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

Model: RIF00-15976
Assembly Number: 300-3170
FCC ID: KE3-3003170

Issue Date: March 9, 2018
Test Dates: February 9-19, 2018, March 8, 2018

UST Project No.: 18-0013

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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: March 9, 2018

TESTING
NVLAP LAB CODE 200162-0

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Table of Contents

List of Figures

Figure **Title** **Page**

List of Tables

Table **Title** **Page**

1 General Information

1.1 Product Description

The Equipment Under Test (EUT) is the Radio Systems Corp, Invisible Fence Brand Model RIF00-15976, GPS pet containment collar. The product uses GPS coordinates to keep a pet within a desired area. The Unit also communicates via 151.82 MHz to a base station to relay battery levels and pet activity.

Rated Maximum Output Power: +16 dBm
Modulation type: GFSK

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 95, Subpart J, MURS.
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 J 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. 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.

1.5 Test Equipment

Table 1 describes test equipment used to evaluate this product.

Table 1. Test Instruments

Instrument Type	Manufacturer	Model	Serial Number	Calibration Due Date
Spectrum Analyzer	Agilent	E4407B	US41442935	6/22/2018
Spectrum Analyzer	Agilent	N9342CN	SG05310114	7/21/2018
RF Preamp	Hewlett-Packard	8449B	3008A00480	12/1/2018
RF Preamp	Hewlett-Packard	8447D	1937A02980	3/7/2018*
Biconical Antenna	EMCO	3110B	9306-1708	5/2/2019 2 yr.
Biconical Antenna	EMCO	3110B	9307-1431	10/23/2019 2 yr.
Log Periodic Antenna	EMCO	3146	9305-3600	5/1/2019 2 yr.
Log Periodic Antenna	EMCO	3146	9110-3236	9/21/2019 2 yr.
Environmental Chamber	Thermotron	SM16	17095	8/7/2018
Regulated Power Supply	TekPower	TP3005T	218311	Verified with 867B Fluke Meter
Multimeter (Graphical)	Fluke	867B	DM7060268	10/10/2018
Signal Generator	Rhode & Schwarz	SMiQ 06B	100403	10/25/2018

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

*This equipment was used only for testing completed prior to March 7, 2018; last use of this equipment for testing described herein was on February 16, 2018

1.6 Modifications to EUT

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

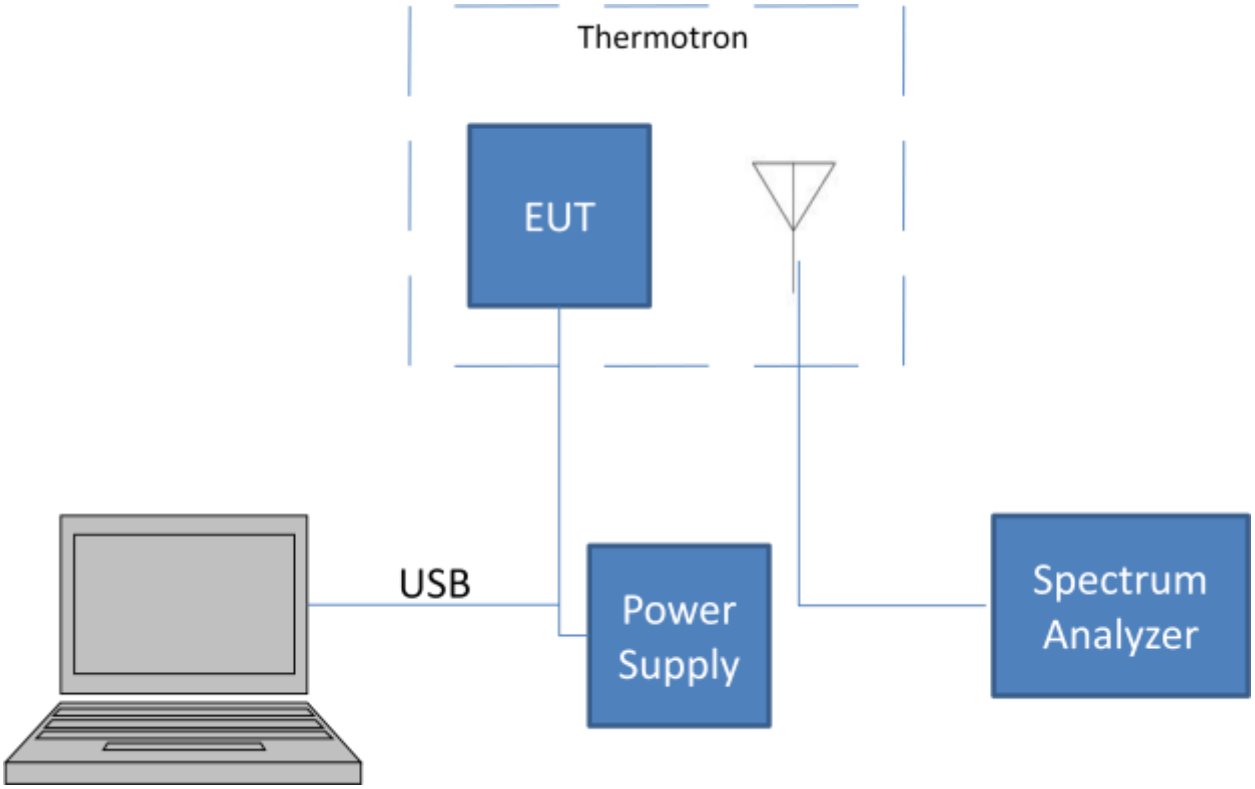


Figure 1. Test Configuration Block Diagram

Note: Thermotron Chamber used for Frequency Stability testing.

Table 2. EUT and Peripherals

EUT MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/ IC ID:	CABLES P/D
GPSC Gen 3 Collar (EUT) Radio Systems	RIF00-15976	Engineering Sample	FCC: KE3-300170 IC: N/A	N/A
PERIPHERAL MANUFACTURER	**MODEL NUMBER**	**SERIAL NUMBER**	**FCC/ IC ID**	**CABLES P/D**
Battery Dongguan Large Electronics Co.	NCR18500A-00BQ001-29	Engineering Sample	N/A	N/A
Programming Tool Radio Systems	RIF00-16436	Engineering Sample	N/A	1 m UD
Laptop HP	Various	Various	Various	1 m UD

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

Table 3. Antennas

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	PART NUMBER	GAIN dB_i	TYPE OF CONNECTOR
TX Antenna	Radio Systems	Integrated	N/A	-19	N/A

2 Output Power

2.1 Maximum Transmitter Power (FCC 2.1046 & 95.2767)

Maximum Transmitter Power was measured using the substitution method outlined in TIA-603-E, 2.2.12 and 2.2.17. The EUT uses an integral antenna therefore the integral antenna technique was applied.

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 .026 mW.
Limit = 2 Watts, Result: PASS

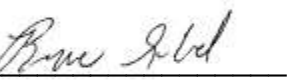
The EUT was determined to comply with the Maximum Allowed Power.

The maximum output power of the EUT using the substitution method was -15.75 dBm at a distance of 3m. The EUT Antenna gain is rated at -19 dBi

Table 4. Field Strength of Fundamental Radiation

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	95.74	95.63	0.11	1.1	1.1	-18.3	-18.17	33	51.17
151.82	93.68	93.65	0.03	0.9	0.9	-15.6	-15.75	33	48.75

Test Dates: February 9 and 15, 2018

Tested By
Signature:  Name: Bruce Arnold

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 C63.10-2013 as a guide, the measurement of the Emission Bandwidth is found to be 4.261 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 4.261 kHz < 11.25 kHz.

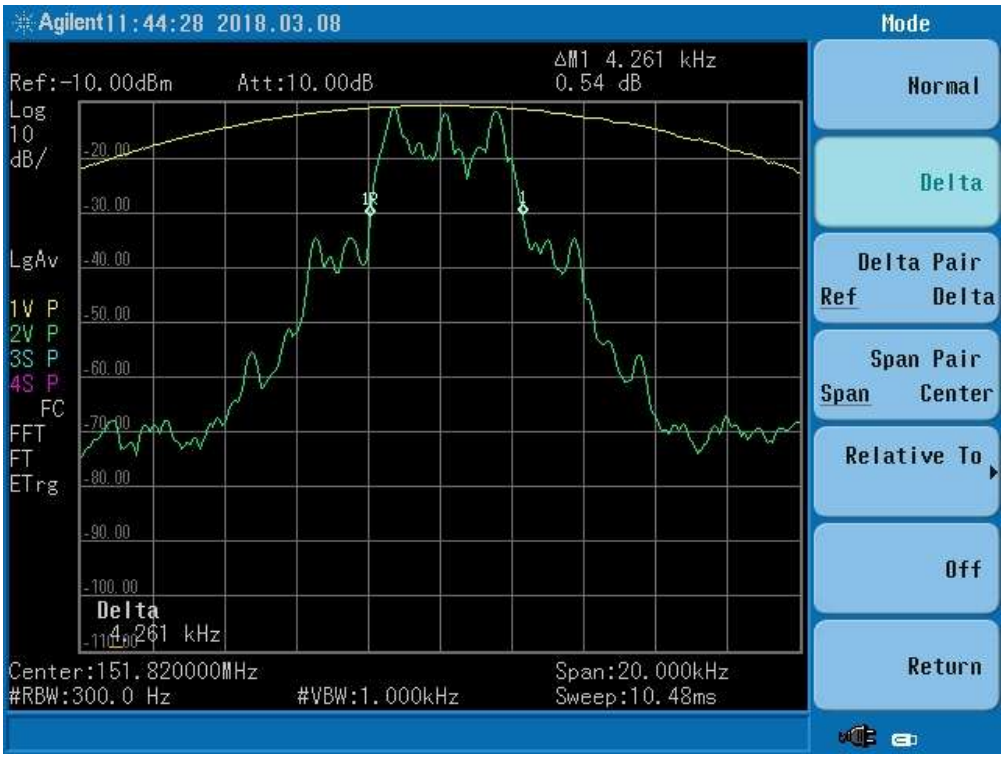


Figure 2. Bandwidth Measurement

Test Date: March 8, 2018

Tested By
Signature: _____ Name: George Yang

4 Unwanted Radiation Emissions (CFR 95.2779 (b),(1)&(2))

This requirement is from 47 CFR Part 2, Subpart J, Sections 1053 and 95.2779. The power of each unwanted emission shall be less than TP (Transmitter Power) as specified in paragraph 4.2 below.

4.1 Test Method

These emissions were measured on the Spectrum Analyzer and test jig.

4.2 FCC Limits

Per CFR Part 95.2779

(b) *Attenuation requirements.* 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.

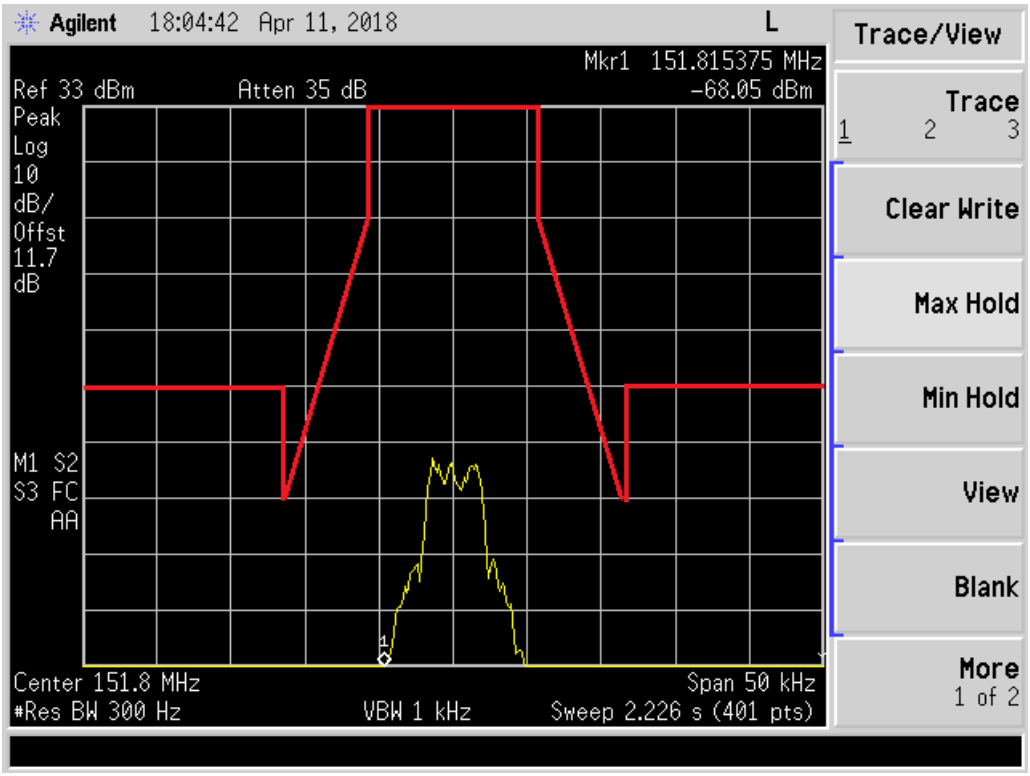


Figure 3. Transmitter Spurious Emissions at Antenna Terminals

Test Date: April 11, 2018

Tested By
Signature: _____ Name: George Yang

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

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 100 kHz. Measurements above 1000 MHz were made with analyzer's resolution bandwidth set to 1 MHz and video bandwidth set to 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 allowed power = 2 Watts = TP
Attenuation Calculation = 50 + 10Log(2) = 53 dB, 33 dBm – 53 dB = -20 dBm
Unwanted emissions Limit= -20 dBm

5.3 Test Results

Table 5. Field Strength of Spurious Radiation

Frequency MHz	Maximum RX Reading (Units A)	Recreated Reading During Substitution (Using Same Units A) - Ideally 0	Difference Column A - B	TX Gain (dBi)	RF Power into TX antenna (dBm) (SG Value-CL)	RF Power into substitution TX antenna (dBm)	Limit (dBm)	Margin Below Limit (dB)	Cable loss (dB)
303.64	45.09	45.22	-0.13	4.9	-69.0	-65.77	-20	45.77	1.67
455.46	39.26	39.45	-0.19	6.5	-74.7	-70.35	-20	50.35	1.72
607.28	46.25	46.26	-0.01	7.1	-63.7	-58.88	-20	38.88	2.28
759.10	50.02	50.05	-0.03	6.4	-56.7	-52.85	-20	32.85	2.55
910.92	40.33	40.42	-0.09	6.5	-66.2	-62.57	-20	42.57	2.87

Sample Calculation at 303.64 MHz:

SG Power Into TX Antenna = Pg (dBm) – cable loss (dB) + antenna gain (dBi)

Pg (column 6) = -69.0
Cable loss (column 10) = 1.67
Antenna gain (column 5)= 4.9

SG Power Into TX Antenna = -65.77 dBm

Limit	-20.00 (dBm)
RF Power into TX Antenna	-65.77 (dBm)
Margin	45.77 (dB)

Test Date: February 9-16, 2018

Tested By
Signature: _____ Name: Bruce Arnold

Table 6. Field Strength of Spurious Radiation

Frequency MHz	Maximum RX Reading (Units A)	Recreated Reading During Substitution (Using Same Units A) - Ideally 0	Difference Column A - B	TX Gain (dBi)	TX Gain Relative to Dipole (dBd)	RF Power into TX antenna (dBm) (SG Value-CL)	RF Power into substitution TX antenna (dBm)	Limit (dBm)	Margin Below Limit (dB)	Cable loss (dB)
1062.74	56.37	56.19	0.18	6.9	4.8	-57.7	-54.86	-20	34.89	1.96
1214.56	58.70	58.67	0.03	7.6	5.5	-54.3	-50.90	-20	30.90	2.11
1366.38	51.34	51.34	0.00	7.9	5.8	-65.9	-62.24	-20	42.24	2.14
1518.20	57.38	57.10	0.28	8.9	6.8	-54.7	-50.28	-20	30.28	2.35

Sample Calculation at 1062.74 MHz:

SG Power Into TX Antenna = Pg (dBm) – cable loss (dB) + antenna gain (dBi)

Pg (column 7) = -57.7
Cable loss (column 11) = 1.96
Antenna gain (column 6)= 4.8

SG Power Into TX Antenna = -54.86 dBm

Limit	-20.00 (dBm)
RF Power into TX Antenna	-54.86 (dBm)
Margin	34.86 (dB)

Test Date: February 9-16, 2018

Tested By
Signature: _____ Name: Bruce Arnold

6 Frequency Stability (CFR 2.1055) and Accuracy (CFR 95.2765(a))

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 battery for the EUT was removed and the EUT was powered with a variable DC power supply. The voltage was varied between the nominal operating voltage 85 % of the nominal value and 115 % of the nominal value. The fundamental frequency for each voltage setting was compared to the nominal voltage ambient temperature measurement and reported as compared to the limit.

6.2 FCC Limits

MURS transmitters must maintain a frequency stability of 2.0 ppm if designed to operate with a bandwidth of 6.25 kHz or less. Since this EUT was measured to have a bandwidth of 4.26 kHz the limit applied was 2.0 ppm.

6.3 Test Results

Table 7. Frequency Deviation/Stability

Temperature (˚C)	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)	Limit (ppm)
-30	151.820100	151.820025	0.5	2.00
-20	151.820050	151.820025	0.2	2.00
-10	151.820025	151.820025	0.1	2.00
0	151.820022	151.820025	0.0	2.00
10	151.820032	151.820025	0.1	2.00
20	151.820025	151.820025	0.1	2.00
30	151.820005	151.820025	-0.1	2.00
40	151.819970	151.820025	-0.3	2.00
50	151.819942	151.820025	-0.5	2.00

Actual TX Frequency was: 151.820025 MHz

Sample Calculation at -30˚C

$$\text{Deviation} = \frac{|(151.820100 - 151.820025)|}{151.820025} = 0.00000049 = 0.5 \text{ ppm} < 2 \text{ ppm}$$

Table 8. Voltage Deviation/Stability

Voltage Variation	Measured Frequency (MHz)	Allocated Frequency (MHz)	Deviation (ppm)	Limit (ppm)
85.7%*	151.820017	151.820017	0.00	2.00
100%	151.820017	151.820017	0.00	2.00
115%	151.820017	151.820017	0.00	2.00

* NOTE: The EUT shut down when the voltage was set to 85% therefore the test was performed at the lowest possible voltage.

Sample Calculation at 115%

$$\text{Deviation} = \frac{|(151.820017 - 151.820017)|}{151.820017} = 0.00000000 = 0.00 \text{ ppm} < 2 \text{ ppm}$$

Test Date: February 14-15, 2018

Tested By
Signature:  Name: Bruce Arnold