



Application

For

**Title 47 USC Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of
Certification for an Intentional Radiator per Part 15, Subpart C,
Paragraphs 15.207 and 15.209**

And

**Industry Canada, Radio Standards Specifications:
RSS Gen Issue 5 and RSS-210 Issue 9**

For the

**Radio Systems
Long Wire Module 10X**

Model: RIG00-16947

**FCC ID: KE3-3003590
IC: 2721A-3003590**

**UST Project: 19-0406
Test Date: November 11-22, 2019
Report Issue Date: December 20, 2019**

Total Pages in This Report : 23

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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 December 20, 2019



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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Radio Systems
10427 Petsafe Way
Knoxville, TN 37932

MODEL: RIG00-16947

FCC ID: KE3-3003590

IC: 2721A-3003590

DATE: December 20, 2019

This report concerns (check one): Original grant ☒
Class II change
Equipment type: Low Power Transmitter Module (9 kHz -30 MHz)

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

If yes, defer until: N/A
date

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:

US Tech
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Agency Agreements
Letter of Confidentiality
Block Diagram(s)
Test Configuration Photographs
External Photographs
Theory of Operation
Modular Approval Letters

Application Forms
Equipment Label(s)
Schematic(s)
Internal Photographs
Nerve Stimulation Rpt.
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1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to the FCC Rules and Regulations Part 15, Sections 207 and 209, and IC RSS 210 Issue 9.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on September 23, 2019 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Radio Systems, Boundary Plus ® 2.0 Long Wire Module 10X, Model RIG00-16947.

The EUT is part of a pet containment and avoidance system that consists of a central data collection unit, a long wire transmitter that defines the containment perimeter, one or more remote receivers that are attached to pet collars, zero or more avoidance transmitters (either short wire or coil transmitters), and zero or more appliance transmitters (coil transmitters that integrated into entry/exit doors, water fountains, feeders, etc.). The EUT is the avoidance transmitter in this system.

The EUT integrated in the host device by plugging into the Long Wire Module slot dedicated for this module.

Fundamental frequency of operation: 15 kHz, 20 kHz or 25 kHz and is user selectable. The output power levels and bandwidth are the same no matter which frequency is selected. For testing purpose the 25 kHz signal was selected as the representative test frequency.

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 FCC subpart C Intentional Radiators and per *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 FCC subpart B Unintentional Radiators requirements.

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A list of EUT and Peripherals is found in Table 1 following. A block diagram of the tested system is shown in Figure 1. Test configuration photographs 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 US5301. Additionally this site has been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A.

1.6 Related Submittals

The EUT is subject to the following FCC authorizations:

- a) Certification under section 15.207 and 15.209 as a transmitter module
- b) SDoC under 15.101 as a digital device.

The SDoC requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the SDoC authorization report (Parts 15.107 and 15.109) for the EUT is included herein.

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Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID	CABLES P/D
EUT				
Transmitter/ Radio Systems Corp	RIG00-16947	Engineering Sample	Pending: FCC ID: KE3-3003590 IC: 2721A-3003590	N/A
Peripherals				
Host Transmitter/ Radio Systems Corp	RIG00-16936	0C990003EC	Pending: FCC ID: KE3- 3003591	P U
Power Adapter/ Radio Systems	SPS-02C5- 1C-US-VI	Production Sample	N/A	P U

U= Unshielded
P= Power

S= Shielded
D= Data

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2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are indicated.

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	8/17/2020
SPECTRUM ANALYZER	DSA815	RIGOL	DSA8A1803 00138	12/11/2019 Extended
PREAMP	8447D	HEWLETT-PACKARD	1937A02980	5/07/2020
PREAMP	8449B	HEWLETT-PACKARD	3008A00480	4/08/2020
LOOP ANTENNA	6502	ETS LINDGREN	9810-3246	1/22/2020 2 yr
BICONICAL ANTENNA	3110B	EMCO	9307-1431	01/23/2020 Extended
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	2/01/2021 2 yr
LISN x 2	9247-50- TS-50-N	SOLAR ELECTRONICS	955824 & 955825	4/03/2020

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 to the EUT during testing.

2.3 Number of Measurements for Intentional Radiators (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 below.

Table 3. 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

Because the EUT operates at 15kHz, 20kHz or 25kHz, 1 test frequency was used.

2.4 Frequency Range of Radiated Measurements (Part 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 5 times the highest internal clock frequency.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the following:

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.

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, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

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 be expressed logarithmically in dB.

NOTE: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG) the duty cycle factor calculated will be applied.

2.6 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. Only the antenna(s) listed in Table 4 will be used with this module.

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	TYPE OF CONNECTOR
Antenna 1	Radio Systems	Wire Loop Antenna	Engineering Sample	Electrical Contacts

Note: This requirement does not apply to carrier current devices.

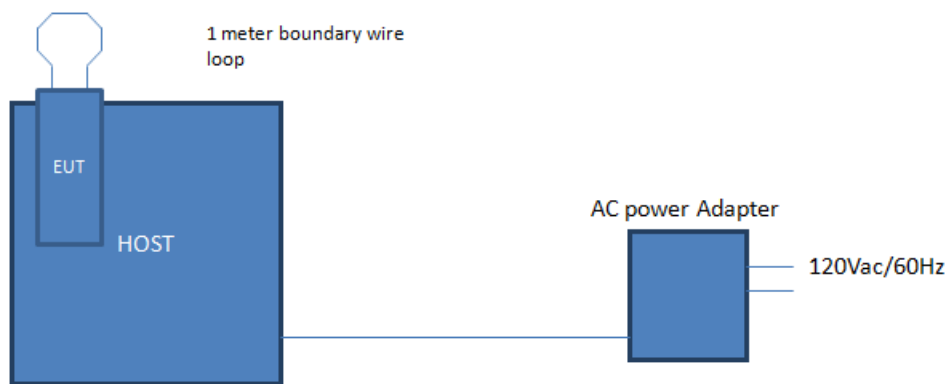


Figure 1. Block Diagram of Test Configuration (intentional)

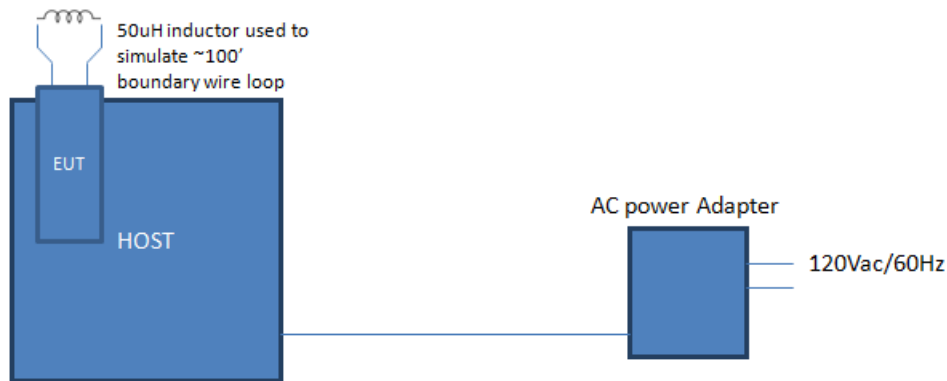


Figure 2. Block Diagram of Test Configuration (unintentional)

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 spurious emissions cannot exceed the limits of 15.209. Radiated Harmonics and other Spurious Emissions are examined for this requirement; see paragraph 2.1.

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2.8 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

Power line conducted emissions testing was performed to ensure that with the EUT in operation (exercising all transmitter functions), the complete system continues to meet the applicable requirements for CFR 15.207. Results are displayed along with the 15.107 power line test data in the sections below.

2.9 Intentional Radiator, Radiated Emissions (CFR 15.209, (IC RSS 210))

Radiated Radio measurements: The EUT was placed into a continuous transmit mode of operation and a preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the product. To obtain the worst case results, the EUT was placed on a table top of a non-conductive table, 80 cm above the ground floor. The EUT was positioned 3 meters away from the receiving antenna during testing (1 meter at frequencies above 6 GHz and if the emissions were less than 6 dB from the noise floor). The EUT was tested in X, Y and Z axes or the position of normal operation to determine the worst case orientation. Radiated measurements below 30 MHz were tested with a RBW = 9 kHz; emissions below 1 GHz were tested with a RBW = 120 kHz and radiated measurements above 1 GHz were measured using a RBW = 1 MHz. VBW was set to three times the RBW value.

For radiated emissions, any emission that was greater than 20 dB from the applicable limit was not recorded. If radiated emissions above 1 GHz were measured at a distance of 1 meter, the measured value at 1 meter was extrapolated to the results at 3 meters using an inverse distance extrapolation factor of -20 dB/decade. Results are displayed along with the 15.109 test data in the sections below.

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2.10 99% Occupied Bandwidth (IC RSS 210, A8.1)

These measurements were performed while the EUT was in a constant transmit mode. A method similar to the marker delta method was used to capture the points. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW $\geq$ RBW. The results of this test are given in Table 7 and Figure 2.

Table 5. 20 dB Bandwidth and 99% Occupied Bandwidth

Frequency (kHz)	99% Occupied Bandwidth (kHz)
25.0	2.4948

*Note: Test completed using Agilent E4407B Spectrum Analyzer, Calibration Due Date 8/17/2020.

Test Date: November 8, 2019

Tested By
Signature: _____



Name: Mark Afroozi

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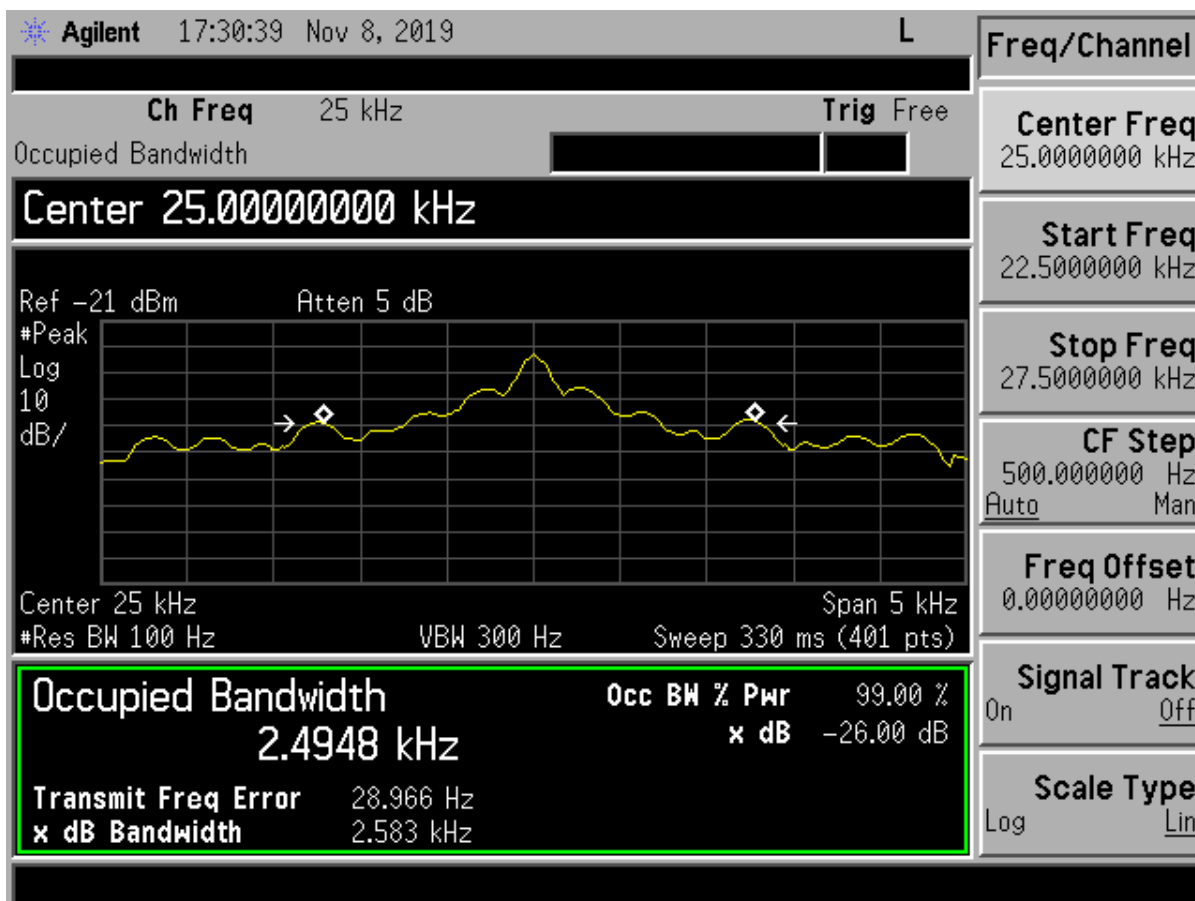


Figure 3. 99% Bandwidth

2.11 Unintentional/Intentional Radiator, Power line Emissions (CFR 15.107 and 15.207)

The power line conducted voltage emissions measurements have been carried out in accordance with CFR 15.107, per ANSI C63.4:2014 and ANSI C63.4:2013, Paragraph 7, with a spectrum analyzer connected to a LISN and the EUT placed into a continuous mode of transmission.

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The worst-case results for conducted emissions were determined to be produced when the EUT was operating under continuous transmission. The worst-case measurement occurred on the PHASE line at 0.5250 MHz. The emission level was 6.6 dB from the applicable limit. All other emissions were at least 7.5 dB from the limit. These results are reported in the table following

Table 6. Transmitter Power Line Conducted Emissions Test Data, (15.107 and 15.207)

150 KHz to 30 MHz with Class B Limits						
Test: Power Line Conducted Emissions				Client: Radio Systems Corp		
Project: 19-0406				Model: RIG00-16947		
Frequency (MHz)	Test Data (dBuV)	LISN+CL-PA (dB)	Results (dBuV)	AVG Limits (dBuV)	Margin (dB)	Detector PK, QP, or AVG
120 Vac, 60 Hz Phase						
0.1634	47.77	0.07	47.84	55.3	7.5	PK
0.5250	36.67	2.73	39.40	46.0	6.6	QP
2.0930	34.31	0.07	34.38	46.0	11.6	QP
5.1670	37.44	0.06	37.50	50.0	12.5	PK
10.2000	31.44	0.34	31.78	50.0	18.2	PK
24.4160	35.47	1.15	36.62	50.0	13.4	PK
120Vac, 60 Hz Neutral						
0.1645	43.57	0.12	43.69	55.2	11.5	PK
0.5842	36.12	0.53	36.65	46.0	9.4	QP
1.2600	35.03	0.50	35.53	46.0	10.5	QP
5.7920	33.49	0.28	33.77	50.0	16.2	PK
19.5830	30.16	1.18	31.34	50.0	18.7	PK
25.0160	38.99	1.68	40.67	50.0	9.3	PK

Sample Calculation at 0.1634 MHz:

Magnitude of Measured Frequency	47.77 dBuV
+Correction Factors	0.07 dB
Corrected Results	47.84 dBuV

Test Date: September 4, 2019

Tested by
 Signature: 

Name: Afzal Fazal

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2.12 Unintentional/Intentional Radiator, Radiated Emissions (CFR 15.109 and 15.209)

Radiated emissions disturbance Measurements were performed with EUT in constant transmit mode and using an instrument having both peak and quasi-peak detectors over the frequency range of 9 kHz to 1 GHz. Measurements of the radiated emissions were made with the receiver antenna at a distance of 3 m from the boundary of the test unit.

The test antenna was varied from 1 m to 4 m in height while watching the analyzers' display for the maximum magnitude of the signal at the test frequency. The antenna polarization (horizontal or vertical) and test sample azimuth were varied during the measurements to find the maximum field strength readings to record.

The worst-case radiated emission in the range of 9 kHz to 1 GHz was 7.2 dB below the limit at 142.84 MHz. This signal is found in Table 8. All other radiated emissions were 10.1 dB or more below the limit.

Note: An intentional emission testing was performed with a single 1 meter wire loop connected to the Long Wire module. This simulated worst case operation however in its normal operation the boundary wire will never be this short, therefore a 50uH inductor was used to simulate a larger loop area (~100'). This configuration is regarded as the normal operating test configuration and used for unwanted unintentional emissions measurements. See Test Configuration photograph exhibit for images.

Collocation and simultaneous broadcasting testing note: The host device incorporates a 151.82 MHz MURS transmitter radio (pending FCC ID: KE3-3003591) and an approved WiFi device (FCC ID: 2AC7Z-ESP32WROOM32U). During spurious emissions testing both these radios as well as the Long Wire radio being evaluated in this report was ON and exercising throughout testing. The test data collected is considered the worst case data and is presented in the tables below to show that the collocation of these radios into one single host product does not cause emissions that exceed the applicable limits.

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2.13 Radiated Emission Limits - General Requirements

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

Note: from 30 MHz to above 960 MHz the Part 15.209 limits are identical to Part 15.109 Class B limits.

Example Fundamental Limit calculation:

at 10.7 kHz = $2400/10.7 = 224.3$ uV/m @ 300 m

Conversion from uV/m to dBuV/m = $20 \log 224.3 = 47.02$ dBuV/m

Conversion from 300 to 3 m = $40 \log (300/3) = 80$

Limit at 3 meter = $47.02 + 80 = 127.02$ dBuV/m

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Table 7. Spurious Radiated Emissions 9 kHz to 30 MHz (15.209)

Test: FCC Part 15, Para 15.209				Client: Radio Systems Corp			
Project: 19-0406				Model: RIG00-16947			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	AVG Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
0.025	75.98	13.46	89.44	119.7	3 meters.	30.2	PK
0.080	57.68	12.46	70.14	110.1	3 meters.	40.0	PK
0.130	50.62	12.16	62.78	105.7	3 meters.	42.9	PK
0.180	48.34	12.16	60.50	102.6	3 meters.	42.1	PK
0.500	36.40	11.76	48.16	73.0	3 meters.	24.8	PK
4.540	31.40	11.19	42.59	69.5	3 meters.	27.0	PK
All other detected emissions were 20 dB or more below the applicable limit.							

- (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
- No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic

Sample Calculations: at 0.025 MHz, 75.98 dBuV + (13.46) = 89.44 dBuV/m
 Limit @ 3m= 119.7 dBuV/m
 Margin= 30.2 dB

Test Date: November 12, 2019

Tested by
 Signature: 

Name: John Freeman

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Table 8. Spurious Radiated Emissions (CFR 15.109, 15.209), 30 MHz to 1000 MHz

30 MHz to 1000 MHz with Class B Limits							
Test: Radiated Emissions				Client: Radio Systems Corp			
Project: 19-0406				Model: RIG00-16947			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector PK or QP
35.67	43.85	-15.04	28.81	40.0	3m./VERT	11.2	QP
78.45	38.59	-18.05	20.54	40.0	3m./VERT	19.5	QP
128.32	42.61	-14.29	28.32	43.5	3m./HORZ	15.2	QP
141.07	48.68	-13.22	35.46	43.5	3m./VERT	8.0	QP
141.63	52.97	-13.62	39.35	43.5	3m./HORZ	4.2	QP
191.88	50.54	-11.21	39.33	43.5	3m./HORZ	4.2	QP
214.54	50.52	-14.53	35.99	43.5	3m./HORZ	7.5	QP
214.67	53.20	-14.63	38.57	43.5	3m./VERT	4.9	QP
386.67	45.26	-9.44	35.82	46.0	3m./HORZ	10.2	QP
388.00	35.93	-9.61	26.32	46.0	3m./VERT	19.7	QP
413.33	46.05	-8.96	37.09	46.0	3m./HORZ	8.9	QP
418.67	48.82	-9.18	39.64	46.0	3m./VERT	6.4	QP

Sample Calculation at 35.67 MHz:

Magnitude of Measured Frequency	43.85 dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-15.04 dB/m
Corrected Result	28.81 dBuV/m

Test Date: November11, 2019

Tested by
 Signature: 

Name: Afzal Fazal

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
KE3-3003590
2721A-3003590
19-0406
December 20, 2019
Radio Systems
RIG00-16947

Table 9. Spurious Radiated Emissions (CFR 15.109, 15.209), 1 GHz to 2 GHz

1 GHz to 2 GHz with Class B Limits							
Test: Radiated Emissions				Client: Radio Systems			
Project: 19-0406				Model: RIG00-16947			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	AVG Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector PK, or AVG
All emissions were more than 20 dB below the limit.							

Test Date: November 11, 2019

Tested by
Signature: Afzal Fazal

Name: Afzal Fazal

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
KE3-3003590
2721A-3003590
19-0406
December 20, 2019
Radio Systems
RIG00-16947

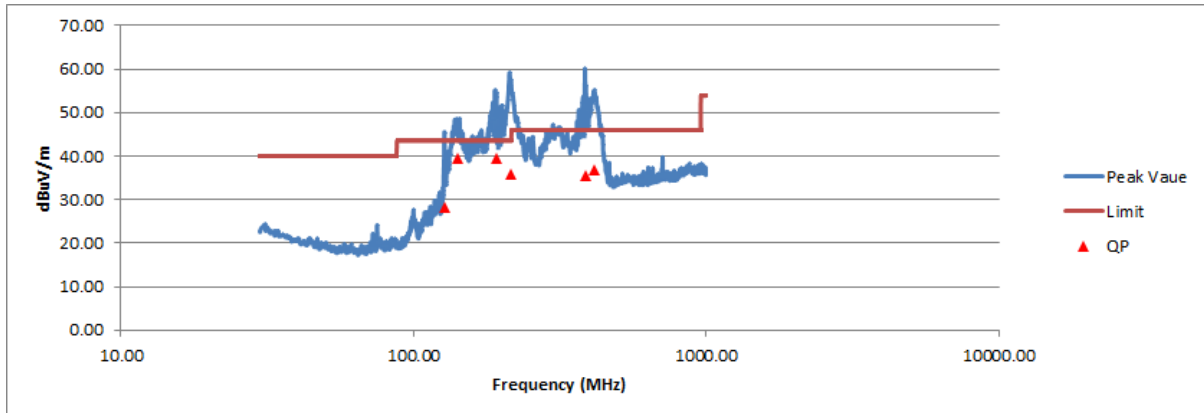


Figure 4. Radiated Emissions Graphical Data, 30 - 1000 MHz – Horizontal

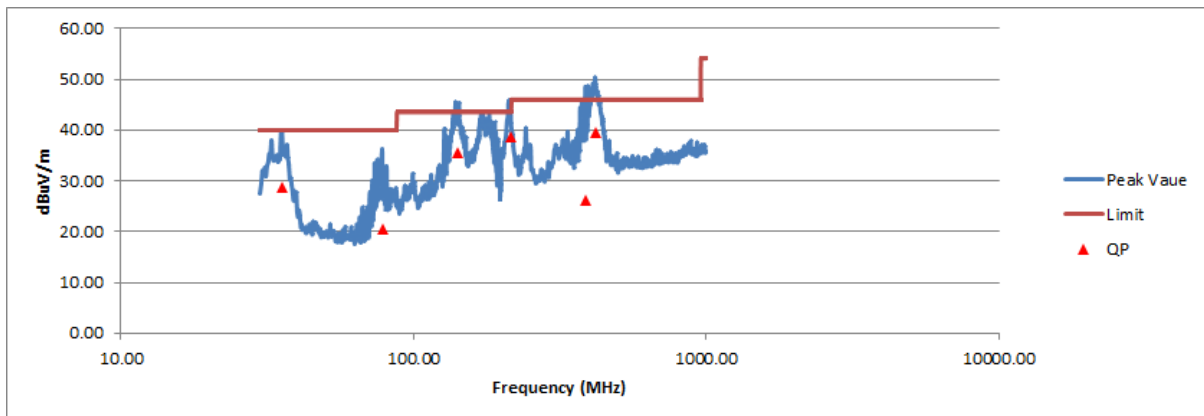


Figure 5. Radiated Emissions Graphical Data, 30 - 1000 MHz – Vertical

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
KE3-3003590
2721A-3003590
19-0406
December 20, 2019
Radio Systems
RIG00-16947

2.14 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4. 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 ± 2.85 dB. The data listed in this test report does have sufficient margin to negate the effects of uncertainty. Therefore, the EUT unconditionally meets this requirement.

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 ± 5.40 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 data listed in this test report does not have sufficient margin to negate the effects of uncertainty. Therefore, the EUT conditionally meets this requirement.