Testing Tomorrow's Technology

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: 22-0237

Issue Date: August 30, 2022

Total Pages: 25

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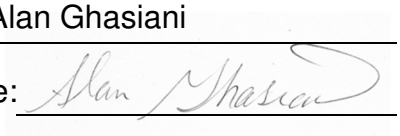
Testing Tomorrow's Technology

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: 

Title: Compliance Engineer – President

Date: August 30, 2022

NVLAP TESTING

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

Company Name:	Neptune Technology Group
Address:	1600 Alabama Hwy 229 Tallassee, AL 36078 USA
Model:	MRX920v4
FCC ID:	P2SMRXV4
IC ID:	4171B- P2SMRXV4
Date:	August 30, 2022

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):	21.58
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:	N/A

Report prepared by:

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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:

The RF Board (p/n 13530) was changed in the MRX920v4;
no other board or component has changed in its design since the last C2PC request.

No frequencies are added or changed in MRX920v4 by this C2PC. No changes were made to the software/firmware controlling the RF Board since the last C2PC. Therefore, transmitter modulation, frequency hopping characteristics, and receiver local oscillators are also unchanged.

The changes are considered proprietary therefore the details of the changes are provided in a separate exhibit titled: MRX920v4, RF Board Class 2 Permissive Change August 2022

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 test were performed:

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

All other test 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 August 29, 2022 in good operating condition.

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 FCC ID: SQGBL653U, IC: 3147A-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

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.

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.

Table 1. EUT and Peripherals

EUT MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID	CABLES P/D
Neptune Technology Group.	MRX920v4	Engineering Sample	FCC ID: P2SMRXV4 IC ID: 41271B-MRXV4 contains: FCC ID:SQGBL653U IC: 3147A-BL653U	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

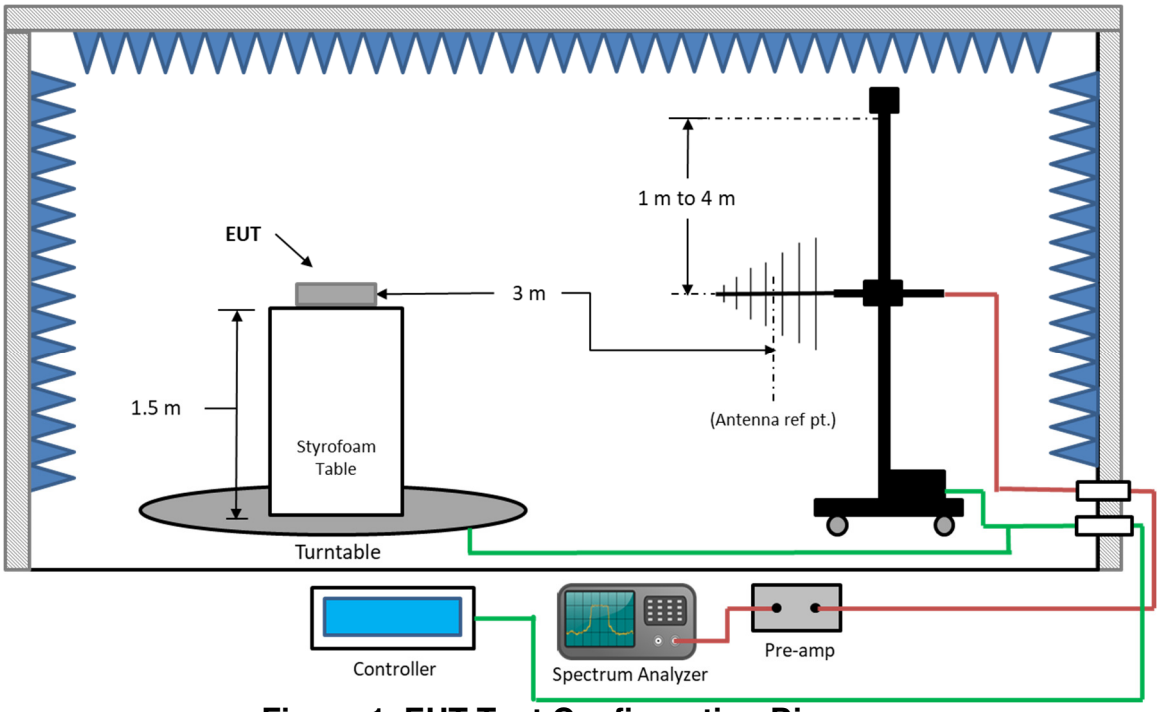


Figure 1. EUT Test Configuration Diagram

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	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CALIBRATION DUE DATE
Spectrum Analyzer	Agilent	E4407B	US41442935	9/02/2022 2 yr.
Rf Preamp 100 kHz To 1.3 GHz	Hewlett-Packard	8447D	1937A02980	6/9/2023
Preamp 1.0 GHz To 26.0 GHz	Hewlett-Packard	8449B	3008A00914	2/11/2023
Biconical Antenna	EMCO	3110B	9306-1708	8/17/2023 2 yr.
Log Periodic Antenna	EMCO	3146	9110-3236	12/13/2023 2 yr.
Double Ridged Horn Antenna	A. H. Systems	SAS-571	605	4/28/2024 2 yr.
High Pass Filter	Mini-Circuits, Inc.	VHF-1320 15542	3 0843	7/16/2023
10 Db ATTENUATOR	MECA	604-20-1	N/A	8/23/2023

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 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 911.07 MHz to 919.08 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.

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

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

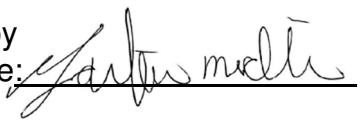
The EUT was programmed to operate at a normal operating output power across the bandwidth. For this test the normal operating output power of the radio was programmed to output +21 dBm in the radio's test firmware. A proprietary RF cable provided by Neptune Technology Group was connected between the EUT's antenna output port and spectrum analyzer. For protection, an 8 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 911.07 MHz to 919.08 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	21.47	140.28	1000
919.08	21.58	143.87	1000

Test Date: August 29, 2022

Tested by
Signature:  Test Engineer: Gabriel Medina

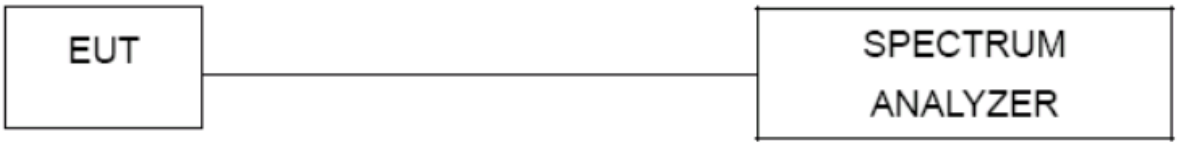


Figure 2. Conducted Radio Setup

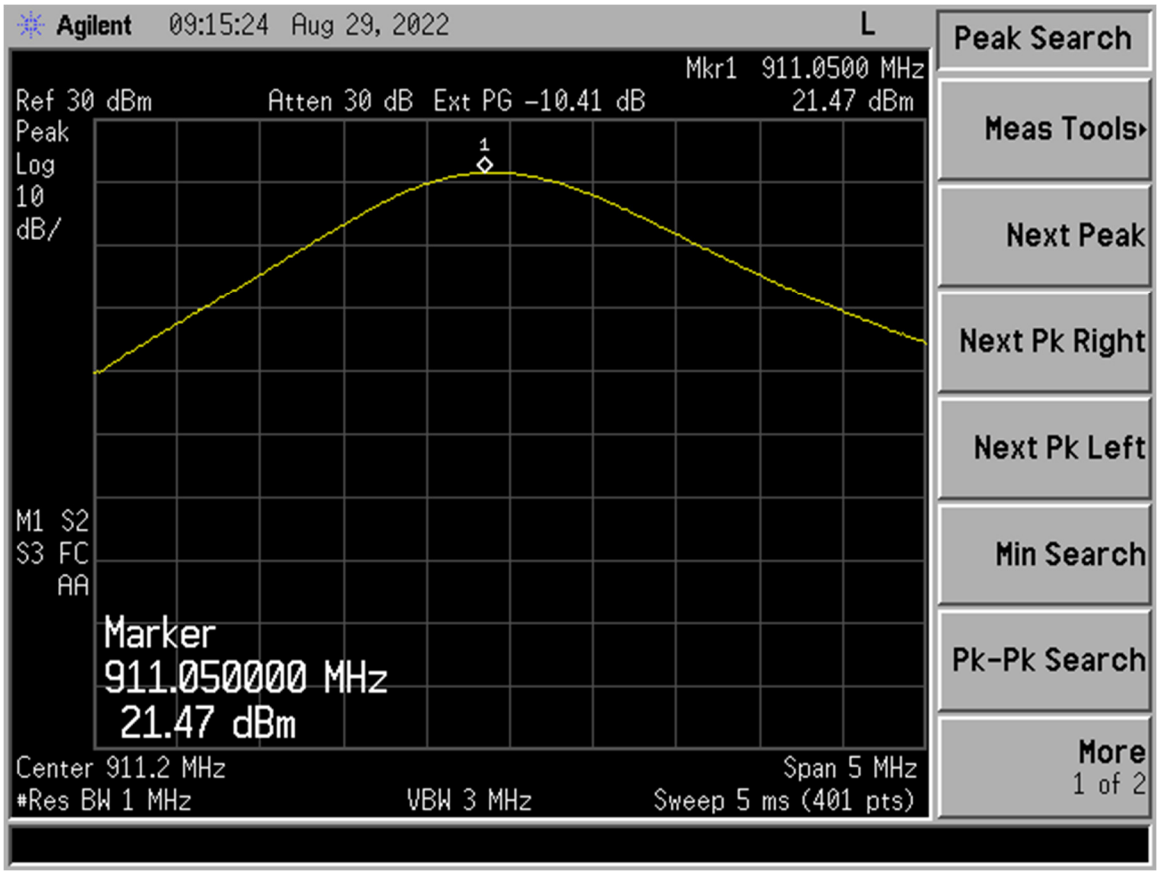


Figure 3. Peak Output Power – Low Channel

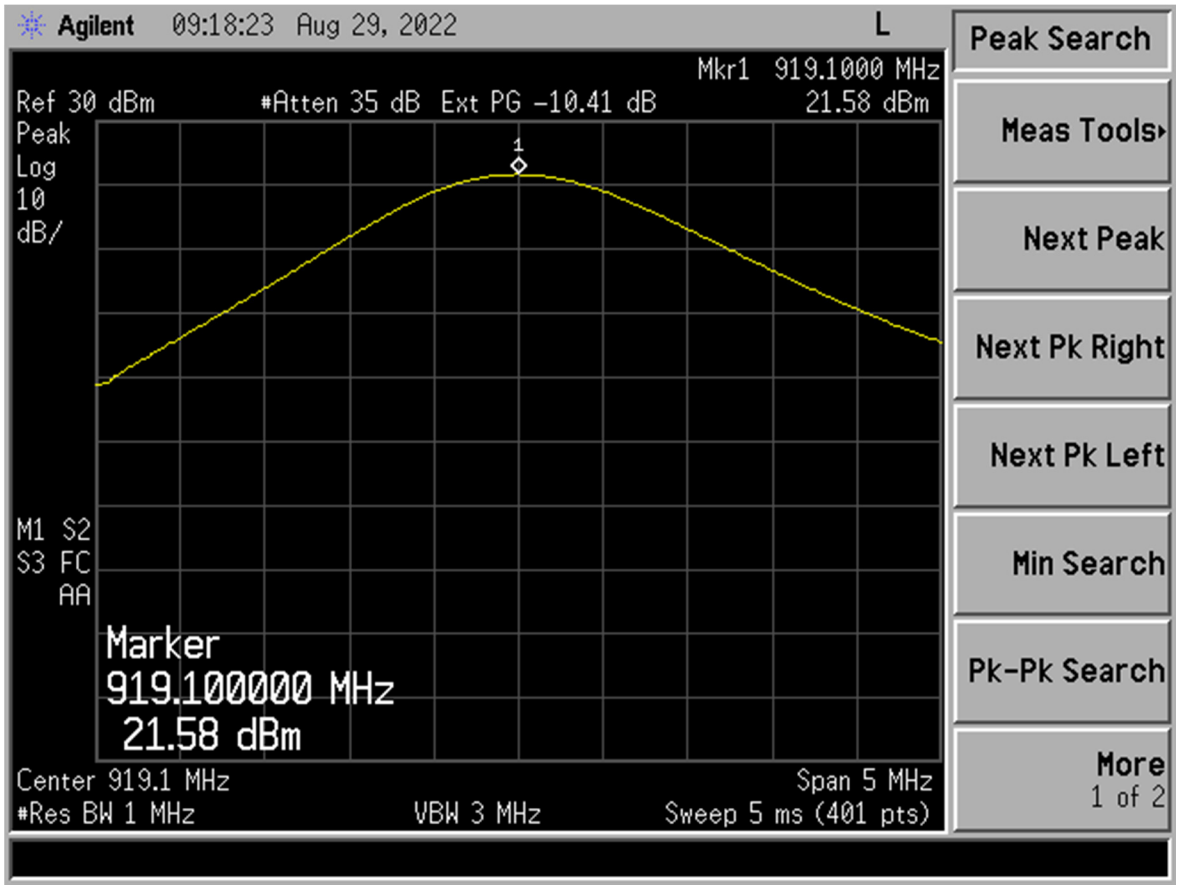


Figure 4. Peak Output Power - High Channel

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

For radiated measurements, the EUT was set into a collocated 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 ≥ 3 x 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 Y axis (EUT on its side). The worst-case test results of the fundamental and harmonics are presented in the table below.

Radiated Emissions measurements were conducted starting at 30 MHz up to 10 times the highest clock frequency. Emissions below 30 MHz were not reassessed for this permissive change.

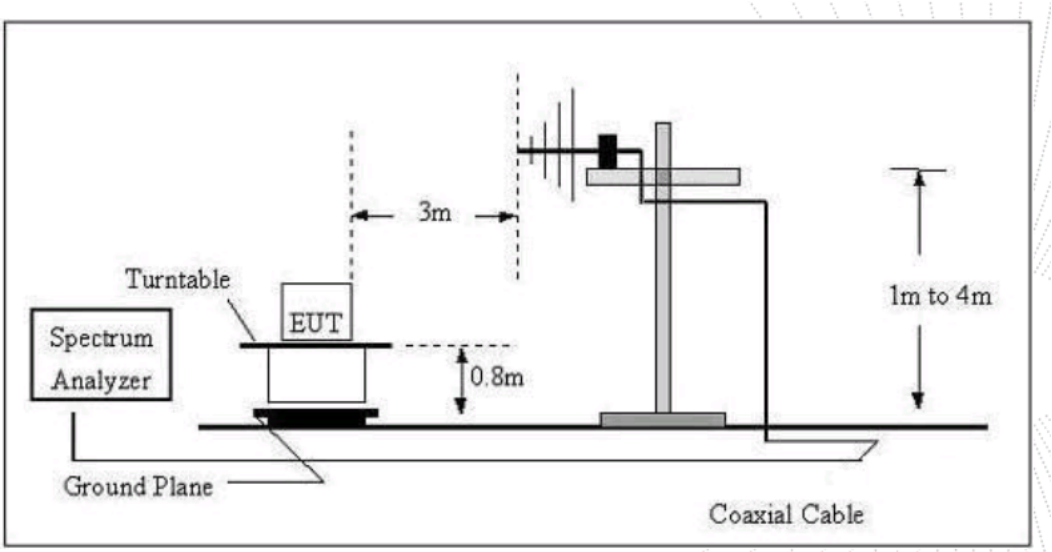


Figure 5. Radiated Emissions Test Setup (below 1 GHz)

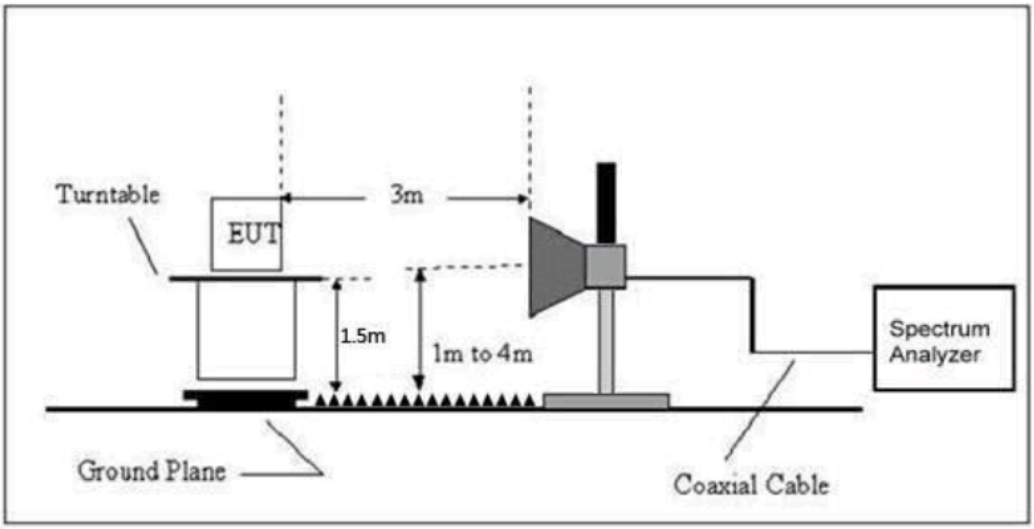


Figure 6. Radiated Emissions Test Setup (above 1 GHz)

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								
911.09	97.55	0.00	22.62	120.17	--	3m./VERT	--	**PK**
1822.00	53.75	0.00	-9.42	44.33	74.0	3.0m./VERT	29.7	**PK**
2733.00	52.53	0.00	-5.15	47.38	74.0	3.0m./VERT	26.6	**PK**
Note 1	--	--	--	--	--	--	--	--
High Channel								
919.09	98.03	0.00	22.62	120.65	--	3m./VERT	--	**PK**
1840.00	73.87	0.00	-9.22	43.53	74.0	3.0m./VERT	30.5	**PK**
2753.00	52.75	0.00	-5.28	46.86	74.0	3.0m./VERT	27.1	**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 911.07 MHz:

Magnitude of Measured Frequency	97.55	dBuV
+Additional Factor	0.00	dB
+Antenna Factor + Cable Loss - Amplifier Gain	+22.62	dB/m
Corrected Result	120.17	dBuV/m

Test Date: August 29, 2022

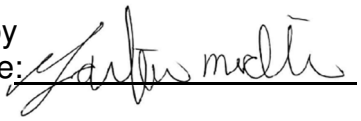
Tested by
Signature:  Test Engineer: Gabriel Medina

Table 8. Average Radiated Fundamental and Harmonic Emissions

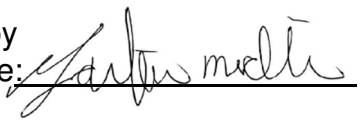
Test: FCC Part 15.247 / 15.209								
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector**
Low Channel								
911.09	75.62	0.00	22.62	98.24	--	3m./VERT	--	**QP**
1822.00	38.84	0.00	-9.42	29.42	54.0	3.0m./VERT	24.6	**AVG**
2733.00	52.53	0.00	-5.15	47.38	74.0	3.0m./VERT	26.6	**PK**
Note 1	--	--	--	--	--	--	--	--
High Channel								
919.09	73.87	0.00	22.62	96.49	--	3m./VERT	--	**QP**
1840.00	35.58	0.00	-9.22	26.36	54.0	3.0m./VERT	27.6	**AVG**
2753.00	34.36	0.00	-5.28	29.08	54.0	3.0m./VERT	24.9	**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 911.09 MHz:

Magnitude of Measured Frequency	75.62	dBuV
+Additional Factor (Duty cycle correction)	0.00	dB
+Antenna Factor + Cable Loss - Amplifier Gain	+22.62	dB/m
Corrected Result	98.24	dBuV/m

Test Date: August 29, 2022

Tested by
Signature:  Test Engineer: Gabriel Medina

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 15.209, 15.247(d) 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

Note: To satisfy co-location requirements, all radios that can operate simultaneously were ON and transmitting during this testing. The worst-case emissions is present below.

Table 9. Spurious Radiated Emissions (30 MHz – 1 GHz)

30 MHz to 1 GHz **Test:** FCC Part 15.209, 15.247(d)							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector PK / QP**
90.96	53.47	-18.03	35.44	43.5	3m./HORZ	8.1	**PK**
186.77	45.22	-12.03	33.19	43.5	3m./HORZ	10.3	**PK**
351.92	53.91	-10.95	42.96	46.0	3m./HORZ	3.0	**PK**
502.16	45.05	-6.81	38.24	46.0	3m./HORZ	7.8	**PK**
90.96	55.99	-17.43	38.56	43.5	3m./VERT	4.9	**PK**
186.77	45.38	-11.23	34.15	43.5	3m./VERT	9.3	**PK**
385.82	52.06	-11.10	40.96	46.0	3m./VERT	5.0	**PK**
502.22	45.90	-8.41	37.49	46.0	3m./VERT	8.5	**PK**

Note: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. Attenuation below the general limits specified in § 15.209(a) is not required.

Sample Calculation at 90.96 MHz:

Magnitude of Measured Frequency	53.47	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-18.03	dB/m
Corrected Result	35.44	dBuV/m

Test Date: August 29, 2022

Tested by
Signature:  Test Engineer: Gabriel Medina

Table 10. Spurious Radiated Emissions (1 GHz – 25 GHz)

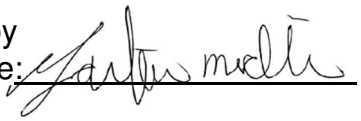
1 GHz to 25 GHz **Test:** FCC Part 15.209, 15.247(d)							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector PK / AVG**
1490.00	57.42	-11.96	45.46	54.0	3.0m./HORZ	8.5	**PK**
1242.00	39.05	-13.53	25.52	54.0	3.0m./VERT	28.5	**AVG**
1490.00	37.58	-12.78	24.80	54.0	3.0m./VERT	29.2	**AVG**
No additional emissions other than harmonics of the fundamental frequency were detected.							

Note: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. Attenuation below the general limits specified in § 15.209(a) is not required.

Sample Calculation at 1276.00 MHz:

Magnitude of Measured Frequency	36.61	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-12.93	dB/m
Corrected Result	23.68	dBuV/m

Test Date: August 29, 2022

Tested by
Signature:  Test Engineer: Gabriel Medina

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.

END TEST REPORT