1601 North A.W. Grimes Blvd., Suite B
Round Rock, TX 78665
e-mail: info@ptitest.com
(512) 244-3371 Fax: (512) 244-1846

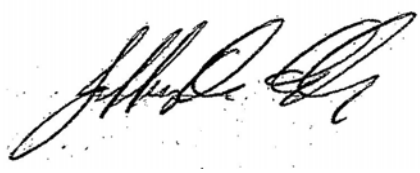
June 11, 2014

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

Dear Bandele:

Thank you for allowing Professional Testing (EMI), Inc. an opportunity to perform testing for Wireless Seismic, Inc. Enclosed is the Wireless Certification Report for the WRU Model 01-0001. This report can be used to demonstrate compliance with FCC and IC requirements for wireless devices in North America.

Sincerely,



Jeffrey A. Lenk
President

Attachment

Project 15298-15

# Wireless Seismic, Inc.
# Wireless Remote Unit (WRU) V4
# Model 01-0001

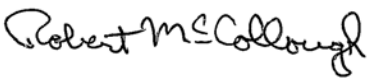
## Wireless Certification Report
## FCC 47 CFR Part 15C
## IC RSS-210

Prepared for:
Wireless Seismic, Inc.
13100 Southwest Freeway
Suite 150
Sugar Land, TX 77478
By

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

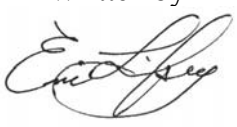
June 11, 2014

Reviewed by



Robert McCollough
Director of Testing Services

Written by



Eric Lifsey
EMC Engineer

## Revision History

| Revision Number | Description | Date |
|---|---|---|
| 00 | Initial draft released | June 11, 2014 |
| 01 | Revised per client comments. | June 11, 2014 |
| 02 | Revised per Rob McCollough comments. | June 12, 2014 |
| | | |

**Table of Contents**

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

# Certificate of Compliance

| Applicant | Device & Test Identification | |
|---|---|---|
| Wireless Seismic, Inc. (Bandele Adepoju) | FCC ID: | YZO-00106 |
| 13100 Southwest Freeway | Industry Canada ID: | 10081A-WSI00106 |
| Suite 150 | Model(s): | 01-0001 |
| Sugar Land, TX 77478 | Part Number(s): | 10-0029 |
| Certificate Date: June 11, 2014 | Laboratory Project ID: | 15298-15 |

The **Wireless Seismic, Inc., WRU 01-0001** was tested utilizing the following documents and found to be in compliance with the required criteria.

| Standard | 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 | 15.205 | 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, and Supplement C, Ed. 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) |

*Exposure is reported separately from this document.

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

Lab Code 200062-0

Jeffrey A. Lenk
President

This report has been reviewed and accepted by Wireless Seismic, Inc. The undersigned is responsible for ensuring that the WRU 01-0001 will continue to comply with the applicable rules.

_____
Representative of Wireless Seismic, Inc.

# 1 Introduction

## 1.1 Scope

The purpose of the EMC testing was to determine compliance with FCC and Industry Canada rules. This report describes the extent to which the equipment under test (EUT) conformed to the standards to which it was tested and the manner in which that testing was conducted.

## 1.2 EUT Description

The EUT is the WRU. The EUT is intended to be used outdoors, commonly remote locations, to measure seismic disturbances (man-made generally) and relay that information by wireless means using the 2.4 GHz band in hopping mode.

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

The system tested consisted of the following:

**Table 1.2.1: Equipment Under Test**

| **Manufacturer & Model, EUT:** | **Serial #** | **Description** |
|---|---|---|
| Wireless Seismic<br>Model 01-0001 | 0120800000150 | Remote seismic monitor |
| **Manufacturer & Model, Attachment(s):** | | |
| Comet<br>Model CFA-245 (Gain 5.5 dBi max) | None | Fiberglass monopole antenna |
| **Cords and Cables - None** | | |
| **Oscillator Frequencies** | | |
| 16MHz Oscillator, and communicates on radio channels in the range of 2403 MHz to 2475 MHz. | | |

## 1.3 EUT Operation

This device is for outdoor use. It operates as long as charged batteries are connected. Combined with other same or similar units, they are placed at widely-spaced strategic locations on the surface of the soil. Each unit is activated by attaching the external battery packs. They then poll over the air for a collection device designated as the Line Interface Unit (LIU) where they send seismic disturbance measurements. When a seismic event occurs (typically man-made), the device collects the seismic levels and reports the data to the LIU.

The LIU is interfaced to a computer system which collects the seismic data and converts the measurements to a 3-d image of structures beneath the soil surface.

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

## 1.4 Modifications to Equipment

No modifications were made to the EUT during the performance of the tests.

## 1.5 Test Site

Radiated and conducted measurements of emissions were made at Professional Testing Inc. (EMI), Site 45, Austin, Texas, USA.

Measurements of extremes were performed at Professional Testing Inc., 1601 N. A. W. Grimes Blvd., Suite B, Round Rock, Texas, USA.

# 2 Peak Output Power, Conducted

## 2.1 Test Procedure

Power was measured by connection to the EUT using a power attenuator of nominal loss 20 dB and its loss factor was applied. The EUT was connected to the LIU by radiated fields. The EUT was exercised at maximum power at the recorded power setting. Conducted output power measurements were made for the bottom, middle and top channels of the EUT.

## 2.2 Test Criteria

| 47 CFR (USA) // IC (Canada) | | |
|---|---|---|
| Section Reference | Parameter | Date |
| 15.247(a)(3), 15.247(b)(1) // RSS-210 Issue 8, A2.9 | Fundamental Power Conducted<br>Limit: 0.125 Watt (21 dBm) | 2014-05-14 |

This device employs 19 hopping channels. Power is limited to 0.125 W per rule for hopping systems employing less than 75 hopping channels.

## 2.3 Test Results

The emissions from the EUT were measured for the standard 3 channels and are reported below. The power setting level was 15. The 20 dB bandwidth measured just over 3 MHz so resolution and video bandwidth for the power measurement was set to 10 MHz.

The EUT satisfied the limits.

| Table 2.3.1 Maximum Peak Output Power, Conducted | | |
|---|---|---|
| **Frequency (GHz)** | **Measured Power EIRP (dBm)** | **Limit (dBm)** |
| 2.403 | 19.90 | 21 |
| 2.440 | 19.56 | 21 |
| 2.475 | 19.14 | 21 |

## 2.4 Test Equipment

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| ALN-077 | Rohde & Schwarz | FSP-30 | Spectrum Analyzer | 2015-01-29 |
| C248 | Pasternack | N/A | Cable | 2015-05-14 |
| A105 | Narda | 768A-20 | RF Attenuator, 20 W, 20 dB | 2015-05-16 |
| 0881 | Thermotron | S-1.2C | Environmental Chamber S/N 27131 | 2014-09-13 |
| None | BK Precision | 1710 | Bench Power Supply S/N 261 0200 0081 | Cal In Use |
| 2087 | Fluke | 189 | DMM, True RMS | 2015-03-06 |

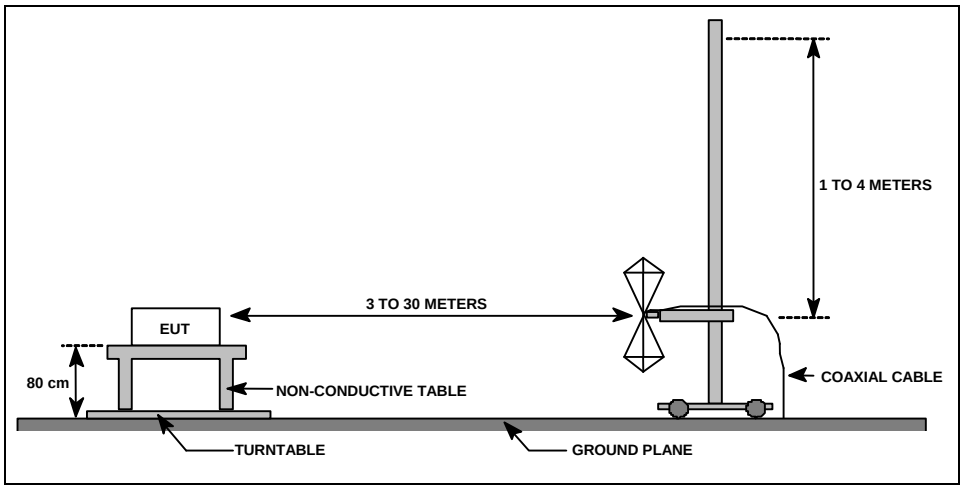
# 3 Power Spectral Density, Conducted

This test is applicable to wide band modulation schemes including direct sequence spread spectrum (DSSS) but not to frequency hopping spread spectrum (FHSS) schemes. This device uses FHSS exclusively. Therefore this test does not apply.

# 4 Transmitter/Receiver Unwanted Emissions, Spurious Domain, Radiated

## 4.1 Test Procedure

The field strength was measured at frequencies from 30 MHz up to 1 GHz at a distance of 10 meters; 1 GHz to 25 GHz at a distance of 3 meters. The EUT was switched on with normal modulation. A diagram showing the test setup is given below.




**Spurious Radiated Emissions – Test Setup**

The support equipment including the LIU was placed outside of the chamber and communicated with the EUT by an antenna located inside the chamber and approximately 3 meters from the EUT. The antenna was connected by coaxial cable that passed through the chamber sub-floor to the cable feed-through panel. A fixed attenuator was added to the LIU to minimize its signal strength.

## 4.2 Test Criteria

| 47 CFR (USA) // IC (Canada) | | |
|---|---|---|
| Section Reference | Parameter | Date(s) |
| 15.247, 15.209 // RSS-Gen Issue 3, 4.9, 4.10 | Field Strength of Radiated Spurious/Harmonic Emissions | 2014-05-13 |

## 4.3 Test Results

In the hopping transmit/receive mode, emissions were measured from 30 MHz to 25 GHz.

In the non-hopping single-channel mode, emissions were measured in transmit/receive mode from 1 GHz to 25 GHz. Three channels were selected; lowest, middle, and highest.

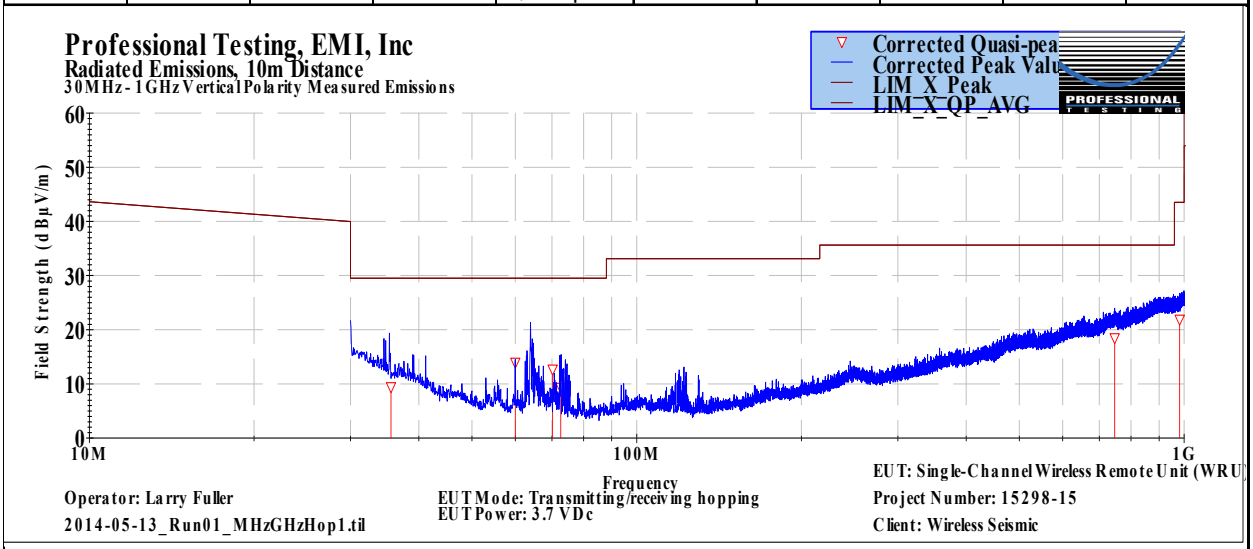
The radiated emissions generated by the EUT were below the applicable limits.

**Table 4.3.1: Vertical, Spurious Radiated Emissions – T/R, Hopping, Below 1 GHz**

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| **Test Method:** | ANSI C63.4–2003: "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). | | |
| **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):** | 5/13/2014 | **EUT Serial #:** | 120800000150 |
| **Customer:** | Wireless Seismic | **EUT Part #:** | N/A |
| **Project Number:** | 15298-15 | **Test Technician:** | Larry Fuller |
| **Purchase Order #:** | | **Supervisor:** | Rob McCollough |
| **Equip. Under Test:** | Single-Channel Wireless Remote | **Witness' Name:** | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| **EUT Line Voltage:** | 3.7 VDC | **EUT Power Frequency:** | N/A N/A |
| **Antenna Orientation:** | Vertical | **Frequency Range:** | 30MHz to 1GHz |
| **EUT Mode of Operation:** | | Transmitting/receiving hopping | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 35.5719 | 10 | 251 | 1.53 | Quasi-peak | 23.5 | 9.424 | 29.5 | -20.1 | Pass |
| 60.0082 | 10 | 181 | 3.17 | Quasi-peak | 35.3 | 13.952 | 29.5 | -15.5 | Pass |
| 70.2244 | 10 | 29 | 1.76 | Quasi-peak | 34.1 | 12.689 | 29.5 | -16.8 | Pass |
| 72.6141 | 10 | 144 | 2.18 | Quasi-peak | 30.9 | 9.312 | 29.5 | -20.2 | Pass |
| 746.84 | 10 | 285 | 1.62 | Quasi-peak | 21.7 | 18.475 | 35.6 | -17.1 | Pass |
| 981.598 | 10 | 41 | 2.83 | Quasi-peak | 21.1 | 21.921 | 43.5 | -21.6 | Pass |



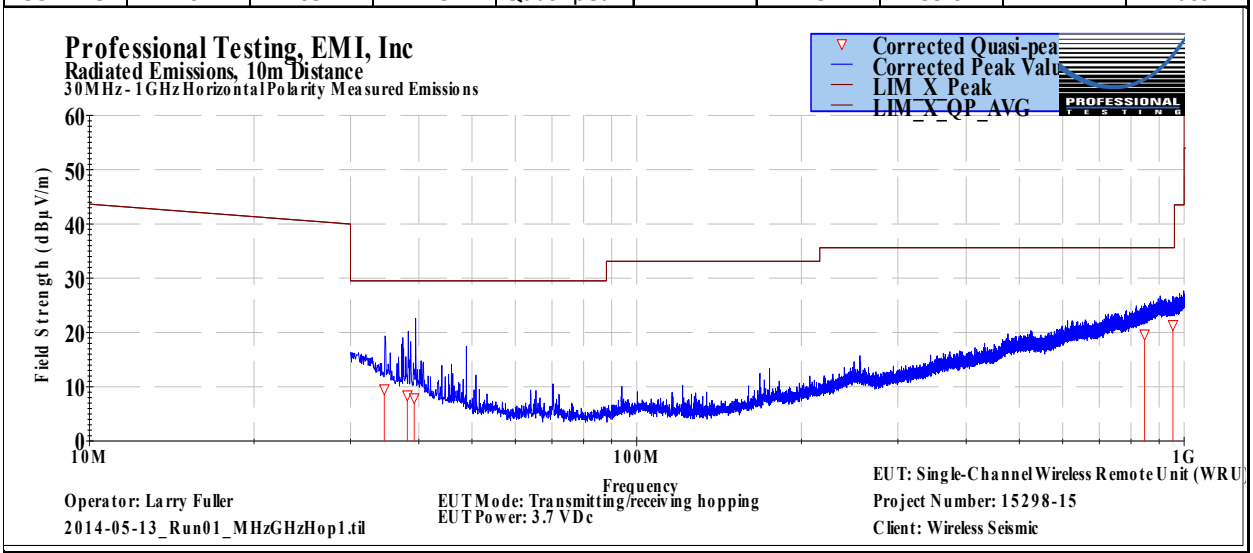

≤ 1GHz Vertical Antenna Polarity Measured Emissions

**Table 4.3.2: Horizontal, Spurious Radiated Emissions – T/R, Hopping, Below 1 GHz**

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| **Test Method:** | ANSI C63.4–2003: "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). | | |
| **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):** | 5/13/2014 | **EUT Serial #:** | 120800000150 |
| **Customer:** | Wireless Seismic | **EUT Part #:** | N/A |
| **Project Number:** | 15298-15 | **Test Technician:** | Larry Fuller |
| **Purchase Order #:** | | **Supervisor:** | Rob McCollough |
| **Equip. Under Test:** | Single-Channel Wireless Remote | **Witness' Name:** | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| **EUT Line Voltage:** | 3.7 VDC | **EUT Power Frequency:** | N/A N/A |
| **Antenna Orientation:** | Horizontal | **Frequency Range:** | 30MHz to 1GHz |
| **EUT Mode of Operation:** | | Transmitting/receiving hopping | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 34.7428 | 10 | 22 | 2.27 | Quasi-peak | 23 | 9.426 | 29.5 | -20.1 | Pass |
| 38.1433 | 10 | 107 | 2.44 | Quasi-peak | 23.7 | 8.221 | 29.5 | -21.3 | Pass |
| 39.4317 | 10 | 296 | 1.39 | Quasi-peak | 24 | 7.796 | 29.5 | -21.7 | Pass |
| 48.6317 | 10 | 127 | 3.18 | Quasi-peak | 23.7 | 3.984 | 29.5 | -25.5 | Pass |
| 846.971 | 10 | 297 | 1.08 | Quasi-peak | 21.4 | 19.728 | 35.6 | -15.9 | Pass |
| 954.243 | 10 | 65 | 2.8 | Quasi-peak | 21.1 | 21.377 | 35.6 | -14.2 | Pass |



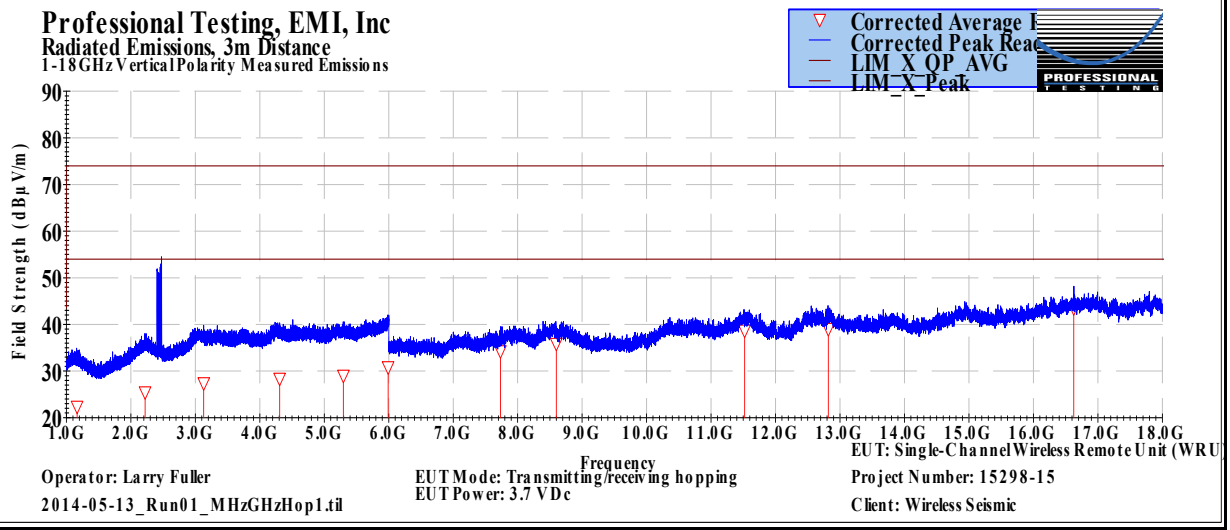

≤ 1GHz Horizontal Antenna Polarity Measured Emissions

## Table 4.3.3: Vertical, Spurious Radiated Emissions – T/R, Hopping, Above 1 GHz

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| Test Method: | ANSI C63.4–2003: "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). | | |
| 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): | 5/13/2014 | EUT Serial #: | 120800000150 |
| Customer: | Wireless Seismic | EUT Part #: | N/A |
| Project Number: | 15298-15 | Test Technician: | Larry Fuller |
| Purchase Order #: | | Supervisor: | Rob McCollough |
| Equip. Under Test: | Single-Channel Wireless Remote | Witness' Name: | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 | | |
|---|---|---|---|---|---|
| EUT Line Voltage: | 3.7 | VDC | EUT Power Frequency: | N/A | N/A |
| Antenna Orientation: | Vertical | | Frequency Range: | Above 1GHz | |
| EUT Mode of Operation: | | | Transmitting/receiving hopping | | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1165.33 | 3 | 79 | 0 | Average | 35.1 | 22.39 | 54.0 | -31.6 | Pass |
| 2220.32 | 3 | 187 | 0 | Average | 34.5 | 25.456 | 54.0 | -28.5 | Pass |
| 3129.86 | 3 | 258 | 0 | Average | 34.9 | 27.416 | 54.0 | -26.5 | Pass |
| 4307.27 | 3 | 212 | 0 | Average | 33.6 | 28.39 | 54.0 | -25.6 | Pass |
| 5297.22 | 3 | 315 | 0 | Average | 32.4 | 29.018 | 54.0 | -24.9 | Pass |
| 5991.18 | 3 | 179 | 0 | Average | 31.2 | 30.849 | 54.0 | -23.1 | Pass |
| 7732.76 | 3 | 64 | 0 | Average | 27.8 | 34.29 | 54.0 | -19.7 | Pass |
| 8598.49 | 3 | 283 | 0 | Average | 27.7 | 35.858 | 54.0 | -18.1 | Pass |
| 11519.7 | 3 | 279 | 0 | Average | 27.5 | 38.706 | 54.0 | -15.3 | Pass |
| 12819.2 | 3 | 131 | 0 | Average | 28 | 39.032 | 54.0 | -14.9 | Pass |
| 16624.3 | 3 | 153 | 0 | Average | 27.6 | 43.48 | 54.0 | -10.5 | Pass |



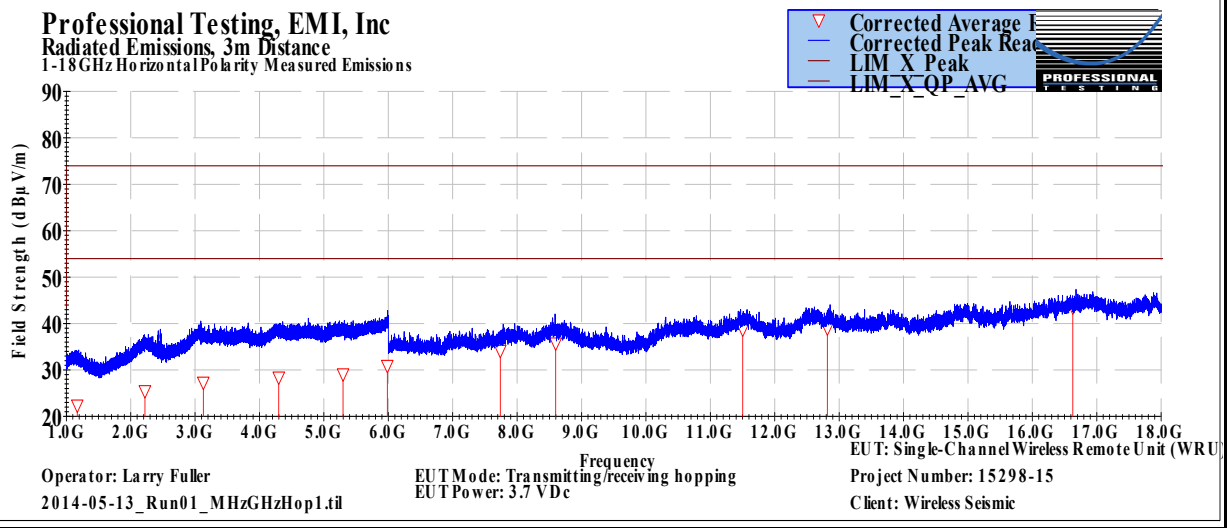

> 1GHz Vertical Antenna Polarity Measured Emissions

**Table 4.3.4: Horizontal, Spurious Radiated Emissions – T/R, Hopping, Above 1 GHz**

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| **Test Method:** | ANSI C63.4–2003: "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). | | |
| **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):** | 5/13/2014 | **EUT Serial #:** | 120800000150 |
| **Customer:** | Wireless Seismic | **EUT Part #:** | N/A |
| **Project Number:** | 15298-15 | **Test Technician:** | Larry Fuller |
| **Purchase Order #:** | | **Supervisor:** | Rob McCollough |
| **Equip. Under Test:** | Single-Channel Wireless Remote | **Witness' Name:** | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| **EUT Line Voltage:** | 3.7 VDC | **EUT Power Frequency:** | N/A N/A |
| **Antenna Orientation:** | Horizontal | **Frequency Range:** | Above 1GHz |
| **EUT Mode of Operation:** | | Transmitting/receiving hopping | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1170.47 | 3 | 259 | 0 | Average | 35.1 | 22.366 | 54.0 | -31.6 | Pass |
| 2221.22 | 3 | 9 | 0 | Average | 34.5 | 25.473 | 54.0 | -28.5 | Pass |
| 3127.69 | 3 | 281 | 0 | Average | 34.7 | 27.278 | 54.0 | -26.7 | Pass |
| 4297.95 | 3 | 258 | 0 | Average | 33.6 | 28.405 | 54.0 | -25.6 | Pass |
| 5296.39 | 3 | 136 | 0 | Average | 32.5 | 29.086 | 54.0 | -24.9 | Pass |
| 5985.19 | 3 | 26 | 0 | Average | 31.3 | 30.913 | 54.0 | -23.0 | Pass |
| 7738.77 | 3 | 76 | 0 | Average | 27.6 | 34.18 | 54.0 | -19.8 | Pass |
| 8598.29 | 3 | 245 | 0 | Average | 27.6 | 35.749 | 54.0 | -18.2 | Pass |
| 11503.6 | 3 | 322 | 0 | Average | 27.5 | 38.761 | 54.0 | -15.2 | Pass |
| 12817.5 | 3 | 75 | 0 | Average | 27.9 | 38.988 | 54.0 | -15.0 | Pass |
| 16629.7 | 3 | 144 | 0 | Average | 27.6 | 43.479 | 54.0 | -10.5 | Pass |



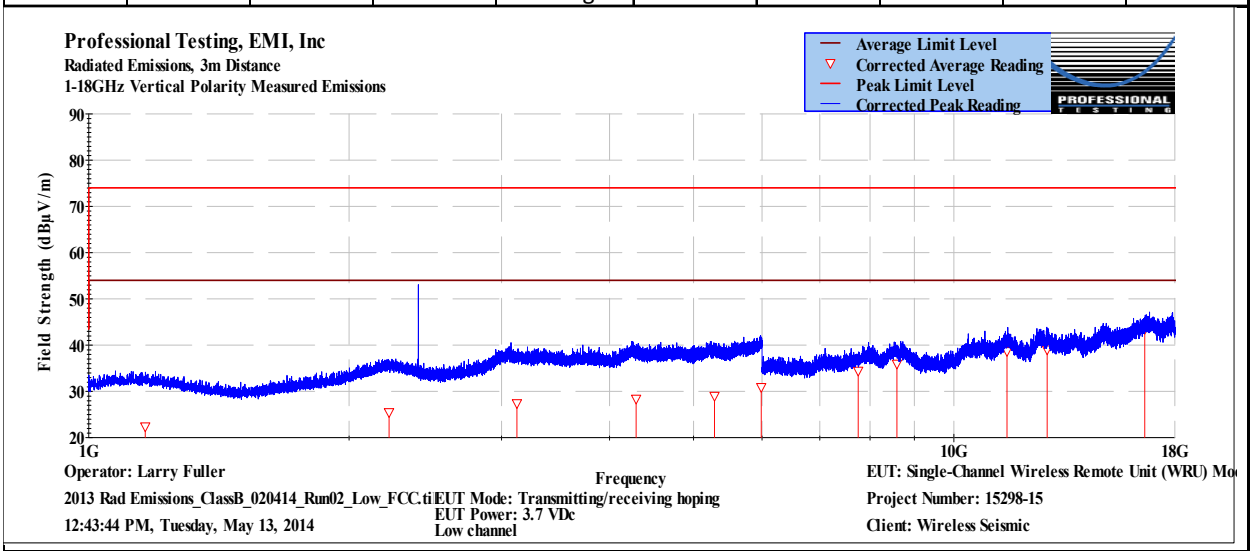

> 1GHz Horizontal Antenna Polarity Measured Emissions

## Table 4.3.5: Vertical, Spurious Radiated Emissions – T/R, Above 1 GHz, Low Channel

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| Test Method: | ANSI C63.4–2003: "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). | | |
| 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): | 5/13/2014 | EUT Serial #: | 120800000150 |
| Customer: | Wireless Seismic | EUT Part #: | N/A |
| Project Number: | 15298-15 | Test Technician: | Larry Fuller |
| Purchase Order #: | | Supervisor: | Rob McCollough |
| Equip. Under Test: | Single-Channel Wireless Remote | Witness' Name: | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| EUT Line Voltage: | 3.7 VDC | EUT Power Frequency: | N/A N/A |
| Antenna Orientation: | Vertical | Frequency Range: | Above 1GHz |
| EUT Mode of Operation: | | Transmitting/receiving Low Channel | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1162.44 | 3 | 4 | 1 | Average | 35.2 | 22.378 | 54.0 | -31.6 | Pass |
| 2223.69 | 3 | 40 | 1 | Average | 34.5 | 25.487 | 54.0 | -28.5 | Pass |
| 3125.55 | 3 | 280 | 1 | Average | 34.9 | 27.406 | 54.0 | -26.6 | Pass |
| 4292.59 | 3 | 206 | 1 | Average | 33.6 | 28.392 | 54.0 | -25.6 | Pass |
| 5288.08 | 3 | 75 | 1 | Average | 32.4 | 28.987 | 54.0 | -25.0 | Pass |
| 5988.25 | 3 | 85 | 1 | Average | 31.3 | 30.896 | 54.0 | -23.1 | Pass |
| 7749.69 | 3 | 340 | 1 | Average | 27.8 | 34.437 | 54.0 | -19.5 | Pass |
| 8592.38 | 3 | 314 | 1 | Average | 27.8 | 35.958 | 54.0 | -18.0 | Pass |
| 11512.7 | 3 | 218 | 1 | Average | 27.5 | 38.703 | 54.0 | -15.3 | Pass |
| 12812.1 | 3 | 345 | 1 | Average | 28 | 39.025 | 54.0 | -14.9 | Pass |
| 16612.5 | 3 | 99 | 1 | Average | 27.6 | 43.455 | 54.0 | -10.5 | Pass |



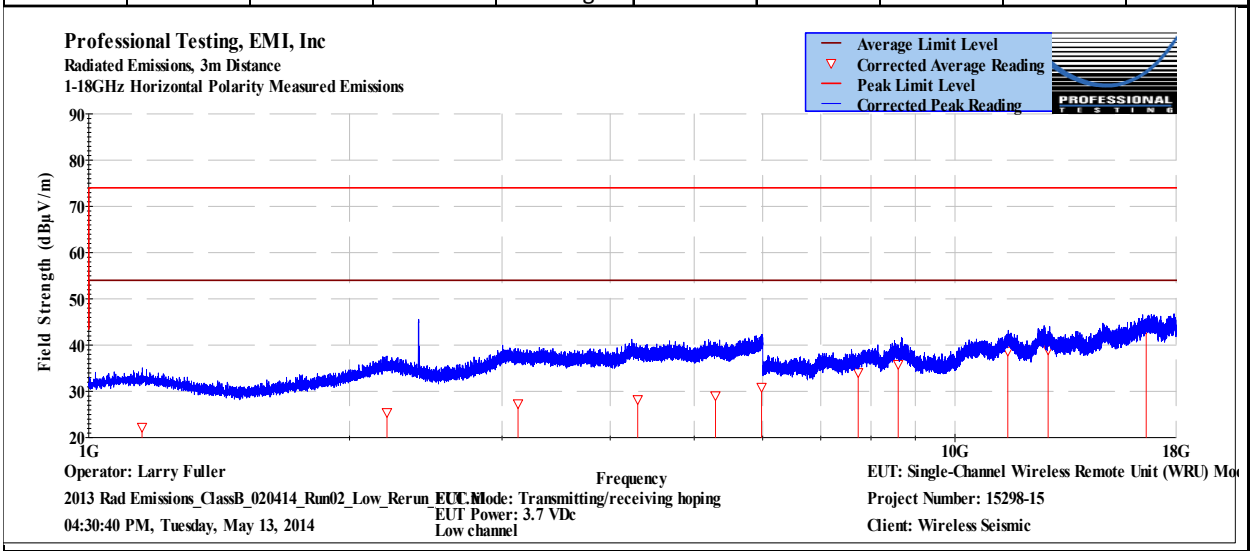

> 1GHz Vertical Antenna Polarity Measured Emissions

## Table 4.3.6: Horizontal, Spurious Radiated Emissions – T/R, Above 1 GHz, Low Channel

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| Test Method: | ANSI C63.4–2003: "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). | | |
| 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): | 5/13/2014 | EUT Serial #: | 120800000150 |
| Customer: | Wireless Seismic | EUT Part #: | N/A |
| Project Number: | 15298-15 | Test Technician: | Larry Fuller |
| Purchase Order #: | | Supervisor: | Rob McCollough |
| Equip. Under Test: | Single-Channel Wireless Remote | Witness' Name: | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| EUT Line Voltage: | 3.7 VDC | EUT Power Frequency: | N/A N/A |
| Antenna Orientation: | Horizontal | Frequency Range: | Above 1GHz |
| EUT Mode of Operation: | | Transmitting/receiving Low Channel | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1152.08 | 3 | 246 | 1 | Average | 35.1 | 22.28 | 54.0 | -31.7 | Pass |
| 2209.12 | 3 | 61 | 1 | Average | 34.5 | 25.485 | 54.0 | -28.5 | Pass |
| 3130.53 | 3 | 311 | 1 | Average | 34.9 | 27.377 | 54.0 | -26.6 | Pass |
| 4302.59 | 3 | 10 | 1 | Average | 33.5 | 28.266 | 54.0 | -25.7 | Pass |
| 5289.69 | 3 | 48 | 1 | Average | 32.5 | 29.098 | 54.0 | -24.9 | Pass |
| 5981.66 | 3 | 100 | 1 | Average | 31.3 | 30.947 | 54.0 | -23.0 | Pass |
| 7732.85 | 3 | 14 | 1 | Average | 27.6 | 34.117 | 54.0 | -19.8 | Pass |
| 8600.09 | 3 | 28 | 1 | Average | 27.7 | 35.884 | 54.0 | -18.1 | Pass |
| 11510.4 | 3 | 318 | 1 | Average | 27.5 | 38.754 | 54.0 | -15.2 | Pass |
| 12809.7 | 3 | 180 | 1 | Average | 27.9 | 39.017 | 54.0 | -14.9 | Pass |
| 16626.2 | 3 | 189 | 1 | Average | 27.6 | 43.489 | 54.0 | -10.5 | Pass |



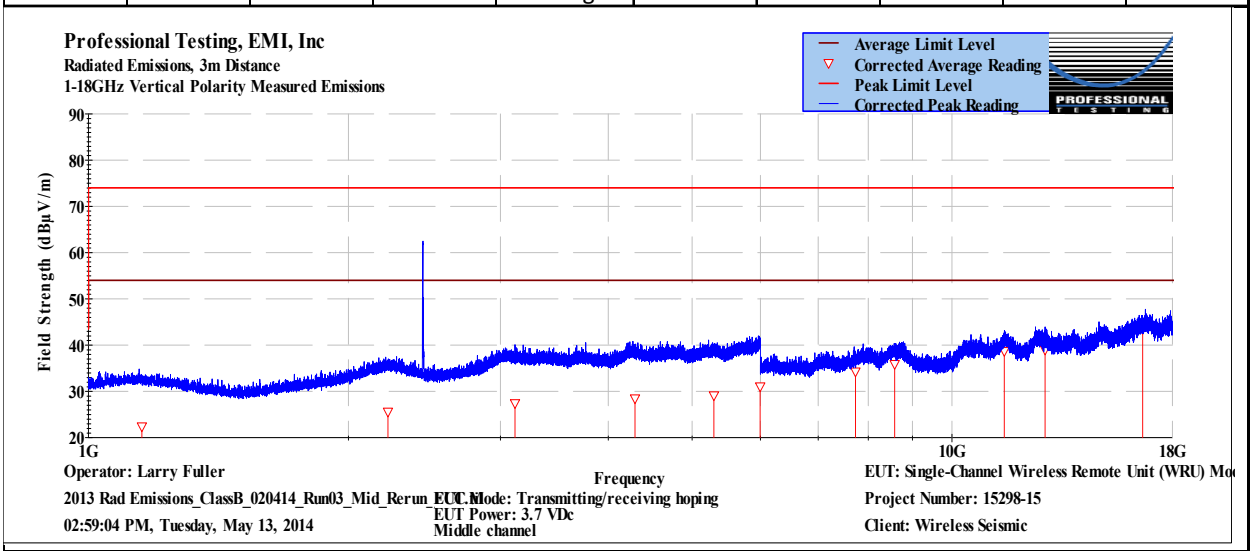

> 1GHz Horizontal Antenna Polarity Measured Emissions

## Table 4.3.7: Vertical, Spurious Radiated Emissions – T/R, Above 1 GHz, Mid Channel

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| Test Method: | ANSI C63.4–2003: "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). | | |
| 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): | 5/13/2014 | EUT Serial #: | 120800000150 |
| Customer: | Wireless Seismic | EUT Part #: | N/A |
| Project Number: | 15298-15 | Test Technician: | Larry Fuller |
| Purchase Order #: | | Supervisor: | Rob McCollough |
| Equip. Under Test: | Single-Channel Wireless Remote | Witness' Name: | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| EUT Line Voltage: | 3.7 VDC | EUT Power Frequency: | N/A N/A |
| Antenna Orientation: | Vertical | Frequency Range: | Above 1GHz |
| EUT Mode of Operation: | | Transmitting/receiving Mid Channel | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1153.26 | 3 | 212 | 1 | Average | 35.2 | 22.387 | 54.0 | -31.6 | Pass |
| 2222.66 | 3 | 228 | 1 | Average | 34.6 | 25.579 | 54.0 | -28.4 | Pass |
| 3118.62 | 3 | 143 | 1 | Average | 34.9 | 27.405 | 54.0 | -26.6 | Pass |
| 4294.86 | 3 | 64 | 1 | Average | 33.7 | 28.451 | 54.0 | -25.5 | Pass |
| 5301.42 | 3 | 291 | 1 | Average | 32.5 | 29.112 | 54.0 | -24.8 | Pass |
| 5996.72 | 3 | 33 | 1 | Average | 31.3 | 31.028 | 54.0 | -22.9 | Pass |
| 7731.57 | 3 | 150 | 1 | Average | 27.8 | 34.271 | 54.0 | -19.7 | Pass |
| 8581.85 | 3 | 40 | 1 | Average | 27.8 | 35.896 | 54.0 | -18.1 | Pass |
| 11497.6 | 3 | 196 | 1 | Average | 27.4 | 38.694 | 54.0 | -15.3 | Pass |
| 12815.6 | 3 | 198 | 1 | Average | 27.9 | 39.003 | 54.0 | -15.0 | Pass |
| 16630.3 | 3 | 259 | 1 | Average | 27.6 | 43.462 | 54.0 | -10.5 | Pass |




> 1GHz Vertical Antenna Polarity Measured Emissions

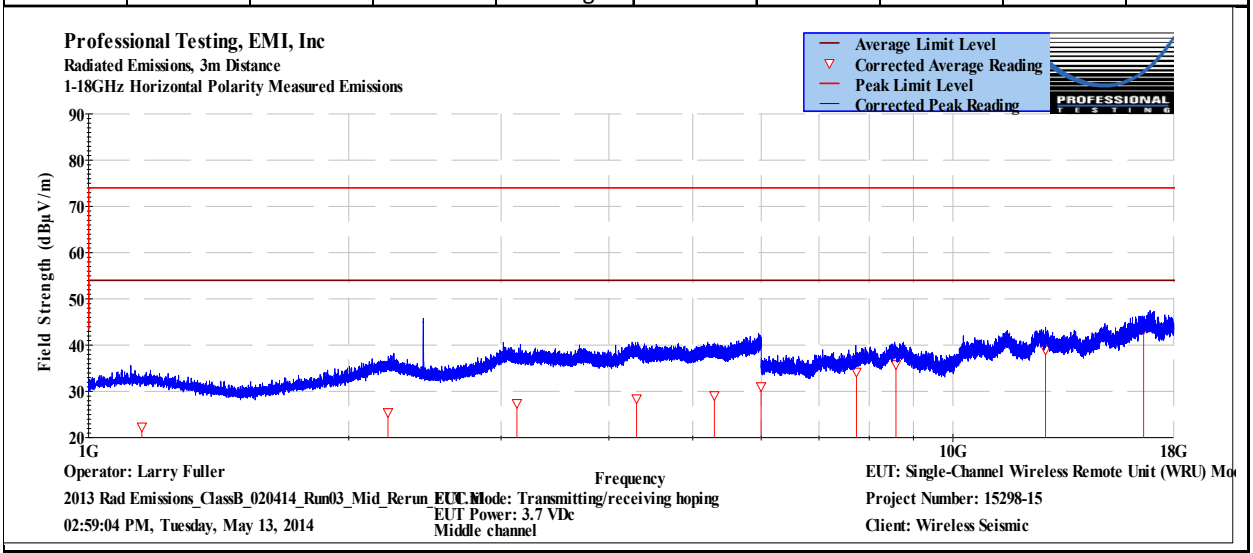
## Table 4.3.8: Horizontal, Spurious Radiated Emissions – T/R, Above 1 GHz, Mid Channel

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| **Test Method:** | ANSI C63.4–2003: "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). | | |
| **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):** | 5/13/2014 | **EUT Serial #:** | 120800000150 |
| **Customer:** | Wireless Seismic | **EUT Part #:** | N/A |
| **Project Number:** | 15298-15 | **Test Technician:** | Larry Fuller |
| **Purchase Order #:** | | **Supervisor:** | Rob McCollough |
| **Equip. Under Test:** | Single-Channel Wireless Remote | **Witness' Name:** | Bandele Adepoju |

**Radiated Emissions Test Results Data Sheet** — **Page: 1 of 1**

| | | | |
|---|---|---|---|
| **EUT Line Voltage:** | 3.7 VDC | **EUT Power Frequency:** | N/A N/A |
| **Antenna Orientation:** | Horizontal | **Frequency Range:** | Above 1GHz |
| **EUT Mode of Operation:** | | Transmitting/receiving Mid Channel | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1152.3 | 3 | 135 | 1 | Average | 35.2 | 22.365 | 54.0 | -31.6 | Pass |
| 2219.96 | 3 | 242 | 1 | Average | 34.5 | 25.472 | 54.0 | -28.5 | Pass |
| 3129.98 | 3 | 128 | 1 | Average | 34.9 | 27.45 | 54.0 | -26.5 | Pass |
| 4305.74 | 3 | 120 | 1 | Average | 33.7 | 28.455 | 54.0 | -25.5 | Pass |
| 5296.37 | 3 | 260 | 1 | Average | 32.5 | 29.132 | 54.0 | -24.8 | Pass |
| 5997.73 | 3 | 181 | 1 | Average | 31.4 | 31.075 | 54.0 | -22.9 | Pass |
| 7734.7 | 3 | 111 | 1 | Average | 27.7 | 34.216 | 54.0 | -19.7 | Pass |
| 8590.29 | 3 | 192 | 1 | Average | 27.7 | 35.851 | 54.0 | -18.1 | Pass |
| 12799.5 | 3 | 21 | 1 | Average | 27.9 | 39.004 | 54.0 | -15.0 | Pass |
| 16617.2 | 3 | 237 | 1 | Average | 27.5 | 43.434 | 54.0 | -10.5 | Pass |



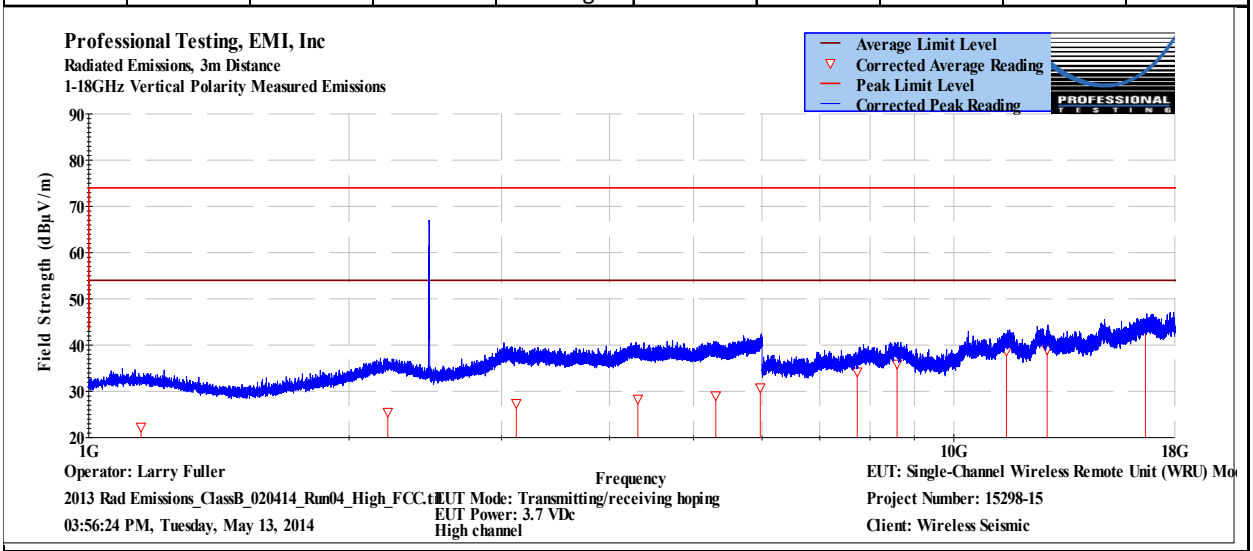

**> 1GHz Horizontal Antenna Polarity Measured Emissions**

## Table 4.3.9: Vertical, Spurious Radiated Emissions – T/R, Above 1 GHz, High Channel

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| **Test Method:** | ANSI C63.4–2003: "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). | | |
| **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):** | 5/13/2014 | **EUT Serial #:** | 120800000150 |
| **Customer:** | Wireless Seismic | **EUT Part #:** | N/A |
| **Project Number:** | 15298-15 | **Test Technician:** | Larry Fuller |
| **Purchase Order #:** | | **Supervisor:** | Rob McCollough |
| **Equip. Under Test:** | Single-Channel Wireless Remote | **Witness' Name:** | Bandele Adepoju |

| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| **EUT Line Voltage:** | 3.7 VDC | **EUT Power Frequency:** | N/A N/A |
| **Antenna Orientation:** | Vertical | **Frequency Range:** | Above 1GHz |
| **EUT Mode of Operation:** | | Transmitting/receiving High Channel | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1149.54 | 3 | 324 | 1 | Average | 35.2 | 22.328 | 54.0 | -31.6 | Pass |
| 2216.88 | 3 | 248 | 1 | Average | 34.6 | 25.535 | 54.0 | -28.4 | Pass |
| 3120.92 | 3 | 41 | 1 | Average | 34.9 | 27.433 | 54.0 | -26.5 | Pass |
| 4312.59 | 3 | 308 | 1 | Average | 33.6 | 28.385 | 54.0 | -25.6 | Pass |
| 5305.57 | 3 | 123 | 1 | Average | 32.5 | 29.11 | 54.0 | -24.8 | Pass |
| 5973.84 | 3 | 240 | 1 | Average | 31.3 | 30.825 | 54.0 | -23.1 | Pass |
| 7732.49 | 3 | 208 | 1 | Average | 27.7 | 34.238 | 54.0 | -19.7 | Pass |
| 8594.84 | 3 | 22 | 1 | Average | 27.8 | 35.957 | 54.0 | -18.0 | Pass |
| 11502.9 | 3 | 254 | 1 | Average | 27.5 | 38.759 | 54.0 | -15.2 | Pass |
| 12814.2 | 3 | 286 | 1 | Average | 28 | 39.038 | 54.0 | -14.9 | Pass |
| 16640.2 | 3 | 72 | 1 | Average | 27.6 | 43.506 | 54.0 | -10.5 | Pass |



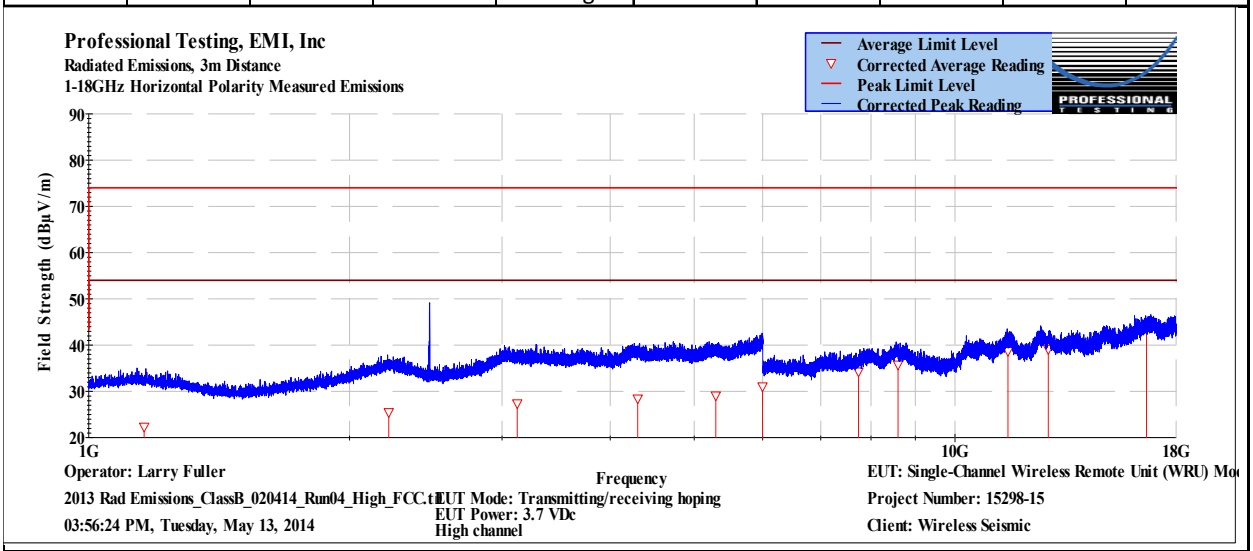

> 1GHz Vertical Antenna Polarity Measured Emissions

## Table 4.3.10: Horizontal, Spurious Radiated Emissions – T/R, Above 1 GHz, High Channel

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| Test Method: | ANSI C63.4–2003: "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). | | |
| 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): | 5/13/2014 | EUT Serial #: | 120800000150 |
| Customer: | Wireless Seismic | EUT Part #: | N/A |
| Project Number: | 15298-15 | Test Technician: | Larry Fuller |
| Purchase Order #: | | Supervisor: | Rob McCollough |
| Equip. Under Test: | Single-Channel Wireless Remote | Witness' Name: | Bandele Adepoju |

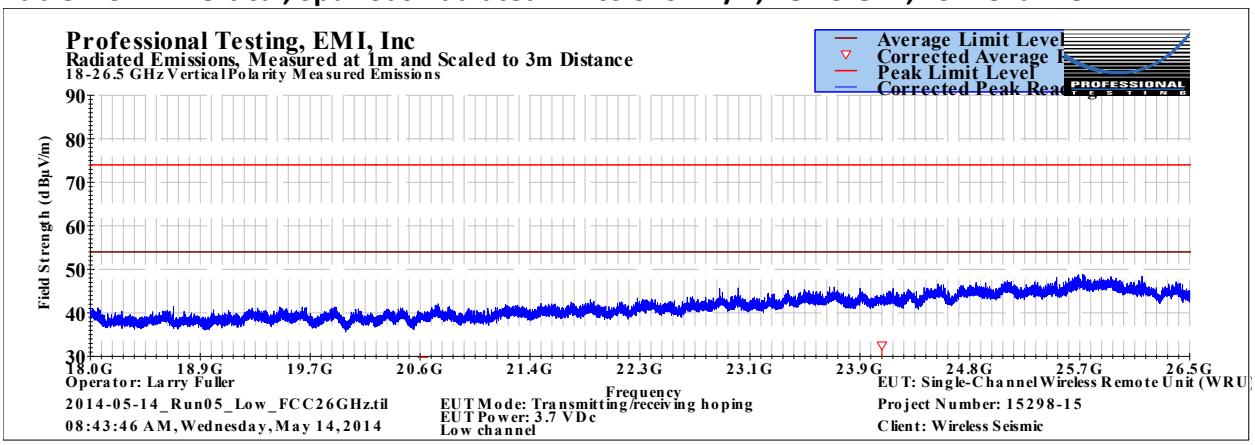
| Radiated Emissions Test Results Data Sheet | | | Page: 1 of 1 |
|---|---|---|---|
| EUT Line Voltage: | 3.7 VDC | EUT Power Frequency: | N/A N/A |
| Antenna Orientation: | Horizontal | Frequency Range: | Above 1GHz |
| EUT Mode of Operation: | | Transmitting/receiving High Channel | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 1158.79 | 3 | 32 | 1 | Average | 35.1 | 22.319 | 54.0 | -31.6 | Pass |
| 2220.06 | 3 | 204 | 1 | Average | 34.5 | 25.459 | 54.0 | -28.5 | Pass |
| 3124.11 | 3 | 8 | 1 | Average | 34.8 | 27.373 | 54.0 | -26.6 | Pass |
| 4303.8 | 3 | 90 | 1 | Average | 33.6 | 28.424 | 54.0 | -25.5 | Pass |
| 5295.92 | 3 | 117 | 1 | Average | 32.5 | 29.087 | 54.0 | -24.9 | Pass |
| 5995.12 | 3 | 333 | 1 | Average | 31.4 | 31.035 | 54.0 | -22.9 | Pass |
| 7738.6 | 3 | 147 | 1 | Average | 27.7 | 34.251 | 54.0 | -19.7 | Pass |
| 8597.93 | 3 | 225 | 1 | Average | 27.6 | 35.759 | 54.0 | -18.2 | Pass |
| 11514.3 | 3 | 126 | 1 | Average | 27.4 | 38.682 | 54.0 | -15.3 | Pass |
| 12817.4 | 3 | 333 | 1 | Average | 28 | 39.091 | 54.0 | -14.9 | Pass |
| 16638.1 | 3 | 45 | 1 | Average | 27.6 | 43.507 | 54.0 | -10.5 | Pass |

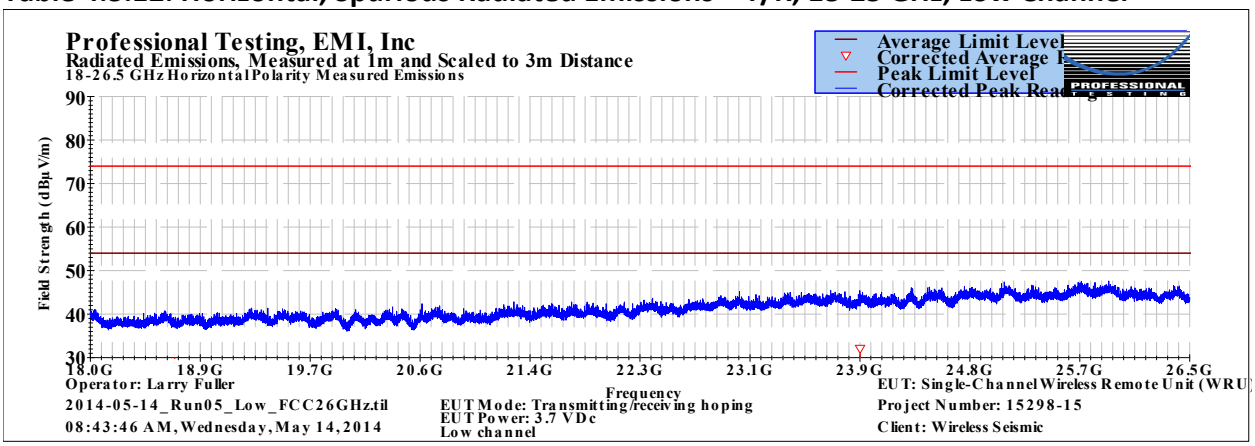



> 1GHz Horizontal Antenna Polarity Measured Emissions

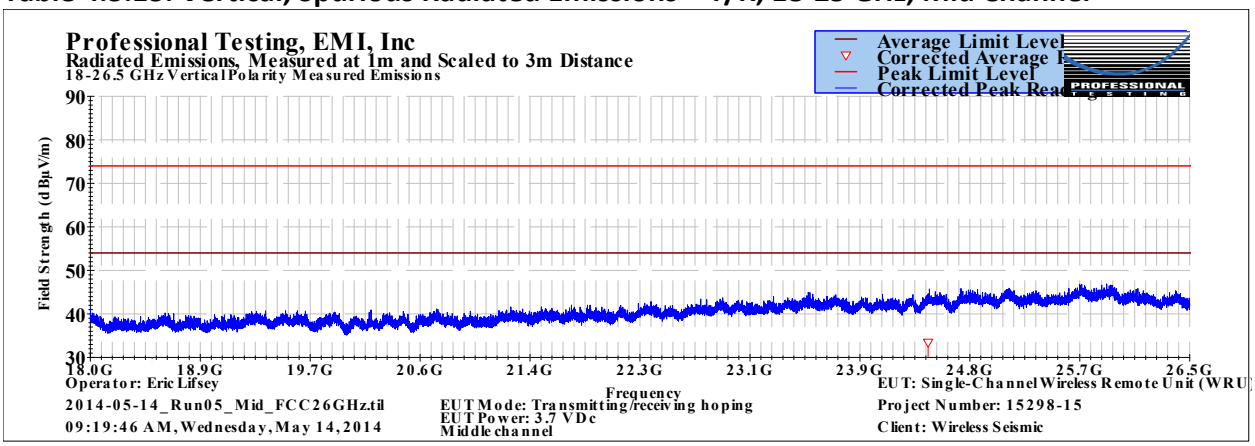
## Table 4.3.11: Vertical, Spurious Radiated Emissions – T/R, 18-25 GHz, Low Channel



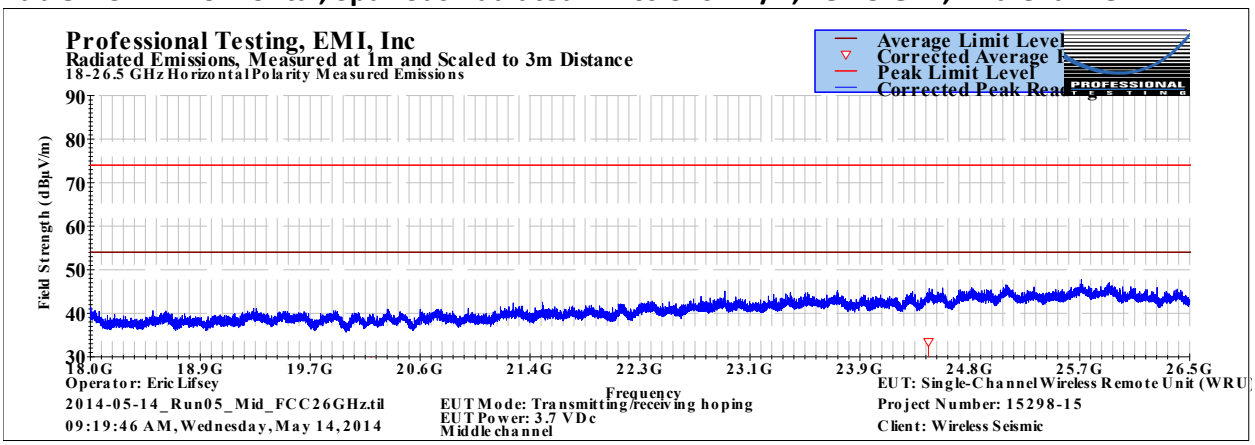

## Table 4.3.12: Horizontal, Spurious Radiated Emissions – T/R, 18-25 GHz, Low Channel



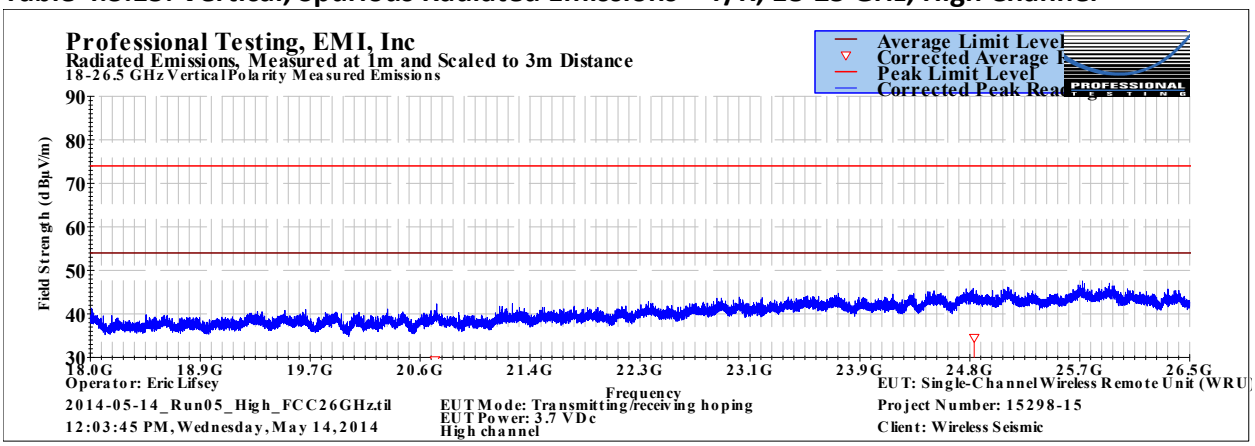
## Table 4.3.13: Vertical, Spurious Radiated Emissions – T/R, 18-25 GHz, Mid Channel



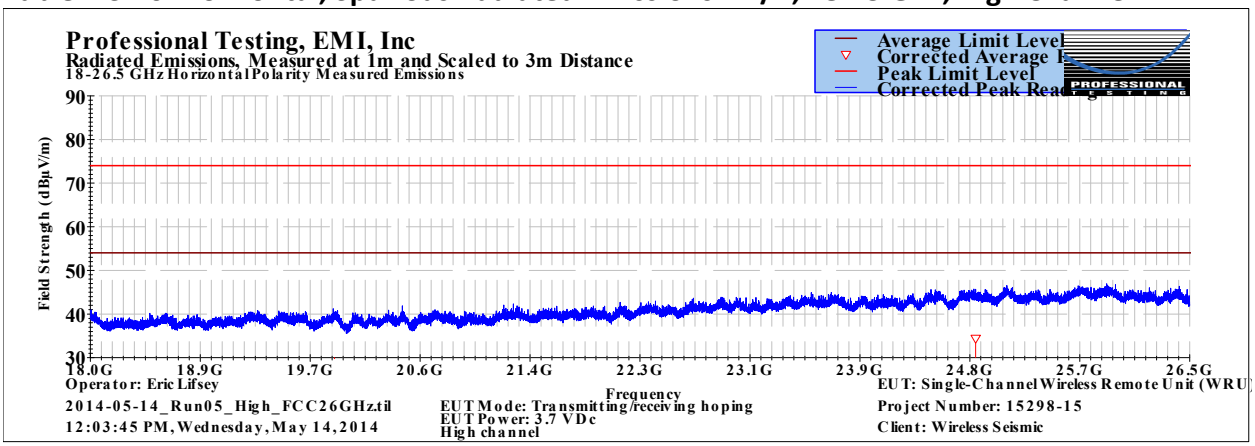

## Table 4.3.14: Horizontal, Spurious Radiated Emissions – T/R, 18-25 GHz, Mid Channel



## Table 4.3.15: Vertical, Spurious Radiated Emissions – T/R, 18-25 GHz, High Channel




## Table 4.3.16: Horizontal, Spurious Radiated Emissions – T/R, 18-25 GHz, High Channel



## Table 4.3.17: Spurious Radiated Emissions – Instrument Bandwidth and Measurement Time

| 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 | 300 | 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.

## 4.4 Test Equipment

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| **Test Method:** | **ANSI C63.4–2003: "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,** | | |
| **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):** | **5/13/2014** | **EUT Serial #:** | **120800000150** |
| **Customer:** | **Wireless Seismic** | **EUT Part #:** | **N/A** |
| **Project Number:** | **15298-15** | **Test Technician:** | **Larry Fuller** |
| **Purchase Order #:** | | **Supervisor:** | **Rob McCollough** |
| **Equip. Under Test:** | **Single-Channel Wireless Remote** | **Witness' Name:** | **Bandele Adepoju** |

**Radiated Emissions Test Equipment List**

| | |
|---|---|
| **Tile! Software Version:** | **4.2.A, May 23, 2010, 08:38:52 AM** |
| **Test Profile:** | **Radiated Emissions_Profile Version October 12, 2011** |

| Asset # | Manufacturer | Model | Equipment Nomenclature | Serial Number | Calibration Due Date |
|---|---|---|---|---|---|
| 1509A | Braden | N/A | TDK 10M Chamber, NSA < 1 GHz | DAC-012915-005 | 7/29/2014 |
| 1890 | HP | 8447F | Preamp/Amp, 9kHz-1300MHz, 28/25dB | 3313A05298 | 1/22/2015 |
| 1937 | Agilent | E4440A | Spectrum Analyzer, 3 Hz - 26.5 GHz | MY44303298 | 12/2/2015 |
| 1926 | ETS-Lindgren | 3142D | Antenna, Biconilog, 26 MHz - 6 GHz | 00135454 | 7/29/2014 |
| C027 | N/A | RG214 | Cable Coax, N-N, 25m | none | 9/26/2014 |
| 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 |
| 1542 | A.H. Systems | SAS-572 | Antenna, Horn 18-26.5GHz, 20dB gain | 225 | N/A |
| 1509B | Braden | N/A | TDK 10M Chamber, VSWR > 1 GHz | DAC-012915-005 | 7/16/2014 |
| 2004 | Miteq | AFS44-00101800-2S-10P-44 | Amplifier, 40dB, .1-18GHz | 0 | 11/19/2014 |
| C030 | N/A | 0 | Cable Coax, N-N, 30m | none | 9/26/2014 |
| Loaner-ETS | ETS-Lindgren | 3117 | Antenna, Double Ridged Guide Horn, 1 - 18 GHz | 135203 | 1/14/2015 |
| 1325 | EMCO | 1050 | Controller, Antenna Mast | 9003-1461 | N/A |
| 1973 | Agilent | 83017A | Amplifier, Microwave 0.5-26.5 GHz | MY39500497 | 1/16/2015 |

# 5 Spurious Emissions, Receiver, Radiated

The EUT alternately transmits and receives. The measurements in the previous section for transmit mode will apply.

# 6 Transmitter Unwanted Emissions, Band Edge, Conducted

## 6.1 Test Procedure

EUT is placed into normal transmit operation on the nearest band edge channel. The spectrum analyzer is centered on the band edge frequency with span sufficient to include the peak of the adjacent fundamental signal. Using peak detection, the analyzer measures emissions in max-hold mode. The measurement range includes two standard bandwidths from the respective band edge and some beyond to see the emission profile clearly. If required, the band-edge marker-delta method of C63.4 is utilized.

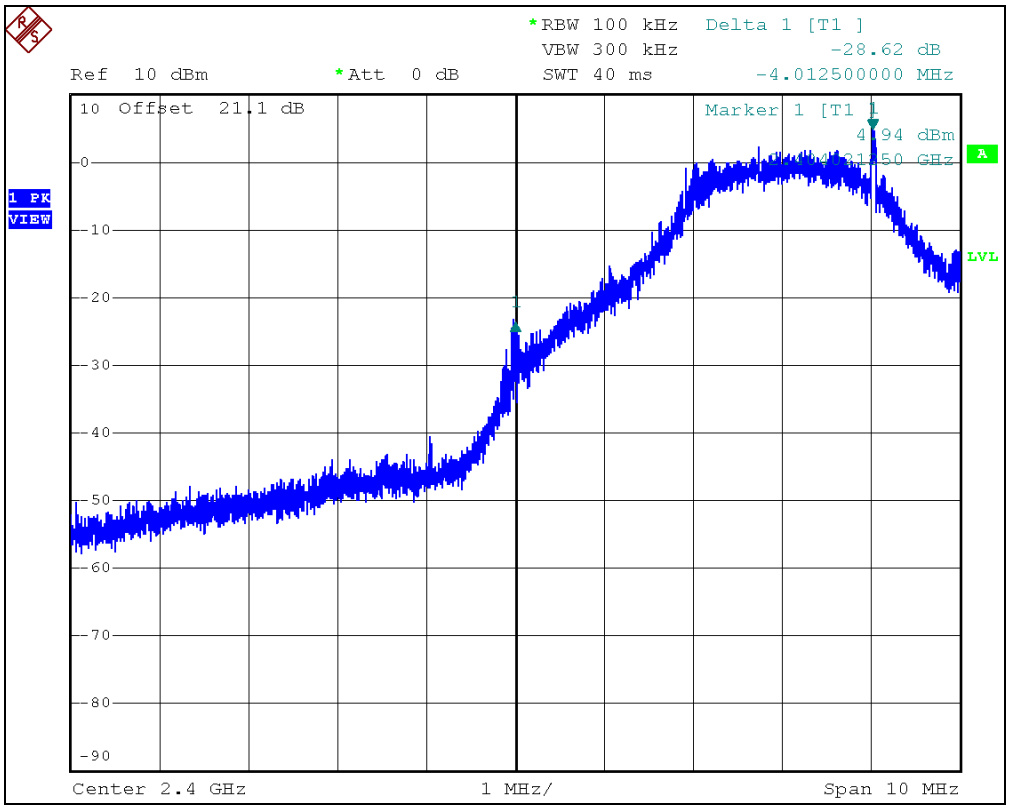
## 6.2 Test Criteria

| 47 CFR (USA) // IC (Canada) | | |
|---|---|---|
| Section Reference | Parameter | Date(s) |
| 15.247, 15.205, 15.209 // RSS-Gen Issue 3, 4.9 | Unwanted Emissions Adjacent to Authorized Band, Conducted | 2014-05-15 |

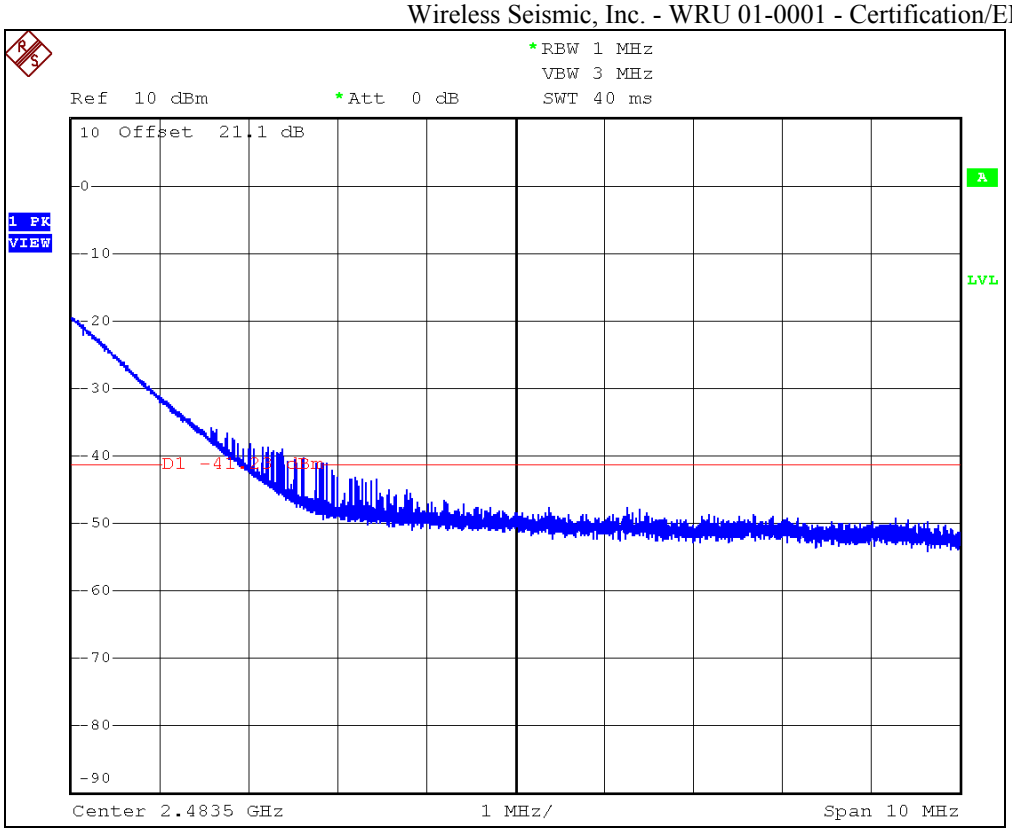
The limit applied is according to whether or not a restricted band applies.

## 6.3 Test Results

The EUT satisfied the criteria. Measured results appear below.




**Lower Band Edge, -20 dBc Criteria Satisfied**




**Upper Band Edge, 15.209 Criteria Satisfied**

## 6.4 Test Equipment

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| ALN-077 | Rohde & Schwarz | FSP-30 | Spectrum Analyzer | 2015-01-29 |
| C248 | Pasternack | N/A | Cable | 2015-05-14 |
| A105 | Narda | 768A-20 | RF Attenuator, 20 W, 20 dB | 2015-05-16 |
| 0881 | Thermotron | S-1.2C | Environmental Chamber S/N 27131 | 2014-09-13 |
| None | BK Precision | 1710 | Bench Power Supply S/N 261 0200 0081 | Cal In Use |
| 2087 | Fluke | 189 | DMM, True RMS | 2015-03-06 |

# 7 Transmitter/Receiver, Unwanted Emissions, Conducted

Conducted spurious measurements were made on the receiver at the Professional Testing Site 45, located in Austin, Texas, determine the radio frequency noise conducted from the EUT on the antenna port.

## 7.1 Test Procedure

The transmitter was operated with modulation and in frequency hopping mode for measurements below the operating band. Measurements above 3 GHz were in unmodulated mode on fixed non-hopping channels.

## 7.2 Test Criteria

| 47 CFR (USA) // IC (Canada) | | |
|---|---|---|
| Section Reference | Parameter | Date(s) |
| 15.247, 15.209 // RSS-Gen Issue 3, 4.9, 4.10 | Conducted Spurious/Harmonic Emissions | 2014-05-15 |

## 7.3 Test Results

Emissions were measured with a spectrum analyzer. The EUT was transmitting into a resistive RF power attenuator rated 20 Watts 20 dB. Factors for losses and attenuator were directly input into the spectrum analyzer as a reference level offset.

The EUT was operated in hopping mode for measurements up to an including the operating band, such that it could be seen that the transmitter was operating and in hopping mode. Above the operating band, the measurement began at just below the operating band so the non-hopping transmit signal could be confirmed. Measurements were taken up to 25 GHz. Visual inspection of the plots confirms no measureable emissions in the required spectrum.

The conducted emissions generated by the EUT were below the applicable limits.

**Table 7.3.1: Spurious, T/R, Hopping, Conducted, 10 MHz to 1000 MHz**

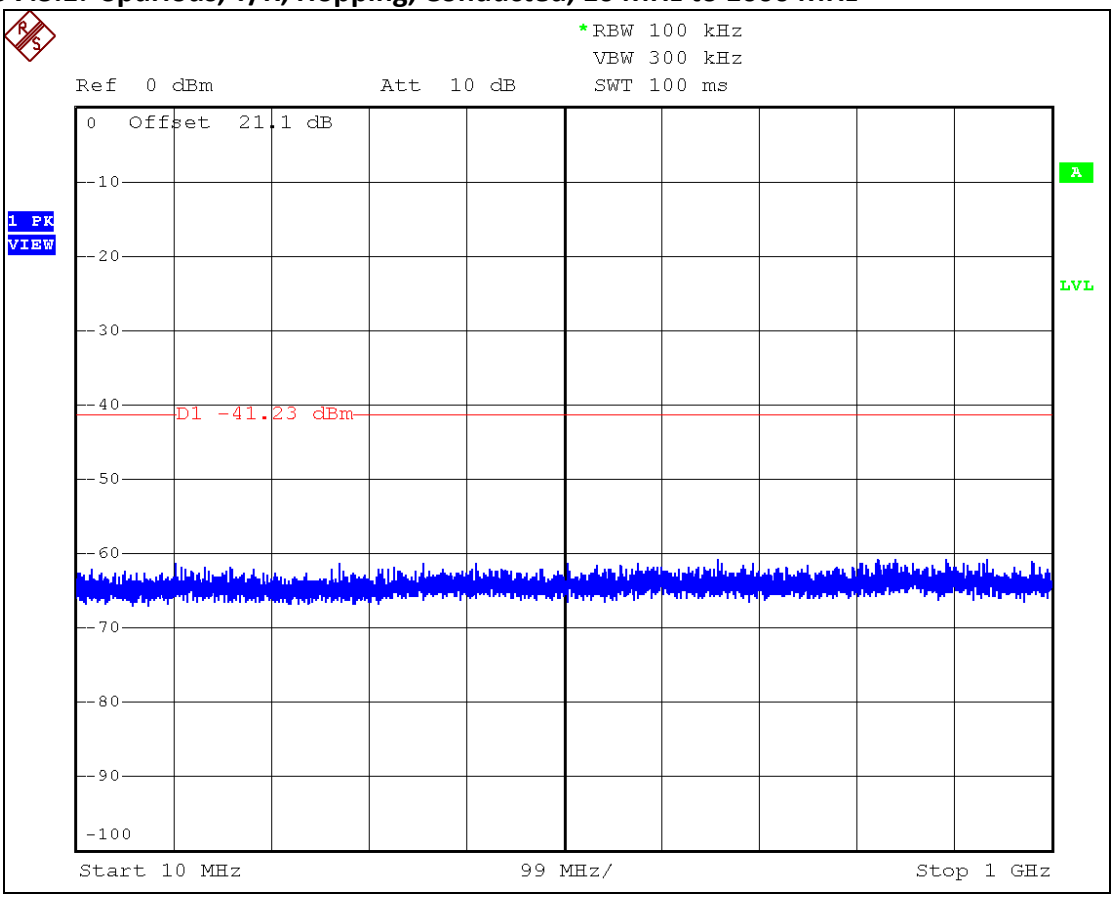


**Table 7.3.2: Spurious, T/R, Hopping, Conducted, 1000 MHz to 2000 MHz**

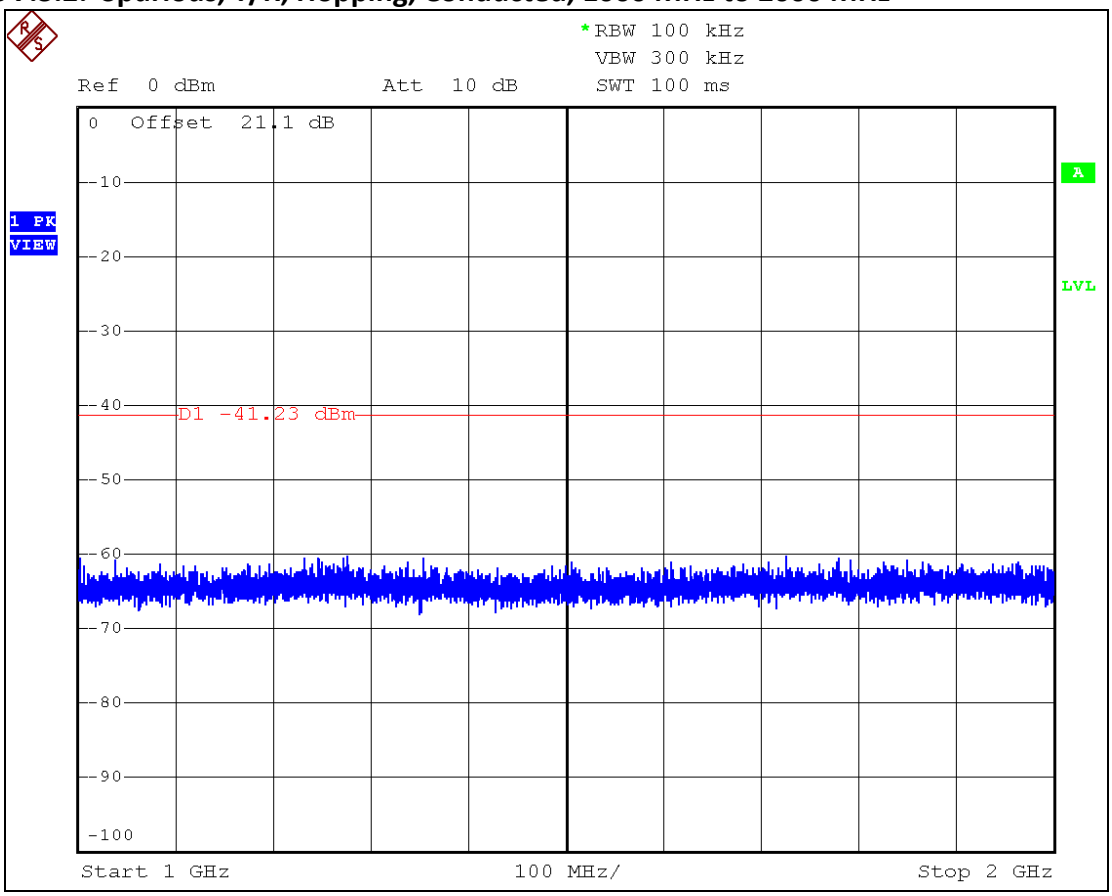


**Table 7.3.2: Spurious, T/R, Hopping, Conducted, 2000 MHz to 2500 MHz**

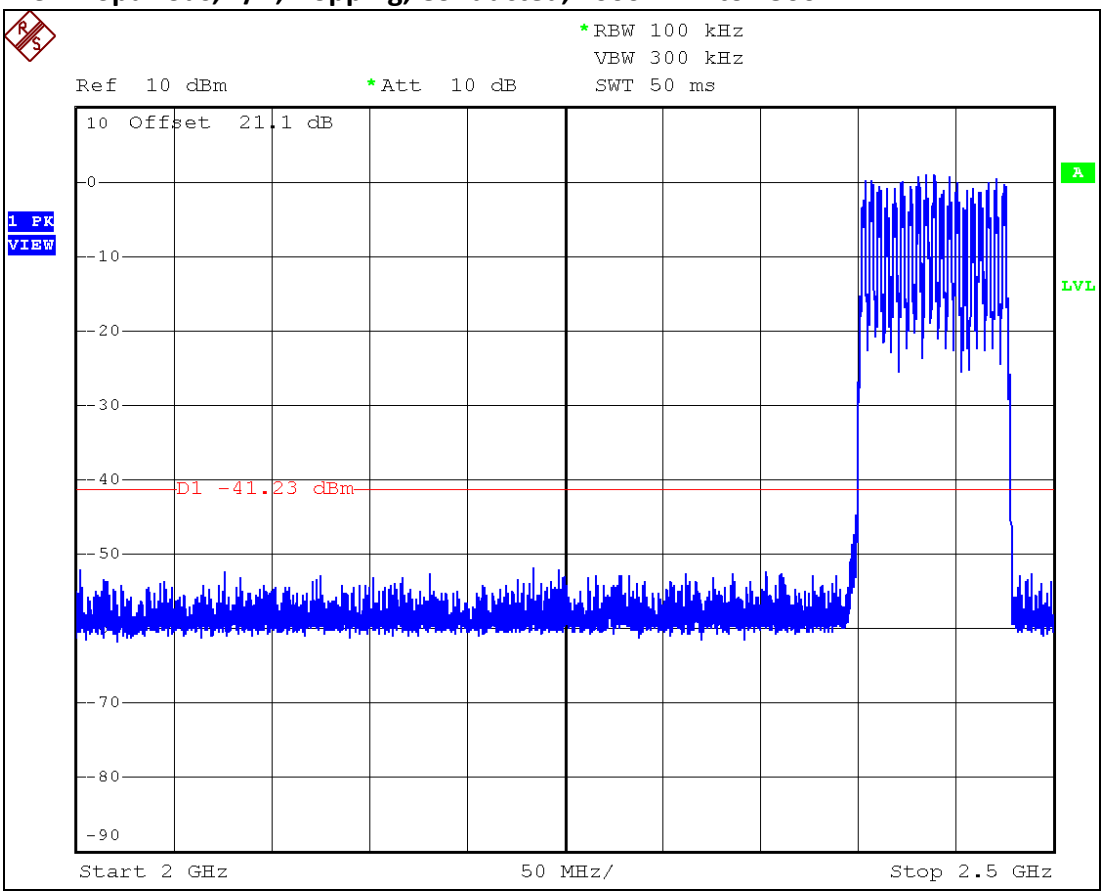


**Table 7.3.2: Spurious, T/R, Low Channel, Conducted, 2200 MHz to 10000 MHz**

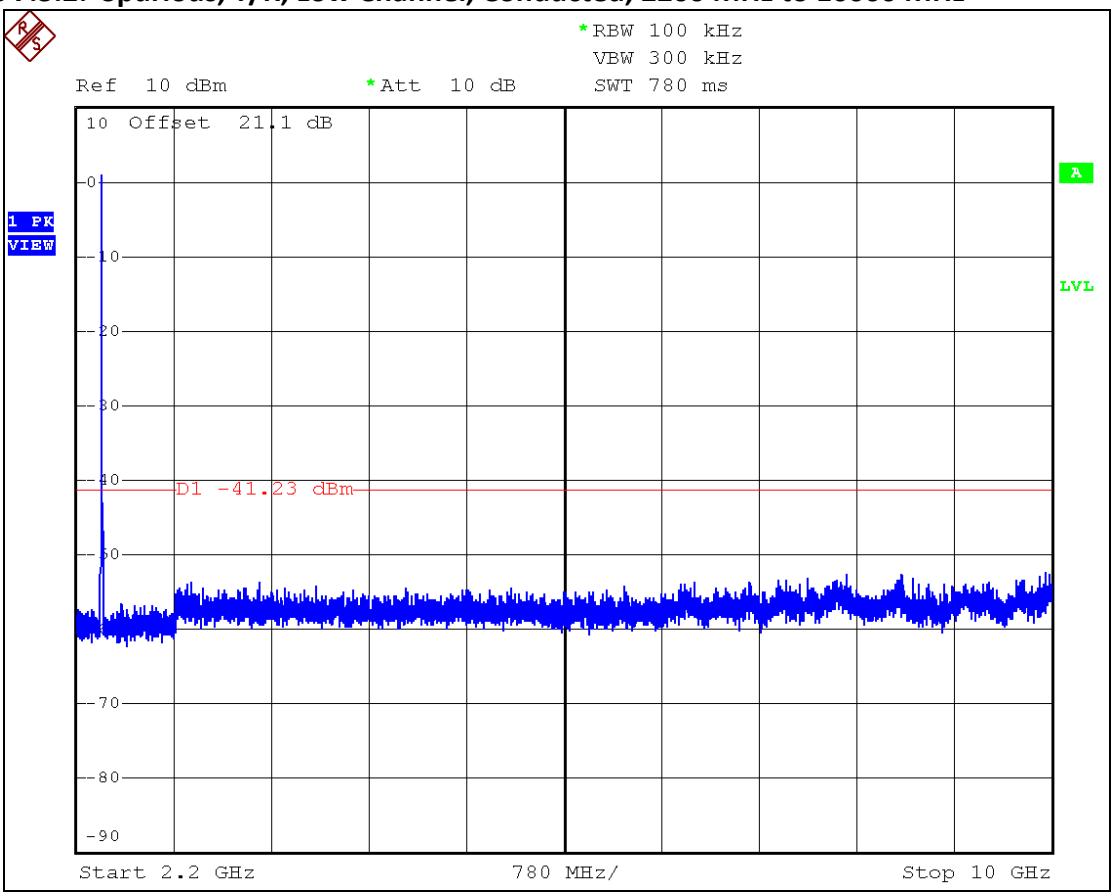


**Table 7.3.2: Spurious, T/R, Low Channel, Conducted, 10000 MHz to 25000 MHz**

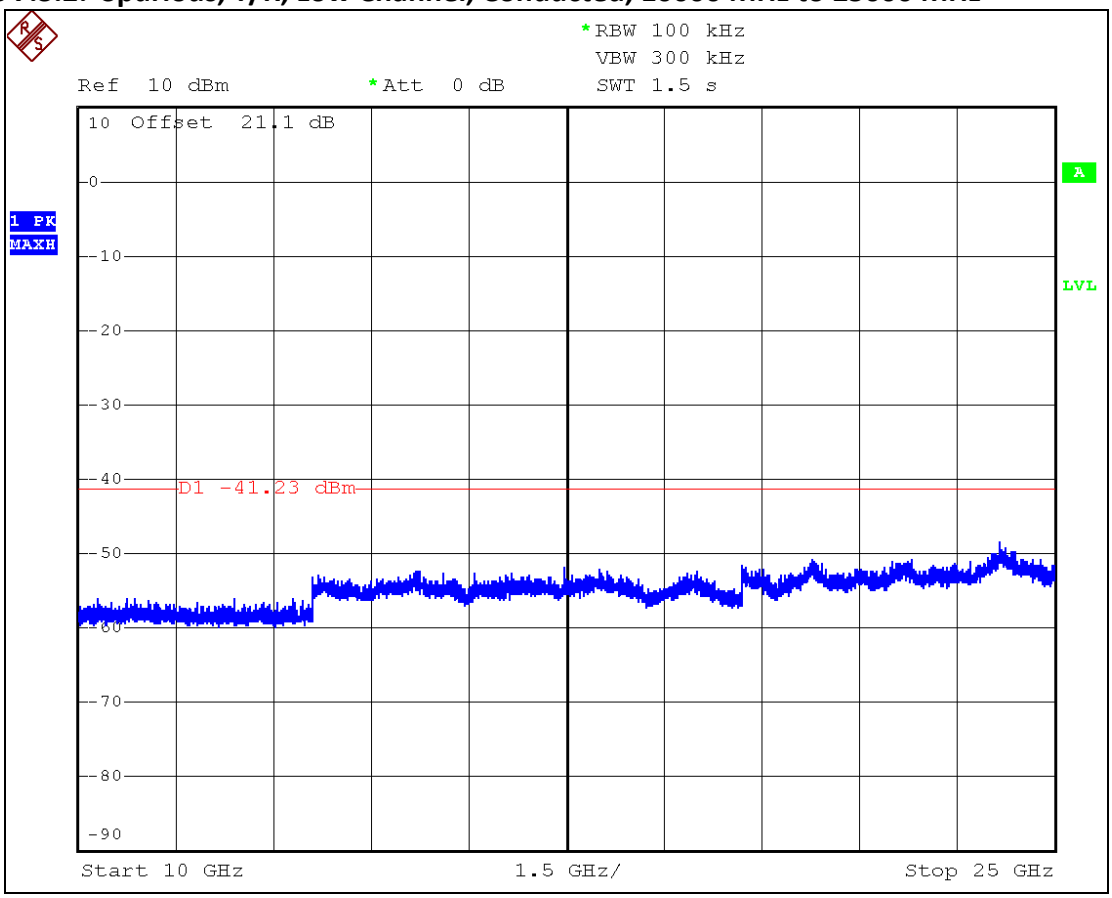


**Table 7.3.2: Spurious, T/R, Middle Channel, Conducted, 2200 MHz to 10000 MHz**

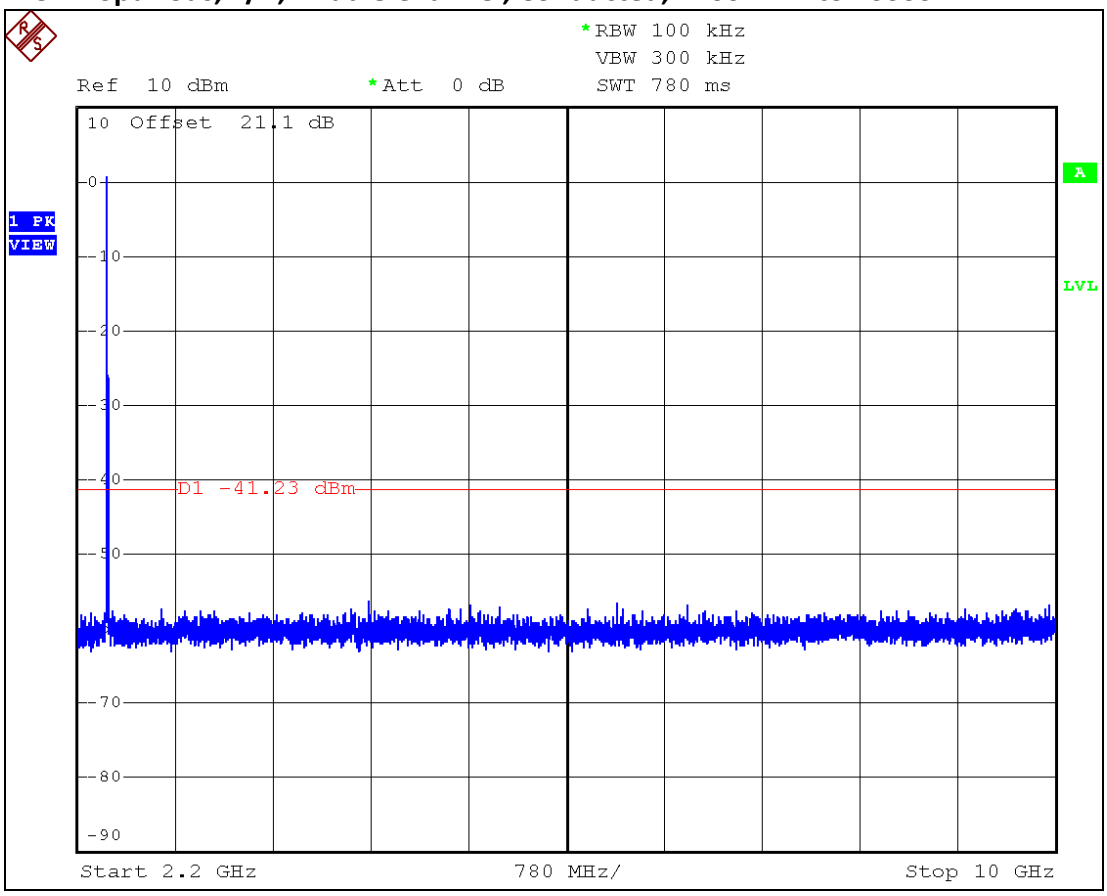


**Table 7.3.2: Spurious, T/R, Middle Channel, Conducted, 10000 MHz to 25000 MHz**

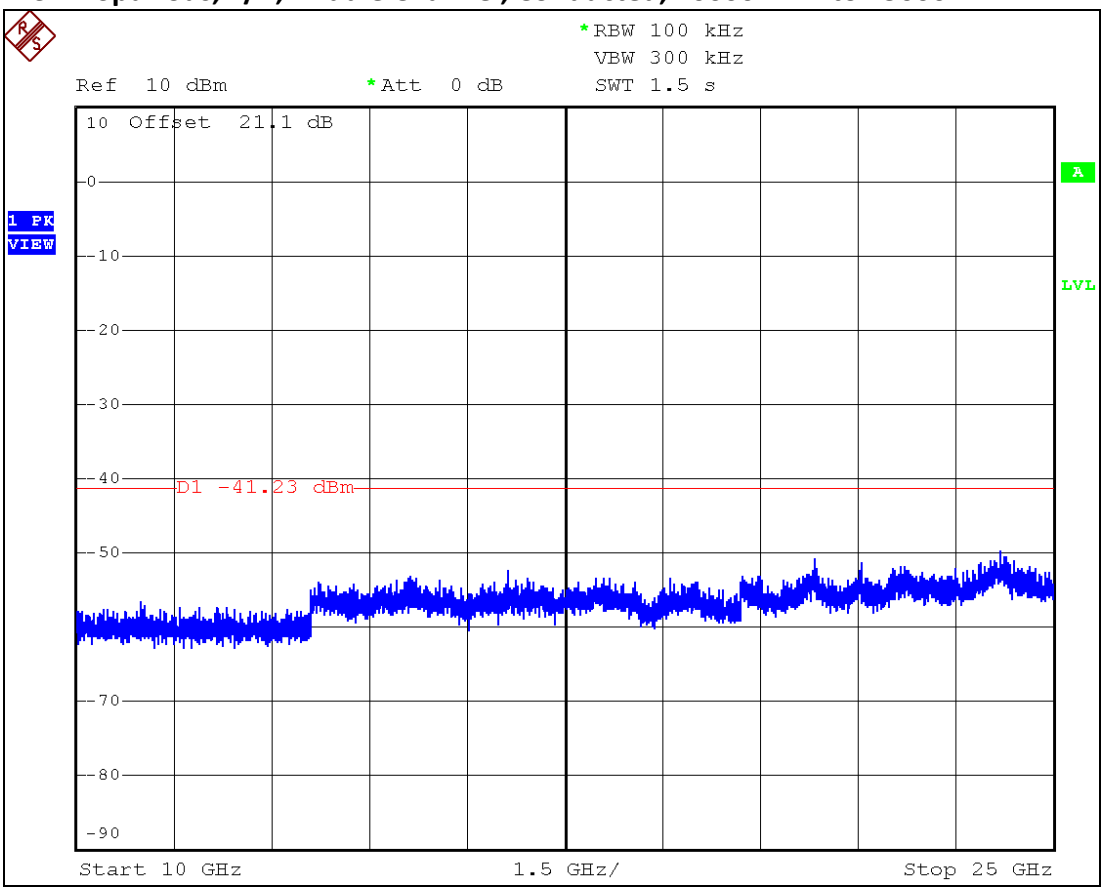


**Table 7.3.2: Spurious, T/R, High Channel, Conducted, 2200 MHz to 10000 MHz**

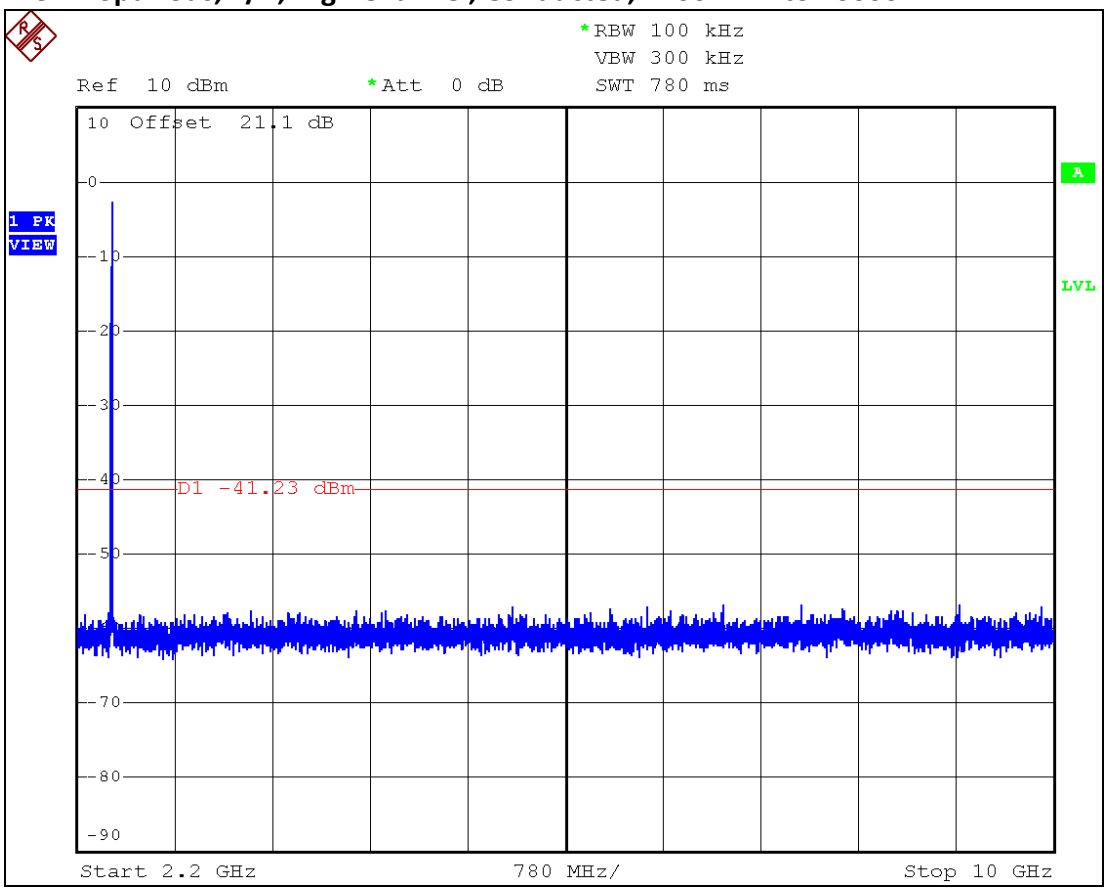
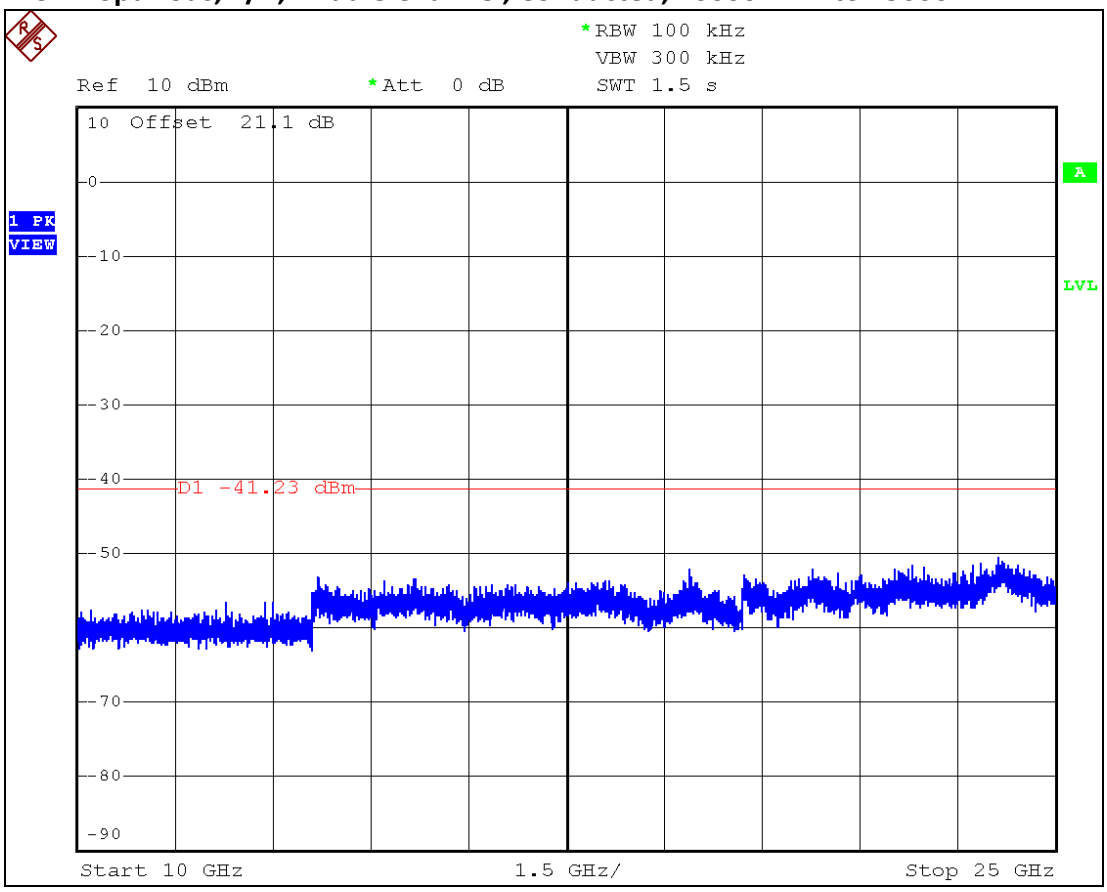


**Table 7.3.2: Spurious, T/R, Middle Channel, Conducted, 10000 MHz to 25000 MHz**




## 7.4 Test Equipment

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| ALN-077 | Rohde & Schwarz | FSP-30 | Spectrum Analyzer | 2015-01-29 |
| C248 | Pasternack | N/A | Cable | 2015-05-14 |
| A105 | Narda | 768A-20 | RF Attenuator, 20 W, 20 dB | 2015-05-16 |

# 8 Occupied Bandwidth

## 8.1 Test Procedure

The measurement was performed using conducted coupling via power attenuator. Hopping is disabled for this test.

## 8.2 Test Criteria

This measurement is performed for verifying minimum bandwidth, for other reporting purposes, and to determine bandwidth required for entire bandwidth power measurement.

## 8.3 Test Results

| **Bandwidth 6 dB<br>Minimum 500 kHz** |
|---|

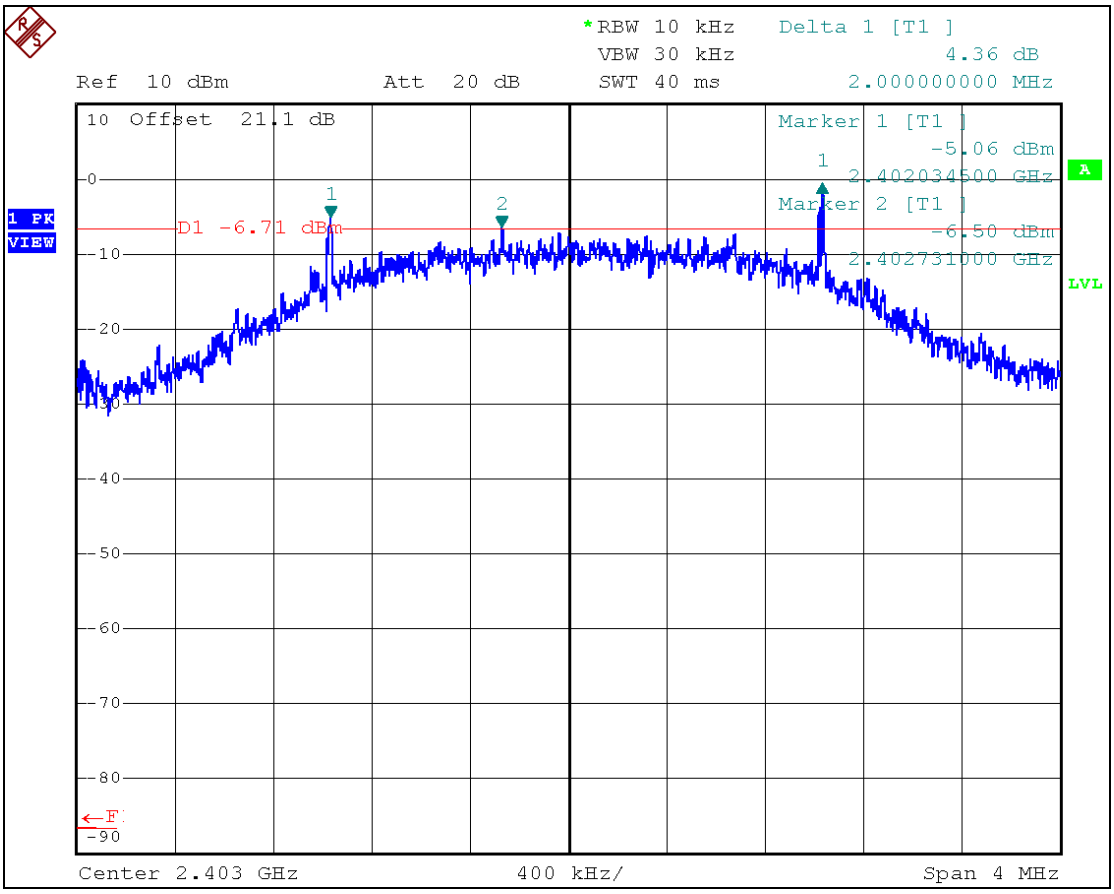
| Low Channel Measured BW (kHz) | Mid Channel Measured BW (kHz) | High Channel Measured BW (kHz) | **Minimum BW (kHz)** |
|---|---|---|---|
| 2000.0 | 2004.5 | 2009.0 | **2000.0** |

| **Bandwidth 20 dB<br>Measure and Report** |
|---|

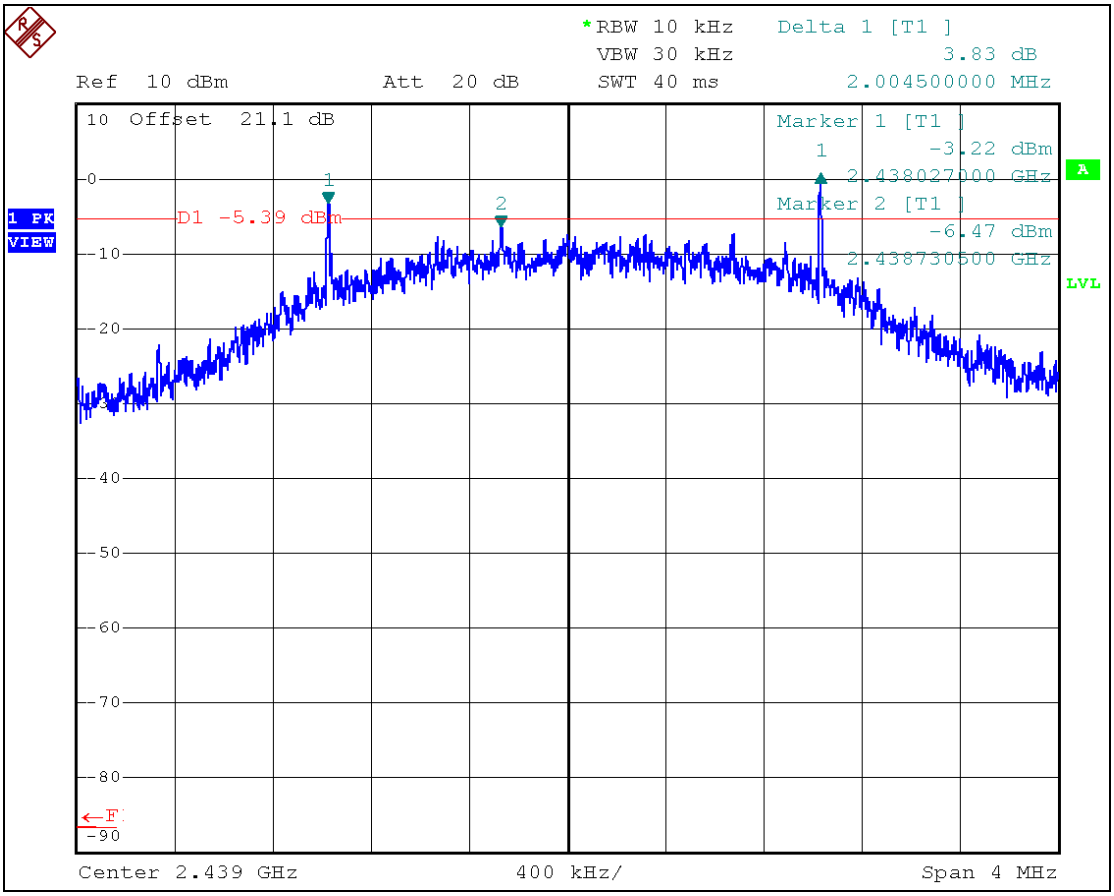
| Low Channel Measured BW (kHz) | Mid Channel Measured BW (kHz) | High Channel Measured BW (kHz) | **Reported Maximum BW (kHz)** |
|---|---|---|---|
| 3093.5 | 2776.0 | 2888.0 | **3093.5** |

Plotted measurements appear on the following pages.

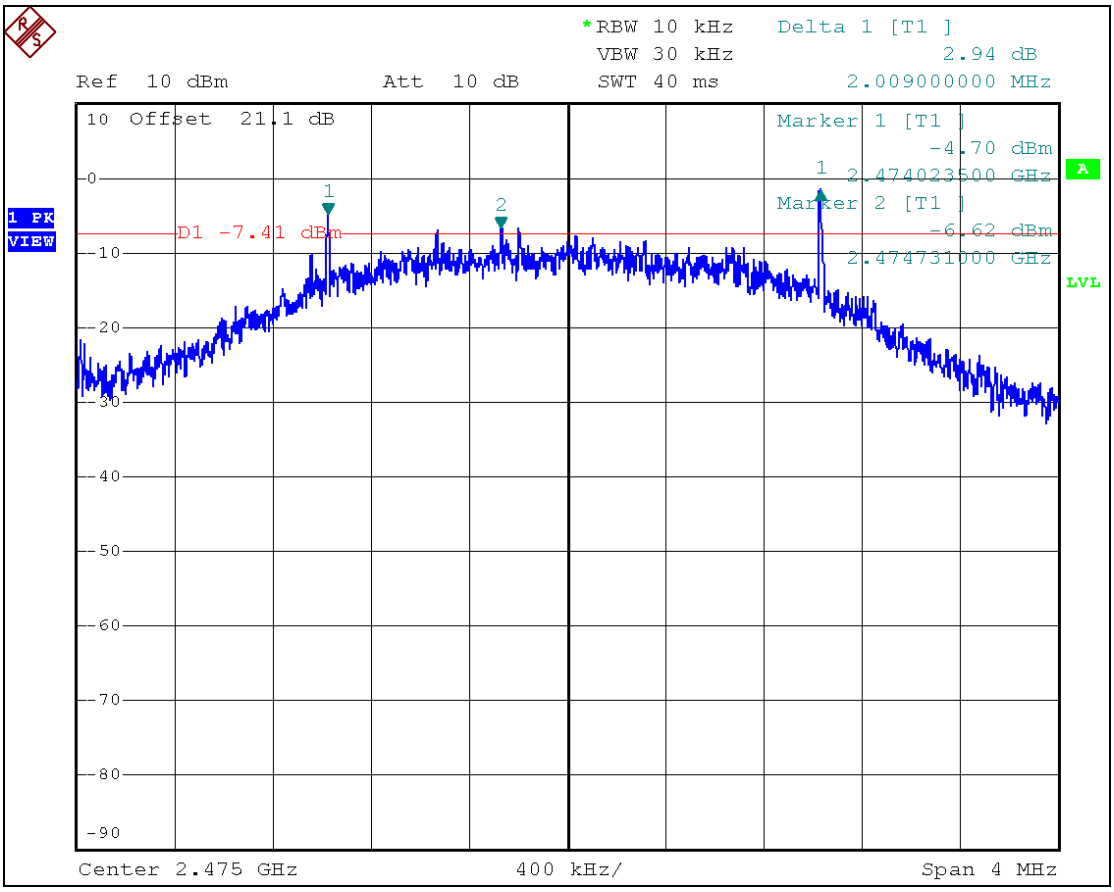
**Plot 8.3.1 Bandwidth, 6 dB, Low Channel**



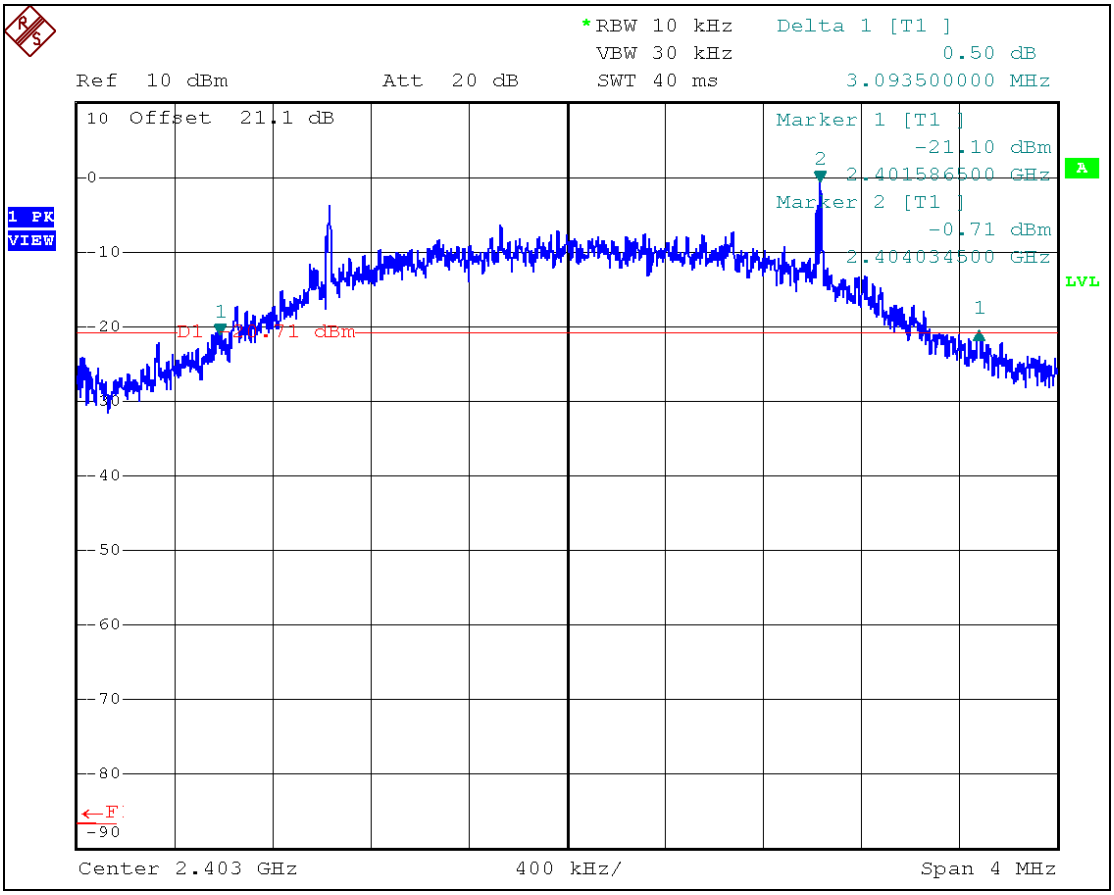
## Plot 8.3.2 Bandwidth, 6 dB, Middle Channel



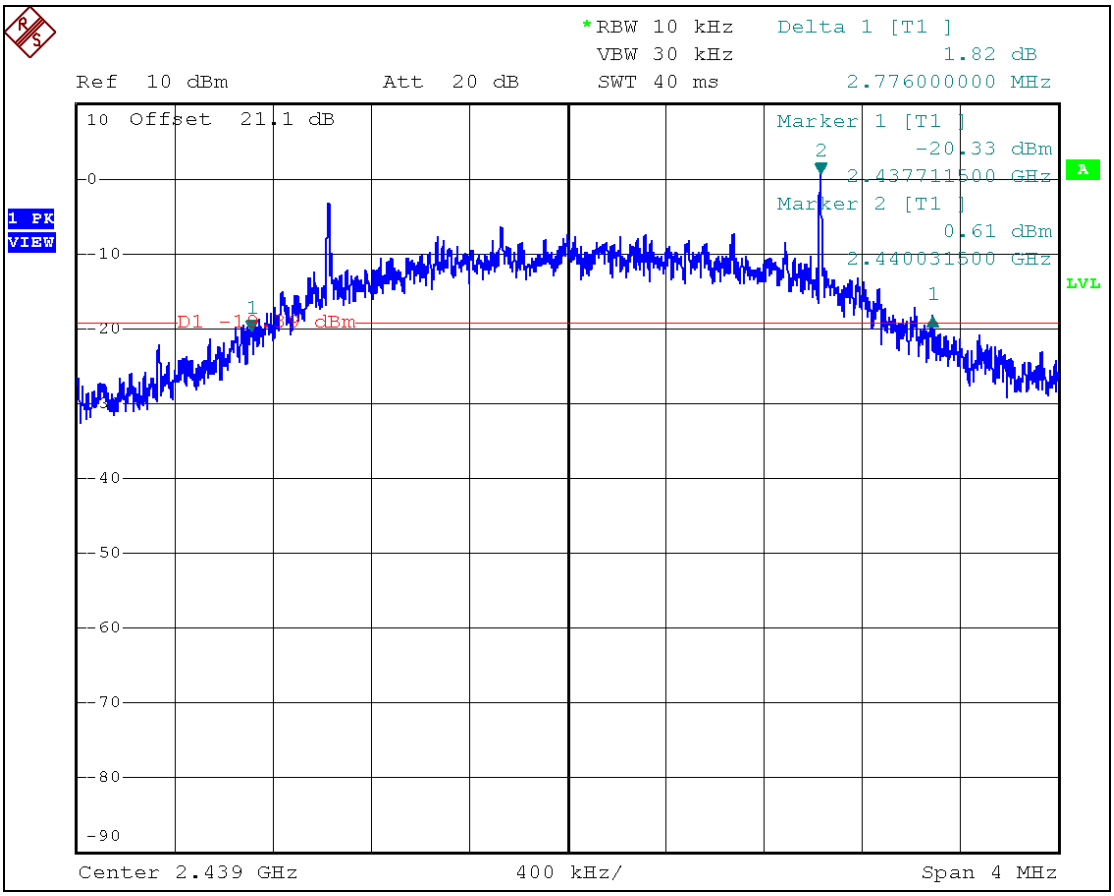
## Plot 8.3.3 Bandwidth, 6 dB, High Channel



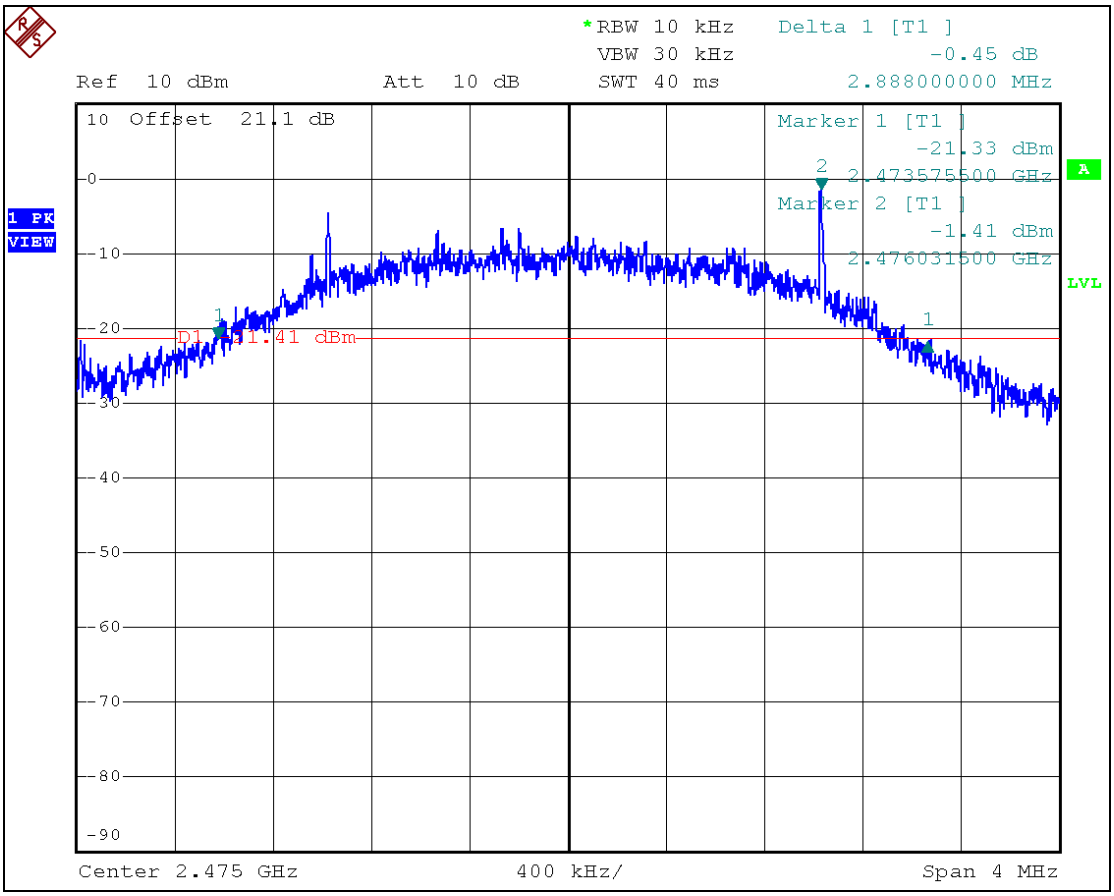
## Plot 8.3.4 Bandwidth 20 dB, Low Channel



**Plot 8.3.5 Bandwidth 20 dB, Middle Channel**



**Plot 8.3.6 Bandwidth 20 dB, High Channel**




## 8.4 Test Equipment

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| ALN-077 | Rohde & Schwarz | FSP-30 | Spectrum Analyzer | 2015-01-29 |
| C248 | Pasternack | N/A | Cable | 2015-05-14 |
| A105 | Narda | 768A-20 | RF Attenuator, 20 W, 20 dB | 2015-05-16 |

# 9 Frequency Hopping Characteristics

This is a frequency hopping device. 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.

## 9.1 Test Procedure

A conducted setup was used for this evaluation. 'Zero span' mode was used on the spectrum analyzer to measure time.

## 9.2 Test Criteria

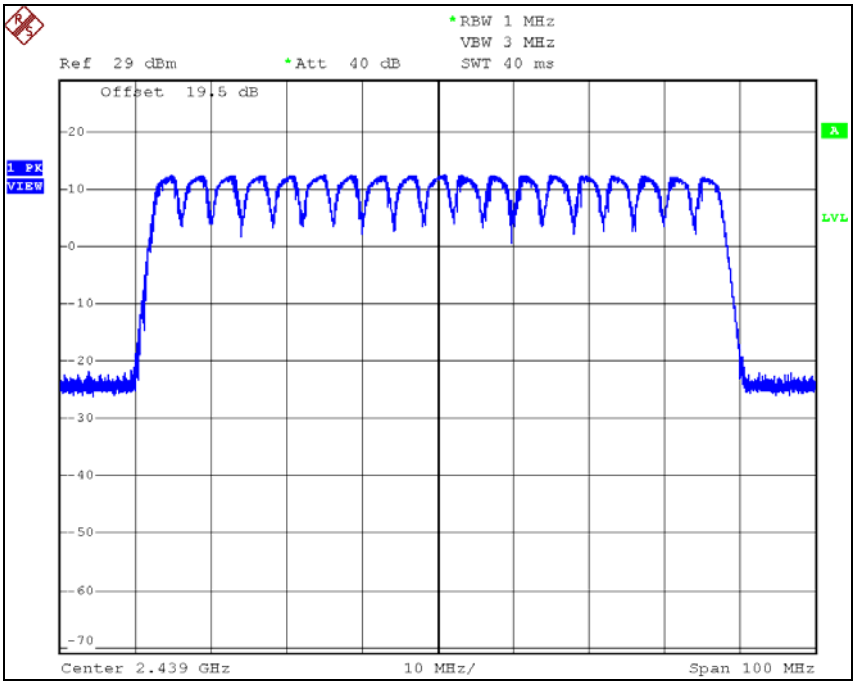
| Hopping Criteria | |
|---|---|
| **Parameter** | **Limit** |
| Number of Hopping Channels | 15, or 15 / BW |
| Hopping Channel Separation, Minimum | OBW or 100 kHz |
| Maximum Accumulated Dwell Time | 400 ms |

## 9.3 Test Results

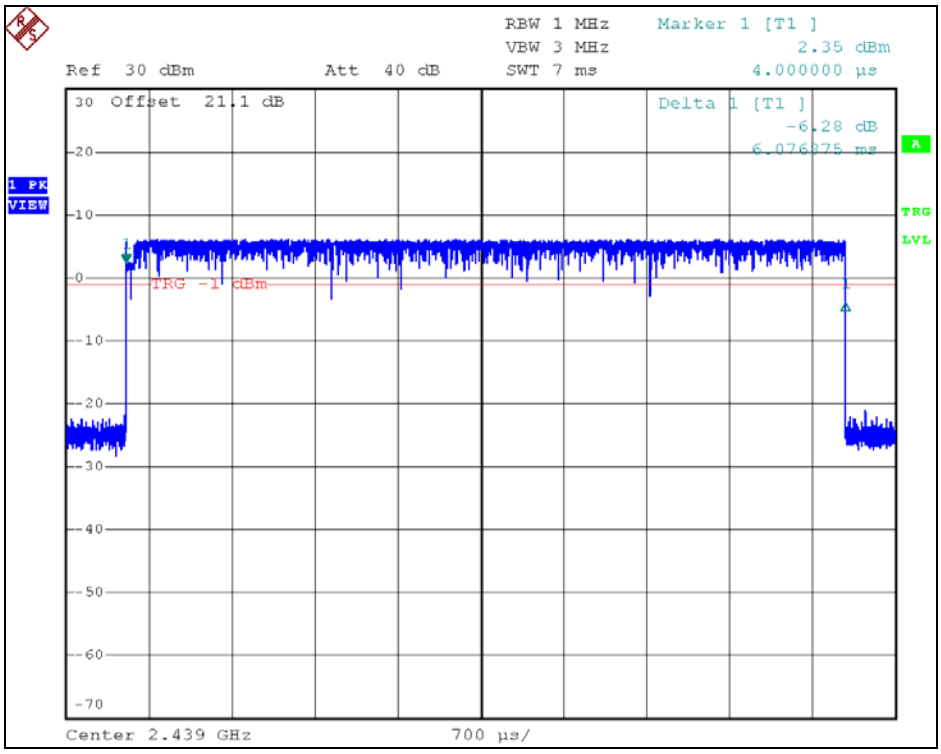
| Hopping Time Measurements | | |
|---|---|---|
| **Parameter** | **Measurement** | **Units** |
| Number of Hopping Channels (minimum 15) | 19 | channels |
| Hopping Channel Separation | 3.998 | MHz |
| Channel Dwell Time | 6.1 | ms |
| Return to Channel Time | 304 | ms |

| Occupancy Calculations | | |
|---|---|---|
| **Parameter** | **Calculation** | **Result** |
| Time to Assess Occupancy Time (Period) | 400 ms * 19 channels | 7.6 s |
| Number of Channel Events over Period | 7.6 s / 304 ms | 25 events |
| Accumulated Dwell Time (limit 400 ms) | 25 * 6.1 ms | 152.5 ms |

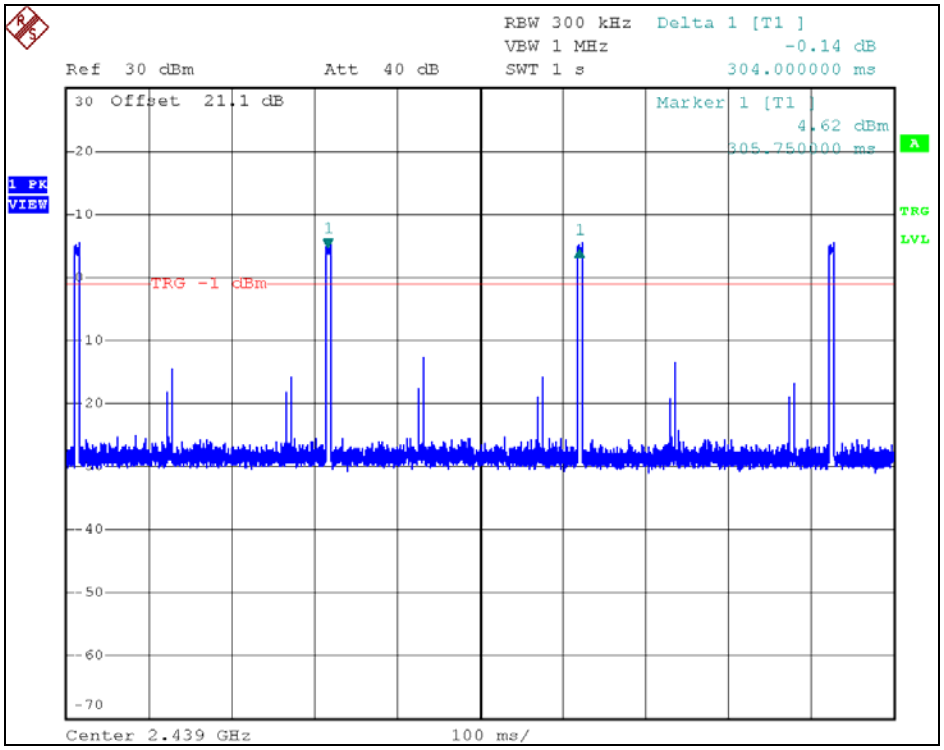
The EUT satisfies the criteria. Plotted measurements appear on the following pages.



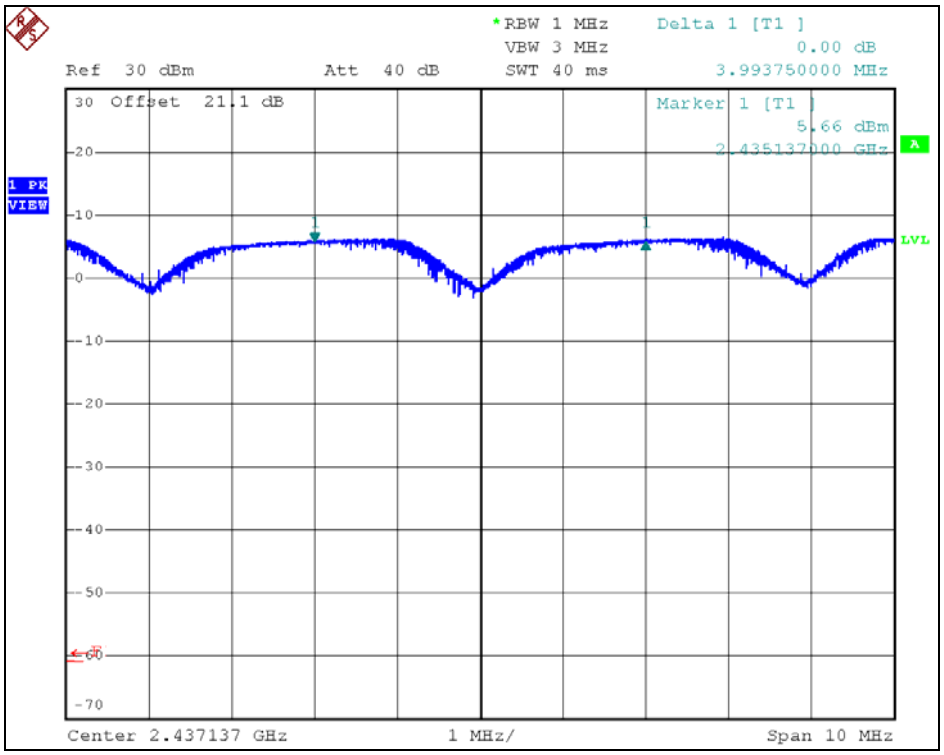

Number of Hopping Channels




Channel Dwell Time (Worst-Case)




Return to Channel Measurement




Channel Separation Measurement

## 9.4 Test Equipment

| Asset # | Manufacturer | Model # | Description | Calibration Due |
|---|---|---|---|---|
| ALN-077 | Rohde & Schwarz | FSP-30 | Spectrum Analyzer | 2015-01-29 |
| C248 | Pasternack | N/A | Cable | 2015-05-14 |
| A105 | Narda | 768A-20 | RF Attenuator, 20 W, 20 dB | 2015-05-16 |

## 9.5 Hopping Protocol Details

The following pseudo-random hopping table illustrates the logical and physical channels on which the transceiver hops. The starting point is chosen pseudo-randomly. Each sequential hop uses the next row in the table and then repeats from the last row back to the first.

**Table of Hopping Channels and Frequencies**

| Channel Index | Hop magnitude from last (+ direction) | Hop magnitude from last (- direction) | Frequency (MHZ) | Frequency change (MHZ) |
|---|---|---|---|---|
| 4 | 5 | -14 | 2415 | -56 |
| 12 | 8 | -11 | 2447 | 32 |
| 17 | 5 | -14 | 2467 | 20 |
| 8 | 10 | -9 | 2431 | -36 |
| 1 | 12 | -7 | 2403 | -28 |
| 5 | 4 | -15 | 2419 | 16 |
| 11 | 6 | -13 | 2443 | 24 |
| 19 | 8 | -11 | 2475 | 32 |
| 2 | 2 | -17 | 2407 | -68 |
| 7 | 5 | -14 | 2427 | 20 |
| 16 | 9 | -10 | 2463 | 36 |
| 10 | 13 | -6 | 2439 | -24 |
| 3 | 12 | -7 | 2411 | -28 |
| 14 | 11 | -8 | 2455 | 44 |
| 6 | 11 | -8 | 2423 | -32 |
| 15 | 9 | -10 | 2459 | 36 |
| 9 | 13 | -6 | 2435 | -24 |
| 13 | 4 | -15 | 2451 | 16 |
| 18 | 5 | -14 | 2471 | 20 |



There are two modes of operation for the LIU and WRU devices: 1) discovery and 2) cycle (or hopping). Each process will be described separately below.

**Discovery**

During discovery, two units interact such that one is the master and the other is the slave. This mode uses a table of 19 channels. These are the same 19 channels used during cycle mode. The master begins the interaction by transmitting a beacon request on the frequency that would be used in cycle mode if the unit was currently connecting in cycle mode. The master will continue to beacon on each cycle until the slave responds. This assures that all 19 channels will be used so that the beacon at some point will align with the channel the slave is listening on. The transmitter begins at the index that the normal hopping sequence would have used at the cycle. The beacon message contains information on the node it expects to respond to the beacon and a table index which is the channel that the Beacon is transmitted on. Upon completion of the transmission, the master listens. This process repeats every 16 ms until the master establishes communications with 1 and only 1 other device. The Master after receiving the slave's response will send a ACK acknowledging to the Slave that he heard his response. This message exchange is similar to what happens in cycle mode.

The timing for the functional beacon cycle is :
 Beacon Request (Tx from LIU)= 206.3 µsec
 Beacon Response (Tx from WRU)=150.3 µsec
 Response ACK (Tx from LIU) =147.1 µsec
 Total = 503.7 µsec

The maximum time of occupancy of any channel for a device in discovery-master mode over the specified period in section (iii) above is 239.25 ms (see below). The discovery-mode uses one channel per cycle.

**P = 0.4 s * 19 = 7.6 seconds**
**where P is the period within which average channel occupancy < 400 ms**
**C = 7.6 s/16ms = 475**
**where C is the number of beacon cycles within P**
**O = (206.3us+150.3+147.1) * 475 = 239. 25 ms**
**$O_s$ = 206.3us* 475 = 97.9ms**
**where O is the average channel occupancy within P**

**Where $O_s$ is the channel occupancy of the single longest transmission from a device.**

The scenario above is worst case description. The full 503.7 us transmission set would never occur more than once. The typical cycle would be the 206.3 us Beacon request without a response. Once the response occurs (a single 503.7 us transmission set) the LIU and WRU move to cycle mode and no longer use beacon mode. The real time of occupancy is closer to 97.9 ms.

The worst case single device transmission time will be 206.3 us. The worst case exchange on one frequency before hopping will be 503.7 us.

The slave device periodically turns on its receiver to listen for the Beacon messages. The period is randomly selected between 1 and 1.5 sec. This

random process is designed to reduce the likelihood that several slave devices in the vicinity will hear and respond to the master's messages. The receiver channel is pseudo-randomly chosen from the same 19 channel table as the master. If within 304 ms, the slave does not hear a Beacon message, the receiver is shut off and the process begins again. If the slave does hear the Beacon message, it will set its receiver to the channel specified by the index contained within the message and respond. Upon reception of the Beacon message the slave will respond by transmitting a Beacon response message containing pertinent information to the slave device. Clearly the slave does not violate the average channel occupancy limit described above.

**Cycle**

Before describing the channel hopping process it is necessary to describe the transition from discovery mode to cycle mode.

The transition, which Wireless Seismic, Inc. refers to as "formation," is very similar to the discovery process. The process begins with the LIU being provided with the linear order of the WRU devices in its control (seismic instruments are laid out in a line separated by a predetermined distance on the order of 10 – 100 meters). The LIU determines the serial number of the closest two devices (one on each side) and begins a process of beaconing, as in the discovery process. Any slave device that hears the message will change the receiver channel to the index in the Beacon message and come into cycle. However, the Beacon message contains the serial number of the device expected to transition and a pseudo-randomly selected index into the 19-channel cycle-mode table. Once the Beacon message is transmitted by the LIU, it will set its receiver to the same channel specified by the aforementioned index and await a communication from the targeted device. If no slave device matches the serial number, then the process simply repeats at the LIU. Eventually, the targeted device will hear the Beacon message and switch to the appropriate channel from the cycle-mode table. The LIU follows this process for the two nearest devices specified in the provided table, following which, the formed devices repeat the process for one targeted device its immediate downlink neighbor.

Once a device has been formed, it remains in cycle mode until commanded to exit and return to the slave mode (listening only).

The cycle mode is a repeating process whereby uplink/downlink pairs progress through the pseudo-random cycle-mode table alternating an uplink transmission interval and a downlink receiving interval; the complete cycle consumes 16 milliseconds.

In this way, seismic data can be propagated upstream as in a bucket-brigade.

Each interval contains a further division to accommodate downstream communications that are used for acknowledging reception and for propagating commands. This interval is significantly shorter than the upstream interval in order to maximize upstream bandwidth.

The system time is divided into 16ms cycles. This is divided into two 8 ms periods. On one of the 8ms periods a WRU is transmitting Data toward the LIU and on the next 8 ms period it is receiving data to pass on to the LIU on the following period. The LIU always is in the receiving data mode regardless of the 1st or second 8ms period. It does this to receive data from two

separate subnets. The timing below is described in reference to a WRU in Data Transmit mode and the LIU in receive.

Data Cycle Timing:

- **Command Message (Tx From LIU) = 206.3 µsec**
- **Data Message (Tx From WRU)= 6187.1 µsec**
- **ACK (Tx From LIU)=147.1 µsec**
- **Total = 6540.5 µsec**

The 206.2 µs Command message is the worst case time as the system does not always send a actual command. The TX time for the command message when the actual command is null is 130 us. This is the more typical command message length.

The 6187.1 µs Data message is also a worst case timing . The message is variable size depending on the amount of data to TX at that time.

The same channel is used for the 3 messages listed in this 8 ms time period. The remainder of the 8ms is idle with no transmissions.

Therefore, the worst case time of occupancy of any channel for communicating pair in cycle mode over the specified period in section (iii) above is (see below).

**P = 0.4 s * 19 = 7.6 seconds**
**where P is the period within which average channel occupancy < 400 ms**
**C = 7.6 s/16ms = 475**
**where C is the number of data cycles within P**
**O = (6540.5 µs * 475)/19 = 163.5 ms**
**where O is the average channel occupancy within P**

The worst case time of occupancy for the WRU communicating in cycle mode over the specified period for one channel is:

**P = 0.4 s * 19 = 7.6 seconds**
**where P is the period within which average channel occupancy < 400 ms**
**C = 7.6 s / 16 ms = 475**
**where C is the number of data cycles within P**
**O = (6187 µs * 475)/19 = 154.6 ms**
**where O is the average channel occupancy within P**

Note that, in cycle-mode, the LIU is always in the receive interval, alternately receiving from one neighbor, then the next. This means that the LIU transmission time is far less than that of the WRU and therefore meets the requirement of section (iii) above. Its worst case time of occupancy is listed below:

**P = 0.4 s * 19 = 7.6 seconds**
**where P is the period within which average channel occupancy < 400 ms**
**C = 7.6 s / 16 ms = 475**

**where C is the number of data cycles within P**

**O = (206.3 us * 475)/19 = 5.1 ms**

**where O is the average channel occupancy within P**

**Channel Repetition**

Note that each WRU functions as a master on one link (downlink) AND a slave on the other link (uplink), whether a downlink WRU exists or not. Every 8 ms the WRU switches between master and slave, and changes channels in the process, executing the 3-message handshake in the uplink and downlink directions. The complete cycle lasts 16 ms. The uplink and downlink connections have different indexes into the hopping table. The downlink index is equal to the uplink index plus one. Both uplink and downlink indexes increment every 8 ms. This results in each connection using alternating even/odd indexes in the pseudo-random hopping table each time the index wraps around. The period of this pattern is thus 16 ms x 19 channels = 304 ms, however channel reuse will be observed at 8 ms x (19 channels -2) = 136 ms, due to the index shift between the uplink and downlink connections. Note that both the uplink and downlink connections each utilize all 19 channels before reuse, so the WRU uses all channels equally on average.

**Adaptive Hopping**

The RT-System 2 does not perform adaptive frequency hopping. Instead, it has a hop set that was generated as a pseudo-random sequence, each with its own seed.

There is no channel coordination between transmitters in the system. Once two interacting devices establish their beginning channel index, they frequency hop with no regard for what other transmitters are doing. As per the discovery and cycle mode descriptions, the beginning channel index is established in a random way using pseudo-randomly generated indexes as well as pseudo-randomly listening devices.

# 10 Antenna Requirements

## 10.1 Test Procedure

Antenna construction and specifications are reviewed and reported. Parameters with bearing upon relevant rules are evaluated.

## 10.2 Test Criteria

| 47 CFR (USA) // IC (Canada) | | |
|---|---|---|
| Section Reference | Parameter | Date(s) |
| 15.205 // RSS-Gen Issue 3, 7.1.2 | Conducted Spurious/Harmonic Emissions | 2014-05-15 |

## 10.3 Test Results

The EUT was tested with the following antenna:

| Antenna Specifications | |
|---|---|
| **Parameter** | **Observation** |
| Manufacturer | Comet |
| Model | CFA-245-32E |
| Type | Dipole |
| Connector | Type 'HPQN' Quick-Connect, based on common N type connector. |
| Peak Gain | 5.5 dBi |
| Installation Method | Professional |

Antenna gain is below the 6 dB criteria for considering antenna gain with power.

The EUT was found to meet the requirements due to the following:

*The antenna is required to be professionally installed by Wireless Seismic or its authorized agents. A contract is enforced and covers this requirement.*

# Appendix A: 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 1000 MHz | 10 m | 4.8 |
| | 1 to 18 GHz | 3 m | 5.7 |

**End of Report**

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