Testing Tomorrow's Technology

Application for Certification

Per
Title 47 USC Part 2, Subpart J, Equipment Authorization Procedures, Paragraph 2.907, Certification and Part 15, Subpart C, Intentional Radiators, Paragraph 15.231, Periodic Operation in the band 40.66 MHz to 40.70 MHz and above 70 MHz
And
Innovation, Science, and Economic Development Canada Certification Per
RSS-Gen General Requirements for Radio Apparatus
And
RSS-210 License-Exempt Radio Apparatus: Category I Equipment

For the

Radio Systems Corporation

Model: FS-TRN

FCC ID: KE3-3003227
IC ID: 2721A-3003227
UST Project: 17-0149
Issue Date: July 18, 2017

Number of Pages in this report: 18

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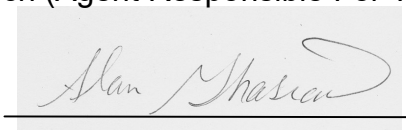
Testing Tomorrow's Technology

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: Alan Ghasiani

Title: President – Consulting Engineer

Date: July 18, 2017

TESTING
NVLAP LAB CODE 200162-0

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MEASUREMENT/TECHNICAL REPORT

COMPANY NAME: Radio Systems Corporation
PRODUCT: FS-TRN
FCC ID: KE3-3003227
IC: 2721A-3003227
DATE: July 18, 2017

This report concerns (check one): Original grant X
Class II change_____

Equipment type: 433 MHz Transmitter Module

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? yes_____ No X

If yes, defer until:_____
date

__N.A.__ agrees to notify the Commission by__N.A.__
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

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Alpharetta, GA 30004

Phone Number: (770) 740-0717
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Table of Contents

Paragraph Title Page

List of Figures

Figure **Title** **Page**

List of Tables

Tables **Title** **Page**

1. General Information

This report is prepared as a means of presenting test data to be used by a Telecom Certification Body in determination of whether this product is permitted for unlicensed dissemination to the general public according to the Innovation, Science, and Economic Development Canada and FCC Rules and Regulations for RF Devices Intentional Radiators.

1.1 Product Description

The Equipment under Test (EUT) is the Radio Systems Corporation Free Spirit Trainer, Model FS-TRN. The system consists of a receiver collar and a low powered handheld transmitter. The receiver collar is not evaluated in this test report. The EUT communicates with the receiver. The EUT is a 433 MHz wireless dog trainer. A transmitter is paired with a receiver which uses a proprietary RF protocol to wirelessly send tones, vibrations or static correction command signals

The EUT is low power 433 MHz transmitter and operates at a periodic rate that exceeds the limits of paragraph (a) of 15.231 therefore paragraph (e) is invoked.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on April 28, 2017 in good operating condition.

1.3 Related Submittal(s)/Grant(s)

The EUT is subject to the following FCC Equipment Authorizations:

a) Certification of the transmitter.

b) Verification as a Class B digital device.

2. Tests and Measurements

2.1 Configuration of Tested System

The Test sample was tested per *ANSI C63.4, Methods of Measurement from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014).* Radiated emissions data were taken according to paragraph 8.0 with the test receiver or spectrum analyzer's resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process. There were no interconnecting cables to manipulate in an attempt to maximize emissions; however, the physical position of the EUT was varied through the three mutually exclusive orthogonal planes in an attempt to maximize the emissions. The worse case position is the position used for final measurements and is gathered in this test report. A block diagram of the tested system is shown in Figure 1.

2.2 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA. This site has been fully described and registered with the FCC, under site registration number 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1 and is also a NVLAP accredited test lab; lab code 200162-0.

2.3 Test Equipment

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID:	CABLES P/D
Transmitter Radio Systems Corporation (EUT)	FS-TRN	Engineering Sample	Pending: FCC ID: KE3-3003227 IC:2721A-3003227	None

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

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
SPECTRUM ANALYZER	8593E	HEWLETT PACKARD	3205A60124	8/23/2017
BICONICAL ANTENNA	3110B	EMCO	9307-1431	8/25/2017 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	9/21/2018 2 yr
HORN ANTENNA	3115	EMCO	9107-3723	9/22/2018 2 yr
PRE-AMPLIFIER	8449B	HEWLETT-PACKARD	3008A00480	10/26/2017
PRE-AMPLIFIER	8477D	HEWLETT-PACKARD	1937A02980	11/01/2017
CALCULATION PROGRAM	N/A	N/A	Ver. 6.0	N/A

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

2.4 EUT Antenna Description (FCC Sec. 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 Radio Systems Corporation, Model FS-TRN incorporates the antenna(s) detailed in Table 3.

Table 3. Antenna Description

MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN (dBi)	TYPE OF CONNECTOR
Radio Systems Corp	Integrated antenna (Inductor)	None	-3.69 dBi	Inductive trace antenna

2.5 Modifications to Equipment

No modifications were needed to bring the EUT into compliance with the FCC Part or IC RSS requirements.

2.6 Test Procedure

The EUT was configured as shown in the following block diagram(s) and photograph(s). The sample was tested per ANSI C63.4, Methods of Measurement for Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014) following US Tech's procedures paragraph 7 for conducted and paragraph 8 for radiated. Conducted and radiated emissions data were taken with the test receiver or spectrum analyzer's resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements are peak unless stated otherwise. The video filter on the spectrum analyzer was OFF throughout the evaluation process. Interconnecting cables were manipulated as necessary to maximize emissions. The EUT was rotated 360 degrees with the turntable to maximize emissions. The physical position of the EUT was varied through the three mutually exclusive orthogonal planes in an attempt to maximize the emissions. The final setup description is found in the test section of this report.

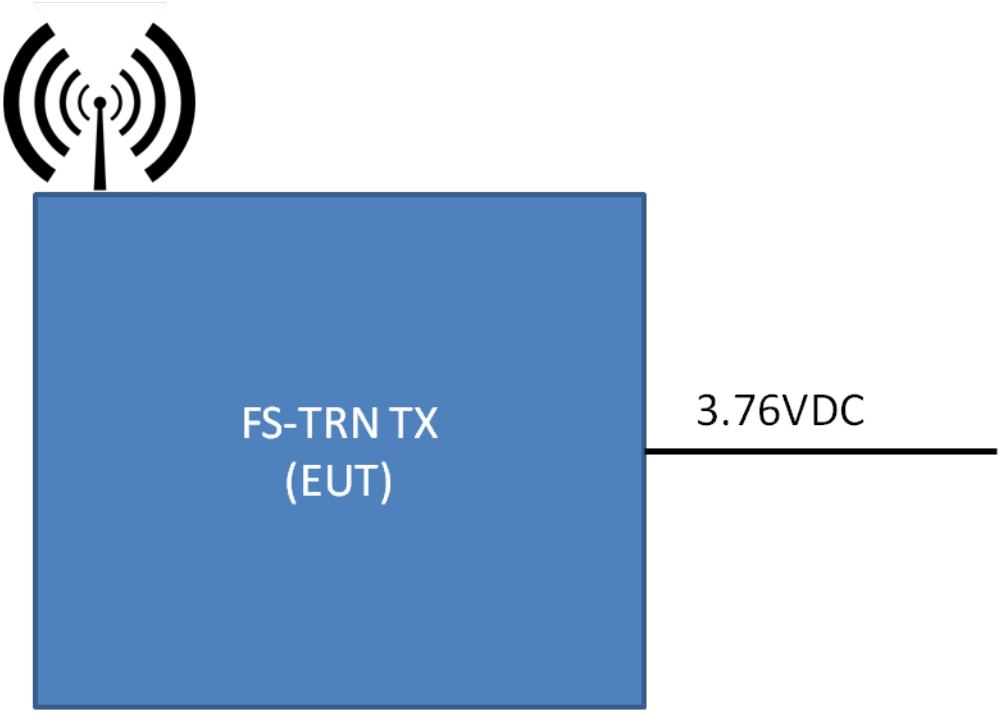

Figure 1. Block Diagram of Test Configuration

2.7 Pulse Averaging/Duty Cycle (47 CFR 15.35 (c))

The duty cycle de-rating factor used in the calculation of average radiated limits (per CFR 15.209 and 15.35(c)) is described below. This factor was calculated by first determining the worst case scenario for system operation. With the worst case operating scenario the transmission duty cycle is calculated as:

Total Time On from Figure 3. = 3.05 mS

(3.05 mS Total Time On)/(100mS FCC Standard) = 0.0305 Numeric Duty Cycle
Duty Cycle = 20 Log (0.0305) = -30.31 dB

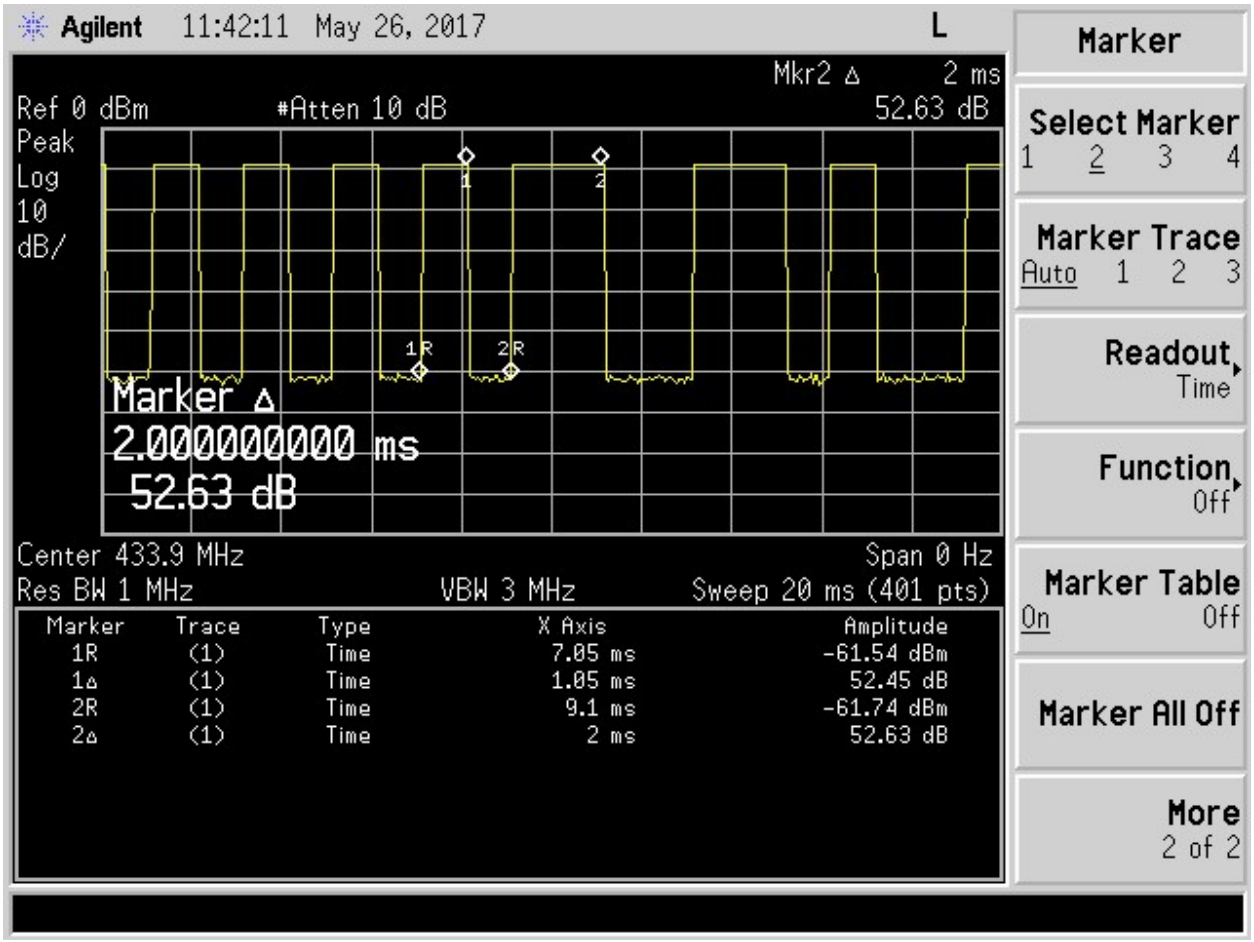

Figure 2. Duty Cycle

2.8 Compliance to CFR 15.231(e)

According to CFR 15.231(e), transmitters which are not able to meet the requirements for CFR 15.231(a) can evoke the requirements laid out in CFR 15.231(e). In this case the EUT is not able to meet all the requirements of CFR 15.231(a) therefore CFR 15.231(e) was applied.

2.8.1 Field Strength of Fundamental (47 CFR 15.231(b), 15.231(e))

The results of the measurements for peak fundamental emissions are given in Table 4. The EUT emissions measurement was started by setting up the Antenna in the vertical orientation at a distance of 3 meters from the EUT and at a height of 1.0 meters above the ground. The EUT's major axis was set normal to the direction of the measuring antenna.

The Spectrum Analyzer (SA) displays were set to: Channel A free-running, Channel B to Max-Hold. Choose a frequency or frequency range and scan it at a coupled rate. When a signal is detected, raise and lower the antenna to maximize the signal.

When the signal has been maximized, the antenna height is fixed the turn-table is rotated through 360 degrees to further maximize the signal.

When all signals have been maximized for antenna height and direction, the EUT case is carefully maneuvered in each of the three mutually exclusive orthogonal planes while observing the same Max-hold/free-running SA display indication. When the EUT position is found that further maximizes the signal, record the antenna height, rotation orientation, EUT orthogonal position and signal strength on the data sheet for that particular frequency.

Next, the measurement antenna is re-oriented to a Horizontal polarization at 1 meter height and the process described above is repeated. All signals within 6 dB of the limit are recorded.

Finally, the collected data is input into the calculation spread sheet. The spread sheet is designed to calculate for the true value that is collected. The spread sheet takes into account the SA reading, the antenna correction factor, cable losses and duty cycle factors. See the data tables herein.

2.8.2 Limits for Operation in the Band above 70 MHz (CFR15.231(b) 15.231(e))

This limit versus frequency table is as follows (test distance = 3.0 meters):

Fundamental Frequency (MHz)	Limit Fundamental (Average) uV/m	Limit Harmonics and other spurious (Average) uV/m
260 to 470	3,750 to 12,500	375 to 1,250
Above 470	12,500	1,250
* Linear Interpolation		

Note: formula 1: $limit_1 = E = 10^{(m*\log(F))+b}$
2: $limit_2 = E = 10^{(m*\log(F))+b}$
$m = 2.034^1, 2.034^2$
$b = -1.337^1, -2.337^2$
E= Electric field strength
F= frequency in MHz

The frequency spectrum above the fundamental to its 10^{th} harmonic was examined and measured for signals falling into the restricted bands of 15.205. If average emissions measurements are employed, the provisions in 15.35 for averaging pulsed emissions and for limiting peak emissions were applied. All other spurious emissions meets the limits of 15.209.

Table 4. Intentional Radiated Emissions, CFR 15.231 below 1 GHz

Test: FCC Part 15, Paragraph 15.209, 15.231(b)			**Client:** Radio Systems Corporation					
Project: 17-0149			**Model:** FS-TRN					
Frequency (MHz)	**Test Data (dBuV)**	**Factor (dB)**	**AF+CA -AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
434.20	67.59	-	18.75	86.34	*100.5	3m./HORZ	14.1	**PK**
434.20	45.43	-	18.75	64.18	80.5	3m./HORZ	16.3	**AVG**
867.79	53.29	-	-0.18	53.11	94.4	3m./HORZ	41.3	**PK**

1. (*) Peak limit applied
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic

Sample Calculation at 434.20 MHz

Magnitude of Measured Frequency	67.59	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	18.75	dB/m
+Additional Factor	-30.31	dB
Corrected Result	56.03	dBuV/m

Test Date: May 5, 2017
Tested By
Signature:  Name: Robert K. Mills

Table 5. Intentional Radiated Emissions CFR 15.231 above 1 GHz

Test: FCC Part 15, Paragraph 15.209, 15.231(b)			**Client:** Radio Systems Corporation					
Project: 17-0149			**Model:** FS-TRN					
Frequency (MHz)	**Test Data (dBuV)**	**Factor (dB)**	**AF+CA -AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
1301.69	53.77	-	-8.11	45.66	61.9	3.0m./HORZ	16.2	**PK**
1735.61	53.40	-	-7.20	46.20	61.9	3.0m./HORZ	15.7	**PK**
2169.53	55.13	-	-3.43	51.70	61.9	3.0m./HORZ	10.2	**PK**
2603.42	64.10	-	-2.65	61.45	61.9	3.0m./HORZ	0.4	**PK**
3037.37	40.62	-	-0.25	40.37	61.9	3.0m./HORZ	21.5	**PK**
3471.26	49.17	-	0.73	49.90	61.9	3.0m./HORZ	12.0	**PK**
3905.13	39.43	-	1.97	41.40	61.9	3.0m./HORZ	20.5	**PK**
4339.13	40.18	-	2.67	42.85	61.9	3.0m./HORZ	19.1	**PK**

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

Sample Calculation at 1301.69 MHz

Magnitude of Measured Frequency	53.77	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-8.11	dB/m
+Duty Cycle	0	dB
Corrected Result	45.66	dBuV/m

Test Date: May 5, 2017
Tested By
Signature:  Name: Robert K. Mills

2.8.3 Bandwidth of Fundamental (CFR15.231(c))

The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. Bandwidth is determined by those frequencies that are at least 20 dB down on either side of the center frequency of the pulse.

0.0025 x 433,920,000.00 = 1.0848 MHz

The measured bandwidth is 55.500 kHz, which is well within the limit. See the figure below.

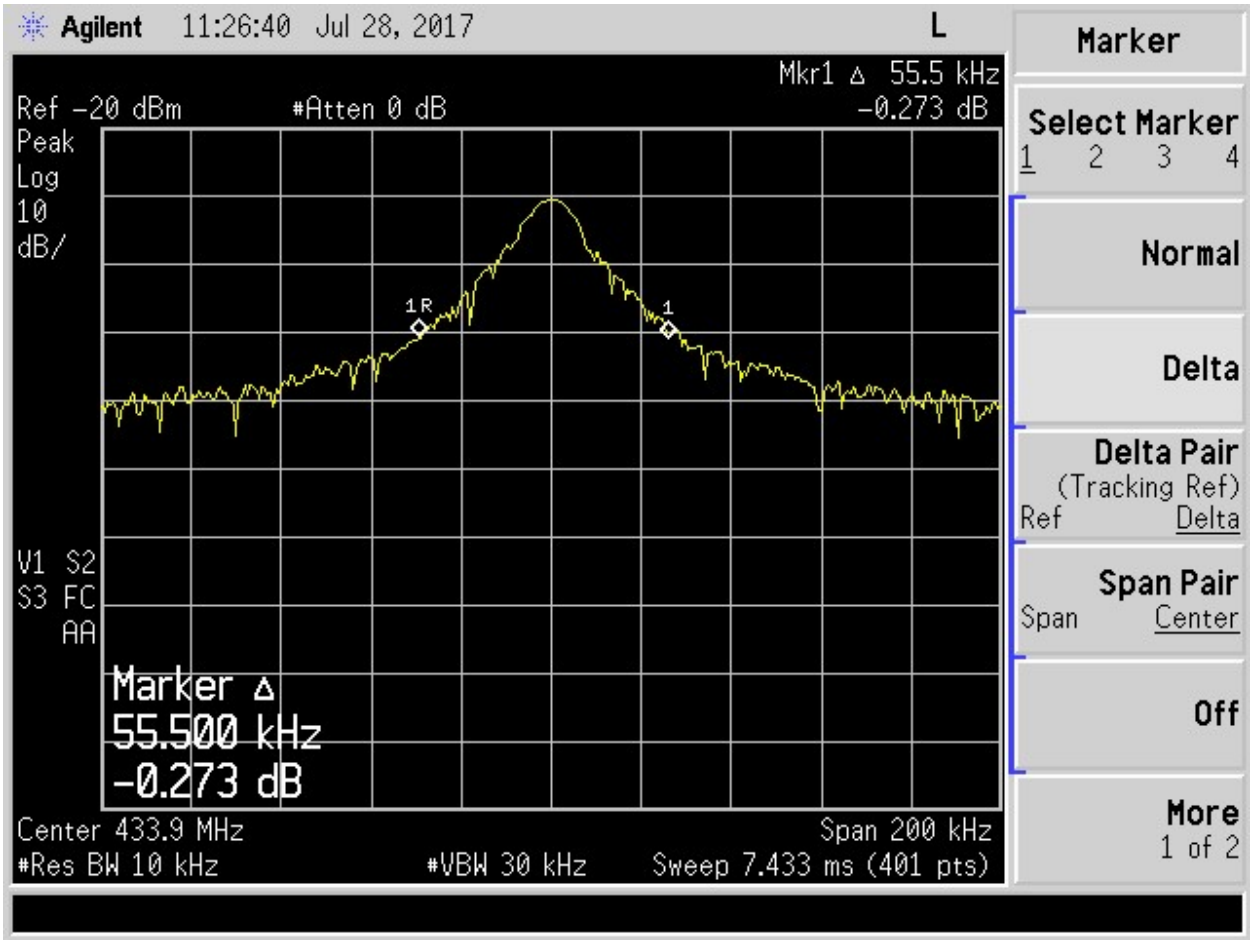

Figure 3. Occupied Bandwidth (20 dB BW)

2.9 Radiated Spurious Emissions and Power Line Conducted Emissions (CFR 15.209, 15.207)

When applicable, the EUT is placed in a state representative of how the device will function under normal operation. The radiated spurious emissions were measured over the frequency range of 150 kHz to 30 MHz and 30 MHz to the 5th harmonic of the fundamental frequency of the intentional transmitter. The test results are shown below.

The EUT is battery operated and does not connect to the AC mains; therefore testing for compliance with 15.207 was not applicable.

Table 6. Intentional Radiated Emissions, 150 kHz - 30 MHz

Tested By: RKM		Test: Part 15B, Para 15.209			Client: Radio Systems Corporation			
		Project: 17-0149			Model: FS-TRN			
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor (dB)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Method**
No emissions found greater than 20 dB below the applicable limit.								

Sample Calculation: N/A

Test Date: May 8, 2017

Tested By
Signature:  Name: Robert K. Mills

Table 7. Intentional Radiated Emissions, 30-1000 MHz

Tested By: RKM		Test: Part 15B, Para 15.209		Client: Radio Systems Corporation			
		Project: 17-0149		Model: FS-TRN			
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor (dB)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Method**
845.00	30.27	--	-0.74	29.53	46.0	3.0m./HORZ	16.5	**PK**
717.00	29.06	--	-1.65	27.41	46.0	3.0m./HORZ	18.6	**PK**
832.00	28.85	--	-1.79	27.06	46.0	3.0m./VERT	18.9	**PK**
909.00	30.40	--	-0.09	30.31	46.0	3.0m./VERT	15.7	**PK**
No other emissions found greater than 20 dB below the applicable limit.								

1. No additional factor applied.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 5th harmonic of highest clock frequency

Sample Calculation at 845.00 MHz

Magnitude of Measured Frequency	30.27	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-0.74	dB/m
+Additional Factor	0.00	dB
Corrected Result	29.53	dBuV/m

Test Date: May 8, 2017
Tested By
Signature:  Name: Robert K. Mills

Table 8. Intentional Radiated Emissions, above 1 GHz

Tested By: RKM		Test: Part 15B, Para 15.209		Client: Radio Systems Corporation				
		Project: 17-0149		Model: FS-TRN				
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor (dB)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Method**
1173.00	48.50	--	-8.24	40.26	54.0	3.0m./HORZ	13.7	**PK**
1304.00	54.06	--	-7.50	46.56	54.0	3.0m./VERT	7.4	**PK**
No other emissions found greater than 20 dB below the applicable limit.								

1. No additional factor applied.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 5th harmonic of highest clock frequency

Sample Calculation at 1173.00 MHz

Magnitude of Measured Frequency	48.50	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-8.24	dB/m
+Duty Cycle	0	dB
Corrected Result	40.26	dBuV/m

Test Date: May 8, 2017
Tested By
Signature: _____ Name: Robert K. Mills

2.10 Measurement Uncertainty

2.10.1 Conducted Emissions Measurement Uncertainty

Measurement uncertainty (within a 95% confidence level) for this test is ± 2.85 dB.

Not applicable. The EUT is battery powered.

2.10.2 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 ± 5.40 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 ± 5.19 dB

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.08 dB (3 m distance).

The data listed in this test report does have sufficient margin to negate the effects of uncertainty. The EUT unconditionally passes this requirement.

3. Conclusions

The EUT is deemed to have unconditionally met all the requirements of Title 47 USC Part 2, Subpart J, Equipment Authorization Procedures, Paragraph 2.907, Certification and Part 15, Subpart C, Intentional Radiators, Paragraph 15.231, Periodic Operation in the band 40.66 MHz to 40.70 MHz and above 70 MHz and Innovation, Science, and Economic Development Canada Certification Per RSS-Gen General Requirements for Radio Apparatus and RSS-210 License-Exempt Radio Apparatus: Category I Equipment.