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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

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Reviewed by



Larry Finn  
Chief Technical Officer

Written by



Eric Lifsey  
EMC Engineer

**Revision History**

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

Corrections:

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# Compliance Certificate

Applicant	Device & Test Identification
Long Range Systems, LLC (John Weber) 4550 Excel Parkway Suite 200 Addison, Texas 75001 USA Certificate Date: 20 Apr 2016	FCC ID: 2AB60ZBEBACON Industry Canada ID: 5501A-ZBEBACON Model(s): ZB-Beacon 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, 2400-2483.5 MHz, 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 (All 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.

Eric Lifsey  
EMC Engineer

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

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

<b>Table 1.2.2: Support Equipment</b>		
<b>Manufacturer / Model</b>	<b>Serial #</b>	<b>Description</b>
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

<b>Table 1.6.1 Measurement Corrections</b>	
<b>Parameter</b>	<b>From Sums Of</b>
<b>Radiated Field Strength</b>	Raw Measured Level + Antenna Factor + Cable Losses – Amplifier Gain
<b>Conducted Antenna Port</b>	Raw Measured Level + Attenuator Factor + Cable Losses
<b>Conducted Mains Port</b>	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

<b>Table 1.7.1: Applicable Documents</b>	
<b>Document</b>	<b>Title</b>
47 CFR	Part 15 – Radio Frequency Devices Subpart C -Intentional Radiators
RSS-247 Issue 1	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
ANSI C63.10:2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

<b>Table 1.7.2: Applicable Clauses</b>		
<b>Parameter</b>	<b>FCC Part 15 Rule Paragraphs</b>	<b>IC RSS References</b>
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
15.247(a)(3) // RSS-247 5.2	Fundamental Power Conducted Limits 1 W Limit Restated as Field: 125.23 dB $\mu$ V/m @ 3 m	12 Apr 2017 13 Apr 2017

### 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 dB $\mu$ V/m @ 10 m Vertical Polarity	Measured Peak Power dB $\mu$ V/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 Power, Peak, Radiated, Antenna 2			
Frequency MHz	Measured Peak Power dB $\mu$ V/m @ 10 m Vertical Polarity	Measured Peak Power dB $\mu$ V/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

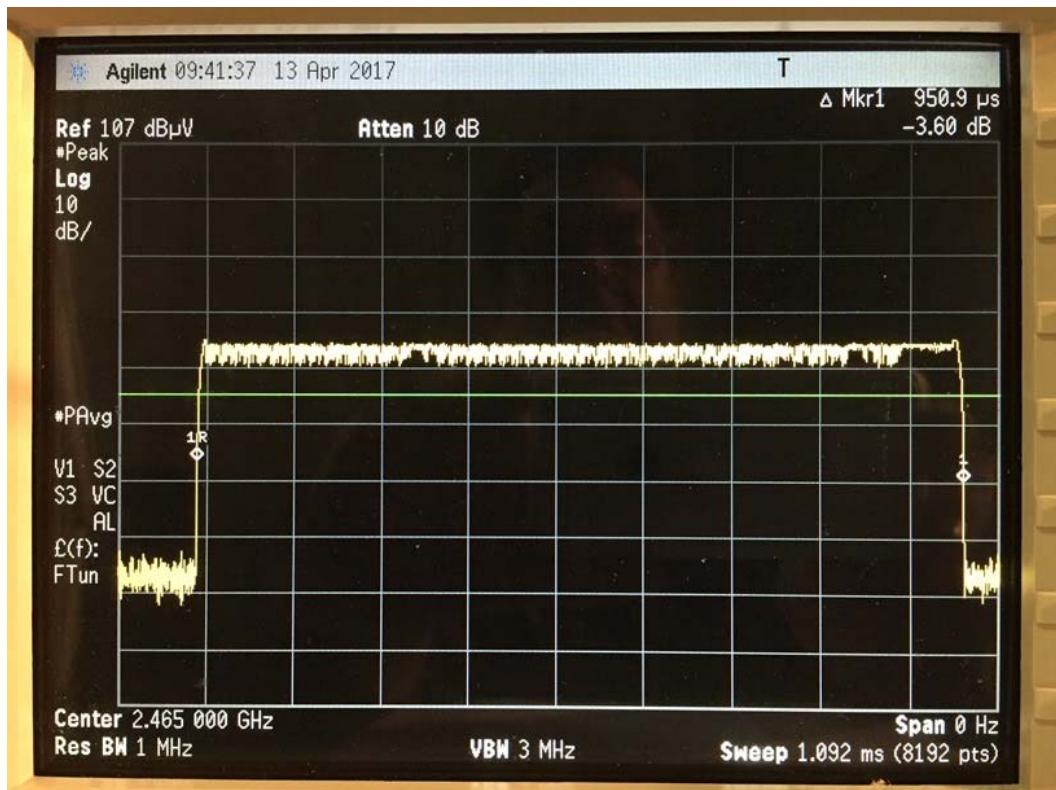
Measurement is based on intervals not to exceed 100 msec. Maximum transmitter on time is divided by the lesser of 100 msec or the actual measured minimum transmitter interval time. The result is converted to dB and applied as needed to peak measurements of transmitter artifacts to determine average power.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

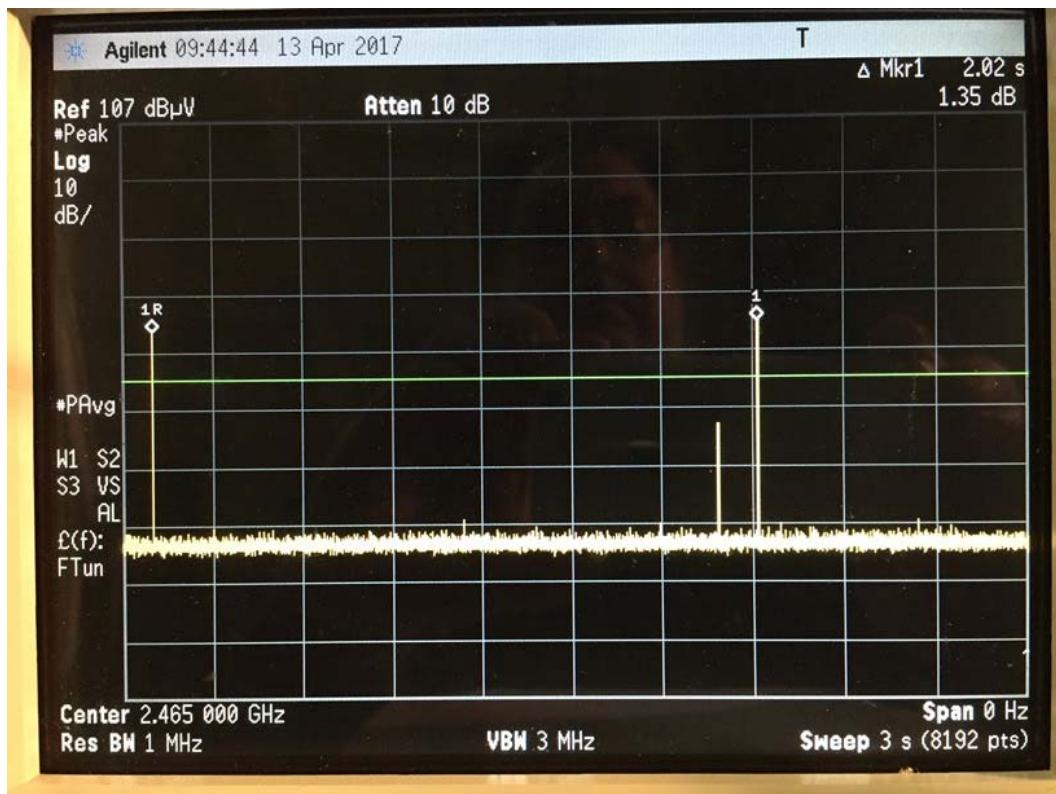
**Table 2.4.1 Duty Cycle Results and Average Duty Cycle Factor Result**

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 <sub>10</sub> (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

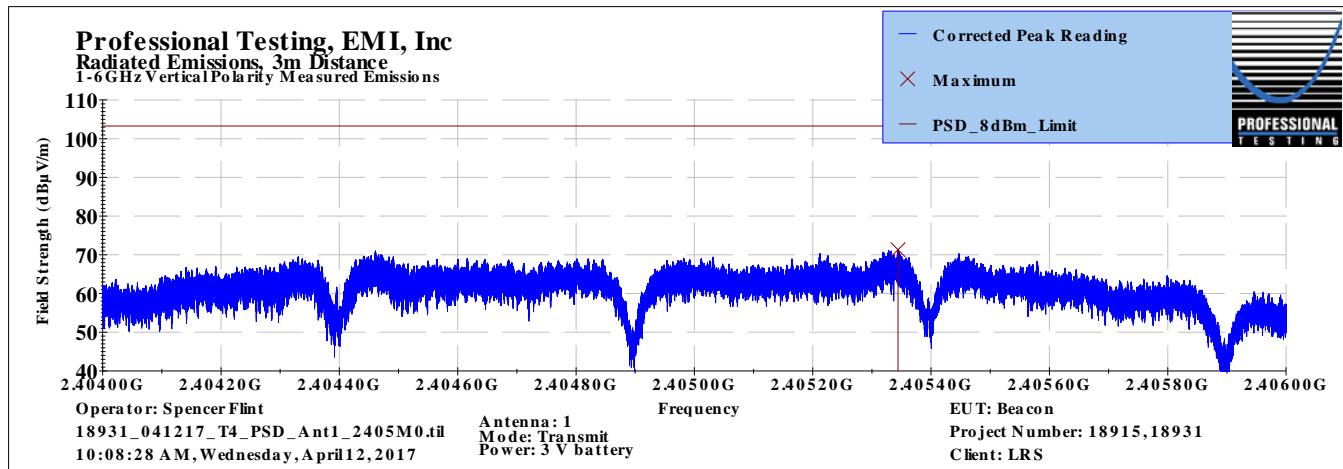
47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date
15.247(e) // RSS-247, 5.2	Power Spectral Density, Conducted Limit: 8 dBm / 3 kHz Restated as field strength limit: 103.23 dB $\mu$ V/m at 3 m	12 Apr 2017

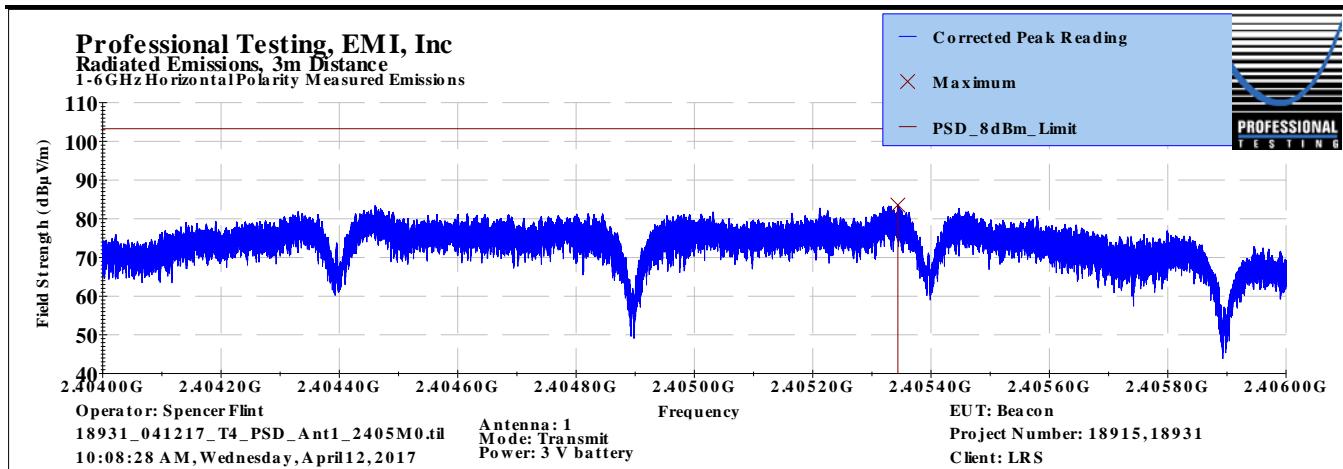
### 3.3 Test Results

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 dB $\mu$ V/m @ 10 m Vertical Polarity	Measured Peak Power dB $\mu$ V/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.

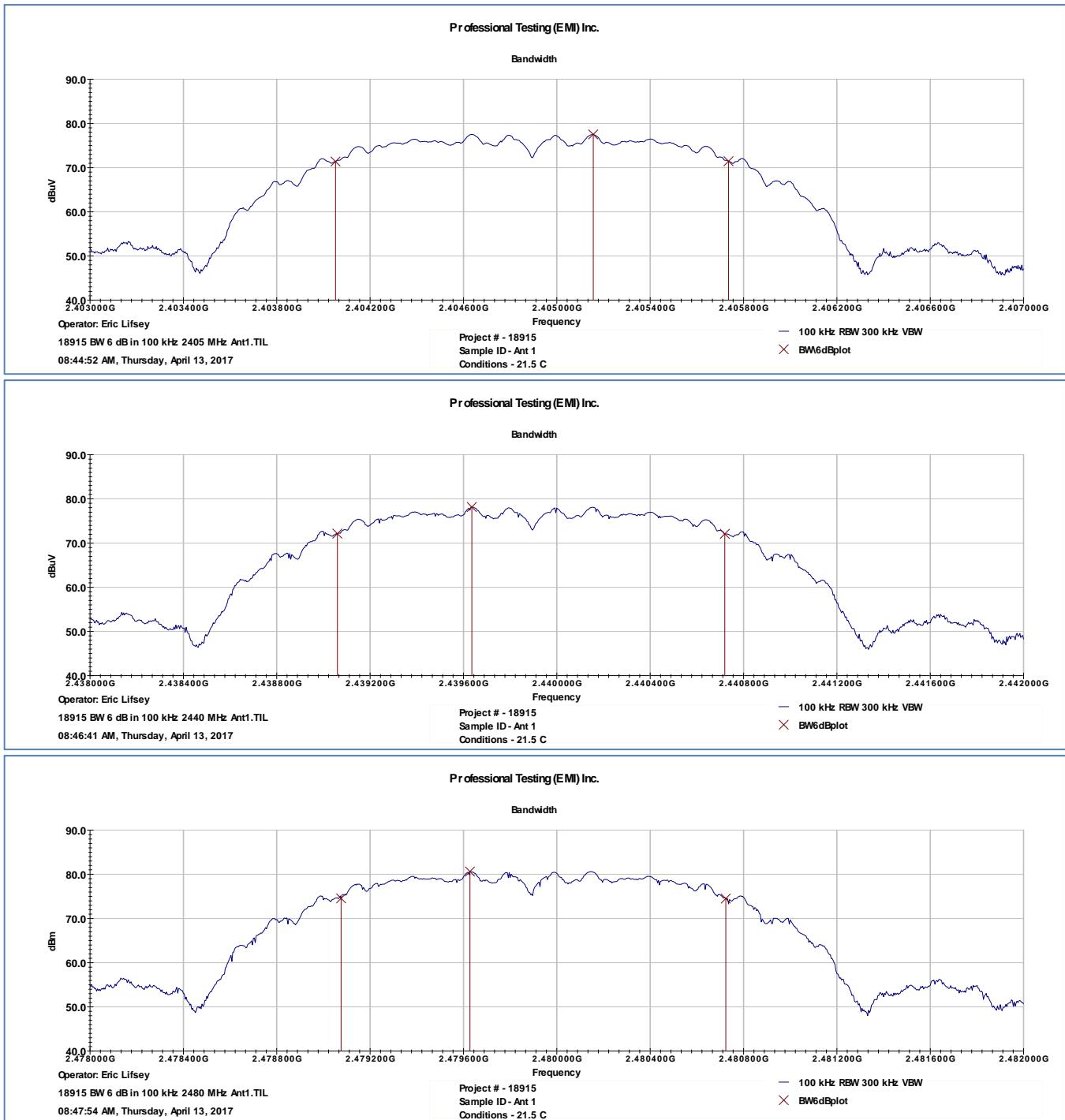
The EUT was found to be in compliance with applicable requirements.

Table 4.3.1 Antenna 1			
Bandwidth 6 dB, Minimum 500 kHz in 100 kHz RBW			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Minimum BW (kHz)
1684	1660	1648	<b>1648</b>
Bandwidth 20 dB, Measure and Report			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Maximum BW (kHz)
2516	2532	2564	<b>2564</b>

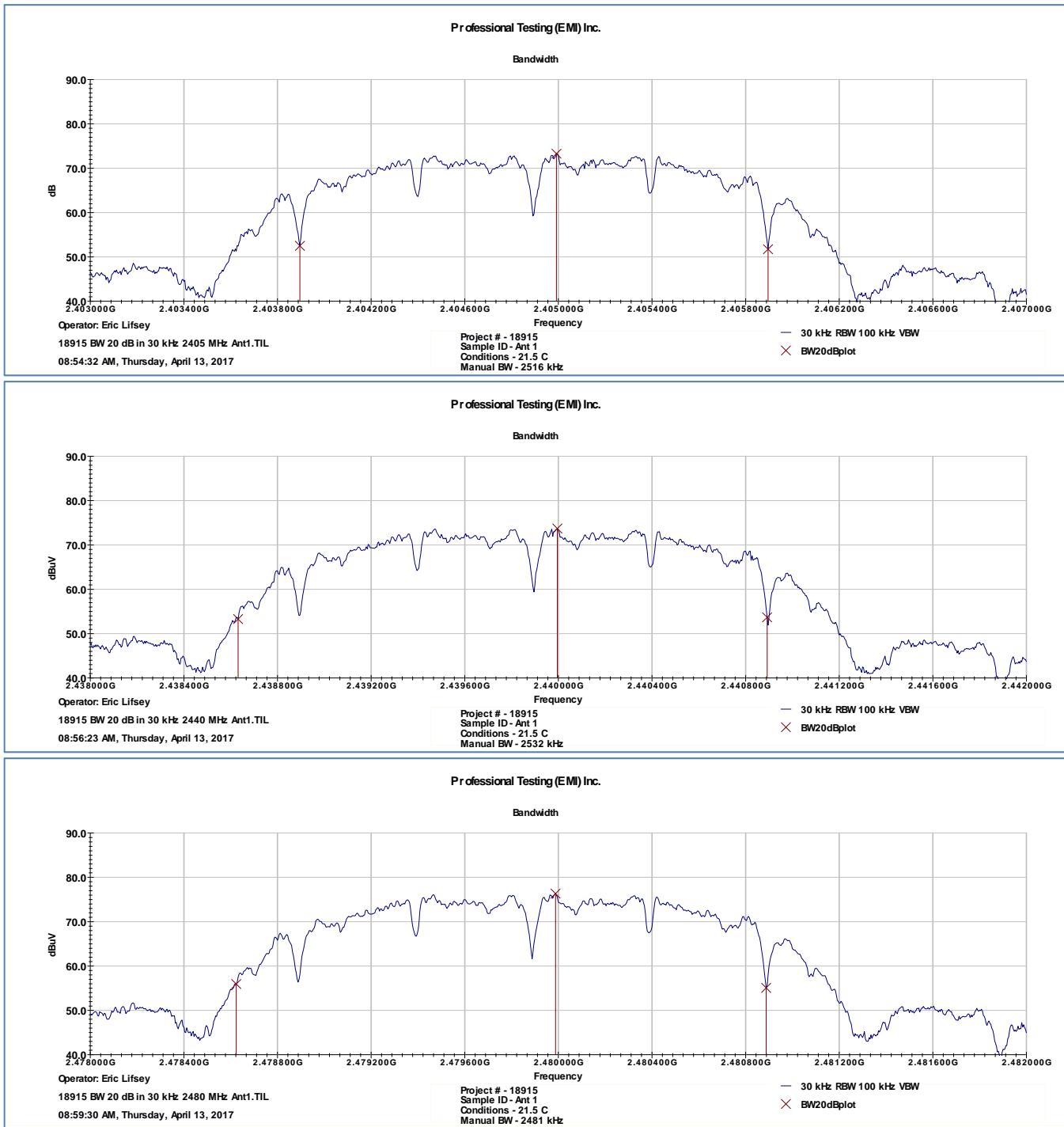
Table 4.3.2 Antenna 2			
Bandwidth 6 dB, Minimum 500 kHz in 100 kHz RBW			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Minimum BW (kHz)
1692	1652	1692	<b>1652</b>
Bandwidth 20 dB, Measure and Report			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Maximum BW (kHz)
2524	2540	2528	<b>2540</b>

Plotted measurements appear on the following pages.

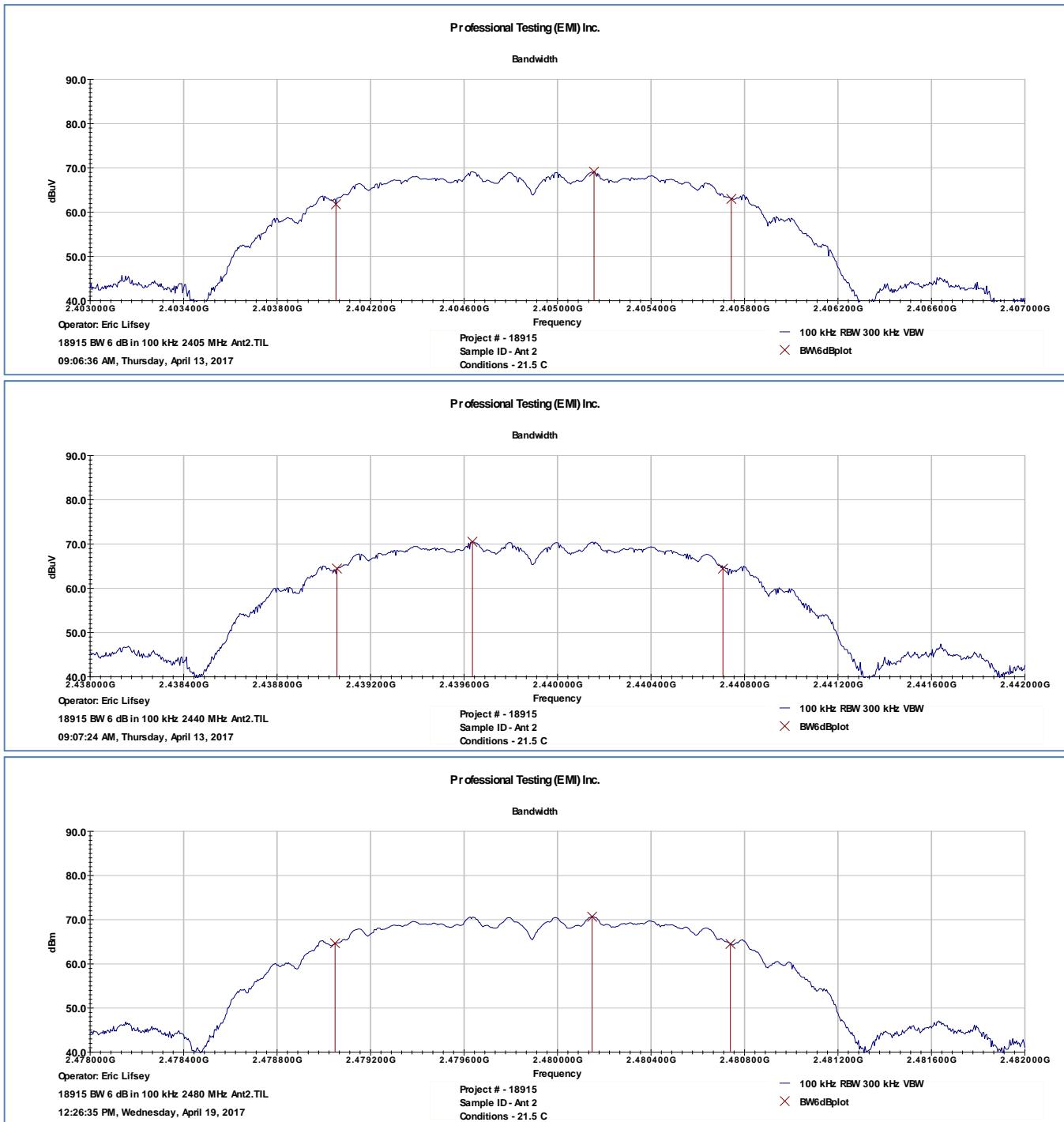
### 4.3.1 Bandwidth Plots, 6 dB, Antenna 1



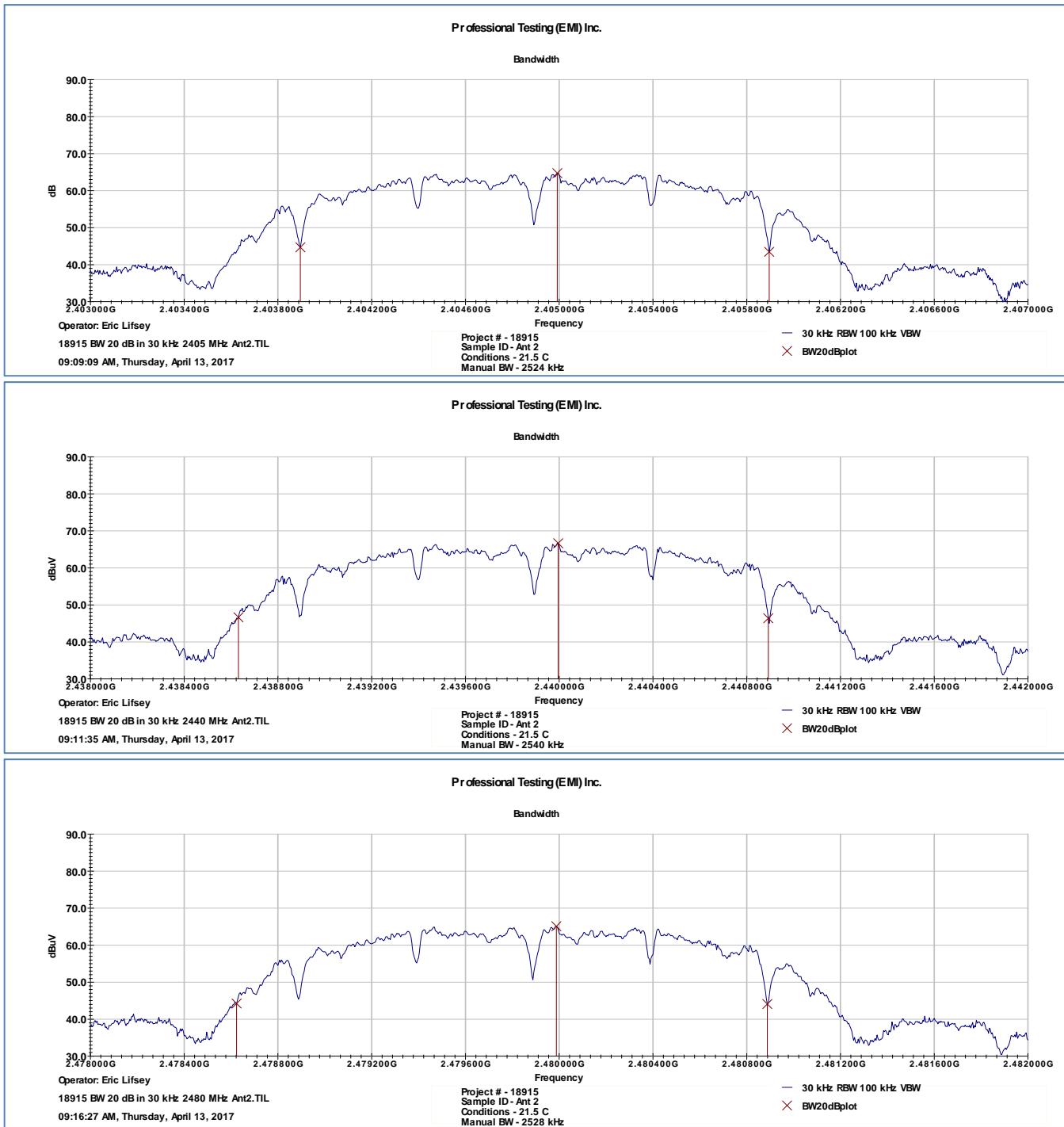
#### 4.3.2 Bandwidth Plots, 20 dB, Antenna 1



### 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 // RSS-247 5.5, RSS-Gen 4.9	Unwanted Emissions Adjacent to Authorized Band, Radiated	12 Apr 2017

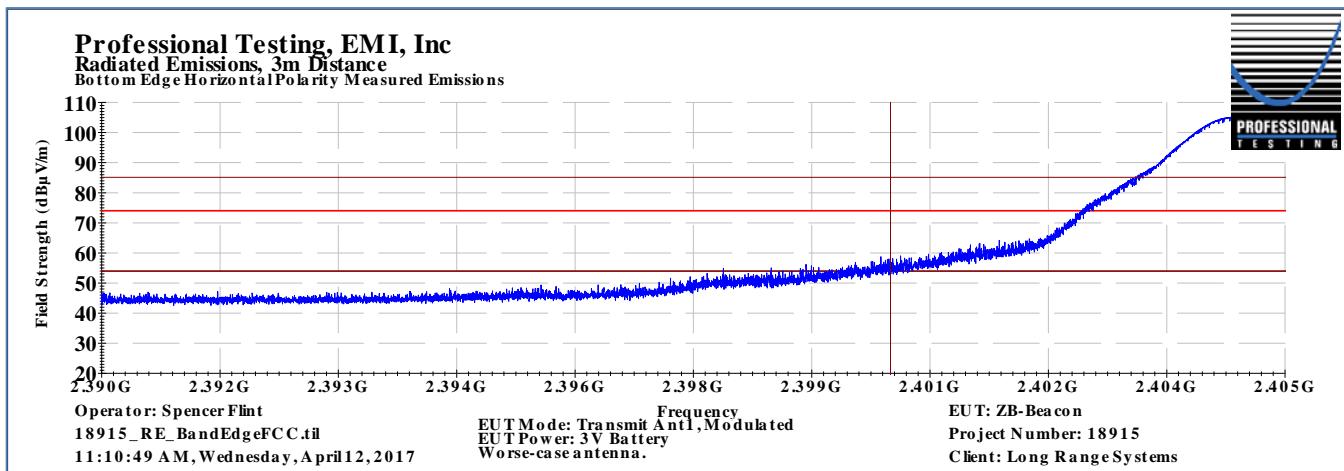
### 5.3 Test Results

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.

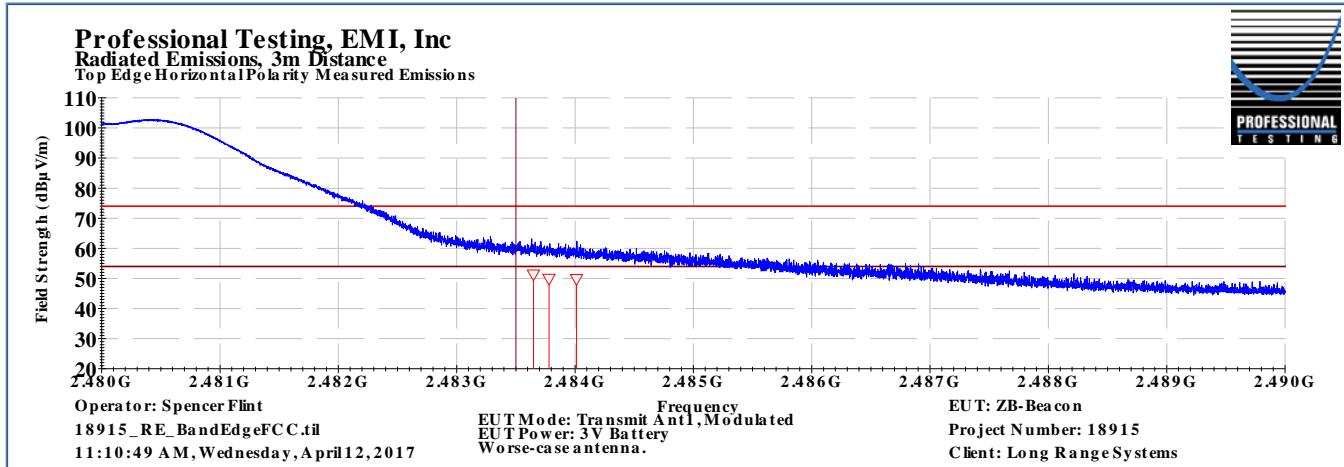
The EUT satisfied the criteria. Plotted results of peak detection appear on the following pages.

### 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**

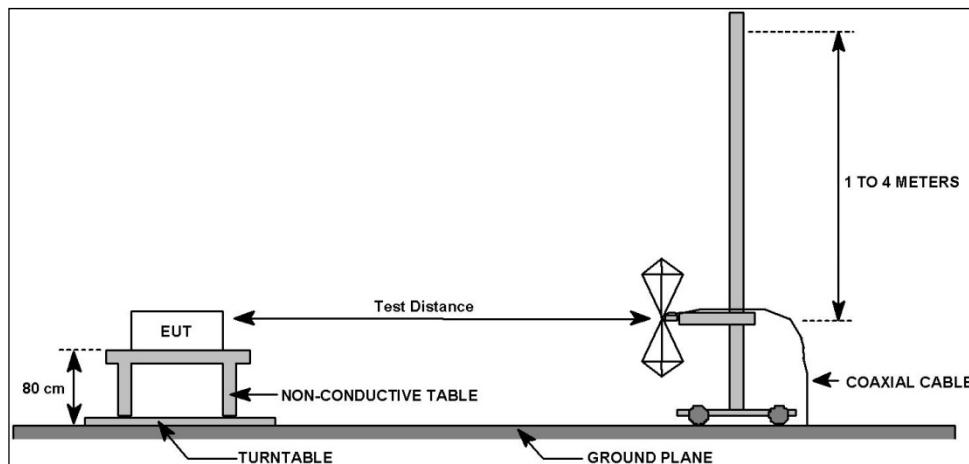
Frequency (MHz)	Raw Peak (dB $\mu$ V)	Raw Avg (dB $\mu$ V)	Azimuth (deg)	Height (cm)	Corrected Peak (dB $\mu$ V)	Corrected Avg (dB $\mu$ V)
2483.65	69.1	59.6	40	322	60.810	51.288
2483.78	68.4	58.2	50	228	60.054	49.852
2484.01	68.9	58.1	51	266	60.601	49.806

## 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

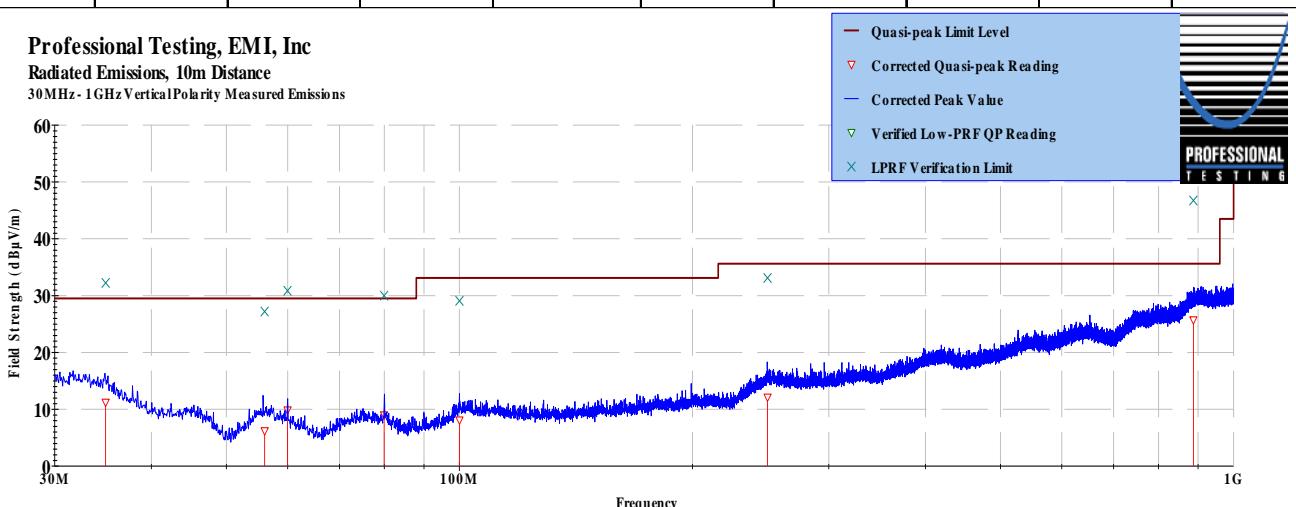
47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.209 // RSS-247 5.5, RSS-Gen 4.9 & 4.10	Field Strength of Radiated Spurious/Harmonic Emissions Receive Mode	13 Apr 2017

### 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

Professional Testing, EMI, Inc.									
<b>Test Method:</b>	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices								
<b>In accordance with:</b>	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits								
<b>Section:</b>	15.109								
<b>Test Date(s):</b>	4/13/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #3 (antenna 2)						
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	None						
<b>Project Number:</b>	18915-10	<b>Test Technician:</b>	Bob Redoutey						
<b>Purchase Order #:</b>	N/A	<b>Supervisor:</b>	Lisa Arndt						
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	None						
Radiated Emissions Test Results Data Sheet									
Page: 1 of 1									
<b>EUT Line Voltage:</b>	3 VDC	<b>EUT Power Frequency:</b>	-	N/A					
<b>Antenna Orientation:</b>	Vertical	<b>Frequency Range:</b>	30MHz to 1GHz						
<b>EUT Mode of Operation:</b>					<b>Receive Mode</b>				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
34.9255	10	160	3.61	Quasi-peak	23	11.239	29.5	-18.3	Pass
56.0396	10	232	1.76	Quasi-peak	24	6.207	29.5	-23.3	Pass
59.9924	10	280	3.87	Quasi-peak	28.1	9.869	29.5	-19.6	Pass
79.9374	10	152	3.82	Quasi-peak	27.5	8.997	29.5	-20.5	Pass
100.004	10	245	1.33	Quasi-peak	24.6	8.085	33.1	-25.0	Pass
250.11	10	40	1.82	Quasi-peak	22.1	12.114	35.6	-23.5	Pass
887.492	10	210	2.04	Quasi-peak	21.4	25.717	35.6	-9.9	Pass
<b>Professional Testing, EMI, Inc</b> Radiated Emissions, 10m Distance 30 MHz - 1 GHz Vertical Polarity Measured Emissions									
									
Operator: Bob Redoutey				EUT Mode: Receive Mode					
18915_FCC_2016 RE_ClassB - 032117.tif				EUT Power: 3 VDC Battery					
08:10:37 PM, Thursday, April 13, 2017					Project Number: 18915-10				
					Client: Long Range Systems				
<b>≤ 1GHz Vertical Antenna Polarity Measured Emissions</b>									

# Professional Testing, EMI, Inc.

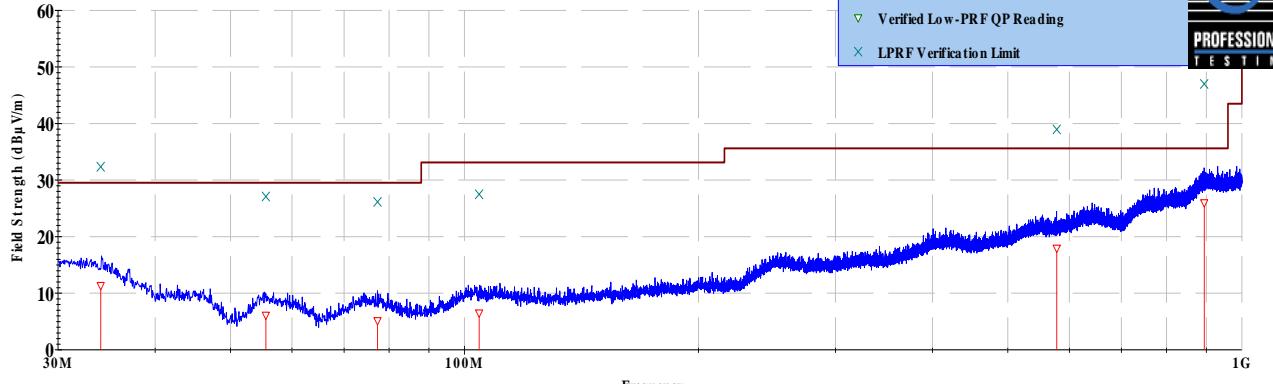
<b>Test Method:</b>	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
<b>In accordance with:</b>	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.109		
<b>Test Date(s):</b>	4/13/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #3 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	None
<b>Project Number:</b>	18915-10	<b>Test Technician:</b>	Bob Redoutey
<b>Purchase Order #:</b>	N/A	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	None

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>	3 VDC	<b>EUT Power Frequency:</b>	- N/A						
<b>Antenna Orientation:</b>	Horizontal	<b>Frequency Range:</b>	30MHz to 1GHz						
<b>EUT Mode of Operation:</b>			<b>Receive Mode</b>						
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/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	6.094	29.5	-23.4	Pass
77.2872	10	182	1.51	Quasi-peak	23.2	5.133	29.5	-24.4	Pass
104.429	10	80	3.87	Quasi-peak	23	6.489	33.1	-26.6	Pass
577.95	10	244	1.56	Quasi-peak	22	17.94	35.6	-17.7	Pass
894.427	10	57	1.15	Quasi-peak	21.4	25.977	35.6	-9.6	Pass

Professional Testing, EMI, Inc  
Radiated Emissions, 10m Distance  
30MHz - 1GHz Horizontal Polarity Measured Emissions



Operator: Bob Redoutey

18915\_FCC\_2016 RE\_ClassB - 032117.til  
08:10:37 PM, Thursday, April 13, 2017EUT Mode: Receive Mode  
EUT Power: 3 VDC Battery

EUT: LRS Beacon

Project Number: 18931-10  
Client: Long Range Systems**≤ 1GHz Horizontal Antenna Polarity Measured Emissions**

### 6.3.2 Up to 13 GHz

Professional Testing, EMI, Inc.									
<b>Test Method:</b>	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices								
<b>In accordance with:</b>	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits								
<b>Section:</b>	15.109								
<b>Test Date(s):</b>	4/13/2017			<b>EUT Serial #:</b>	#1 (antenna 1) #3 (antenna 2)				
<b>Customer:</b>	Long Range Systems			<b>EUT Part #:</b>	None				
<b>Project Number:</b>	18915-10			<b>Test Technician:</b>	Bob Redoutey				
<b>Purchase Order #:</b>	N/A			<b>Supervisor:</b>	Lisa Arndt				
<b>Equip. Under Test:</b>	ZB-Beacon			<b>Witness' Name:</b>	None				
Radiated Emissions Test Results Data Sheet							Page:	1	of 1
<b>EUT Line Voltage:</b>	3 VDC			<b>EUT Power Frequency:</b>	- N/A				
<b>Antenna Orientation:</b>	Vertical			<b>Frequency Range:</b>	Above 1GHz				
<b>EUT Mode of Operation:</b>					<b>Receive Mode</b>				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
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
Professional Testing, EMI, Inc Radiated Emissions, 3m Distance 1-18 GHz Vertical Polarity Measured Emissions									
Operator: Bob Redoutey 18915_FCC_2016 RE_ClassB - 032117.til 08:10:38 PM, Thursday, April 13, 2017									
EUT Mode: Receive Mode EUT Power: 3 VDC Battery Project Number: 18931-10 Client: Long Range Systems									
<b>&gt; 1GHz Vertical Antenna Polarity Measured Emissions</b>									

# Professional Testing, EMI, Inc.

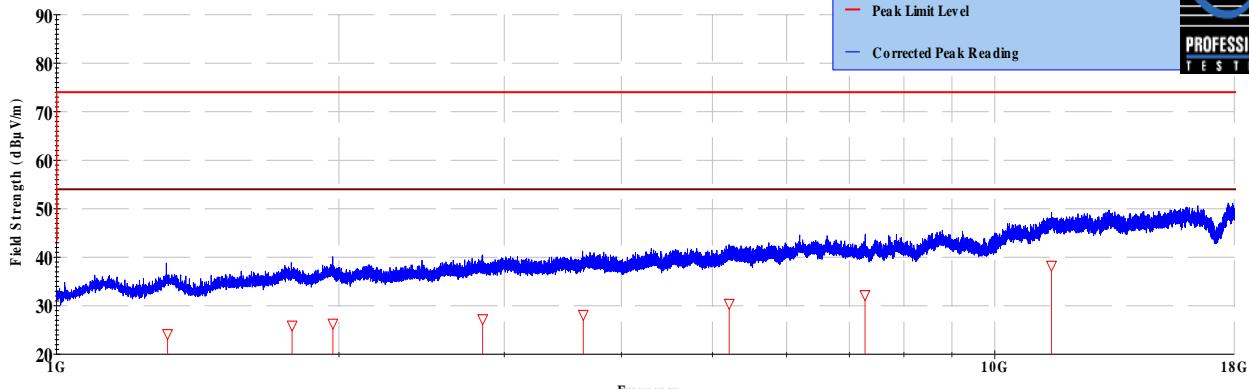
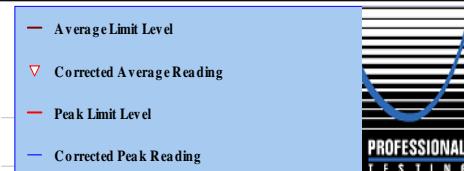
<b>Test Method:</b>	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
<b>In accordance with:</b>	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.109		
<b>Test Date(s):</b>	4/13/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #3 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	None
<b>Project Number:</b>	18915-10	<b>Test Technician:</b>	Bob Redoutey
<b>Purchase Order #:</b>	N/A	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	None

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>	3 VDC	<b>EUT Power Frequency:</b>	- N/A						
<b>Antenna Orientation:</b>	Horizontal	<b>Frequency Range:</b>	Above 1GHz						
<b>EUT Mode of Operation:</b>			<b>Receive Mode</b>						
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/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

Professional Testing, EMI, Inc  
Radiated Emissions, 3m Distance  
1-18GHz Horizontal Polarity Measured Emissions



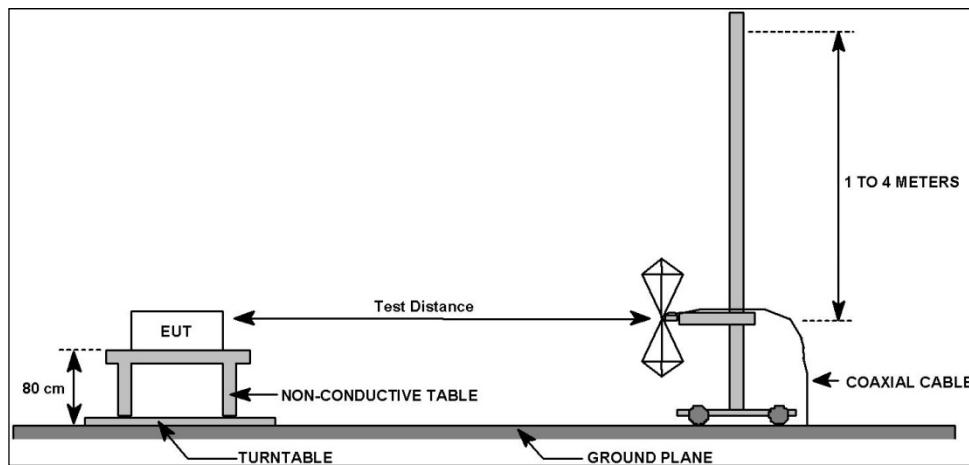
> 1GHz Horizontal Antenna Polarity Measured Emissions

## 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

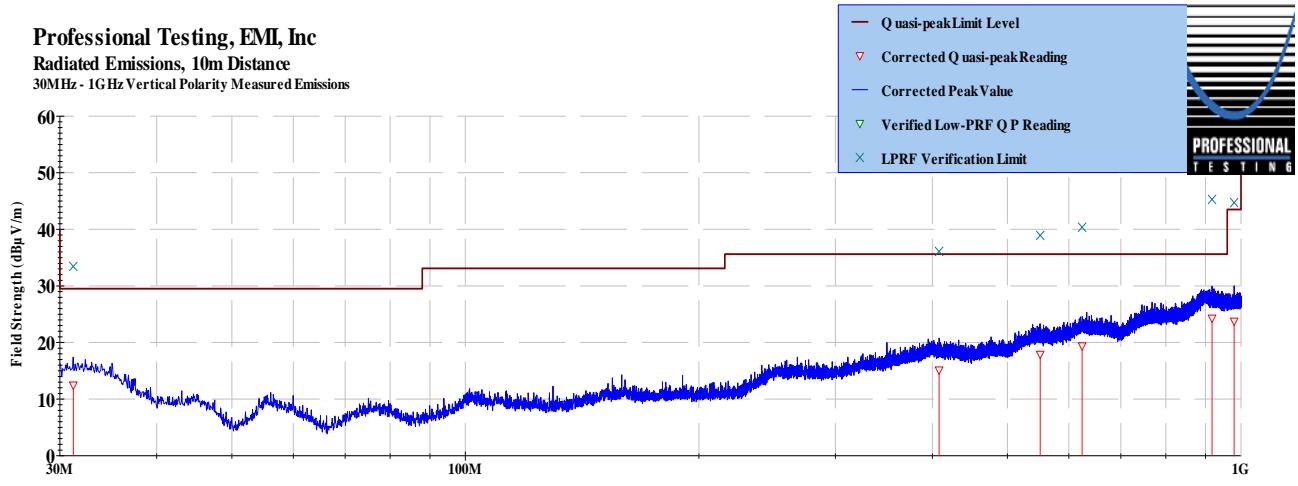
### 7.3 Test Results

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

Professional Testing, EMI, Inc.									
Test Method: ANSI C63.10-2013									
In accordance with: FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits									
Section: 15.209									
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:	Vertical			Frequency Range:	30MHz to 1GHz				
EUT Mode of Operation:					Transmitting (Mid Channel - 2440 MHz)				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (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	-20.5	Pass
551.02	10	59	3.39	Quasi-peak	22.1	17.903	35.6	-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
 <p>Professional Testing, EMI, Inc Radiated Emissions, 10m Distance 30MHz - 1GHz Vertical Polarity Measured Emissions</p> <p>Field Strength (dB<math>\mu</math>V/m)</p> <p>Frequency</p> <p>Operator: Spencer Flint 18931_2016 RE_FCC_2440M_30M-26G.til 10:17:38 AM, Tuesday, April 11, 2017</p> <p>EUT Mode: TX CW Mode #1 (ant.1) #2 (ant.2) EUT Power: 3V Battery Powered</p> <p>EUT: ZB-Beacon Project Number: 18931 Client: Long Range Systems</p>									
$\leq$ 1GHz Vertical Antenna Polarity Measured Emissions									

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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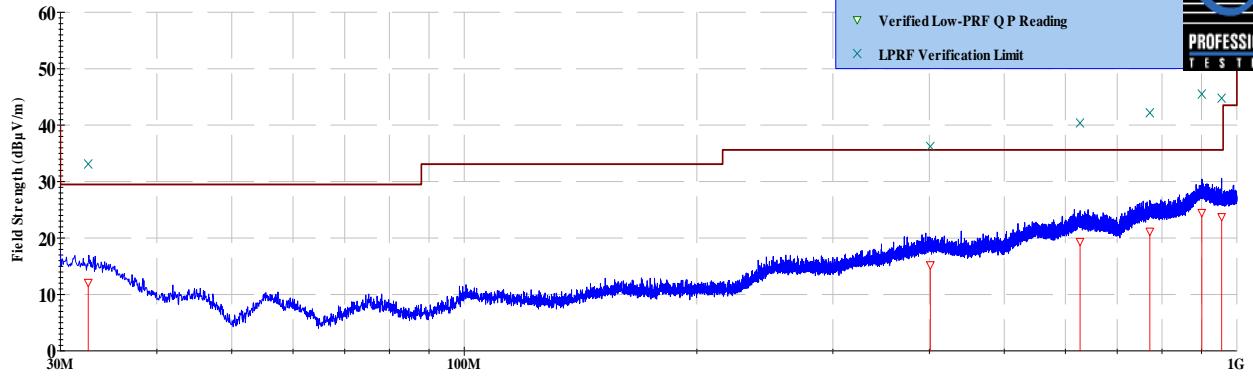
<b>Antenna Orientation:</b>	Horizontal	<b>Frequency Range:</b>	30MHz to 1GHz
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### EUT Mode of Operation:

Transmitting (Mid Channel - 2440 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/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	19.371	35.6	-16.2	Pass
771.74	10	20	1.42	Quasi-peak	21.6	21.19	35.6	-14.4	Pass
900.829	10	350	2.6	Quasi-peak	21.2	24.502	35.6	-11.1	Pass
955.754	10	39	2.02	Quasi-peak	21	23.766	35.6	-11.8	Pass

**Professional Testing, EMI, Inc**  
Radiated Emissions, 10m Distance  
30MHz - 1GHz Horizontal Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2440M\_30M-26G.til

10:17:38 AM, Tuesday, April 11, 2017

EUT Mode: TX CW Mode #1 (ant.1) #2 (ant.2)  
EUT Power: 3V Battery Powered

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

## ≤ 1GHz Horizontal Antenna Polarity Measured Emissions

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

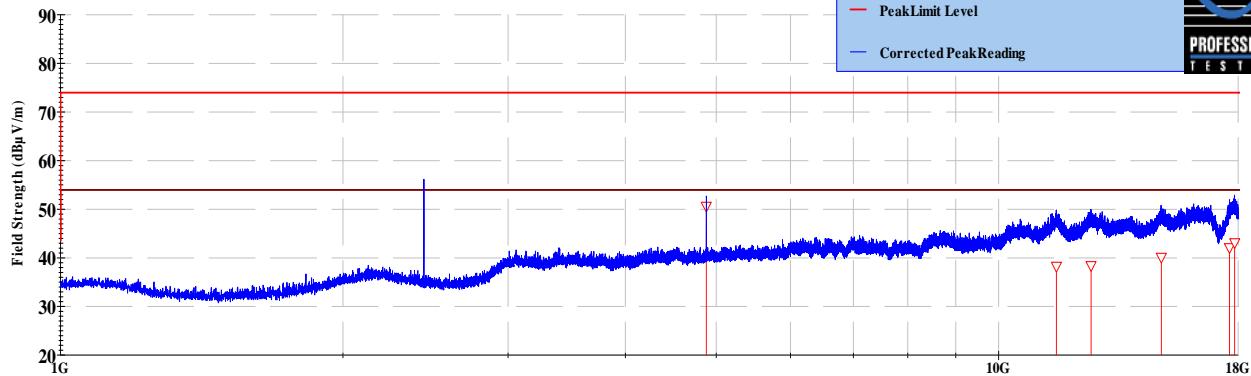
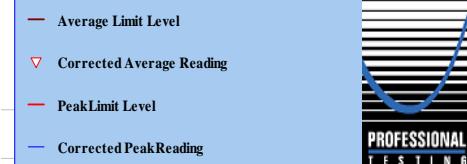
<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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<b>Antenna Orientation:</b>	Vertical	<b>Frequency Range:</b>	Above 1GHz		
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### EUT Mode of Operation: Transmitting (Mid Channel - 2440 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4879.73	3	330	1.78	Average	54.1	50.581	54.0	-3.4	Pass
11523.2	3	311	3.47	Average	27.2	38.227	54.0	-15.7	Pass
12546.4	3	173	3.01	Average	27.6	38.357	54.0	-15.6	Pass
14904.8	3	45	1.43	Average	28.4	40.097	54.0	-13.9	Pass
17618.6	3	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

Professional Testing, EMI, Inc  
Radiated Emissions, 3m Distance  
1-18GHz Vertical Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2440M\_30M-26G.til

11:45:56 AM, Tuesday, April 11, 2017

EUT Mode: TX CW Mode #1 (ant.1) #2 (ant.2)  
EUT Power: 3V Battery Powered

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

**> 1GHz Vertical Antenna Polarity Measured Emissions**

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

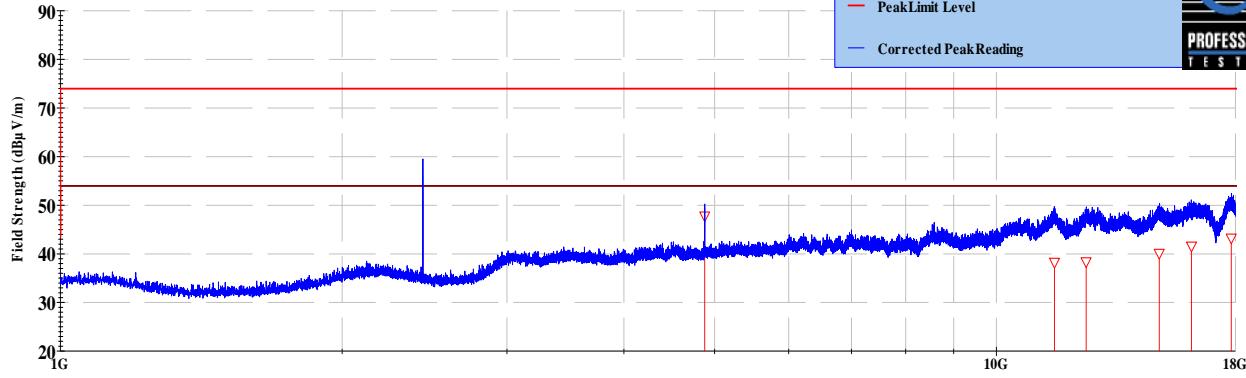
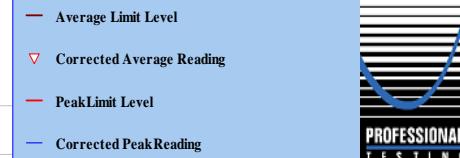
<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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<b>Antenna Orientation:</b>	Horizontal	<b>Frequency Range:</b>	Above 1GHz
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### EUT Mode of Operation: Transmitting (Mid Channel - 2440 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4879.9	3	292	1.88	Average	51.2	47.753	54.0	-6.2	Pass
11534.3	3	171	3.72	Average	27.3	38.219	54.0	-15.7	Pass
12468.4	3	31	3.83	Average	27.6	38.334	54.0	-15.6	Pass
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	-12.4	Pass
17816	3	122	2.25	Average	27.1	43.213	54.0	-10.7	Pass

Professional Testing, EMI, Inc  
Radiated Emissions, 3m Distance  
1-18GHz Horizontal Polarity Measured Emissions



**> 1GHz Horizontal Antenna Polarity Measured Emissions**

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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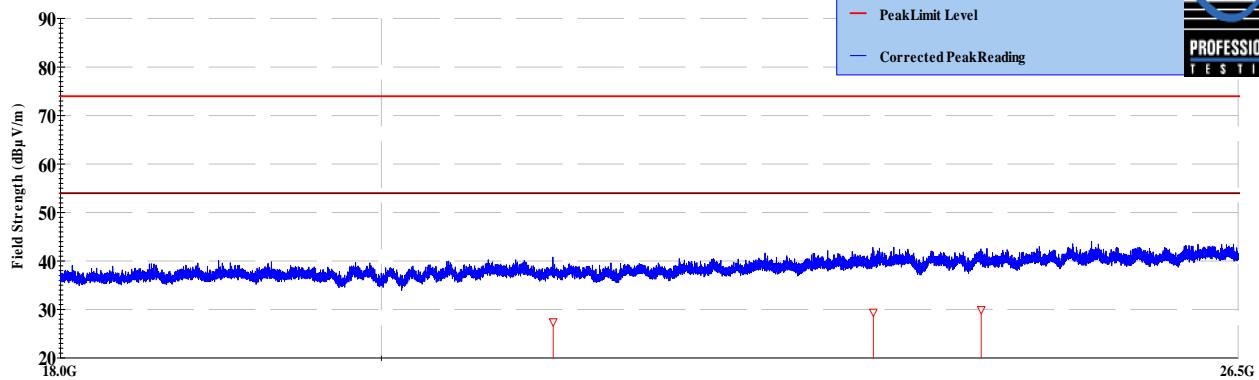
<b>Antenna Orientation:</b>	Vertical	<b>Frequency Range:</b>	Above 1GHz		
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### EUT Mode of Operation: Transmitting (Mid Channel - 2440 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
21162.1	3	20	1	Average	33.2	27.403	54.0	-26.6	Pass
23507.2	3	44	1	Average	34.1	29.41	54.0	-24.5	Pass
24355.6	3	302	1	Average	33.9	29.922	54.0	-24.0	Pass

### Professional Testing, EMI, Inc

Radiated Emissions, Measured at 1m and Scaled to 3m Distance  
18-26.5 GHz Vertical Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2440M\_30M-26G.til

04:33:05 PM, Tuesday, April 11, 2017

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

### > 1GHz Vertical Antenna Polarity Measured Emissions

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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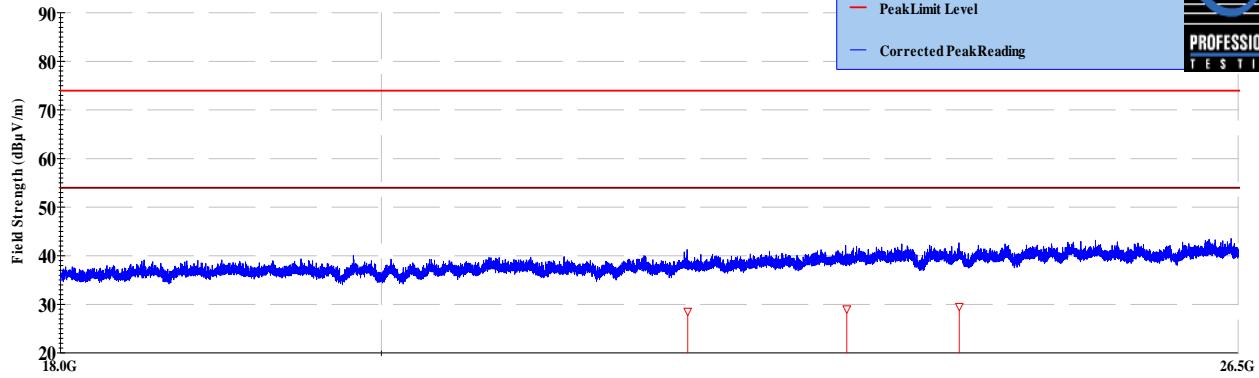
<b>Antenna Orientation:</b>	Horizontal	<b>Frequency Range:</b>	Above 1GHz		
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### EUT Mode of Operation: Transmitting (Mid Channel - 2440 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
22116.8	3	121	1	Average	33.8	28.513	54.0	-25.4	Pass
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 1m and Scaled to 3m Distance  
18-26.5 GHz Horizontal Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2440M\_30M-26G.til

04:33:05 PM, Tuesday, April 11, 2017

EUT Mode: TX CW Mode #1 (ant.1) #2 (ant.2)

EUT Power: 3V Battery Powered

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

**> 1GHz Horizontal Antenna Polarity Measured Emissions**

### 7.3.2 Bottom Channel, 1 GHz to 25 GHz

Professional Testing, EMI, Inc.									
Test Method: ANSI C63.10-2013									
In accordance with: FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits									
Section: 15.209									
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:	Vertical			Frequency Range:	Above 1GHz				
EUT Mode of Operation:					Transmitting (Bottom Channel - 2405 MHz)				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4809.79	3	21	1.8	Average	56.3	52.588	54.0	-1.4	Pass
7164.82	3	281	1.91	Average	29.7	32.556	54.0	-21.4	Pass
11512.3	3	171	2.15	Average	27.3	38.375	54.0	-15.6	Pass
12510.2	3	9	3.87	Average	27.8	38.563	54.0	-15.4	Pass
17730.7	3	145	3.5	Average	26.7	42.677	54.0	-11.3	Pass
<p>Professional Testing, EMI, Inc Radiated Emissions, 3m Distance 1-18GHz Vertical Polarity Measured Emissions</p> <p>Field Strength (dB<math>\mu</math>V/m)</p> <p>Frequency</p> <p>1G 10G 18G</p> <p>Operator: Spencer Flint 18931_2016 RE_FCC_2405M_1-26G.tfl 03:00:46 PM, Tuesday, April 11, 2017</p> <p>EUT Mode: TX CW #1 (ant.1) #2 (ant.2) EUT Power: 3V Battery</p> <p>EUT: ZB-Beacon Project Number: 18931 Client: Long Range Systems</p>									
> 1GHz Vertical Antenna Polarity Measured Emissions									

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

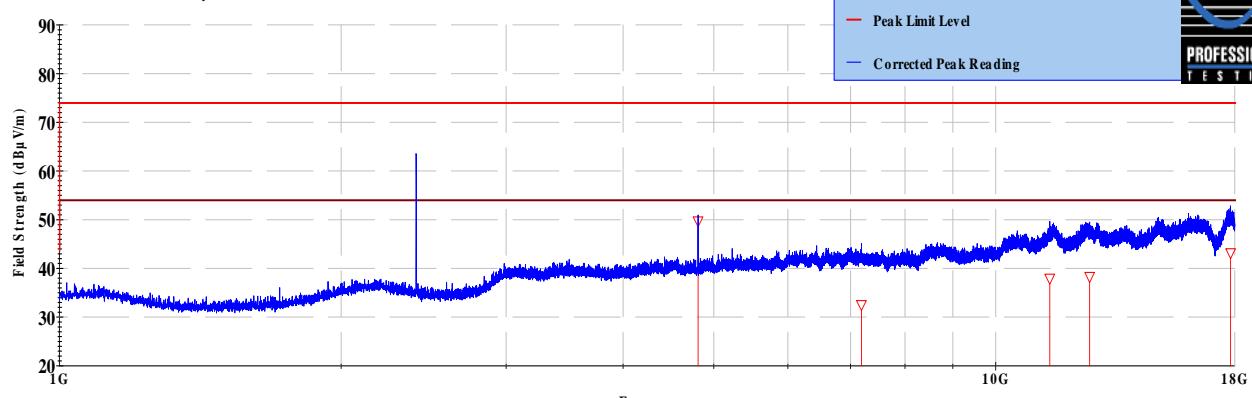
<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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<b>Antenna Orientation:</b>	Horizontal	<b>Frequency Range:</b>	Above 1GHz		
-----------------------------	------------	-------------------------	------------	--	--

### EUT Mode of Operation: Transmitting (Bottom Channel - 2405 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
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	Average	27.1	37.937	54.0	-16.0	Pass
12598.6	3	167	2.73	Average	27.6	38.299	54.0	-15.7	Pass
17817.9	3	84	1.74	Average	27.1	43.172	54.0	-10.8	Pass

Professional Testing, EMI, Inc  
Radiated Emissions, 3m Distance  
1-18 GHz Horizontal Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2405M\_1-26G.fil

03:00:46 PM, Tuesday, April 11, 2017

EUT Mode: TX CW #1 (ant.1) #2 (ant.2)  
EUT Power: 3V Battery

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

> 1GHz Horizontal Antenna Polarity Measured Emissions

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

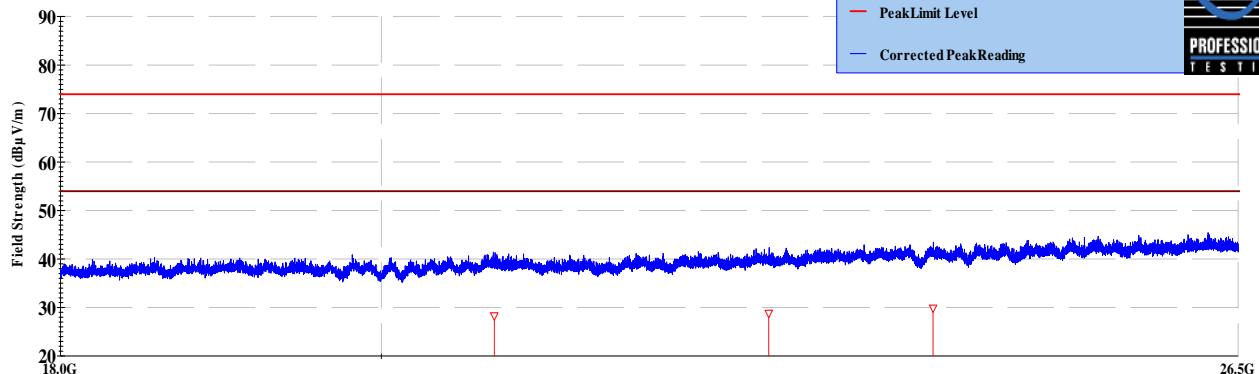
## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>		3	<b>VDC</b>	<b>EUT Power Frequency:</b>		0	N/A		
<b>Antenna Orientation:</b>		Vertical		<b>Frequency Range:</b>		Above 1GHz			
<b>EUT Mode of Operation:</b>				<b>Transmitting (Bottom Channel - 2405 MHz)</b>					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
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

### Professional Testing, EMI, Inc

Radiated Emissions, Measured at 1m and Scaled to 3m Distance  
18-26.5 GHz Vertical Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2405M\_1-26G.til

03:58:26 PM, Tuesday, April 11, 2017

EUT Mode: TX CW #1 (ant.1) #2 (ant.2)

EUT Power: 3V Battery

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

## > 1GHz Vertical Antenna Polarity Measured Emissions

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

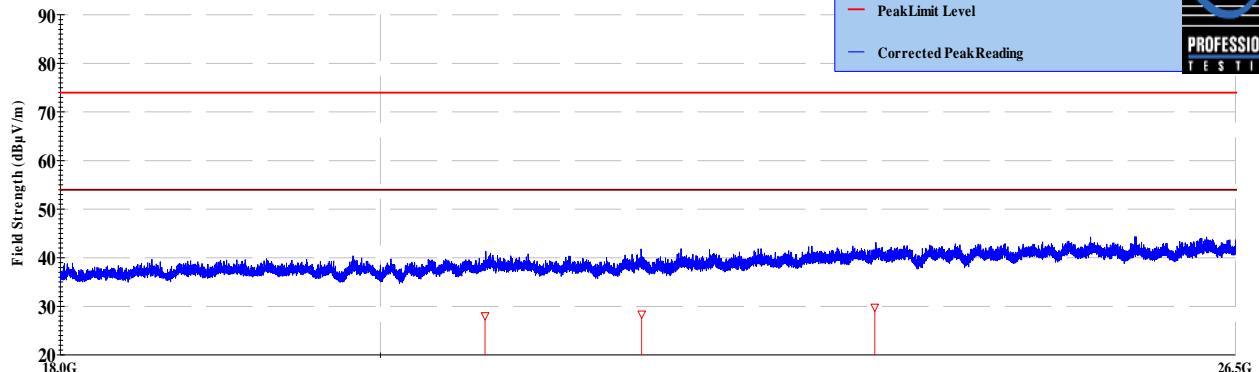
## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>		3	<b>VDC</b>	<b>EUT Power Frequency:</b>		0	N/A		
<b>Antenna Orientation:</b>			<b>Frequency Range:</b>			<b>Above 1GHz</b>			
<b>EUT Mode of Operation:</b>				<b>Transmitting (Bottom Channel - 2405 MHz)</b>					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
20701	3	88	1	Average	33.7	28.045	54.0	-25.9	Pass
21796.6	3	269	1	Average	34	28.378	54.0	-25.6	Pass
23533.2	3	13	1	Average	34.4	29.78	54.0	-24.2	Pass

### Professional Testing, EMI, Inc

Radiated Emissions, Measured at 1m and Scaled to 3m Distance  
18-26.5 GHz Horizontal Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2405M\_1-26G.til

03:58:26 PM, Tuesday, April 11, 2017

EUT Mode: TX CW #1 (ant.1) #2 (ant.2)

EUT Power: 3V Battery

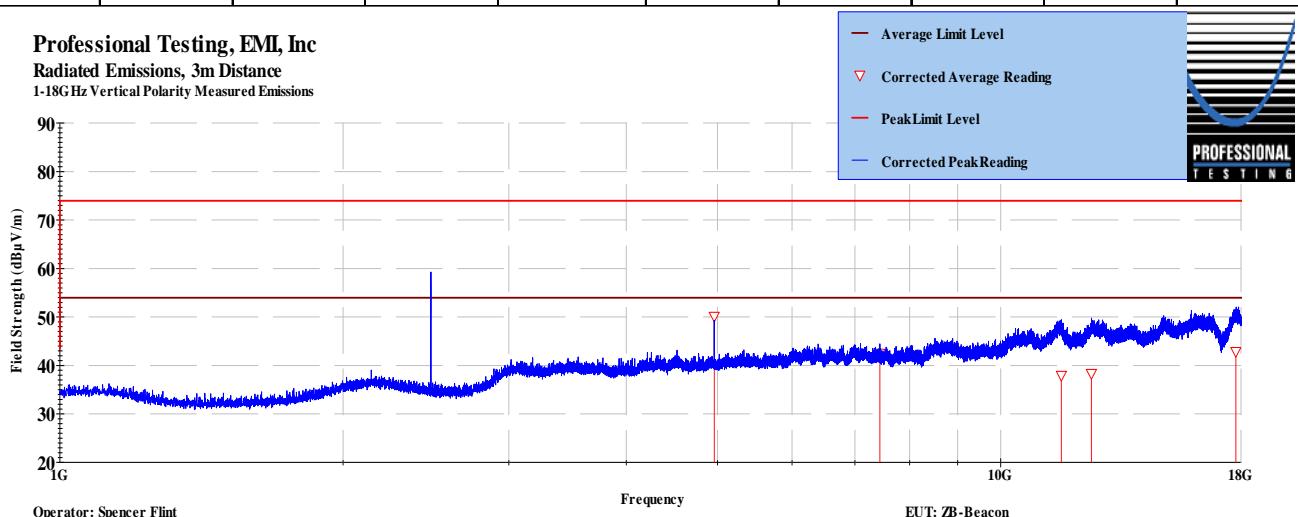
EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

**> 1GHz Horizontal Antenna Polarity Measured Emissions**

### 7.3.3 Top Channel, 1 GHz to 25 GHz

Professional Testing, EMI, Inc.									
Test Method: ANSI C63.10-2013									
In accordance with: FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits									
Section: 15.209									
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:	Vertical			Frequency Range:	Above 1GHz				
EUT Mode of Operation:					Transmitting (Top Channel - 2480 MHz)				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
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
<b>Professional Testing, EMI, Inc</b> Radiated Emissions, 3m Distance 1-18GHz Vertical Polarity Measured Emissions									
									
Operator: Spencer Flint 18931_2016 RE_FCC_2480M_1-26G.til 01:30:38 PM, Tuesday, April 11, 2017									
EUT Mode: TX CW #1 (ant.1) #2 (ant.2) EUT Power: 3V Battery Client: Long Range Systems									
<b>&gt; 1GHz Vertical Antenna Polarity Measured Emissions</b>									

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

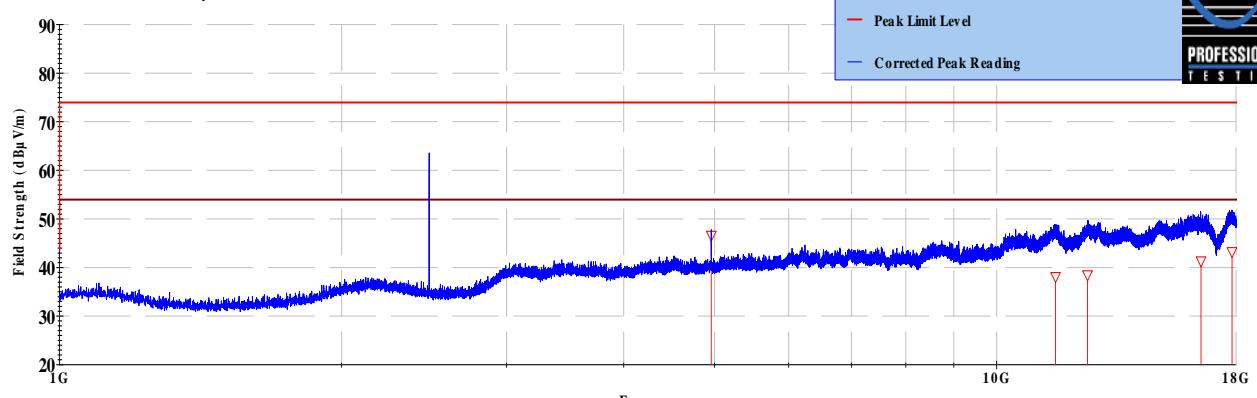
<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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<b>Antenna Orientation:</b>	Horizontal	<b>Frequency Range:</b>	Above 1GHz		
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### EUT Mode of Operation: Transmitting (Top Channel - 2480 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4959.96	3	123	1.88	Average	49.8	46.569	54.0	-7.4	Pass
11556.8	3	297	2.96	Average	27.3	38.086	54.0	-15.9	Pass
12500.6	3	118	1.91	Average	27.7	38.442	54.0	-15.5	Pass
16519.9	3	299	1.61	Average	27.1	41.316	54.0	-12.6	Pass
17824.3	3	304	1.41	Average	27.1	43.213	54.0	-10.7	Pass

Professional Testing, EMI, Inc  
Radiated Emissions, 3m Distance  
1-18GHz Horizontal Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2480M\_1-26G.til

01:30:38 PM, Tuesday, April 11, 2017

EUT Mode: TX CW #1 (ant.1) #2 (ant.2)  
EUT Power: 3V Battery

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

> 1GHz Horizontal Antenna Polarity Measured Emissions

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>	3	<b>VDC</b>	<b>EUT Power Frequency:</b>	0	N/A
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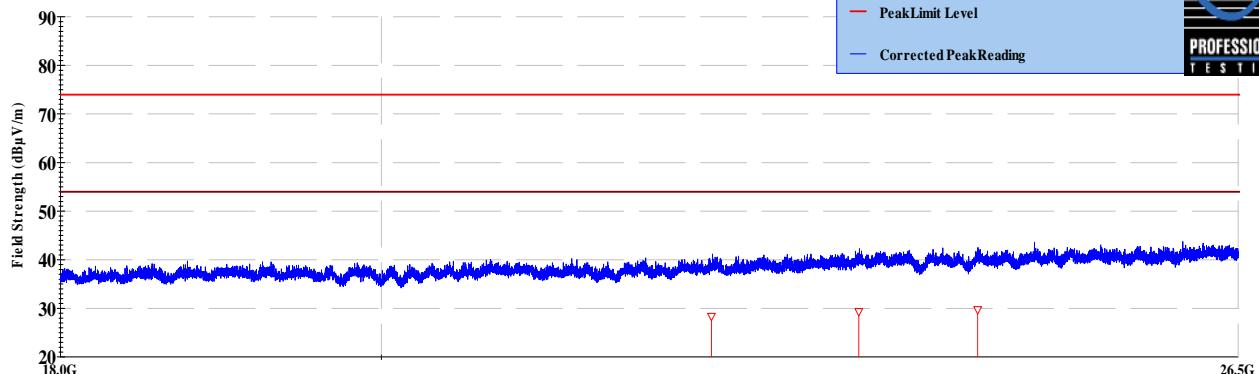
<b>Antenna Orientation:</b>	Vertical	<b>Frequency Range:</b>	Above 1GHz		
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### EUT Mode of Operation: Transmitting (Top Channel - 2480 MHz)

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
22290.5	3	204	1	Average	33.5	28.307	54.0	-25.7	Pass
23395.3	3	203	1	Average	34.1	29.292	54.0	-24.7	Pass
24327.5	3	60	1	Average	33.6	29.676	54.0	-24.3	Pass

### Professional Testing, EMI, Inc

Radiated Emissions, Measured at 1m and Scaled to 3m Distance  
18-26.5 GHz Vertical Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2480M\_1-26G.til

05:04:36 PM, Tuesday, April 11, 2017

EUT Mode: TX CW #1 (ant.1) #2 (ant.2)

EUT Power: 3V Battery

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

### > 1GHz Vertical Antenna Polarity Measured Emissions

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10-2013

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

<b>Test Date(s):</b>	4/11/2017	<b>EUT Serial #:</b>	#1 (antenna 1) #2 (antenna 2)
<b>Customer:</b>	Long Range Systems	<b>EUT Part #:</b>	0
<b>Project Number:</b>	18931	<b>Test Technician:</b>	Spencer Flint
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Lisa Arndt
<b>Equip. Under Test:</b>	ZB-Beacon	<b>Witness' Name:</b>	Sam Siddiqui

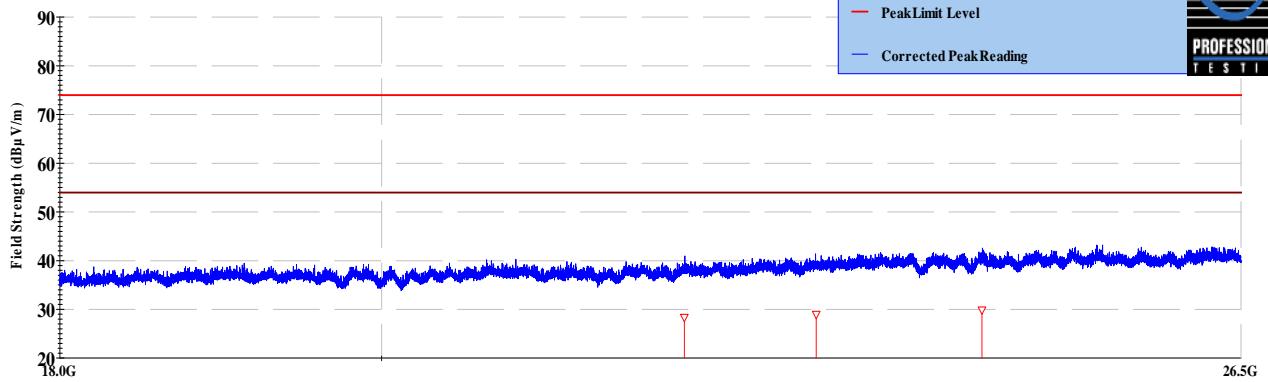
## Radiated Emissions Test Results Data Sheet

Page: 1 of 1

<b>EUT Line Voltage:</b>		3	<b>VDC</b>	<b>EUT Power Frequency:</b>		0	N/A		
<b>Antenna Orientation:</b>			<b>Frequency Range:</b>			<b>Above 1GHz</b>			
<b>EUT Mode of Operation:</b>					<b>Transmitting (Top Channel - 2480 MHz)</b>				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dB $\mu$ V)	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
22085	3	188	1	Average	33.6	28.306	54.0	-25.7	Pass
23059.3	3	160	1	Average	34.1	28.923	54.0	-25.0	Pass
24345	3	13	1	Average	33.8	29.831	54.0	-24.1	Pass

### Professional Testing, EMI, Inc

Radiated Emissions, Measured at 1m and Scaled to 3m Distance  
18-26.5 GHz Horizontal Polarity Measured Emissions



Operator: Spencer Flint

18931\_2016 RE\_FCC\_2480M\_1-26G.til

05:04:36 PM, Tuesday, April 11, 2017

EUT Mode: TX CW #1 (ant.1) #2 (ant.2)

EUT Power: 3V Battery

EUT: ZB-Beacon

Project Number: 18931

Client: Long Range Systems

**> 1GHz Horizontal Antenna Polarity Measured Emissions**

## 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
<b>Manufacturer:</b> 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	HP	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
	1 to 18 GHz	3 m	5.7

**End of Report**

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