Certification Test Report

FCC ID: 2AJ3810233
IC: 22055-10233

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

Report Number: 16-0445.W06.1C

Manufacturer: Yardarm Technologies, Inc.
Model: BA10233

Test Begin Date: September 28, 2016
Test End Date: October 5, 2016

Report Issue Date: November 28, 2018

FOR THE SCOPE OF ACCREDITATION UNDER Certificate Number: AT-2021

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

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This report contains 20 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 Certification.

1.2 Product Description

Product Name: Firearm Sensor

The BA10233 is a Bluetooth Low Energy radio device that senses the insertion and removal of a firearm in a holster. Once a firearm state change has been detected, the Bluetooth Low Energy radio transfers this information to a host device.

Technical Information:

Detail	Description
Frequency Range	2402 – 2480 MHz
Number of Channels	40
Modulation Format	GFSK
Operating Voltage	3.5 Vdc – 4.2 Vdc (Battery) / 5 Vdc (USB)
Antenna Type / Gain	Printed Meandering Trace Antenna / -3dBi gain

Manufacturer Information:
QSR Automations
2301 Stanley Gault Pkwy
Louisville, KY 40223

EUT Serial Numbers: ACS #1 (Radiated Emissions / Power line Conducted Emissions)
ACS #2 (RF Conducted)

Test Sample Condition: The test samples were provided in good working order with no visible defects.

1.3 Test Methodology and Considerations

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

For Radiated Emissions, the EUT was programmed to generate a continuously modulated signal on each channel investigated. The EUT was evaluated in three orthogonal orientations. The worst case orientation was Z-orientation for spurious emissions and X-orientation for band edges. See test setup photos for more information.

For RF Conducted Emissions, the EUT was programmed to generate a continuously modulated signal on each channel investigated. The EUT was modified with an SMA connector to facilitate connection to the test equipment.

The EUT is a battery powered device with provisions for connection to the public utilities for charging the internal battery. Power line conducted emissions was performed with the radio connected to a laptop and charging via a USB cable.

Power setting during test: +3 dBm

2 TEST FACILITIES

2.1 Location

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

TUV SUD America
5015 B.U. Bowman Drive
Buford, GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598

2.2 Laboratory Accreditations/Recognitions/Certifications

TUV SUD America is accredited to ISO/IEC 17025 by the ANSI-ASQ National Accreditation Board/ANAB accreditation program, and has been issued certificate number AT-2021 in recognition of this accreditation. Unless otherwise specified, all tests methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

The Semi-Anechoic Chamber Test Site, Open Area Test Site (OATS) and Conducted Emissions Site 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 Registration Number: 391271
ISED Canada Lab Code: IC 23597
VCCI Member Number: 1831

- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

2.3 Radiated Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

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 150cm in diameter and is located 160cm 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 table 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 chases from the turntable to the pit that allow 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.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

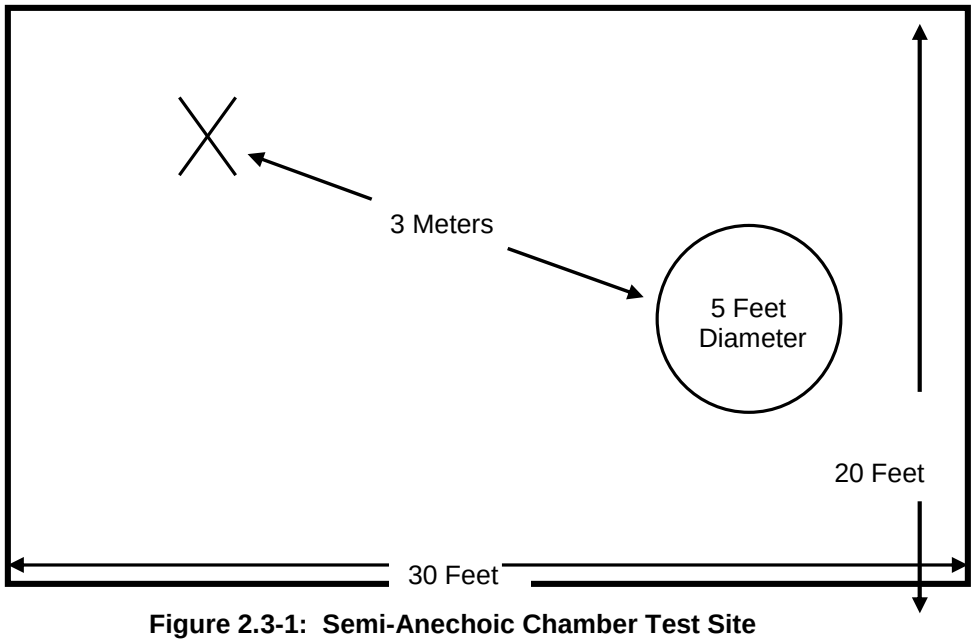

Figure 2.3-1: Semi-Anechoic Chamber Test Site

2.3.2 Open Area Tests Site (OATS)

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' 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.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow 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 pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane; however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 2.3-2 below:

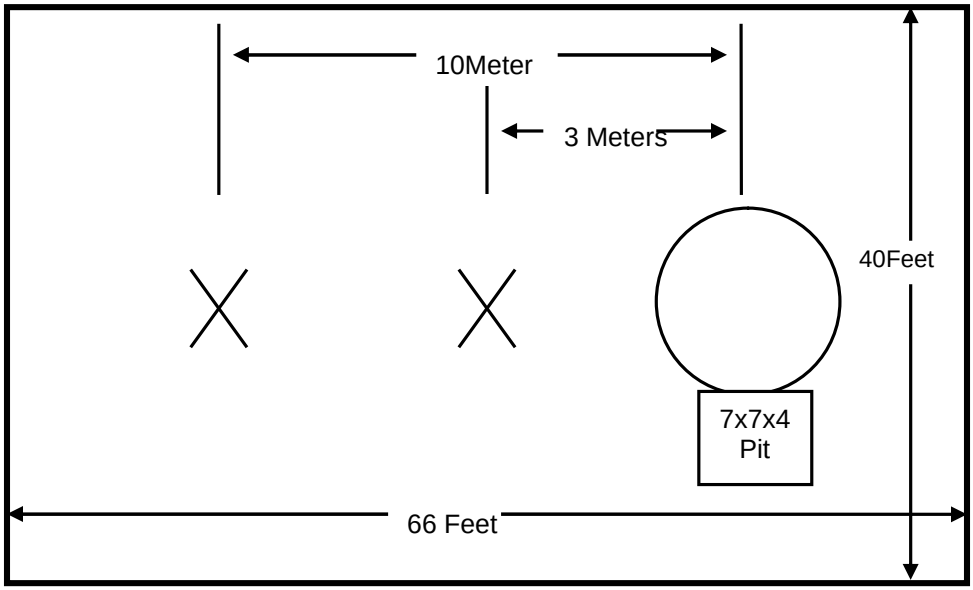

Figure 2.3-2: Open Area Test Site

2.4 Conducted Emissions Test Site Description

The AC mains conducted EMI site is located in the main EMC lab. It consists of an 8' x 8' solid aluminum horizontal ground reference plane (GRP) bonded every 3" to an 8' X 8' vertical ground plane.

The site is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

A diagram of the room is shown below in figure 4.1.3-1:

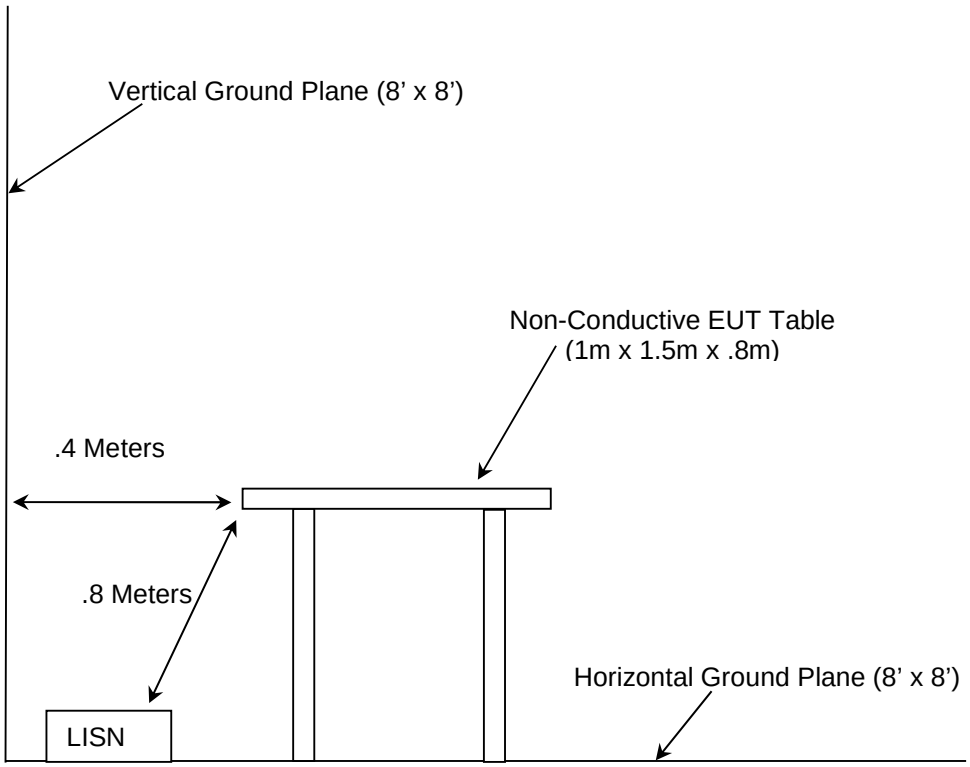

Figure 2.4-1: AC Mains Conducted EMI Site

3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.4-2014: American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40GHz
- 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, 2018
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2018
- FCC KDB 558074 D01 DTS Meas Guidance v04 - Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247, April 8, 2017.
- 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, Feb 2017
- ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 5, April 2018.

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

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
30	Spectrum Technologies	DRH-0118	Antennas	970102	4/30/2015	4/30/2017
40	EMCO	3104	Antennas	3211	2/10/2015	2/10/2017
73	Agilent	8447D	Amplifiers	2727A05624	7/21/2016	7/21/2017
167	ACS	Chamber EMI Cable Set	Cable Set	167	10/20/2015	10/20/2016
267	Agilent	N1911A	Meters	MY45100129	8/24/2015	8/24/2017
268	Agilent	N1921A	Sensors	MY45240184	8/13/2015	8/13/2017
324	ACS	Belden	Cables	8214	5/2/2016	5/2/2017
334	Rohde&Schwarz	3160-09	Antennas	49404	11/4/2010	NCR
338	Hewlett Packard	8449B	Amplifiers	3008A01111	8/21/2015	8/21/2017
340	Aeroflex/Weinschel	AS-20	Attenuators	7136	7/12/2016	7/12/2017
345	Suhner Sucoflex	102A	Cables	1077/2A	7/12/2016	7/12/2017
412	Electro Metrics	LPA-25	Antennas	1241	8/8/2016	8/8/2018
422	Florida RF	SMS-200AW-72.0-SMR	Cables	805	10/30/2015	10/30/2016
432	Microwave Circuits	H3G020G4	Filters	264066	5/13/2016	5/13/2017
616	Florida RF Cables	SMRE-200W-12.0-SMRE	Cables	N/A	9/2/2016	9/2/2017
622	Rohde & Schwarz	FSV40	Analyzers	101338	7/15/2016	7/15/2018
676	Florida RF Labs	SMS-290AW-480.0-SMS	Cables	MFR2Y194	9/3/2015	9/3/2016
3010	Rohde & Schwarz	ENV216	LISN	3010	7/11/2016	7/11/2017
RE112	Rohde & Schwarz	ESIB26	Receiver	836119/012	7/13/2016	7/13/2017
RE619	Rhode & Schwarz	ESU26	Spectrum Analyzers	1302.6005K26 Ser. 100190	11/5/2014	1/5/2017

5 SUPPORT EQUIPMENT

Table 5-1: Support Equipment

Item	Equipment Type	Manufacturer	Model Number	Serial Number
1	Laptop Computer	Dell	Latitude E7250	BBQDF72
2	Laptop Power Supply	Dell	LA65NS2-01	CN-06TM1C-72438-591-6C6E-A04
3	USB Mouse	Kensington	M01131	A1416A00862
4	Headphones	Skullcandy	N/A	N/A

Table 5-2: Cable Description

Item	Cable Type	Length	Shield	Termination
A	USB Cable	200 cm	No	1 – EUT
B	DC Power Cable	250 cm	No	1 – 2
C	AC Power Cable	100 cm	No	2 – AC Mains
D	USB Cable	150 cm	No	1 – 3
E	Stereo Wires	125 cm	No	1 – 4

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

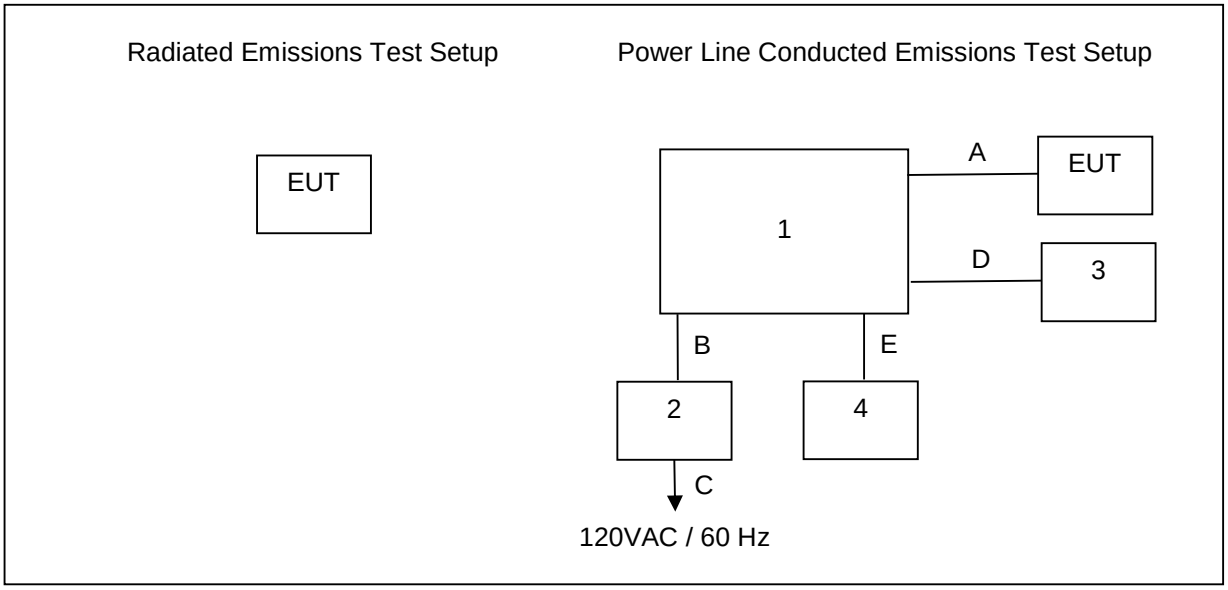

Figure 6-1: Test Setup Block Diagram

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 Printed Meandering Trace antenna with a gain of -3dBi. The antenna is integral to the device and cannot be removed or replaced by the end user, therefore satisfying the requirements of 15.203.

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

7.2.1 Measurement Procedure

ANSI C63.10 section 6 was the guiding document for this evaluation. 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 = Applicable Limit - Corrected Reading

7.2.2 Measurement Results

Performed by: Sean Vick

Table 7.2.2-1: Conducted EMI Results Line 1

Frequency (MHz)	Corrected Reading		Limit (dBuV)	Margin (dB)	Line	Correction (dB)
	Quasi-Peak (dBuV)	Average (dBuV)				
0.174033	---	27.05	54.66	27.61	L1	9.7
0.174033	53.64	---	64.67	11.03	L1	9.7
0.220441	---	29.81	52.59	22.78	L1	9.7
0.220441	52.05	---	62.62	10.57	L1	9.7
0.415030	---	27.01	47.42	20.41	L1	9.7
0.415030	47.29	---	57.44	10.15	L1	9.7
0.507515	---	22.35	46.00	23.65	L1	9.7
0.507515	44.26	---	56.00	11.74	L1	9.7
0.628357	---	24.32	46.00	21.68	L1	9.7
0.628357	38.32	---	56.00	17.68	L1	9.7
1.459519	---	25.92	46.00	20.08	L1	9.8
1.459519	34.66	---	56.00	21.34	L1	9.8

Table 7.2.2-2: Conducted EMI Results Line 2

Frequency (MHz)	Corrected Reading		Limit (dBuV)	Margin (dB)	Line	Correction (dB)
	Quasi-Peak (dBuV)	Average (dBuV)				
0.256112	---	25.38	51.31	25.93	N	9.7
0.256112	47.77	---	61.35	13.58	N	9.7
0.392986	---	26.52	47.85	21.33	N	9.7
0.392986	49.93	---	57.87	7.94	N	9.7
0.647996	---	15.22	46.00	30.78	N	9.7
0.647996	35.06	---	56.00	20.94	N	9.7
15.307314	---	26.59	50.00	23.41	N	10.2
15.307314	34.46	---	60.00	25.54	N	10.2
16.696293	---	26.47	50.00	23.53	N	10.3
16.696293	35.61	---	60.00	24.39	N	10.3
16.714129	---	26.62	50.00	23.38	N	10.3
16.714129	35.55	---	60.00	24.45	N	10.3

7.3 6dB / 99% Bandwidth – FCC 15.247(a)(2), ISED Canada: RSS-247 5.2(1)

7.3.1 Measurement Procedure

The 6dB bandwidth was measured in accordance with the FCC KDB 558074 D01 DTS Meas Guidance. 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 ndB down function of the spectrum analyzer was utilized to determine the 6 dB 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 to 1% to 5% of the occupied bandwidth. The video bandwidth was set to 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 [kHz]	99% Bandwidth [kHz]
2402	690.76	1117.93
2440	688.26	1119.18
2480	709.51	1082.15

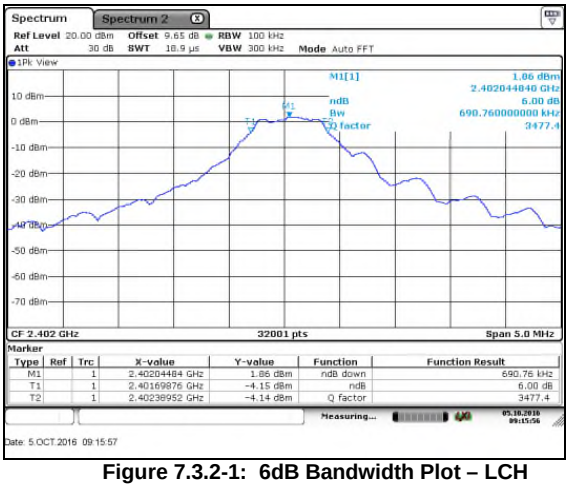

Figure 7.3.2-1: 6dB Bandwidth Plot – LCH

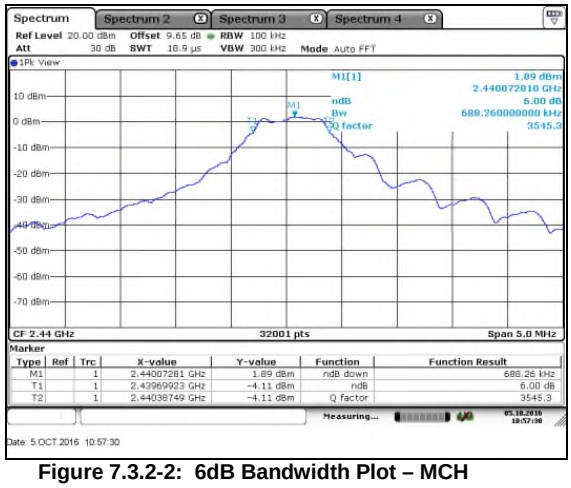

Figure 7.3.2-2: 6dB Bandwidth Plot – MCH

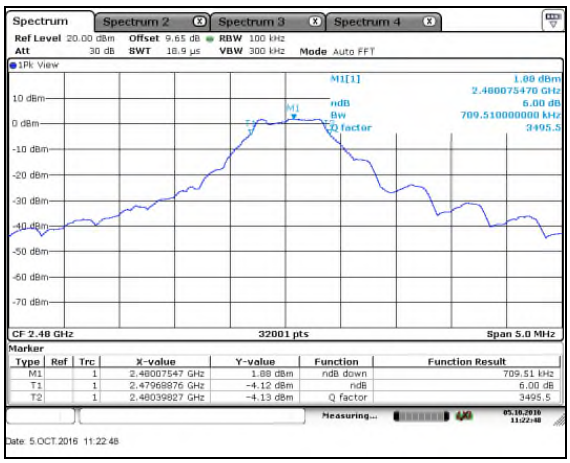

Figure 7.3.2-3: 6dB Bandwidth Plot – HCH

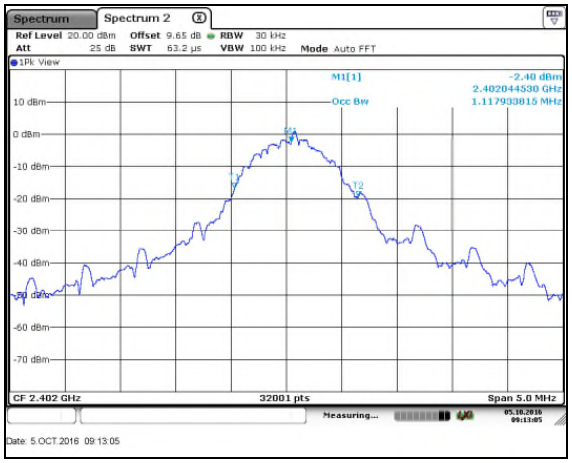

Figure 7.3.2-4: 99% Bandwidth Plot – LCH

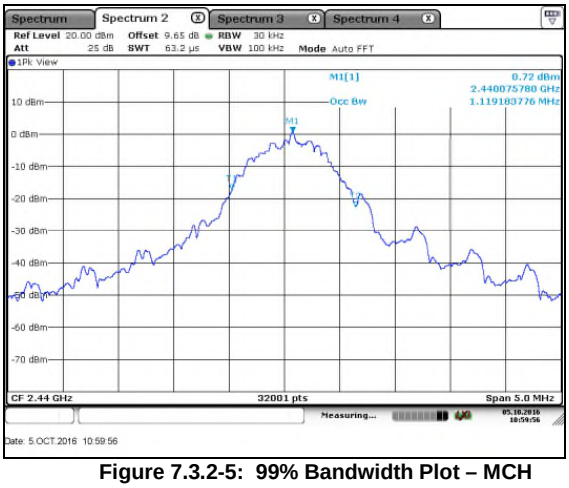

Figure 7.3.2-5: 99% Bandwidth Plot – MCH

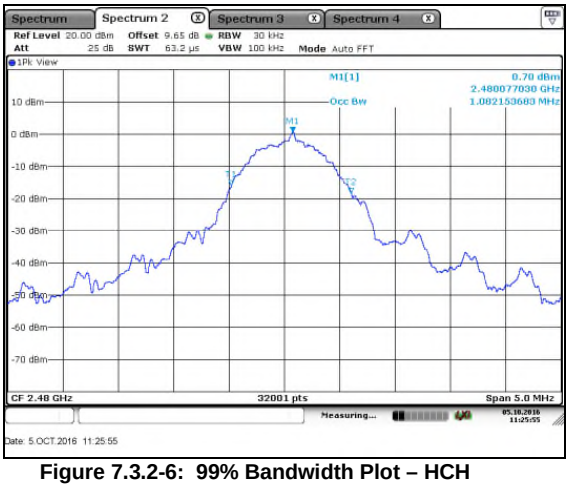

Figure 7.3.2-6: 99% Bandwidth Plot – HCH

7.4 Fundamental Emission Output Power – FCC 15.247(b)(3), ISED Canada: RSS-247 5.4(4)

7.4.1 Measurement Procedure

The maximum peak conducted output power was measured in accordance with FCC KDB 558074 D01 DTS Meas Guidance utilizing the PKPM1 Peak power meter method. The RF output of the equipment under test was directly connected to the input of the power meter applying suitable attenuation. A peak detector was used.

7.4.2 Measurement Results

Performed by: Ryan McGann

Table 7.4.2-1: Maximum Peak Conducted Output Power

Frequency [MHz]	Level [dBm]
2402	1.88
2440	1.97
2480	1.99

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 DTS Meas Guidance. 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. Span was set to 1.5 times the DTS bandwidth. The trace was set to max hold with a peak detector active. The resulting spectrum analyzer peak level was used to determine the reference level with respect to the 20 dBc limit. The spectrum span was then adjusted for the measurement of spurious emissions from 30MHz to 25GHz, 10 times the highest fundamental frequency.

Band-edge compliance was determined using the conducted marker-delta method in which the radio frequency power that is produced by the EUT is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power.

7.5.1.2 Measurement Results

Performed by: Ryan McGann

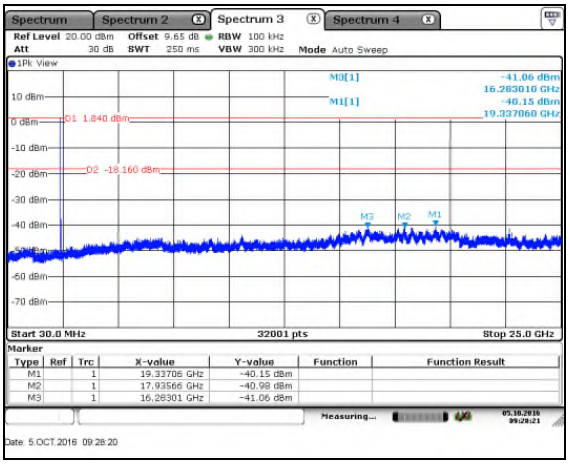

Figure 7.5.1.2-1: 30 MHz – 25 GHz – LCH

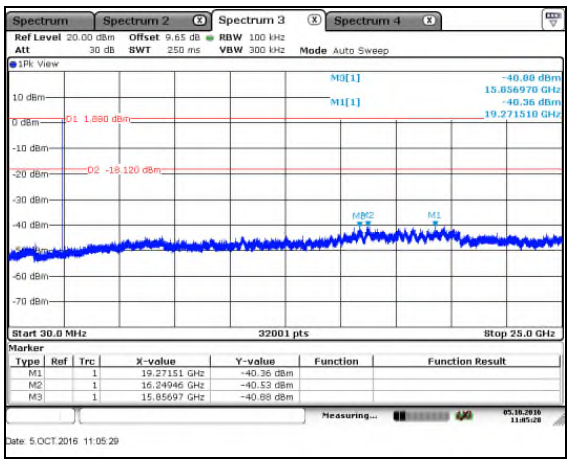

Figure 7.5.1.2-2: 30 MHz – 25 GHz – MCH

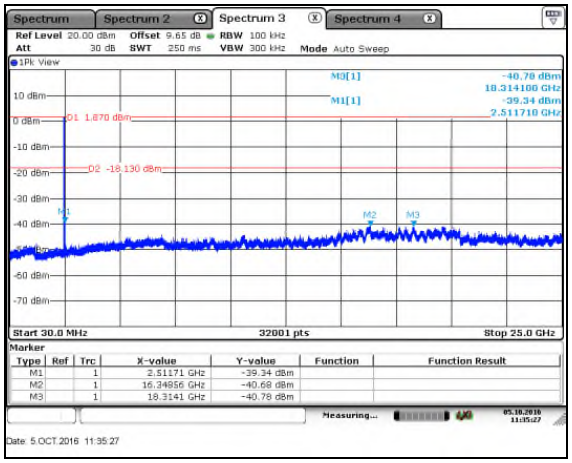

Figure 7.5.1.2-3: 30 MHz – 25 GHz – HCH

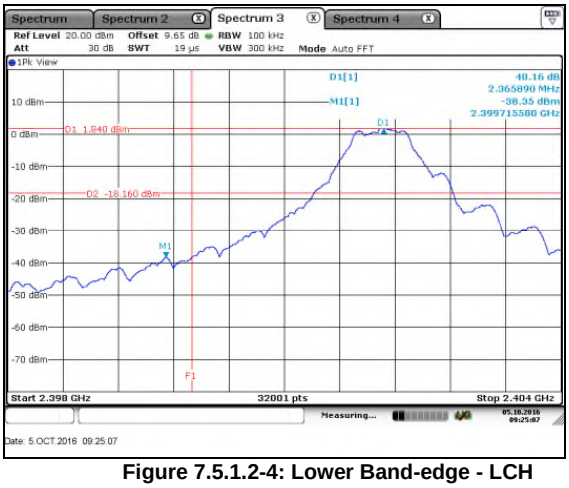

Figure 7.5.1.2-4: Lower Band-edge - LCH

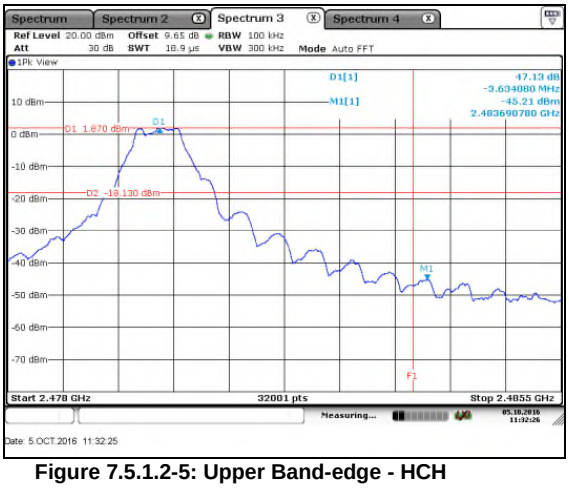

Figure 7.5.1.2-5: Upper Band-edge - HCH

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 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a RBW of 120 kHz and a VBW of 300 kHz. For frequencies above 1000MHz, 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

For average radiated spurious emission measurements that fall in restricted bands, using a 1.74% duty cycle, the measured level was reduced by a factor 35.19dB. The duty cycle correction factor is determined using the formula: 20log (1.74/100).

The duty cycle for the BA10233 is hardwired to the device and limited by the protocol of the radio device, therefore the duty cycle is not accessible by the device or the end user. A detail explanation of the duty cycle is provided in the theory of operation accompanying this report.

7.5.2.3 Measurement Results

Performed by: Jaime Smith

Table 7.5.2.3-1: Radiated Spurious Emissions Tabulated Data

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Low Channel										
4804	37.10	24.00	H	1.70	38.80	-9.49	74.0	54.0	35.2	63.5
4804	50.10	44.50	V	1.70	51.80	11.01	74.0	54.0	22.2	43.0
Middle Channel										
4880	37.10	24.50	H	1.93	39.03	-8.76	74.0	54.0	35.0	62.8
4880	44.70	32.70	V	1.93	46.63	-0.56	74.0	54.0	27.4	54.6
7320	36.40	24.00	H	7.57	43.97	-3.62	74.0	54.0	30.0	57.6
7320	36.30	24.00	V	7.57	43.87	-3.62	74.0	54.0	30.1	57.6
High Channel										
2483.5	55.50	34.60	H	-5.09	50.41	-5.68	74.0	54.0	23.6	59.7
2483.5	48.00	34.10	V	-5.09	42.91	-6.18	74.0	54.0	31.1	60.2
4960	51.00	41.00	H	2.18	53.18	7.99	74.0	54.0	20.8	46.0
4960	57.90	52.40	V	2.18	60.08	19.39	74.0	54.0	13.9	34.6

7.5.2.4 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: 37.10 + 1.70 = 38.80dBuV/m
Margin: 74.0dBuV/m – 38.80dBuV/m = 35.2dB

Example Calculation: Average

Corrected Level: 24.00 + 1.70 - 35.19 = -9.49dBuV
Margin: 54.0dBuV - -9.49dBuV =63.5dB

7.6 Maximum Power Spectral Density in the Fundamental Emission – FCC 15.247(e) ISED Canada: RSS-247 5.2(2)

7.6.1 Measurement Procedure

The power spectral density was measured in accordance with the FCC KDB 558074 D01 DTS Meas Guidance utilizing the PKPSD (peak PSD) method. 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 DTS bandwidth. The trace was set to max hold with a peak detector active.

7.6.2 Measurement Results

Performed by: Ryan McGann

Table 7.6.2-1: Peak Power Spectral Density

Frequency (MHz)	PSD Level (dBm)
2402	-9.30
2440	-9.82
2480	-11.07

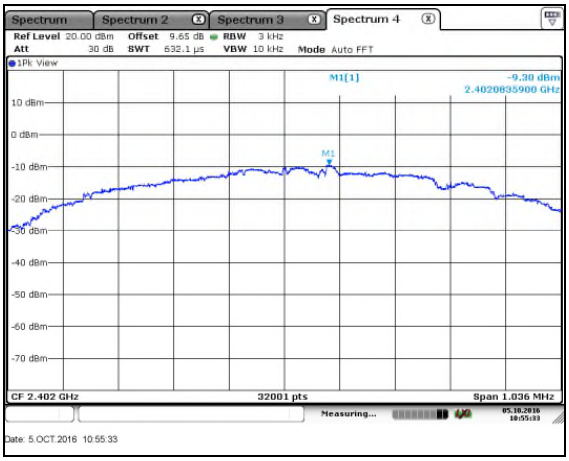

Figure 7.6.2-1: PSD Plot – LCH

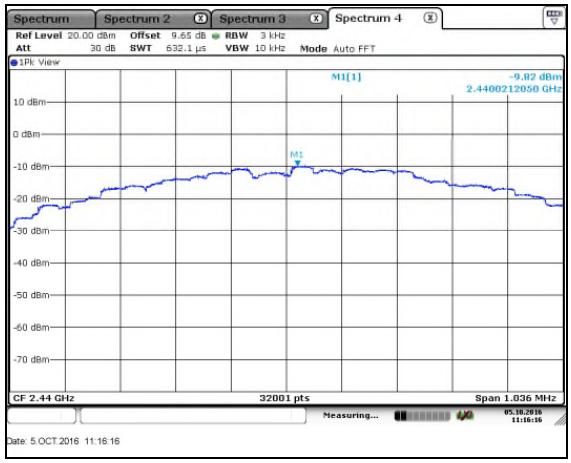

Figure 7.6.2-2: PSD Plot – MCH

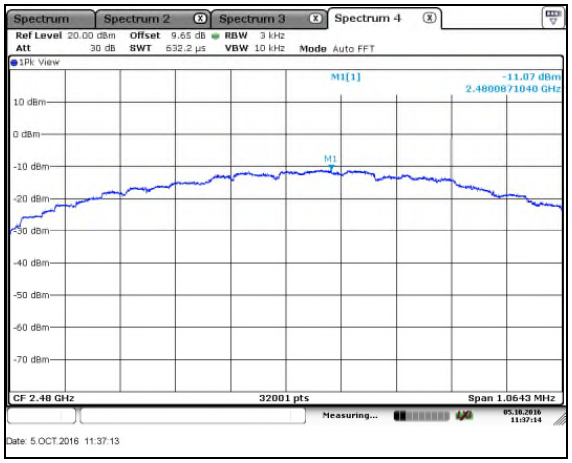

Figure 7.6.2-3: PSD Plot – HCH

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	± 2.832×10^{-8}
AC Power Line Conducted Emissions	± 3.360 dB

9 CONCLUSION

In the opinion of TUV SUD America the BA10233, manufactured by Yardarm Technologies, Inc. meets the requirements of FCC Part 15 subpart C and ISED Canada's Radio Standards Specification RSS-247.

END REPORT