

## ELECTROMAGNETIC COMPATIBILITY TEST REPORT

PREPARED FOR TORINO POWER SOLUTIONS  
BY QAI LABORATORIES



**Report Reference Number:** E10796-1601  
**Total Number of Pages:** 29  
**Date of Issue:** September 7, 2016

**EMC Test Laboratory:** **QAI Laboratories Inc.**  
**Address:** 834 80<sup>th</sup> Street SW, Everett, WA, 98203  
**Phone:** (425) 512-8419

**Laboratory Accreditations (per ISO/IEC 17025:2005):**



**American Association for Laboratory Accreditation Certificate Number: 3657.01**

This report has been completed in accordance with the requirements of ISO/IEC 17025. Test results contained in this report are within QAI Laboratories ISO/IEC 17025 accreditation. QAI Laboratories authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for the use by the company's employees only.

**EMC Client:** Torino Power Solutions Inc.  
**Address:** # 275 – 625 West Kent Ave, North Vancouver, BC Canada, V6P 6T7  
**Phone:** (604) 637 – 5707 Ext 603  
**Fax:** ()

**Applicable Test Standards:** FCC Title 47 Part 15 Subpart C & Subpart B, RSS-210 Issue 8,  
RSS-Gen & ICES-003 Issue 6

**Equipment Tested** Interrogator  
**Model Number:** I1000  
**FCC ID:** 2AJC2I1000  
**Manufacturer:** Torino Power Solutions Inc

## REVISION HISTORY

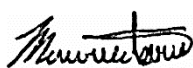
Date	Report Number	Rev #	Details	Author's Initials
Aug 16, 2016	E10796-1601-Torino Power Solutions	1.0	Initial Release	PS
Sept 7, 2016	E10796-1601-Torino Power Solutions	1.1	Minor revisions	BB
Sept 26, 2016	E10796-1601-Torino Power Solutions	1.2	Minor revisions	BB
<i>All previous versions of this report have been superseded by the latest dated revision as listed in the above table. Please dispose of all previous electronic and paper printed revisions accordingly.</i>				

## REPORT AUTHORIZATION

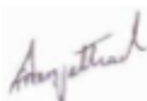
The data documented in this report is for the equipment provided by Torino Power Systems Inc. Tests were conducted on the sample equipment as requested by Torino Power Systems Inc. for the purpose of demonstrating compliance with FCC Title 47 Part 15 Subpart C & Subpart B, RSS-247 Issue 1, RSS-Gen & ICES-003 Issue 6 as agreed upon by Torino Power Systems Inc. as per Quote SH-2016-022903.

Torino Power Systems Inc. is responsible for the tested product configuration, continued product compliance, and for the appropriate auditing of subsequent products as required. This report may comprise partial list of tests that are required for FCC or IC Declaration of Conformity and can only be produced by the manufacturer.

This is to certify that the following report is true and correct to the best of our knowledge.



Written by Maurice Torio  
EMC Technical Writer



Reviewed by Aman Jathaul  
EMC Engineering Manager



Reviewed by Parminder Singh  
Director for the EMC Department

## QAI FACILITIES

Founded in 1994 by a group of experienced certification and testing experts, QAI is an independent third-party testing, inspection and certification organization which serves the building industry, government and individuals with cost effective solutions through our in-house capabilities / services, and an established world-wide network of qualified affiliates. To help get your product to market, trust the provider that many leading global manufacturers do: QAI.

### British Columbia

#### QAI Laboratories Ltd.

#### Main Laboratory/Headquarters

3980 North Fraser Way,  
Burnaby, BC V5J Canada

### Ontario

#### QAI Laboratories Inc.

1081 Meyerside Drive, Unit #14  
Mississauga, ON L5T 1M4 Canada

### Washington

#### QAI Laboratories Inc.

834 80TH Street SW, Suite 200,  
Everett, WA 98203-7008 USA

### Virginia

#### QAI Laboratories Ltd.

1047 Zachary Taylor Hwy,  
Suite A Huntly, VA 22640 USA

### California

#### QAI Laboratories Ltd.

8385 White Oak Avenue Rancho  
Cucamonga, CA 91730 USA

### Oklahoma

#### QAI Laboratories Ltd.

108th East Avenue,  
Tulsa, OK 74116 USA

## QAI EMC ACCREDITATION

QAI EMC is your one-stop regulatory compliance partner for electromagnetic compatibility (EMC) and electromagnetic interference (EMI). Products are tested to the latest and applicable EMC/EMI requirements for domestic and international markets. QAI EMC goes above and beyond being a testing facility—we are your regulatory compliance partner. QAI EMC has the capability to perform RF Emissions and Immunity for all types of electronics manufacturing including Industrial, Scientific, Medical, Information Technology, Telecom, Wireless, Automotive, Marine and Avionics.

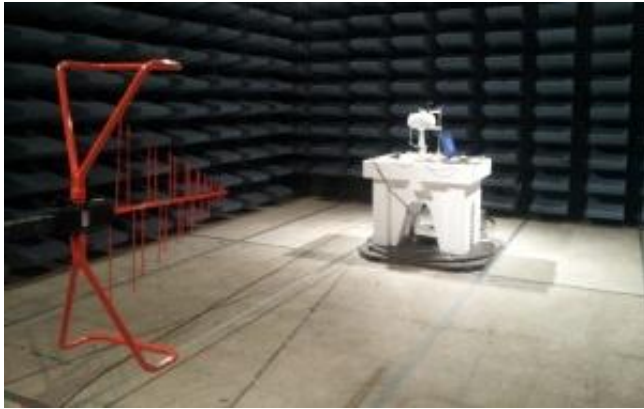
EMC Laboratory Location	FCC Designation (3m SAC)	IC Registration (3m SAC)	A2LA Certificate
Burnaby, BC Canada	CA9543	21146-1	3657.02
Everett, Washington USA	US1151	11876A-1	3657.01



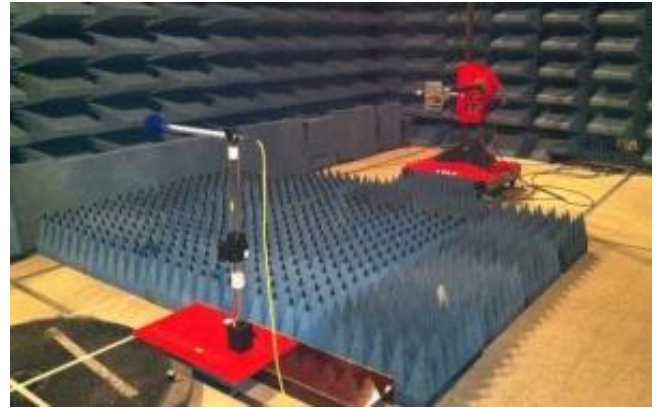
Headquarters & EMC Laboratory in Burnaby, BC



EMC Laboratory in Everett, Washington



**3 m Semi-Anechoic Chamber (SAC) in Burnaby, BC**



**3 m Semi-Anechoic Chamber (SAC) in Burnaby, BC**



**10 m Open Area Test Site (OATS) in British Columbia, Canada**



**3 m Semi-Anechoic Chamber (SAC) in Everett, Washington**



**3 m Semi-Anechoic Chamber (SAC) in Everett, Washington**

## TABLE OF CONTENTS

REVISION HISTORY .....	2
REPORT AUTHORIZATION .....	2
QAI FACILITIES .....	3
QAI EMC ACCREDITATION .....	3
LIST OF TABLES .....	6
LIST OF FIGURES .....	6
Section I: EXECUTIVE SUMMARY .....	7
1.1 Purpose.....	7
1.2 Scope.....	7
1.3 Summary of Results .....	7
Section II: GENERAL INFORMATION .....	9
2.1 Product Description.....	9
2.2 Environmental Conditions .....	11
2.3 Measurement Uncertainty .....	11
2.4 Worst Test Case .....	11
2.5 Sample Calculations of Emissions Data .....	12
2.6 Test Equipment List.....	13
Section III: REQUIREMENTS FOR THE US MARKET (FCC) & THE ..CANADIAN MARKET (IC) Exigences pour le Marché Canadien .....	14
3.1 Antenna Requirements .....	14
3.2 RF Peak Power Output.....	14
3.3 Occupied Bandwidth.....	14
3.3 Peak to Average Power Ratio .....	15
3.5 Out-of-Band Emissions (Band Edge).....	15
3.6 Conducted Spurious Emissions.....	15
3.7 AC Mains Conducted Emissions .....	15
3.8 Radiated Spurious Emissions – Transmit Mode .....	16
3.9 Radiated Spurious Emissions – Receive Mode.....	19
Appendix A: RF PEAK POWER OUTPUT DATA.....	20
Appendix B: OCCUPIED BANDWIDTH DATA .....	21
Appendix C: PEAK TO AVERAGE POWER RATIO .....	22
Appendix D: OUT-OF-BAND EMISSIONS (BANDEDGE) .....	23
Appendix F: CONDUCTED SPURIOUS EMISSIONS.....	24
Appendix G: RADIATED SPURIOUS EMISSIONS – TRANSMIT MODE .....	25
Appendix H: RADIATED SPURIOUS EMISSIONS – RECEIVE MODE.....	27
Appendix I: TEST SETUP PICTURES .....	28
Appendix K: ABBREVIATIONS.....	29



## LIST OF TABLES

Table 1: Field strength of fundamental .....	20
Table 2: 20dB/6dB Occupied Bandwidth .....	21
Table 3: Peak to Average Power Ratio Data.....	22
Table 4: Out-of-Band Emissions Data .....	23
Table 5: Conducted Spurious Emissions 30M - 25G Hz – FLO/FMID/FHI .....	24
Table 6: Radiated Spurious Emissions 30M - 1G Hz – FLO/FMID/FHI .....	25
Table 7: Radiated Harmonics Spurious Emissions 1G - 25G Hz – FLO/FMID/FHI .....	26
Table 8: Radiated Spurious Emissions 1G - 25G Hz – FLO/FMID/FHI.....	26

## LIST OF FIGURES

Figure 1: Radiated Emissions Test Setup at SAC.....	28
Figure 2: Radiated Emissions Test Setup at SAC.....	28
Figure 3: Radiated Emissions Test Setup at SAC.....	<b>Error! Bookmark not defined.</b>

## Section I: EXECUTIVE SUMMARY

### 1.1 Purpose

The purpose of this report is to demonstrate certification and document the compliance data of **Interrogator Model 11000**, manufactured by Torino Power Solutions Inc.

### 1.2 Scope

The information documented in this report is based on the test methods and levels as per Quote 16SH06291:

- **CFR Title 47 FCC Part 15** – Radio Frequency Devices, Subpart C – Intentional Radiators.
  - o **15.203** Antenna Requirement
  - o **15.205** Restricted Bands of Operation
  - o **15.207** Conducted Limits
  - o **15.209** Radiated Emissions Limits: General Requirements
  - o **15.249** Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz
- **CFR Title 47 FCC Part 15** – Radio Frequency Devices, Subpart B – Unintentional Radiators
  - o **15.107** Conducted Limits
  - o **15.109** Radiated Emissions Limits: General Requirements

The tests documented in this report were performed in accordance with ANSI C63.4, ANSI C63.10, RSS-Gen and FCC KDB 558074 D01 DTS Measurement Guidance v03r05.

### 1.3 Summary of Results

The following tests demonstrate “FCC Part 15.249” Electromagnetic Compatibility compliance for “Torino Power Solutions Inc. Interrogator Model A”

The following testing was performed pursuant to FCC Title 47 Part 15 Subpart B & Subpart C

Test or Measurement	Applicable FCC Rule Parts	Description	Performance Criteria
Antenna Requirement	FCC 47 CFR Part 15.203	<i>Permanently attached antenna/unique coupling (not required). Professionally installed..., in accordance with §15.31(d), must be measured at installation site</i>	Complies
RF Peak Power Output	FCC Part 15.249 (a)	<i>Field strength of fundamental: 50 mV/m or 94 dBuV/m at 3m</i>	Complies
Conducted Spurious Emissions	FCC Part 15.249 (d) FCC Part 15.205	<i>Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation. Field strength of harmonics: 500 uV/m or 54 dBuV/m at 3m</i>	Complies
Peak/Average Ratio	FCC Part 15.249 (e)	<i>Peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.</i>	Complies
Restricted Bands (Bandedge)	FCC Part 15.205	<i>Bandedge of 2310M - 2390M, 2483.M – 2500M</i>	Complies
Radiated Spurious Emissions – Transmit Mode	FCC Part 15.209, FCC Part 15.249 (d), FCC Part 15.205	<i>Radiated emissions requirements as stated in the Standards. Field strength of harmonics: 500 uV/m or 54 dBuV/m at 3m</i>	Complies
Radiated Spurious Emissions – Receive Mode	FCC Part 15.209	<i>Radiated emissions requirements as stated in the Standards.</i>	Complies

**The following testing was performed pursuant to Industry Canada ICES-003 Issue 6**

Test or Measurement	Applicable Industry Canada Rule Parts	Description	Performance Criteria
Antenna Requirement	RSS-Gen 7.1.2	<i>Permanently attached antenna/unique coupling (not required). Professionally installed...</i>	Complies
RF Peak Power Output	RSS 210 Issue 8 Annex 8	<i>Field strength of fundamental: 50 mV/m or 94 dBuV/m at 3m</i>	Complies
Conducted Spurious Emissions	RSS 210 Issue 8 Annex 8	<i>Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation. Field strength of harmonics: 500 uV/m or 54 dBuV/m at 3m</i>	Complies
Peak/Average Ratio	RSS 210 Issue 8 Annex 8	<i>Peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.</i>	Complies
Restricted Bands (Bandedge)	RSS-210 Issue 8 Annex 2 Section A2.2 (b)	<i>Bandedge of 2310M - 2390M, 2483.M – 2500M</i>	Complies
Radiated Spurious Emissions – Transmit Mode	RSS-210 Issue 8 Annex 2 Section A2.9, RSS-Gen Section 7.2.5.	<i>Radiated emissions requirements as stated in the Standards. Field strength of harmonics: 500 uV/m or 54 dBuV/m at 3m</i>	Complies
Radiated Spurious Emissions – Receive Mode	RSS-210 Issue 8 Annex 2 Section A2.2 (b), ICES-003 Issue 6	<i>Radiated emissions requirements as stated in the Standards.</i>	Complies



## Section II: GENERAL INFORMATION

### 2.1 Product Description

The information provided in this section describes the Equipment Under Test (EUT) and the corresponding Auxiliary Equipment as needed to perform the tests as complete system.

#### Equipment Under Test (EUT) Information

<b>EUT</b>	IEEE 802.15.4 Wireless Communications Module
<b>Functional Description</b>	The I1000 is a power line monitor system consists of an interrogator and sensors operates from 2.406GHz to 2.474GHz in 50kHz frequency steps.
<b>Operational Description</b>	Interrogator is a radar-like frequency scanning device that searches the sensors in operating frequency band. Sensors are passive resonator devices that reflect the signal at its resonant frequency. Interrogator consists of transmitter, receiver, CPU/control board, wireless modem, and power supply consisting of battery, battery charger and filtered DC-DC converter. Interrogator operates from 2.406GHz to 2.474GHz in 50kHz frequency step.
<b>FRN</b>	0025785346
<b>FCC ID</b>	2AJC2I1000
<b>IC Certification Number</b>	
<b>Manufacturer</b>	Torino Power Systems Ltd.
<b>Model No.</b>	Interrogator I1000
<b>Serial No.</b>	ENG001
<b>Transmitter Type</b>	Zigbee
<b>Frequency Band</b>	2406-2474 MHz
<b>Transmit Power</b>	-1.43 dBm (EIRP)
<b>Modulation</b>	PWM
<b>Number of Channels</b>	6800
<b>Test Channels</b>	2406, 2440 and 2474MHz
<b>Antenna Description</b>	Mini Directional Antenna VPOL MD24-12 2.4GHz 12dBi
<b>Antenna Gain</b>	12 dBi
<b>Voltage Ratings</b>	Battery powered
<b>Software and Firmware</b>	Internal test mode
<b>Received Date</b>	July 15, 2016
<b>Received by</b>	Aman Jathaul
<b>Sample Log</b>	QAI Product Control Log (QM 1305 - Sample Inventory)

#### Auxiliary Equipment Information

Equipment	Manufacturer	Product Description	Additional	Model No.



## 2.2 Environmental Conditions

The equipment under test was operated and tested under the following environmental conditions:

Parameter	Conditions
Location	Indoors
Temperature	22-28°C
Relative Humidity	39.7 - 54.4%

## 2.3 Measurement Uncertainty

Parameter	Uncertainty
Radiated Emissions, 30MHz-1GHz	± 2.40 dB
Radiated Emissions, 1GHz-40GHz	± 2.48 dB
Radio Frequency	±1,5 x 10 <sup>-5</sup> MHz
Total RF Power Conducted	±1.36 dB
Spurious Emissions, Conducted	±1.36 dB
RF Power Density, Conducted	±1.36 dB
Temperature	±1°C
Humidity	±5 %
DC and low frequency voltages	±3 %

## 2.4 Worst Test Case

Worst-case orientation was determined during the preliminary testing. The final radiated emissions were performed in the worst-case orientation.

## 2.5 Sample Calculations of Emissions Data

Radiated and conducted emissions were performed using EMC32 software developed by Rohde & Schwarz. Transducer factors such as Antenna Factors, cable losses and amplifier gains are stored in the test templates and used to perform emissions measurements. Data is generated from the EMC32 consisting of product details, emission plots and final data tables as shown below.

Frequency (MHz)	Quasi-Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
42.663900	33.0	1000.000	120.000	100.0	H	70.0	13.2	7.5	40.5

Quasi Peak reading shown in the table above is already corrected by the software using correction factor shown in column “Corr.” The correction factor listed under “Corr.” table calculated as:

$$\text{Corr. (dB)} = \text{Antenna factor} + \text{Cable loss}$$

Or

$$\text{Corr. (dB)} = \text{Antenna factor} + \text{Cable Loss} - \text{Amp gain (if pre-amplifier was used)}$$

The final Quasi peak reading shown in the data is calculated by the software using following equation:

$$\text{Corrected Quasi Peak (dBµV/m)} = \text{Raw Quasi Peak Reading} + \text{Antenna factor} + \text{Cable loss}$$

To obtain the final Quasi-Peak or Average reading during power line conducted emissions, transducer factors are included in the final measurement as shown below.

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	44.3	1000.000	9.000	0.6	21.7	66.0

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	27.2	1000.000	9.000	0.6	28.8	56.0

Quasi Peak or Average reading shown in above table is already corrected by the software using the correction factor shown in column “Corr.” The correction factor listed under “Corr.” table calculated as:

$$\text{Corr. (dB)} = \text{Antenna factor} + \text{Cable loss}$$

The final Quasi peak or Average reading shown in the data is calculated by the software using following equation:

$$\text{Corr. Quasi Peak/Average Reading (dBµV)} = \text{Raw Quasi Peak/Average Reading} + \text{Antenna factor} + \text{Cable loss}$$

The allowable margin from the limits, as per the standards, were calculated for both radiated and conducted emissions:

$$\text{Margin (dB)} = \text{Limit} - \text{Quasi-Peak or Average reading}$$

## 2.6 Test Equipment List

The tables below contain all the equipment used by QAI Laboratories in conducting all tests on the Equipment Under Test (EUT) as per Section 1.3. The calibration interval for test equipment is 3 years or less as specified by QAI Quality Manual.

### Emissions Test Equipment

Manufacturer	Model	Description	Serial No.	Calibration Due Date
Sunol Sciences	SM46C	Turntable	051204-2	N/A
Sunol Sciences	TWR95	Mast	TREML0001	N/A
Sunol Sciences	JB3	Biconilog Antenna 30M – 3G Hz	A120106	24-Sep-2017
ETS Lindgren	2165	Turntable	00043677	N/A
ETS Lindgren	2125	Mast	00077487	N/A
Rohde & Schwarz	ESU40	EMI Receiver	100011	20-Nov-2017
Fischer	FCC-LISN-50-25-2-08	LISN 150k - 30M Hz	2041	19-Nov-2018
ETS Lindgren	S201	3-meter Semi-Anechoic Chamber	1030	N/A
ETS Lindgren	3117	Horn Antenna 1G - 18G Hz	00075944	29-Aug-2016
AH Systems	PAM118	Amplifier 10K - 18G Hz	189	Conditional Use
California Instruments	PACS-1	Harmonics and flicker analyzer	72569	18 July 2018
California Instruments	OMNI 1-18 I	Programmable Impedance Flicker test	N/A	18 July 2018
California Instruments	3001ix	Power supply	HK52117	18 July 2018
Mini Circuit	8400+	High Pass Filter	N/A	N/A
Mini Circuit	2700A+	High Pass Filter	N/A	N/A
EMCO	3160-09	Standard gain Horn Antenna	9701-1071	30 August 2017
EMCO	6502	Loop Antenna	2178	21 August 2017
A.H. Systems Inc.	PAM-1840VH	Pre-Amp	152	14 June 2016

### Measurement Software List

Manufacturer	Model	Version	Description
Rhode & Schwarz	EMC 32	6.20.0	Emissions Pre-scan Test Software

## Section III: REQUIREMENTS FOR THE US MARKET (FCC) & THE CANADIAN MARKET (IC) Exigences pour le Marché Canadien

### 3.1 Antenna Requirements

The purpose of this requirement is to ensure no other antenna, except for that provided by the responsible party, shall be used with the Equipment-Under-Test (EUT) as defined in FCC 47 CFR Part 15.203 & RSS-Gen Section 7.1.2:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. ... Further, this requirement **does not apply to intentional radiators that must be professionally installed**, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with § 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

*The EUT is professionally installed. The permanently attached antenna requirement does not apply.*

### 3.2 RF Peak Power Output

This test ensures for systems operating in the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz does not exceed the maximum conducted output power as per the standards, FCC Part 15.249 (a), RSS 210 Issue 8.

The test was conducted as defined by the standards above with the antenna port of the EUT directly connected to a spectrum analyzer. The field strength of fundamental shall not exceed 50mV/m at 3m or 94dBuV/m, this corresponds to a limit of -3.38 dBm EIRP.

*The EUT was tested without modification and complies with the standards on July 16, 2016*

*Please refer to Appendix A of this report for the RF Peak Power Output Data.*

### 3.3 Occupied Bandwidth

This test ensures the bandwidth of the Equipment-Under-Test (EUT) is recorded as per the standards, FCC Part 2.1049.

The test was conducted as defined by the standards above with the antenna port of the EUT directly connected to a spectrum analyzer.

*The EUT was tested without modification and complies with the standards on July 16, 2016*

*Refer to Appendix B of this report for the Occupied Bandwidth data.*



### 3.3 Peak to Average Power Ratio

This test ensures the peak to average power ratio of the Equipment-Under-Test (EUT) is within the limits as per the standards, FCC Part 15.247 (e).

The test was conducted as defined by the standards above with the antenna port of the EUT directly connected to the spectrum analyzer. The maximum peak to average power ratio of the EUT, as per the standards, shall be 20dB.

*The EUT was tested without modification and complies with the standards on July 16, 2016*

*Refer to Appendix C of this report for the Peak to Average Power Ratio data.*

### 3.5 Out-of-Band Emissions (Band Edge)

The purpose of this test is to make certain that Out-of-Band Emissions (Band Edge) from the Equipment Under Test (EUT) does not exceed the limits as per the standards, FCC Part 15.249 (d), RSS 210 Issue 8.

The test was conducted as defined by the standards above.

*The EUT was tested without modification and complies with the standards on July 16, 2016.*

*Refer to Appendix D of this report for the Out-of-Band Emissions (Band Edge) data.*

### 3.6 Conducted Spurious Emissions

This test ensures conducted spurious emissions from the Equipment Under Test (EUT) does not exceed the limits as per the standards, FCC Part 15.247 (d), FCC Part 15.207, FCC Part 15.209 (a), RSS 210 Issue 8.

The test was conducted as defined by the standards above. Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in § 15.209, whichever is the lesser attenuation. As specified in § 15.249(a), field strength of harmonics shall be less than 500 uV/m (54 dBuV/m) at 3m or 40dBc. Therefore harmonics and conducted spurious emissions shall be attenuated by 40 dB.

*The EUT was tested without modification and complies to the standards on July 16, 2016.*

*Refer to Appendix F of this report for the Conducted Spurious Emissions data.*

### 3.7 AC Mains Conducted Emissions

This test is not required as the EUT is battery powered.

### 3.8 Radiated Spurious Emissions – Transmit Mode

The purpose of this test is to make certain that the radiated spurious emissions from the Equipment Under Test (EUT) while in transmit mode does not exceed the limits as per the standards, FCC Part 15.249 (d), FCC Part 15.209 (a), FCC Part 15.205, IC RSS-247 Issue 1, RSS-Gen Section 7.2.5.

The test was conducted as defined by the standards above. The EUT was positioned in the center of the turntable in the SAC. The transmitter was set for continuous transmission. The lowest, middle and highest channels in the 2400-2483.5 MHz band were measured for all radiated emissions 30M - 25G Hz.

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general field strength limits listed in RSS-Gen, whichever is less stringent. In measuring unwanted emissions, the spectrum shall be investigated from 30 MHz or the lowest radio frequency signal generated in the equipment, whichever is lower, without going below 9 kHz, up to at least the frequency if the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower. Unwanted emissions falling into restricted bands of shall comply with the limits specified below.

Frequency (MHz)	Field Strength	
	uV/m @ 3m	dBµV/m at 3m
30 – 88	100	40.0
88 - 216	150	43.5
216 - 960	200	46.0
960 - 1000	500	54.0

# **FCC PART 15.205 – Restricted Bands of Operation:**

- (a) Except as shown in paragraph (d) of FCC Part 15.205, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
1 0.495-0.505*	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(2)
13.36-13.41			

**Note 1:** \*FCC-specific

**Note 2:** Canada-specific frequency ranges - 3.020-3.026, 5.677-5.683, 121.94-123.0, 149.9-150.05, 162.0125-167.17, 167.72-173.2, 1300-1427, 2483.5-2500, 3500-3600,

**Note 3:** (2) Above 38,6 GHz

- (b) Except as provided in paragraphs (d) and (e) FCC PART 15.205, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in § 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in § 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in § 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in § 15.35 apply to these measurements.

# RESTRICTED FREQUENCY BANDS (RSS-GEN)

MHz
0.090-0.110
2.1735-2.1905
3.020-3.026
4.125-4.128
4.17725-4.17775
4.20725-4.20775
5.677-5.683
6.215-6.218
6.26775-6.26825
6.31175-6.31225
8.291-8.294
8.362-8.366
8.37625-8.38675
8.41425-8.41475
12.29-12.293
12.51975-12.52025
12.57675-12.57725
13.36-13.41
16.42-16.423
16.69475-16.69525
16.80425-16.80475
25.5-25.67
37.5-38.25
73-74.6
74.8-75.2
108-138
156.52475-156.52525
156.7-156.9

MHz
240-285
322-335.4
399.9-410
608-614
960-1427
1435-1626.5
1645.5-1646.5
1660-1710
1718.8-1722.2
2200-2300
2310-2390
2655-2900
3260-3267
3332-3339
3345.8-3358
3500-4400
4500-5150
5350-5460
7250-7750
8025-8500

GHz
9.0-9.2
9.3-9.5
10.6-12.7
13.25-13.4
14.47-14.5
15.35-16.2
17.7-21.4
22.01-23.12
23.6-24.0
31.2-31.8
36.43-36.5
Above 38.6

**Note:** Certain frequency bands listed in Table 3 and in bands above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in the 200- and 300- series RSSs, such as RSS-210 and RSS-310, which contain the requirements that apply to licence-exempt radio apparatus.

Measurements were made by using a spectrum analyzer, receiver, 200Hz RBW average detector for the frequency range 9-150KHz, 9kHz RBW average detector for the Frequency range 150kHz to 30MHz, 120kHz RBW quasi-peak detector using the appropriate antennas, amplifiers and filters. The measurement results are obtained as described below:

$$E \text{ [dB}\mu\text{V/m]} = \text{Un-Corrected Value} + \text{ATOT}$$

Where ATOT = total correction factor including cable loss, antenna factor and preamplifier gain (ATOT = LCABLES + AF - AMP).

*The EUT was tested without modification and complies to the standards on July 15, 2016.*

*Refer to Appendix G of this report for the Radiated Spurious Emissions – Transmit Mode data.*

### 3.9 Radiated Spurious Emissions – Receive Mode

This test ensures the radiated spurious emissions by the Equipment Under Test (EUT) while in receive mode does not exceed the limits as per the standards, FCC Part 15.249 (d), FCC Part 15.209 (a), RSS-247 Issue 1, & ICES-003 Issue 6.

The test was conducted as defined by the standards above. The EUT was positioned in the center of the turntable in the SAC. The transmitter was set for continuous transmission. The lowest, middle and highest channels in the 2400-2483.5 MHz band were measured for all radiated emissions 30M - 25G Hz.

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

In measuring unwanted emissions, the spectrum shall be investigated from 30 MHz or the lowest radio frequency signal generated in the equipment, whichever is lower, without going below 9 kHz, up to at least the frequency ... if the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower. Unwanted emissions falling into restricted bands of shall comply with the limits specified below.

Frequency (MHz)	Field Strength	
	uV/m @ 3-m	Calculated dBµV/m at 3m
30 – 88	100	40.0
88 - 216	150	43.5
216 - 960	200	46.0
960 - 1000	500	54.0

Measurements were made by using a spectrum analyzer, receiver, 200Hz RBW average detector for the frequency range 9-150KHz, 9kHz RBW average detector for the Frequency range 150kHz to 30MHz, 120kHz RBW quasi-peak detector using the appropriate antennas, amplifiers and filters. The measurement results are obtained as described below:

$$E \text{ [dBµV/m]} = \text{Un-Corrected Value} + \text{ATOT}$$

Where ATOT = total correction factor including cable loss, antenna factor and preamplifier gain (ATOT = LCABLES + AF - AMP).

*The EUT was tested without modification and complies with the standards on July 15, 2016.*

*Refer to Appendix H of this report for the Radiated Spurious Emissions – Receive Mode data.*

## Appendix A: RF PEAK POWER OUTPUT DATA

**Table 1: Field strength of fundamental**

Channel	Frequency (MHz)	EIRP (dBuV/m) @3m	Antenna Gain (dBi)	Limit (dBm)	Margin (dB)
Low	2406	93.2	12	94	0.8
Middle	2440	93.8	12	94	0.2
High	2474	92.7	12	94	1.3

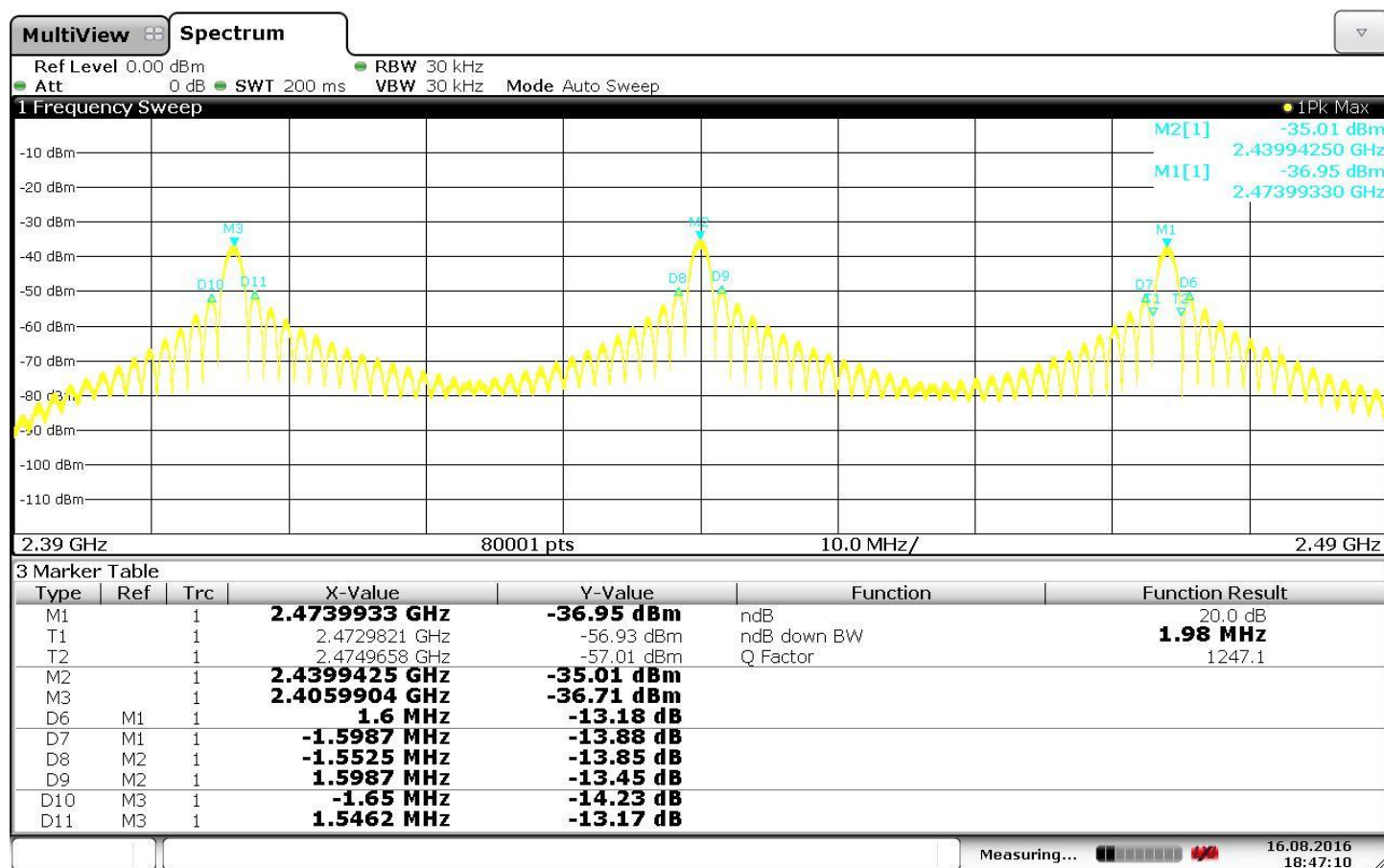
The EUT antenna gain as stated by the manufacturer is 12dBi. The peak output power of 93.8 dBuV/m @3m corresponds to an ERP of -3.58 dBm (0.4388 mW) or EIRP of -1.43 dBm (0.7196 mW)



## Appendix B: OCCUPIED BANDWIDTH DATA

Table 2: 20dB/6dB Occupied Bandwidth

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	20dB Bandwidth (MHz)
Low	2406	1.05	1.98
Mid	2440	1.10	1.99
High	2474	1.09	1.98



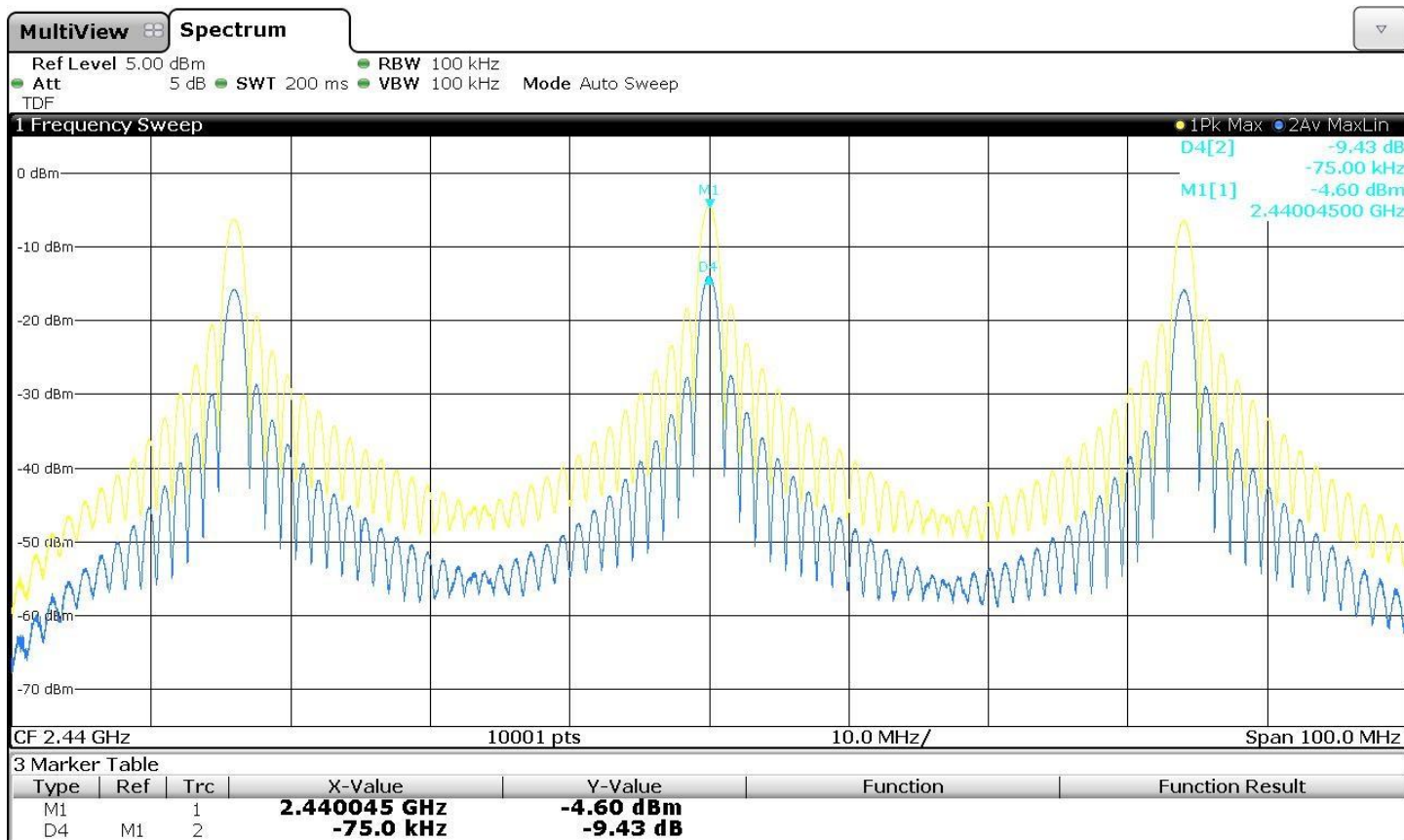
18:47:11 16.08.2016

Plot 1: Occupied Bandwidth (Typical)

## Appendix C: PEAK TO AVERAGE POWER RATIO

Table 3: Peak to Average Power Ratio Data

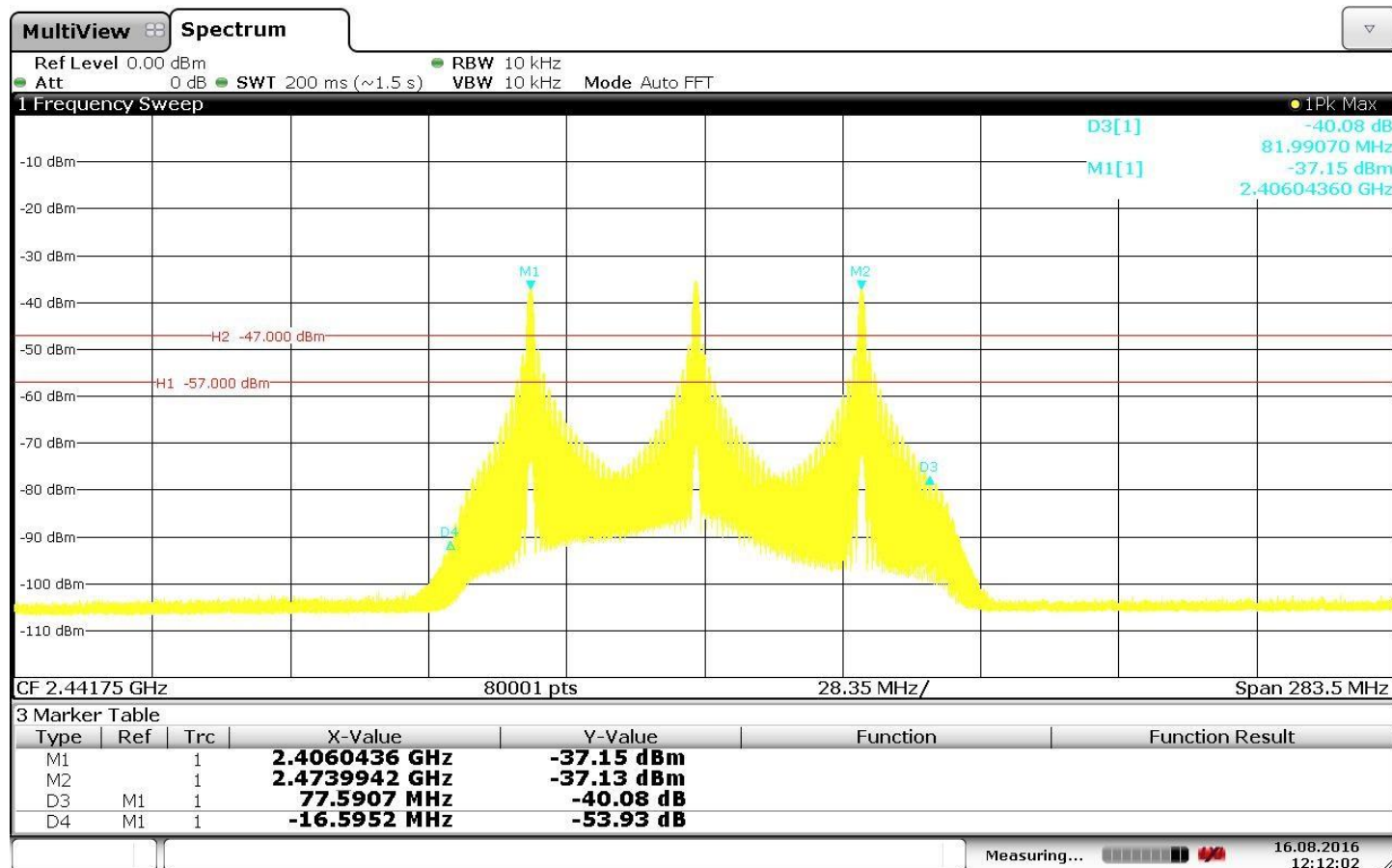
Frequency (MHz)	Peak/Average (dBm)	Limit (dB)	Margin (dB)
2440	9.4	20	11.6



## Appendix D: OUT-OF-BAND EMISSIONS (BANDEDGE)

Table 4: Out-of-Band Emissions Data

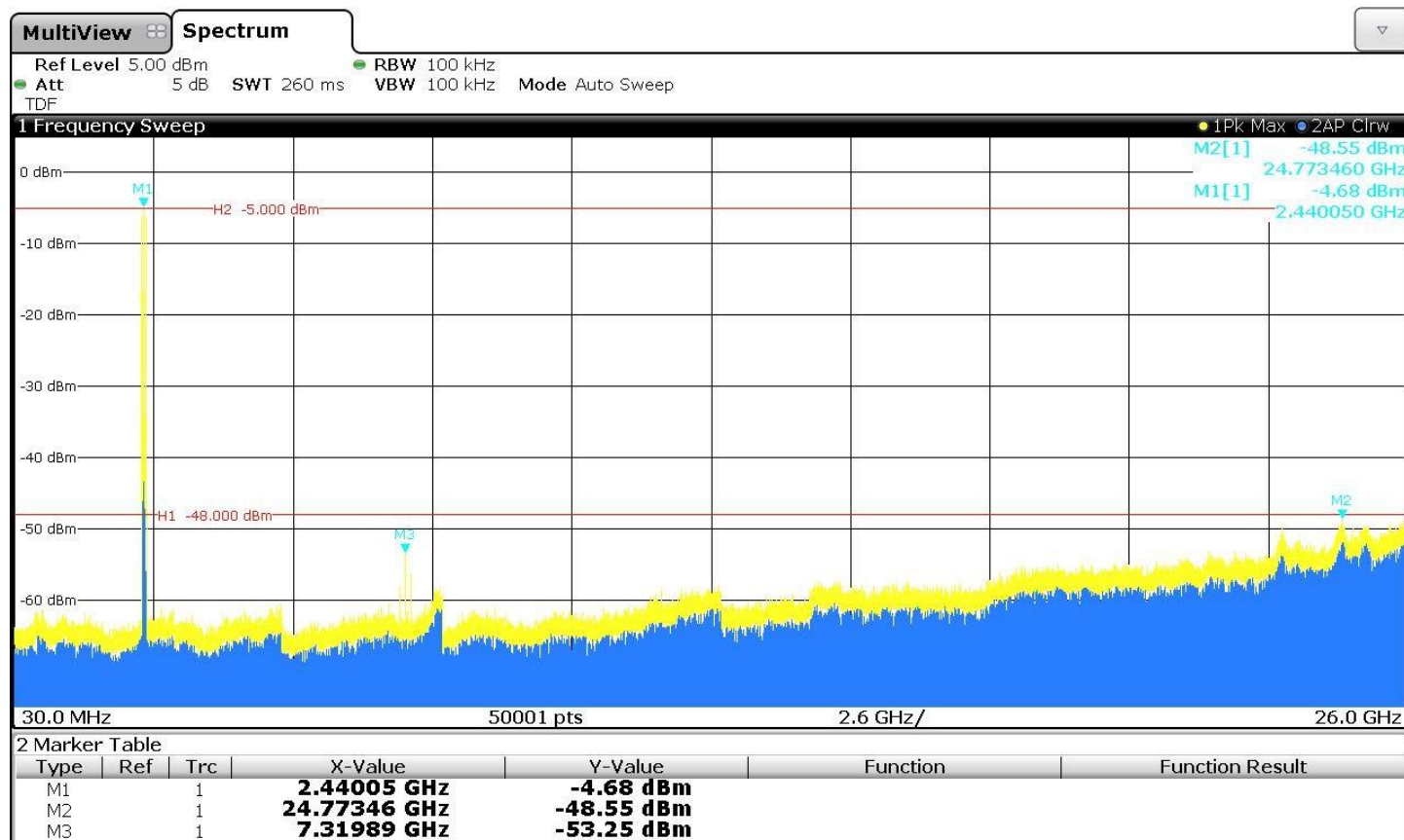
Frequency (MHz)	Out-of-Band Emissions (dBc)	Minimum Limit (dBc)	Margin (dB)
2400	53.9	40	13.9
2483.5	-40.1	40	0.1



12:12:03 16.08.2016

Plot 2: Out-of-Band Emissions (Bandedge)

## Appendix F: CONDUCTED SPURIOUS EMISSIONS



**Plot 3: Conducted Spurious Emissions 30M - 25G Hz – FLO/FMID/FHI**

Plot shown is for reference only. Data was measured at appropriate span and RBW for discrete measurements. Correction factor for cable loss and antenna factor are included in internal transducer factor used in sweep.

**Table 5: Conducted Spurious Emissions 30M - 25G Hz – FLO/FMID/FHI**

Frequency (MHz)	Measured Peak (dBm)	Attenuation (dBc)	Min Attenuation (dB)	Margin (dB)
2440	-4.7	-	-	-
7319	-48.7	44.0	40	4.0
24773	-53.8	49.1	40	9.1

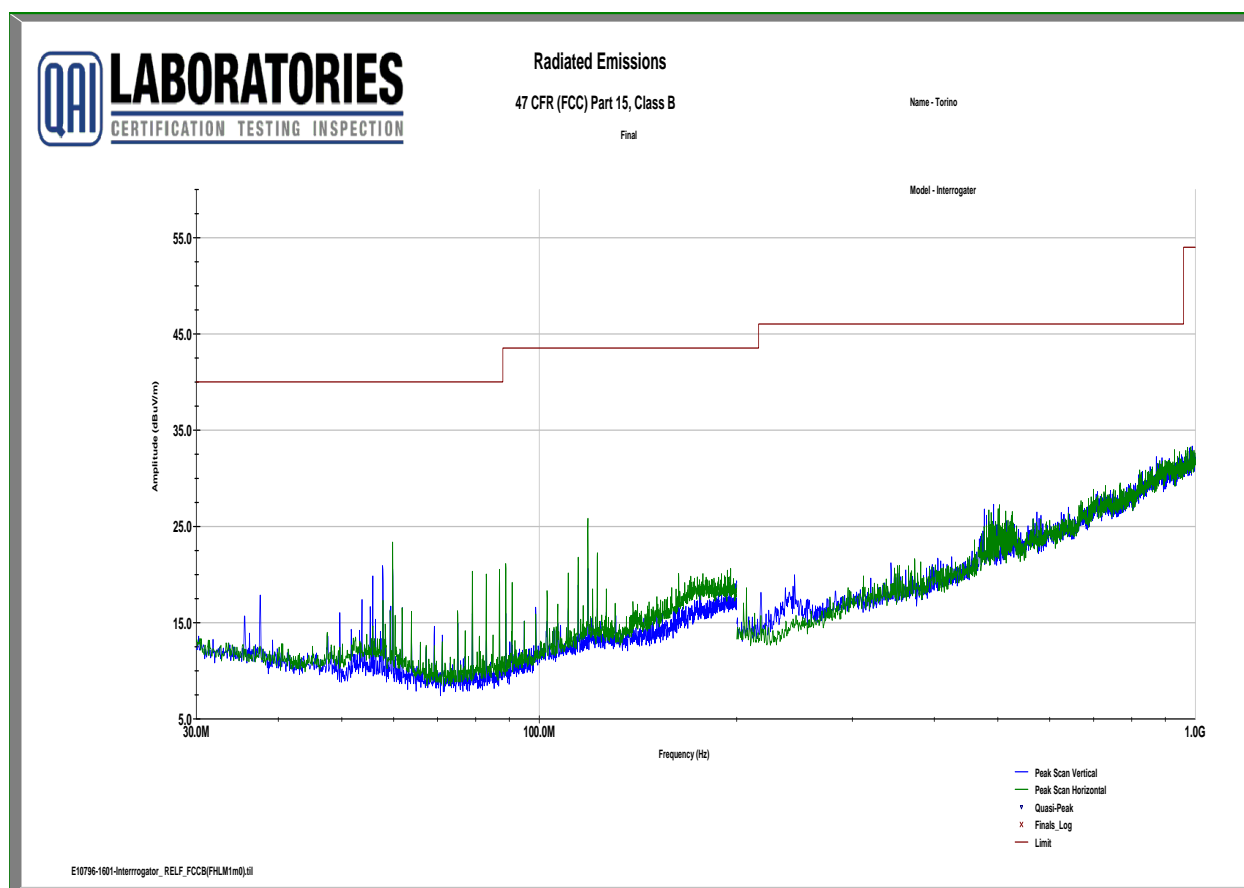
## Appendix G: RADIATED SPURIOUS EMISSIONS – TRANSMIT MODE

**Table 6: Radiated Spurious Emissions 30M - 1G Hz – FLO/FMID/FHI**

Frequency (MHz)	Measured Peak (dBuV/m)	Polarization	Correction (dB)	Corrected Peak (dBuV/m)	Peak Limit (dB)	Margin (dB)
59.77	45.1	VERT	-15.4	29.7	40	10.3
79.04	33.8	VERT	-15.3	18.5	40	21.5
86.69	32.5	VERT	-15.0	17.5	40	22.5
114.63	39.4	VERT	-12.9	26.5	43.5	17.0
118.62	40.2	VERT	-12.0	28.2	43.5	15.3
122.60	38.3	VERT	-11.7	26.6	43.5	16.9

Notes: 1. No other emissions found within 20dB of limit.

2. Data collected is peak and compared to average limit unless noted.



**Plot 4: Radiated Spurious Emissions 30M - 1G Hz – Transmit Mode**

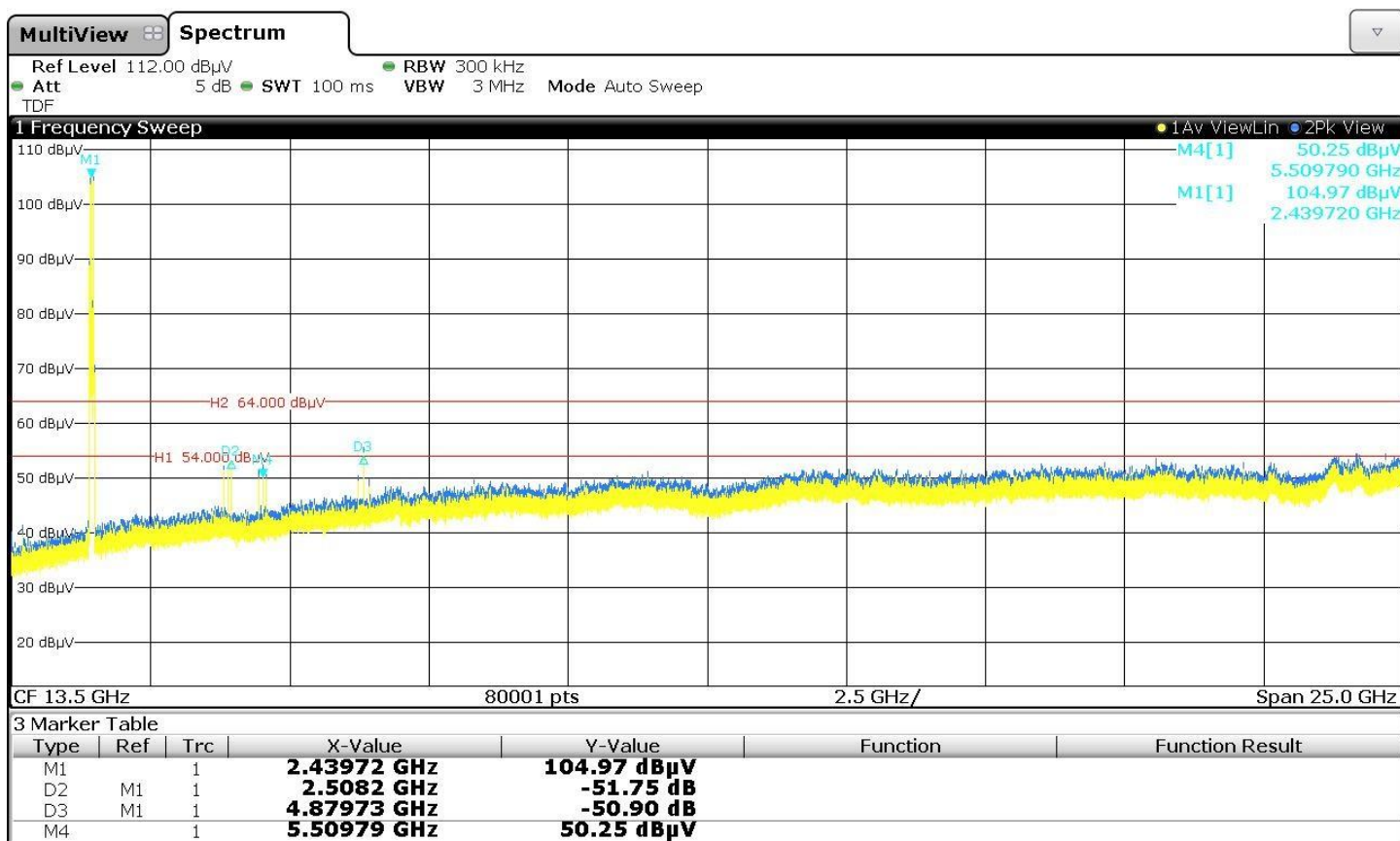
**Table 7: Radiated Harmonics Spurious Emissions 1G - 25G Hz – FLO/FMID/FHI**

Frequency/ Harmonic (MHz)	Measured Peak (dBm)	Attenuation (dBc)	Min Attenuation (dB)	Margin (dB)
2440	105.0	-	-	-
2nd		51.7	40	11.7
3rd		50.9	40	9.1

**Table 8: Radiated Spurious Emissions 1G - 25G Hz – FLO/FMID/FHI**

Frequency (MHz)	Measured Peak (dBuV/m)	Polarization	Correction (dB)	Distance Correction (dB)	Corrected Peak (dBuV/m)	Ave Limit (dB)	Ave Margin (dB)
5510	50.6	HORZ	0	-9.5	41.1	54	12.9

Notes: 1. Correction factor for cable loss and antenna factor are included in internal transducer factor used in sweep.  
2. Data collected is peak and compared to average limit unless noted.



**Plot 5: Radiated Spurious Emissions 1G – 25G Hz (FHI/FMI/FLO)**

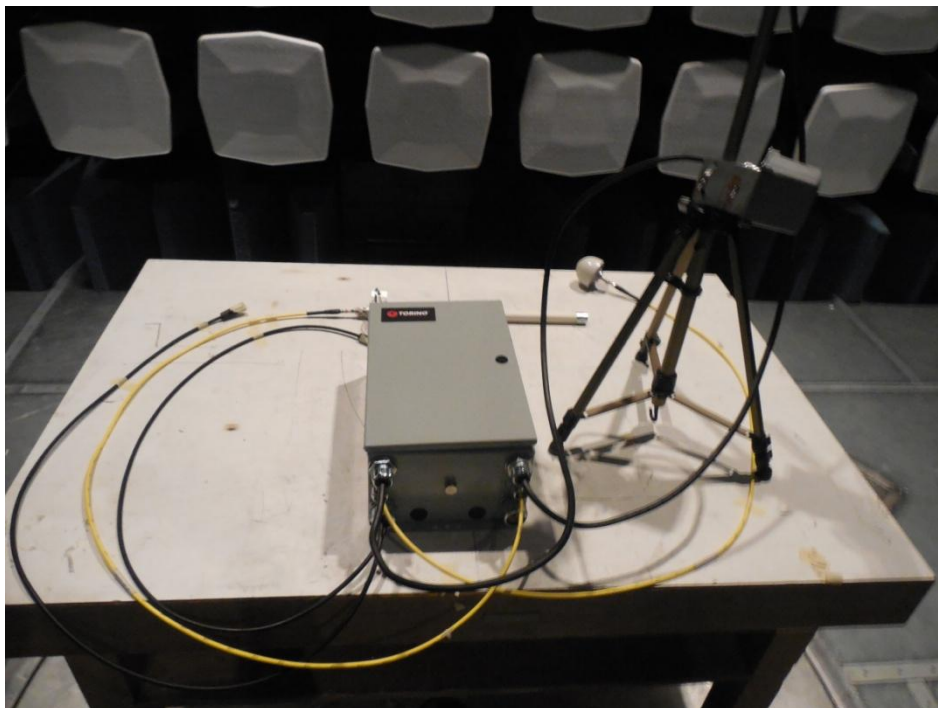
Plot shown is for reference only, at 1m measurement distance. No emissions other than those listed were found above the noise floor. Correction factor for cable loss and antenna factor are included in internal transducer factor used in sweep.



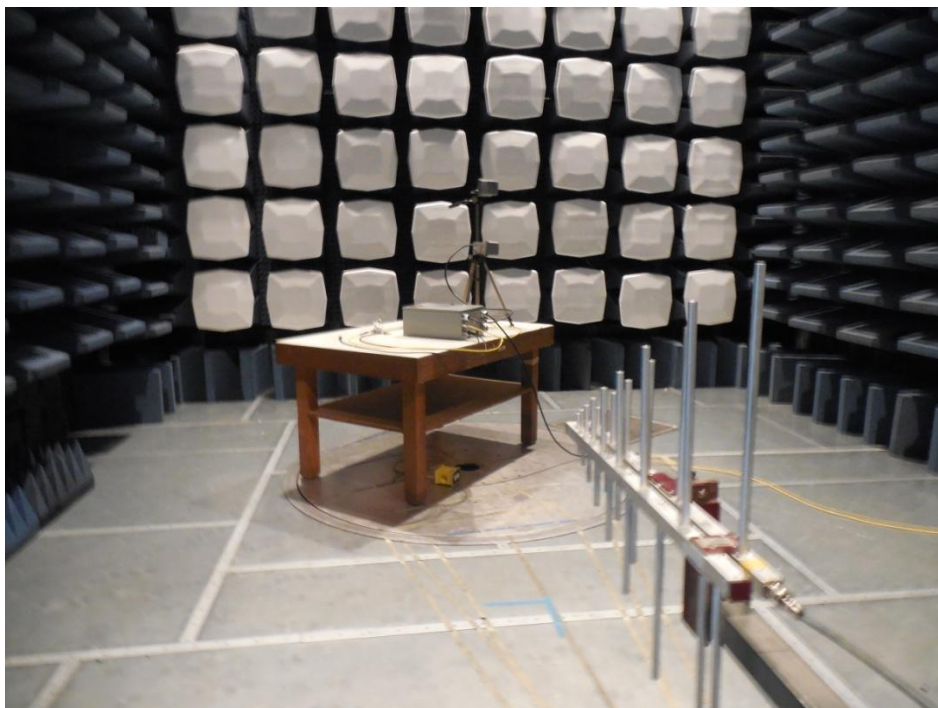
## **Appendix H: RADIATED SPURIOUS EMISSIONS – RECEIVE MODE**

Emission data in transmit mode 15.209 is considered worst-case and sufficient to demonstrate compliance to 15.109, receive mode (digital device).

## Appendix I: TEST SETUP PICTURES



**Figure 1: Radiated Emissions Test Setup at SAC**



**Figure 2: Radiated Emissions Test Setup at SAC**

## Appendix K: ABBREVIATIONS

Abbreviation	Definition
AC	Alternating Current
CE	European Conformity
CISPR	Comité International Spécial des Perturbations Radioélectriques
DC	Direct Current
EFT	Electrical Fast Transient
E.I.R.P.	Equivalent Isotropically Radiated Power
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
ESD	ElectroStatic Discharge
EUT	Equipment Under Test
FCC	Federal Communications Commission
IC	Industry Canada
ICES	Interference-Causing Equipment Standard
LISN	Line Impedance Stabilizing Network
OATS	Open Area Test Site
RF	Radio Frequency
RMS	Root-Mean-Square
SAC	Semi-Anechoic Chamber

[ END OF REPORT ]