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Project 14464-15

**Wireless Seismic 4-Channel/3-Channel Wireless Remote Unit (WRU)**  
**Wireless Certification Report**

Prepared for:

**Wireless Seismic, Inc.**  
13100 Southwest Freeway, Suite 150  
Sugar Land, TX 77478

By

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

December 24, 2013

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Written by:

Larry Finn  
Regulatory Design Engineer

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Revision	Description	Date
01	Add FCC ID to certificate page.	2013-11-19 Eric Lifsey
02	Corrected spurious emissions limit	2013-12-16 Larry Finn
02	Removed incorrect formula from MPE table	2013-12-16 Larry Finn
03	Corrected spurious setup information.	2013-12-17 Eric Lifsey
04	Corrections per ACB comments.	2013-12-24 Eric Lifsey



## Certificate of Compliance

Applicant: Wireless Seismic, Inc.  
Applicant's Address: 13100 Southwest Freeway, Suite 150  
Sugar Land, TX 77478

FCC ID: YZO-00104  
Model: 10-0023 (3-Channel WRU), 10-0032 (4-Channel WRU)  
Project Number: 14464-15

The **4-Channel Wireless Remote Unit (Model 10-0023)** was tested utilizing the following documents and found to be in compliance with the required criteria.

Standard	Issue / Section / Part	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	15.207	Conducted limits.
FCC 47 CFR Part 15 C	15.205	Restricted Bands of Operation
KDB718828	DR01	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
KDB412172	D01	Guidelines for Determining the ERP and EIRP of an RF Transmitting System
OET Bulletin 65	Edition 97-01, Including Supplement C, Edition 01-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
RSS-210	Issue 8	Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
RSS-Gen	Issue 3	General Requirements and Information for the Certification of Radio Apparatus
RSS-102	Issue 4	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

I, Jeffrey A. Lenk, for Professional Testing (EMI), Inc., being familiar with the FCC rules and test procedures, have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

Jeffrey A. Lenk  
President

This report has been reviewed and accepted by Wireless Seismic, Inc.. The undersigned is responsible for ensuring that the devices listed above, will continue to comply with the applicable rules.

\_\_\_\_\_  
Representative of Wireless Seismic, Inc.

# 1 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. The procedures of ANSI C63.4: 2009 were used for making all radiated enclosure and mains emission measurements.

## 1.2 EUT Description

The Wireless Seismic 4-Channel Wireless Remote Unit (Model 10-0032) is an outdoor deployable seismic instrument. The device communicates to other system components through an internal 2.4GHz FHSS radio, of which the evaluation is described in this report.

The device is powered solely through 3.7VDC Li-Ion batteries which must be removed to facilitate charging (no provisions for battery charging are integrated into this unit), and as such no conducted emissions measurements were required.

Also considered in this investigation was a 3-Channel version of the EUT (Model 10-0023). The 3-Channel version contained no changes to the RF transmitter portion of the EUT, and was otherwise identical to the 4-Channel with the exception of discrete components depopulated to disable the 4<sup>th</sup> analog channel. The PCB design was unchanged between the two models.

As a result of these changes, the 3-Channel version was evaluated for spurious emissions to ensure that the electrical performance was not degraded over the 4-Channel version. Both models will be marketed under the same FCC/IC ID as the changes were not such as to require an additional FCC/IC ID be used.

## 1.3 Antenna Configuration

The device utilizes a type 'N' RF connector for attachment of its antenna. Antennas supplied with the unit are professionally installed by Wireless Seismic or its authorized agents.

## **1.4 EUT Operation**

The EUT was controlled via custom testing software provided by Wireless Seismic. This allowed for output power, channel, and frequency hopping control. A Wireless Seismic LIU (FCC ID: YZO-00600) was used to interface to the EUT in the same manner as would be used in actual operation. For conducted testing, the LIU antenna port was cabled through a directional coupler to the WRU and Spectrum Analyzer. A 40dB attenuator was used to attenuate the LIU signal to allow proper measurement of the WRU (EUT) parameters.

## **1.5 EUT Modifications**

No modifications were made to the EUT during evaluation. The unit supplied was a pre-production device.

## **1.6 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 RS-212, 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.

## 2 Test Summary

EUT transmitter characteristics are shown below in Table 1 and were used to select the proper tests to demonstrate compliance.

<b>Professional Testing, EMI, Inc.</b>									
<b>FCC 15.247 / RSS-210: Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz</b>									
In accordance with: 47 CFR Part 15 C; RSS-210 Issue 8; KDB 718828									
Test Date(s): 7/31/13 - 9/18/13	EUT Serial #: N/A								
Customer: Wireless Seismic	EUT Part #: 10-0023								
Project Number: 14464-15	Test Technician: Eric Lifesy								
Purchase Order #: N/A	Supervisor: Rob McCollough								
Equip. Under Test: 4-Channel Wireless Remote Unit	Witness' Name: N/A								
<b>Device Type</b> <input type="checkbox"/> Digital Modulation <input checked="" type="checkbox"/> Frequency Hopping <input type="checkbox"/> Hybrid System	<b>Operating Frequency Range</b> <input checked="" type="checkbox"/> 902-928 MHz <input checked="" type="checkbox"/> 2400-2483.5 MHz <input type="checkbox"/> 5725-5850 MHz								
<b>Antenna / Device Configuration</b>									
<input checked="" type="checkbox"/> Single Beam / Non-Fixed <input type="checkbox"/> Fixed Point-to-Point <input type="checkbox"/> Multiple Beams									
<b>Device Power</b> <input checked="" type="checkbox"/> AC Mains Powered / Hybrid <input checked="" type="checkbox"/> Battery Powered	<b>Measurement Type</b> <input checked="" type="checkbox"/> Conducted <input type="checkbox"/> Radiated								
<b>Test Channels</b> Number of Test Channels 3	<b>Antenna Details</b> Number of Antenna Ports 1								
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 30%;">Channel</th> <th style="width: 70%;">Frequency (MHz)</th> </tr> </thead> <tbody> <tr> <td>Low</td> <td>2403</td> </tr> <tr> <td>Mid</td> <td>2439</td> </tr> <tr> <td>High</td> <td>2475</td> </tr> </tbody> </table>	Channel	Frequency (MHz)	Low	2403	Mid	2439	High	2475	Number of Antenna Types 1
Channel	Frequency (MHz)								
Low	2403								
Mid	2439								
High	2475								
<b>Modulation Schemes</b> Number of Modulation Schemes 1	<b>Device Details</b> FCC ID: TBD								
Modulation Scheme List FHSS	IC ID: TBD								
	Number of Channels: 19								
	Operating Frequency Range: 2403 - 2475 MHz								
	Input Power Details: 3.7VDC Li-Ion Battery Powered (2 Batteries)								

**Table 1: EUT Characteristics**

Project 14464-15: Wireless Seismic 4-Channel WRU

Table 2 below summarizes the test results obtained during the evaluation of the 4-Channel/3-Channel Wireless Remote Unit. All aspects of the EUT were found to be within compliance with the applicable rules.

Professional Testing, EMI, Inc.			
FCC 15.247 / RSS-210: Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz			
In accordance with: 47 CFR Part 15 C; RSS-210 Issue 8; KDB 718828			
Test Date(s): 7/31/13 - 9/18/13		EUT Serial #: N/A	
Customer: Wireless Seismic		EUT Part #: 10-0023	
Project Number: 14464-15		Test Technician: Eric Lifsey	
Purchase Order #: N/A		Supervisor: Rob McCollough	
Equip. Under Test: 4-Channel Wireless Remote Unit		Witness' Name: N/A	
Summary of Test Results			
Standard Section	Test Type and Limit	Result	Details
RSS-Gen 7.2.4 / 15.207	AC Powerline Conducted Emissions	NOT APPLICABLE	--
RSS-210 A8.1 / 15.247a(1)	Number of Hopping Channels: Min: 15	PASS	19 Channels Present
RSS-210 A8.1 / 15.247a(1)	Channel Occupancy Time: Max: 0.4s per 7.6s	PASS	Occupancy Time Does not Exceed Maximum Limit
RSS-210 A8.1 / 15.247a(1)	Hopping Channel Separation: Min: 3632.5 kHz	PASS	Minimum Channel Separation: 4000 kHz
RSS-210 A8.1,A8.2 / 15.247a	Occupied Bandwidth: N/A	NOT APPLICABLE	--
RSS-210 A8.4 / 15.247b	Maximum Peak Output Power: Max: 20.969 dBm	PASS	Max Antenna Port Power: 20.88 dBm, Max EIRP: 26.38 dBm
RSS-210 8.5 / 15.247d	Out-of-Band Emissions: Peak Power Method	PASS	Minimum margin: -5.1 dB @ 7316.2 MHz
RSS-Gen 6	Receiver Spurious Emissions (IC Only)	PASS	No Emissions Detected Above Limit
RSS-210 8.2 / 15.247e	Power Spectral Density: N/A	NOT APPLICABLE	--
RSS-Gen 7.1.2 / 15.203	Antenna Requirements	PASS	Highest Antenna Gain: 5.5 dBi Using Comet CFA-245-32E Dipole Antenna
RSS-102 / 15.247i	RF Exposure Requirements	PASS	Maximum RF field density: 8.64E-2 mW/cm <sup>2</sup>
Applicable Rules and Standards			
Standard	Issue / Section / Part	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	15.207	Conducted limits.	
FCC 47 CFR Part 15 C	15.205	Restricted Bands of Operation	
KDB718828	DR01	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247	
DA 00-705	March 30, 2000 Release	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems	
KDB412172	D01	Guidelines for Determining the ERP and EIRP of an RF Transmitting System	
OET Bulletin 65	Edition 97-01, Including Supplement C, Edition 01-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields	
RSS-210	Issue 8	Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment	
RSS-Gen	Issue 3	General Requirements and Information for the Certification of Radio Apparatus	
RSS-102	Issue 4	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)	

Table 2: Results Summary



### 3 Test Results

#### 3.1 AC Powerline Conducted Emissions

##### 3.1.1 Equipment Used

N/A

##### 3.1.2 Test Procedure

N/A

##### 3.1.3 Test Results

Not applicable since the EUT is battery powered with no provision for battery charging.

#### 3.2 Frequency Hopping Characteristics

Number of hopping channels, channel occupancy time and channel spacing were evaluated. Data reported is for the observed worst-case operating mode of the EUT. Occupied bandwidth was used as the limit for channel spacing and is reported in the appropriate section of this report.

##### 3.2.1 Equipment Used

Asset #	Manufacturer	Model #	Description	Calibration Due
1342	Rohde & Schwarz	FSP-30	Spectrum Analyzer	2015-01-29
C248	Pasternack	N/A	Cable	2014-02-06
0835	Narda	3293-1	Forward Power Coupler, -10 dB	2014-06-11

**Table 3: Conducted Test Equipment List**

##### 3.2.2 Test Procedure

A conducted setup was used for this evaluation, and is shown in Figure 1 below. 'Zero span' mode was used on the Spectrum Analyzer to measure the return to channel time. The calculation is shown in Table 4 below.

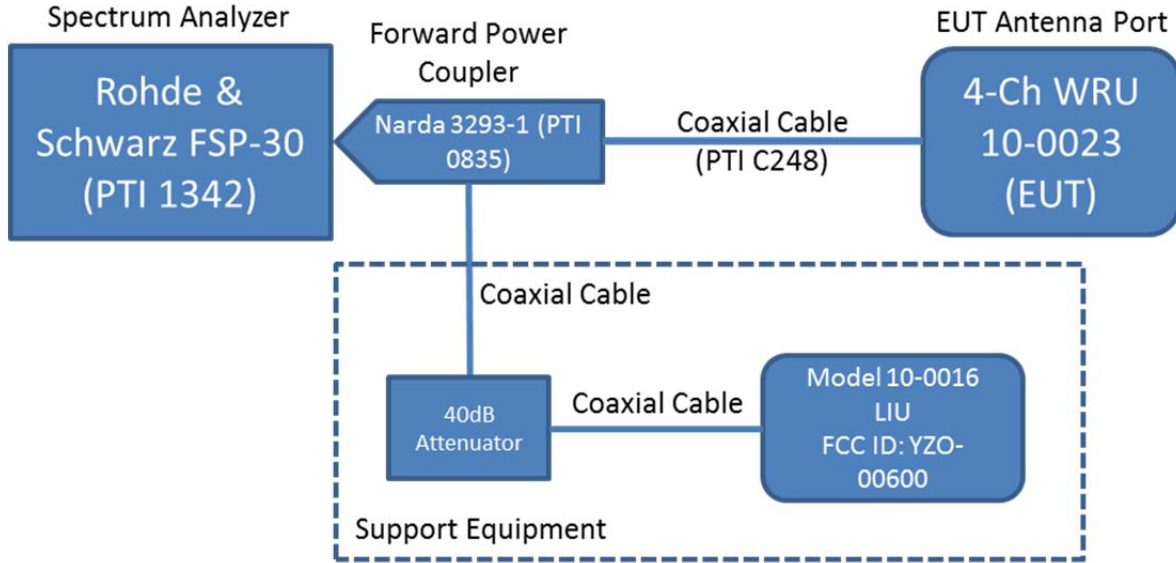


Figure 1: Conducted Test Setup

3.2.3 Test Results

Professional Testing, EMI, Inc.																	
15.247a(1),ii,iii, RSS-210 A8.1: Frequency Hopping Parameters																	
Test Date(s): 7/31/13 - 8/27/13									EUT Serial #: N/A								
Customer: Wireless Seismic									EUT Part #: 10-0023								
Project Number: 14464-15									Test Technician: Eric Lifsey								
Purchase Order #: N/A									Supervisor: Rob McCollough								
Equip. Under Test: 4-Channel Wireless Remote Unit									Witness' Name: N/A								
Frequency Hopping Measurement Results <input type="checkbox"/> Limit 2.4GHz Band to 125mW																	
Channel	Frequency (MHz)	Port	Modulation	20dB Bandwidth			Number of Hopping Channels			Hopping Channel Separation			Channel Occupancy Time				
				Value (kHz)	Limit (kHz)	Result (P/F)	Value	Limit	Result (P/F)	Value	Limit	Result (P/F)	Value (s)	Period (s)	Limit (s)	Period (s)	Result (P/F)
Low	2403	1	FHSS	3165	n/a	n/a	19	15	PASS	4000	3165	PASS	0.0416	7.6	0.4	7.6	PASS
Mid	2439	1	FHSS	3577.5	n/a	n/a	19	15	PASS	4000	3577.5	PASS	0.0416	7.6	0.4	7.6	PASS
High	2475	1	FHSS	3632.5	n/a	n/a	19	15	PASS	4000	3632.5	PASS	0.0416	7.6	0.4	7.6	PASS
Modifications or Test Notes																	
Maximum measured occupancy time (Dwell Time) for longest pulse mode: 743µs Time to asses occupancy time: 0.4ms x # Channels = 0.4 x 19 = 7.6s Time to return to one channel (Minimum): 137ms Number of channel events over evaluated period: 7.6s / 137ms = 56 (Rounding up) Maximum occupancy time per period: 56 x 743µs = 41.6ms																	

Table 4: Frequency Hopping Parameters

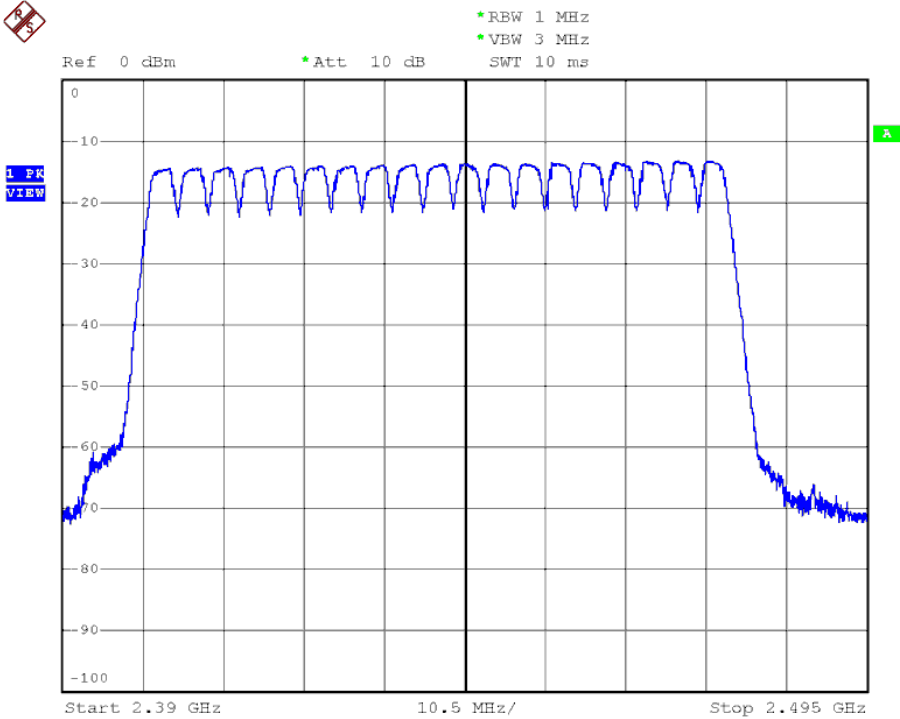


Figure 2: Number of Hopping Channels

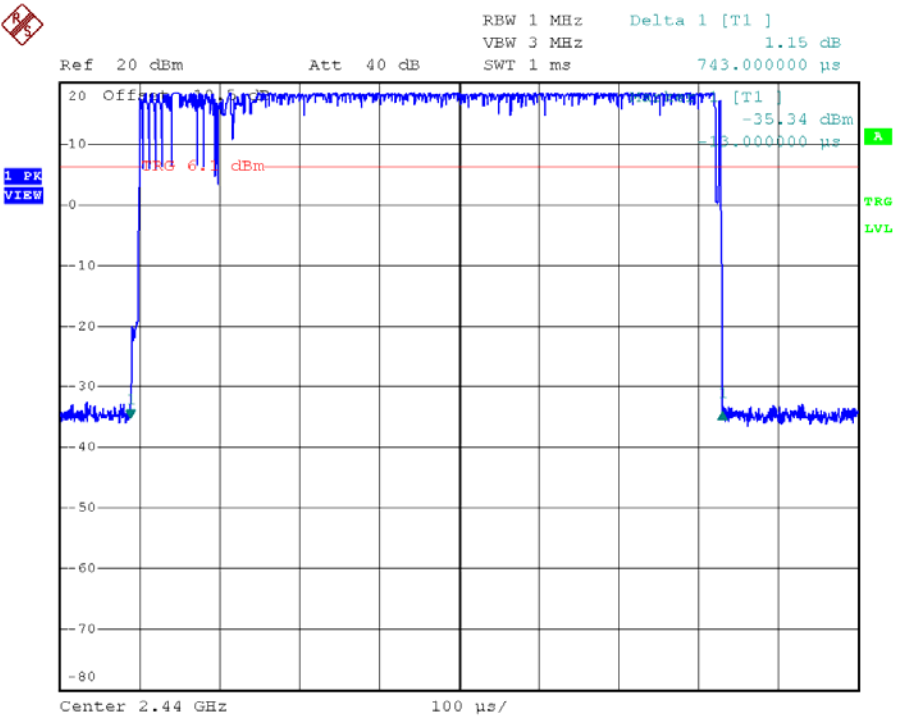


Figure 3: Channel Dwell Time (Worst-Case)

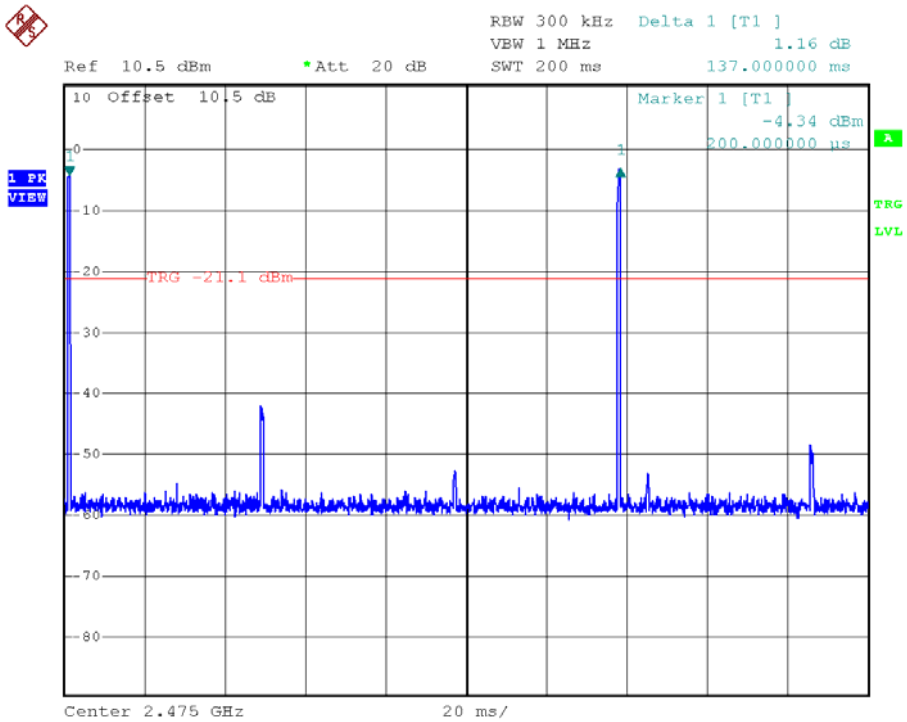


Figure 4: Return to Channel Measurement

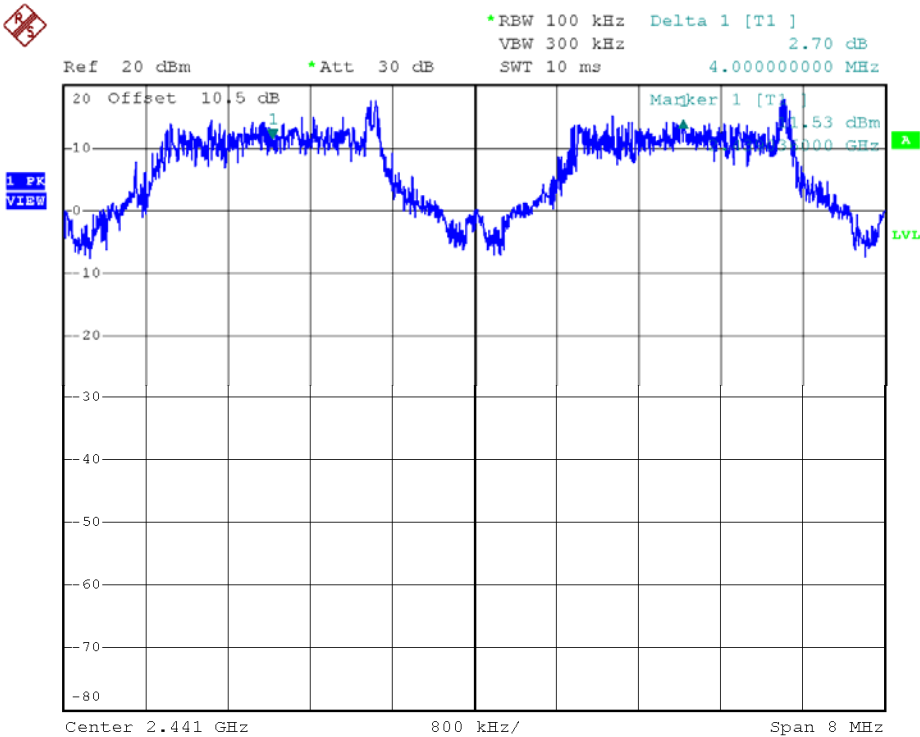


Figure 5: Channel Separation Measurement

### 3.3 Occupied Bandwidth

20dB bandwidth was measured in support of the hopping channel separation measurements detailed in section 3.2.

#### 3.3.1 Equipment Used

See Table 3 in Section 3.2.1.

#### 3.3.2 Test Procedure

The bandwidth at the point 20dB below the highest in-band spectral density was measured for the low, middle and high channel using the setup shown in Figure 1 (Section 3.2.2).

#### 3.3.3 Test Results

Tabulated results are shown in Table 4 of Section 3.2.3. Figures 6-8 below contain the spectrum analyzer data used in the measurement.

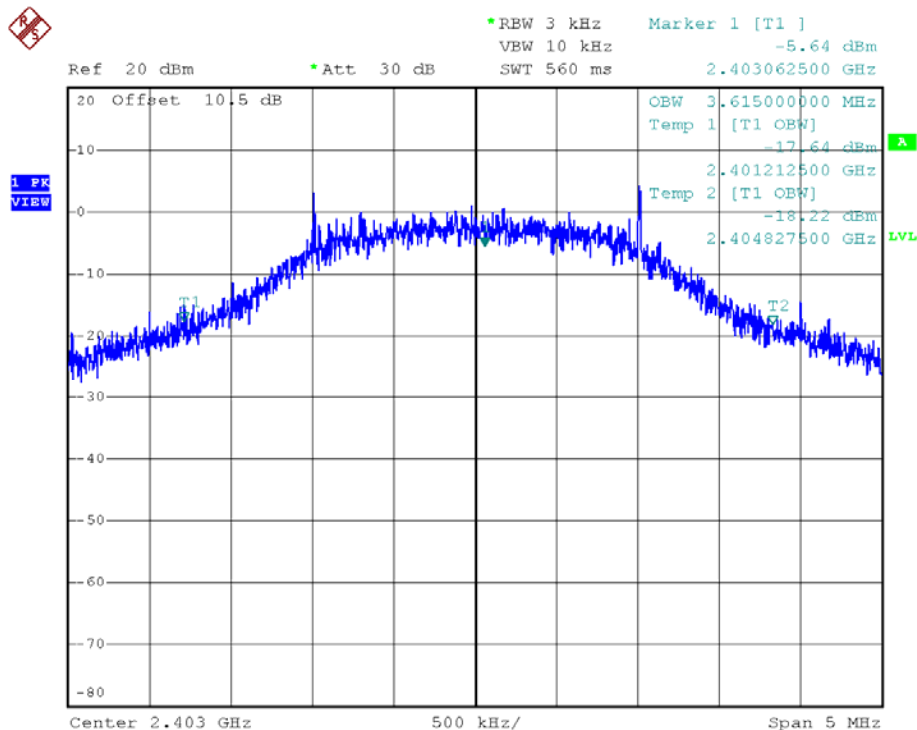


Figure 6: 20dB Bandwidth Measurement for Low Channel

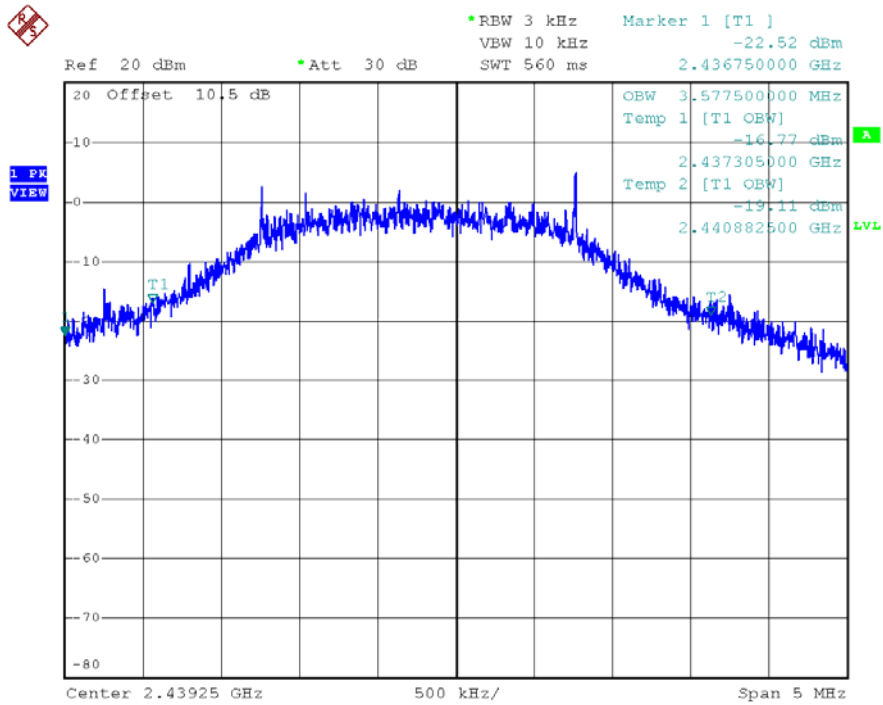


Figure 7: 20dB Bandwidth Measurement for Mid Channel

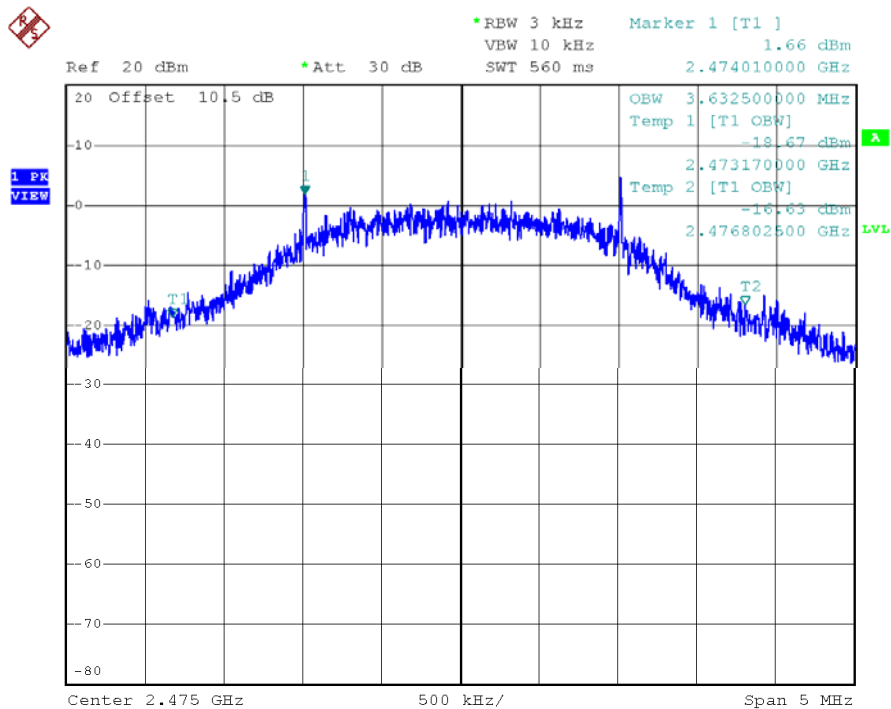


Figure 8: 20dB Bandwidth Measurement for High Channel

### 3.4 Peak Output Power

Conducted output power measurements were made for the bottom, middle and top channels of the EUT.

#### 3.4.1 Equipment Used

See Table 3 in Section 3.2.1.

#### 3.4.2 Test Procedure

Conducted output power measurements were made for each channel using the setup detailed in Figure 1. The Spectrum Analyzer was configured for 10MHz RBW with a 20MHz span for the power measurements.

#### 3.4.3 Test Results

Professional Testing, EMI, Inc.															
15.247b(1),b(2), RSS-210 A8.4: Peak Output Power for Frequency Hopping Devices															
Test Date(s): 7/31/13 - 9/18/13						EUT Serial #: N/A									
Customer: Wireless Seismic						EUT Part #: 10-0023									
Project Number: 14464-15						Test Technician: Eric Lifsey									
Purchase Order #: N/A						Supervisor: Rob McCollough									
Equip. Under Test: 4-Channel Wireless Remote Unit						Witness' Name: N/A									
Peak Power Measurements															
Channel	Frequency (MHz)	Port	Modulation	Ant. Peak Gain (dBi)	Pol.	Test Data	Conducted Test Data Correction Factors				Ant. Factor	Corrected Antenna Port Peak Power			EIRP Value (dBm)
							N/A (dB)	N/A (dB)	N/A (dB)	N/A (dB)		Max (dB)	Value (dBm)	Limit (dBm)	
Low	2403	1	FHSS	5.5	N/A	20.88	0	0	0	0	0.00	20.9	20.969	PASS	26.4
Mid	2439	1	FHSS	5.5	N/A	20.64	0	0	0	0	0.00	20.6	20.969	PASS	26.1
High	2475	1	FHSS	5.5	N/A	20.82	0	0	0	0	0.00	20.8	20.969	PASS	26.3

Table 5: Maximum Conducted Output Power

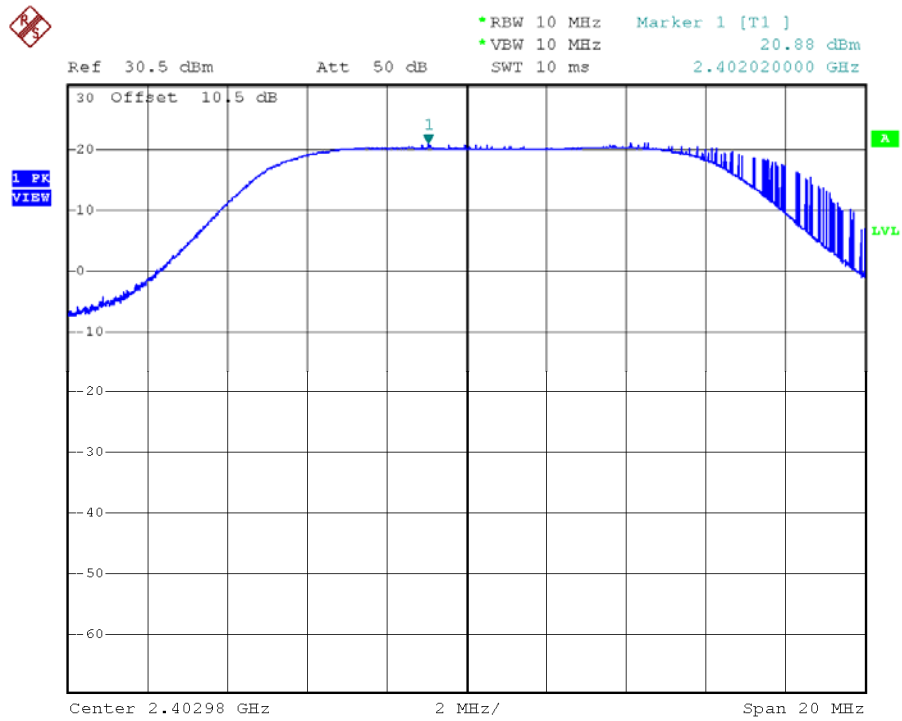


Figure 9: Peak Output Power, Low Channel

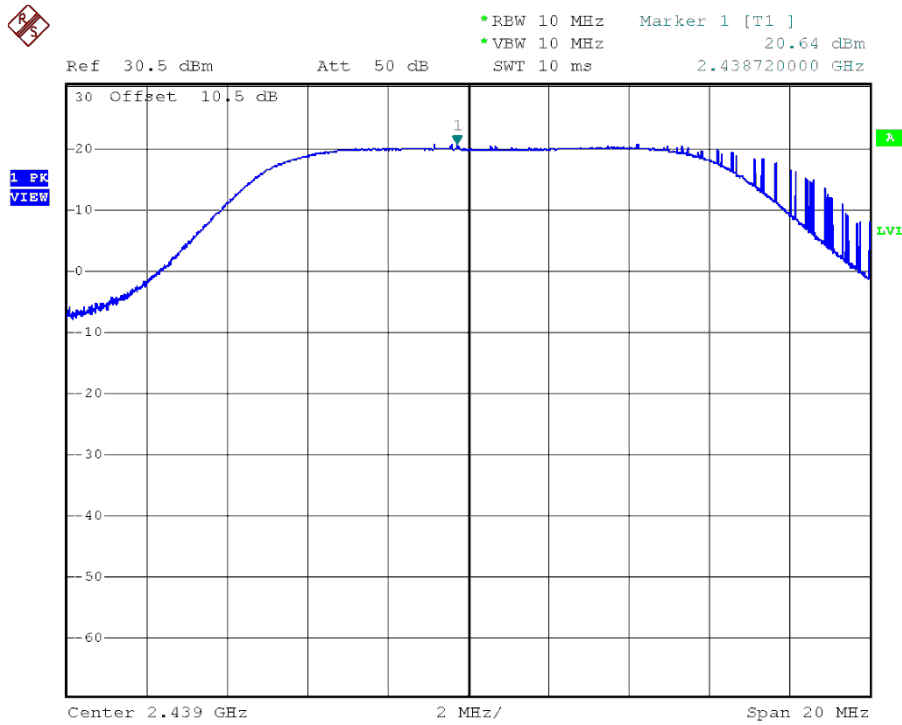


Figure 10: Peak Output Power, Middle Channel



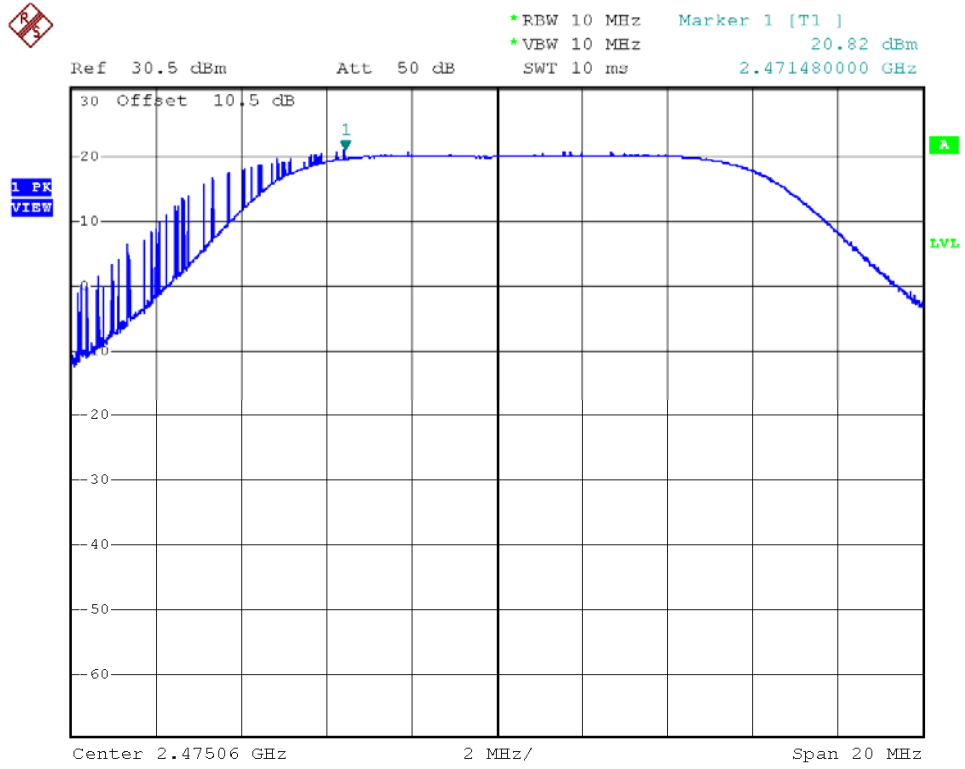


Figure 11: Peak Output Power, High Channel

### 3.5 Out of Band Emissions

#### 3.5.1 Equipment Used

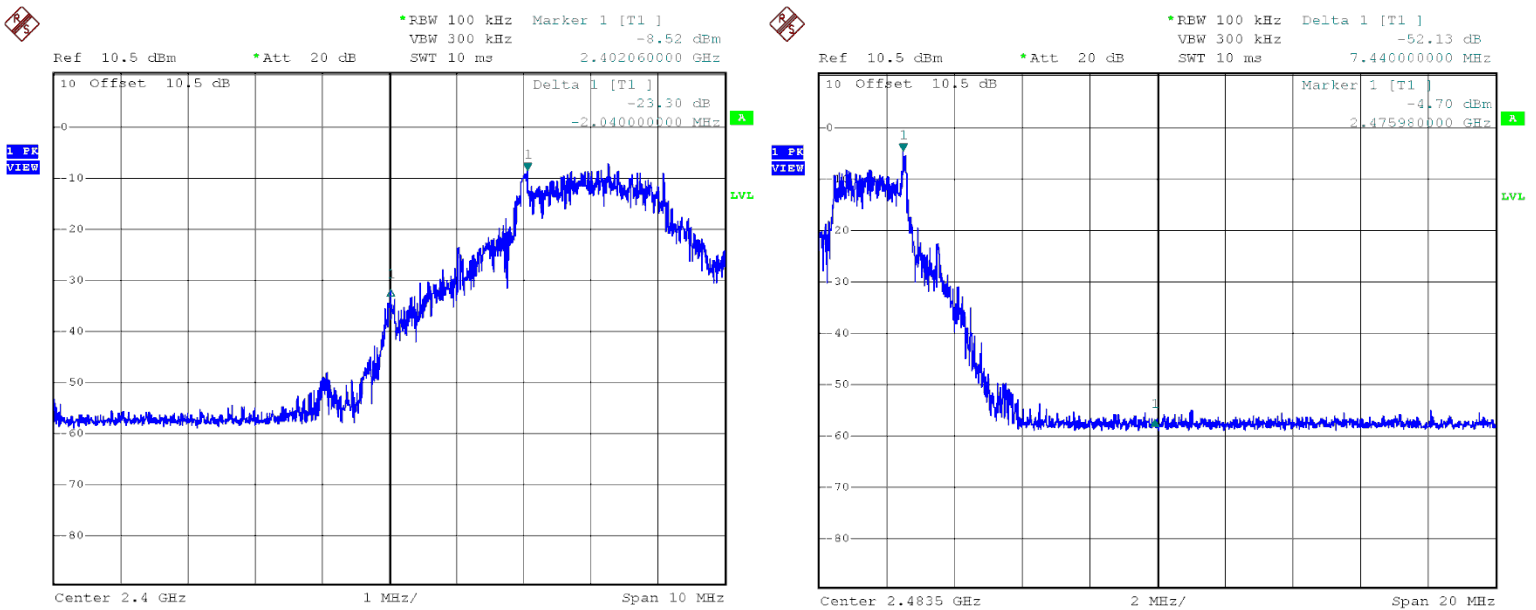
See Table 3 in Section 3.2.1.

#### 3.5.2 Test Procedure

Conducted out of band emissions were investigated using the test setup detailed in Figure 1. Any emissions above the noise floor were noted and checked for compliance. The band edges were also checked for compliance with 15.247d.

All emissions and band-edge levels were found to comply with the required limits.

#### 3.5.3 Test Results



**Figure 12: Band-Edge Measurement Results**

The RF link between the EUT and LIU controls the operating mode of the EUT, including disabling hopping and modulation as required. Hopping mode is exercised below and up to the operating band; above the band where harmonics appear the EUT is in single channel mode unmodulated.

Conducted spurious emissions measurements were taken from 30MHz – 25GHz using a spectrum analyzer configured with a 100 kHz RBW as per 15.247d. All emissions detected were noted in Table 6 below.

The original measurement of fundamental power in 10 MHz RBW was adjusted by the bandwidth correction factor of -20 dB to 100 kHz RBW. This result was then reduced by the 15.247d level of -20 dB to produce the limit for non-restricted band emissions. If emissions appeared in the 15.205 restricted bands the limits of 15.209 were applied.

Professional Testing, EMI, Inc.													
15.247d, RSS-210 A8.5: Antenna Port Spurious Emissions													
Test Date(s): 7/31/13 - 9/18/13					EUT Serial #: N/A								
Customer: Wireless Seismic					EUT Part #: 10-0023								
Project Number: 14464-15					Test Technician: Eric Lifsey								
Purchase Order #: N/A					Supervisor: Rob McCollough								
Equip. Under Test: 4-Channel Wireless Remote Unit					Witness' Name: N/A								
Emissions Limit Measurements										Peak Power Method			
Channel	Frequency (MHz)	Port	Modulation	Ant.	Pol.	Fundamental Maximum Power (RBW = 100kHz)		Conducted Measurement Correction Factors			Corr. Max Fundamental Power Value (dBm)	Meas. Config	15.247d Emissions Limit* Value (dBm)
						Conducted (dBm)		N/A (dB)	N/A (dB)	N/A (dB)			
Low	2403	1	FHSS	1	Max	0.88		0	0	0	0.9	1	-19.1
Mid	2439	1	FHSS	1	Max	0.64		0	0	0	0.6	2	-19.4
High	2475	1	FHSS	1	Max	0.82		0	0	0	0.8	3	-19.2

\* Only applied to emissions outside restricted bands per 15.205. 15.209 limits are applicable to restricted band emissions.

Harmonic / Spurious Emissions Measurements																
Meas. Config	Meas. Pol.	Measurement Frequency (MHz)	Emission Type	Restr. Band?	15.209 Limit (dBm)	Limit Type	Harmonic / Spurious Conducted (dBm)	Corr. Factors			Meas. Type	Duty Cycle	Duty Cycle (dB)	Corr. EIRP (dBm)	Limit Value (dBm)	Result (P/F)
								C248 (dB)	0835 (dB)	N/A (dB)						
1	N/A	9613.9	Harmonic	No	-41.25	15.247	-52.51	-2.98	2.21	0	--	--	0	-46.2	-19.1	PASS
2	N/A	7316.2	Harmonic	Yes	-41.25	15.209	-53.26	-2.58	1.18	0	--	--	0	-46.4	-41.2	PASS

Formulas Used for Calculations	
<p>EIRP to Field Strength Calculation</p>	<p>1.3.1. Field Strength Approach (linear terms):  <math display="block">eirp = p_t \times g_t = (E \times d)^2 / 30 \quad (1)</math>                     where:                      • <math>p_t</math> = transmitter output power in watts,                      • <math>g_t</math> = numeric gain of the transmitting antenna (unitless),                      • <math>E</math> = electric field strength in V/m,                      • <math>d</math> = measurement distance in meters (m).  <math display="block">erp = eirp / 1.64 = (E \times d)^2 / (30 \times 1.64) \quad (2)</math>                     where all terms are as previously defined.</p> <p style="text-align: right;">Duty Cycle Correction Factor per 15.35c  <math display="block">DCCF = 20 \log_{10}(\text{Duty Cycle}_{meas})</math></p>

Table 6: Conducted Spurious Emissions

### 3.6 Receiver Spurious Emissions

Receiver spurious emissions were investigated to ensure compliance with Industry Canada regulations.

Frequency (MHz)	Field Strength (microvolts/m at 3 metres) *
30-88	100
88-216	150
216-960	200
Above 960	500

**Table 7: Industry Canada Receiver Spurious Emissions Limits**

#### 3.6.1 Equipment Used

See Table 9 in section 3.10.1. Receiver spurious emissions were performed at 10m distance as allowed per the IC rules.

#### 3.6.2 Test Procedure

Receiver spurious emissions were performed as outlined in section 3.10.2 for transmitter enclosure spurious emissions. The only difference being that the transmitter was inactive during testing.

#### 3.6.3 Test Results

All emissions were found to be within the required limits.

### 3.7 Power Spectral Density

#### 3.7.1 Equipment Used

N/A

#### 3.7.2 Test Procedure

N/A

#### 3.7.3 Test Results

Not applicable due to frequency hopping operation.

### 3.8 Antenna Requirements

The Wireless Seismic 4-Channel/3-Channel Wireless Remote Unit was tested with the following antenna:

Manufacturer: **Comet**  
Model: **CFA-245-32E**  
Type: **Dipole**  
Connector: **Type 'N'**  
Peak Gain: **5.5 dBi**  
Installation Method: **Professional**

The 4-Channel/3-Channel WRU antenna was found to meet the requirements of 15.203 and RSS-Gen 7.1.2 due to the following:

*The antenna is required to be professionally installed by Wireless Seismic or its authorized agents.*

### 3.9 RF Exposure

The 4-Channel/3-Channel WRU is a mobile device, and requires that the user be >20cm from the antenna while in operation. This use case is consistent with the operation of the device, as it will be deployed in outdoor environments and operated remotely.

MPE values have been calculated below using the maximum output power and peak antenna gain (Maximum EIRP). The calculated result at a 20cm exposure distance is well below the allowable threshold.

Professional Testing, EMI, Inc.											
15.247i, RSS-102: RF Exposure Analysis											
Test Date(s): 7/31/13 - 9/18/13						EUT Serial #: N/A					
Customer: Wireless Seismic						EUT Part #: 10-0023					
Project Number: 14464-15						Test Technician: Eric Lifesey					
Purchase Order #: N/A						Supervisor: Rob McCollough					
Equip. Under Test: 4-Channel Wireless Remote Unit						Witness' Name: N/A					
RF Exposure Calculations <input checked="" type="checkbox"/> Mobile (Ant >= 20cm) <input type="checkbox"/> Portable (Ant < 20cm)											
Channel	Frequency (MHz)	Port	Modulation	Peak Ant. Gain (dBi)	Pol.	EIRP (mW)	Waiver Limit (60/f(GHz)) (mW)	Minimum Exposure Distance (cm)	RF Field Density (mW/cm <sup>2</sup> )	MPE Limit (mW/cm <sup>2</sup> )	Result (P/F)
Low	2403	1	FHSS	5.5	Max	434.510	24.97	20	8.64E-02	1.00	PASS
Mid	2439	1	FHSS	5.5	Max	411.150	24.60	20	8.18E-02	1.00	PASS
High	2475	1	FHSS	5.5	Max	428.549	24.24	20	8.53E-02	1.00	PASS

Formulas Used for Calculations	
<p>RF Power Density Calculation</p>	$S = \frac{PG}{4\pi R^2} \quad (3)$ <p>where: S = power density (in appropriate units, e.g. mW/cm<sup>2</sup>)                      P = power input to the antenna (in appropriate units, e.g., mW)                      G = power gain of the antenna in the direction of interest relative to an isotropic radiator                      R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)</p> <p>or:</p> $S = \frac{EIRP}{4\pi R^2} \quad (4)$ <p>where: EIRP = equivalent (or effective) isotropically radiated power</p>

**Table 8: MPE Calculations for 4-Channel/3-Channel WRU @ 20cm Exposure Distance**

### 3.10 Enclosure Radiated Emissions

Both the 4-Chanel and 3-Channel WRU’s were evaluated from 30MHz to above the 10<sup>th</sup> harmonic to ensure compliance to FCC 15.205, 15.209 and RSS-Gen 6. All data is presented for the 4-Channel version. Only the 30MHz to 1GHz data is presented for the 3-Channel version as the emissions above 1GHz showed no significant differences.

#### 3.10.1 Equipment Used

Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Pasternack	PE9490	BNC Male to N Female Adapter, 50-ohm	N/A	8/27/2013
1890	HP	8447F	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	1/8/2014
1930	Agilent	E4440A-239	Spectrum Analyzer, 3 Hz - 26.5 GHz	MY45304903	7/11/2014
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	00135454	7/29/2014
C027	N/A	RG214	Cable Coax, N-N, 4.5m	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	Pasternack	PE6061-50	BNC Male Termination, 50-ohm	N/A	6/19/2014
1594	Miteq	AFS44-00102650	Amplifier, 1-26.5GHz, 42dB	none	10/15/2013
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	11/26/2013
C030	N/A	RG214	Cable Coax, N-N, 25m	none	9/7/2013
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	00110313	1/30/2014
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A

**Table 9: Radiated Emissions Equipment List**

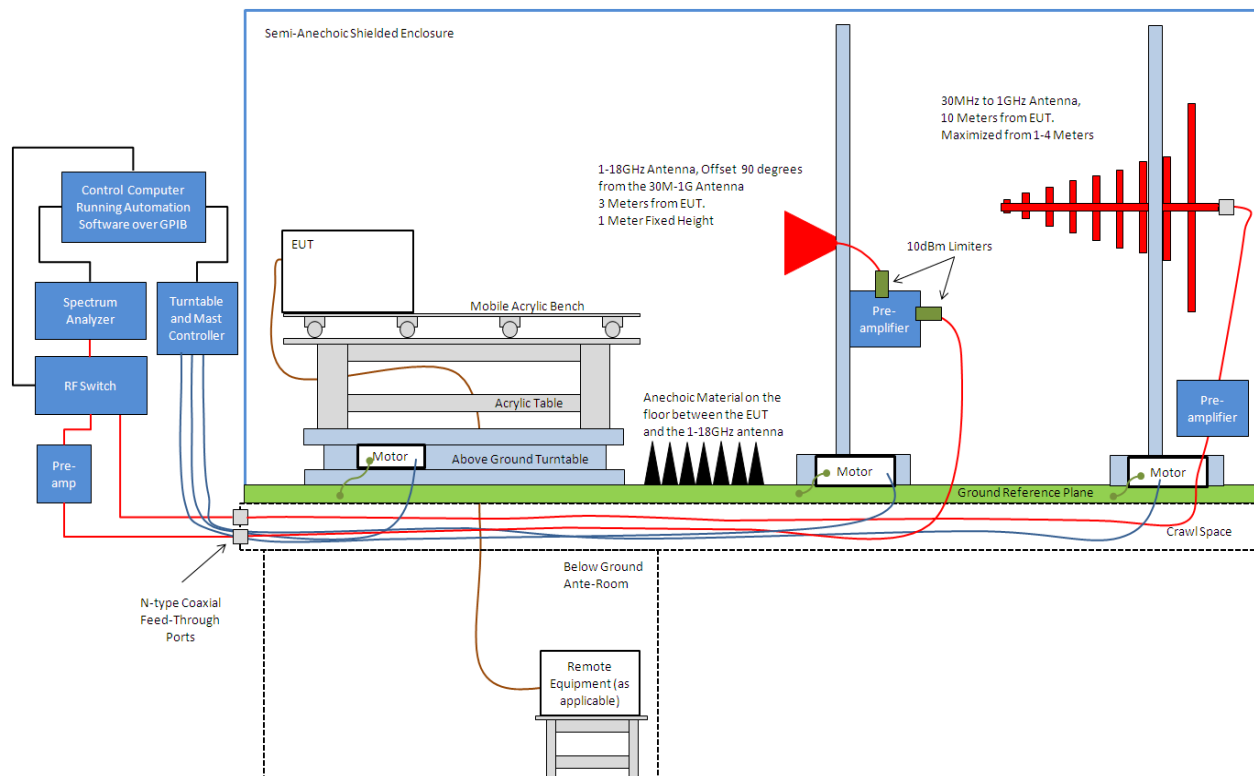
### 3.10.2 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable at a distance of 10 meters from the measurement antenna.

Support equipment necessary for operation of the EUT was placed below the chamber in the shielded ante-chamber.

The EUT transmit port is populated with the antenna designated for final use. The support equipment, designated LIU, is coupled into the chamber on a short gray antenna and attenuated to minimize impact on measurement. The LIU issues commands strictly by RF link to control the EUT.

Spurious/harmonic emissions above 1 GHz peak were measured with average and peak detection with a resolution bandwidth of 1 MHz and measured at a distance of 1 meter. Average detection was used to determine compliance of the EUT if the peak did not meet the average limit. Non-harmonic emissions must satisfy the average limit and the peak limit (20 dB above average). A diagram showing the test setup is given as Figure 13.



**Figure 13: Radiated Emissions Test Setup**



3.10.3 Test Results

4-Channel Spurious Emissions Results (Model 10-0032):

Professional Testing, EMI, Inc.			
<b>Test Method:</b>	ANSI C63.4–2009: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).		
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.209		
<b>Test Date(s):</b>	7/30/2013	<b>EUT Serial #:</b>	None
<b>Customer:</b>	Wireless Seismic	<b>EUT Part #:</b>	10-0032
<b>Project Number:</b>	14464-10	<b>Test Technician:</b>	Larry Fuller
<b>Purchase Order #:</b>		<b>Supervisor:</b>	Rob McCollough
<b>Equip. Under Test:</b>	4-Channel Wireless Remote Unit (WRU)	<b>Witness' Name:</b>	Bandeke Adepoju

Radiated Emissions Test Results Data Sheet								Page:	1	of	1
<b>EUT Line Voltage:</b>		3.7	VDC		<b>EUT Power Frequency:</b>		N/A	N/A			
<b>Antenna Orientation:</b>		Vertical			<b>Frequency Range:</b>		30MHz to 1GHz				
<b>EUT Mode of Operation:</b>					<b>LIU test</b>						
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		
101.472	10	295	1.17	Quasi-peak	32	12.88	33.1	-20.2	Pass		
101.98	10	218	1.54	Quasi-peak	28.2	9.064	33.1	-24.0	Pass		
104.969	10	78	1.46	Quasi-peak	27.8	8.583	33.1	-24.5	Pass		
175.99	10	355	1.34	Quasi-peak	35.1	18.692	33.1	-14.4	Pass		
207.998	10	19	1.36	Quasi-peak	35.2	20.36	33.1	-12.7	Pass		
971.963	10	235	2.86	Quasi-peak	21	25.742	43.5	-17.8	Pass		

Table 10: <1GHz Vertical Polarization Radiated Emissions Measurements (4-Ch)

**Professional Testing, EMI, Inc.**

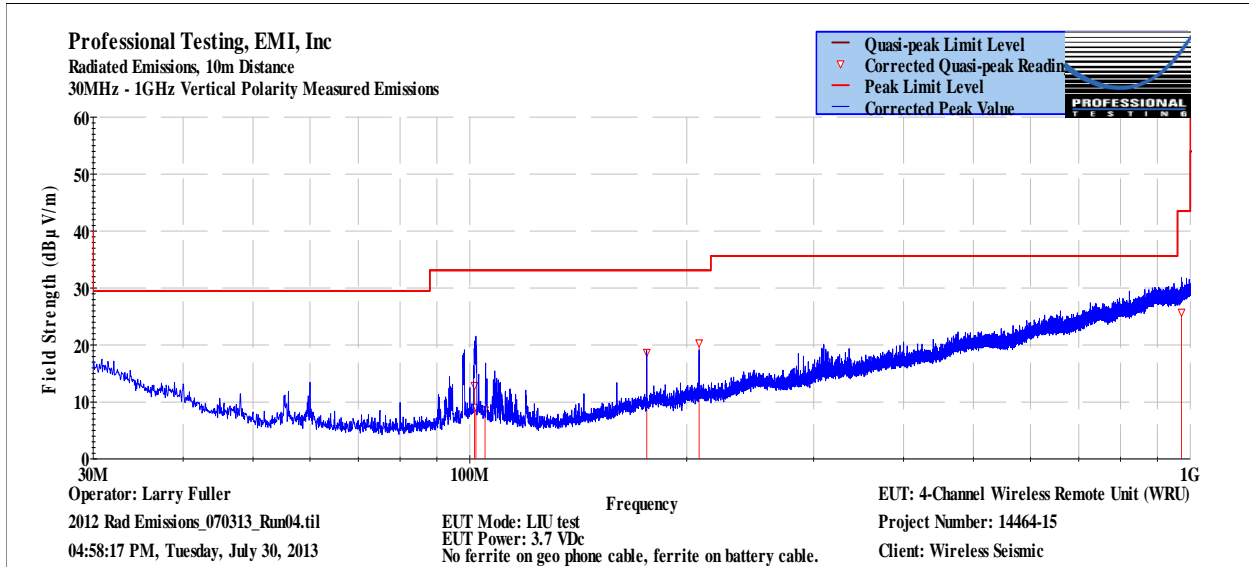
<b>Test Method:</b>	ANSI C63.4–2009: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).		
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.209		
<b>Test Date(s):</b>	7/30/2013	<b>EUT Serial #:</b>	None
<b>Customer:</b>	Wireless Seismic	<b>EUT Part #:</b>	10-0032
<b>Project Number:</b>	14464-10	<b>Test Technician:</b>	Larry Fuller
<b>Purchase Order #:</b>		<b>Supervisor:</b>	Rob McCollough
<b>Equip. Under Test:</b>	4-Channel Wireless Remote Unit (WRU)	<b>Witness' Name:</b>	Bandeke Adepoju

**Radiated Emissions Test Results Data Sheet**

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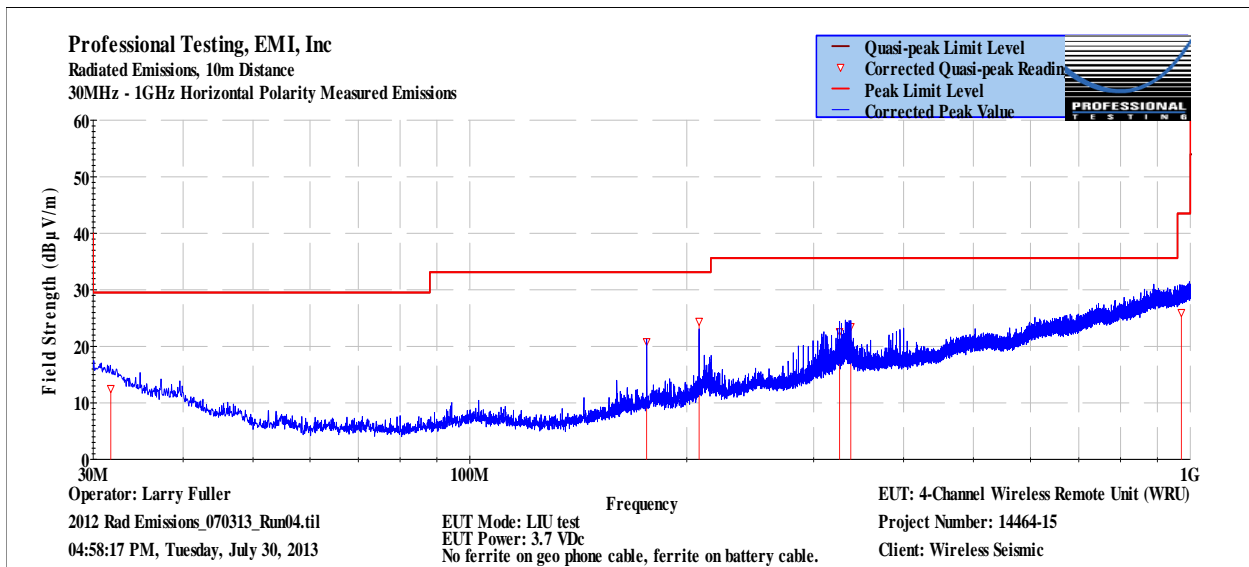
<b>EUT Line Voltage:</b>		3.7 VDC		<b>EUT Power Frequency:</b>		N/A N/A			
<b>Antenna Orientation:</b>		Horizontal		<b>Frequency Range:</b>		30MHz to 1GHz			
<b>EUT Mode of Operation:</b>					<b>LIU test</b>				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
31.7369	10	295	2.83	Quasi-peak	24.3	12.5	29.5	-17.0	Pass
175.988	10	99	3.65	Quasi-peak	37.2	20.8	33.1	-12.3	Pass
208.01	10	89	3.91	Quasi-peak	39.3	24.4	33.1	-8.7	Pass
325.974	10	83	3.07	Quasi-peak	33.3	22.6	35.6	-13.0	Pass
337.967	10	302	2.81	Quasi-peak	33.8	23.5	35.6	-12.1	Pass
971.783	10	223	1.28	Quasi-peak	21.2	26.0	43.5	-17.5	Pass

**Table 11: <1GHz Horizontal Polarization Radiated Emissions (4-Ch)**



Peak detection results.

Figure 14: <1GHz Vertical Polarization Radiated Emissions (4-Ch)



Peak detection results.

Figure 15: <1GHz Horizontal Polarization Radiated Emissions (4-Ch)

**Professional Testing, EMI, Inc.**

<b>Test Method:</b>	ANSI C63.4–2009: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).		
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.209		
<b>Test Date(s):</b>	7/30/2013	<b>EUT Serial #:</b>	None
<b>Customer:</b>	Wireless Seismic	<b>EUT Part #:</b>	10-0032
<b>Project Number:</b>	14464-10	<b>Test Technician:</b>	Larry Fuller
<b>Purchase Order #:</b>		<b>Supervisor:</b>	Rob McCollough
<b>Equip. Under Test:</b>	4-Channel Wireless Remote Unit (WRU)	<b>Witness' Name:</b>	Bandeke Adepoju

**Radiated Emissions Test Results Data Sheet**

Page: 1 of 1

<b>EUT Line Voltage:</b>	3.7	VDC	<b>EUT Power Frequency:</b>	N/A	N/A				
<b>Antenna Orientation:</b>	Vertical		<b>Frequency Range:</b>	Above 1GHz					
<b>EUT Mode of Operation:</b>			<b>LIU test</b>						
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
3683.85	3	165	1	Average	75.1	29.30	54.0	-24.7	Pass
4987.16	3	32	1	Average	74.8	31.468	54.0	-22.5	Pass
5741.42	3	190	1	Average	73.8	31.112	54.0	-22.8	Pass
7120.72	3	248	1	Average	69.5	33.53	54.0	-20.4	Pass
10853.3	3	134	1	Average	60.9	35.723	54.0	-18.2	Pass
15760.7	3	65	1	Average	58.5	36.634	54.0	-17.3	Pass

See the graphical results on the following pages for the peak detection levels.

**Table 12: 1-18GHz Vertical Polarization Radiated Emissions (4-Ch)**

**Professional Testing, EMI, Inc.**

<b>Test Method:</b>	ANSI C63.4–2009: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).		
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.209		
<b>Test Date(s):</b>	7/30/2013	<b>EUT Serial #:</b>	None
<b>Customer:</b>	Wireless Seismic	<b>EUT Part #:</b>	10-0032
<b>Project Number:</b>	14464-10	<b>Test Technician:</b>	Larry Fuller
<b>Purchase Order #:</b>		<b>Supervisor:</b>	Rob McCollough
<b>Equip. Under Test:</b>	4-Channel Wireless Remote Unit (WRU)	<b>Witness' Name:</b>	Bandeke Adepoju

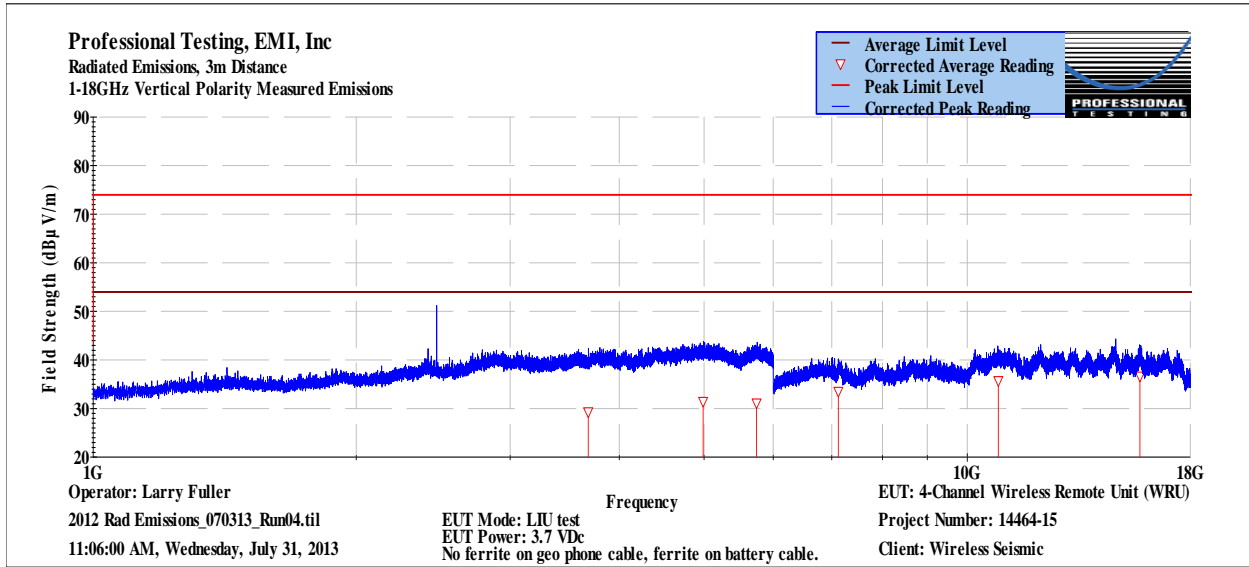
**Radiated Emissions Test Results Data Sheet**

Page: 1 of 1

<b>EUT Line Voltage:</b>	3.7	VDC	<b>EUT Power Frequency:</b>	N/A	N/A				
<b>Antenna Orientation:</b>	Horizontal		<b>Frequency Range:</b>	Above 1GHz					
<b>EUT Mode of Operation:</b>			<b>LIU test</b>						
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
3695.8	3	335	1	Average	75.1	29.4	54.0	-24.6	Pass
5001.92	3	336	1	Average	74.5	31.2	54.0	-22.7	Pass
5752.57	3	29	1	Average	73.7	31.1	54.0	-22.8	Pass
7122.11	3	96	1	Average	69.2	33.3	54.0	-20.7	Pass
10848.8	3	119	1	Average	61	35.8	54.0	-18.1	Pass
15742.8	3	127	1	Average	58.4	36.6	54.0	-17.4	Pass

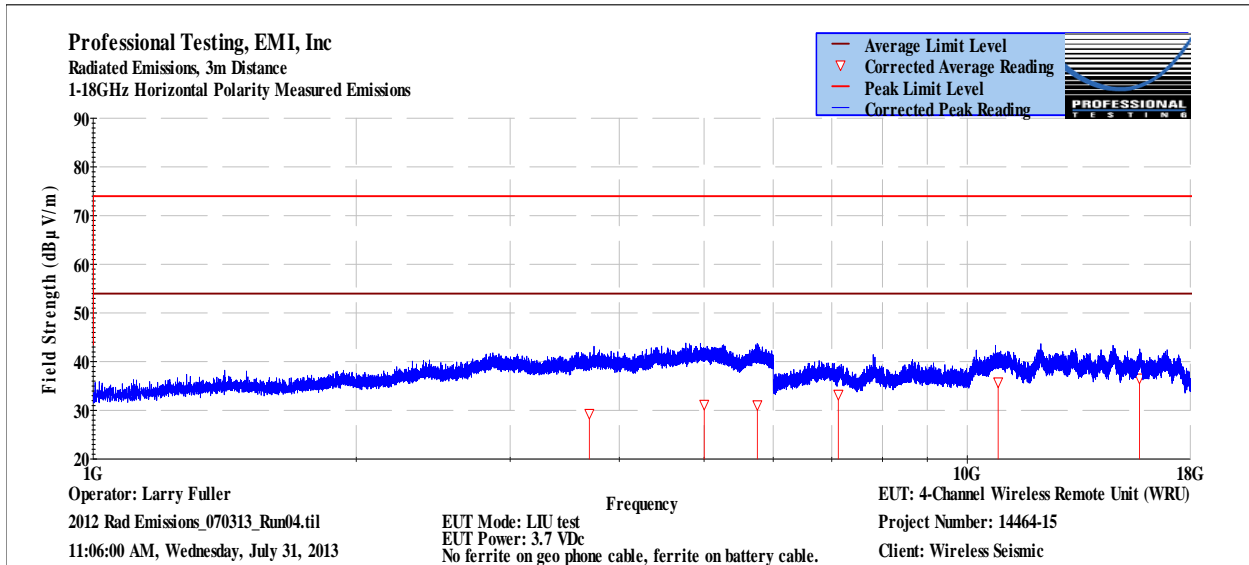
See the graphical results on the following pages for the peak detection levels.

**Table 13: 1-18GHz Horizontal Polarization Radiated Emissions (4-Ch)**



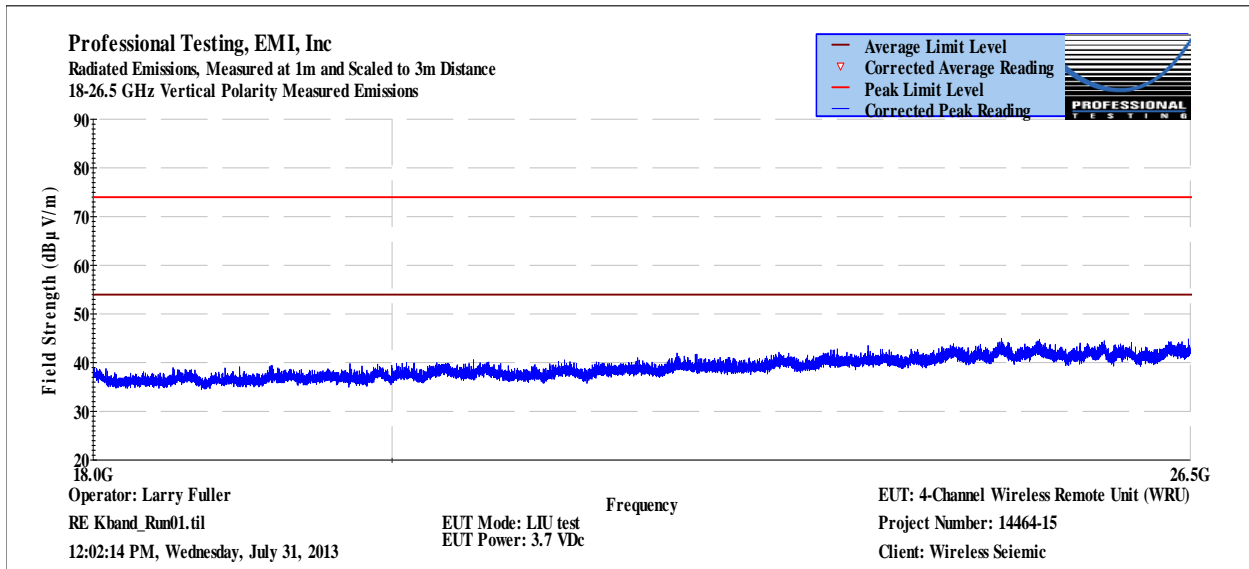
Peak detection results. All peak detection levels were below the average limits.

**Figure 16: 1-18GHz Vertical Polarization Radiated Emissions (4-Ch)**



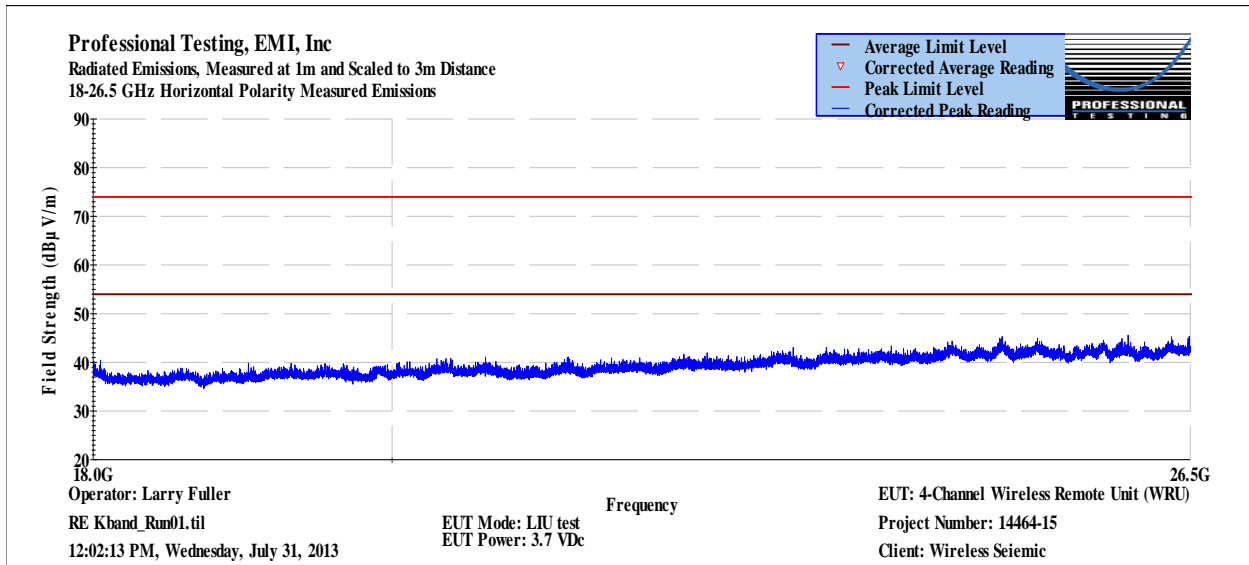
Peak detection results. All peak detection levels were below the average limits.

**Figure 17: 1-18GHz Horizontal Polarization Radiated Emissions (4-Ch)**



Peak detection results.

Figure 18: 18-26.5GHz Vertical Polarization Radiated Emissions (4-Ch)



Peak detection results.

Figure 19: 18-26.5GHz Horizontal Polarization Radiated Emissions (4-Ch)

3-Channel Spurious Emissions Results (Model 10-0023):

The 3-channel WRU was also examined for spurious emissions. Above 1GHz showed no differences from the 4-Channel version. 30MHz to 1GHz showed slight differences, but all results were well within required limits. The 30MHz to 1GHz emissions data for the 3-Channel unit is presented here.

### Professional Testing, EMI, Inc.

<b>Test Method:</b>	ANSI C63.4–2009: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).		
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.209		
<b>Test Date(s):</b>	9/11/2013	<b>EUT Serial #:</b>	None
<b>Customer:</b>	Wireless Seismic	<b>EUT Part #:</b>	10-0023
<b>Project Number:</b>	14464	<b>Test Technician:</b>	Eric Lifsey
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Rob McCollough
<b>Equip. Under Test:</b>	3 Channel Wireless Remote Unit	<b>Witness' Name:</b>	Bandeled Adepoju

**Radiated Emissions Test Results Data Sheet**

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<b>EUT Line Voltage:</b>		DC	VDC	<b>EUT Power Frequency:</b>		n/a	N/A		
<b>Antenna Orientation:</b>		Vertical		<b>Frequency Range:</b>		30MHz to 1GHz			
<b>EUT Mode of Operation:</b>				<b>Transmitting/hopping</b>					
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
59.9855	10	303	3.89	Quasi-peak	28.9	8.04	29.5	-21.5	Pass
80.023	10	61	2.14	Quasi-peak	31.2	9.913	29.5	-19.6	Pass
107.424	10	102	1.76	Quasi-peak	28.7	9.429	33.1	-23.7	Pass
176.003	10	10	1.18	Quasi-peak	33.6	17.274	33.1	-15.8	Pass
208.013	10	358	1.28	Quasi-peak	32.7	17.811	33.1	-15.3	Pass
329.985	10	315	1.46	Quasi-peak	30.9	20.286	35.6	-15.3	Pass

**Table 14: <1GHz Vertical Polarization Radiated Emissions Measurements (3-Ch)**



**Professional Testing, EMI, Inc.**

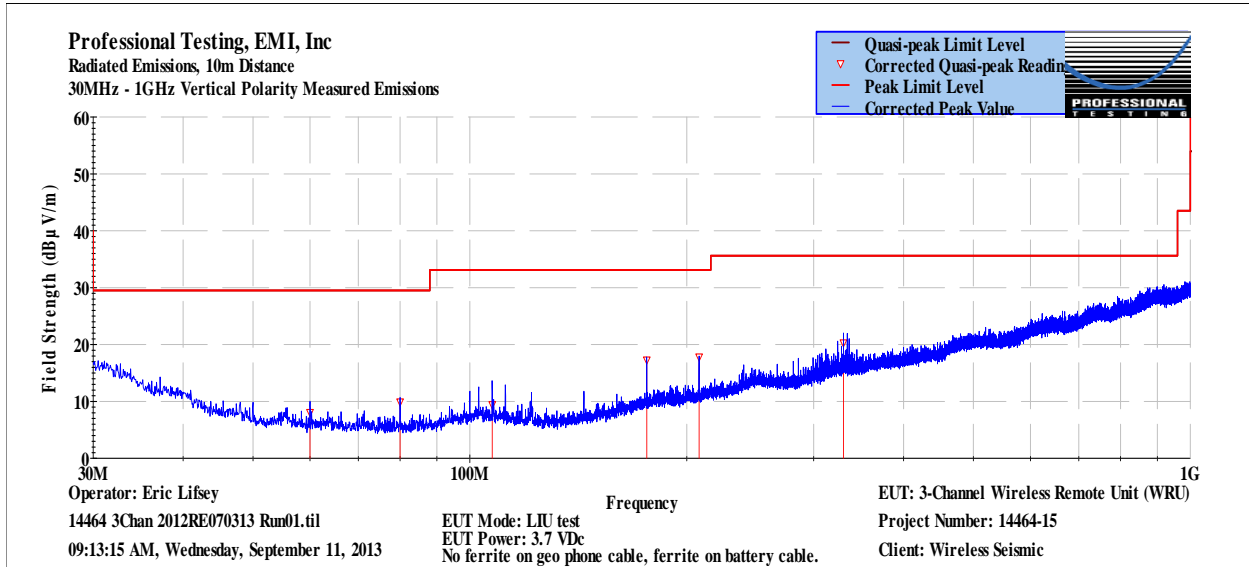
<b>Test Method:</b>	ANSI C63.4–2009: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).		
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
<b>Section:</b>	15.209		
<b>Test Date(s):</b>	9/11/2013	<b>EUT Serial #:</b>	None
<b>Customer:</b>	Wireless Seismic	<b>EUT Part #:</b>	10-0023
<b>Project Number:</b>	14464	<b>Test Technician:</b>	Eric Lifsey
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Rob McCollough
<b>Equip. Under Test:</b>	3 Channel Wireless Remote Unit	<b>Witness' Name:</b>	Bande Adepaju

**Radiated Emissions Test Results Data Sheet**

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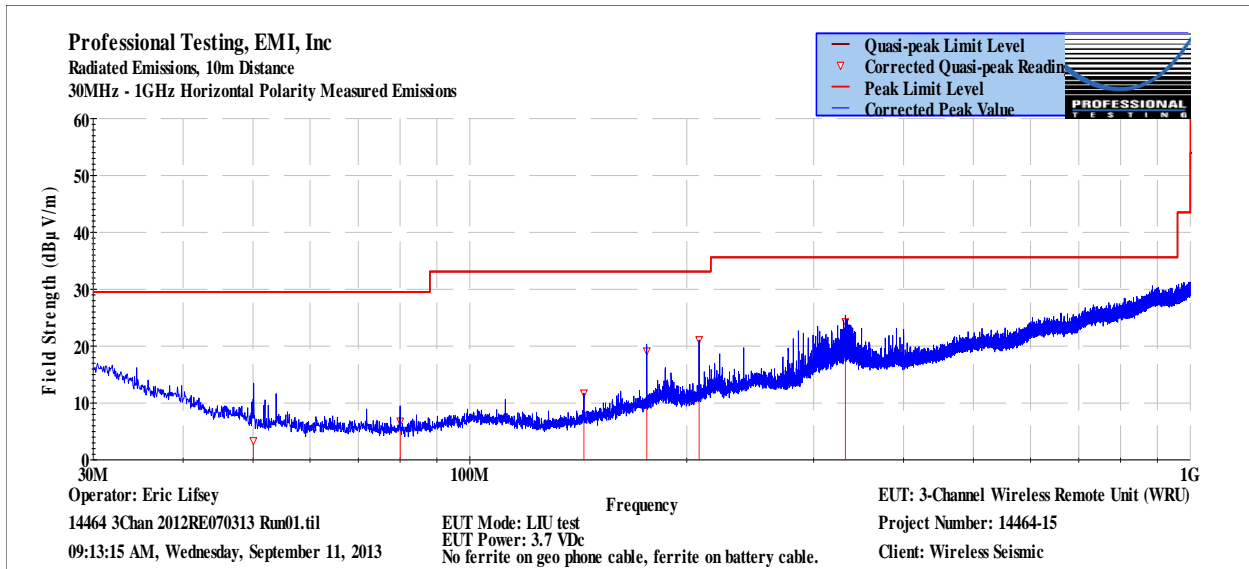
<b>EUT Line Voltage:</b>	DC	VDC	<b>EUT Power Frequency:</b>	n/a	N/A				
<b>Antenna Orientation:</b>	Horizontal		<b>Frequency Range:</b>	30MHz to 1GHz					
<b>EUT Mode of Operation:</b>			<b>Transmitting/Hopping</b>						
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
50.0538	10	89	3	Quasi-peak	23.2	3.4	29.5	-26.1	Pass
80.0266	10	38	2.32	Quasi-peak	28	6.8	29.5	-22.7	Pass
143.99	10	253	3.22	Quasi-peak	30.7	11.8	33.1	-21.4	Pass
176.001	10	171	3.53	Quasi-peak	35.5	19.2	33.1	-13.9	Pass
208.015	10	72	3.69	Quasi-peak	36	21.1	33.1	-12.0	Pass
331.989	10	64	2.72	Quasi-peak	34.8	24.3	35.6	-11.3	Pass

**Table 15: <1GHz Horizontal Polarization Radiated Emissions Measurement (3-Ch)**



Peak detection results.

Figure 20: <1GHz Vertical Polarization Radiated Emissions (3-Ch)



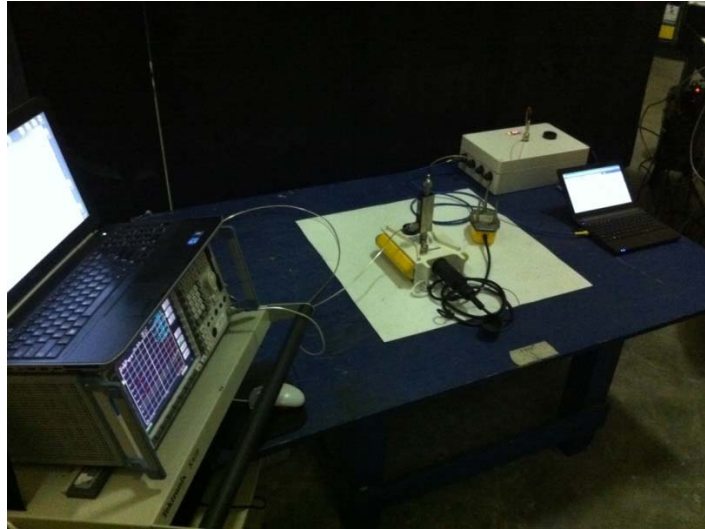
Peak detection results.

Figure 21: <1GHz Horizontal Polarization Radiated Emissions (3-Ch)

## 4 Setup Photos

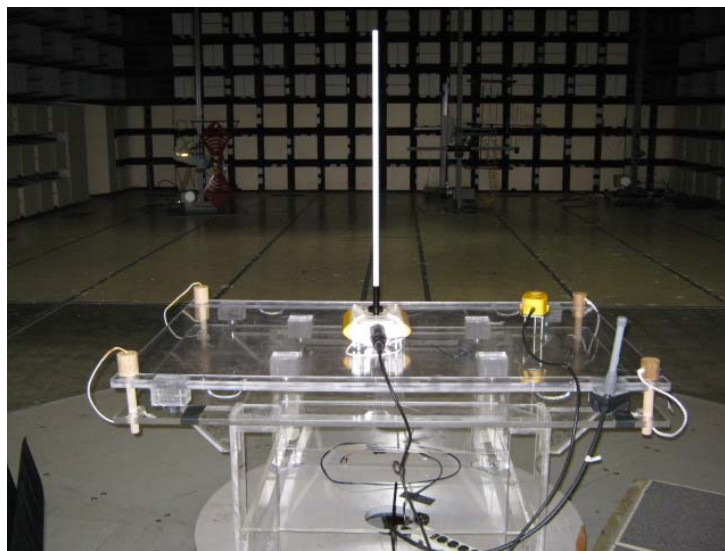
### 4.1.1 RF Conducted Test Setup

Figure 21 below shows the physical embodiment of Figure 1 in Section 3.2.2.

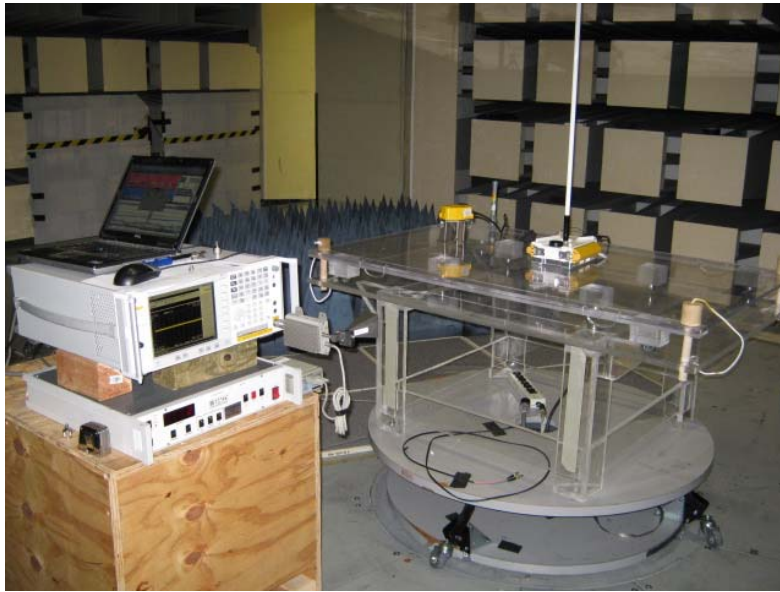


**Figure 22: RF Conducted Test Setup**

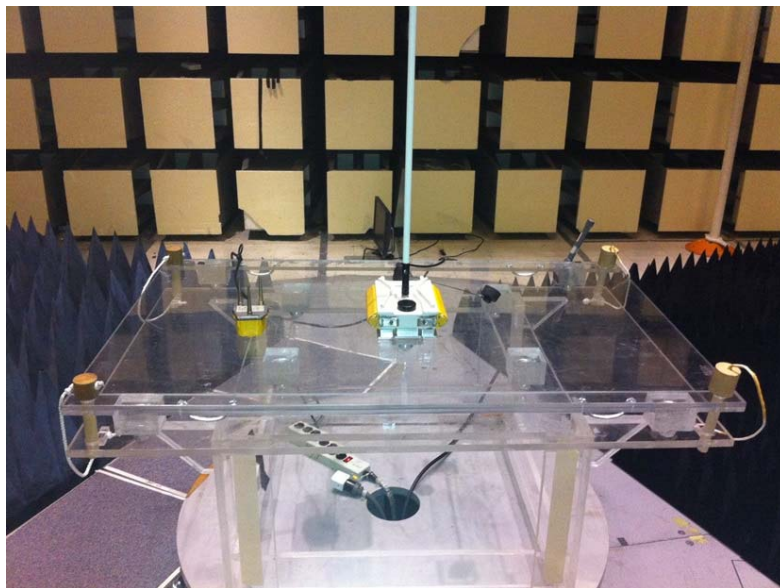
### 4.1.2 Radiated Spurious Emissions Test Setup



**Figure 23: Spurious Emissions Setup, 30MHz – 18GHz, 4-Channel WRU**



**Figure 24: Spurious Emissions Setup, 18MHz – 25GHz, 4-Channel WRU**



**Figure 25: Spurious Emissions Setup, 30MHz – 18GHz, 3-Channel WRU**

Report End