Testing Tomorrow's Technology

Application

For

Permissive Change per

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 4 and RSS-210 Issue 9

For the

Radio Systems

Model: BOUNDARY PLUS DL TRANSMITTER

FCC ID: KE3-3001186
IC: 2721A-3001186

UST Project: 16-0154
Issue Date: September 12, 2016

Total Pages in This Report: 20

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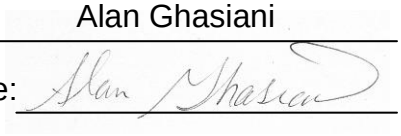
I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date September 12, 2016

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Radio Systems

MODEL: BOUNDARY PLUS DL TRANSMITTER

FCC ID: KE3-3001186

IC: 2721A-3001186

DATE: September 12, 2016

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

Equipment type: 7.5 kHz or 10.7 kHz Transmitter Module

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:

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Alpharetta, GA 30004

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1 General Information

1.1 Purpose of this Report

The originally tested radio product has been modified therefore this report has been generated and submitted for evaluation. The changes made to this product include the following:

- Change of surge protection components on the output terminals to provide more robust surge protection.
- Increased the transmitter's internal voltage to allow driving higher impendence perimeter loop wire.
- The PCB layout has been redesigned to improve grounding and reduce noise.
- Bypass capacitors were also changed.

The RF drive circuits are the same as they were originally. Based on these changes the radio product was retested to show that it continues to meet the applicable requirements of 15.207 and 15.209.

The original model number was BOUNDARY PLUS TRANSMITTER; the model number for the modified product is: BOUNDARY PLUS DL TRANSMITTER.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on June 6, 2016 in good operating condition.

1.3 Product Description

The Equipment Under Test (EUT) is the Radio Systems Model BOUNDARY PLUS DL TRANSMITTER. The BOUNDARY PLUS DL TRANSMITTER is a pet containment system loop transmitter. It produces a modulated current in the wire that forms the perimeter of the pets' allowable area in the yard. There are two different selectable system frequencies, 7.5 and 10.7 kHz. There is also two different signal options, "Normal" and "SSP-A". Normal signal will activate the pet collar on either side of the loop boundary and only while it is receiving the signal. SSP-A will only active the collar when the pet crosses the boundary from the inside to outside direction and stop activation on the outside to inside transition.

The EUT can operate at 10.7 kHz and 7.5 kHz. Since no limits are set below 9 kHz, the EUT was only tested at 10.7 kHz.

Frequency: 7.5 kHz or 10.7 kHz
Modulation: OOK

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 A Digital equipment Verification 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 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

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.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
Radio Systems (EUT)	Boundary Plus DL Transmitter	Engineering Sample	FCC ID: KE3-3001186 IC: 2721A-3001186	2 m UP
AC Adapter Battery Charger Radio Systems	650-231-21	Production Sample	None	2 m UP
Pet Collar Invisible Fence	Various	Various	Various	None

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

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

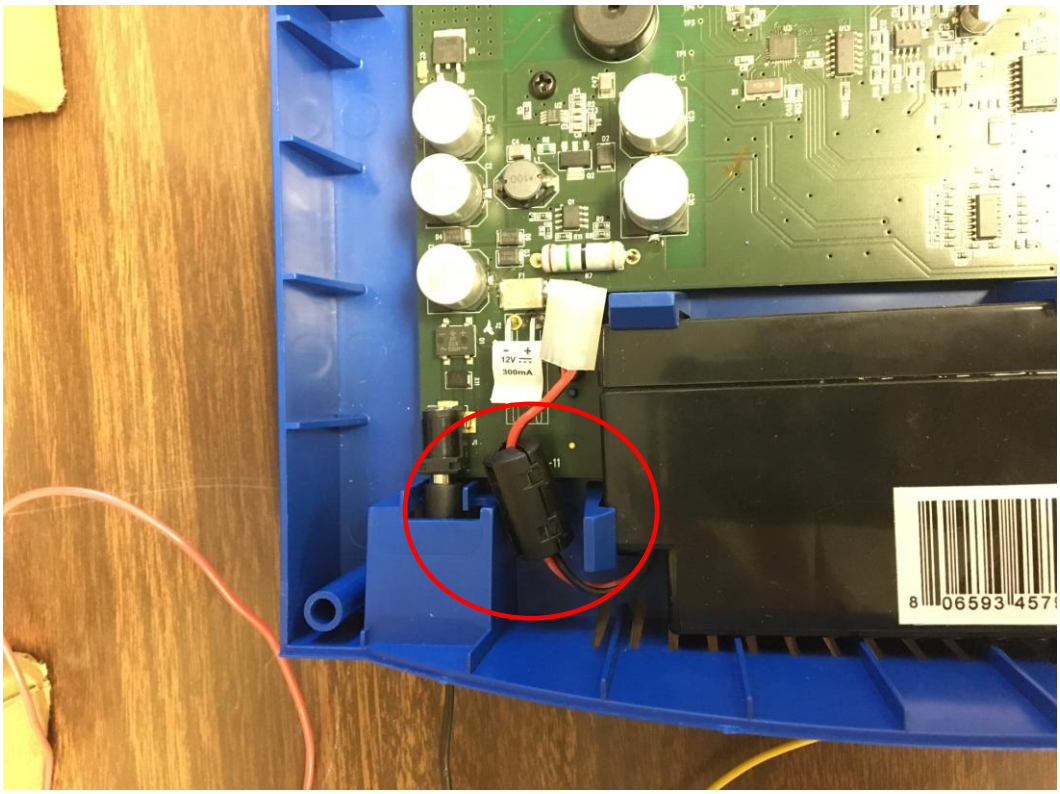
TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	E4407B	Agilent	US41442935	2/11/2016
SPECTRUM ANALYZER	8593E	HEWLETT-PACKARD	3325A00807	8/5/2016
PREAMP	8447D	HEWLETT-PACKARD	1937A02980	12/2/2015
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	9/28/2015 2 yr
BICONICAL ANTENNA	3110B	EMCO	9307-1431	8/25/2015 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	11/19/2014 2 yr
LISN x 2	9247-50-TS-50-N	Solar Electronics	910494 & 910496	11/30/2015

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

In order to meet the requirements of 15.207 and 15.209 the following modification was made to the EUT:

- A ferrite core, Fair-Rite Model: 0431173951 was added to the battery leads on the Battery. See photograph below.



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 7.5 kHz or 10.7 kHz, 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 10^{th} 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:

2.5.1 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.

2.5.2 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.

2.5.3 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.

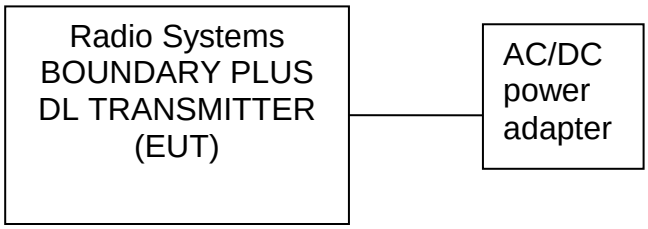


Figure 1. Block Diagram of Test Configuration

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

The EUT is battery-powered and includes an AC/DC battery charger; 100/240 V and 50/60 Hz. 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. These measurements were completed while the EUT was connected to the battery charger and transmitting while charging.

Table 4. Transmitter Power Line Conducted Emissions Test Data, (P15.207)

150 KHz to 30 MHz 15.207 Limits						
Test: Power Line Conducted Emissions				**Client:** Radio Systems		
Project: 16-0154				**Model:** BOUNDARY PLUS DL TRANSMITTER		
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						
0.1693	52.39	0.44	52.83	55.0	2.2	**PK**
0.1693	45.78	0.44	46.22	55.0	8.8	**QP**
0.6742	41.20	0.17	41.37	46.0	4.6	**PK**
0.6742	31.80	0.17	31.97	46.0	14.0	**QP**
4.5140	35.15	0.33	35.48	46.0	10.5	**PK**
5.7416	35.14	0.36	35.50	50.0	14.5	**PK**
13.7600	40.95	0.80	41.75	50.0	8.3	**PK**
28.0000	28.58	1.21	29.79	50.0	20.2	**PK**
120VAC, 60 Hz Neutral						
0.1675	52.57	0.43	53.00	55.1	2.1	**PK**
0.1675	45.43	0.43	45.86	55.1	9.2	**QP**
0.7617	33.48	0.22	33.70	46.0	12.3	**PK**
1.2600	32.77	0.21	32.98	46.0	13.0	**PK**
5.6660	32.64	0.37	33.01	50.0	17.0	**PK**
13.7500	43.10	0.89	43.99	50.0	6.0	**PK**
13.7500	37.42	0.89	38.31	50.0	11.7	**QP**
27.8100	27.98	1.16	29.14	50.0	20.9	**PK**

Note: (*) denotes QP Limit used.

SAMPLE CALCULATION at 0.1693 MHz:

Magnitude of Measured Frequency	52.39	dBuV
+ Cable Loss+ LISN Loss	0.44	dB
=Corrected Result	52.83	dBuV
Limit	55.00	dBuV
-Corrected Result	52.83	dBuV
Margin	2.20	dB

Test Date: August 19, 2016
Tested By
Signature: _____ Name: Ashton Picas

2.7 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. 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.

The test data is detailed below for this section. 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. There were no test failures.

Table 5. Radiated Spurious Emissions 9 kHz to 30 MHz

Test: FCC Part 15, Para 15.209				**Client:** Radio Systems			
Project: 16-0154				**Model:** BOUNDARY PLUS DL TRANSMITTER			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
0.0107	**39.44**	**78.52**	**117.96**	**127.0**	**3 meter**	**9.0**	**PK**
All other detected emissions were 20 dB or more from the applicable limit.							

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

Sample Calculations: at 0.0107 MHz, 39.44 dBuV + (78.52) = 117.96 dBuV/m
Limit @ 3m= 127.0 dBuV/m
Margin= 9.0 dB

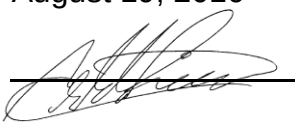
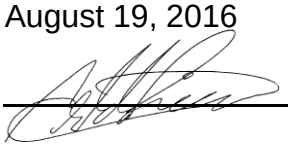
Test Date: August 19, 2016
Tested By
Signature:  Name: Ashton Picas

Table 6. Radiated Spurious Emissions (P15.209), 30 MHz to 1000 MHz

30 MHz to 1000 MHz							
Test: Radiated Emissions				**Client:** Radio Systems			
Project: 16-0154				**Model:** BOUNDARY PLUS DL TRANSMITTER			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
87.88	47.33	-17.58	29.75	40.0	3m./HORZ	10.3	**PK**
99.38	53.96	-17.24	36.72	43.5	3m./HORZ	6.8	**PK**
144.45	55.69	-14.13	41.56	43.5	3m./HORZ	1.9	**QP**
31.63	51.96	-13.11	38.85	40.0	3m./VERT	1.1	**PK**
31.63	43.60	-13.11	30.49	40.0	3m./VERT	9.5	**QP**
87.22	47.92	-17.38	30.54	40.0	3m./VERT	9.5	**PK**
99.45	53.97	-16.54	37.43	43.5	3m./VERT	6.1	**PK**
144.45	53.22	-13.63	39.59	43.5	3m./VERT	3.9	**PK**
144.45	49.31	-13.63	35.68	43.5	3m./VERT	7.8	**QP**

SAMPLE CALCULATION at 87.88 MHz:

Magnitude of Measured Frequency	47.33	dBuV
+ Cable Loss+ LISN Loss	-17.58	dB
=Corrected Result	29.75	dBuV
Limit	40.00	dBuV
-Corrected Result	29.75	dBuV
Margin	10.3	dB

Test Date: August 19, 2016
Tested By
Signature:  Name: Ashton Picas

2.8 20 dB (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 ≥ RBW. The results of this test are given in Table 7 and Figure 2.

Table 7. 20 dB Bandwidth and 99% Occupied Bandwidth

Frequency (kHz)	20 dB (99%) Bandwidth (kHz)
10.7	2.212

Test Date: September 12, 2016
Tested By
Signature: _____ Name: George Yang

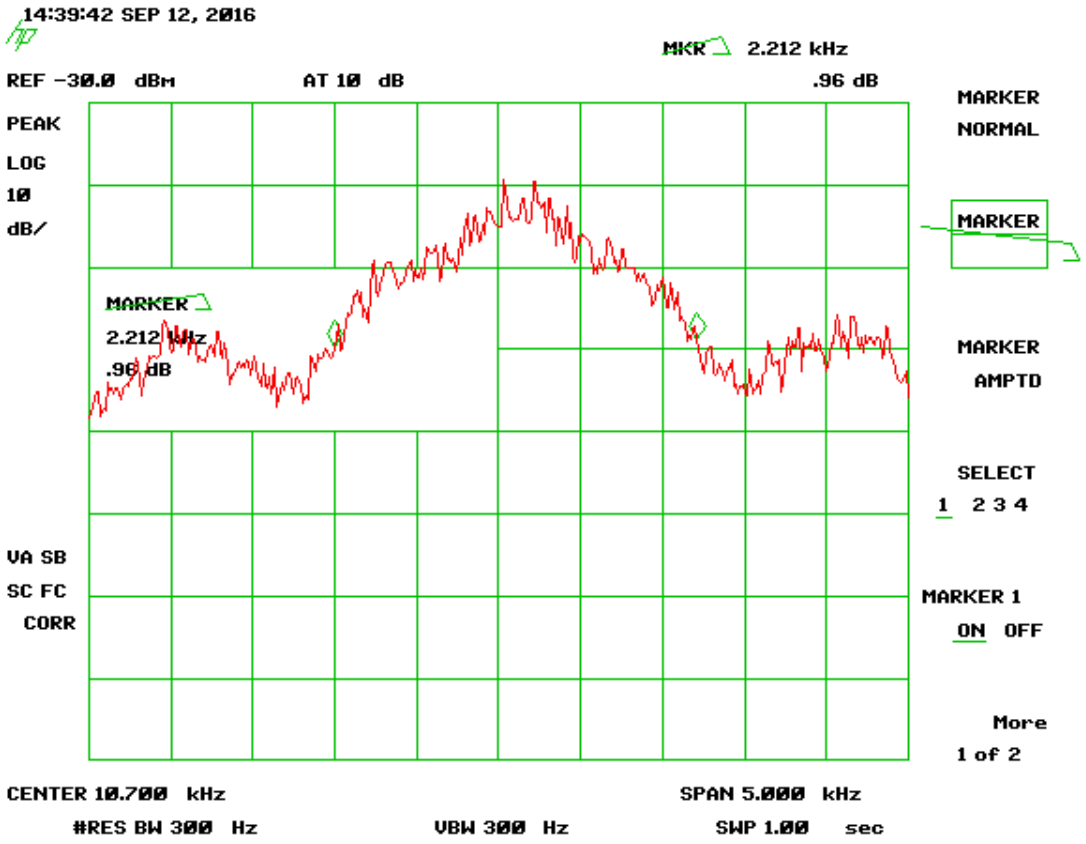


Figure 2. 20 dB (99%) Bandwidth

2.9 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%.

2.9.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.78 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.

2.9.2 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 ± 5.39 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 ± 5.18 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.