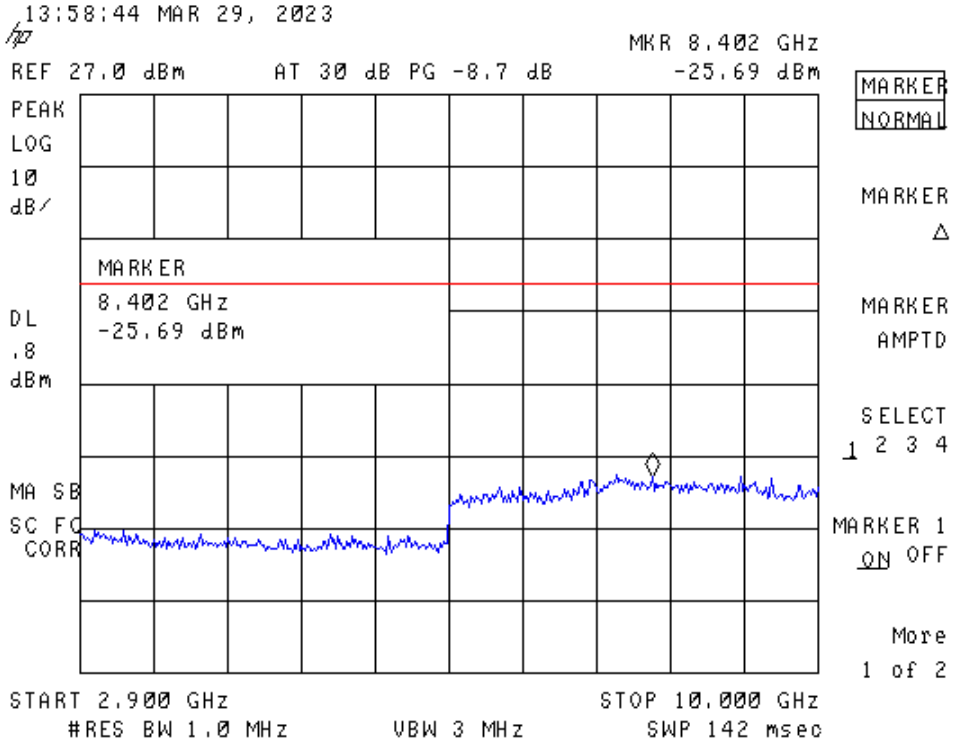


Figure 7. Antenna Conducted Emissions Low Channel, 2.9 to 10 GHz

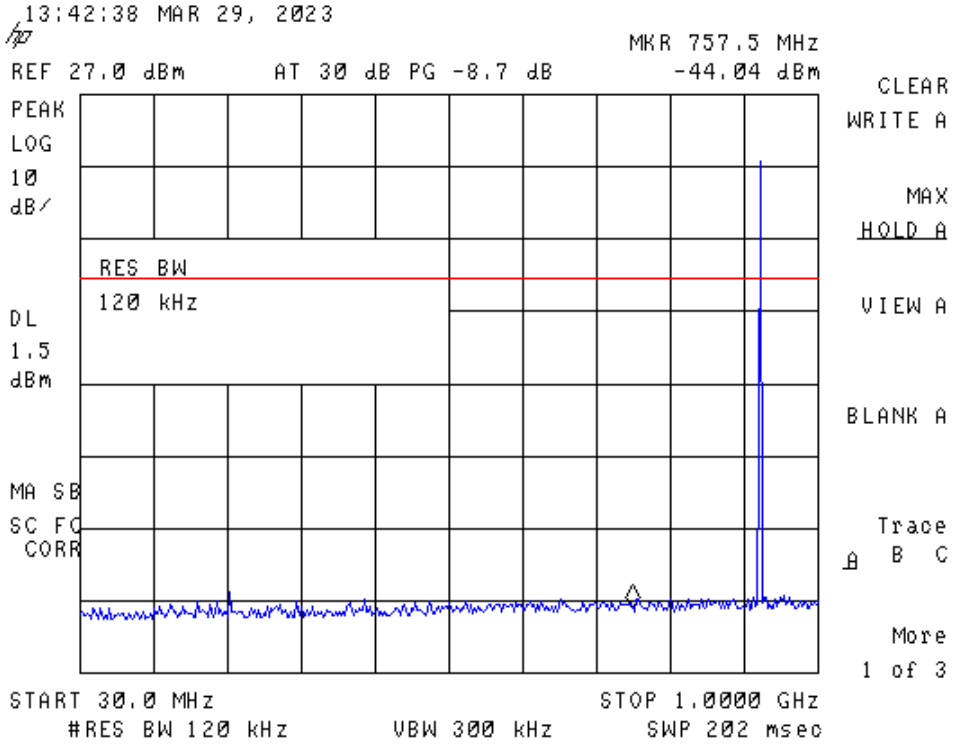


Figure 8. Antenna Conducted Emissions High Channel, 30 MHz to 1 GHz

Note: Large emission seen is the fundamental emission.

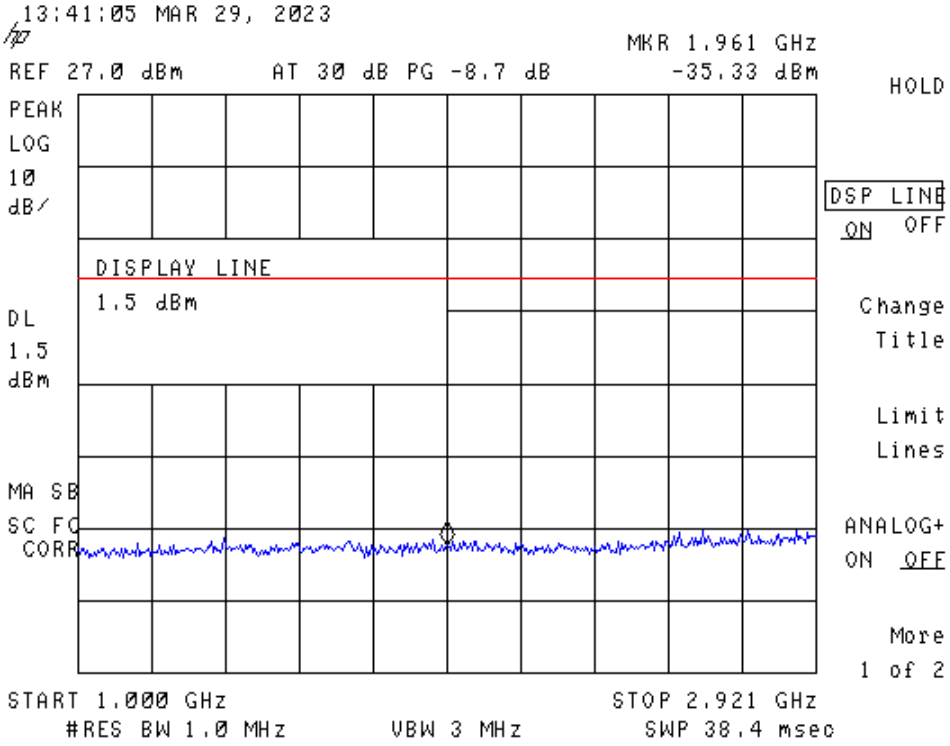


Figure 9. Antenna Conducted Emissions High Channel, 1 to 2.9 GHz

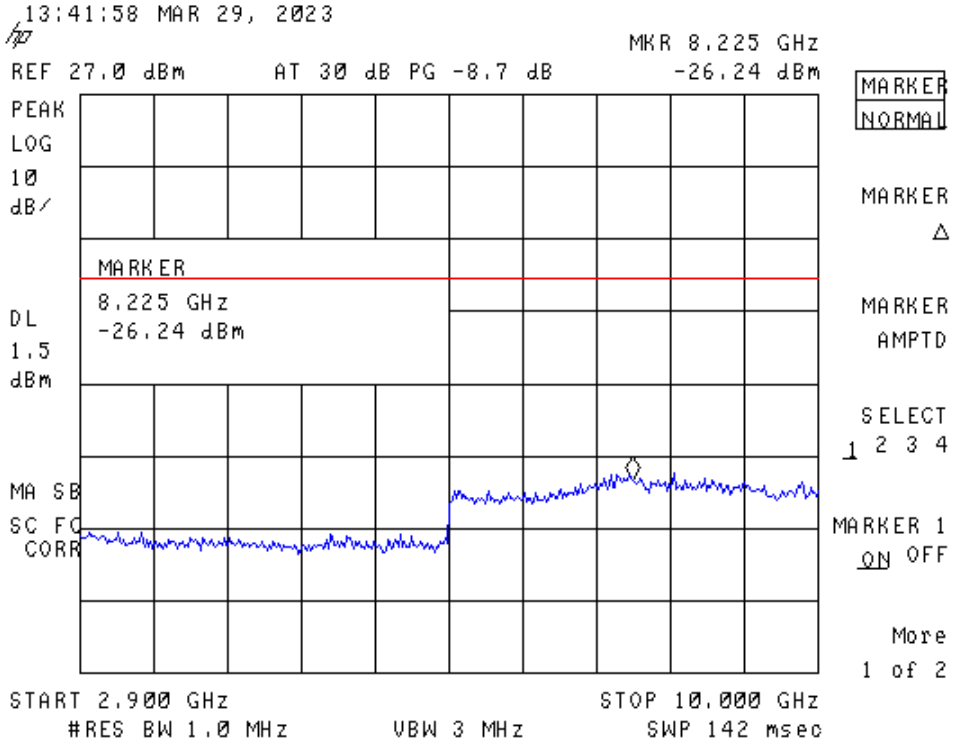


Figure 10. Antenna Conducted Emissions High Channel, 1 to 2.9 GHz

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

Band Edge measurements are made, following the guidelines in ANSI 63.10-2013, with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Conducted measurements are performed to demonstrate compliance with the requirement of 15.247(d) that all emissions outside of the band edges be attenuated by at least 20 dB when compared to its highest in-band value (contained in a 100 kHz band).

To capture the band edge, set the Spectrum Analyzer frequency span large enough (usually around 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.

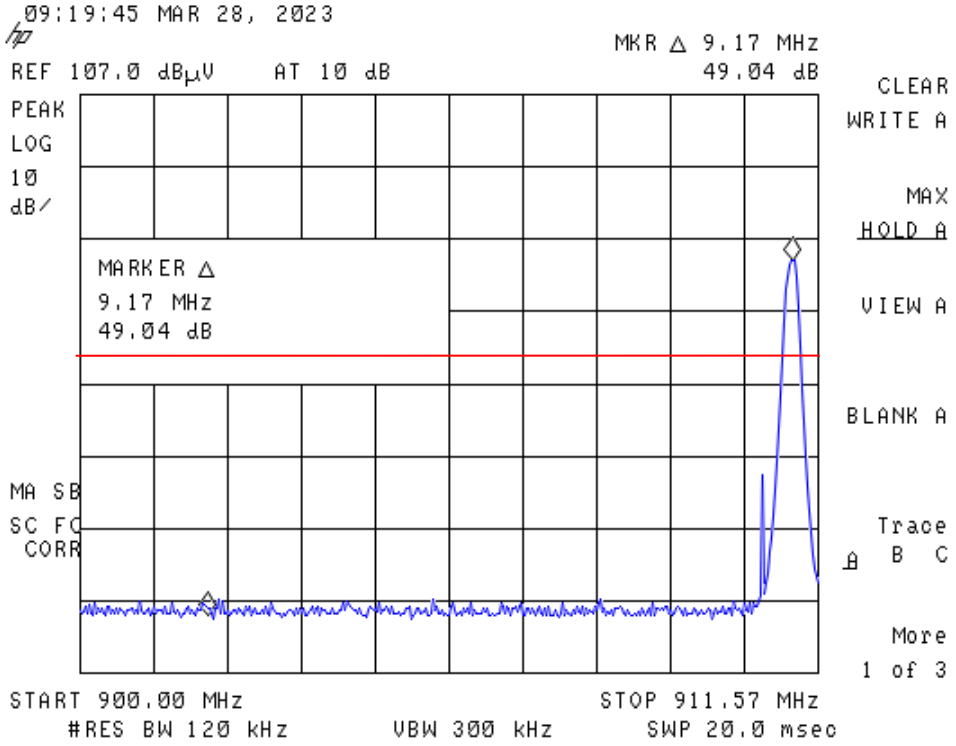


Figure 11. Band Edge Compliance, Low Channel Delta

Measured Delta (from Figure 11)	49.04	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	29.04	dB

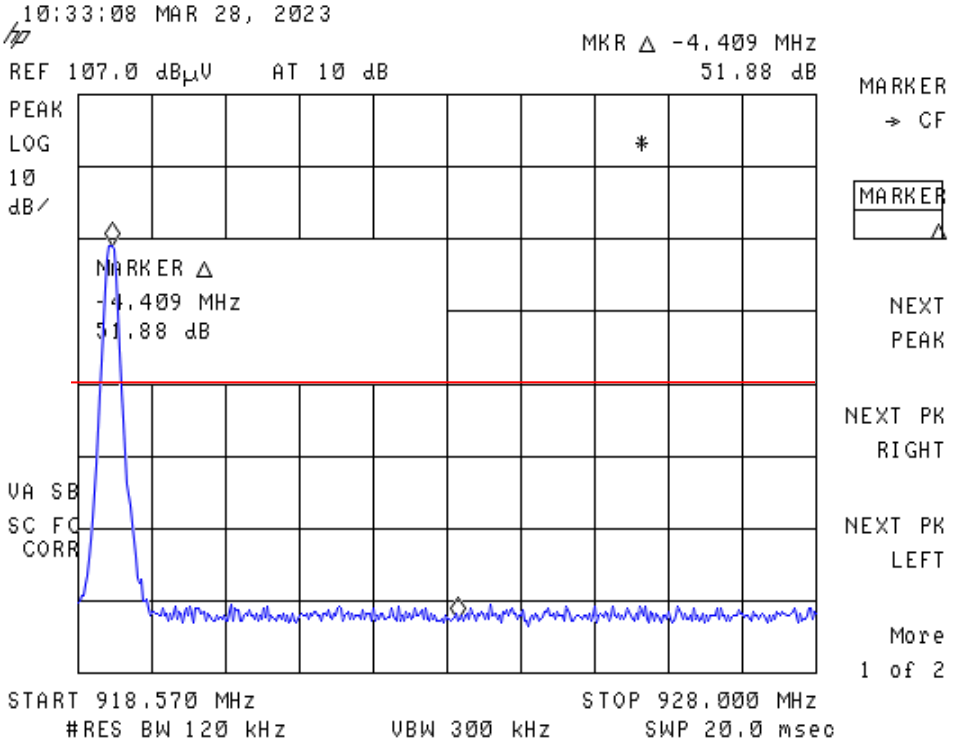


Figure 12. Band Edge Compliance, High Channel Delta

Measured Delta (from Figure 12)	51.88	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	31.88	dB

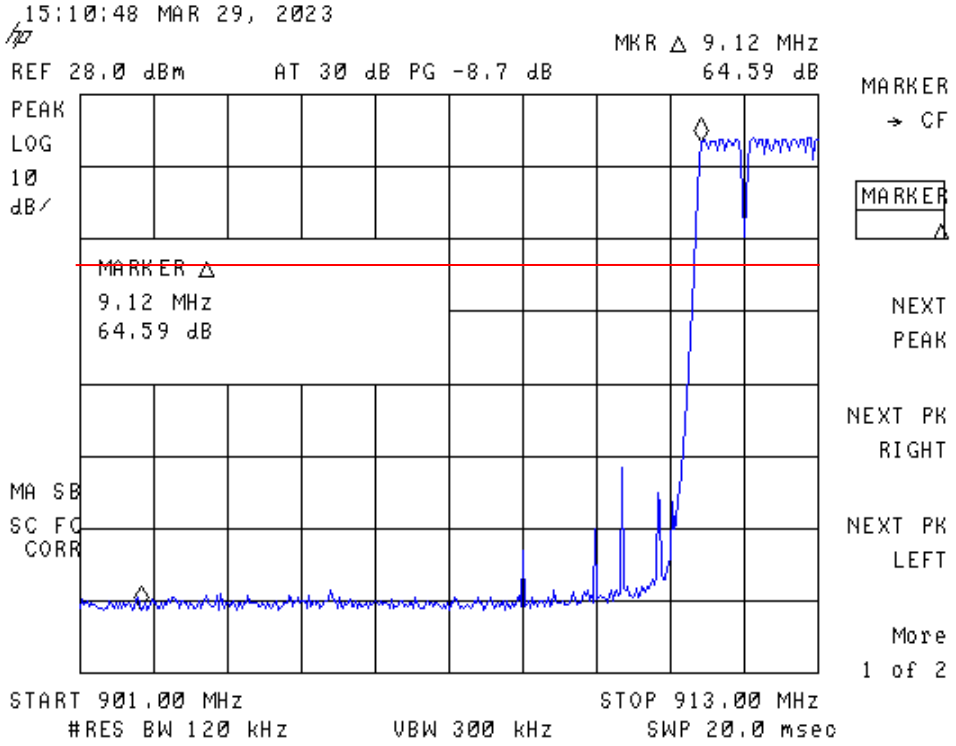


Figure 13. Band Edge Compliance, Low Channel Delta – Channel Hopping

Measured Delta (from Figure 12)	64.59	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	44.59	dB

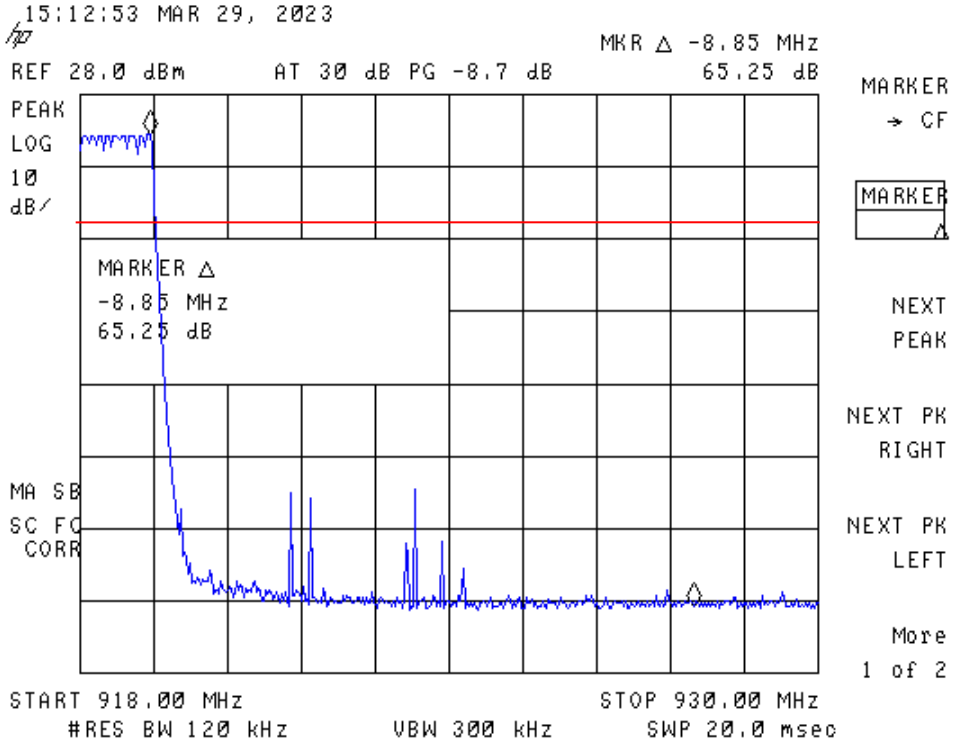


Figure 14. Band Edge Compliance, High Channel Delta – Channel Hopping

Measured Delta (from Figure 13)	65.25	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	45.25	dB

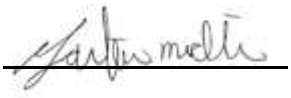
2.12 Twenty dB Bandwidth (CFR 15.247 (a) (1))

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

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

Table 8. Twenty (20) dB Bandwidth

Frequency (MHz)	20 dB Bandwidth (kHz)	Maximum Limit (kHz)	99% Occupied Bandwidth (kHz)
911.0810	72.40	500	67.12
919.0769	72.40	500	67.12

Test Date: March 29, 2023
Tested By
Signature:  Name: Gabriel Medina

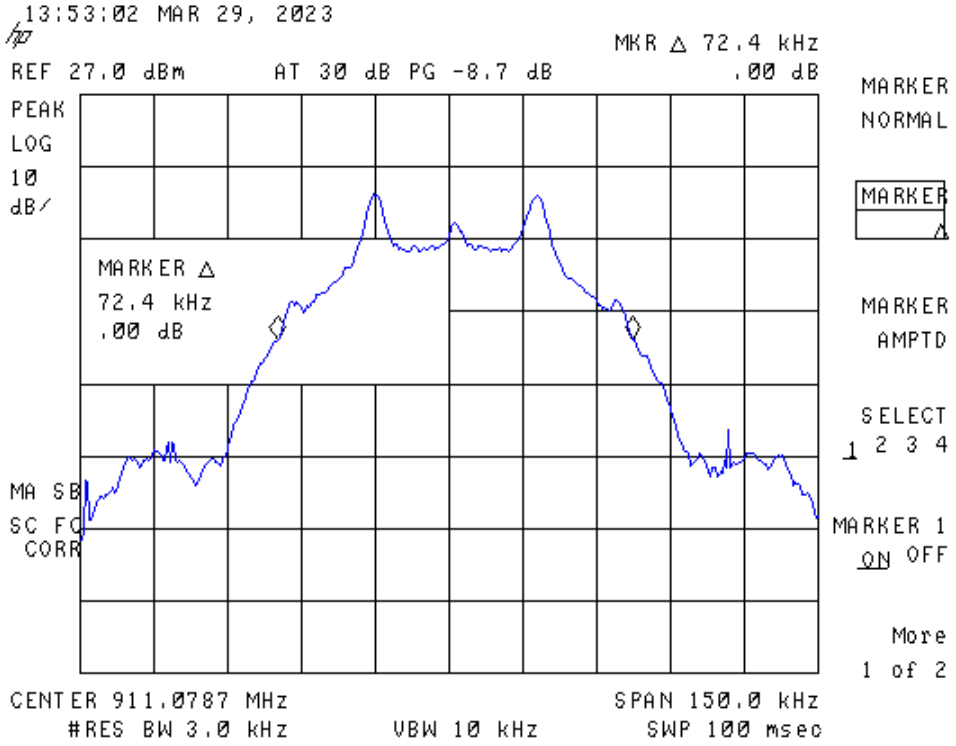


Figure 15. Twenty dB Bandwidth – Low Channel

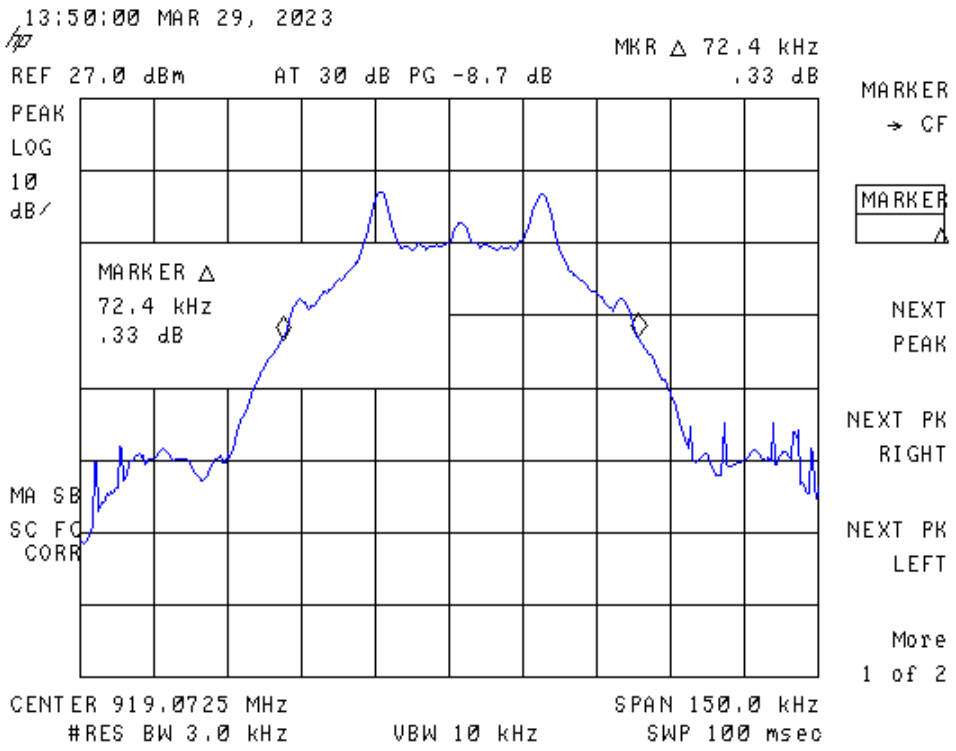


Figure 16. Twenty dB Bandwidth – High Channel

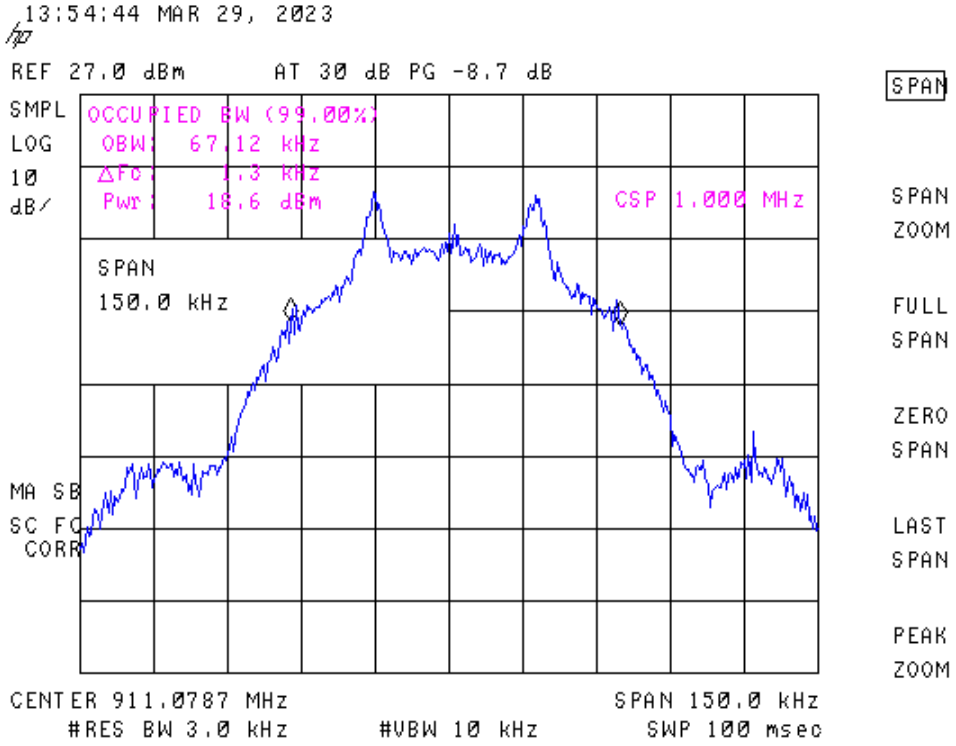


Figure 17. 99% Occupied Bandwidth – Low Channel

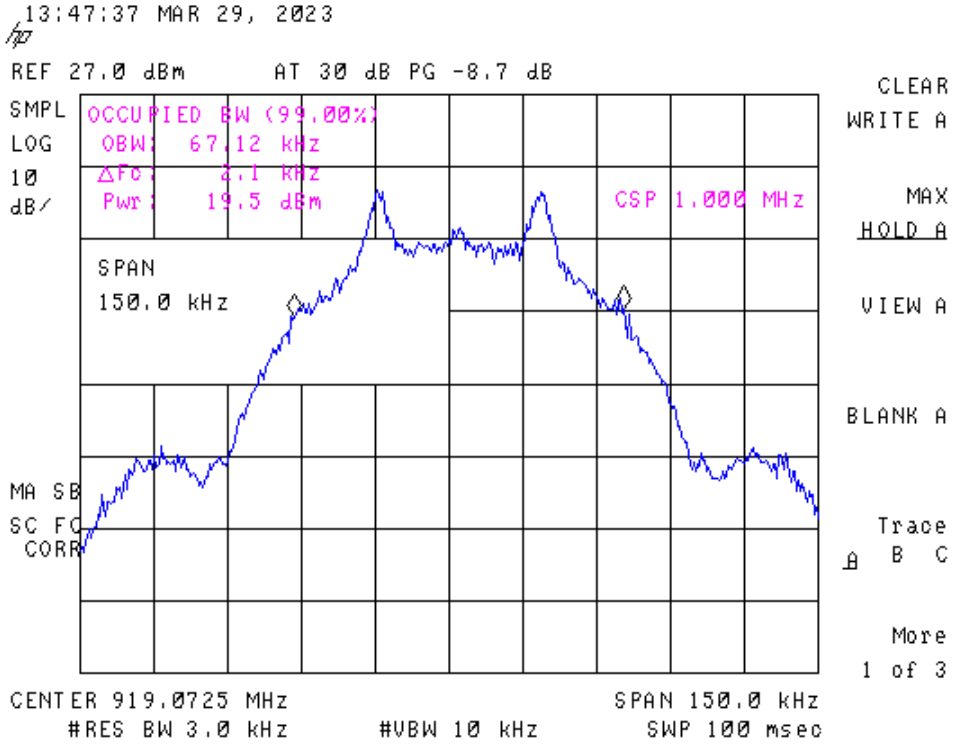


Figure 18. 99% Occupied Bandwidth – High Channel

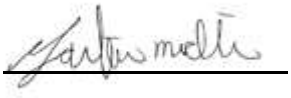
2.13 Maximum Peak Conducted Output Power (CFR 15.247 (b) (2))

For frequency hopping systems in the 902-928 MHz band with at least 50 hopping channels, the maximum peak conducted output power of the intentional radiator shall not exceed 1 watt. Systems with less than 50 hopping channels, but at least 25 hopping channels, the maximum peak conducted output power of the intentional radiator shall not exceed .25 watts. Since the EUT has 50 hopping channels, the maximum peak conducted output power shall not exceed 1 watt.

Peak power within the band 911.1 MHz to 919.1 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 50Ω input impedance. The setup losses were corrected by using a -8.53 dB offset in the analyzer measurements. Peak antenna conducted output power is tabulated in the table below.

Table 9. 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)
911.125	20.75	118.85	1000
919.100	21.48	140.60	1000

Test Date: March 28, 2023
Tested By
Signature:  Name: Gabriel Medina

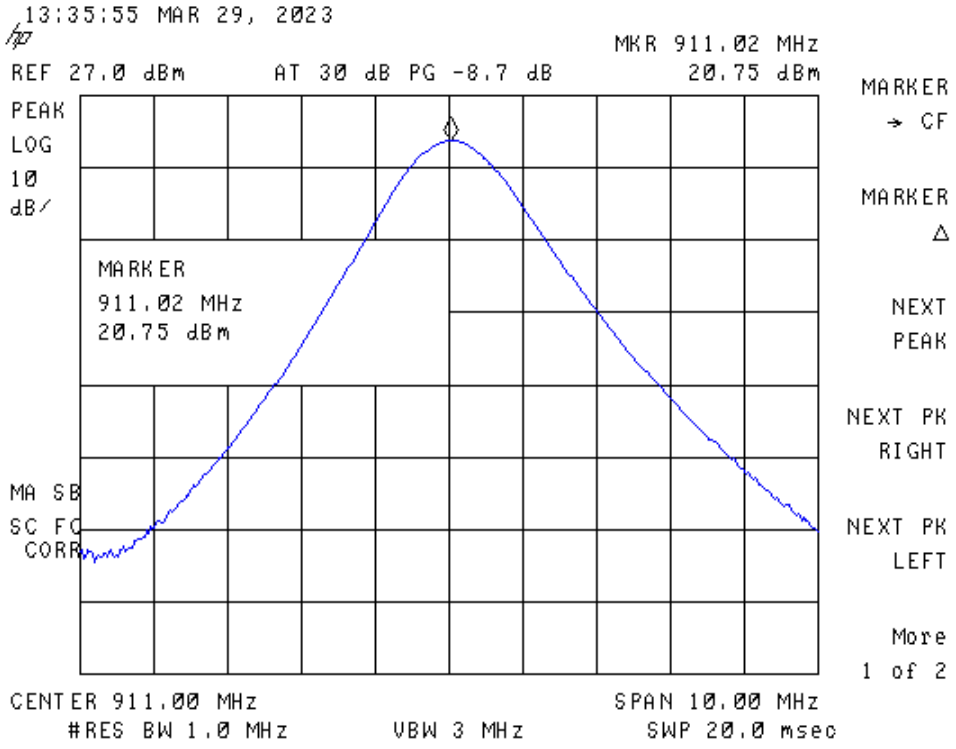


Figure 19. Peak Antenna Conducted Output Power, Low Channel

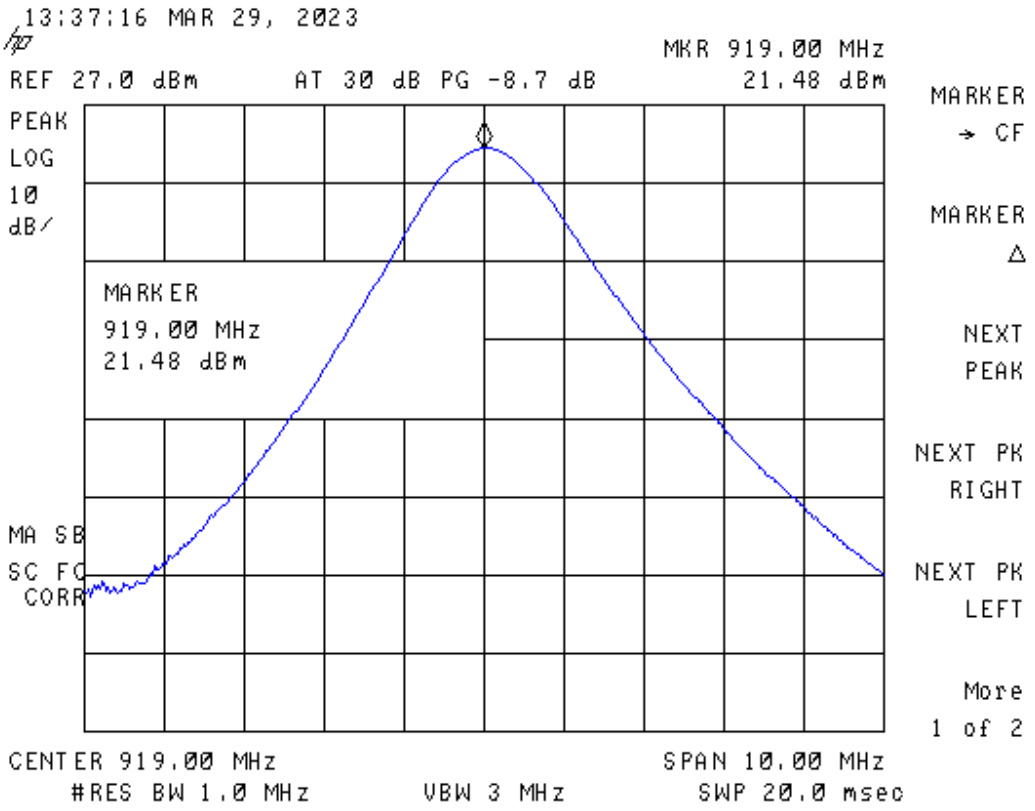


Figure 20. Peak Antenna Conducted Output Power, High Channel

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

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

The test procedures outlined in ANSI C63.10-2013 were used to conduct measurements.

The table below lists all available channels. There are a total of 50 channels.

Table 10. List of Hopping Channels

Number of channels used	TX Hopping Sequence Order (1-50)	TX/RX RF Center Frequency (MHz)
1	1	911.081472
2	11	911.212544
3	21	911.343616
4	31	911.474688
5	41	911.60576
6	7	911.736832
7	17	911.867904
8	27	911.998976
9	37	912.130048
10	47	912.26112
11	3	912.392192
12	13	912.523264
13	23	912.654336
14	33	912.785408
15	43	912.91648
16	9	913.047552
17	19	913.178624
18	29	914.88256
19	39	915.013632
20	49	915.144704
21	5	915.275776
22	15	915.406848
23	25	915.53792
24	35	915.668992
25	45	915.800064
26	2	915.931136
27	12	916.062208
28	22	916.19328
29	32	916.324352
30	42	916.455424
31	8	916.586496
32	18	916.717568
33	28	916.84864
34	38	916.979712
35	48	917.110784
36	4	917.241856
37	14	917.372928
38	24	917.504
39	34	917.635072
40	44	917.766144
41	10	917.897216
42	20	918.028288
43	30	918.15936
44	40	918.290432
45	50	918.421504
46	6	918.552576
47	16	918.683648
48	26	918.81472
49	36	918.945792
50	46	919.076864

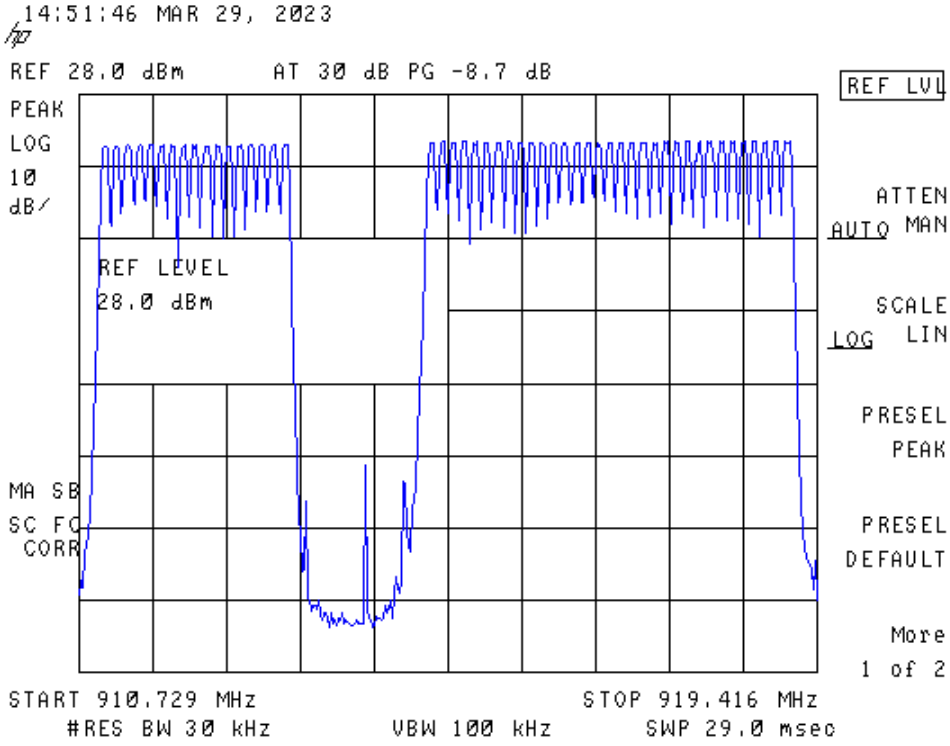


Figure 21. Hopping Channels 1 through 50

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

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. In this case, the 20 dB bandwidth of the Frequency hopping system is greater than 25 kHz, so the minimum requirement used was the 20 dB bandwidth, 72.4 kHz. Therefore, the frequency separation must be greater than 72.4 kHz.

The EUT does meet the frequency separation requirement.

The test procedure outlined in ANSI C63.10-2013 was used to conduct measurements. The EUT hopping function was enabled during the testing.

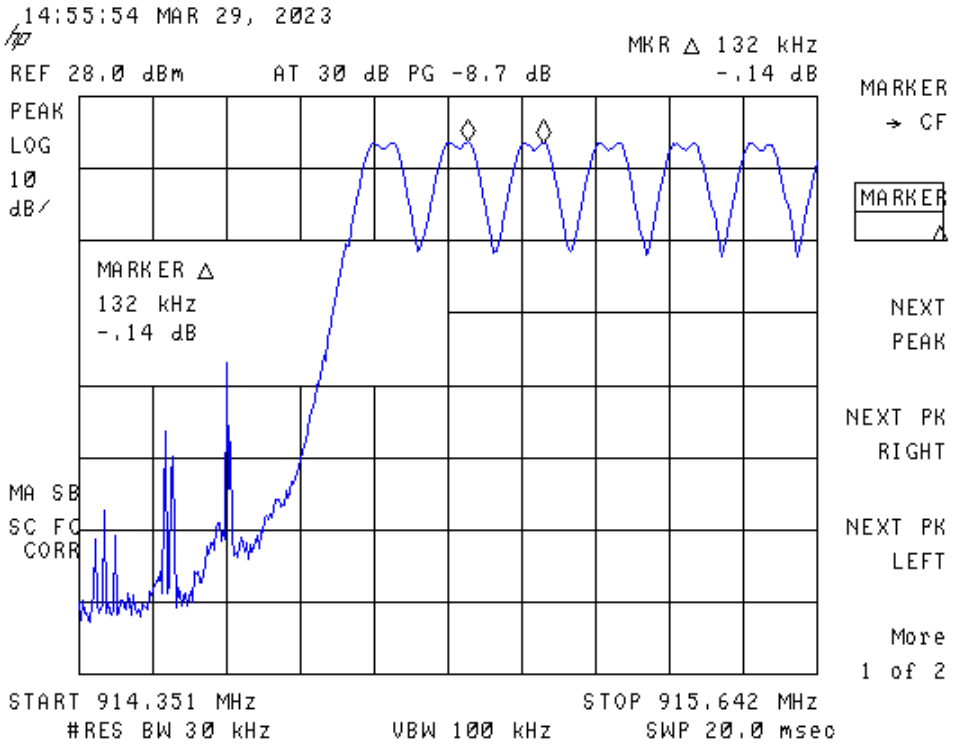


Figure 22. Channel Separation

Measured Delta (Figure 33 above)	132.0 kHz
-Limit (20 dB Bandwidth)	72.4 kHz
Margin	59.6 kHz

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

The customer considers this to be proprietary information. Please see the Theory of Operation exhibit section 7 for occupancy time details.

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

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

2.18 Unintentional Radiator, Radiated Emissions (CFR 15.109)

Radiated emissions disturbance measurements were performed with all the transmitter turned OFF or in receive mode. This test data is presented below to show compliance to this part.

An instrument having both peak and quasi-peak detectors was used to perform the test over the frequency range of 30 MHz to five times the highest clock frequency. Measurements of the radiated emissions were made with the receiver antenna at a distance of 3 m from the boundary of the test unit.

The test antenna was varied from 1 m to 4 m in height while watching the analyzers' display for the maximum magnitude of the signal at the test frequency. The antenna polarization (horizontal or vertical) and test sample azimuth were varied during the measurements to find the maximum field strength readings to record.

NOTE: TESTING PERFORMED WITH BOTH 900 MHz and Bluetooth RADIO IN IDLE/RECEIVE MODE TO COVER CO-LOCATION AND SIMULTANEOUS BROADCASTING.

The worst-case radiated emission in the range of 30 MHz to 25 GHz was 10.1 dB below the limit at 942.5 MHz . This signal is found in Table 11. All other radiated emissions were 12.1 dB or more below the limit.

Table 11. Unintentional Radiator, Spurious Radiated Emissions (CFR 15.109) 30 MHz to 1000 MHz

30 MHz to 1000 MHz with Class B Limits							
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**
35.63	39.50	-14.91	24.59	40.0	3m./VERT	15.4	**QP**
52.79	26.51	-17.09	9.42	40.0	3m./VERT	30.6	**QP**
122.80	39.79	-14.64	25.15	43.5	3m./VERT	18.4	**PK**
377.00	44.60	-11.23	33.37	46.0	3m./VERT	12.6	**PK**
627.50	40.83	-7.08	33.75	46.0	3m./VERT	12.2	**PK**
986.00	38.59	-4.43	34.16	54.0	3m./VERT	19.8	**PK**
94.20	44.83	-16.83	28.00	43.5	3m./HORZ	15.5	**PK**
184.80	40.25	-12.10	28.15	43.5	3m./HORZ	15.4	**PK**
389.00	44.60	-10.13	34.47	46.0	3m./HORZ	11.5	**PK**
627.50	39.48	-5.58	33.90	46.0	3m./HORZ	12.1	**PK**
942.50	38.75	-2.84	35.91	46.0	3m./HORZ	10.1	**PK**

Sample Calculation at 39.50 MHz:

Magnitude of Measured Frequency	39.50	dBuV
+ Cable Loss+Antenna Factor-Amp Gain	-14.91	dB
Corrected Result	34.59	dBuV

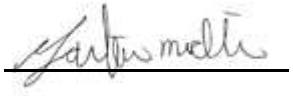
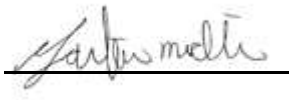
Test Date: March 28, 2023
Tested By
Signature:  Name: Gabriel Medina

Table 12. Unintentional Radiator, Spurious Radiated Emissions (CFR 15.109) 1 GHz to 13 GHz

1 GHz to 13 GHz with Class B Limits							
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**
All emissions were less than 6dB above the noise floor or was the fundamental of the pre-certified Bluetooth radio							

SAMPLE CALCULATION: N/A

Test Date: March 28, 2023
Tested By
Signature:  Name: Gabriel Medina

2.19 Intentional Radiator, Radiated Emissions (CFR 15.209)

Radiated emissions disturbance measurements were performed with both the 900 MHz FHSS transmitter and the 2.4 GHz Bluetooth transmitter circuits ON and transmitting (collocated, simultaneous broadcast). This test data is presented below to show compliance to this part.

An instrument having both peak and quasi-peak detectors was used to perform the test over the frequency range of 30 kHz to five times the highest clock frequency. Measurements of the radiated emissions were made with the receiver antenna at a distance of 3 m from the boundary of the test unit.

The test antenna was varied from 1 m to 4 m in height while watching the analyzers' display for the maximum magnitude of the signal at the test frequency. The antenna polarization (horizontal or vertical) and test sample azimuth were varied during the measurements to find the maximum field strength readings to record.

The worst-case radiated emission in the range of 30 MHz to 25 GHz was 3.5 dB below the limit at 340.84 MHz . This signal is found in Table 13. All other radiated emissions were 9.3 dB or more below the limit.

NOTE: TESTING PERFORMED WITH BOTH 900 MHz and Bluetooth RADIO IN TRANSMIT MODE TO COVER CO-LOCATION AND SIMULTANEOUS BROADCASTING.

Table 13. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209)
9 kHz to 30 MHz

9 kHz to 30 MHz							
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
All emission were less than 6 dB above the noise floor.							

Tested from 30 kHz to 30 MHz

SAMPLE CALCULATION: N/A

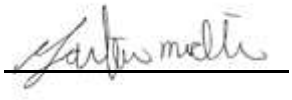
Test Date: March 28, 2023
Tested By
Signature:  Name: Gabriel Medina

Table 14. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209) 30 MHz to 1000 MHz

30 MHz to 1000 MHz with Class B Limits							
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**
89.85	46.36	-16.72	29.64	43.5	3m./VERT	13.9	**PK**
165.20	38.56	-12.38	26.18	43.5	3m./VERT	17.3	**PK**
375.50	45.31	-11.25	34.06	46.0	3m./VERT	11.9	**PK**
628.30	40.35	-7.08	33.27	46.0	3m./VERT	12.7	**PK**
90.07	39.59	-17.22	22.37	43.5	3m./HORZ	21.1	**PK**
198.63	38.63	-11.01	27.62	43.5	3m./HORZ	15.9	**QP**
297.50	44.14	-10.94	33.20	46.0	3m./HORZ	12.8	**PK**
627.50	41.69	-5.58	36.11	46.0	3m./HORZ	9.9	**PK**

Sample Calculation at 89.85 MHz:

Magnitude of Measured Frequency	46.36	dBuV
+ Cable Loss+Antenna Factor-Amp Gain	-16.72	dB
Corrected Result	29.64	dBuV

Test Date: March 28, 2023
Tested By
Signature:  Name: Gabriel Medina

Table 15. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209) 1 GHz to 10 GHz

1 GHz to 10 GHz with Class B Limits							
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**
All emissions were less than 6dB above the noise floor or was the fundamental of the pre-certified Bluetooth radio							

Sample Calculation: N/A

Test Date: March 28, 2023
Tested By
Signature: _____ Name: Gabriel Medina

2.20 Measurement Uncertainty

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

Conducted Emissions Measurement Uncertainty

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

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

Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.39 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.18 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.21dB.

3 Conclusion

Based on the test measurements performed in this test report. The EUT is deemed to have meet all the applicable requirements.