# Test Report

**FCC ID: LV3RF28**
**IC: 3015A-RF28**

**FCC Rule Part: 15.247**
**ISED Canada Radio Standards Specification: RSS-247**

**Report Number: AT72152582-1C0**

Manufacturer: Digitrax, Inc.
Model: RF28

Test Begin Date: October 1, 2019
Test End Date: January 13, 2020

Report Issue Date: February 26, 2020

FOR THE SCOPE OF ACCREDITATION UNDER Certificate Number: 2955.09

This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the Federal Government.


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**This report contains 27 pages**

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# 1 GENERAL

## 1.1 Purpose

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations and Innovation, Science and Economic Development Canada's Radio Standards Specification RSS-247 for the tests documented herein for single modular approval.

## 1.2 Applicant Information

Digitrax, Inc.
2443 Transmitter Road
Panama City, FL 32404, USA

## 1.3 Product Description

The RF28 is an 802.15.4 radio transmitter module with two antenna ports for transmit and receive diversity.

This report documents the Zigbee operation of the sensor module.

Technical Details:

| Detail | Description |
|---|---|
| Frequency Range (MHz) | 2405 – 2475 |
| Number of Channels | 15 |
| Channel Spacing | 5 MHz |
| Modulation Format | DSSS |
| Data Rates | 250kbps |
| Operating Voltage | 3.3Vdc |
| Antenna Type(s) / Gain(s) | Surface Mount Chip / 0.5 dBi<br>(Johanson Technology, P/N: 2450AT18B100) |

Test Sample Serial Number(s): Not Labeled

Test Sample Condition: The equipment was provided in good condition without any physical damage.

## 1.4 Test Methodology and Considerations

All modes of operation, including all data rates, were evaluated and the data presented in this report represents the worst case where applicable.

For RF Conducted measurements, the EUT was modified with a temporary SMA connector in place of the ceramic chip antennas. Output power and Power Spectral Density measurements were performed for both antenna ports and Port B was determined to be the worst-case.

For radiated emissions, the EUT was evaluated in three orthogonal orientations. The worst-case orientation was the X-orientation.

For power line conducted emissions, the EUT was evaluated with a commercially available AC-DC supply.

Power setting during test: 17

# 2 TEST FACILITIES

## 2.1 Location

The radiated and conducted emissions test sites are located at the following addresses:

TÜV SÜD America, Inc.
5945 Cabot Pkwy, Suite 100
Alpharetta, GA 30005
Phone: (678) 341-5900

## 2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America, Inc. is accredited to ISO/IEC 17025 by the American Association for Laboratory Accreditation/A2LA accreditation program and has been issued certificate number 2955.09 in recognition of this accreditation.

Unless otherwise specified, all tests methods described within this report are covered under the ISO/IEC 17025 scopes of accreditation.

The Semi-Anechoic Chamber Test Sites and Conducted Emissions Sites have been fully described, submitted to, and accepted by the FCC, ISED Canada and the Japanese Voluntary Control Council for Interference by information technology equipment.

| | |
|---|---|
| FCC Designation Accreditation Number: | US1233 |
| ISED Canada Lab Code: | 23932 |
| VCCI Member Number: | 1831 |
| • VCCI Registration Number | A-0295 |

## 2.3 Radiated Emissions Test Site Description

### 2.3.1 Semi-Anechoic Chamber Test Site – Chamber A

The Semi-Anechoic Chamber Test Site consists of a 20’ x 30’ x 18’ shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 101 x 101 x 19mm thick and weighs approximately 550 grams. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 5’ in diameter and is located 5’6” from the back wall of the chamber. The chamber is grounded via 1 - 8’ copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is all steel, flush mounted EMCO Model 1060 installed in an all steel frame. The table is remotely operated from inside the control room located 25’ from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Behind the turntable is a 3’ x 6’ x 4’ deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4” PVC chase from the turntable to the pit that allows for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

The chamber rear wall is covered with a mixture of Siepel pyramidal absorber. The side walls of the chamber are partially covered with Siepel pyramidal absorber.

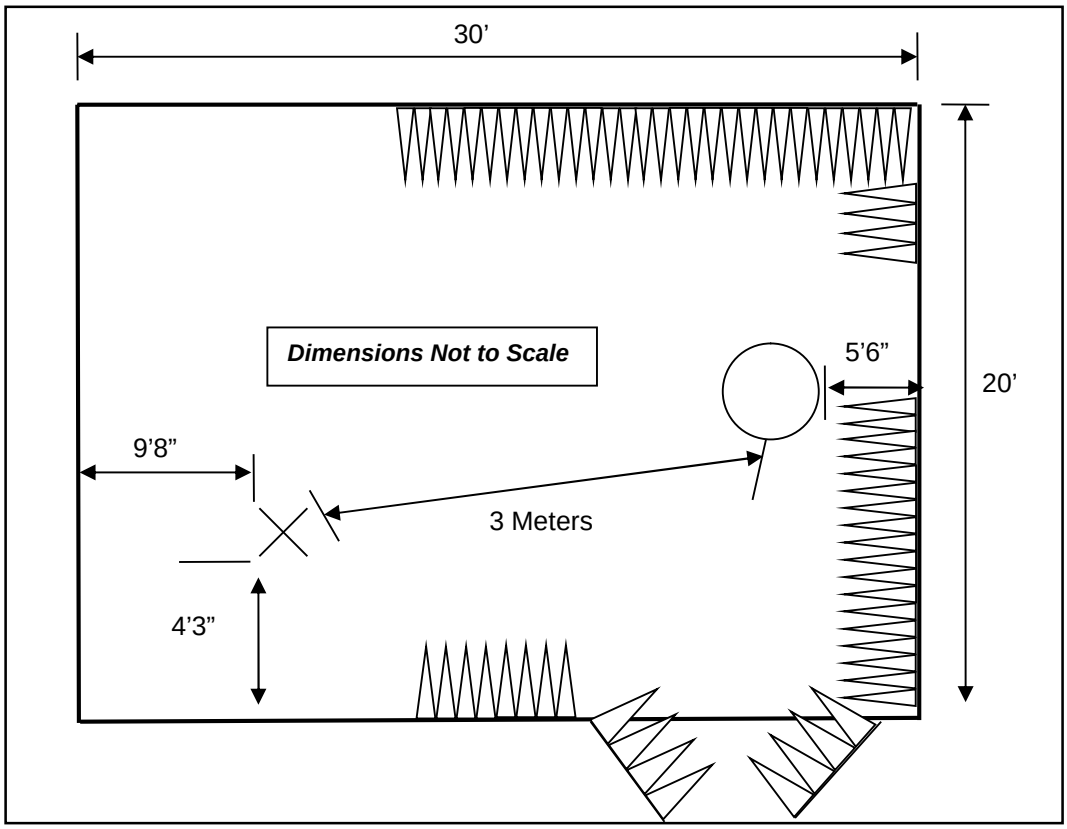



**Figure 2.3.1-1: Semi-Anechoic Chamber Test Site – Chamber A**

### 2.3.2 Semi-Anechoic Chamber Test Site – Chamber B

The Semi-Anechoic Chamber Test Site consists of a 20'W x 30'L x 20'H shielded enclosure. The chamber is lined with ETS-Lindgren Ferrite Absorber, model number FT-1500. The ferrite tile 600 mm x 600 mm (2.62 in x 23.62 in) panels and are mounted directly on the inner walls of the chamber shield.

The specular regions of the chamber are lined with additional ETS-Lindgren PS-600 hybrid absorber to extend its frequency range up to 18GHz and beyond.

The turntable is a 2m ETS-Lindgren Model 2170 and installed off the center axis is located 5'6" from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the shield using #8 solid copper wire.

The antenna mast is an EMCO 1060 and is remotely controlled from the control room for both antenna height and polarization.

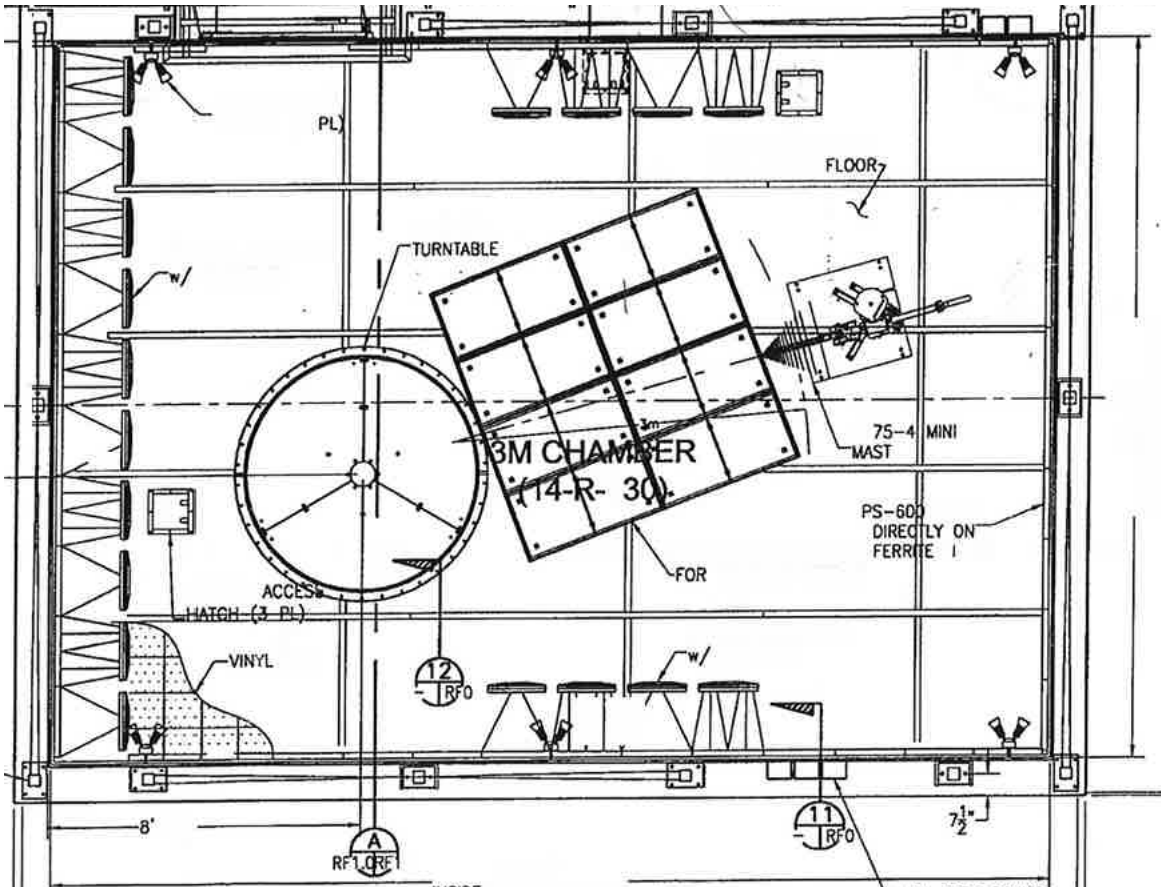



**Figure 2.3.2-1: Semi-Anechoic Chamber Test Site – Chamber B**

## 2.4 Conducted Emissions Test Site Description

### 2.4.1 Conducted Emissions Test Site

The AC mains conducted EMI site is located in the main EMC lab. It consists of a 12' x 10' horizontal coupling plane (HCP) as well as a 12'x8' vertical coupling plane (VCP). The HGP is constructed of 4' x 10' sheets of particle board sandwiched by galvanized steel sheets. These panels are bonded using 11AWG 1/8" x 2" by 10' galvanized sheet steel secured to the panels via by screws. The VCP is constructed of three 4'x8' sheets of 11AWG solid aluminum.

The HCP and VCP are electrically bonded together using 1"x1" angled aluminum secured with screws.

The site is of sufficient size to test tabletop and floor standing equipment in accordance with section 6.1.4 of ANSI C63.10.

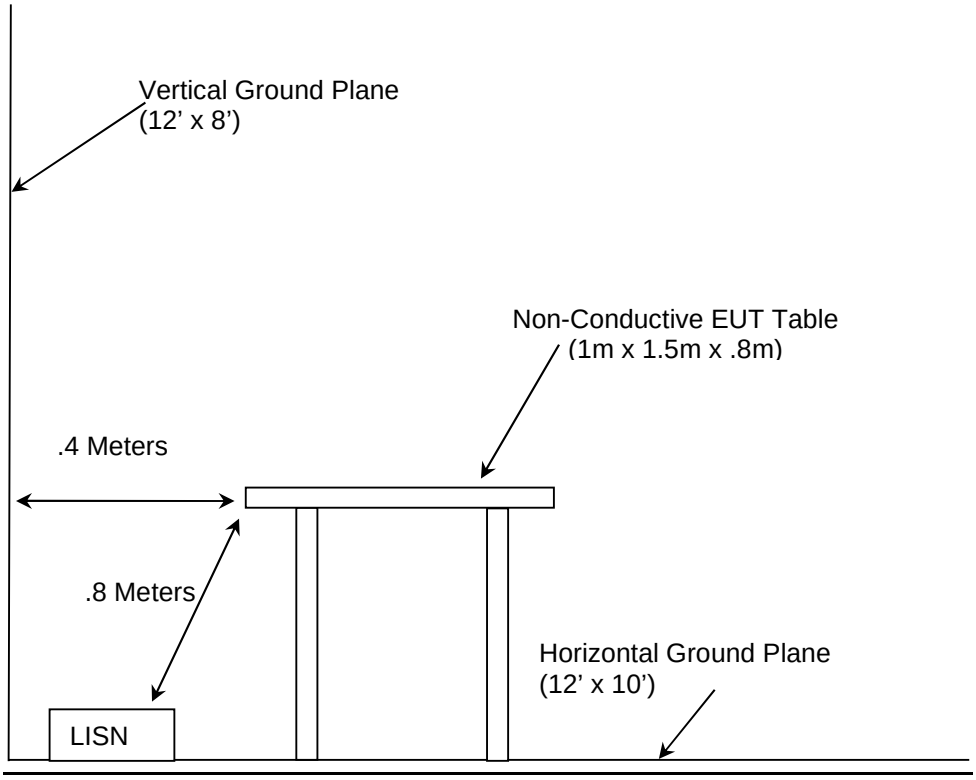



**Figure 2.4.1-1: AC Mains Conducted EMI Site**

## 3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2019
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2019
- FCC KDB 558074 D01 DTS Meas Guidance v05r02 - Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247, April 2, 2019
- ISED Canada Radio Standards Specification: RSS-247 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices, Issue 2, February 2017.
- ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 5, April 2018 + Amendment 1, March 2019

## 4 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

**Table 4-1: Test Equipment**

| Asset ID | Manufacturer | Model | Equipment Type | Serial Number | Last Calibration Date | Calibration Due Date |
|---|---|---|---|---|---|---|
| 22 | Hewlett Packard | 8449B | High Frequency Pre-Amp | 3008A00526 | 07/11/2018 | 07/11/2020 |
| 30 | Spectrum Technologies | DRH-0118 | 1-18GHz Horn Antenna | 970102 | 05/29/2019 | 05/29/2021 |
| 321 | Hewlett Packard | HPC 8447D | Low Freq. Pre-Amp | 1937A02809 | 09/12/2019 | 09/12/2020 |
| 324 | ACS | Belden | Conducted EMI Cable | 8214 | 03/19/2019 | 03/19/2020 |
| 335 | Suhner | SF-102A | Cable (40GHZ) | 882/2A | 07/08/2019 | 07/08/2020 |
| 345 | Suhner Sucoflex | 102A | Cable 42(GHZ) | 1077/2A | 07/09/2019 | 07/09/2020 |
| 432 | Microwave Circuits | H3G020G4 | Highpass Filter | 264066 | 05/31/2019 | 05/31/2020 |
| 622 | Rohde & Schwarz | FSV40 (v3.40) | FSV Signal Analyzer 10Hz to 40GHz | 101338 | 07/30/2018 | 07/30/2020 |
| 628 | EMCO | 6502 | Active Loop Antenna 10kHz-30MHz | 9407-2877 | 02/11/2019 | 11/02/2021 |
| 638 | Rohde & Schwarz | OSP 120 | Open Switch and Control Unit | 101229 | 06/11/2019 | 06/11/2021 |
| 651 | Rohde & Schwarz | TS-PR26 | 18GHz to 26.5GHz Pre-Amplifier | 100023 | 07/10/2019 | 07/10/2020 |
| 652 | Rohde & Schwarz | 3160-09 | High Frequency Antenna 18GHz to 26.5GHz | 060922-21894 | NCR | NCR |
| 813 | PMM | 9010 | EMI Receiver; RF Input 50ohm; 10Hz-50MHz; | 697WW30606 | 02/25/2019 | 02/25/2020 |
| 819 | Rohde & Schwarz | ESR26 | EMI Test Receiver | 101345 | 11/1/2018 | 05/01/2020 |
| 851 | TUV ATLANTA | FMC0101951-100CM | ASAC Cable Set Consisting of 566, 619, and | N/A | 10/01/2019 | 10/01/2020 |
| 852 | Teseq | CBL 6112D | Bilog Antenna; Attenuator | 51617 | 10/15/2018 | 10/15/2020 |
| 871 | (-) | RF Cable | RF Cable(CE Cable) | 871 | 03/18/2019 | 03/18/2020 |
| 3010 | Rohde & Schwarz | ENV216 | Two-Line V-Network | 3010 | 07/10/2019 | 07/10/2020 |

**NCR = No Calibration Required**
**NOTE: All test equipment was used only during active calibration cycles as reported above.**

## 5 SUPPORT EQUIPMENT

**Table 5-1: Support Equipment**

| Item | Equipment Type | Manufacturer | Model Number | Serial Number |
|---|---|---|---|---|
| 1 | Radio Module | Digitrax | RF28 | Not Labeled |
| 2 | Evaluation Board | Digitrax | UR93 | Not Labeled |
| 3 | DC Supply | Digitrax | M150600A001 | 11200002D18070200727 |

**Table 5-2: Cable Description**

| Item | Cable Type | Length | Shield | Termination |
|---|---|---|---|---|
| A | DC Power Cable | 0.5 m | No | 2 – 3 |
| B | AC Power | 2.0 m | No | 3 – AC Mains |

## 6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

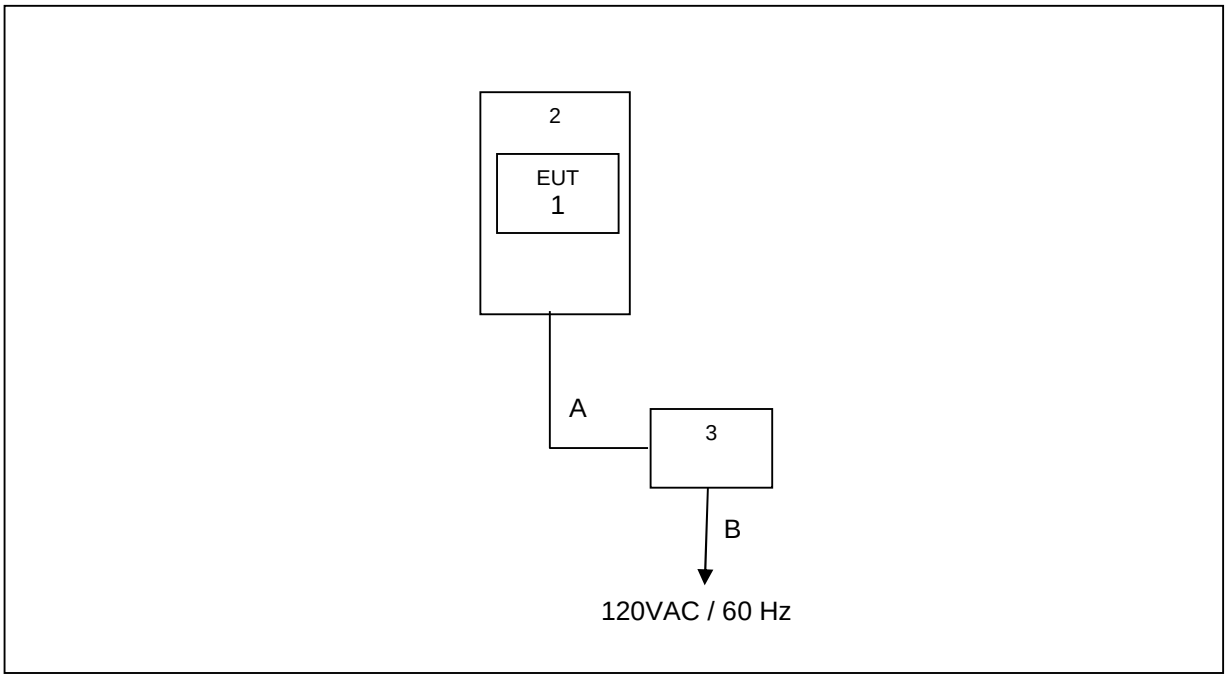



**Figure 6-1: Test Setup Block Diagram**

# 7 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

## 7.1 Antenna Requirement – FCC 15.203

The EUT utilizes a Surface Mount Chip antenna. The antenna is integral to the device and cannot be removed or replaced by the end user. The gain of the antenna is 0.5 dBi.

## 7.2 Power Line Conducted Emissions – FCC 15.207, ISED Canada: RSS-Gen 8.8

### 7.2.1 Measurement Procedure

Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

**Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss**
**Margin = Corrected Reading – Applicable Limit**

### 7.2.2 Measurement Results

Performed by: Sean Vick

**Table 7.2.2-1: Conducted EMI Results – 120VAC/60Hz – Line 1**

| Frequency (MHz) | Corrected Reading | | Limit | | Margin | | Correction (dB) |
|---|---|---|---|---|---|---|---|
| | Quasi-Peak | Average | Quasi-Peak | Average | Quasi-Peak | Average | |
| | (dBµV) | (dBµV) | (dBµV) | (dBµV) | (dB) | (dB) | |
| 0.15 | 25.04 | 19.92 | 66 | 56 | -40.96 | -36.08 | 9.45 |
| 0.154 | 25.7 | 22.65 | 65.78 | 55.78 | -40.08 | -33.13 | 9.45 |
| 0.162 | 25.51 | 13.2 | 65.36 | 55.36 | -39.85 | -42.16 | 9.45 |
| 2.474 | 19.06 | 10.72 | 56 | 46 | -36.94 | -35.28 | 9.73 |
| 2.566 | 19.09 | 10.75 | 56 | 46 | -36.91 | -35.25 | 9.74 |
| 2.726 | 19.7 | 10.81 | 56 | 46 | -36.3 | -35.19 | 9.75 |
| 2.95 | 19.38 | 10.89 | 56 | 46 | -36.62 | -35.11 | 9.77 |
| 2.998 | 25.59 | 12.36 | 56 | 46 | -30.41 | -33.64 | 9.77 |
| 19.902 | 26.75 | 12.02 | 60 | 50 | -33.25 | -37.98 | 9.75 |
| 24.89 | 27.94 | 13.27 | 60 | 50 | -32.06 | -36.73 | 9.83 |

**Table 7.2.2-2: Conducted EMI Results – 120VAC/60Hz – Line 2**

| Frequency (MHz) | Corrected Reading | | Limit | | Margin | | Correction (dB) |
|---|---|---|---|---|---|---|---|
| | Quasi-Peak | Average | Quasi-Peak | Average | Quasi-Peak | Average | |
| | (dBµV) | (dBµV) | (dBµV) | (dBµV) | (dB) | (dB) | |
| 0.15 | 25.07 | 19.01 | 66 | 56 | -40.93 | -36.99 | 9.43 |
| 0.154 | 25.53 | 21.87 | 65.78 | 55.78 | -40.25 | -33.91 | 9.43 |
| 2.402 | 25.39 | 12.93 | 56 | 46 | -30.61 | -33.07 | 9.69 |
| 2.554 | 20.73 | 10.71 | 56 | 46 | -35.27 | -35.29 | 9.7 |
| 2.59 | 19.06 | 10.72 | 56 | 46 | -36.94 | -35.28 | 9.7 |
| 2.686 | 19.1 | 10.76 | 56 | 46 | -36.9 | -35.24 | 9.7 |
| 2.722 | 25.5 | 14.33 | 56 | 46 | -30.5 | -31.67 | 9.7 |
| 2.998 | 25.6 | 12.58 | 56 | 46 | -30.4 | -33.42 | 9.72 |
| 19.998 | 20.37 | 12.03 | 60 | 50 | -39.63 | -37.97 | 9.77 |
| 24.326 | 26.91 | 12.24 | 60 | 50 | -33.09 | -37.76 | 9.83 |

## 7.3 6dB / 99% Bandwidth – FCC 15.247(a)(2), ISED Canada: RSS-247 5.2(a), RSS-GEN 6.7

### 7.3.1 Measurement Procedure

The 6dB bandwidth was measured in accordance with the FCC KDB 558074 D01 Section 8.2 which references Subclause 11.8 of ANSI C63.10. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 100 kHz. The Video Bandwidth (VBW) was set to ≥ 3 times the RBW. The trace was set to max hold with a peak detector active. The marker-delta function of the spectrum analyzer was utilized to determine the 6dB bandwidth of the emission.

The occupied bandwidth measurement function of the spectrum analyzer was used to measure the 99% bandwidth. The span of the analyzer was set to capture all products of the modulation process, including the emission sidebands. The resolution bandwidth was set from 1% to 5% of the occupied bandwidth and the video bandwidth set to at least 3 times the resolution bandwidth. A peak detector was used.

### 7.3.2 Measurement Results

Performed by: Ryan McGann

**Table 7.3.2-1: 6dB / 99% Bandwidth**

| Frequency [MHz] | 6dB Bandwidth [MHz] | 99% Bandwidth [MHz] |
|---|---|---|
| 2405 | 1.6832 | 2.4324 |
| 2440 | 1.7327 | 2.4324 |
| 2475 | 1.7822 | 2.4925 |

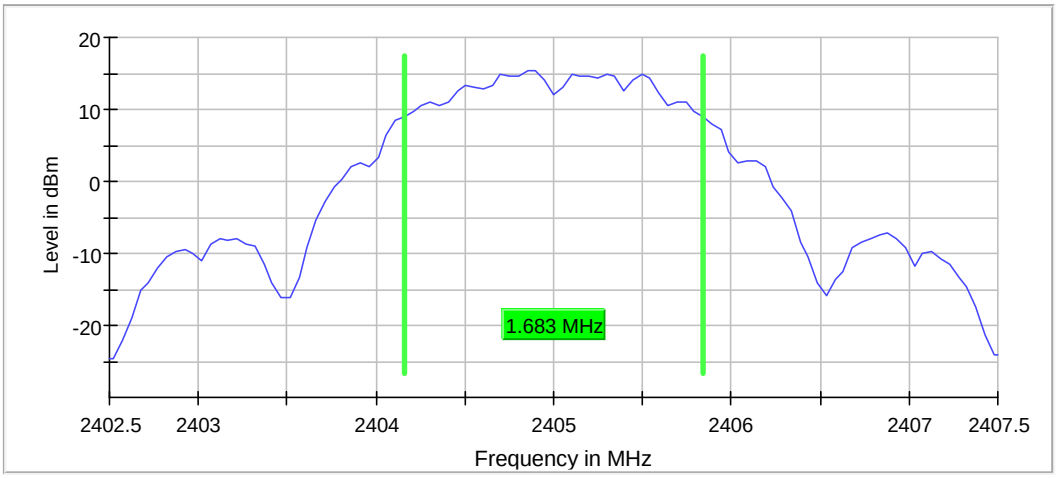



**Figure 7.3.2-1: Sample Plot - 6dB BW**

**Table 7.3.2-2: Sample Measurement Settings (6dB BW)**

| Setting | Instrument Value | Target Value |
|---|---|---|
| Start Frequency | 2.40250 GHz | 2.40250 GHz |
| Stop Frequency | 2.40750 GHz | 2.40750 GHz |
| Span | 5.000 MHz | 5.000 MHz |
| RBW | 100.000 kHz | ~ 100.000 kHz |
| VBW | 300.000 kHz | ~ 300.000 kHz |
| SweepPoints | 101 | ~ 100 |
| Sweeptime | 18.938 µs | AUTO |
| Reference Level | 10.000 dBm | 10.000 dBm |
| Attenuation | 30.000 dB | AUTO |
| Detector | MaxPeak | MaxPeak |
| SweepCount | 100 | 100 |
| Filter | 3 dB | 3 dB |
| Trace Mode | Max Hold | Max Hold |
| Sweeptype | FFT | AUTO |
| Preamp | off | off |
| Stablemode | Trace | Trace |
| Stablevalue | 0.50 dB | 0.50 dB |
| Run | 8 / max. 150 | max. 150 |
| Stable | 5 / 5 | 5 |
| Max Stable Difference | 0.43 dB | 0.50 dB |

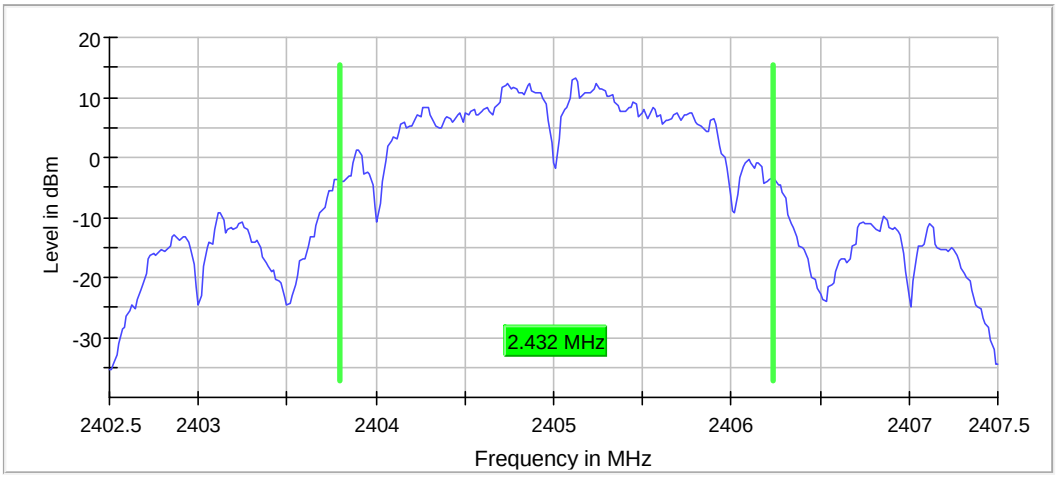



**Figure 7.3.2-2: Sample Plot - 99% OBW**

**Table 7.3.2-3: Sample Measurement Settings (OBW)**

| Setting | Instrument Value | Target Value |
|---|---|---|
| Start Frequency | 2.40250 GHz | 2.40250 GHz |
| Stop Frequency | 2.40750 GHz | 2.40750 GHz |
| Span | 5.000 MHz | 5.000 MHz |
| RBW | 30.000 kHz | >= 25.000 kHz |
| VBW | 100.000 kHz | >= 90.000 kHz |
| SweepPoints | 333 | ~ 333 |
| Sweeptime | 63.218 µs | AUTO |
| Reference Level | 10.000 dBm | 10.000 dBm |
| Attenuation | 30.000 dB | AUTO |
| Detector | MaxPeak | MaxPeak |
| SweepCount | 100 | 100 |
| Filter | 3 dB | 3 dB |
| Trace Mode | Max Hold | Max Hold |
| Sweeptype | FFT | AUTO |
| Preamp | off | off |
| Stablemode | Trace | Trace |
| Stablevalue | 0.30 dB | 0.30 dB |
| Run | 12 / max. 150 | max. 150 |
| Stable | 3 / 3 | 3 |
| Max Stable Difference | 0.28 dB | 0.30 dB |

## 7.4 Fundamental Emission Output Power – FCC 15.247(b)(3), ISED Canada: RSS-247 5.4(d)

### 7.4.1 Measurement Procedure

The maximum conducted output power was measured in accordance with FCC KDB 558074 D01 utilizing the RBW ≥ DTS Bandwidth method. The RF output of the equipment under test was directly connected to the input of the analyzer applying suitable attenuation. Worst-case power across all data rates is reported.

### 7.4.2 Measurement Results

Performed by: Ryan McGann

**Table 7.4.2-1: Conducted Output Power**

| Modulation | Frequency [MHz] | Peak Power [dBm] |
|---|---|---|
| GFSK | 2405 | 19.3 |
| | 2440 | 19.1 |
| | 2475 | 18.9 |

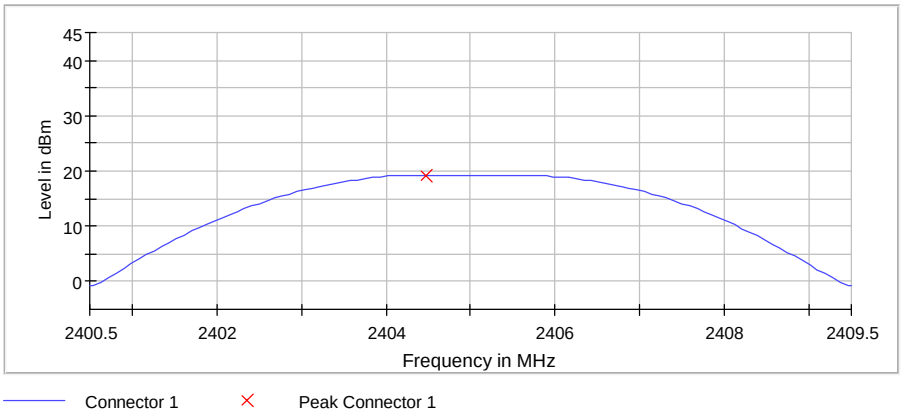



**Figure 7.4.2-1: Sample Plot**

**Table 7.4.2-2: Sample Measurement Settings**

| Setting | Instrument Value | Target Value |
|---|---|---|
| Start Frequency | 2.40050 GHz | 2.40050 GHz |
| Stop Frequency | 2.40950 GHz | 2.40950 GHz |
| Span | 9.000 MHz | 9.000 MHz |
| RBW | 3.000 MHz | >= 2.500 MHz |
| VBW | 10.000 MHz | >= 9.000 MHz |
| SweepPoints | 101 | ~ 101 |
| Sweeptime | 1.271 µs | AUTO |
| Reference Level | 20.000 dBm | 20.000 dBm |
| Attenuation | 40.000 dB | AUTO |
| Detector | MaxPeak | MaxPeak |
| SweepCount | 100 | 100 |
| Filter | 3 dB | 3 dB |
| Trace Mode | Max Hold | Max Hold |
| Sweeptype | FFT | AUTO |
| Preamp | off | off |
| Stablemode | Trace | Trace |
| Stablevalue | 0.50 dB | 0.50 dB |
| Run | 4 / max. 150 | max. 150 |
| Stable | 3 / 3 | 3 |
| Max Stable Difference | 0.01 dB | 0.50 dB |

## 7.5 Emission Levels

### 7.5.1 Emissions into Non-restricted Frequency Bands – FCC 15.247(d); ISED Canada: RSS-247 5.5

#### *7.5.1.1* Measurement Procedure

The unwanted emissions into non-restricted bands were measured conducted in accordance with FCC KDB 558074 D01 Section 8.5. The RF output of the equipment under test was directly connected to the input of the spectrum analyzer applying suitable attenuation. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 100 kHz. The Video Bandwidth (VBW) was set to ≥ 300 kHz. The resulting spectrum analyzer peak level was used to determine the reference level with respect to the 20 dBc limit at the band edges. The spectrum span was then adjusted for the measurement of spurious emissions from 30MHz to 25GHz, 10 times the highest fundamental frequency. The worst-case for each modulation was investigated at the lower and upper band edges.

#### *7.5.1.2* Measurement Results

Performed by: Ryan McGann

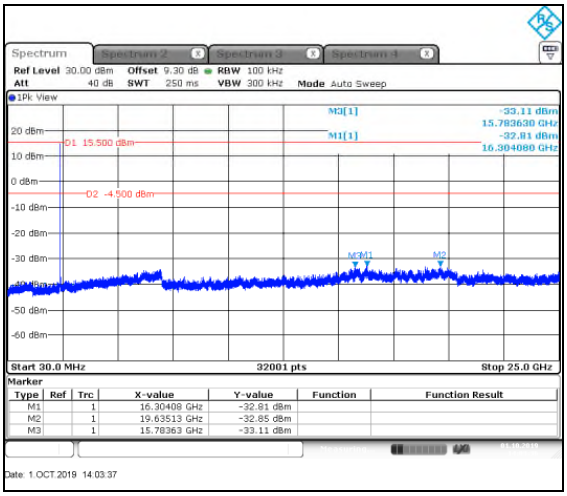



**Figure 7.5.1.2-1: Conduced Spurious Emissions – LCH**

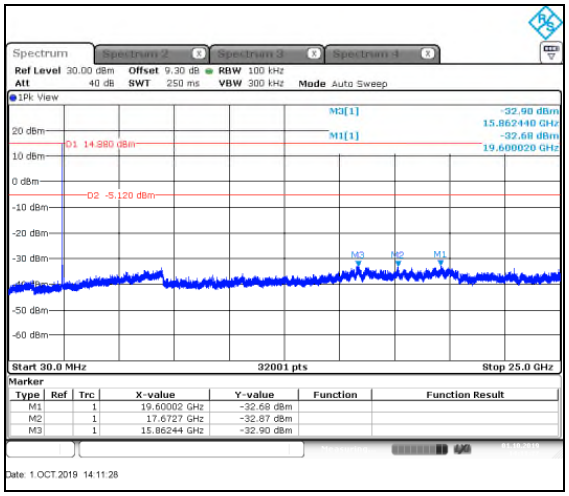



**Figure 7.5.1.2-2: Conducted Spurious Emissions – MCH**

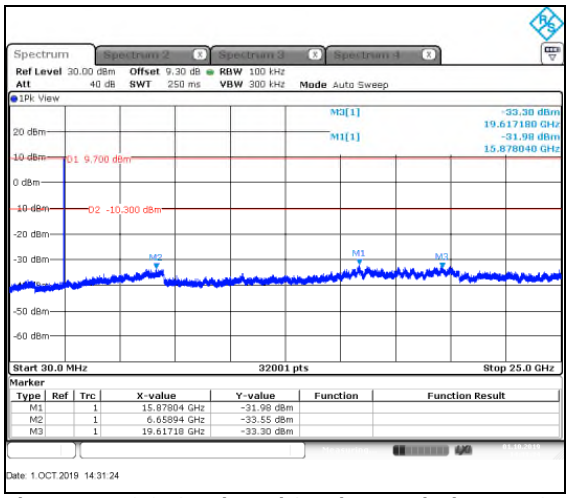



**Figure 7.5.1.2-3: Conducted Spurious Emissions – HCH**

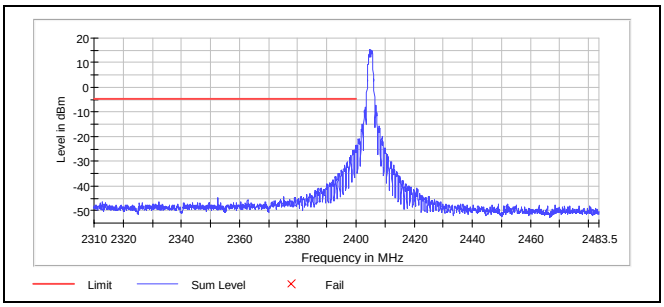



Figure 7.5.1.2-4: Lower Band-edge – Low Channel

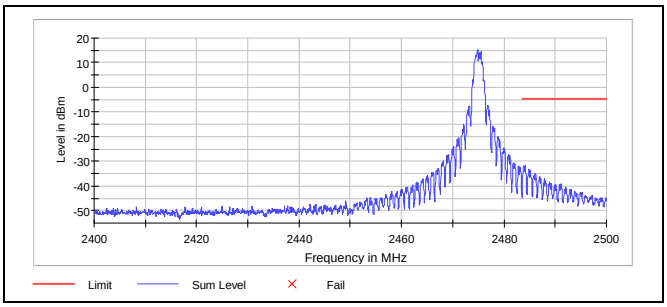



Figure 7.5.1.2-5: Upper Band-edge – High Channel

Table 7.5.1.2-1: Lower Band-edge – Low Channel

| Frequency (MHz) | Level (dBm) | Margin (dB) | Limit (dBm) | Result |
|---|---|---|---|---|
| 2399.925000 | -23.4 | 18.8 | -4.5 | PASS |
| 2399.875000 | -23.4 | 18.9 | -4.5 | PASS |
| 2399.975000 | -23.9 | 19.4 | -4.5 | PASS |
| 2399.825000 | -24.2 | 19.7 | -4.5 | PASS |
| 2399.775000 | -25.4 | 20.9 | -4.5 | PASS |
| 2398.875000 | -25.6 | 21.1 | -4.5 | PASS |
| 2399.075000 | -25.6 | 21.1 | -4.5 | PASS |
| 2399.125000 | -25.8 | 21.3 | -4.5 | PASS |
| 2398.925000 | -26.0 | 21.4 | -4.5 | PASS |
| 2399.725000 | -26.1 | 21.5 | -4.5 | PASS |
| 2398.825000 | -26.1 | 21.6 | -4.5 | PASS |
| 2399.175000 | -26.3 | 21.8 | -4.5 | PASS |
| 2399.225000 | -26.9 | 22.4 | -4.5 | PASS |
| 2398.975000 | -27.1 | 22.6 | -4.5 | PASS |
| 2399.275000 | -27.2 | 22.7 | -4.5 | PASS |

Table 7.5.1.2-2: Upper Band-edge – High Channel

| Frequency (MHz) | Level (dBm) | Margin (dB) | Limit (dBm) | Result |
|---|---|---|---|---|
| 2484.125000 | -31.7 | 26.8 | -4.9 | PASS |
| 2484.175000 | -31.7 | 26.8 | -4.9 | PASS |
| 2483.875000 | -32.0 | 27.1 | -4.9 | PASS |
| 2483.925000 | -32.0 | 27.2 | -4.9 | PASS |
| 2483.825000 | -33.2 | 28.3 | -4.9 | PASS |
| 2484.875000 | -33.2 | 28.3 | -4.9 | PASS |
| 2484.075000 | -33.3 | 28.4 | -4.9 | PASS |
| 2484.825000 | -33.5 | 28.6 | -4.9 | PASS |
| 2484.225000 | -33.5 | 28.6 | -4.9 | PASS |
| 2483.775000 | -33.8 | 28.9 | -4.9 | PASS |
| 2484.925000 | -33.9 | 29.0 | -4.9 | PASS |
| 2485.125000 | -33.9 | 29.0 | -4.9 | PASS |
| 2483.975000 | -34.1 | 29.2 | -4.9 | PASS |
| 2484.025000 | -34.3 | 29.4 | -4.9 | PASS |
| 2485.175000 | -34.4 | 29.5 | -4.9 | PASS |

## 7.5.2 Emissions into Restricted Frequency Bands – FCC: 15.205, 15.209; ISED Canada: RSS-Gen 8.9 / 8.10

### *7.5.2.1* Measurement Procedure

The unwanted emissions into restricted bands were measured radiated over the frequency range of 30MHz to 25GHz, 10 times the highest fundamental frequency.

The EUT was rotated through 360° and the receive antenna height was varied from 1 meter to 4 meters so that the maximum radiated emissions level would be detected. For frequencies below 1000 MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 120 kHz and a video bandwidth VBW of 300 kHz. For frequencies above 1000 MHz, peak and average measurements were made with RBW and VBW of 1 MHz and 3 MHz respectively.

Each emission found to be in a restricted band as defined by section 15.205, including any emission at the operational band-edge, was compared to the radiated emission limits as defined in section 15.209.

### *7.5.2.2* Duty Cycle Correction

An operational duty cycle of 30% was provided by the applicant; therefore, the average measurements were adjusted by 20 * log(1/DC) = 10.46dB. This is the maximum operational duty-cycle and is hardwired such that under no condition can it be changed or modified by either the device or end user.

### *7.5.2.3* Measurement Results

Performed by: Jeremy Pickens

**Table 7.5.2.3-1: Radiated Spurious Emissions Tabulated Data**

| Frequency (MHz) | Level (dBuV) | | Antenna Polarity | Correction Factors | Corrected Level (dBµV/m) | | Limit (dBµV/m) | | Margin (dB) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pk | Qpk/Avg | (H/V) | (dB) | pk | Qpk/Avg | pk | Qpk/Avg | pk | Qpk/Avg |
| **2405 MHz** | | | | | | | | | | |
| **2390** | 48.60 | 38.90 | H | 1.73 | 50.33 | 30.17 | 74.0 | 54.0 | 23.7 | 23.8 |
| **2390** | 44.80 | 32.90 | V | 1.73 | 46.53 | 24.17 | 74.0 | 54.0 | 27.5 | 29.8 |
| **4810** | 49.70 | 40.40 | H | 10.47 | 60.17 | 40.41 | 74.0 | 54.0 | 13.8 | 13.6 |
| **4810** | 44.90 | 32.40 | V | 10.47 | 55.37 | 32.41 | 74.0 | 54.0 | 18.6 | 21.6 |
| **12025** | 51.30 | 41.00 | H | 26.17 | 77.47 | 56.71 | 83.5 | 63.5 | 6.0 | 6.8 |
| **12025** | 52.80 | 42.50 | V | 26.17 | 78.97 | 58.21 | 83.5 | 63.5 | 4.5 | 5.3 |
| **2440 MHz** | | | | | | | | | | |
| **4880** | 47.00 | 36.60 | H | 10.58 | 57.58 | 36.72 | 74.0 | 54.0 | 16.4 | 17.3 |
| **4880** | 47.70 | 37.90 | V | 10.58 | 58.28 | 38.02 | 74.0 | 54.0 | 15.7 | 16.0 |
| **7320** | 45.40 | 33.20 | H | 15.58 | 60.98 | 38.32 | 74.0 | 54.0 | 13.0 | 15.7 |
| **7320** | 46.40 | 33.50 | V | 15.58 | 61.98 | 38.62 | 74.0 | 54.0 | 12.0 | 15.4 |
| **12200** | 49.70 | 38.30 | H | 27.87 | 77.57 | 55.71 | 83.5 | 63.5 | 5.9 | 7.8 |
| **12200** | 50.50 | 39.50 | V | 27.87 | 78.37 | 56.91 | 83.5 | 63.5 | 5.1 | 6.6 |
| **2475 MHz** | | | | | | | | | | |
| **2483.5** | 58.20 | 48.70 | H | 2.23 | 60.43 | 40.47 | 74.0 | 54.0 | 13.6 | 13.5 |
| **2483.5** | 58.90 | 49.20 | V | 2.23 | 61.13 | 40.97 | 74.0 | 54.0 | 12.9 | 13.0 |
| **4950** | 51.40 | 43.50 | H | 10.69 | 62.09 | 43.73 | 74.0 | 54.0 | 11.9 | 10.3 |
| **4950** | 50.50 | 42.40 | V | 10.69 | 61.19 | 42.63 | 74.0 | 54.0 | 12.8 | 11.4 |
| **7425** | 47.70 | 35.10 | H | 15.73 | 63.43 | 40.37 | 74.0 | 54.0 | 10.6 | 13.6 |
| **7425** | 47.00 | 34.20 | V | 15.73 | 62.73 | 39.47 | 74.0 | 54.0 | 11.3 | 14.5 |
| **12375** | 49.60 | 39.20 | H | 29.58 | 79.18 | 58.32 | 83.5 | 63.5 | 4.3 | 5.2 |
| **12375** | 50.60 | 40.30 | V | 29.58 | 80.18 | 59.42 | 83.5 | 63.5 | 3.3 | 4.1 |

### 7.5.3 Sample Calculation:

$R_C = R_U + CF_T$

Where:

| | | |
|---|---|---|
| $CF_T$ | = | Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only) |
| $R_U$ | = | Uncorrected Reading |
| $R_C$ | = | Corrected Level |
| AF | = | Antenna Factor |
| CA | = | Cable Attenuation |
| AG | = | Amplifier Gain |
| DC | = | Duty Cycle Correction Factor |

**Example Calculation: Peak**

Corrected Level: 50.60 + 29.58 = 80.18dBuV/m
Margin: 83.5dBuV/m – 80.18dBuV/m = 3.3dB

**Example Calculation: Average**

Corrected Level: 40.30 + 29.58 - 10.46 = 59.42dBuV
Margin: 63.5dBuV – 59.42dBuV = 4.1dB

## 7.6 Maximum Power Spectral Density in the Fundamental Emission – FCC 15.247(e) ISED Canada: RSS-247 5.2(b)

### 7.6.1 Measurement Procedure

The power spectral density was measured in accordance with the FCC KDB 558074 D01 utilizing Section 8.4. The RF output of the equipment under test was directly connected to the input of the spectrum analyzer applying suitable attenuation. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 3 kHz. The Video Bandwidth (VBW) was set to 10 kHz. Span was set to 1.5 times the channel bandwidth. The trace was set to max hold with the peak detector active.

### 7.6.2 Measurement Results

Performed by: Ryan McGann

**Table 7.6.2-1: Power Spectral Density**

| Modulation | Frequency [MHz] | PSD [dBm] |
|---|---|---|
| GFSK | 2405 | 7.162 |
| | 2440 | 5.567 |
| | 2475 | 4.678 |

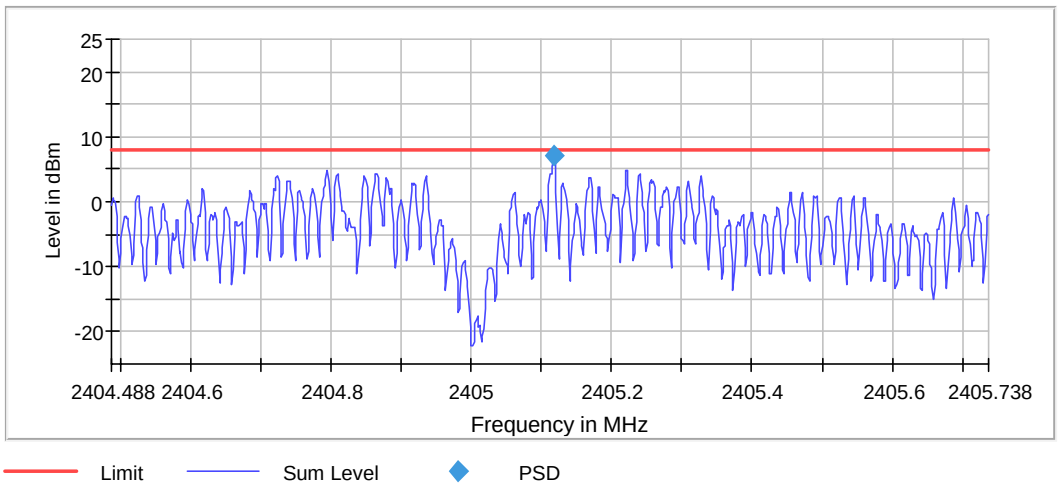



**Figure 7.6.2-1: Sample PSD Plot**

**Table 7.6.2-2: Sample Measurement Settings (PSD)**

| Setting | Instrument Value | Target Value |
|---|---|---|
| Start Frequency | 2.40449 GHz | 2.40449 GHz |
| Stop Frequency | 2.40574 GHz | 2.40574 GHz |
| Span | 1.250 MHz | 1.250 MHz |
| RBW | 3.000 kHz | <= 3.000 kHz |
| VBW | 10.000 kHz | >= 9.000 kHz |
| SweepPoints | 833 | ~ 833 |
| Sweeptime | 13.900 ms | AUTO |
| Reference Level | 10.000 dBm | 10.000 dBm |
| Attenuation | 30.000 dB | AUTO |
| Detector | MaxPeak | MaxPeak |
| SweepCount | 10 | 10 |
| Filter | 3 dB | 3 dB |
| Trace Mode | Max Hold | Max Hold |
| Sweeptype | Sweep | Sweep |
| Preamp | off | off |
| Stablemode | Trace | Trace |
| Stablevalue | 0.50 dB | 0.50 dB |
| Run | 6 / max. 150 | max. 150 |
| Stable | 1 / 1 | 1 |
| Max Stable Difference | 0.40 dB | 0.50 dB |

## 8 ESTIMATION OF MEASUREMENT UNCERTAINTY

The expanded laboratory measurement uncertainty figures ($U_{Lab}$) provided below correspond to an expansion factor (coverage factor) k = 1.96 which provide confidence levels of 95%.

**Table 8-1: Estimation of Measurement Uncertainty**

| Parameter | $U_{lab}$ |
|---|---|
| Occupied Channel Bandwidth | ± 0.009 % |
| RF Conducted Output Power | ± 0.349 dB |
| Power Spectral Density | ± 0.372 dB |
| Antenna Port Conducted Emissions | ± 1.264 dB |
| Radiated Emissions ≤ 1 GHz | ± 5.814 dB |
| Radiated Emissions > 1 GHz | ± 4.318 dB |
| Temperature | ± 0.860 °C |
| Radio Frequency | ± 2.832 x $10^{-8}$ |
| AC Power Line Conducted Emissions | ± 3.360 dB |

## 9 CONCLUSION

In the opinion of TUV SUD the RF28, manufactured by Digitrax, LLC meets the requirements of FCC Part 15 subpart C and ISED Canada's Radio Standards Specification RSS-247 for the tests documented herein.

# Appendix A: Plots

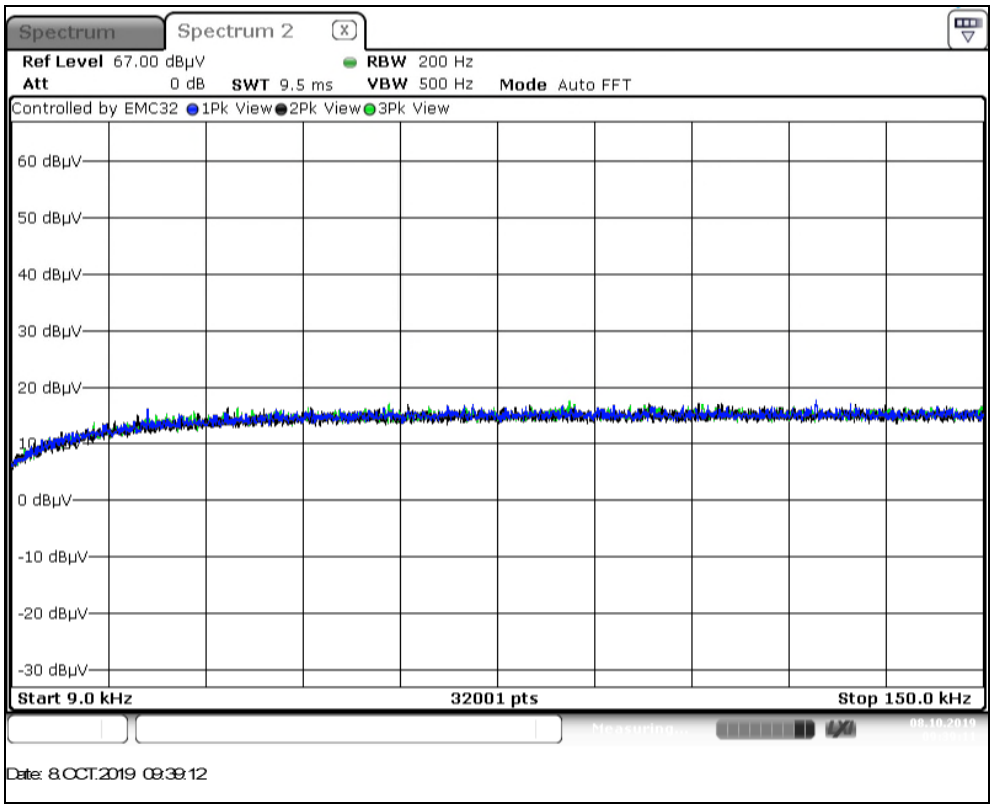
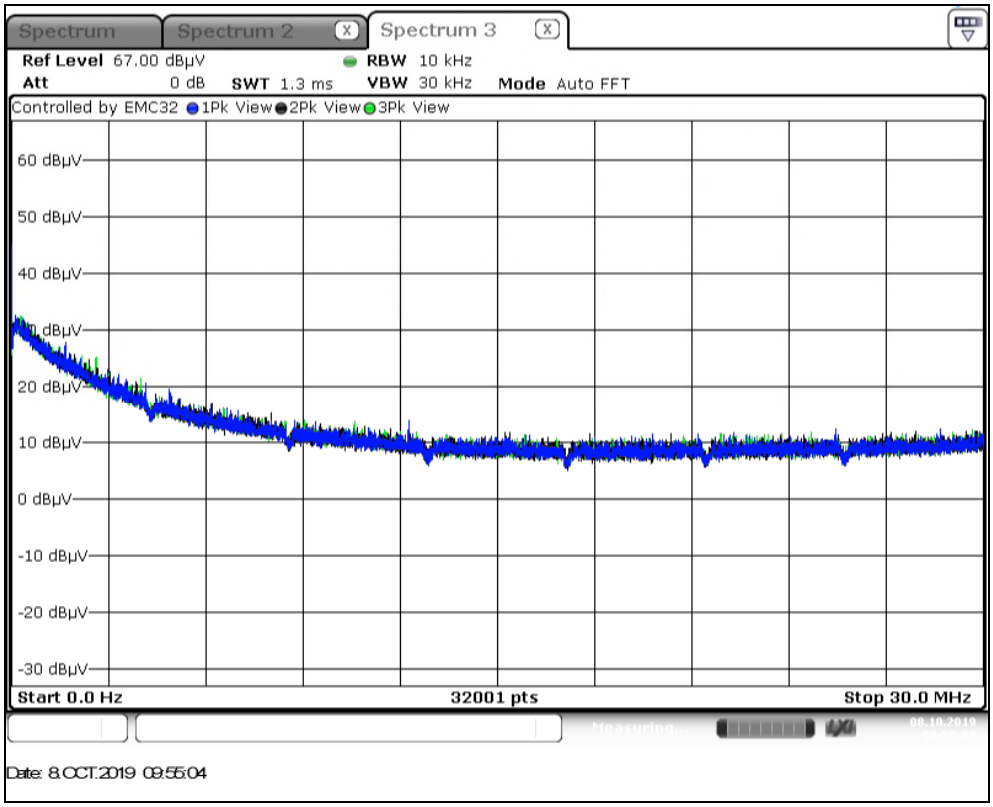
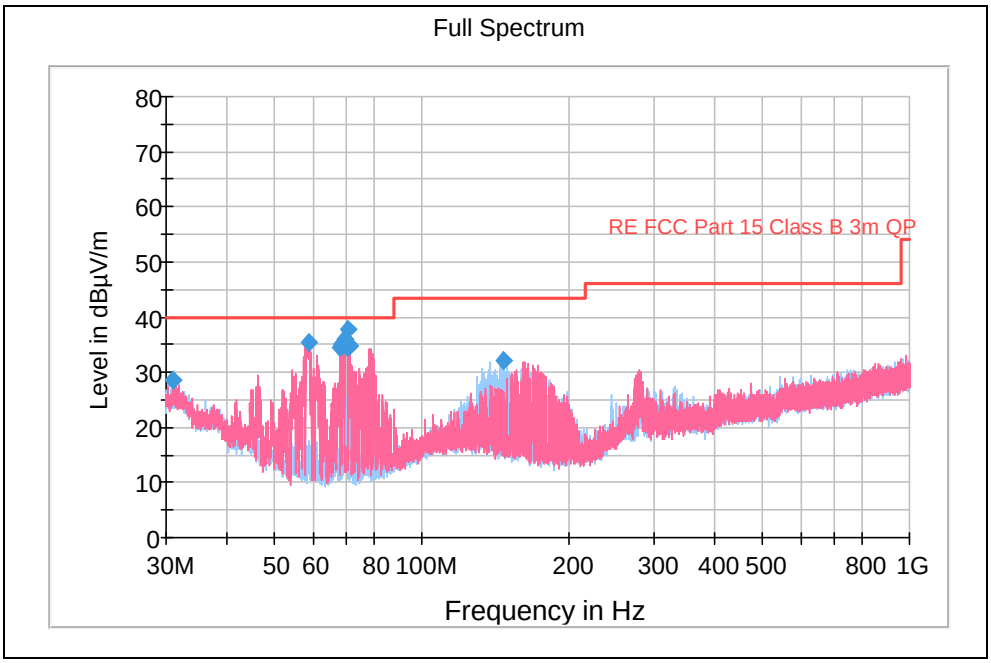



**Figure A-1: Radiated Emissions – 9kHz-150kHz**




**Note: Emissions above the noise floor are related to the driver and not associated with the DUT.**

**Figure A-2: Radiated Emissions – 150kHz-30MHz**




**Note: Emissions above the noise floor are from the digital sections of the DUT and not associated with the radio.**

**Figure A-3: Radiated Emissions – 30MHz-1GHz**

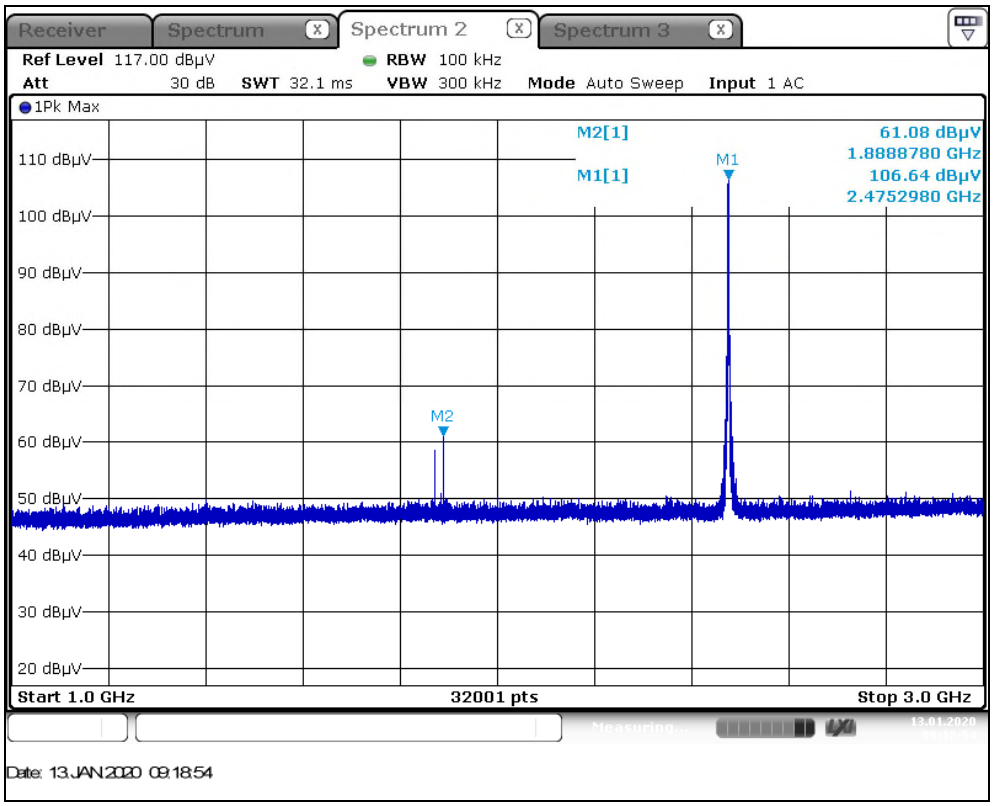



**Figure A-4: Radiated Emissions – 1GHz-3GHz**

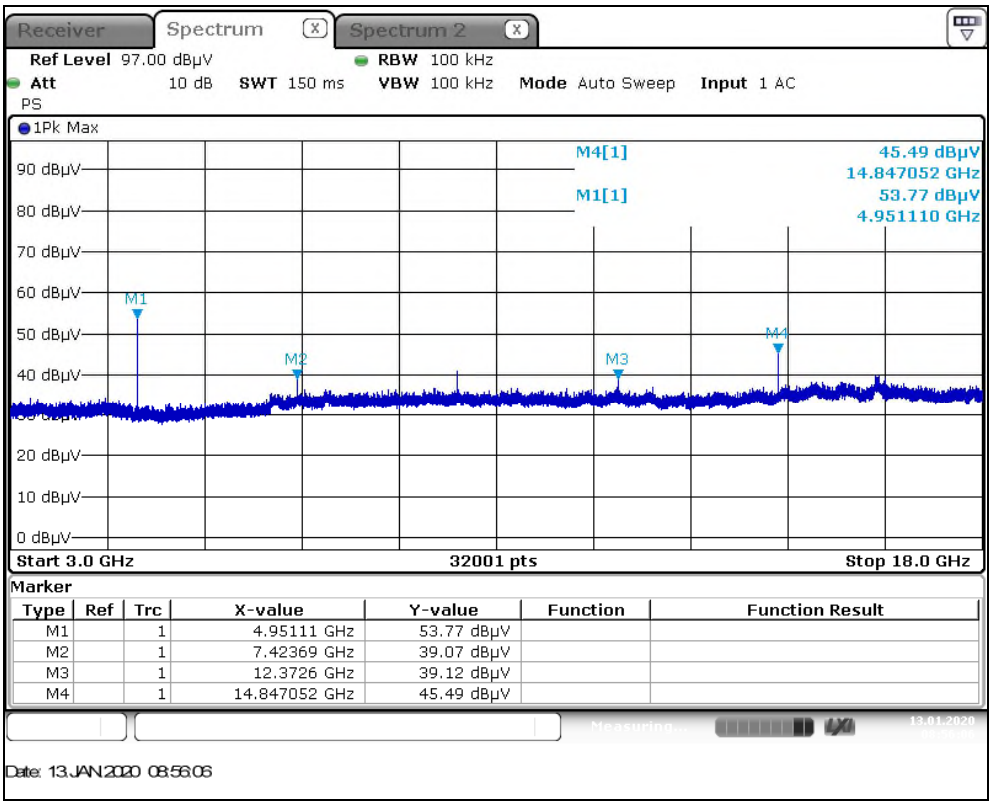



**Figure A-5: Radiated Emissions – 3GHz-18GHz**

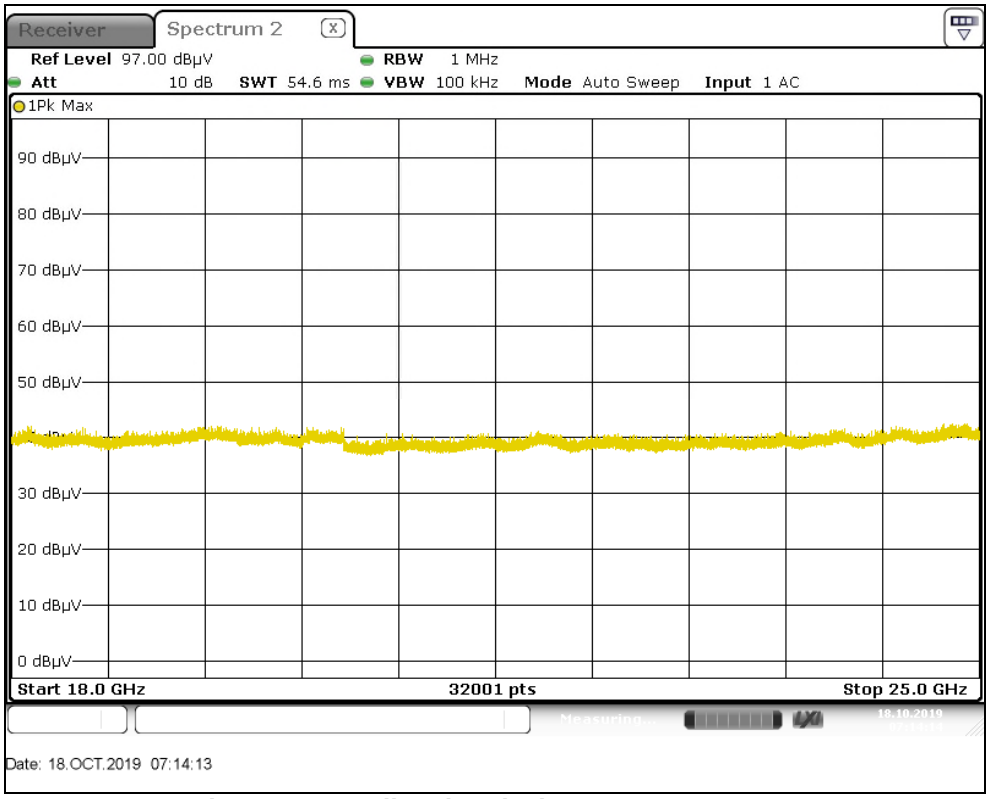



**Figure A-6: Radiated Emissions – 18GHz-25GHz**

# END REPORT