Project 18915-15

Long Range Systems, LLC ZB-Beacon

Wireless Certification Report

Prepared for:

John Weber Long Range Systems, LLC 4550 Excel Parkway Suite 200 Addison, Texas 75001 USA

By

Professional Testing (EMI), Inc. 1601 North A.W. Grimes Blvd., Suite B Round Rock, Texas 78665

20 Apr 2017

Reviewed by

Larry Finn Chief Technical Officer Written by

Eric Lifsey EMC Engineer

Revision History

Revision Number	Description	Date
DRAFT 4	Draft for review.	21 Apr 2017
Final 01	Final issued.	21 Apr 2017

Corrections:

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NOTICE: (1) This Report must not be used to claim product endorsement, by NVLAP, NIST, the FCC or any other Agency. This report also does not warrant certification by NVLAP or NIST. (2) This report shall not be reproduced except in full, without the written approval of Professional Testing (EMI), Inc. (3) The significance of this report is dependent on the representative character of the test sample submitted for evaluation and the results apply only in reference to the sample tested. The manufacturer must continuously implement the changes shown herein to attain and maintain the required degree of compliance.



Compliance Certificate

Applicant	Device & Test Identification	
Long Range Systems, LLC (John Weber)	FCC ID:	2AB6OZBBEACON
4550 Excel Parkway Suite 200	Industry Canada ID:	5501A-ZBBEACON
Addison, Texas 75001 USA	Model(s):	ZB-Beacon
Certificate Date: 20 Apr 2016	Laboratory Project ID:	18915-15

The device named above was tested utilizing the following documents and found to be in compliance with the required criteria:

Requirement	Reference	Detail	
FCC 47 CFR Part 15 C	15.247	Operation within the bands 902-928 MHz, <u>2400-2483.5 MHz</u> , and 5725-5850 MHz.	
FCC 47 CFR Part 15 C	15.209	Radiated emission limits; general requirements.	
FCC 47 CFR Part 15 C	15.107, 15.207	Conducted emission limits.	
FCC 47 CFR Part 15 C	15.205	Restricted Bands of Operation	
KDB 558074 D01	DR01	DTS Measurement Guidance v03r02	
KDB 412172	D01	Guidelines for Determining the ERP and EIRP of an RF Transmitting System	
OET Bulletin 65*	Edition 97-01, and Supplement C, Ed. 01-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields	
RSS-247	Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence- Exempt Local Area Network (LE-LAN) Devices	
RSS-Gen	Issue 4	General Requirements and Information for the Certification of Radio Apparatus	
RSS-102	Issue 5	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (Al Frequency Bands)	

^{*}MPE is reported separately from this document. **Corresponding RSS references are listed in the body of the report.

I, Eric Lifsey, for Professional Testing (EMI), Inc., being familiar with the above requirements and test procedures have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.



This report has been reviewed and accepted by the Applicant. The undersigned is responsible for ensuring that this device will continue to comply with the requirements listed above.

Representative of	Applicant	

1.0 Introduction

1.1 Scope

This report describes the extent to which the equipment under test (EUT) conformed to the intentional radiator requirements of the United States and Canada.

Professional Testing (EMI), Inc., (PTI) follows the guidelines of National Institute of Standards and Technology (NIST) for all uncertainty calculations, estimates, and expressions thereof for electromagnetic compatibility testing.

1.2 EUT Description

Table 1.2.1: Equipment Under Test			
Manufacturer / Model Serial #s Description			
Long Range Systems, LLC Model: ZB-Beacon	1, 2, 3	2400-2483.5 MHz Zigbee DSSS/DTS transceiver	

Table 1.2.2: Support Equipment				
Manufacturer / Model Serial # Description				
none	none	none		

The EUT is a device for managing restaurant patrons at tables. In operation it is affixed under the dining table.

The EUT electronics are on a single circuit board which measures approximately 9 cm x 4.5 cm x 1 cm. In the final application the EUT fits inside a non-conductive plastic enclosure and is powered by two alkaline AAA size batteries.

1.3 EUT Operation

The EUT was exercised in a manner consistent with normal operations.

1.4 Modifications to Equipment

No modifications were made to the EUT during the performance of the test program.

1.5 Test Site

Measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. The site is registered with the FCC under Section 2.948 and Industry Canada per RSS-GEN, and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located at 11400 Burnet Road, Austin, Texas 78758, while the main office is located at 1601 North A.W. Grimes Boulevard, Suite B, Round Rock, Texas, 78665.

1.6 Radiated and Conducted Measurements

Table 1.6 1 Measurement Corrections		
Parameter From Sums Of		
Radiated Field Strength	Raw Measured Level + Antenna Factor + Cable Losses – Amplifier Gain	
Conducted Antenna Port	Raw Measured Level + Attenuator Factor + Cable Losses	
Conducted Mains Port	Raw Measured Level + LISN Factor + Cable/Filter/Limiter Losses	

Additionally, measurement distance extrapolation factors (such as 1/d above 30 MHz) are applied and documented where used.

1.7 Applicable Documents and Clauses

Table 1.7.1: Applicable Documents			
Document	Title		
47 CFR	Part 15 – Radio Frequency Devices		
47 CFR	Subpart C -Intentional Radiators		
RSS-247 Issue 1	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-		
N33-247 ISSUE 1	Exempt Local Area Network (LE-LAN) Devices		
RSS-Gen Issue 4 General Requirements and Information for the Certification of Radio Apparatus			
ANSI C63.10:2013	American National Standard of Procedures for Compliance Testing of Unlicensed		
ANSI CUS.1U.2015	Wireless Devices		

Table 1.7.2: Applicable Clauses			
Parameter	FCC Part 15 Rule Paragraphs	IC RSS References	
Transmitter Characteristics	15.247	RSS-247 5.2 (DTS) & 5.4, RSS-Gen	
Bandwidth	15.247(a)(1), 2.1049, KDB 558074 D01	RSS-Gen 4.6	
Spurious Emission	15.247, 15.209, 15.205	RSS-247 5.5, RSS-GEN 4.9, 4.10	
Band Edge	15.247, 15.205	RSS-247 5.5, RSS-Gen 4.9	
Antenna Requirement	15.203	RSS-Gen 8.3	
Conducted Emissions, Mains	15.207	RSS-Gen 8.8	

2.0 Fundamental Power

2.1 Test Procedure

Peak power is measured using conducted means and with modulation.

2.2 Test Criteria

47 CFR (USA) // IC (Canada)				
Section Reference	Parameter	Date		
	Fundamental Power			
15.247(a)(3) //	Conducted Limits	12 Apr 2017		
RSS-247 5.2	1 W	13 Apr 2017		
	Limit Restated as Field: 125.23 dBμV/m @ 3 m			

2.3 Test Results, Peak Power

The EUT was measured for power by field strength method.

Table 2.3.1 Power, Peak, Radiated, Antenna 1					
Frequency MHz	Measured Peak Power dBμV/m @ 10 m Vertical Polarity	Measured Peak Power dBμV/m @ 10 m Horizontal Polarity	Maximum Measured Peak Power Restated as EIRP dBm		
2402	98.2	107.5	12.3		
2440	97.5	103.2	8.0		
2480	97.0	102.3	7.1		

Measured in 3 MHz RBW, 3 MHz VBW.

Table 2.3.2 Pov	Table 2.3.2 Power, Peak, Radiated, Antenna 2							
Frequency MHz	Measured Peak Power dBμV/m @ 10 m Vertical Polarity	Measured Peak Power dBμV/m @ 10 m Horizontal Polarity	Maximum Measured Peak Power Restated as EIRP dBm					
2402	95.7	99.5	4.3					
2440	97.2	100.4	5.2					
2480	94.1	100.8	5.6					

Measured in 3 MHz RBW, 3 MHz VBW.

The EUT satisfied the requirements.

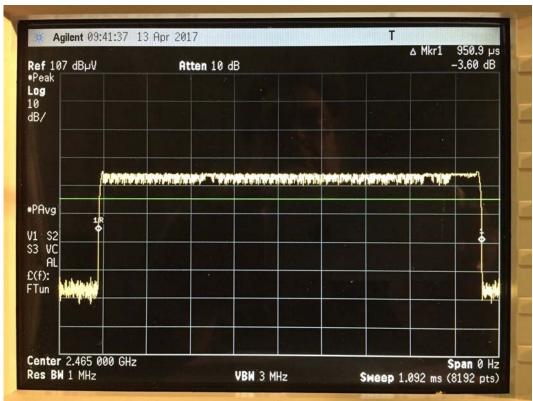
2.4 Test Results, Duty Cycle

Measurement is based on intervals not to exceed 100 msec. Maximum transmitter on time is divided by the lesser of 100 msec or the actual measured minimum transmitter interval time. The result is converted to dB and applied as needed to peak measurements of transmitter artifacts to determine average power. This is not a pass/fail measurement.

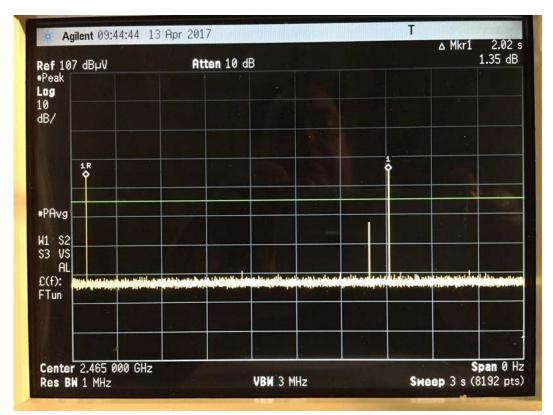
Table 2.4.1 Du	Table 2.4.1 Duty Cycle Results and Average Duty Cycle Factor Result						
Measured On Time (msec)	Measured Time Interval (msec)	Duty Cycle Factor Calculation	Result (dB)	Duty Cycle Factor Allowed (dB)			
0.9509	2020 100 ms used	= 20 * Log ₁₀ (0.9509 msec / 100 msec)	-40.4	-20			

The allowed duty cycle factor is applied to peak measured harmonic signals to find average levels.

Plotted results appear below.



Transmit Event



Transmit Interval

3.0 Power Spectral Density

3.1 Test Procedure

A spectrum analyzer is either connected directly to the EUT or used by radiated means to measure the fundamental emission. It is adjusted to measure the power spectral density in the specified resolution bandwidth.

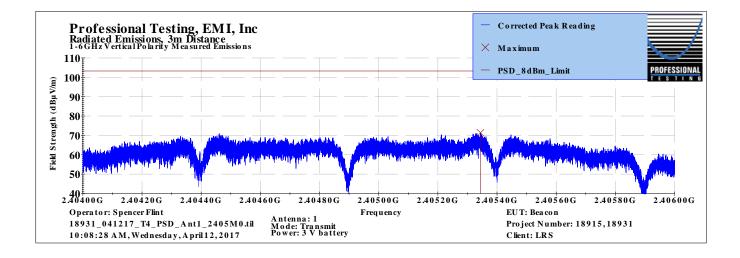
3.2 Test Criteria

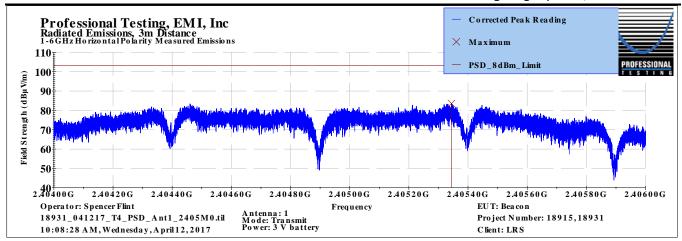
47 CFR (USA) // IC (Canada)							
Section Reference	Parameter	Date					
15.247(e) // RSS-247, 5.2	Power Spectral Density, Conducted Limit: 8 dBm / 3 kHz Restated as field strength limit: 103.23 dBμV/m at 3 m	12 Apr 2017					

3.3 Test Results

The full-bandwidth fundamental peak power measured above the PSD limit for this test only at the lowest channel for which a measurement is included below.

Table 3.3.1 Power Spectral Density, Radiated, Low Channel, Antenna 1 (Worse case.)						
Frequency MHz	Measured Peak Power dBμV/m @ 10 m Vertical Polarity	Measured Peak Power dBμV/m @ 10 m Horizontal Polarity	Maximum Measured PSD Restated as EIRP dBm			
2402	71.3	83.5	-11.7			





4.0 Occupied Bandwidth

4.1 Test Procedure

Bandwidth is measured by radiated means. A recording of the results is included.

4.2 Test Criteria

47 CFR (USA) // IC (Canada)						
Section Reference	Parameter	Date(s)				
14.247(a)(2), 2.1049, KDB 558074 D01 // RSS-Gen 4.6	Bandwidth, 6 dB, 20 dB	13 Apr 2017				

4.3 Test Results

The bandwidth measurement is used to verify DTS characteristics and/or for general reporting for agency application.

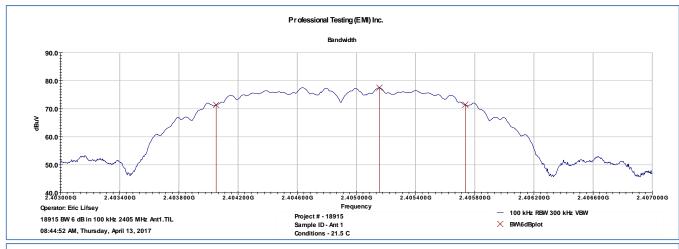
The EUT was found to be in compliance with applicable requirements.

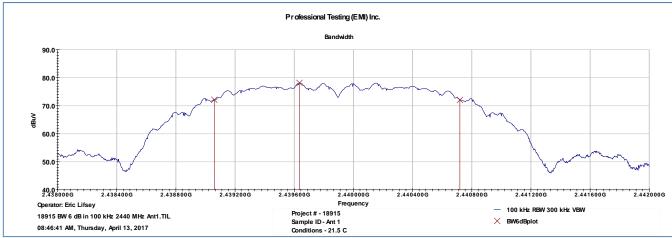
Table 4.3.1 Antenna 1							
Bandwidth 6 dB, Minimum 500 kHz in 100 kHz RBW							
Low Channel Mid Channel High Channel Reported							
Measured BW	Measured BW	Measured BW	Minimum BW				
(kHz)	(kHz)	(kHz)	(kHz)				
1684	1660	1648	1648				
Bandwidth 20 d	B, Measure and R	eport					
Low Channel	Mid Channel	High Channel	Reported				
Measured BW	Measured BW	Measured BW	Maximum BW				
(kHz)	(kHz)	(kHz)	(kHz)				
2516	2532	2564	2564				

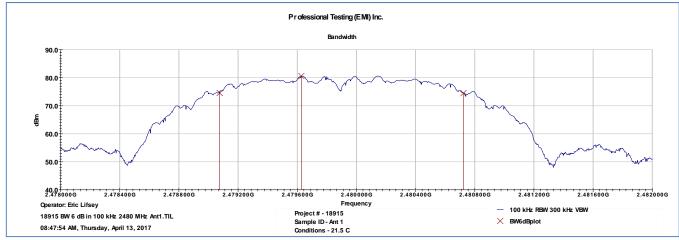
Table 4.3.2 Antenna 2							
Bandwidth 6 dB, Minimum 500 kHz in 100 kHz RBW							
Low Channel	Mid Channel	High Channel	Reported				
Measured BW	Measured BW	Measured BW	Minimum BW				
(kHz)	(kHz)	(kHz)	(kHz)				
1692	1652	1692	1652				
Bandwidth 20 d	B, Measure and R	eport					
Low Channel	Mid Channel	High Channel	Reported				
Measured BW	Measured BW	Measured BW	Maximum BW				
(kHz)	(kHz)	(kHz)	(kHz)				
2524	2540	2528	2540				

Plotted measurements appear on the following pages.

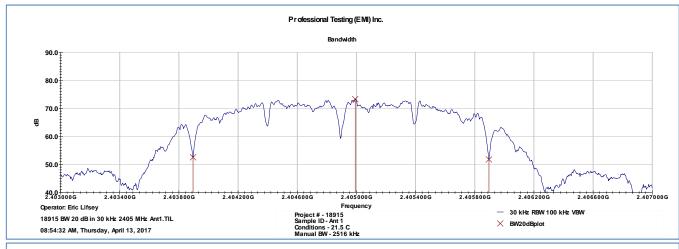
4.3.1 Bandwidth Plots, 6 dB, Antenna 1

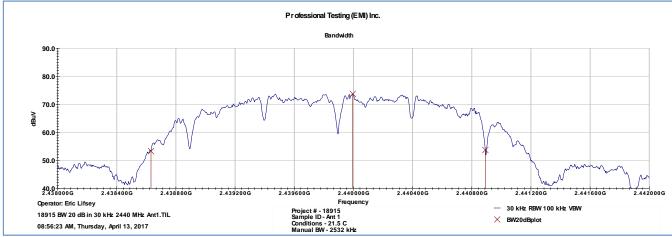


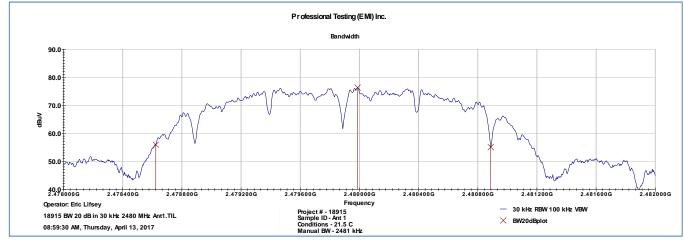




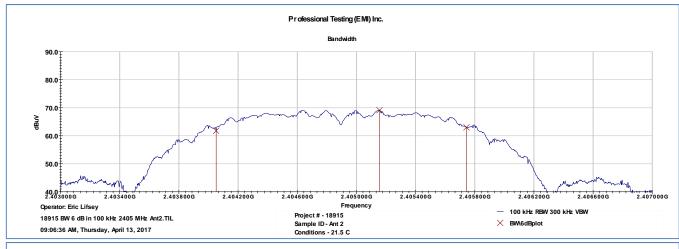
4.3.2 Bandwidth Plots, 20 dB, Antenna 1

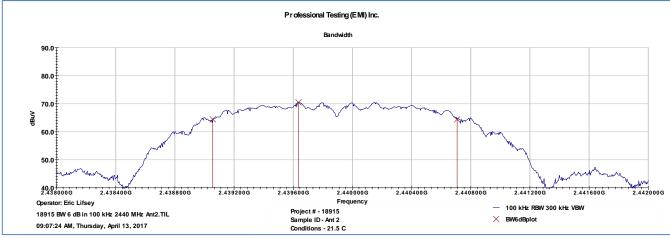


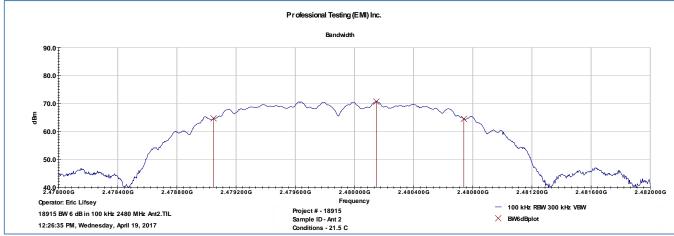




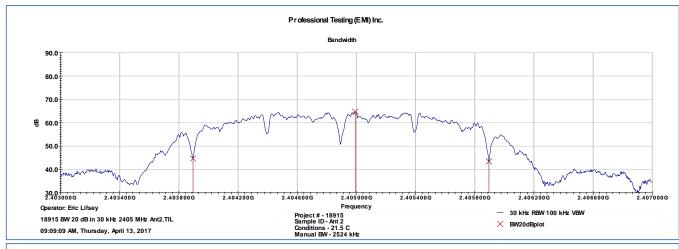
4.3.3 Bandwidth Plots, 6 dB, Antenna 2

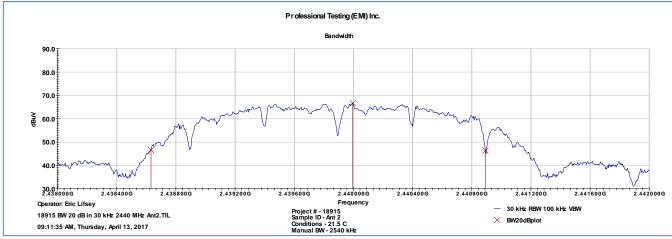


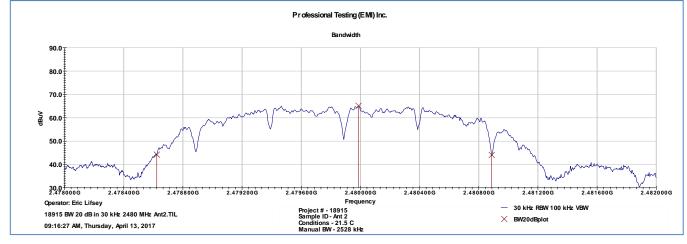




4.3.4 Bandwidth Plots, 20 dB, Antenna 2







5.0 Band Edge

5.1 Test Procedure

EUT is placed into normal transmit operation on the nearest band edge channel. The spectrum analyzer is approximately centered on the band edge frequency with span sufficient to include the peak of the adjacent fundamental signal. Measurement includes at least two standard bandwidths from the respective band edge. If required, the band-edge marker-delta method is utilized.

5.2 Test Criteria

47 CFR (USA) // IC (Canada)						
Section Reference	Parameter	Date(s)				
15.247, 15.205 //	Unwanted Emissions Adjacent to Authorized	12 Apr 2017				
RSS-247 5.5, RSS-Gen 4.9	Band, Radiated	12 Apr 2017				

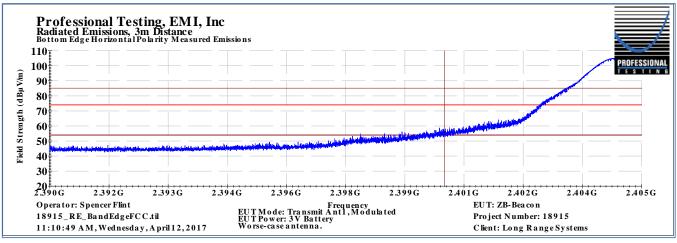
5.3 Test Results

Measurements included more than 2 standard bandwidths (standard bandwidth 1 MHz) from the band edges to provide a clear view of the fundamental and the declining emission levels. Peak detection with max-hold was employed.

Worse case antenna (1) was selected for measurement.

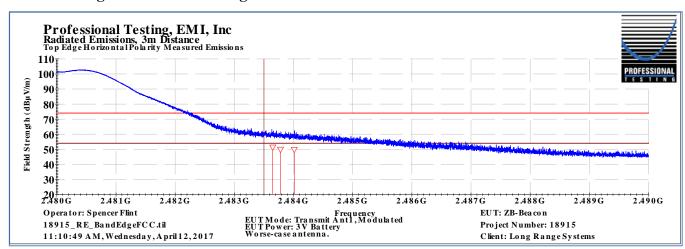
The EUT satisfied the criteria. Plotted results of peak detection appear on the following pages.

5.3.1 Low Channel Band Edge



Peak detection in 100 kHz RBW is employed. The applicable DTS limit -20dBc is the upper limit line.

5.3.2 High Channel Band Edge



Peak detection is employed while the general emission limits for average and peak levels are shown. The applicable duty cycle factor is -20 dB.

The nearest emissions outside limit were also measured with video averaging method in table below:

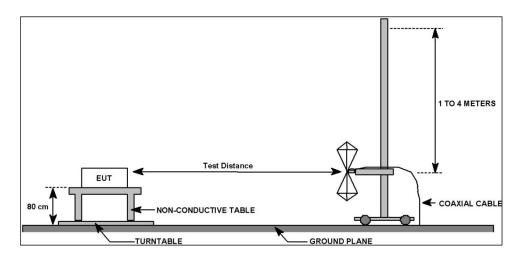
Table 5.3.2.1 Measured Emissions, Upper Band Edge								
Frequency	Raw Peak	Raw Avg	Azimuth	Height	Corrected Peak	Corrected Avg		
(MHz)	(dBµV)	(dBµV)	(deg)	(cm)	(dBuV)	(dBuV)		
2483.65	69.1	59.6	40	322	60.810	51.288		
2483.78	68.4	58.2	50	228	60.054	49.852		
2484.01	68.9	58.1	51	266	60.601	49.806		

6.0 Radiated Spurious Emissions, Receive Mode

6.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The EUT was centered on a rotating turntable. Measurements below 1 GHz were taken at a test distance of 10 meters from the measurement antenna. Above 1 GHz the measurement distance was 3 meters.

Spurious emissions below 1 GHz were measured with quasi-peak detection with a resolution bandwidth of 120 kHz. Above 1 GHz peak measurements were taken and average measured where appropriate and 1 MHz resolution bandwidth. A diagram showing the test setup appears below.



6.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.209 // RSS-247 5.5, RSS-Gen 4.9 & 4.10	Field Strength of Radiated Spurious/Harmonic Emissions Receive Mode	13 Apr 2017

6.3 Test Results

Two EUTs were employed and were configured as serial number 1 for antenna 1 and serial number 3 for antenna 2. Each EUT was tuned to the middle channel and placed in receive mode.

The EUT satisfied the criteria. Recorded data is presented below.

6.3.1 Up to 1 GHz

			Profes	sional Te	sting, EN	ΜI, I	nc.			
Test Metho	od:	ANSI C63.10: Devices	2013: Ameri	can National Sta	andard of Proc	edures	for Co	mpliance Test	ing of Unlice	nsed Wireless
In accorda	nce with:	FCC Part 15.1 Emissions Lin		Federal Regulat	ions Part 47, S	Subpart	B - Un	intentional Ra	diators, Radi	ated
Section:		15.109								
Test Date(s	s):	4/13/2017			EUT Serial	#:		#1 (antenn	a 1) #3 (an	tenna 2)
Customer:	•	Long Range	Systems		EUT Part #:			None	, ,	<u> </u>
Project Nu	mber:	18915-10			Test Techni	ician:		Bob Redou	tey	
Purchase C	Order #:	N/A			Supervisor:			Lisa Arndt	•	
Equip. Und	ler Test:	ZB-Beacon			Witness' N			None		
	F	Radiated Em	issions Test	t Results Data	a Sheet			Pa	ge: 1	of 1
EUT L	ine Voltage	: 3	3 VDC		EUT Pow	ver Fre	quen	cy: -	N/A	
Antenn	a Orientatio	n:	Vertic	al	Frequ	ency R	ange:		30MHz to	1GHz
	EUT N	/lode of Ope	eration:				R	eceive Mod	e	
Frequency	Test	EUT	Antenna		Recorded	Corre	cted			
Measured	Distance	Direction	Height	Detector	Amplitude	Lev		Limit Level	Margin	Test Results
(MHz)	(Meters)	(Degrees)	(Meters)	Function	(dBμV)	(dBµ\		(dBμV/m)	(dB)	
34.9255	10	160	3.61	Quasi-peak	23	11.2	239	29.5	-18.3	Pass
56.0396	10	232	1.76	Quasi-peak	24	6.2	.07	29.5	-23.3	Pass
59.9924	10	280	3.87	Quasi-peak	28.1	9.8	69	29.5	-19.6	Pass
79.9374	10	152	3.82	Quasi-peak	27.5	8.9	97	29.5	-20.5	Pass
100.004	10	245	1.33	Quasi-peak	24.6	8.0	85	33.1	-25.0	Pass
250.11	10	40	1.82	Quasi-peak	22.1	12.3	114	35.6	-23.5	Pass
887.492	10	210	2.04	Quasi-peak	21.4	25.	717	35.6	-9.9	Pass
							— Quasi	-peak Limit Level		
n e	sional Testing,						∇ Corre	cted Quasi-peak Read	ing	
	Emissions, 10m D	islance					- Corre	cted Peak Value		
Radiated	Emissions, 10m Di GHz Vertical Polarity									
Radiated							∇ Verific	ed Low-PRF QP Readi	ng	
Radiated 30MHz-1								ed Low-PRF QP Readi Verification Limit	ng	PROFESSIONAL TESTING
Radiated 30 MHz - 1 60 50 50										
Radiated 30 MHz - 1 60 50 50									ng	
Radiated 30 MHz - 1 60 50 50	GHz V ertical Polarity				×				ng	
Radiated 30 MHz - 1 60 50 50					×				ng	
Radiated 30 MHz - 1 60 50 50	GHz V ertical Polarity	Measured Emissions					× LPRF		ng	
Radiated 30 M Hz - 1 60 - 50 - 50 - 6 (E/A) 40 - 6 (E/A)	GHz V ertical Polarity	Measured Emissions					× LPRF		ng	
Radiated 30 MHz - 1 60 50 50	GHz V ertical Polarity	Measured Emissions					× LPRF		ng	
Radiated 30MHz-1 60	GHz V ertical Polarity	Measured Emissions		alman and the same of the same			× LPRF			
Radiated 30 MHz-1 60 50 50 50 50 50 50 50 50 50 50 50 50 50	GHz V ertical Polarity	Measured Emissions	100M	al-care in his part of the first			× LPRF			
Radiated 30MHz-1 60 50 50 50 50 50 50 50 50 50 50 50 50 50	GHz V ertical Polarity	Measured Emissions					× LPRF			T E S T I N 6
Radiated 30MHz-1 60 50 50 50 50 50 50 50 50 50 50 50 50 50	× × × × × × × × × × × × × × × × × × ×	Measured Emissions X X X All Market Mark	EUT Mod	Free e: Receiv e Mode er: 3 VDC Battery	n at a the same of		× LPRF	Verification Limit		T E S T I N G

							L	ong Range S	ystems, LLC	– ZB-Beacor
			Profess	sional Te	sting, El	ΜI, I	nc.			
Test Metho	od:	ANSI C63 Devices	.10: 2013: Ameri	can National Sta	andard of Proc	edures	for Co	mpliance Test	ting of Unlice	nsed Wireless
In accorda	nce with:	FCC Part : Emissions	15.109 - Code of I Limits	Federal Regulat	ions Part 47, S	Subpart	B - Un	intentional R	adiators, Rad	iated
Section:		15.109			1					
Test Date(s	s):	4/13/20			EUT Serial			#1 (antenn	a 1) #3 (an	tenna 2)
Customer:		Long Range Systems EUT Part #: None								
Project Nu		18915-1	0		Test Techn			Bob Redou	tey	
Purchase C		N/A			Supervisor			Lisa Arndt		
Equip. Und	ier rest:	ZB-Beac	on		Witness' N	ame:		None		
	F	Radiated	Emissions Test	Results Data	Sheet			Pa	ge: 1	of 1
EUT L	ine Voltage	:	3 VDC		EUT Pow	ver Fre	quen	cy:	- N/A	
Antenna	a Orientatio	on:	Horizor	ntal	Frequ	ency F	tange:		30MHz to	1GHz
	EUT N	/lode of (Operation:				R	eceive Mod	е	_
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degree		Detector Function	Recorded Amplitude (dBµV)	Corre Le	vel	Limit Level (dBμV/m)	Margin (dB)	Test Results
34.0449	10	163	2.31	Quasi-peak	23.2	11.	335	29.5	-18.2	Pass
55.5193	10	330	3.02	Quasi-peak	23.8	6.0	94	29.5	-23.4	Pass
77.2872	10	182	1.51	Quasi-peak	23.2	5.1	.33	29.5	-24.4	Pass
104.429	10	80	3.87	Quasi-peak	23		89	33.1	-26.6	Pass
577.95	10	244	1.56	Quasi-peak	22		.94	35.6	-17.7	Pass
894.427	10	57	1.15	Quasi-peak	21.4	25.	977	35.6	-9.6	Pass
Radiated	sional Testing, Emissions, 10m D GHz Horizontal Polar	istance	nissions				CorreCorreVerifi	i-peak Limit Level ected Quasi-peak Rea ected Peak Value ied Low-PRF QP Rea F Verification Limit		PROFESSIONAL TESTING
Field Strength (d B µ V/m) 20 20 20 20 20 20 20 20 20 20 20 20 20	x								×) In the last of t
20	Charles of the Contract of the	J/Mary	A Company of the state of the s	March 11 Same to a live of the control of the contr	white the same of	Many selection 19	The state of the s	A LANGE OF LANGE	7	
n. <u> </u>	<u> </u>	Nithen A market	A section (
18915_FC	Bob Redoutey CC_2016 RE_ClassB PM, Thursday, April 1			Fre: Receive Mode er: 3 VDC Battery	quency		I	EUT: LRS Beacon Project Number: 1893 Client: Long Range S		16
		≤	1GHz Horizont	al Antenna P	olarity Mea	sured	Emiss	sions		

6.3.2 Up to 13 GHz

			Profess	sional Te	sting, EN	MI, Inc.			
Test Metho	d:	ANSI C63.10: Devices	2013: Americ	can National St	andard of Proc	edures for Co	ompliance Test	ing of Unlice	nsed Wireless
In accordan	ice with:	Emissions Lin		ederal Regula	tions Part 47, S	Subpart B - Ur	nintentional Ra	adiators, Rad	iated
Section:		15.109			Τ				
Test Date(s):	4/13/2017			EUT Serial		#1 (antenn	a 1) #3 (an	tenna 2)
Customer:		Long Range	Systems		EUT Part #:		None		
Project Nur		18915-10			Test Techni		Bob Redou	tey	
Purchase O		N/A			Supervisor:		Lisa Arndt		
Equip. Und	er Test:	ZB-Beacon			Witness' Na	ame:	None		
	F	Radiated Em	issions Test	Results Dat	a Sheet		Pa	ge: 1	of 1
EUT Li	ne Voltage	: 3	S VDC		EUT Pow	ver Frequen	ıcy:	N/A	
Antenna	Orientatio	n:	Vertic	al	Frequ	ency Range	•	Above 1	GHz
	EUT N	/lode of Ope	eration:			F	Receive Mod	e	
Frequency Measured	Test Distance	EUT Direction	Antenna Height	Detector Function	Recorded Amplitude	Corrected Level	Limit Level	Margin (dB)	Test Results
(MHz)	(Meters)	(Degrees)	(Meters)		(dBµV)	(dBµV/m)	` ' ' '		
1318.09	3	94	1.24	Average	36.5	24.616	54.0	-29.3	Pass
1744.32	3	122	2.27	Average	35.7	25.753	54.0	-28.2	Pass
1919.96	3	149	2.17	Average	44.7	35.315	54.0	-18.6	Pass
2794.47	3	280	1.86	Average	35.1	27.242	54.0	-26.7	Pass
3647.52	3	39	2.6	Average	35.1	28.196	54.0	-25.8	Pass
4812.36	3	155	1.82	Average	45.7	41.702	54.0	-12.3	Pass
6632.86	3	278	2.98	Average	30.6	32.258	54.0	-21.7	Pass
10313.3	3	195	3.96	Average	26.8	36.725	54.0	-17.2	Pass
l	. 175 (— Aver	age Limit Level		
	sional Testing, Emissions, 3m Dis								
	ertical Polarity Meas						ected Average Reading		
90= -							Limit Level ected Peak Reading		PROFESSIONAL
80						Con	Citta Fan Reading		TESTING
70 - 70 - 70 - 70 - 70 - 70 - 70 - 70 -									
- 60 ± −									
n gth									
st 20 — —							Il mile		
ੂੰ 40 − −			Harden and the state of the sta						
30			China Carlo Car			Ψ			
30	7	γ	7	7					
20							10G		18G
20 ±				Fre	equency		OUT INCH		
	Bob Redoutey					1	EUT: LRS Beacon		
Operator: 1	Bob Redoutey C_2016 RE_ClassB	- 032117.til		e: Receive Mode r: 3 VDC Battery			EUT: LRS Beacon Project Number: 1893	1-10	

						L	ong Range S	systems, LLC	– ZB-Beacor
			Profess	sional Te	sting, EN	VII, Inc.			
Test Metho	d:	ANSI C63.10 Devices	: 2013: Americ	an National St	andard of Proc	edures for Co	mpliance Tes	ting of Unlice	nsed Wireless
In accordan	ce with:	FCC Part 15.		ederal Regulat	tions Part 47, S	Subpart B - Ur	nintentional R	adiators, Radi	iated
Section:		15.109							
Test Date(s):	4/13/2017			EUT Serial	#:	#1 (antenn	a 1) #3 (an	tenna 2)
Customer:		Long Range	Systems		EUT Part #:		None		
Project Nur		18915-10			Test Techni		Bob Redou	tey	
Purchase O		N/A			Supervisor:		Lisa Arndt		
quip. Und	er Test:	ZB-Beacon			Witness' N	ame:	None		
	F	Radiated En	nissions Test	Results Data	a Sheet		Pa	ge: 1	of 1
EUT Li	ne Voltage:		3 VDC		EUT Pow	ver Frequen	cy:	- N/A	
Antenna	Orientatio	n:	Horizon	tal	Frequ	ency Range:		Above 1	GHz
	EUT N	lode of Op	eration:			R	eceive Mod	le	
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1313.27	3	222	1.83	Average	36.1	24.196	54.0	-29.8	Pass
1782.72	3	351	3.57	Average	35.8	25.957	54.0	-28.0	Pass
1970.64	3	189	1.87	Average	35.6	26.342	54.0	-27.6	Pass
2845.58	3	326	3.1	Average	34.9	27.266	54.0	-26.7	Pass
3642.45	3	172	2.51	Average	35.1	28.155	54.0	-25.8	Pass
5211.62	3	204	3.18	Average	33.2	30.433	54.0	-23.5	Pass
7272.19	3	164	3.27	Average	29.4	32.235	54.0	-21.7	Pass
11492.7	3	254	2.35	Average	27.3	38.297	54.0	-15.7	Pass
Radiated	cional Testing, Emissions, 3m Dis orizontal Polarity Mo	tance		.,		∇ Corre	ge Limit Level ected Average Reading Limit Level		
80 -						— Corre	ected Peak Reading		PROFESSIONAL TESTING
Field Strength (d BµV)m)			and the state of t			distriction of the state of the		policy profile profile and a shall be profile	
30				7					
20 E	Dala Dada ut	1 1		Free	quency	 	10G		18G
-	Bob Redoutey C_2016 RE_ClassB -	032117.til		: Receive Mode r: 3 VDC Battery			UT: LRS Beacon Project Number: 1893	1-10	

> 1GHz Horizontal Antenna Polarity Measured Emissions

Client: Long Range Systems

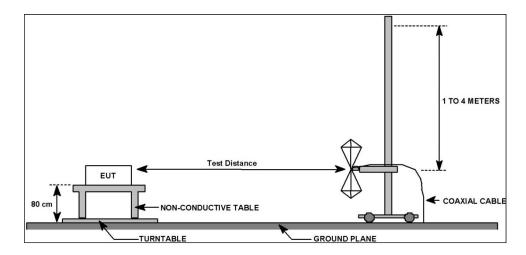
08:10:38 PM, Thursday, April 13, 2017

7.0 Radiated Spurious Emissions, Transmit Mode

7.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The EUT was centered on a rotating turntable. Measurements below 1 GHz were taken at a test distance of 10 meters from the measurement antenna. Above 1 GHz the measurement distance was 3 meters.

Spurious emissions below 1 GHz were measured with quasi-peak detection with a resolution bandwidth of 120 kHz. Above 1 GHz peak measurements were taken and average measured where appropriate using 1 MHz resolution bandwidth. A diagram showing the test setup appears below.



7.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.209 // RSS-247 5.5, RSS-Gen 4.9 & 4.10	Field Strength of Radiated Spurious/Harmonic Emissions Transmit Mode	12 Apr 2017

7.3 Test Results

Modulation was disabled for this test and the transmitter was placed into continuous transmit mode. The three standard channels were measured above 1 GHz; the middle channel was measured starting at 30 MHz.

Two EUTs were employed and were configured as serial number 1 for antenna 1 and serial number 3 for antenna 2. Each EUT was tuned to the specified channel and placed in transmit mode.

The duty cycle averaging factor applies -20.0 dB to the peaks recorded for the harmonics. Since the peak measurement satisfied the peak limit with margin, the average emission would equally satisfy the average limit. The video-averaged measurements of the harmonics can be disregarded.

7.3.1 Middle Channel, 30 MHz to 25 GHz

			Profes	sional Te	sting, El	VII, Inc.		·		
Test Metho	od:	ANSI C63.10	0–2013							
In accordar	nce with:	Limits	.209 - Code of	Federal Regulat	ions Part 47,	Subpart C - II	ntentional	Radiators	, Radiate	ed Emissions
Section:		15.209								
Test Date(s	s):	4/11/2017	7		EUT Serial	#:		<u>enna 1)</u>	#2 (ant	tenna 2)
Customer:		Long Rang	ge Systems		EUT Part #:		0			
Project Nur	mber:	18931			Test Techn	ician:	Spence	r Flint		
Purchase O		0			Supervisor		Lisa Arr			
Equip. Und	er Test:	ZB-Beacor	1		Witness' N	ame:	Sam Sic	diqui		
	F	Radiated Er	nissions Test	t Results Data	Sheet			Page:	1	of 1
EUT Li	ine Voltage:	:	3 VDC		EUT Pov	ver Freque	ncy:	0	N/A	
Antenna	a Orientatio	n:	Vertic	al	Frequ	ency Range	e:	301	MHz to	1GHz
	EUT N	/lode of Op	eration:		Tra	ansmitting	(Mid Cha	annel - 2	2440 M	Hz)
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Le	_	largin (dB)	Test Results
31.2257	10	100	1.22	Quasi-peak	24.2	12.45	29.5	; -	17.1	Pass
408.101	10	7	1.33	Quasi-peak	22.2	15.094	35.6	j -	20.5	Pass
551.02	10	59	3.39	Quasi-peak	22.1	17.903	35.6	j -	17.7	Pass
624.011	10	57	4.01	Quasi-peak	22	19.364	35.6	; -	16.2	Pass
917.75	10	220	2.99	Quasi-peak	21.3	24.277	35.6	; -	11.3	Pass
980.177	10	333	1.52	Quasi-peak	21	23.72	43.5	, -	19.8	Pass
Radiated 30MHz - 10 60	Spencer Flint	Distance Measured Emissions M-26G.til	100M EUT Mod	Fre e: TX CW Mode #1 (ant. er: 3V Battery Powered	quency 1) #2 (ant.2)	∇ Cc— Cc∇ Ve	asi-peakLimit Le rrected Q uasi-pe rrected Peak Val rified Low-PRF (RF Verification I	eak Reading due Q P Reading Limit X Y Tr: 18931		PROFESSIONAL X X X X X X X X X X X X X X X X X X X
Operator: 18931_2016			EUT Mod	e: TX CW Mode #1 (ant.		-		r: 18931		1G

							L	ong Range S	Systems, LLO	C – ZB-Beacor
			Profess	sional Te	sting, El	ΜI, I	nc.			
Test Metho	d:	ANSI C63	.10–2013							
In accordar	ice with:	FCC Part : Limits	15.209 - Code of I	Federal Regulat	tions Part 47,	Subpar	t C - Int	entional Rad	iators, Radiat	ed Emissions
Section:		15.209			1					
Test Date(s):	4/11/20			EUT Serial				na 1) #2 (an	tenna 2)
Customer:			nge Systems		EUT Part #:			0	• . •	
Project Nur		18931 0			Test Techn			Spencer Fl	int	
Purchase O Equip. Und		ZB-Beac			Supervisor: Witness' N			Lisa Arndt Sam Siddio	i	
Equip. Onu	ei iest.	ZD-Deac	OII		WILLIESS IN	aiiie.		Sain Siduit	₁ uı	
	F	Radiated	Emissions Test	Results Data	a Sheet			Pa	ige: 1	of 1
EUT Li	ne Voltage:		3 VDC		EUT Pov	ver Fr	equen	cy:	0 N/A	
Antenna	Orientatio	n:	Horizor	ntal	Frequ	ency l	Range:	:	30MHz to	1GHz
	EUT N	/lode of (Operation:		Tra	ansmi	itting (Mid Chann	el - 2440 N	1Hz)
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degree	- 0	Detector Function	Recorded Amplitude (dBµV)	Le	ected vel V/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
32.5907	10	231	1.44	Quasi-peak	23.8	12	.12	29.5	-17.4	Pass
401.091	10	117	2.19	Quasi-peak	22.3	15.	218	35.6	-20.4	Pass
626.607	10	214	1.39	Quasi-peak	22	_	371	35.6	-16.2	Pass
771.74	10	20	1.42	Quasi-peak	21.6	_	.19	35.6	-14.4	Pass
900.829	10	350	2.6	Quasi-peak	21.2		502	35.6	-11.1	Pass
955.754	10	39	2.02	Quasi-peak	21	23.	766	35.6	-11.8	Pass
Radiated	cional Testing Emissions, 10m l Hz Horizontal Polarit	Distance	ssions				∇ CorreCorre∇ Verif	i-peakLimit Level ected Q uasi-peakRea ected PeakValue ied Low-PRF Q P Re Verification Limit		PROFESSIONAL TESTING
Field Strength (dB _a V/m) ×									× ×	× ×
2 WW	Manager .					Allelas Industri		Ÿ	- Y - F - T	
10 7	Who who will be the will be th	Market Market	Marings	Magagith-designated palent heliteral	Marie Property Control of the Contro				_	
0		May Property								
18931_2016	Spencer Flint RE_FCC_2440M_30 M, Tuesday, April 11, 2			Free: TX CW Mode #1 (ant.1 r: 3V Battery Powered	quency 1) #2 (ant.2)		P	UT: ZB-Beacon roject Number: 1893 lient: Long Range Sys		1G
		≤	1GHz Horizont	al Antenna P	Polarity Mea	sured	l Emis	sions		

Professional Testing, EMI, Inc. Test Method: ANSI C63.10-2013 FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions In accordance with: Limits 15.209 Section: Test Date(s): 4/11/2017 **EUT Serial #:** "#1 (antenna 1) #2 (antenna 2) **Customer:** EUT Part #: **Long Range Systems** Spencer Flint **Project Number:** 18931 Test Technician: Lisa Arndt Purchase Order #: Supervisor: 0 **ZB-Beacon** Witness' Name: Sam Siddiqui **Equip. Under Test: Radiated Emissions Test Results Data Sheet** of 1 1 Page: **EUT Line Voltage:** 3 VDC **EUT Power Frequency:** 0 N/A **Antenna Orientation:** Vertical **Frequency Range:** Above 1GHz **EUT Mode of Operation:** Transmitting (Mid Channel - 2440 MHz) EUT Recorded Corrected Frequency Test **Antenna** Limit Level Detector Margin Measured Distance Direction Height Amplitude Level **Test Results Function** (dBµV/m) (dB) (MHz) (Meters) (Degrees) (Meters) (dB_µV) $(dB\mu V/m)$ 4879.73 3 330 1.78 54.1 50.581 54.0 -3.4 Pass Average 11523.2 3 3.47 Average 27.2 38.227 54.0 -15.7 Pass 311 173 12546.4 3.01 27.6 3 Average 38.357 54.0 -15.6Pass 14904.8 3 45 1.43 Average 28.4 40.097 54.0 -13.9 Pass 3 17618.6 185 1.42 Average 27 42.053 54.0 -11.9 Pass 17849.1 3 258 1.16 Average 27 43.092 54.0 -10.9 Pass Average Limit Level Professional Testing, EMI, Inc Radiated Emissions, 3m Distance Corrected Average Reading 1-18G Hz Vertical Polarity Measured Emissions PeakLimit Level 90 PROFESSIONAL Corrected Peak Reading 80 Field Strength (dBµV/m) 70 60 50 40 30 20± Frequency EUT: ZB-Beacon Operator: Spencer Flint EUT Mode: TX CW Mode #1 (ant.1) #2 (ant.2) 18931_2016 RE_FCC_2440M_30M-26G.til Project Number: 18931 EUT Power: 3V Battery Powered 11:45:56 AM, Tuesday, April 11, 2017 Client: Long Range Systems

> 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc. Test Method: ANSI C63.10-2013 FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions In accordance with: Limits 15.209 Section: Test Date(s): 4/11/2017 **EUT Serial #:** "#1 (antenna 1) #2 (antenna 2) **Customer:** EUT Part #: **Long Range Systems** Spencer Flint **Project Number:** 18931 Test Technician: Lisa Arndt Purchase Order #: Supervisor: 0 **ZB-Beacon** Witness' Name: Sam Siddiqui **Equip. Under Test:** of **Radiated Emissions Test Results Data Sheet** 1 Page: 1 **EUT Line Voltage:** 3 VDC **EUT Power Frequency:** 0 N/A **Antenna Orientation:** Horizontal **Frequency Range:** Above 1GHz **EUT Mode of Operation:** Transmitting (Mid Channel - 2440 MHz) EUT Recorded Frequency Test **Antenna** Corrected Limit Level Detector Margin Measured Distance Direction Height Amplitude Level **Test Results Function** (dBµV/m) (dB) (MHz) (Meters) (Degrees) (Meters) (dB_µV) $(dB\mu V/m)$ 4879.9 3 292 1.88 51.2 47.753 54.0 -6.2 Average **Pass** 11534.3 3 3.72 Average 27.3 38.219 54.0 -15.7 Pass 171 27.6 12468.4 3 31 3.83 Average 38.334 54.0 -15.6Pass 14925.3 3 47 2.35 Average 28.3 40.091 54.0 -13.9 Pass 16155.6 3 84 3.31 Average 27 41.563 54.0 -12.4Pass 17816 3 122 2.25 Average 27.1 43.213 54.0 -10.7 Pass Average Limit Level Professional Testing, EMI, Inc Radiated Emissions, 3m Distance Corrected Average Reading 1-18G Hz Horizontal Polarity Measured Emissions PeakLimit Level 90 PROFESSIONAL Corrected Peak Reading 80 Field Strength (dBµV/m) 70 60 50 40 30 20± Frequency EUT: ZB-Beacon Operator: Spencer Flint EUT Mode: TX CW Mode #1 (ant.1) #2 (ant.2) 18931_2016 RE_FCC_2440M_30M-26G.til Project Number: 18931 EUT Power: 3V Battery Powered Client: Long Range Systems 11:45:56 AM, Tuesday, April 11, 2017

> 1GHz Horizontal Antenna Polarity Measured Emissions

								L	ong Ra	ange Sy	stems, LLC	– ZB-B	eacor
				Profess	sional Te	sting, El	ΜI,	Inc.					
Test Metho	d:	ANSI C	53.10-	-2013									
In accordan	ice with:	FCC Par Limits	t 15.2	09 - Code of I	ederal Regulat	tions Part 47,	Subpai	rt C - Int	entiona	al Radia	tors, Radiate	ed Emiss	sions
Section:		15.209											
Test Date(s):	4/11/2	2017			EUT Serial	#:		#1 (ar	ntenna	1) #2 (ant	enna 2	2)
Customer:		Long R	lange	Systems		EUT Part #:			0				
Project Nur	nber:	18931				Test Techn	ician:		Spend	er Flin	t		
Purchase O	rder #:	0				Supervisor			Lisa A	rndt			
Equip. Und	er Test:	ZB-Bea	acon			Witness' N	ame:		Sam S	iddiqu	i <u> </u>		
	F	Radiate	d Em	issions Test	Results Data	a Sheet				Pag	e: 1	of	1
EUT Li	ne Voltage		3	VDC		EUT Pow	ver Fr	equen	су:	0	N/A		
Antenna	Orientatio	n:		Vertic	al	Frequ	ency	Range:			Above 1	GHz	
	EUT N	/lode of	f Ope	ration:		Tra	ansm	itting (Mid C	hanne	l - 2440 M	Hz)	
Frequency Measured (MHz)	Test Distance (Meters)	EU ⁻ Direct (Degre	ion	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corr	rected evel uV/m)	Limit (dBµ\	Level	Margin (dB)	Test R	esult
21162.1	3	20)	1	Average	33.2	27	.403	54	.0	-26.6	Pa	SS
23507.2	3	44		1	Average	34.1	29	9.41	54	.0	-24.5	Pa	SS
24355.6	3	302	2	1	Average	33.9	29	.922	54	.0	-24.0	Pa	SS
Radiated	ional Testing Emissions, Meas z Vertical Polarity M	ured at 1m	and Sc	aled to 3m Distand	ce			▽ Corre	age Limit Le ected Avera Limit Level ected Peak I	age Reading		PROFESS T E S T	SIONAL I N G
Field Strength (aB VV)	ale properties and the later	Mary and the state of the state			فيحار إدرا وموسادية فرير وعافدا	Language of male		hand bing like		Markle grant at	المرابعاتين الإرداف الأدرا	All land little	
30 -					Y			Y		7			
18931_2016	Spencer Flint RE_FCC_2440M_30 M, Tuesday, April 11, 2				Fre: TX CW Mode #1 (ant.)	quency 1) #2 (ant.2)		P	UT: ZB-Bea Troject Num		ns	26.5	G
			> 10	GHz Vertica	l Antenna Po	larity Meas	ured	Emissi	ons				

Test Date(s): 4/11/2017 EUT Serial #: #1 (antenna 1) #2 (antenna 2) Customer: Long Range Systems EUT Part #: 0 Project Number: 18931 Test Technician: Spencer Flint Purchase Order #: 0 Supervisor: Lisa Arndt Equip. Under Test: ZB-Beacon Witness' Name: Sam Siddiqui Radiated Emissions Test Results Data Sheet Page: 1 of 1 EUT Line Voltage: 3 VDC EUT Power Frequency: 0 N/A Antenna Orientation: Horizontal Frequency Range: Above 1GHz EUT Mode of Operation: Transmitting (Mid Channel - 2440 MHz) Frequency Test EUT Antenna Detector Recorded Corrected Limit Level Margin									L	ong R	ange Sy	/stems, Ll	.C – ZB-	Beacor
FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits section: 15.209 lest Date(s): 4/11/2017					Profess	sional Te	sting, EN	ΜI, I	lnc.					
Limits lection: 15.209 lection: 15.209 lection: 15.209 lection: 15.209 lection: 15.209 lection: 16.201 15.209 lection: 18931 Test Technician: Spencer Flint leading	Test Metho	d:	ANSI C	53.10-	2013									
EUT Part #: #1 (antenna 1) #2 (antenna 2)	In accordan	ce with:		t 15.2	09 - Code of F	ederal Regulat	ions Part 47, S	Subpar	t C - Int	ention	al Radia	tors, Radia	ted Emi	ssions
Customer: Long Range Systems EUT Part #: O Supervisor: Lisa Arnot Spencer Flint Spencer Flint Supervisor: Lisa Arnot Lisa	Section:		15.209											
Project Number: 18931 Test Technician: Spencer Flint Durchase Order #: 0 Supervisor: Lisa Arndt Quip. Under Test: ZB-Beacon Witness' Name: Sam Siddiqui Radiated Emissions Test Results Data Sheet Page: 1 of 1 EUT Line Voltage: 3 VDC EUT Power Frequency: 0 N/A Antenna Orientation: Horizontal Frequency Range: Above 1GHz Transmitting (Mid Channel - 2440 MHz) Frequency Range: Above 1GHz Transmitting (Mid Channel - 2440 MHz) Frequency Range: Above 1GHz Transmitting (Mid Channel - 2440 MHz) Frequency Range: Above 1GHz Transmitting (Mid Channel - 2440 MHz) Frequency Range: Above 1GHz Transmitting (Mid Channel - 2440 MHz) Frequency Range: Above 1GHz Transmitting (Mid Channel - 2440 MHz) Frequency Range: Above 1GHz Transmitting (Mid Channel - 2440 MHz) Test Result (dBµV/m) (dB) Test Result (dBµV/m) (dB) Test Result (dBµV/m) (ab) Test Result (dBµV/m) (ab) Test Result (dBµV/m) (ab) Test Result (dBµV/m) (ab) Test Result (dBµV/m) Test Result (dBµV/m) (ab) Test Result (dBµV/m) (ab) Test Result (ab) Test Re	Test Date(s):	4/11/2	2017			EUT Serial	#:		#1 (a	ntenna	1) #2 (a	ntenna	2)
Purchase Order #: O Supervisor: Usa Arndt Equip. Under Test: ZB-Beacon Witness' Name: Sam Siddiqui	Customer:		_	Range	Systems		EUT Part #:							
Radiated Emissions Test Results Data Sheet Radiated Emissions Test Results Data Sheet Page: 1 of 1 EUT Line Voltage: 3 VDC EUT Power Frequency: 0 N/A Antenna Orientation: Horizontal Frequency Range: Above 1GHz EUT Mode of Operation: Transmitting (Mid Channel - 2440 MHz) Frequency Test Distance (Meters) Distance (Meters) Direction Height (Degrees) (Meters) Direction	Project Nur	nber:	_				Test Techni	ician:				it		
Radiated Emissions Test Results Data Sheet							<u> </u>			_				
EUT Line Voltage: 3	Equip. Und	er Test:	ZB-Bea	acon			Witness' N	ame:		Sam	Siddiqu	ıi		
Frequency Test EUT Antenna Detector GlaμV Margin GlaμV Glau GlaμV Margin GlaμV Glau GlaμV Glau		R	Radiate	d Em	issions Test	Results Data	a Sheet				Pag	e: 1	of	1
EUT Mode of Operation: Transmitting (Mid Channel - 2440 MHz) Frequency Test Distance Direction Height Detector Function Margin (dBμV/m) (dBμV/m	EUT Li	ne Voltage:		3	VDC		EUT Pow	ver Fr	equen	су:	0	N/A	4	
Test Distance Direction Height Detector Function Height Hight Limit Level (dBμV/m) (dBμ	Antenna	Orientatio	n:		Horizon	tal	Frequ	ency l	Range:			Above	1GHz	
Measured (MHz) Distance (MHz) Di		EUT N	lode o	f Ope	ration:		Tra	ansmi	itting (Mid C	hanne	l - 2440 ľ	ИHz)	
23303.7 3 249 1 Average 34 29.023 54.0 -24.9 Pass 24180.9 3 329 1 Average 33.6 29.531 54.0 -24.4 Pass Professional Testing, EMI, Inc Radiated Emissions, Measured at Im and Scaled to 3m Distance 18-26.5 G Hz Horizontal Polarity Measured Emissions 90 80 80 80 80 80 80 80 80 80 80 80 80 80	Frequency Measured (MHz)	Distance	Direct	tion	Height		Amplitude	Le	evel	_		_	Test	Results
23303.7 3 249 1 Average 34 29.023 54.0 -24.9 Pass 24180.9 3 329 1 Average 33.6 29.531 54.0 -24.4 Pass Professional Testing, EMI, Inc Radiated Emissions, Measured at Im and Scaled to 3m Distance 18-26.5 GHz Horizontal Polarity Measured Emissions 90 80 40 40 40 40 40 40 40 40 40 40 40 40 40	22116.8	3	12:	1	1	Average	33.8	28.	.513	54	1.0	-25.4	Р	ass
Professional Testing, EMI, Inc Radiated Emissions, Measured at 1m and Scaled to 3m Distance 18-26.5 G Hz Horizontal Polarity Measured Emissions 90 80 80 60 60 70 10 10 10 10 10 10 10 10 10 10 10 10 10	23303.7	3	249	9	1	Average	34	29.	.023	54	1.0	-24.9	Р	ass
Professional Testing, EVII, IIIC Radiated Emissions, Measured at Im and Scaled to 3m Distance 18-26.5 GHz Horizontal Polarity Measured Emissions 90 80 80 80 80 80 80 80 80 80 80 80 80 80	24180.9	3	329	9	1	Average	33.6	29.	.531	54	1.0	-24.4	P	ass
	Radiated 18-26.5 GH 90 80 80 (III 70 1899) 60 18.06 Operator: S	Emissions, Meast Horizontal Polarity !	ured at 1m	and Sc	EUT Mode	Fre: TX CW Mode #1 (ant.)			▼ Corre	ected Aver Limit Level ected Peak	age Reading Reading		TES	N 6
	04:33:05 PM	I, Tuesday, April 11, 2		> 1GI	Hz Horizont	al Antenna F	Polarity Mea	sured			Range Syste	ms		

7.3.2 Bottom Channel, 1 GHz to 25 GHz

			Profess	sional Te	sting, El	MI, Ir	c.				
Test Metho	od:	ANSI C63.10	-2013								
n accordai	nce with:	Limits	209 - Code of F	ederal Regulat	ions Part 47,	Subpart	: - Intenti	onal Radi	ators, Rad	diated Em	issions
Section:		15.209						-		-	
Test Date(s	s):	4/11/2017			EUT Serial			(antenn	a 1) #2 ((antenna	a 2)
Customer:		Long Range	e Systems		EUT Part #	-	0				
Project Nu		18931			Test Techn			encer Fli	nt		
Purchase C		0			Supervisor			Arndt			
quip. Und	er Test:	ZB-Beacon			Witness' N	ame:	Sar	n Siddiq	ui		
	R	Radiated En	nissions Test	Results Data	Sheet			Pa	ge:	1 of	1
EUT L	ine Voltage:		3 VDC		EUT Pov	ver Fre	uency:	() N	/A	
Antenn	a Orientatio	n:	Vertic	al	Frequ	ency Ra	nge:		Abov	e 1GHz	
	EUT N	lode of Op	eration:		Trar	nsmittir	g (Botto	m Chan	nel - 24	05 MHz)	
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Correc Lev (dBµV	el Lin	nit Level ΒμV/m)	Margi (dB)	ITest	Results
4809.79	3	21	1.8	Average	56.3	52.5	38	54.0	-1.4	.	Pass
7164.82	3	281	1.91	Average	29.7	32.5	56	54.0	-21.4	4 F	Pass
11512.3	3	171	2.15	Average	27.3	38.3	75	54.0	-15.6		Pass
12510.2	3	9	3.87	Average	27.8	38.5	53	54.0	-15.4	4 F	Pass
17730.7	3	145	3.5	Average	26.7	42.6	77	54.0	-11.3	3 F	Pass
Radiated	sional Testing, Emissions, 3m Dis	tance ured Emissions				7	Average Lim Corrected A Peak Limit L Corrected Pe	v era g e R ea d ing ev el			ESSIONAL
· · · ‡											18G

Professional Testing, EMI, Inc. Test Method: ANSI C63.10-2013 FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions In accordance with: Limits 15.209 Section: Test Date(s): 4/11/2017 **EUT Serial #:** #1 (antenna 1) #2 (antenna 2) **Customer: Long Range Systems** EUT Part #: Spencer Flint **Project Number:** 18931 Test Technician: Purchase Order #: Supervisor: Lisa Arndt 0 **Equip. Under Test: ZB-Beacon** Witness' Name: Sam Siddiqui **Radiated Emissions Test Results Data Sheet** of Page: 1 1 **EUT Line Voltage: VDC** 0 3 **EUT Power Frequency:** N/A **Antenna Orientation:** Horizontal **Frequency Range: Above 1GHz EUT Mode of Operation:** Transmitting (Bottom Channel - 2405 MHz) EUT Recorded Corrected Frequency Test **Antenna** Detector Limit Level Margin Measured Distance Direction Height Amplitude Level **Test Results Function** $(dB\mu V/m)$ (dB) (dBµV/m) (MHz) (Meters) (Degrees) (Meters) (dBµV) 4809.68 3 257 2.48 Average 53.4 49.71 54.0 -4.2 Pass 7187.62 3 331 2.27 Average 29.6 32.512 54.0 -21.4 Pass 11422.3 3 172 2.79 27.1 37.937 54.0 -16.0 Pass Average 12598.6 3 167 2.73 Average 27.6 38.299 54.0 -15.7 Pass 3 -10.8 17817.9 84 1.74 Average 27.1 43.172 54.0 Pass - A verage Limit Level Professional Testing, EMI, Inc Radiated Emissions, 3m Distance 1-18 GHz Horizontal Polarity Measured Emissions ∇ Corrected Average Reading Peak Limit Level PROFESSIONAL Corrected Peak Reading 80 Strength (dBµV/m) 70 60 50 Field 40 30 20± 18G EUT: ZB-Beacon Operator: Spencer Flint EUT Mode: TX CW #1 (ant.1) #2 (ant.2) 18931 2016 RE FCC 2405M 1-26G.til Project Number: 18931 EUT Power: 3V Battery 03:00:46 PM, Tuesday, April 11, 2017 Client: Long Range Systems > 1GHz Horizontal Antenna Polarity Measured Emissions

								L	ong Ra	inge Sy	stems, LLO	C – ZB	-Beaco
				Profess	sional Te	sting, El	ΜI, I	lnc.					
Test Metho	od:	ANSI C6	3.10–2	013									
n accordar	nce with:	FCC Part	15.20	9 - Code of I	ederal Regulat	ions Part 47,	Subpar	rt C - Int	entiona	ıl Radia	tors, Radiat	ed Em	issions
Section:		15.209											
Test Date(s	s):	4/11/2	017			EUT Serial	#:		#1 (an	tenna	1) #2 (an	tenna	a 2)
Customer:		Long R	ange S	Systems		EUT Part #:			0				
Project Nui	mber:	18931				Test Techn	ician:		Spenc	er Flin	it		
Purchase O		0				Supervisor			Lisa A				
quip. Und	er Test:	ZB-Bea	con			Witness' N	ame:		Sam S	iddiqu	ıi		
	F	Radiated	d Emis	sions Test	Results Data	a Sheet				Pag	e: 1	of	1
EUT Li	ine Voltage	:	3	VDC		EUT Pow	ver Fr	equen	су:	0	N/A		
Antenna	a Orientatio	n:		Vertic	al	Frequ	ency	Range:			Above 1	.GHz	
	EUT N	/lode of	Opera	ation:						Chanr	nel - 2405	MHz)
Frequency Measured (MHz)	Test Distance (Meters)	EUT Directi (Degre	on	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corr	ected evel iV/m)	Limit I (dBµV	Level	Margin (dB)		: Result
20755.9	3	71		1	Average	33.9	28	.231	54.	.0	-25.7		Pass
22714.4	3	278		1	Average	33.9	28	.752	54.	.0	-25.2		Pass
23973.7	3	245		1	Average	34	29.	.823	54.	.0	-24.1		Pass
Radiated 18-26.5 GH 90 80 18-26.5 GH 90 80 18-26.5 GH 90 1	Sional Testing Emissions, Meas tz Vertical Polarity M	ured at 1m	and Scale	d to 3m Distance		quency		▽ Corr — Peak — Corr	age Limit Le ected Avera Limit Level ected Peak R	ge Reading		E	ESSIONAL I I N 6
18931_2016	Spencer Flint 5 RE_FCC_2405M_1-2 M, Tuesday, April 11, 2				: TX CW #1 (ant.1) #2 (ar: 3V Battery	ant.2)		P	:U1: ZB-Bea Project Numb Client: Long I	per: 18931	ms		
			> 1GI	Iz Vertica	Antenna Po	larity Meas	ured	Emissi	ons				

								L	ong Ra	ange Sy	/stems, LLO	C – ZB-	Beacor
				Profess	sional Te	sting, EN	ΛI,	Inc.					
Test Metho	od:	ANSI C	63.10-	-2013									
In accordar	nce with:	FCC Pa	rt 15.2	09 - Code of I	ederal Regulat	ions Part 47, S	Subpai	rt C - Int	ention	al Radia	tors, Radiat	ed Emi	ssions
Section:		15.209)										
Test Date(s	s):	4/11/	2017			EUT Serial	# :		#1 (aı	ntenna	1) #2 (an	tenna	2)
Customer:		Long I	Range	Systems		EUT Part #:			0				
Project Nui	nber:	18931				Test Techni	ician:	!	Spend	cer Flir	it		
Purchase O	rder #:	0				Supervisor:			Lisa A				
Equip. Und	er Test:	ZB-Be	acon			Witness' Na	ame:		Sam S	Siddiqu	ıi iı		
	F	Radiate	ed Em	issions Test	: Results Data	a Sheet				Pag	ge: 1	of	1
EUT Li	ne Voltage:		3	VDC		EUT Pow	er Fr	equen	су:	0	N/A		
Antenna	Orientatio	n:		Horizor	ıtal	Freque	ency	Range:			Above 1	.GHz	
	EUT N	/lode o	f Ope	ration:		-				Chanı	nel - 2405	MHz)	
Frequency	Test	EU	т	Antenna	Detector	Recorded	Corr	rected		Level	Margin		Daarilka
Measured (MHz)	Distance (Meters)	Direc (Degr		Height (Meters)	Function	Amplitude (dBμV)		evel มV/m)	(dBµ	V/m)	(dB)	lest	Results
20701	3	88	3	1	Average	33.7	28	.045	54	.0	-25.9	P	ass
21796.6	3	26		1	Average	34	_	.378		.0	-25.6	P	ass
23533.2	3	13	3	1	Average	34.4	29	9.78	54	.0	-24.2	P	ass
Radiated 18-26.5 GH 90 THE RADIAN (WARD) AND	Sional Testing. Emissions, Meast z Horizontal Polarity N	ured at 1n	and Sca	Y	Free	quency		▼ Corre	age Limit Located Avera	age Reading		T E S	SSIONAL T N 6
18931_2016	RE_FCC_2405M_1-2 M, Tuesday, April 11, 2				: TX CW #1 (ant.1) #2 (a r: 3V Battery	nt.2)		P	roject Num		ms		
			> 1GI	Hz Horizont	al Antenna P	olarity Mea	sure	d Emis	sions				

7.3.3 Top Channel, 1 GHz to 25 GHz

est Method:					sting, EN					
est Methou.	,	ANSI C63.10	-2013							
n accordance v	vith:	FCC Part 15.7 Limits	209 - Code of F	ederal Regulat	tions Part 47, S	Subpar	t C - Int	entional Radi	iators, Radia	ted Emissions
ection:		15.209			_					
est Date(s):		4/11/2017			EUT Serial			#1 (antenn	a 1) #2 (ar	ntenna 2)
Customer:		Long Range	e Systems		EUT Part #:			0		
Project Number		18931			Test Techni			Spencer Fli	nt	
urchase Order		0			Supervisor:			Lisa Arndt		
quip. Under T	est:	ZB-Beacon			Witness' Na	ame:		Sam Siddio	lui	
	Ra	adiated Em	nissions Test	Results Data	a Sheet			Pa	ge: 1	of 1
EUT Line \	oltage:		3 VDC		EUT Pow	er Fr	equen	cy:	0 N/A	\
Antenna Ori	entation	n:	Vertica	al	Freque	ency l	Range:		Above	1GHz
	EUT M	ode of Op	eration:					Top Chann	el - 2480 N	ЛHz)
Measured Dis	Test stance eters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Le	ected vel V/m)	Limit Level (dBµV/m)	Margin (dB)	Test Result:
4959.67	3	20	1.55	Average	53.3	50.	105	54.0	-3.9	Pass
7439.42	3	245	1.3	Average	38.7	42.	482	54.0	-11.5	Pass
11598.1	3	339	2.11	Average	27.3	37.	936	54.0	-16.0	Pass
12484.8	3	220	2.92	Average	27.5	38.	306	54.0	-15.7	Pass
17777.2	3	262	2.78	Average	26.8	42.	844	54.0	-11.1	Pass
Professional Radiated Emiss 1-18G Hz Vertical I 90 80 80 10 10 10 10 10 10 10 10 10 10 10 10 10	ions, 3m Dis	stance ed Emissions		Free: TX CW #1 (ant.1) #2 (r. r. y) Battery	equency ant.2)		✓ Corre — Peaki — Corre	age Limit Level ected Average Readi Limit Level ected Peak Reading 10G UT: ZB-Beacon roject Number: 1893	Y Y	PROFESSIONAL I E S T I N 6

							L	ong Ran	ge Sys	tems, LLC	– ZB-B	eacor
			Profess	sional Te	sting, El	MI, I	nc.					
Test Metho	d:	ANSI C63.1	0–2013									
In accordan	ice with:	FCC Part 15 Limits	.209 - Code of I	Federal Regulat	tions Part 47, S	Subpart	C - Int	entional I	Radiato	ors, Radiate	ed Emiss	sions
Section:		15.209						_				
Test Date(s):	4/11/201	7		EUT Serial			#1 (ant	enna :	1) #2 (ant	enna 2	2)
Customer:			ge Systems		EUT Part #:			0				
Project Nur		18931			Test Techn			Spence				
Purchase O		0			Supervisor:			Lisa Arr				
Equip. Und	er Test:	ZB-Beacoi	1		Witness' N	ame:		Sam Sid	ldiqui			
	F	Radiated E	missions Test	Results Dat	a Sheet				Page	: 1	of	1
EUT Li	ne Voltage:	:	3 VDC		EUT Pov	ver Fre	quen	су:	0	N/A		
Antenna	Orientatio	n:	Horizor	ntal	Frequ	ency R	ange:			Above 10	GHz	
	EUT N	lode of Op	eration:		Tra	ansmit	ting (Top Cha	nnel	- 2480 MI	Hz)	
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corre Lev (dBµ\	/el	Limit Le (dBμV/	_	Margin (dB)	Test R	esults
4959.96	3	123	1.88	Average	49.8	46.5	569	54.0		-7.4	Pa	SS
11556.8	3	297	2.96	Average	27.3	38.0	086	54.0	١	-15.9	Pa	SS
12500.6	3	118	1.91	Average	27.7	38.4	142	54.0)	-15.5	Pa	SS
16519.9	3	299	1.61	Average	27.1	41.3	316	54.0)	-12.6	Pa	SS
17824.3	3	304	1.41	Average	27.1	43.2	213	54.0)	-10.7	Pa	SS
Radiated 1-18GHzH	sional Testing, Emissions, 3m Dis torizontal Polarity Mo	tance					▽ Corre	ge Limit Level cted Average R Limit Level cted Peak Read	J		PROFESS	
80 Field Strength (d Bu Vm) (a Bu Vm) (d Bu Vm	n bistig and de service and a side	A Latter Company of the American		Free	quency	de direction de la constantina	the state of the s	100	<u>who</u>	Y	186	
18931_201	Spencer Flint 16 RE_FCC_2480M PM, Tuesday, April 11	_		e: TX CW#1 (ant.1) #2 r: 3V Battery			Pi	UT: ZB-Beacon roject Number: lient: Long Rai	18931	s		

> 1GHz Horizontal Antenna Polarity Measured Emissions

								L	ong Ra	inge Sy	stems, LLC	C – ZB-	Beaco
			Pr	ofes	sional Te	sting, El	ΜI,	lnc.					
Test Metho	d:	ANSI C63	.10–2013										
n accordar	ice with:	FCC Part :	L5.209 - C	Code of I	Federal Regulat	ions Part 47,	Subpai	rt C - Int	entiona	I Radia	tors, Radiat	ed Emi	ssions
Section:		15.209											
Test Date(s):	4/11/20	17			EUT Serial	#:		#1 (an	tenna	1) #2 (an	tenna	2)
Customer:		Long Ra	nge Syst	ems		EUT Part #:	1		0				
Project Nur		18931				Test Techn	ician:		Spenc		t		
Purchase O		0				Supervisor			Lisa A				
Equip. Und	er Test:	ZB-Beac	on			Witness' N	ame:		Sam S	iddiqu	ıi		
	F	Radiated	Emissio	ns Test	Results Data	a Sheet				Pag	e: 1	of	1
EUT Li	ne Voltage	:	3	VDC		EUT Pow	ver Fr	equen	су:	0	N/A		
Antenna	Orientatio	n:		Vertic	al	Frequ	ency	Range:			Above 1	GHz	
	EUT N	/lode of (Operatio	n:		Transmitting (Top Chann				nanne	nnel - 2480 MHz)		
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degree	n He	tenna eight eters)	Detector Function	Recorded Amplitude (dBµV)	Le	ected evel iV/m)	Limit L		Margin (dB)	Test	Results
22290.5	3	204		1	Average	33.5	28	.307	54.	.0	-25.7	Р	ass
23395.3	3	203		1	Average	34.1	29	.292	54.	.0	-24.7	P	ass
24327.5	3	60		1	Average	33.6	29	.676	54.	.0	-24.3	P	ass
Radiated	cional Testing Emissions, Meas z Vertical Polarity M	ured at 1m ar		3m Distan				∨ Corr	age Limit Level ected Avera; Limit Level ected Peak R	ge Reading		T E S	SSIONAL TIN 6
18931_2016	Spencer Flint RE_FCC_2480M_1-2 M, Tuesday, April 11, 2				Free: TX CW #1 (ant.1) #2 (ar: 3V Battery	quency ant.2)		P	CUT: ZB- Bea Project Numb Client: Long F	er: 18931	ms		
		:	> 1GHz \	/ertica	l Antenna Po	larity Meas	ured	Emissi	ons				

								L	ong R	ange Sy	stems, LLC	– ZB-B	Beaco
-				Profess	sional Te	sting, EN	ΜI, I	lnc.					
Test Metho	od:	ANSI C	63.10-	-2013									
In accorda	nce with:	FCC Pa	rt 15.2	:09 - Code of I	ederal Regula	tions Part 47, S	Subpar	t C - Int	ention	al Radia	tors, Radiat	ed Emis	sions
Section:		15.209)										
Test Date(s	s):	4/11/	2017			EUT Serial	#:		#1 (a	ntenna	1) #2 (ant	tenna :	2)
Customer:		Long I	Range	Systems		EUT Part #:			0				
Project Nu	mber:	18931				Test Techni	ician:		Spen	cer Flin	it		
Purchase C	rder #:	0				Supervisor:			Lisa A	Arndt			
Equip. Und	er Test:	ZB-Be	acon			Witness' N	ame:		Sam	Siddiqu	ıi		
	F	Radiate	ed Em	issions Test	Results Dat	a Sheet				Pag	e: 1	of	1
EUT L	ine Voltage	:	3	VDC		EUT Pow	ver Fr	equen	су:	0	N/A		
Antenn	a Orientatio	n:		Horizor	ıtal	Freque	ency	Range:			Above 1	GHz	
	FUT N	/lode o	f One	eration:		-	-			`hanne	l - 2480 M	Hz)	
									lope	Jilailiic	1 2400 141	<i>.</i> ,	
Frequency Measured (MHz)	Test Distance (Meters)	Direc (Degr	tion	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Le	ected evel eV/m)	-	Level V/m)	Margin (dB)	Test R	Resul
22085	3	18	8	1	Average	33.6	28.	.306	54	1.0	-25.7	Pa	iss
23059.3	3	16		1	Average	34.1	_	.923	_	1.0	-25.0		iss
24345	3	13	3	1	Average	33.8	29.	.831	54	1.0	-24.1	Pa	iss
Radiated	sional Testing Emissions, Meas Iz Horizontal Polarity	ured at 1n	n and Sc	raled to 3m Distan	ce			▽ Corr	age Limit I ected Aver Limit Leve	rage Reading		PROFES	SIONAL
Field Strength (dBµV/m) 00 00 00 00 00 00 00 00 00 00 00 00 00	a lang ja distance ja and shake the lang sa	telike esk wik	tal about 18 and		ital-ma, an iti an sa shi					J. Marine		111 711	
30 20 18.0G							7			<u> </u>			
Operator:	Spencer Flint 6 RE_FCC_2480M_1-:	26G.til			Free: TX CW #1 (ant.1) #2 (r: 3V Battery	equency (ant.2)			EUT: ZB-Be Project Nu	eacon mber: 18931		26.	อเร

8.0 Antenna Construction Requirements

8.1 Procedure

A direct examination of the antenna construction is performed and compared to rule criteria that prevent wireless device antennas from being modified by end users.

8.2 Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.203 // RSS-Gen 8.3	Antenna Construction	17 Apr 2017

8.3 Results

Table 10.3.1 Antenna Construction Details
Manufacturer: Long Range Systems, LLC
Antennas (2) are shortened inverted F printed on circuit board; no connectors present.
Gain 0 dBi. Effect of gain is included in radiated measurements.

The antenna design above satisfies the requirements of the rules.

9.0 Equipment

9.1 Radiated Emissions 30 MHz to 25 GHz

Radiated Emissions Test Equipment List					
Tile! Software Version:	4.2.A, May 23, 2010, 08:38:52 AM				
Test Profile:	2016 RE_ClassA - Boresite+Mast_LowPRF_030617.til or 2016 RE_ClassB - Boresite+Mast_LowPRF_030617.til				

Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Braden	N/A	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	7/10/2017
1890	HP	8447F	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	2/1/2018
1937	Agilent	E4440A	Spectrum Analyzer, 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	11/15/2017
2172	ETS-Lindgren	3142C	Antenna, Biconilog, 26 MHz-3GHz	49383	11/27/2018
C027D	PTI	None	Relay	none	N/A
1327	EMCO	1050	Controller, Antenna Mast	none	N/A
0942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1969	НР	11713A	Attenuator/Switch Driver	3748A04113	N/A
1509B	Braden	N/A	TDK 10M Chamber, VSWR > 1 GHz	DAC-012915-005	6/19/2017
2004	Miteq	AFS44-00101800- 2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/11/2018
C030	none	none	Cable Coax, N-N, 30m	none	10/1/2017
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
819	EMCO	3115	Antenna, Horn, DRG, 1-18GHz	113	8/4/2018
1542	A.H. Systems	SAS-572	Antenna, Horn 18-26.5GHz, 20dB gain	225	11/20/2018
1974	Agilent	83017A	Amplifier, Microwave 0.5-26.5 GHz	MY39500684	11/17/2018

9.2 Bandwidth and Duty Cycle

Asset #	Manufacturer	Model # Description		Calibration Due
2295	Agilent	E4440A	Spectrum Analyzer	30 Sep 2017
None	ETS	5211	Shielded Test Enclosure	CNR
None	PTI	None	2 GHz Sleeve Dipole Sense Antenna	CNR
None	Various	None	Coaxial Cables, RG type	CNR

10.0 Measurement Bandwidths

Radiated Emissions Spectrum Analyzer Bandwidth and Measurement Time - Peak Scan							
Frequency Band Start (MHz)	Frequency Band Stop (MHz)	6 dB Bandwidth (kHz)	Number of Ranges Used	Measurement Time per Range			
0.009	0.15	0.3	2	Multiple Sweeps			
0.15	30	9	6	Multiple Sweeps			
30	1000	120	2	Multiple 800 mS Sweeps			
1000	6000	1000	2	Multiple Sweeps			
6000	18000	1000	2	Multiple Sweeps			
18000	26500	1000	2	Multiple Sweeps			

*Notes:

- 1. The settings above are specifically calculated for the E4440A series of spectrum analyzers, which have 8,000 data points per range.
- 2. The measurement receiver resolution bandwidth setting was 300 Hz for quasi-peak measurements from 9-150 kHz.
- 3. The measurement receiver resolution bandwidth setting was 9 kHz for quasi-peak measurements from 0.15-30 MHz.
- 4. The measurement receiver resolution bandwidth setting was 120 kHz for quasi-peak measurements from 30-1000 MHz.
- 5. The measurement receiver resolution bandwidth setting was 1 MHz for average measurements from 1-18 GHz.

Conducted Emissions Spectrum Analyzer Bandwidth and Measurement Time							
Frequency Band Start (MHz)	Frequency Band Stop (MHz)	6 dB Bandwidth (kHz)	Number of Ranges Used	Measurement Time per Range			
0.01	0.15	0.3	7	Five 1 second sweeps			
0.15	30	9	20	Five 1 second sweeps			

*Notes

- 1. The settings above are specifically calculated for the HP856X series of spectrum analyzers, which have 1,000 data points per range.
- 2. The measurement receiver resolution bandwidth setting was 300 Hz for quasi-peak measurements from 10-150 kHz.
- 3. The measurement receiver resolution bandwidth setting was 9 kHz for quasi-peak measurements from 0.15-30 MHz.

Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1: Summary of Measurement Uncertainties for Site 45

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Mains Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Telecom Conducted Emissions	150 kHz to 30 MHz	N/A	2.8
Radiated Emissions	30 to 1,000 MHz	10 m	4.8
Radiated Emissions	1 to 18 GHz	3 m	5.7

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