



Class 2 Permissive Change Test Report

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

RSS-247 Issue 2: Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices

For the

Neptune Technology Group

Model: MRX920v4

**FCC ID: P2SMRXV4
IC ID: 4171B-MRXV4**

UST Project: 21-0028

Issue Date: March 16, 2021

Total Pages: 26

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



Testing Tomorrow's Technology

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: Alan Ghasiani

Title: Compliance Engineer – President

Date: March 16, 2021



NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

Company Name:	Neptune Technology Group
Address:	1600 Alabama Hwy 229 Tallasse, AL 36078 USA
Model:	MRX920v4
FCC ID:	P2SMRXV4
IC ID:	4171B- P2SMRXV4
Date:	March 16, 2021

This report concerns (check one): ☐ Original ☒ Class II Permissive Change

Equipment type: 900 MHz ISM Radio Transceiver

Technical Information:

Radio Technology:	FHSS
Frequency of Operation (MHz):	911.08 – 919.07
Output Power (dBm):	18.32
Type of Modulation:	OOK
Data/Bit Rate (M)bps:	1200 Baud
Antenna Gain (dBi):	Refer to Tables 5 and 6
Software used to program EUT:	PMIT v2.2.210208.74
EUT firmware:	2.3
Power setting:	248

Report prepared by:

US Tech

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List of Attachments

FCC Agency Agreement	ISED Agency Agreement
Application Forms	Test Configuration Photographs
Internal Photographs	Letter of Confidentiality
Canadian Rep Letter	FCC to IC Cross Reference
Permissive Changer Letter	Schematic(s)

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1 General Information

1.1 Purpose of this Report

The purpose of this report is to file for a Class II Permissive change for the following reasons:

Two RF SPDT relays (K1 & K2) were replaced with two high linearity semiconductor RF switches (SKY134929-001, U12 and U13). Resistor R45 was changed from a pull-down to a pull-up resistor. An unused directional coupler (CPL1) and an unused bias tee (T1) were also removed from the transmit/receive path of the circuitry. The support circuitry for the directional coupler was also removed and an ESD diode D8 was added, but not to the transmit path.

Due to the changes above, the equipment was re-evaluated for continued compliance with Part 15.247, 15.209 and RSS-247 requirements. Based on the changes above the following tests were performed:

- Intentional Radiated emissions Part 15.247(d)
- Spurious Radiated emissions Part 15.209
- Bandwidth measurements
- Output Power measurements

All other tests were deemed to be not affected by the changes.

The test data has been collected and is presented herein for consideration.

1.2 Characterization of Test Sample

The samples used for testing were received by US Tech on February 22, 2021 in good operating condition.

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1.3 Product Description

The EUT remains the same as previously tested:

The Equipment Under Test (EUT) is the Neptune Technology Group Model MRX920v4. 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 BT900-SA (FCC ID: SQGBT900). 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

Component changes were made to the antenna interface power (AIP) board, model 13524, to increase performance and reliability. The components that were changed are in the RF path; therefore, additional testing was performed for compliance to a Class II Permissive Change. These changes are identified in the schematics submitted along with this test report.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for the intentional radiator aspect of the device and *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 the unintentional radiator aspect of the device as well as FCC subpart B and C of Part 15 and per FCC KDB Publication number 558074 v05r02 for Digital Transmission Systems Operating Under section 15.247.

Per FCC Parts 15.107 and 15.109, digital RF conducted and radiated emissions below 1 GHz were measured with the spectrum analyzer's resolution bandwidth (RBW) adjusted to 9 kHz and 120 kHz, respectively. All measurements performed above 1 GHz were made with a RBW of 1 MHz. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was set to 3 times the RBW or as required per the standard throughout the evaluation process.

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A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs for spurious and fundamental emissions 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 186022. Additionally, this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittal(s)/Grant(s)

The EUT is subject to the following FCC Equipment Authorizations:

- a) Certification under section 15.209 as a transmitter.
- b) SDoC under 15.101 as a digital device.

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Table 1. EUT and Peripherals

EUT MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID	CABLES P/D
Neptune Technology Group.	MRX920v4	MRX401407	FCC ID: P2SMRXV4 IC ID: 41271B-MRXV4	P
PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID	CABLES P/D
12V Marine Battery	N/A	Engineering Sample	N/A	P
Battery Charger Duralast	DL-15	SWC1539	N/A	P
Antenna See antenna details	--	--	--	--

S= Shielded, U= Unshielded, 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		Part Number	2.0 m
	Generic		Various	
	Shield Type	Shield Termination	Back-shell	
	N/A	N/A	N/A	
Antenna Cable LMR-200-MA	Manufacturer		Part Number	3.5 m
	Times Microwave Systems		68999	
	Shield Type	Shield Termination	Back-shell	
	B	360	MS	

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

Back-shell

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

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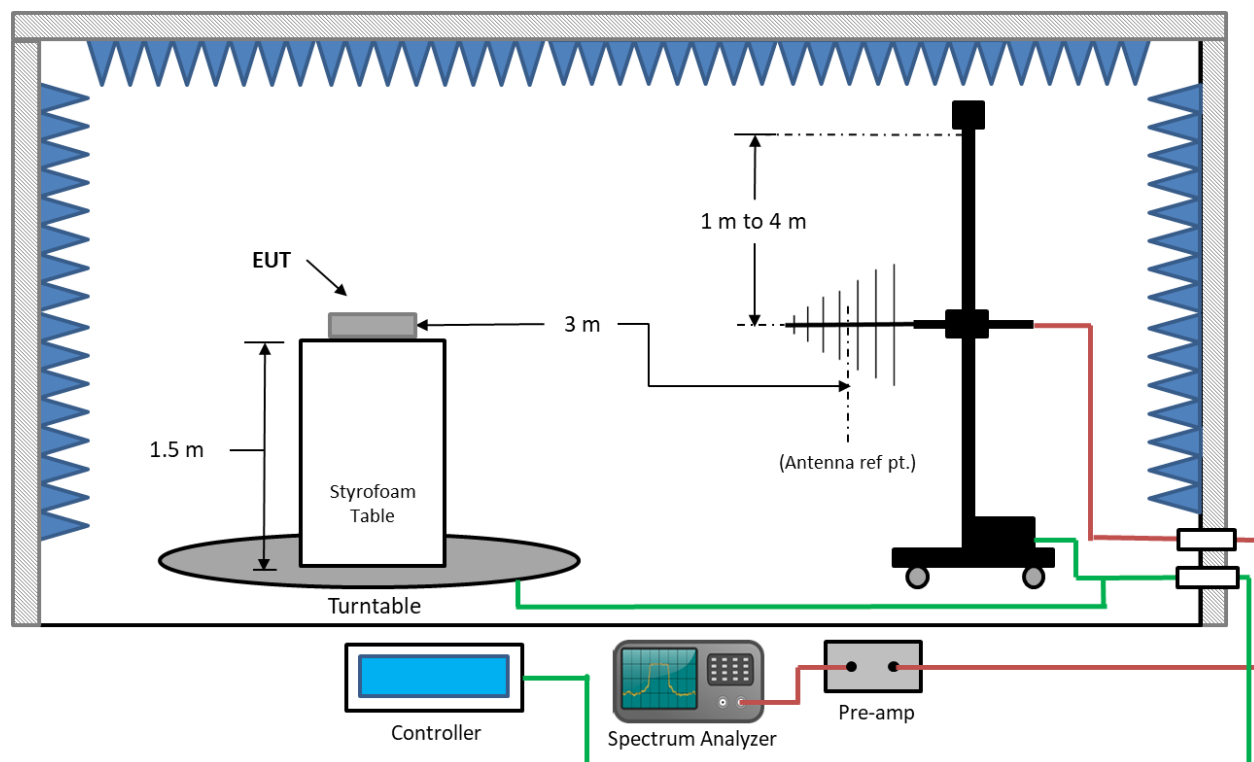


Figure 1. EUT Test Configuration Diagram

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2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product.

Table 3. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	9/02/2022 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
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	4/06/2022 2 yr.
BICONICAL ANTENNA	3110B	EMCO	9306-1708	6/07/2021 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	5/1/2021 2 yr extended
DOUBLE RIDGED HORN ANTENNA	SAS-571	A. H. Systems	605	2/28/2022 2 yr.
HIGH PASS FILTER	VHF-1320 15542	MINI-CIRCUITS, INC.	3 0843	5/11/2021
20 dB ATTENUATOR	4T-20	API/WEINSCHEL	59078	6/30/2021

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

No modifications were made by US Tech to bring the EUT into compliance with FCC Part 15.247 and RSS-247 requirements.

2.3 Number of Measurements for Intentional Radiators (CFR 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 as follows:

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

The EUT operates over the range of 911.08 MHz to 919.07 MHz (7.99 MHz); therefore, two test frequencies were evaluated.

2.4 Frequency Range of Radiated Measurements (CFR 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 the range specified in 2.4.1 above; whichever is the higher range of investigation.

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2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the parameters listed in the following paragraphs.

2.5.1 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.

2.5.2 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 that is measured using a peak detector. The peak limit shall be 20 dB greater than the average limit. 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 also be expressed logarithmically in dB. In this case, the Duty Cycle Correction Factor was determined from the manufacturer's claim.

2.6 Transmitter Duty Cycle (Part 15.35(c))

The Duty Cycle calculations are confidential and can be provided upon request by contacting Neptune Technology Group.

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 emissions cannot exceed the limits of 15.209. Radiated harmonics and other spurious emissions are examined for this requirement see paragraph 2.10.

2.8 EUT Antenna Requirements (CFR 15.203)

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The antenna details are as follows:

Table 5. Antenna 1

Manufacturer	Model	Type	Gain (dBi)	Connector
Laird	B8965C	Monopole	+5.1	Reverse TNC

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2.9 Maximum Peak Conducted Output Power (CFR 15.247(b)(3))

The EUT was programmed to operate at a normal operating output power across the bandwidth. For this test the normal operating output power of the radio was programmed to 248 in the radio's test firmware. A proprietary RF cable provided by Neptune Technology Group was connected between the EUT's antenna output port and spectrum analyzer. For protection, a 20 dB attenuator was connected to the RF input of the spectrum analyzer. The attenuator factor was accounted for in all antenna-port, conducted RF measurements.

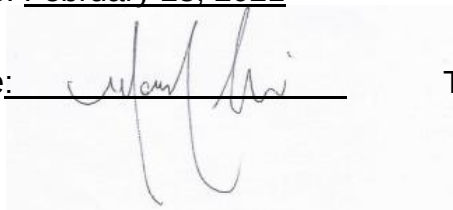
Peak power within the band 911.08 MHz to 919.07 MHz was measured per FCC KDB Publication 558074v05r02 and ANSI C63.10-2013. The results are presented in Table 7.

Table 6. Peak Antenna Conducted Output Power per Part 15.247 (b)(3)

Frequency of Fundamental (MHz)	P _{Cond} (dBm)	P _{Cond} (mW)	FCC Limit (mW Maximum)
911.07	19.11	81.47	1000
919.08	19.36	86.30	1000

Test Date: February 23, 2021

Signature: _____



Test Engineer: Mark Afroozi

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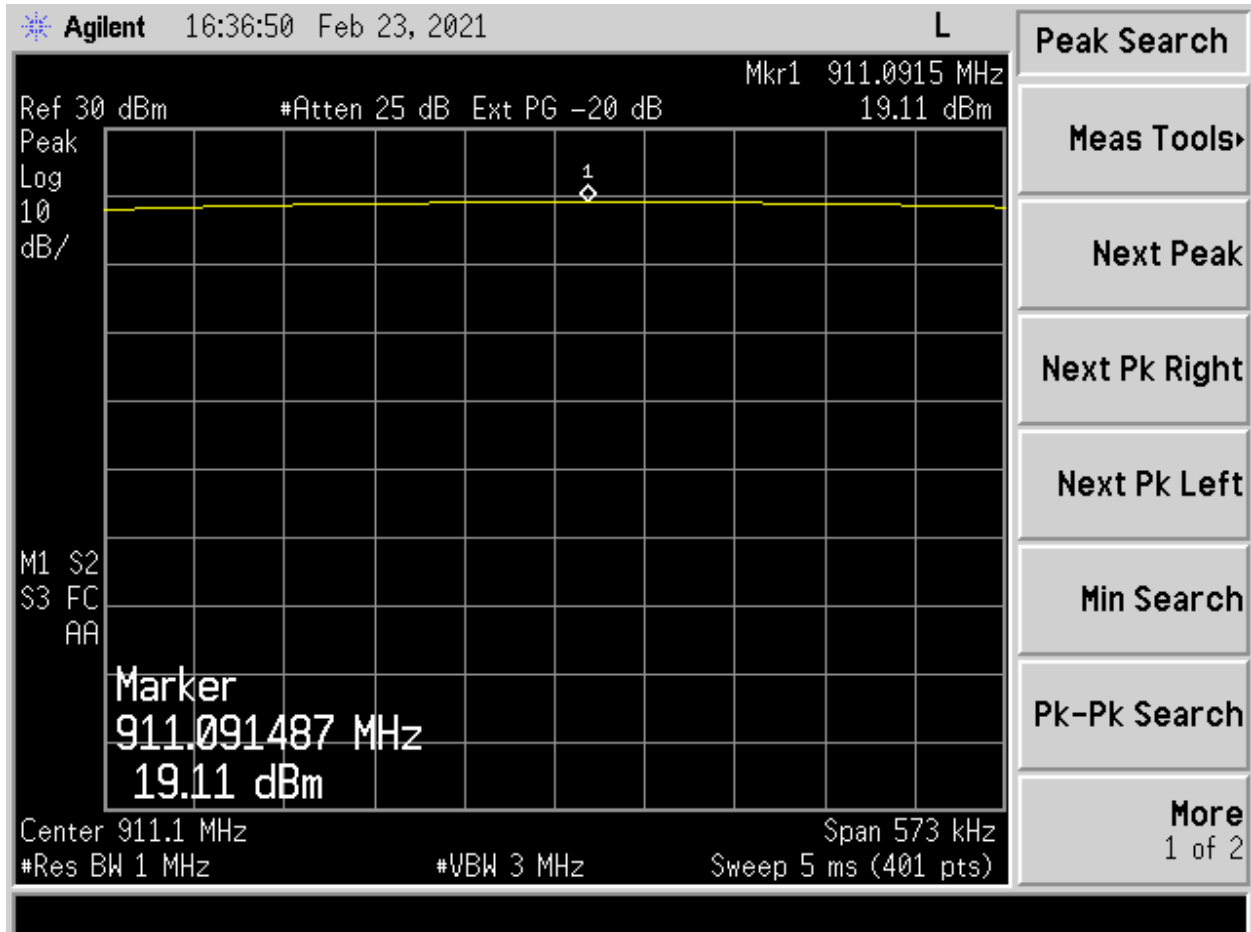


Figure 2. Peak Output Power – Low Channel

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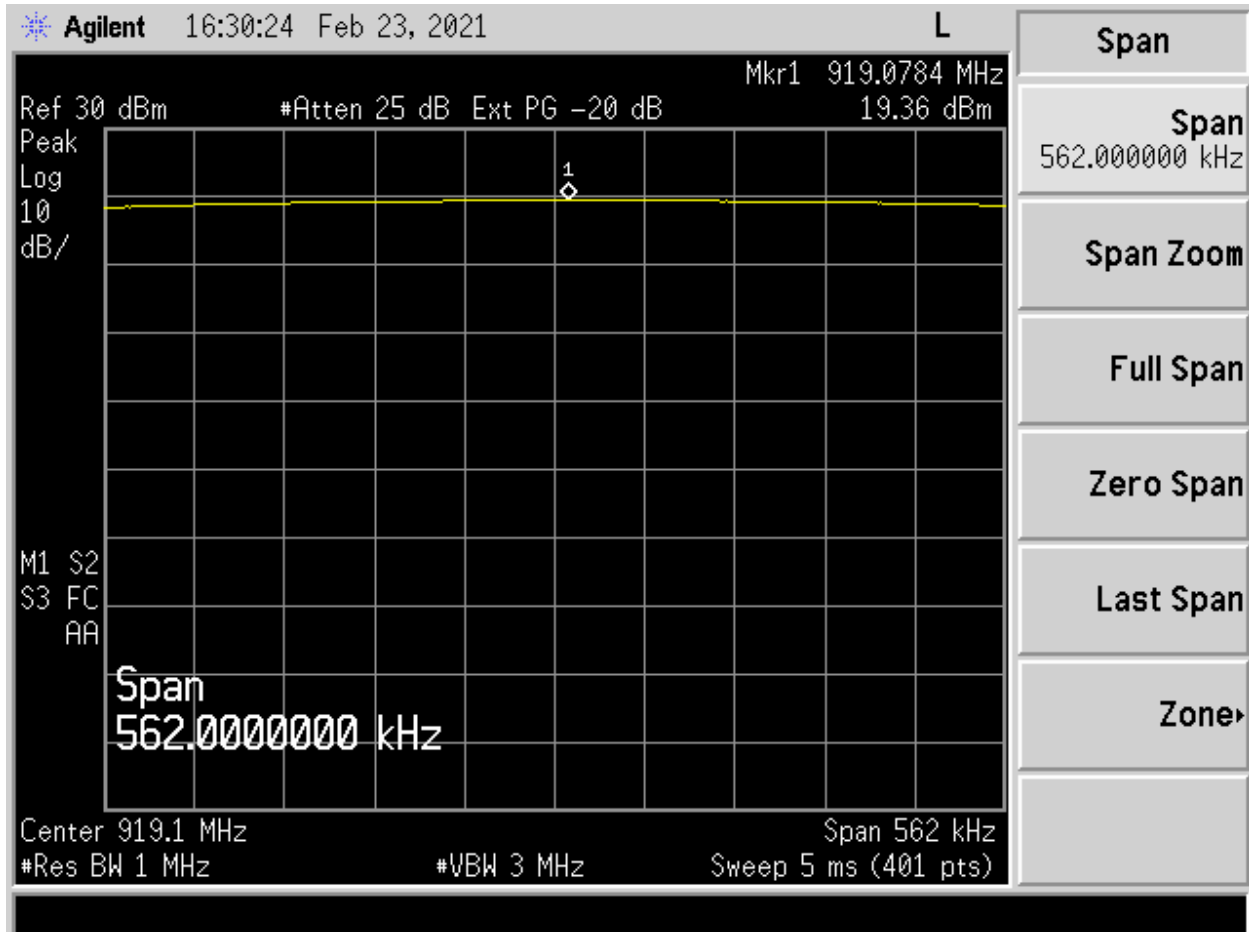


Figure 3. Peak Output Power - High Channel

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

For radiated measurements, the EUT was set into a continuous transmission mode. Below 1 GHz, the RBW of the measuring instrument was set equal to 120 kHz. Peak measurements above 1 GHz were measured using a RBW = 1 MHz, with a VBW $\geq 3 \times$ RBW. The results of peak radiated spurious emissions falling within restricted bands are given in Table 5 below. For average measurements above 1 GHz, the emissions were measured using an average detector. The measurement of each signal detected was maximized by rotating the turntable 360° clockwise and counterclockwise and raising and lowering the receive antenna between 1 and 4 meters in height while monitoring the ever changing spectrum analyzer display with Trace A in the Max-Hold mode and Trace B in the Clear-Write mode for the largest signal visible. The emission from the EUT was measured and recorded when both maxima were simultaneously satisfied.

2.10.1 EUT Worst Case Test Configuration

On the test site, the EUT was placed on top of a polystyrene table 80 cm above the ground plane inside a semi-anechoic test chamber. The EUT was evaluated in each of its three axes (X/Y/Z) while transmitting on the channel that produced the highest output power for worst case condition. The position of the EUT determined to be worst case was with the EUT positioned along its X axis (top of EUT facing up). The worst case test results of the fundamental and harmonics are presented in the table below.

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Table 7. Peak Radiated Fundamental and Harmonic Emissions

Test: FCC Part 15.247 / 15.209								
Frequency (MHz)	Test Data (dBuV)	Additional Factor	AF+CL-PA (dB/m)	Corrected Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector
Low Channel								
911.08	93.14	--	25.03	118.17	--	3.0m./VERT	--	PK
2733.24	53.78	--	-5.42	48.36	74.0	3.0m./VERT	25.6	PK
Note 1	--	--	--	--	--	--	--	--
High Channel								
919.07	95.25	--	25.00	120.25	--	3m./VERT	--	PK
2757.21	54.79	--	-5.54	49.25	74.0	3.0m./VERT	24.7	PK
Note 1	--	--	--	--	--	--	--	--

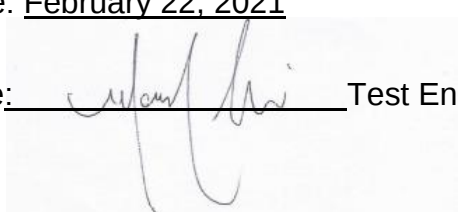
Notes:

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic

Sample Calculation at 911.08 MHz:

Magnitude of Measured Frequency	93.14	dBuV
+Additional Factor	0.00	dB
+Antenna Factor + Cable Loss - Amplifier Gain	25.03	dB/m
Corrected Result	118.17	dBuV/m

Test Date: February 22, 2021

Signature:  Test Engineer: Mark Afroozi

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Table 8. Average Radiated Fundamental and Harmonic Emissions

Test: FCC Part 15.247 / 15.209								
Frequency (MHz)	Test Data (dBuV)	Additional Factor	AF+CL-PA (dB/m)	Corrected Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector
Low Channel								
911.08	92.73	--	25.03	117.76	--	3m./VERT	--	QP
2733.24	44.05	--	-5.42	38.63	54.0	3.0m./VERT	15.4	AVG
Note 1	--	--	--	--	--	--	--	--
High Channel								
919.07	94.91	--	25.00	119.91	--	3m./VERT	--	QP
2757.21	45.86	--	-5.54	40.32	54.0	3.0m./VERT	13.7	AVG
Note 1	--	--	--	--	--	--	--	--

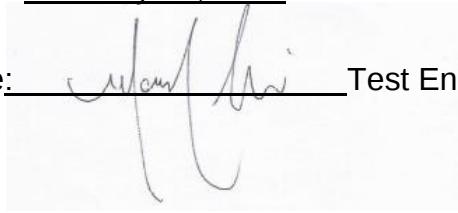
Notes:

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic.

Sample Calculation at 911.08 MHz:

Magnitude of Measured Frequency	92.73	dBuV
+Additional Factor (Duty cycle correction)	0.00	dB
+Antenna Factor + Cable Loss - Amplifier Gain	25.03	dB/m
Corrected Result	117.76	dBuV/m

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Signature:  Test Engineer: Mark Afroozi

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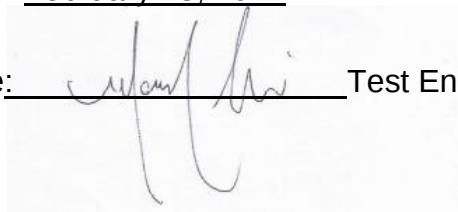
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2.11 20 dB and 99% Occupied Bandwidth (CFR 2.1049 & RSS-Gen 6.7)

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. The RBW was set to 3 kHz and with the VBW $\geq$ RBW. The results of this test are given in the Table and Figures following.

Frequency (MHz)	20 dB Bandwidth (kHz)	Maximum FCC Bandwidth (kHz)	99 % Occupied Bandwidth (kHz)
911.08	74.441	500	68.276
919.07	72.438	500	67.557

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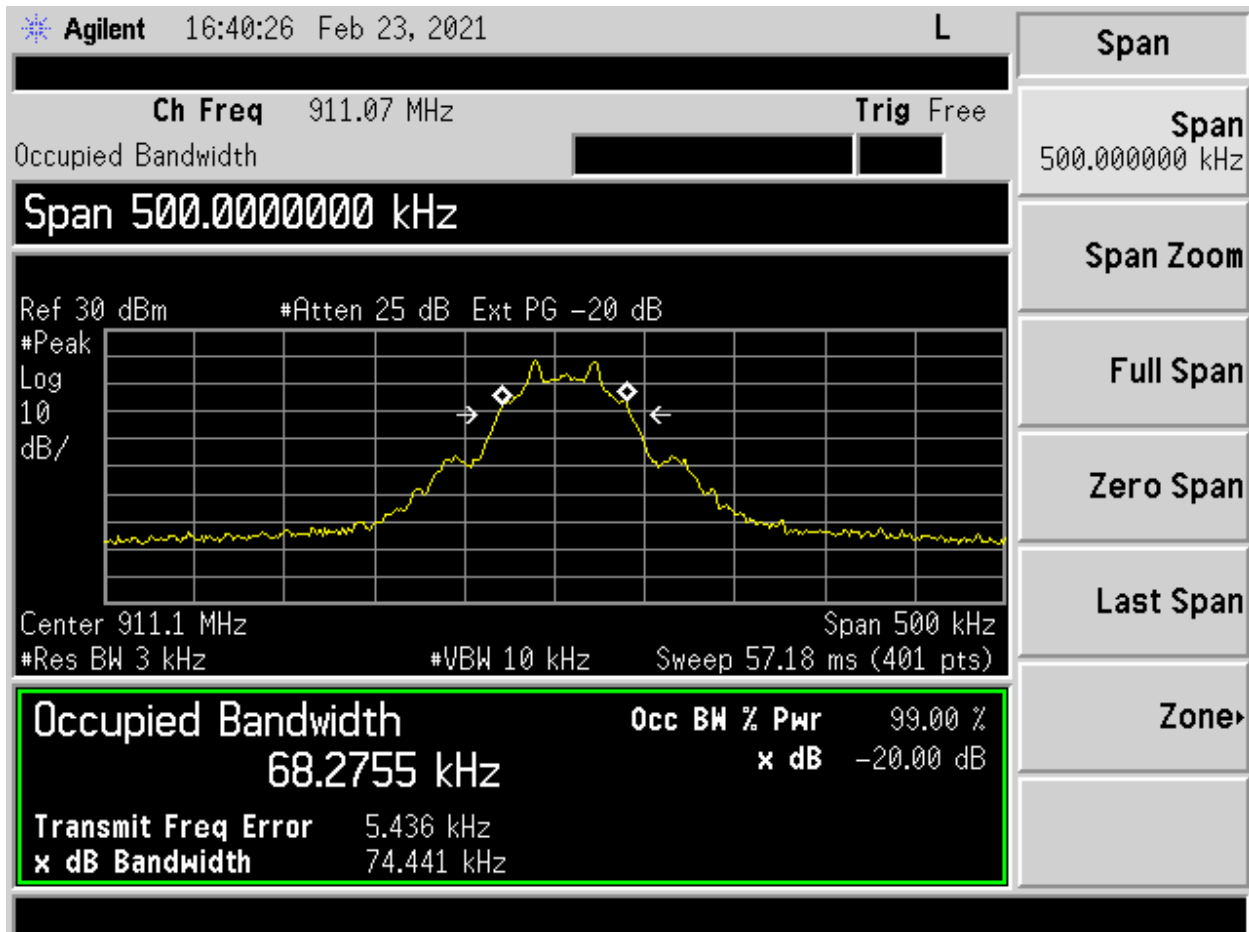


Figure 4. 20 dB and 99% Occupied Bandwidth – Low Channel
(Worst Case Plot)

2.12 Intentional Radiator Power Line Conducted Emissions (CFR 15.207)

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

2.13 Unwanted Emissions of the Intentional Radiator, (CFR 15.109, 15.209 and 15.33(a))

The test data provided herein is to support the verification requirement for unwanted radiated emissions coming from the EUT in a transmitting state per 15.209 and was investigated from 9 kHz or the lowest operating clock frequency to 10 GHz or to the tenth harmonic of the highest fundamental frequency. The EUT was put into a continuous transmit mode of operation and tested as detailed in ANSI C63.10:2013, Clause 6.4.6. Data is presented in the table below.

The measurement bandwidths for each frequency scan that was evaluated were set as follows:

Frequency Span	RBW / VBW
9 kHz – 150 kHz	300 Hz / 1 kHz
150 kHz – 30 MHz	9 kHz / 30 kHz
30 MHz – 1 GHz	120 kHz / 300 kHz
Above 1 GHz	1 MHz / 3 MHz

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Table 9. Spurious Radiated Emissions (9 kHz – 30 MHz)

9 kHz to 30 MHz with Class B Limits							
Test: FCC Part 15.109 / 15.209							
Frequency (MHz)	Test Data (dBuV)	AF+CL-PA (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK / QP / AVG
All emissions were more than 20 dB below the applicable limit.							

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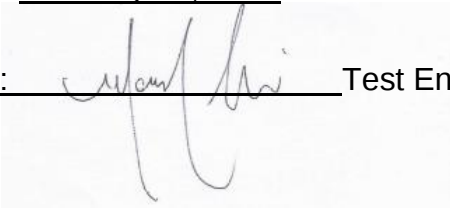
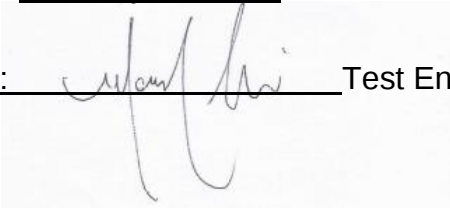
Signature:  Test Engineer: Mark Afroozi

Table 10. Spurious Radiated Emissions (30 MHz – 1 GHz)

30 MHz to 1 GHz with Class B Limits							
Test: FCC Part 15.109 / 15.209							
Frequency (MHz)	Test Data (dBuV)	AF+CL-PA (dB)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK / QP
31.88	44.07	-13.33	30.74	40.0	3m./VERT	9.3	PK
88.00	48.70	-16.96	31.74	40.0	3m./HORZ	8.3	PK
186.70	47.91	-11.35	36.56	43.5	3m./HORZ	6.9	PK
466.10	44.68	-7.95	36.73	46.0	3m./VERT	9.3	QP
472.04	46.90	-7.66	39.24	46.0	3m./VERT	6.8	PK
All other emissions were more than 20 dB below the applicable limit.							

Test Date: February 23, 2021

Signature:  Test Engineer: Mark Afroozi

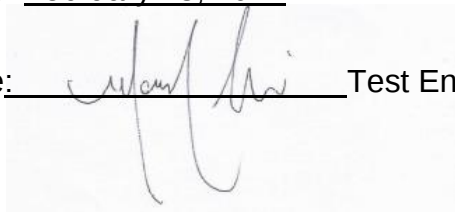
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Table 11. Spurious Radiated Emissions (1 GHz – 10 GHz)

1 GHz to 10 GHz with Class B Limits							
Test: FCC Part 15.109 / 15.209							
Frequency (MHz)	Test Data (dBuV)	AF+CL-PA (dB)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK / AVG
1711.10	51.69	-7.89	43.80	54.0	3.0m./VERT	10.2	PK
1536.10	52.50	-9.67	42.83	54.0	3.0m./VERT	11.2	PK
5186.80	30.31	-0.28	30.03	54.0	3.0m./VERT	24.0	AVG
No additional emissions other than harmonics of the fundamental frequency were detected.							

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2.14 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2:2011. A coverage factor of $k=2$ was used to give a level of confidence of approximately 95%.

2.14.1 Conducted Emissions Measurement Uncertainty

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

2.14.2 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 ± 5.3 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 ± 5.1 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna (Above 1000 MHz) is ± 5.1 dB.

3 Test Results

The EUT is deemed to have met the requirements of the standards cited within the test report when tested as detailed in the test report.