



Testing Tomorrow's Technology

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

**BOUNDARY PLUS 2.0 INDOOR SHIELDS WIRELESS 10X, Model: RAC00-16950
BOUNDARY PLUS 2.0 WIRELESS MASK, Model: RAC00-16993
BOUNDARY PLUS 2.0 OUTDOOR SHIELDS WIRELESS 10X, Model: RAC00-16953**

**FCC ID: KE3-3003600
IC: 2721A-3003600**

**UST Project: 20-0075 & 20-0090
Test Dates: October 2, 2019 – April 15, 2020
Report Issue Date: April 15, 2020**

Total Pages in This Report: 24

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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: April 15, 2020



NVLAP LAB CODE 200162-0

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Radio Systems
MODEL(s): RAC00-16950, RAC00-16993, & RAC00-16953
FCC ID: KE3-3003600
IC: 2721A-3003600
DATE: April 15, 2020

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

Equipment type: Low Power Transmitter (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
3505 Francis Circle
Alpharetta, GA30004

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

Table of Contents

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
1	General Information.....	6
1.1	Purpose of this Report.....	6
1.2	Characterization of Test Sample.....	6
1.3	Product Description	6
1.4	Configuration of Tested System.....	7
1.5	Test Facility.....	7
2	Tests and Measurements.....	10
2.1	Test Equipment.....	10
2.2	Modifications to EUT Hardware	10
2.3	Number of Measurements for Intentional Radiators (15.31(m)).....	11
2.4	Frequency Range of Radiated Measurements (Part 15.33).....	11
2.4.1	Intentional Radiator.....	11
2.4.2	Unintentional Radiator	11
2.5	Measurement Detector Function and Bandwidth (CFR 15.35)	12
2.6	EUT Antenna Requirements (CFR 15.203)	12
2.7	Restricted Bands of Operation (Part 15.205).....	14
2.8	Intentional Radiator, Power Line Conducted Emissions (CFR 15.207).....	14
2.9	Intentional Radiator, Radiated Emissions (CFR 15.209, (IC RSS 210))	14
2.10	99% Occupied Bandwidth (IC RSS 210, A8.1).....	15
2.11	Unintentional/Intentional Radiator, Power line Emissions (CFR 15.107 and 15.207) 16	
2.12	Unintentional/Intentional Radiator, Radiated Emissions (CFR 15.109 and 15.209) 18	
2.13	Radiated Emission Limits - General Requirements	19
2.14	Measurement Uncertainty	24
2.14.1	Conducted Emissions Measurement Uncertainty	24
2.14.2	Radiated Emissions Measurement Uncertainty	24

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

List of Figures

<u>Figures</u>	<u>Title</u>	<u>Page</u>
Figure 1.	Block Diagram of Test Configuration	13
Figure 2.	99% Bandwidth.....	16
Figure 3.	Graphical Data of Radiated Emissions, 30-1000 MHz – Horizontal.....	23
Figure 4.	Graphical Data of Radiated Emissions, 30-1000 MHz –Vertical.....	23

List of Tables

<u>Table</u>	<u>Title</u>	<u>Page</u>
Table 1.	EUT and Peripherals.....	9
Table 2.	Test Instruments	10
Table 3.	Number of Test Frequencies for Intentional Radiators.....	11
Table 4.	Allowed Antenna(s).....	13
Table 5.	20 dB Bandwidth and 99% Occupied Bandwidth	15
Table 6.	Transmitter Power Line Conducted Emissions Test Data, (15.107 and 15.207).....	17
Table 7.	Radiated Emissions 9 kHz to 30 MHz (15.209) – Indoor & Outdoor	20
Table 8.	Unintentional Radiator, Peak Radiated Emissions (CFR 15.109, 15.209), 30 MHz to 1000 MHz, Indoor & Outdoor.....	21
Table 9.	Unintentional Radiator, Peak Radiated Emissions (CFR 15.109), 1 GHz to 2 GHz, Indoor & Outdoor	22

List of Attachments

FCC Agency Agreement	ISED Agency Agreement
Canadian Representative Agreement	Application Forms
Confidentiality Request Letter	Equipment Label(s)
Block Diagram(s)	Schematic(s)
Test Configuration Photographs	Internal Photographs
External Photographs	Theory of Operation
User's Manual	ISED Cross Reference

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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 February 12, 2020 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Radio Systems, Boundary Plus ® 2.0 Transmitter, Models RAC00-16950, RAC00-16993, and RAC00-16953. The difference between the models are as follows: The model RAC00-16950 and RAC-16993 are indoor versions of the EUT and the RAC00-16953 is an outdoor version of the EUT. The hardware and components within all models are essentially identical expect for the power input circuits. The outdoor version is designed to be used with either an internal lithium poly battery or with four D cell batteries. The indoor version of the EUT is designed to be used with a rechargeable lithium battery or an approved AC/DC power supply adapter. The intentional circuits for all models are identical therefore in this report the model RAC00-16993 was tested as the representative sample for all models.

All models are part of the Boundary Plus 2.0 pet containment and avoidance system. The Boundary Plus 2.0 pet containment and avoidance system 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 system services an area consistent with a residential property.

The Boundary Plus 2.0 Indoor & Outdoor Two Port Hosts are optional avoidance transmitters. The units are placed at the location of the intended avoidance area. The coil transmitter output driver consists of an “H-Bridge” amplifier. The amplifier produces an OOK modulated current in the coil which results in a similarly modulated magnetic field about the coil. It operates at one of the

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

following fundamental frequencies: 15kHz, 20kHz or 25kHz. The modulation data rate is 1250 bps and the data represent an 8-bit "filed ID" unique within the local system. The field ID may be repeated at one of the following rates: 3, 4, or 8 Hz. Magnetic field detection range for a compatible receiver is also controlled in the coil transmitter and may be set from 1.5 to 4.5 feet in one-half-foot increments.

The model designation signifies whether the transmitter is transmitting a signal to activate the pet collar or a masked signal that will not activate the pet collar. Models RAC00-16950 and RAC00-16953 both transmit a signal that activates the pet collar, the model RAC00-16993 transmits a signal that does not activate the pet collar (Masked signal). This signal is generated from the low frequency transmitter at either 15 kHz, 20 kHz or 25 kHz and has been evaluated in a separate test report.

The present report is an evaluation of the MURS radio feature. From a hardware and electrical design perspective the models are identical therefore the MURS radio feature is the same regardless of which model is tested, in this case the model RAC00-16993 was tested as the representative sample for all models.

1.4 Configuration of Tested System

The Test Sample was tested 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 and per *ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for FCC subpart C Intentional Radiators.

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 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 also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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.
- b) Verification under 15.101 as a digital device.
- c) Certification under FCC Part 95 as MURS transmitter (only for US Version of product, reported under separate cover).

The Verification 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 Verification authorization report (Parts 15.107 and 15.109) for the EUT is included herein.

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

FCC Part 15 Certification/ RSS 210
 KE3-3003600
 2721A-3003600
 20-0075 & 20-0090
 April 15, 2020
 Radio Systems
 RAC00-16950, RAC00-16993, & RAC00-16953

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID/IC (pending)	CABLES P/D
EUT				
Transmitter/ Radio Systems Corp	RAC00-16950	0C9C00045C	FCC ID: KE3-3003600 IC: 2721A-3003600	D
Transmitter/ Radio Systems Corp	RAC00-16953	0DB80003f3	FCC ID: KE3-3003600 IC: 2721A-3003600	D
Transmitter/ Radio Systems Corp	RAC00-16993	0C9C00046B	FCC ID: KE3-3003600 IC: 2721A-3003600	D
Peripherals				
Power Adapter/ Radio Systems	SPS-02C5-1C- US-VI	Production Sample	N/A	2.0 m UP

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

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

FCC Part 15 Certification/ RSS 210
 KE3-3003600
 2721A-3003600
 20-0075 & 20-0090
 April 15, 2020
 Radio Systems
 RAC00-16950, RAC00-16993, & RAC00-16953

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	8/20/2020
SPECTRUM ANALYZER	DSA815	RIGOL	DSA8A1803 00138	12/10/2021
PREAMP	8447D	HEWLETT- PACKARD	1937A02980	5/7/2020
PREAMP	8449B	HEWLETT- PACKARD	3008A00480	4/8/2020
LOOP ANTENNA	6502	ETS LINDGREN	9810-3246	1/22/2020*
BICONICAL ANTENNA	3110B	EMCO	9306-1708	6/27/2021 2 yr. Cal
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	2/01/2021 2 yr
LISN x 2	9247-50- TS-50-N	SOLAR ELECTRONICS	955824 & 955825	4/3/2020*

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

(*) Testing completed before calibration due date.

2.2 Modifications to EUT Hardware

No modifications were made to the EUT during testing.

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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.

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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.

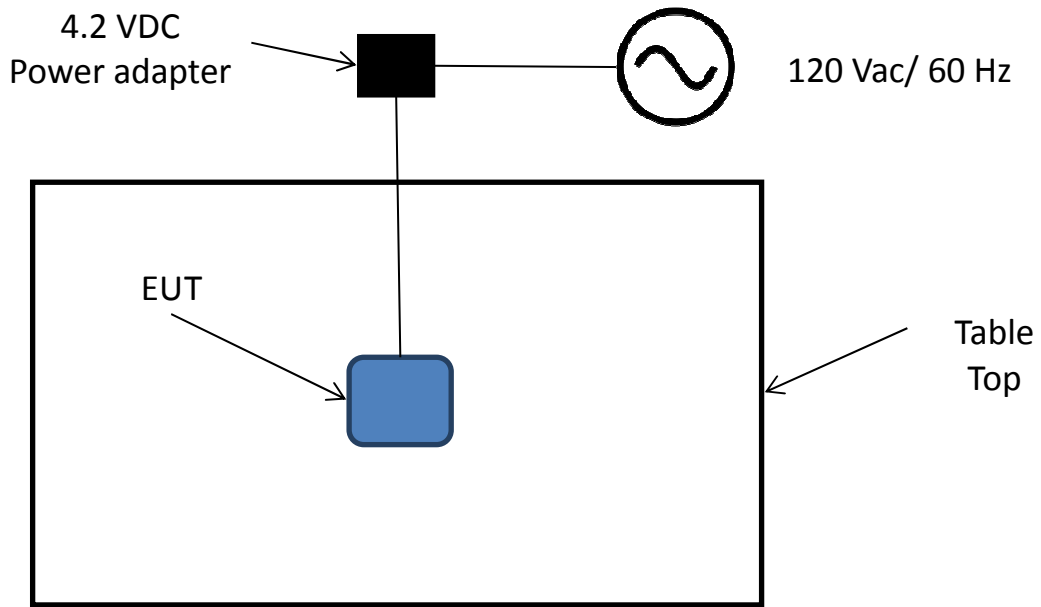


Figure 1. Block Diagram of Test Configuration

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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.

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.

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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.

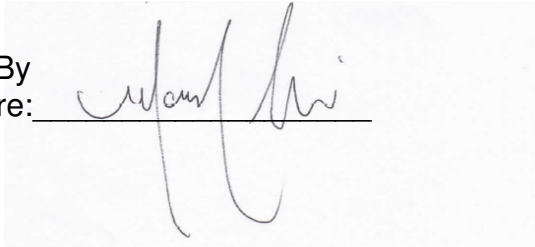
Table 5. 20 dB Bandwidth and 99% Occupied Bandwidth

Frequency (kHz)	99% Occupied Bandwidth (kHz)	20 dB Bandwidth (kHz)
25.0	3.1684	2.603

*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

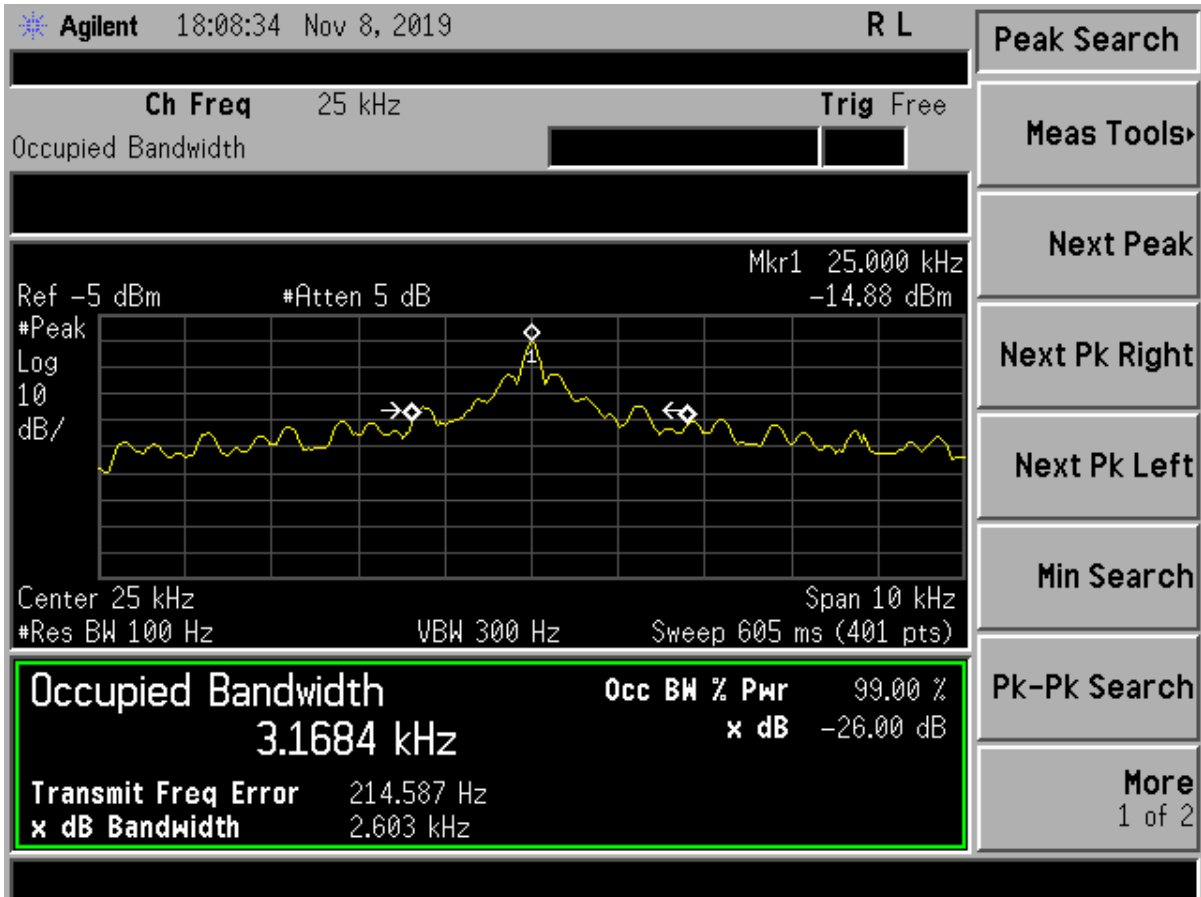


Figure 2. 99% Bandwidth

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.

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 0.4376 MHz. The emission level was 4.6 dB Quasi Peak from the applicable limit. All other emissions were at least 5.2 dB from the limit. These results are reported in the table following.

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

FCC Part 15 Certification/ RSS 210
 KE3-3003600
 2721A-3003600
 20-0075 & 20-0090
 April 15, 2020
 Radio Systems
 RAC00-16950, RAC00-16993, & RAC00-16953

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

150KHz to 30 MHz with Class B Limits						
Test: Power Line Conducted Emissions				Client: Radio Systems Corp		
Project: 20-0075				Model: RAC00-16993 & RAC00-16953		
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						
0.4376	39.82	2.73	42.55	47.1	4.6	QP
0.8517	40.26	0.59	40.85	46.0	5.2	QP
1.0467	38.69	0.86	39.55	46.0	6.5	QP
6.7000	36.13	0.16	36.29	50.0	13.7	PK
10.6170	33.47	0.32	33.79	50.0	16.2	PK
22.2500	29.57	0.98	30.55	50.0	19.5	PK
20.8500	27.59	0.65	28.24	50.0	21.8	PK
120Vac, 60 Hz Neutral						
0.4282	38.66	0.10	38.76	47.3	8.5	PK
0.9000	39.86	0.09	39.95	46.0	6.1	PK
1.0467	34.42	0.50	34.92	46.0	11.1	QP
6.6500	32.93	0.29	33.22	50.0	16.8	PK
11.0170	30.03	0.58	30.61	50.0	19.4	PK
29.0500	31.76	2.27	34.03	50.0	16.0	PK

Note: (*) denotes QP Limit used.

SAMPLE CALCULATION at 0.4376 MHz:

Magnitude of Measured Frequency	39.82	dBuV
+ Cable Loss+ LISN Loss	2.73	dB
=Corrected Result	42.55	dBuV

Test Date: October 8, 2019

Tested by
 Signature: 

Name: John Freeman

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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 3m 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.

All measured emissions were greater than 20 dB below the limit from the range of 9kHz to 2 GHz

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

FCC Part 15 Certification/ RSS 210
 KE3-3003600
 2721A-3003600
 20-0075 & 20-0090
 April 15, 2020
 Radio Systems
 RAC00-16950, RAC00-16993, & RAC00-16953

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.

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

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

FCC Part 15 Certification/ RSS 210
 KE3-3003600
 2721A-3003600
 20-0075 & 20-0090
 April 15, 2020
 Radio Systems
 RAC00-16950, RAC00-16993, & RAC00-16953

Table 7. Radiated Emissions 9 kHz to 30 MHz (15.209) – Indoor & Outdoor

Test: FCC Part 15, Para 15.209				Client: Radio Systems Corp			
Project: 20-0075				Model: RAC00-16993 & RAC00-16953			
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
0.08	57.68	12.46	70.14	110.1	3 meters.	40.0	PK
0.53	39.08	11.96	51.04	73.2	3 meters.	22.1	PK
2.78	31.05	11.49	42.54	69.5	3 meters.	27.0	PK
4.54	31.40	11.19	42.59	69.5	3 meters.	27.0	PK
13.18	31.19	11.01	42.20	69.5	3 meters.	27.3	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 0.53 MHz, 39.08 dBuV + (11.96) = 51.04 dBuV/m
 Limit @ 3m= 73.2 dBuV/m
 Margin= 22.1 dB

Test Date: October 8, 2019

Tested by
 Signature: 

Name: John Freeman

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

FCC Part 15 Certification/ RSS 210
 KE3-3003600
 2721A-3003600
 20-0075 & 20-0090
 April 15, 2020
 Radio Systems
 RAC00-16950, RAC00-16993, & RAC00-16953

Table 8. Unintentional Radiator, Peak Radiated Emissions (CFR 15.109, 15.209), 30 MHz to 1000 MHz, Indoor & Outdoor

30 MHz to 1000 MHz with Class B Limits							
Test: Radiated Emissions				Client: Radio Systems			
Project: 20-0075				Model: RAC00-16993 & RAC00-16953			
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
39.53	40.72	-14.17	26.55	40.0	3m./VERT	13.5	QP
92.49	52.98	-17.54	35.44	43.5	3m./VERT	8.10	QP
93.28	59.24	-17.34	41.90	43.5	3m./HORZ	1.60	QP
137.85	39.90	-14.49	25.41	43.5	3m./HORZ	18.1	QP
142.96	45.76	-14.07	31.69	43.5	3m./VERT	11.8	QP
168.02	55.04	-12.97	42.07	43.5	3m./HORZ	1.40	QP
171.31	53.13	-12.88	40.25	43.5	3m./VERT	3.30	QP
200.46	37.58	-13.80	23.78	43.5	3m./VERT	19.7	QP
207.09	40.84	-14.29	26.55	43.5	3m./HORZ	17.0	QP
242.41	36.21	-13.69	22.52	46.0	3m./HORZ	23.5	QP
261.49	39.12	-12.81	26.31	46.0	3m./HORZ	19.7	QP
267.44	50.22	-12.81	37.41	46.0	3m./VERT	8.60	PK

Tested from 30 MHz to 1 GHz

SAMPLE CALCULATION at 39.53 MHz:

Magnitude of Measured Frequency	40.72 dBuV
+Correction Factors	-14.17 dB/m
Corrected Result	26.55 dBuV/m

Test Date: October 8, 2019

Tested by
 Signature: 

Name: John Freeman

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

FCC Part 15 Certification/ RSS 210
 KE3-3003600
 2721A-3003600
 20-0075 & 20-0090
 April 15, 2020
 Radio Systems
 RAC00-16950, RAC00-16993, & RAC00-16953

Table 9. Unintentional Radiator, Peak Radiated Emissions (CFR 15.109), 1 GHz to 2 GHz, Indoor & Outdoor

1 GHz to 2 GHz with Class B Limits							
Test: Radiated Emissions				Client: Radio Systems			
Project: 20-0075				Model: RAC00-16993 & RAC00-16953			
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.							

Tested from 1 GHz to 2 GHz

SAMPLE CALCULATION: N/A

Test Date: February 21, 2020

Tested by
 Signature: Afzal Fazal

Name: Afzal Fazal

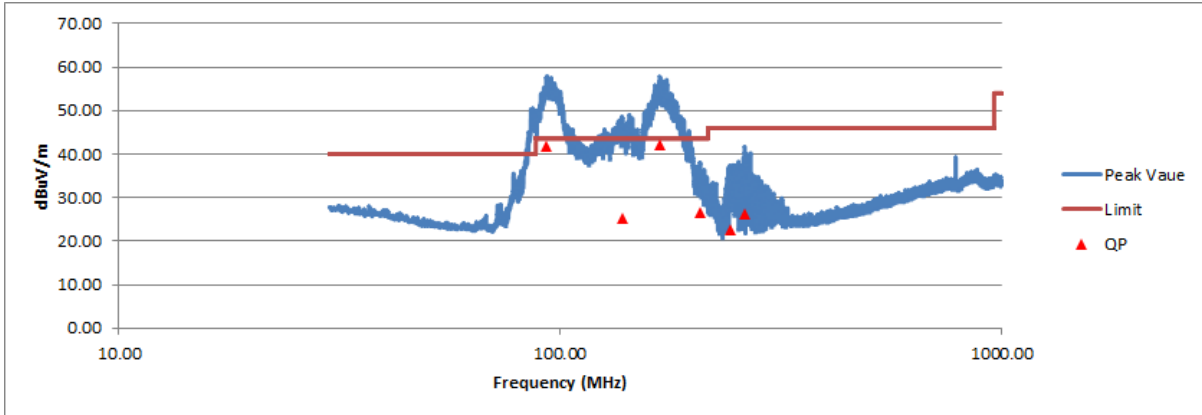


Figure 3. Graphical Data of Radiated Emissions, 30-1000 MHz – Horizontal

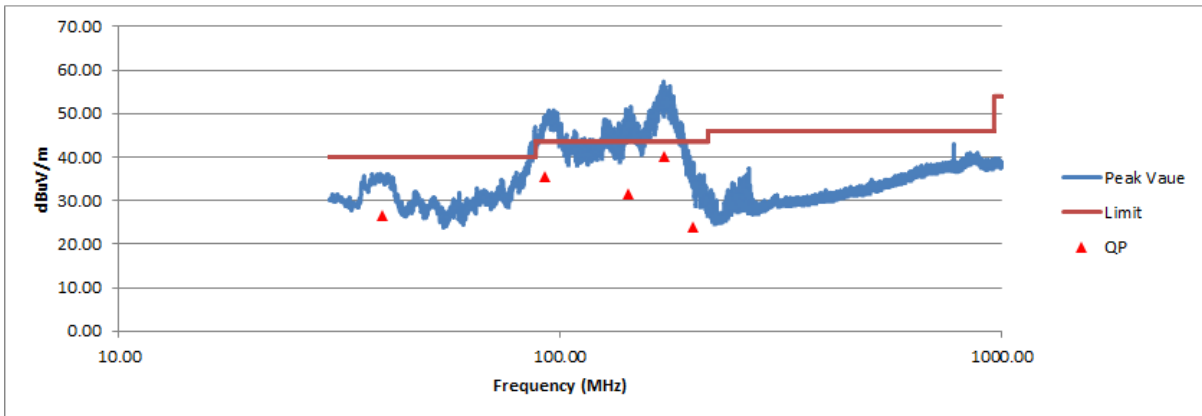


Figure 4. Graphical Data of Radiated Emissions, 30-1000 MHz –Vertical

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

FCC Part 15 Certification/ RSS 210
KE3-3003600
2721A-3003600
20-0075 & 20-0090
April 15, 2020
Radio Systems
RAC00-16950, RAC00-16993, & RAC00-16953

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.