Testing Tomorrow's Technology

Report of

Title 47 CFR Part 95 Subpart J, Multi User Radio Services (MURS) and TIA-603-E (2016) Land Mobile FM or PM- Communications Equipment Measurement and Performance Standard

For the
Radio Systems Corporation

Family Name: Boundary Plus 2.0
Model Name: BP 2.0 Computer Collar Unit
Model: RIG00-16937
FCC ID: KE3-3003578

Issue Date: November 12, 2019
Test Dates: October 10 - 16 2019

UST Project No.: 19-0392

Total Number of Pages Contained in this Report: 20

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I certify that I am authorized to sign for the test facility 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: 

Name: George Yang

Title: Laboratory Manager

Date: November 12, 2019

NVLAP LAB CODE 200162-0

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1 General Information

1.1 Product Description

The Equipment Under Test (EUT) is the Radio Systems Corporation, Model RIG00-16937 and is part of the Boundary Systems Plus 2.0 family. It is a connected system based on a new transmit signal type that will operate at three new operating frequencies (15kHz, 20kHz or 25kHz). This permits operation in Boundary Plus mode where currently signal interference prevents acceptable operation. The system will consist of a connected 4-port module-based control panel that can be configured one of seven ways (Hub, Hub/Transmitter, Transmitter, Hub/GPS, Hub/Transmitter/GPS, Transmitter/GPS or GPS Base [future]), connected indoor and outdoor Shields® units, connected Doorman™ Pet Door (future) and connected receiver. Each receiver is individually configurable to each transmitter (i.e. action taken by the receiver when receiving the unique transmit code) through selections made in the customer account via CLOUD services. The receiver is predominantly off and utilizes the MURS band for data communications between units. The following data in this report refers to the receiver (MURS transceiver).

Rated Maximum Rated Output Power: +16 dBm
Measured Output Power (ERP): 7.9 dBm
Modulation type: GFSK
Data Rate: 3.6 kbps
Frequency Deviation: 1.428 kHz

1.2 Related Submittal(s)/Grant(s)

The EUT is subject to the following authorizations:

a) Certification as a 151.82 MHz, MURS transmitter per FCC Part 2, Subpart J and Part 95, Subpart J, MURS and Subpart E, Technical Requirements.
b) Verification under 15.101 as a digital device and receiver.

1.3 Test Methodology

These measurements were conducted in accordance with the requirements of Title 47 CFR Part 95, Subpart E and TIA-603-E (2016). All measurements are in terms of peak values unless stated otherwise. The measurement system video bandwidth was set to at least three times that of the resolution bandwidth to prevent the introduction of amplitude smoothing throughout the evaluation process. If interconnecting cables are part of the measurement setup then they were manipulated as necessary to maximize emissions. A block diagram of the tested system is shown in Figure 1.

1.4 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 registration number US5301. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1. US Tech is an accredited laboratory under the National Voluntary Laboratory Accreditation Program (NVLAP), Lab Code: 200162-0.

The shielded semi anechoic EMC Chamber and the conducted disturbance measurement facilities used to collect the radiated and conducted emissions data are located at 3505 Francis Circle, Alpharetta, GA (USA). These test sites meet the requirements given in ANSI C63.4:2014.

1.4.1 Radiated Emissions Test Site (Shielded Semi Anechoic EMC Chamber)

The radiated emissions disturbance measurement facility consists of an 8.5 m long by 5.5 m wide and 5.6 m high shielded semi anechoic EMC Chamber. The chamber is lined with ferrite core and RF absorbers. The quiet zone is 2.0 m.

The test facility layout is shown in the figure below. A remotely controlled 2.0 m diameter flush-mounted turntable is provided for rotating (through at least 360 degrees) the EUT. A non-conductive table, 1.5 m long by 1.0 m wide by 0.8 m high is used in conjunction with the turntable for tabletop equipment. Electrical service for the EUT is provided through openings at the center of the turntable.

Provision for receiving antenna power and data wires is provided by junction boxes placed at the perimeter of the chamber. The receive antenna mast is remotely controlled and can be varied in height from 1 m to 4 m.

Power and data cables for the radiated disturbance measurement facility are run through PVC tubing under the raised floor or are laid directly upon the ground plane.

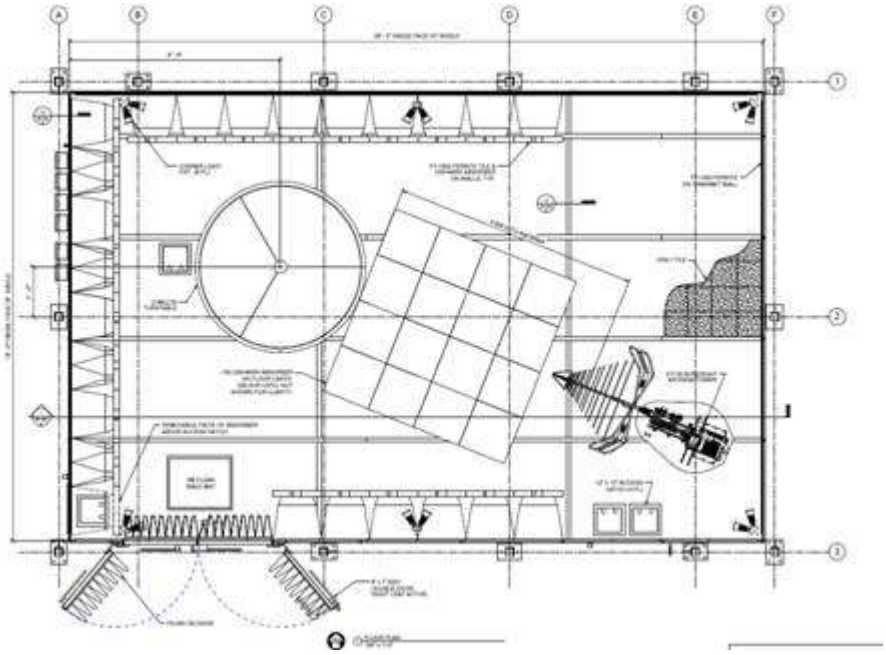


Figure 3. Radiated Emissions Disturbance Measurement Facility Diagram

1.5 Test Equipment

A list of test equipment used for these measurements is found in Table 1 below.

Table 1. Test Instruments

INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	8/17/2020 2 yr. Cal
BICONICAL ANTENNA	3110B	EMCO	9306-1708	6/27/2021
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	8/22/2021
HORN ANTENNA	3115	EMCO	9107-3723	11/28/2020 2 yr.
PRE-AMPLIFIER	8449B	HEWLETT-PACKARD	3008A00480	4/8/2020
PRE-AMPLIFIER	8447D	HEWLETT-PACKARD	1937A02980	5/7/2020

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

1.6 Modifications to EUT

No modifications were necessary to bring the EUT into compliance with FCC Part 95.

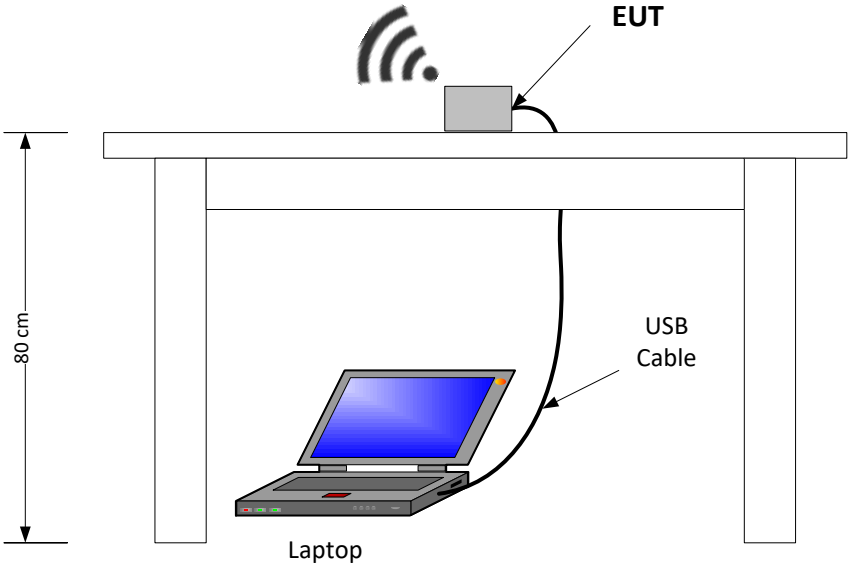


Figure 1. Test Configuration Block Diagram

Table 2. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID	CABLES P/D
BP 2.0 COMPUTER COLLAR UNIT (EUT)	RIG00-16937	Engineering sample	KE3-3003578	D
Laptop	Various	Various	Various	P D

P = Power; D = Data U = Unshielded

Table 3. Antenna

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	PART NUMBER	GAIN dB_i	TYPE OF CONNECTOR
Antenna	Radio Systems Corp	Internal trace loop	N/A	-19.0	Trace

2 Output Power

2.1 Maximum Transmitter Power (FCC 2.1046 & 95.2767)

On the test site, the EUT was placed on top of a non-conductive table, 80 cm above the floor for measurements below 1 GHz and 150 cm above the floor for measurements > 1 GHz. The EUT was also evaluated in three orthogonal positions to determine the worst case position. The front of the EUT faced the measurement antenna located 3 meters away. Each signal measured was maximized by raising and lowering the receive antenna between 1 and 4 meters in height while monitoring the ever changing spectrum analyzer display (with channel A in the Clear-Write mode and channel B in the Max-Hold mode) for the largest signal visible. That exact antenna height where the signal was maximized was recorded for reproducibility purposes. Also, the EUT was rotated about its Y-axis while monitoring the Spectrum Analyzer display for maximum. The EUT azimuth was recorded for reproducibility purposes. The EUT was measured when both maxima were simultaneously satisfied.

The maximum power was measured using the radiated method. The EUT was set up to transmit a continuous signal with >98% duty cycle. The receiver and video bandwidth on the spectrum analyzer was maximized and the span was sufficiently large enough to capture the peak emissions. The peak measurement of the signal was recorded.

2.1.1 Maximum Power Allowed

The maximum power allowed is 2 Watts (or 33 dBm) per FCC 95.2767.

2.1.2 Measured Fundamental Signal

The maximum output power of the EUT as measured below is 7.9 dBm or 0.06 W which is less than 2 W.

The EUT was determined to comply with the Maximum Allowed Power.

Table 4. Maximum Output Power

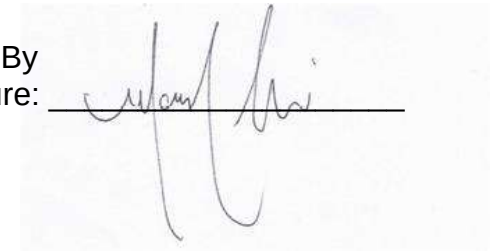
Frequency MHz	Maximum RX Reading (Units A)	Recreated Reading During Substitution (Using Same Units A) - Ideally 0	Difference Column A - B	TX Cable Loss (dB)	TX Gain Relative to Dipole (dB)	RF Power into TX antenna (dBm) (SG Value-CL)	RF Power into substitution TX antenna (dBm)	Limit (dBm)	Margin Below Limit (dB)
151.82	82.49	82.56	-0.07	-0.98	1.6	-4.4	-3.85	33	36.85
151.82	89.39	89.42	-0.03	-0.98	0.9	8.0	7.89	33	25.11

Sample Calculation at 151.82 MHz:

SG Power Into TX Antenna	-4.4	(dBm)
+ TX Gain	1.6	(dB)
+Difference between recreated and Actual	-0.07	(dB)
+TX Cable Loss	-0.98	(dB)
RF Power Into TX Antenna	-3.85	(dBm)

Limit	33.00	(dBm)
RF Power into TX Antenna	-3.85	(dBm)
Margin	36.85	(dB)

Test Date: October 11, 2019

Tested By
Signature:  Name: Mark Afroozi

3 Emissions Bandwidth (Part 95.2773(a))

The EUT was modulated by its own internal sources. The Bandwidth of the Fundamental was measured using a spectrum analyzer, as shown below. A RBW that was > 1% of the authorized bandwidth was used to measure the EUT's bandwidth.

Using the Emission Bandwidth measurement technique of ANSI C63.10-2009 as a guide, the measurement of the Emission Bandwidth is found to be 4.855 kHz.

3.1 Maximum Authorized Bandwidth

The maximum authorized Bandwidth per 95.2773 (a) = 11.25 kHz. The EUT was found to comply with the Maximum Authorized Bandwidth since 4.855 kHz < 11.25 kHz.

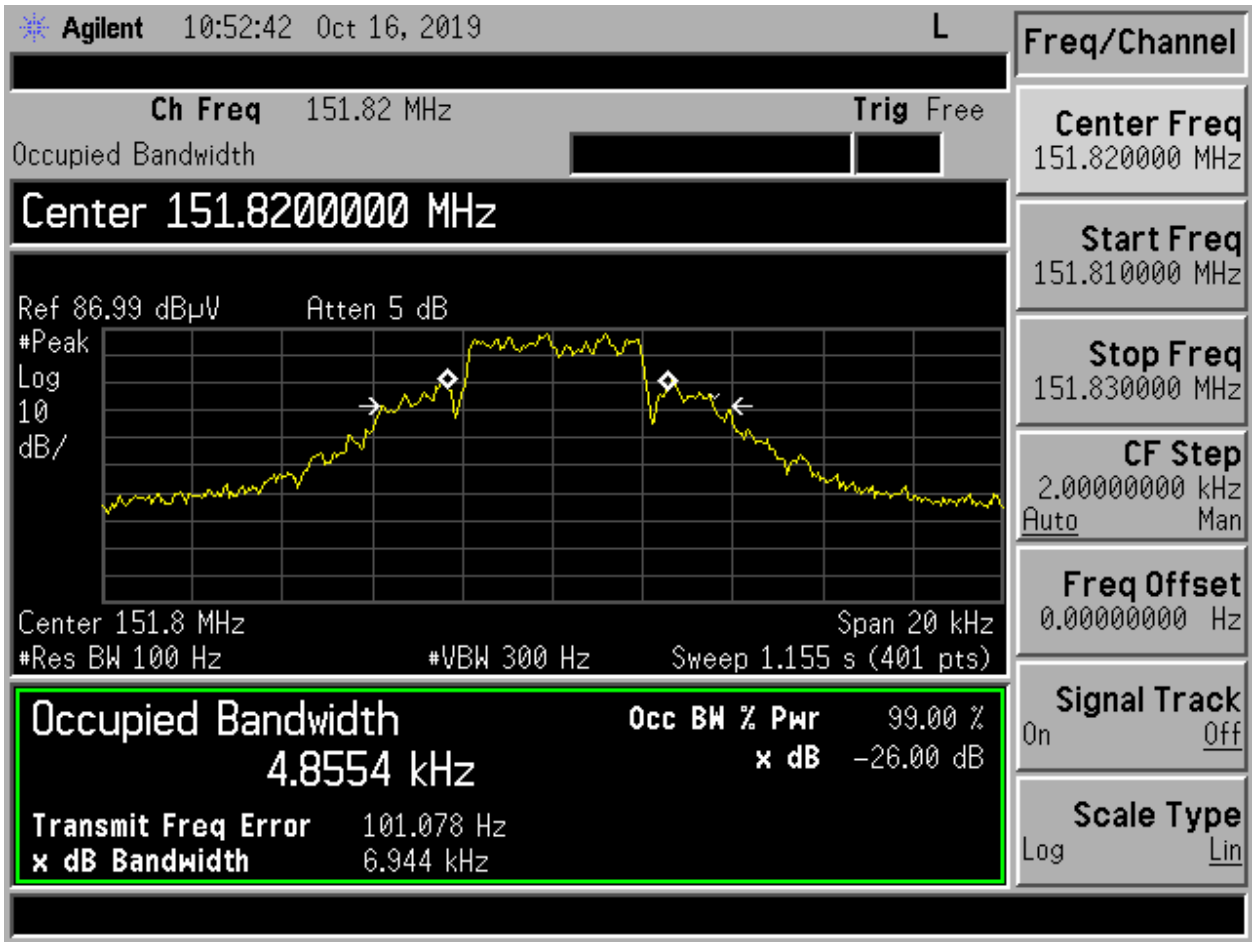


Figure 2. Bandwidth Measurement

Test Date: October 16, 2019

Tested By
Signature: _____ Name: George Yang

4 MURS Unwanted Radiation Emissions (CFR 95.2779)

This requirement is from 47 CFR Part 2, Subpart J, Sections 1053 and 95.2779(b). The power of each unwanted emission shall be less than the transmitter power as specified in paragraph 5.2 below.

4.1 Test Method

These emissions were measured on the Spectrum Analyzer using the radiated method.

4.2 FCC Limits

Per CFR Part 95.2779(b), the power of unwanted emissions must be attenuated below the transmitter output power in Watts (P) by at least:

(1) 7.27(f_d−2.88 kHz) dB on any frequency removed from the channel center frequency by a displacement frequency (f_d in kHz) that is more than 5.625 kHz, but not more than 12.5 kHz.
(2) 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation, on any frequency removed from the channel center frequency by more than 12.5 kHz.

4.3 Test Results

The EUT is designed to operate at 151.8200 MHz and is assumed not to be using any audio low pass filter circuits, therefore only Emissions Mask 1 was applied.

The measured emissions comply with the specified mask as shown below.

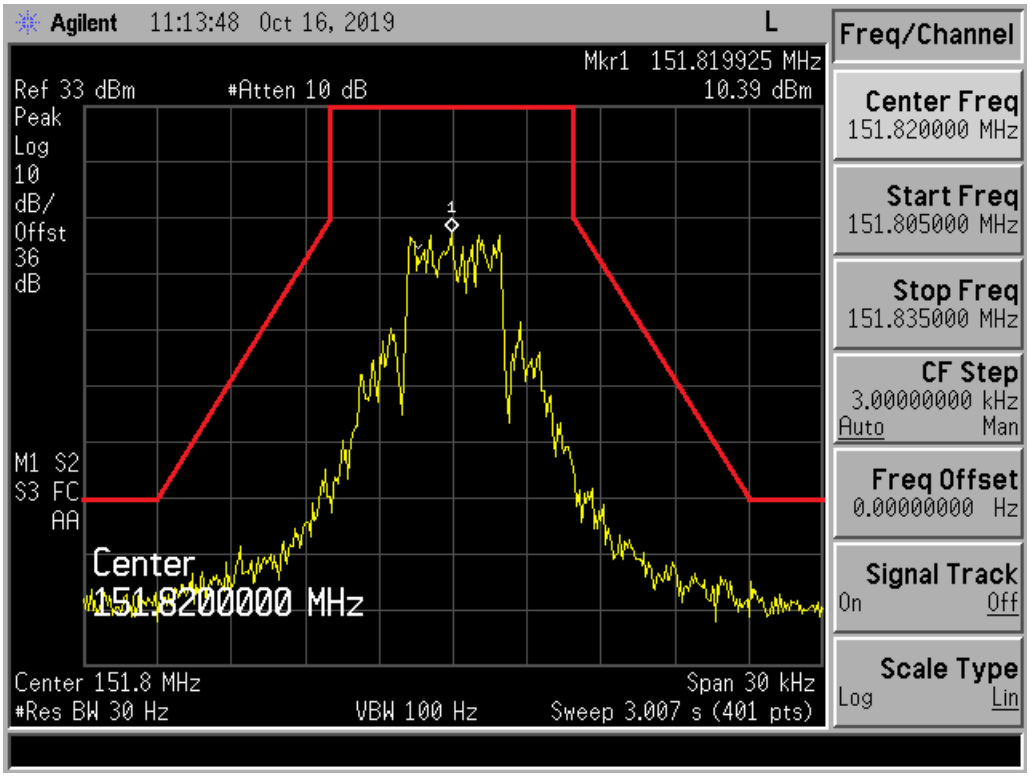


Figure 3. Emission Mask 1

Test Date: October 16, 2019

Tested By
Signature: _____ Name: George Yang

5 Field Strength of Spurious Radiation, (FCC 2.1051 & 95.2779(b)(2))

5.1 Test Method

Spurious emissions were evaluated by the substitution method from 30 MHz to 1.0 GHz at a EUT to antenna distance of 3 meters. The EUT was tested in the far field. Measurements for 30 to 1000 MHz were made with the analyzer's bandwidth set to 120 kHz. Measurements above 1000 MHz were made with analyzer's bandwidth set to 1 MHz and 3 MHz. Since the EUT is part of a portable handheld configuration, the EUT was rotated through the three orthogonal planes to produce the highest emissions relative to the limits. Results are shown in the Table below.

5.2 FCC Limits

The limit is determined using the following information: On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz, the limit will be at least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

Maximum Output Power= 2 Watts = 33.0 dBm
Attenuation Calculation = 50 + 10Log(2) = 53.0 dB
Power Limit = 33 dBm – 53 dB = -20 dBm

5.3 Test Results

Table 5. Field Strength of Spurious Radiation

Frequency MHz	Antenna Position	Maximum RX Reading (Units A)	Recreated Reading During Substitution (Using Same Units A) - Ideally 0	Difference Column A - B	TX Cable Loss (dB)	TX Gain Relative to Dipole (dB)	RF Power into TX antenna (dBm) (SG Value-CL)	RF Power into substitution TX antenna (dBm)	Limit (dBm)	Margin Below Limit (dB)
303.64	1LP3mH*	85.59	85.33	0.26	-1.41	3.6	-24.5	-22.05	-20	2.05
455.46	1LP3mH	73.29	73.23	0.06	-1.72	5.9	-38.5	-34.26	-20	14.26
607.28	1LP3mH	62.82	62.68	0.14	-2.02	6.2	-46.0	-41.68	-20	21.68
759.10	1LP3mH	54.50	54.51	-0.01	-2.24	6.1	-43.0	-39.15	-20	19.15
910.92	1LP3mH	59.03	59.06	-0.03	-2.46	5.7	-42.9	-39.69	-20	19.69
303.64	1LP3mV	84.51	84.6	-0.09	-1.41	3.6	-25.3	-23.20	-20	3.20
455.46	1LP3mV	73.85	73.97	-0.12	-1.72	6.2	-36.3	-31.94	-20	11.94
607.28	1LP3mV	62.90	62.73	0.17	-2.02	6.8	-41.6	-36.65	-20	16.65
759.10	1LP3mV	53.59	53.42	0.17	-2.24	6.8	-50.6	-45.87	-20	25.87
910.92	1LP3mV	58.92	59.00	-0.08	-2.46	6.4	-43.3	-39.44	-20	19.44
1062.74	2HN3mV	63.72	65.01	-1.29	-2.14	4.8	-43.2	-41.86	-20	21.86
1214.56	2HN3mV	58.27	58.15	0.12	-2.14	5.5	-51.2	-47.72	-20	27.72
1366.38	2HN3mV	58.25	58.25	0.00	-2.14	5.8	-50.5	-46.84	-20	26.84
1518.20	2HN3mV	59.68	61.52	-1.84	-2.63	6.8	-45.5	-43.20	-20	23.20

(*) 1LP3mH= Log Periodic antenna #1 at 3 meters in Horizontal polarity

Sample Calculation at 303.64 MHz:

SG Power Into TX Antenna	-24.50 (dBm)
+ TX Gain	3.60 (dB)
+Difference between recreated and Actual	0.26 (dB)
+TX Cable Loss	-1.41 (dB)
RF Power Into TX Antenna	-22.05 (dBm)

Limit	-20.00 (dBm)
RF Power into TX Antenna	-22.05 (dBm)
Margin	2.05 (dB)

Test Date: October 14, 2019

Tested By
Signature: _____ Name: Mark Afroozi

6 Frequency Stability (CFR 2.1055, 95.2765)

6.1 Test Method

The EUT was tested in the Thermotron Environmental Chamber. The humidity was tested to a relative value of no more than 50%. The temperature was varied between -30°C to +50°C in 10° increments. All measurements were referenced back to the frequency measured at +20°C. At each set point the temperature was allowed to stabilize for no less than 30 minutes before measurements were recorded and the temperature changed.

The EUT is battery operated; therefore, voltage stability test is not applicable.

6.2 FCC Limits

Per CFR 95.2765 (a)(b), MURS transmitters must maintain a frequency stability of 2.0 ppm, or 5.0 ppm if designed to operate with a 6.25 kHz bandwidth. Since this EUT was measured to have a bandwidth of 6.944 the limit applied was 5.0 ppm.

6.3 Test Results

Table 6. Frequency Deviation/Stability

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)	Limit (ppm)
-30	151.820174	151.820174	0	5.00
-20	151.820174	151.820174	0	5.00
-10	151.820196	151.820174	0.145	5.00
0	151.820196	151.820174	0.145	5.00
10	151.820174	151.820174	0	5.00
20	151.820174	151.820174	0	5.00
30	151.820174	151.820174	0	5.00
40	151.820174	151.820174	0	5.00
50	151.820174	151.820174	0	5.00

Actual TX Frequency was: 151.820174 MHz

Sample Calculation at -30˚C

$$\text{Deviation} = \frac{|(151.820174 - 151.820174)|}{151.820174} = 0.00 = 0.00 \text{ ppm} < 5\text{ppm}$$

Test Date: October 10, 2019

Tested By
Signature: _____ Name: George Yang