
Project 17650B-15

**OMNI V001
2.4 GHz Aggregator
Bluetooth Radio Section**

Wireless Certification Report

Prepared for:

Virtuix
1826 Kramer Lane, Suite H
Austin, TX 78758

By

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

21 Mar 2016

Reviewed by

A handwritten signature in black ink, appearing to read 'Larry Finn'.

Larry Finn
Chief Technical Officer

Written by

A handwritten signature in black ink, appearing to read 'Eric Lifsey'.

Eric Lifsey
EMC Engineer

Revision History

Revision Number	Description	Date
00	Draft release for review.	29 Feb 2016
01	Revised and final.	21 Mar 2016

Corrections:

The name Brian Olinger is correctly spelled Bryan Olinger.

Table of Contents

Revision History.....	2
Certificate of Compliance	4
1.0 Introduction.....	5
1.1 Scope.....	5
1.2 EUT Description	5
1.3 EUT Operation.....	5
1.4 Modifications to Equipment.....	5
1.5 Test Site	5
1.6 Radiated Measurements	6
1.7 Applicable Documents and Clauses.....	6
2.0 Fundamental Power	7
2.1 Test Procedure	7
2.2 Test Criteria	7
2.3 Test Results.....	7
3.0 Hopping Parameters.....	8
3.1 Test Procedure	8
3.2 Test Criteria	8
3.3 Test Results.....	8
3.3.1 Hopping Timings.....	8
3.3.2 Duty Cycle Timings and Averaging Factor.....	8
4.0 Occupied Bandwidth	9
4.1 Test Procedure	9
4.2 Test Criteria	9
4.3 Test Results.....	9
4.3.1 Bandwidth Plots, 20 dB.....	10
5.0 Band Edge.....	12
5.1 Test Procedure	12
5.2 Test Criteria	12
5.3 Test Results.....	12
5.3.1 Low Channel Band Edge.....	13
5.3.2 High Channel Band Edge	14
6.0 Radiated Spurious Emissions, Receive Mode.....	15
6.1 Test Procedure	15
6.2 Test Criteria	15
6.3 Test Results.....	15
7.0 Radiated Spurious Emissions, Transmit Mode	20
7.1 Test Procedure	20
7.2 Test Criteria	20
7.3 Test Results.....	20
8.0 Antenna Construction Requirements	27
8.1 Procedure	27
8.2 Criteria	27
8.3 Results.....	27
9.0 Equipment and Bandwidths	28
9.1 Equipment for Radiated Power, Band Edge and Spurious Emissions 30 MHz to 18 GHz	28
9.2 Equipment for Bandwidth and Duty Cycle Timings.....	29
9.3 Equipment for 18 to 25 GHz Emission Measurement	29
9.4 Measurement Bandwidths, Radiated.....	29
Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty	30
End of Report	31

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



Certificate of Compliance

Applicant	Device & Test Identification
Virtuix, Inc. (Doug Shuffield) 1826 Kramer Lane, Suite H Austin, TX 78758 Certificate Date: 21 Mar 2016	FCC ID: 2AHFN-OMNIV001 Industry Canada ID: 21168-OMNIV001 Model(s): OMNI V001 Laboratory Project ID: 17650B-15

The device model(s) listed above were tested utilizing the following documents and found to be in compliance with the required criteria.

Requirement**	Reference	Detail
FCC 47 CFR Part 15 C	15.247	Operation within the bands 902-928 MHz, <u>2400-2483.5 MHz</u> , and 5725-5850 MHz.
FCC 47 CFR Part 15 C	15.209	Radiated emission limits; general requirements.
FCC 47 CFR Part 15 C	15.207	Conducted emission limits.
FCC 47 CFR Part 15 C	15.205	Restricted Bands of Operation
KDB 558074 D01	DR01	DTS Measurement Guidance v03r02
KDB 412172	D01	Guidelines for Determining the ERP and EIRP of an RF Transmitting System
OET Bulletin 65*	Edition 97-01, and Supplement C, Ed. 01-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
RSS-247	Issue 1	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-Gen	Issue 4	General Requirements and Information for the Certification of Radio Apparatus
RSS-102	Issue 4	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

*MPE is reported separately from this document. **Corresponding RSS references are listed in the body of the report.

I, Eric Lifsey, for Professional Testing (EMI), Inc., being familiar with the above requirements have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

Eric Lifsey
EMC Engineer

This report has been reviewed and accepted by the Applicant. The undersigned is responsible for ensuring that this device will continue to comply with the requirements listed above.

Representative of Applicant

1.0 Introduction

1.1 Scope

This report describes the extent to which the equipment under test (EUT) conformed to the intentional radiator requirements of the United States and Canada.

Professional Testing (EMI), Inc., (PTI) follows the guidelines of National Institute of Standards and Technology (NIST) for all uncertainty calculations, estimates, and expressions thereof for electromagnetic compatibility testing.

1.2 EUT Description

The EUT is a part of a virtual reality system and known on the design level as the Bluetooth radio. This radio is part of a board with a fixed location in a large floor-mounted base. The board contains two functional radios; a Bluetooth radio and a Gazell radio. The Gazell radio test results are reported separately.

Table 1.2.1: Equipment Under Test		
Manufacturer / Model	Serial #	Description
Virtuix, Inc. OMNI V001	None	2400-2483.5 MHz Bluetooth transceiver.

The device employs a chip antenna. The EUT board is powered from the mains by a wall-wart style power supply with 12 VDC output. The circuit board which comprises the bulk of the system measures approximately 10 x 9 cm.

The overall OMNI system measures approximately 1.2 x 1.2 x 1.1 m and consists of a shallow bowl-like platform and a semi-rigid torso retainer. In normal operation the user occupies the center and is loosely restrained such that movement of torso/legs/feet is allowed though the person does not leave the platform. The OMNI collects user position data of torso using internal hall effect sensors and feet by communication with the POD device on each shoe.

1.3 EUT Operation

The EUT was exercised in a manner consistent with normal operations.

1.4 Modifications to Equipment

No internal/radio modifications were made to the EUT during the performance of the test program. During the test external ferrites were added to USB and DC power cables to suppress radiated broadband switching noise.

1. Ferrite added to USB cable, Laird 23A0434-0A2
2. Ferrite added to power cable, Laird 28A0392-0A2

1.5 Test Site

Measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. The site is registered with the FCC under Section 2.948 and Industry Canada per RSS-GEN, and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located

at 11400 Burnet Road, Austin, Texas 78758, while the main office is located at 1601 North A.W. Grimes Boulevard, Suite B, Round Rock, Texas, 78665.

1.6 Radiated Measurements

Radiated levels are determined as follows:

$$\text{Raw Measured Level} + \text{Antenna Factor} + \text{Cable Losses} - \text{Amplifier Gain} = \text{Corrected Level}$$

Conducted RF levels are determined as follows:

$$\text{Raw Measured Level} + \text{Attenuator Factor} + \text{Cable Losses} = \text{Corrected Level}$$

Conducted mains levels are determined as follows:

$$\text{Raw Measured Level} + \text{LISN Factor} + \text{Cable/Filter/Limiter Losses} = \text{Corrected Level}$$

Additionally, measurement distance extrapolation factors are applied and documented where used.

1.7 Applicable Documents and Clauses

Table 1.7.1: Applicable Documents

Document	Title
47 CFR	Part 15 – Radio Frequency Devices Subpart C -Intentional Radiators
RSS-247 Issue 1	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-Gen Issue 4	General Requirements and Information for the Certification of Radio Apparatus
ANSI C63.4 2009	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low Voltage Electrical and Electronic Equipment

Table 1.7.2: Applicable Clauses

Parameter	FCC Part 15 Rule Paragraphs	IC RSS References
Transmitter Characteristics	15.247(a)(2)	RSS-247 5.2 (DTS) & 5.4, RSS-Gen 6
Power Spectral Density	15.247(e)	RSS-247 5.2 (DTS)
Bandwidth	15.247(a)(2), 2.1049, KDB 558074 D01	RSS-247 5.2 (DTS), RSS-Gen 6.6
Spurious Emission	15.247, 15.209, 15.205	RSS-247 5.5, RSS-GEN 6.13, 7.1
Band Edge	15.247, 15.205	RSS-247 5.5, RSS-Gen 6.13
Antenna Requirement	15.203	RSS-Gen 8.3
Conducted Emissions, Mains	15.207	RSS-Gen 8.8

2.0 Fundamental Power

2.1 Test Procedure

Bandwidth is first determined to select correct entire bandwidth for power measurement and the fundamental field strength is then measured.

2.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date
15.247(a)(2) // RSS-247 5.2	Fundamental Power Conducted Limit: 1 Watt Desired Power Limit: 10 mW Restated as Radiated Limit @ 3 m: 105.23 dBμV/m	25 Jan 2016

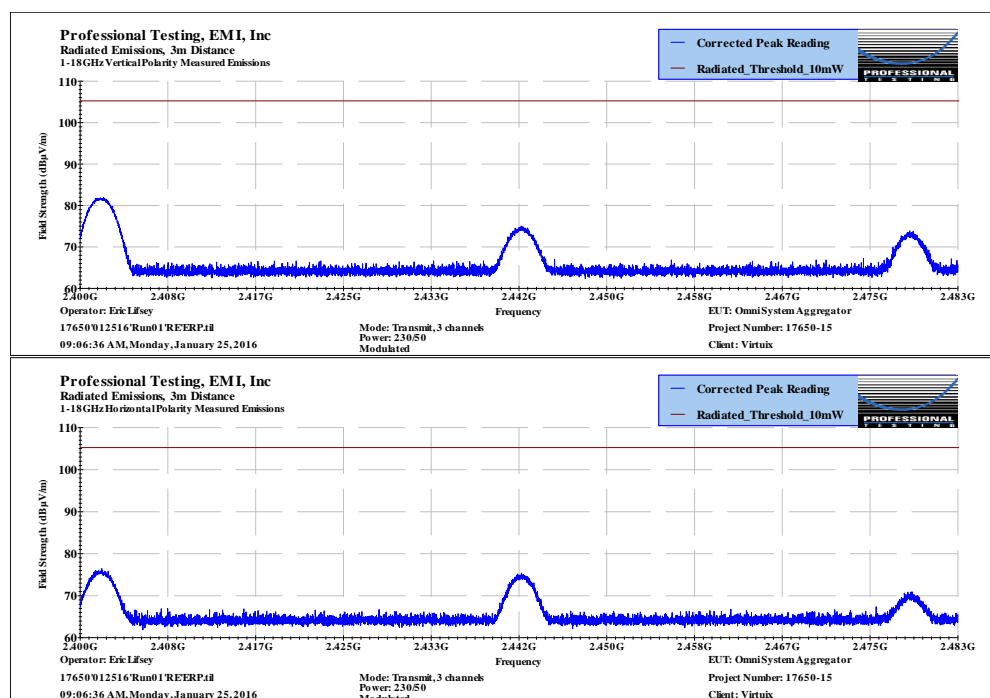
2.3 Test Results

Maximum polarity is as indicated. This device is floor-mounted.

Table 2.3.1 Radiated Power at 3 meters, Maximum Polarity		
Frequency MHz	Measured Radiated Peak Power dBμV/m @ 3m	Maximum Polarity
2402	81.8	V
2442	75.0	V
2480	73.9	V

Measured in 3 MHz RBW, 3 MHz VBW.

The EUT satisfied the requirement. Plotted measurements appear below.



3.0 Hopping Parameters

3.1 Test Procedure

The EUT hopping parameters are determined from either measurement or from chip manufacturer test data. The chip Bluetooth firmware stack is not under the control nor accessible by the applicant. Therefore the manufacturer's test report supplements this report.

3.2 Test Criteria

The referenced report covers the essential hopping measurements of channel separation, channel dwell time, return to channel time, and time of occupancy.

3.3 Test Results

3.3.1 Hopping Timings

See supplementary report:

Nemko 10238472RUS1
 Circa 4 April 2013
 FCC ID: Z64-CC256xEM
 IC ID: 4511-CC256xEM

3.3.2 Duty Cycle Timings and Averaging Factor

Using the supplementary report cited above, the duty cycle factor was determined from channel dwell time and return to channel time. Since return to channel time is normally larger than 100 ms in hopping radios, the limit of 100 ms was used.

Table 3.3.2.1 Duty Cycle Factor Result				
Measured On Time (msec)	Measured Time Period (msec)	Duty Cycle Factor Calculation	Result (dB)	Duty Cycle Factor Allowed (dB)
0.325	100	$= 20 * \text{Log}_{10} (0.325 \text{ msec} / 100 \text{ msec})$	-49.76	-20.0

The allowed duty cycle factor is applied to peak measured harmonic signals to find average levels.

4.0 Occupied Bandwidth

4.1 Test Procedure

The EUT is directly connected to a spectrum analyzer and bandwidth then is measured. A recording of the results is included.

4.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
14.247(a)(2), 2.1049 // RSS-Gen 5.2, RSS-Gen 6.6	Bandwidth 20 dB	21 Jan 2016

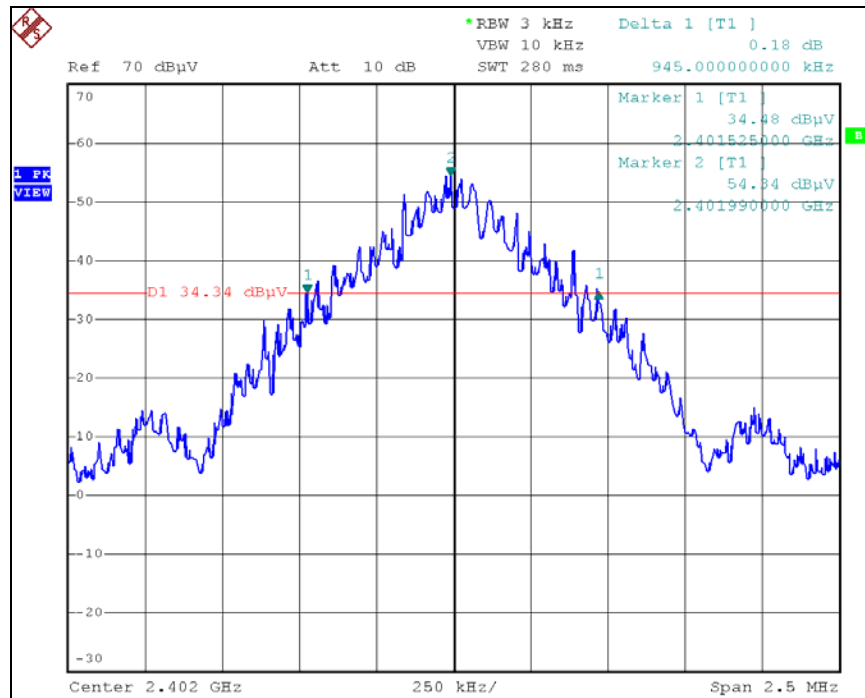
4.3 Test Results

EUT was found to be in compliance with applicable requirements.

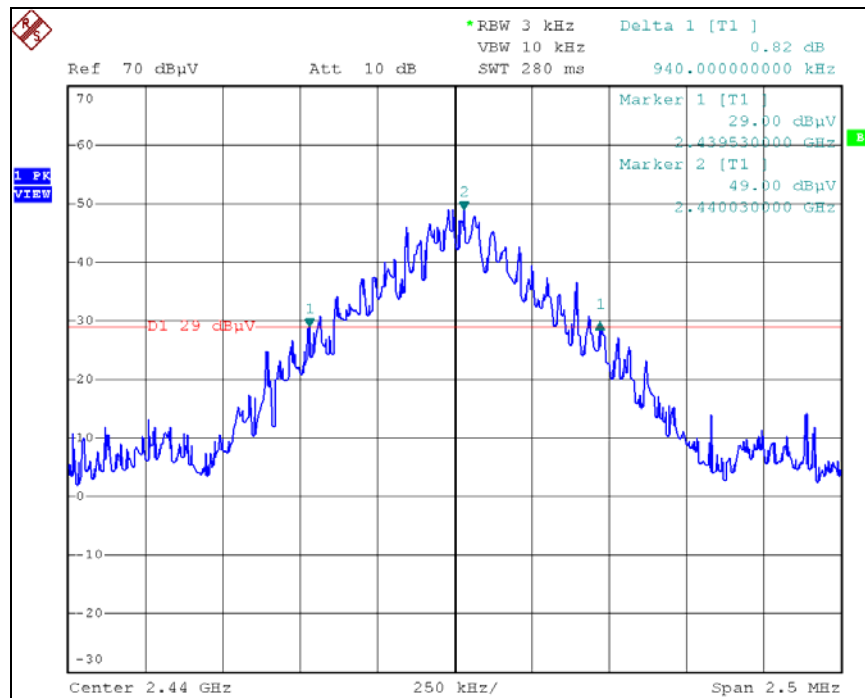
Table 5.3.2 Bandwidth 20 dB, Measure and Report			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Maximum BW (kHz)
945	940	950	950

Plotted measurements appear on the following pages.

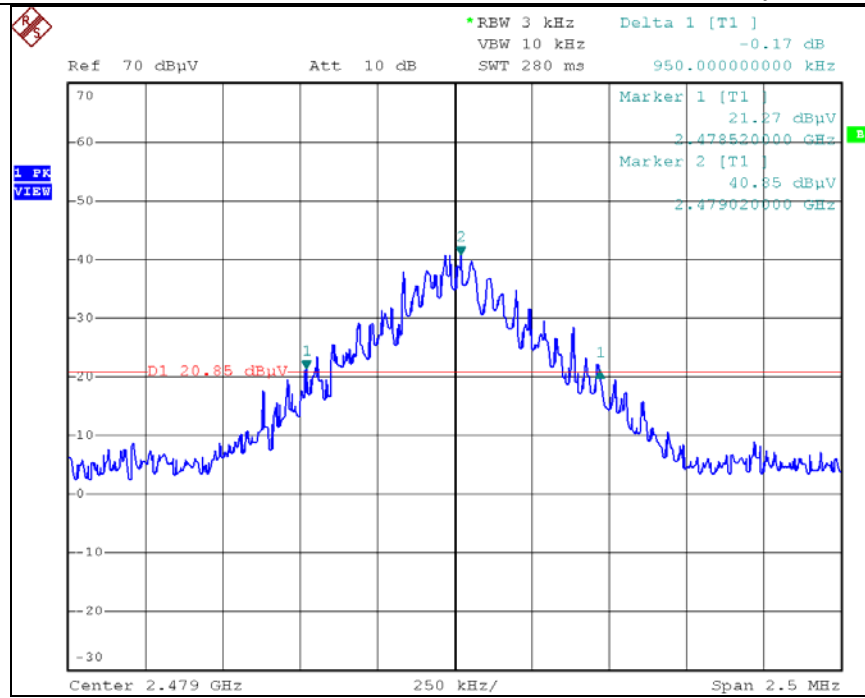
4.3.1 Bandwidth Plots, 20 dB



20 dB, Low Channel



20 dB, Middle Channel



20 dB, High Channel

5.0 Band Edge

5.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable at a distance of 3 meters from the measurement antenna.

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

5.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.205, 15.209 // RSS-247 5.5, RSS-Gen 6.13	Unwanted Emissions Adjacent to Authorized Band, Radiated	25 Jan 2016

5.3 Test Results

Peak detection emissions at band edges were below the applicable general emission average limits and the -20 dBc limit.

The EUT satisfied the requirements.

5.3.1 Low Channel Band Edge

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	1/25/2016	EUT Serial #:	None
Customer:	Virtuix	EUT Part #:	None
Project Number:	17650-15	Test Technician:	Eric Lifsey
Purchase Order #:	NA	Supervisor:	Lisa Arndt
Equip. Under Test:	OMNI System Aggregator	Witness' Name:	Bryan Olinger
Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	230	VAC	
EUT Power Frequency:	50	Hz	
Antenna Orientation:	Vertical		Frequency Range: Above 1GHz
EUT Side Position; Mode of Operation:		BT Transmit Mode, Modulated	
<div style="display: flex; justify-content: space-between;"> <div style="width: 60%;"> <p>Professional Testing, EMI, Inc Radiated Emissions, 3m Distance 1-18GHz Vertical Polarity Measured Emissions</p> <p>Operator: Eric Lifsey 17650\012516\Run01\RETxBandEdgeMask\Lower.tif 09:43:24 AM, Monday, January 25, 2016</p> <p>Mode: Transmit, 2 Ch; low/high, Bluetooth Power: 230/50 Modulated; band-edge and OOB domain</p> </div> <div style="width: 35%; text-align: right;"> <p>EUT: OmniSystem Aggregator Project Number: 17650-15 Client: Virtuix</p> </div> </div>			
Band Edge, Lower			

**EUT Satisfies -20 dBc Criteria and
15.209 General Emission Criteria Below 2400 MHz**

5.3.2 High Channel Band Edge

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	1/25/2016	EUT Serial #:	None
Customer:	Virtuix	EUT Part #:	None
Project Number:	17650-15	Test Technician:	Eric Lifsey
Purchase Order #:	NA	Supervisor:	Lisa Arndt
Equip. Under Test:	OMNI System Aggregator	Witness' Name:	Bryan Olinger
Radiated Emissions Test Results Data Sheet		Page:	1 of 1
EUT Line Voltage:	230	VAC	
EUT Power Frequency:	50	Hz	
Antenna Orientation:	Horizontal		Frequency Range: Above 1GHz
EUT Side Position; Mode of Operation:		BT Transmit Mode, Modulated	
<div style="display: flex; justify-content: space-between;"> <div style="width: 60%;"> <p>Professional Testing, EMI, Inc Radiated Emissions, 3m Distance 1-18GHz Vertical Polarity Measured Emissions</p> <p>Field Strength (dB μV/m)</p> <p>Frequency</p> <p>Operator: Eric Lifsey</p> <p>17650\012516\Run02\RE\TxBandEdgeMask\Upper.tif</p> <p>09:52:35 AM, Monday, January 25, 2016</p> <p>Mode: Transmit, 2 Ch; low/high, Bluetooth</p> <p>Power: 230/50</p> <p>Modulated; band-edge and OOB domain</p> <p>EUT: OmniSystem Aggregator</p> <p>Project Number: 17650-15</p> <p>Client: Virtuix</p> </div> <div style="width: 35%; text-align: right;"> <p>PROFESSIONAL TESTING</p> </div> </div>			
Band Edge, Upper			

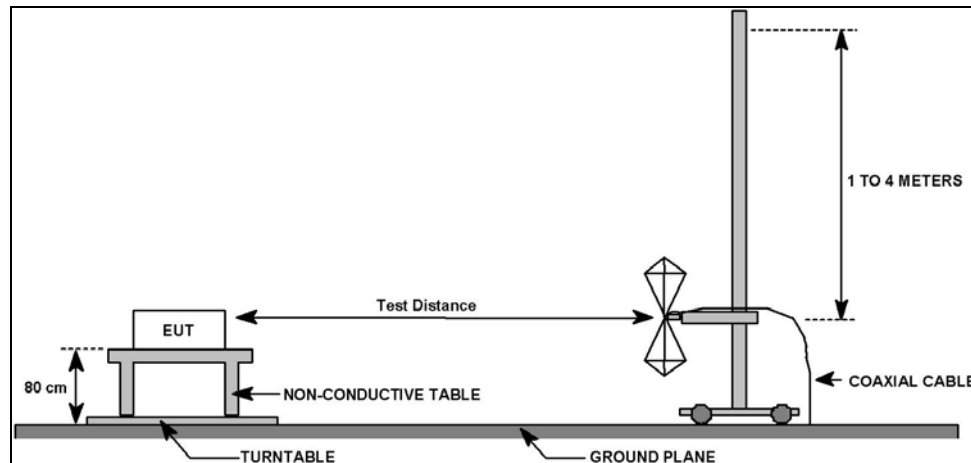
**EUT Satisfies -20 dBc Criteria and
General Emission 15.209 Criteria Above 2.4835 GHz**

6.0 Radiated Spurious Emissions, Receive Mode

6.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable. The measurement antenna is scanned from 1 to 4 meters in height.

Spurious emissions below 1 GHz were measured with peak and quasi-peak detection with a resolution bandwidth of 120 kHz at a distance of 10 meters. Above 1 GHz the measurement distance was 3 meters with resolution bandwidth of 1 MHz and using peak and average detection. A diagram showing the test setup is given in the figure below.



Field Strength of Spurious Emissions Test Setup

6.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.209 // RSS-247 5.5, RSS-Gen 7.1	Field Strength of Radiated Spurious/Harmonic Emissions	20 Jan 2016

6.3 Test Results

The EUT satisfied the criteria. Recorded data is presented below.

Table 7.3.1: Radiated Spurious Emissions, Receive Mode, Below 1 GHz, Vertical Polarity

Professional Testing, EMI, Inc.									
Test Method:		ANSI C63.4-2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).							
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits							
Section:		15.209							
Test Date(s):		1/20/2016			EUT Serial #:		0		
Customer:		Virtuix			EUT Part #:		0		
Project Number:		17650-15			Test Technician:		Eric Lifsey		
Purchase Order #:		NA			Supervisor:		Lisa Arndt		
Equip. Under Test:		PODS			Witness' Name:		Brian Olinger		
Radiated Emissions Test Results Data Sheet								Page: 1 of 1	
EUT Line Voltage:		230 VAC		EUT Power Frequency:		50 Hz			
Antenna Orientation:		Vertical			Frequency Range:		30MHz to 1GHz		
EUT Mode of Operation:					Receive Mode, Center Channel				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBμV)	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
62.1924	10	41	1.32	Quasi-peak	31.4	11.811	29.5	-17.7	Pass
63.1552	10	61	1.66	Quasi-peak	32.8	12.597	29.5	-16.9	Pass
103.273	10	64	1.47	Quasi-peak	37.9	21.497	33.1	-11.6	Pass
128.018	10	0	2	Quasi-peak	39.2	21.897	33.1	-11.2	Pass
130.204	10	0	2	Quasi-peak	42.2	24.886	33.1	-8.2	Pass
131.293	10	0	2	Quasi-peak	39.8	22.555	33.1	-10.5	Pass
132.397	10	0	2	Quasi-peak	45.6	28.376	33.1	-4.7	Pass
133.492	10	0	2	Quasi-peak	44	26.772	33.1	-6.3	Pass
134.564	10	0	2	Quasi-peak	41.4	24.178	33.1	-8.9	Pass
135.656	10	344	1.58	Quasi-peak	40.2	22.907	33.1	-10.2	Pass
135.656	10	0	2	Quasi-peak	46.2	28.943	33.1	-4.2	Pass
136.756	10	0	2	Quasi-peak	45.2	27.932	33.1	-5.2	Pass

Professional Testing, EMI, Inc

Radiated Emissions, 10m Distance

30MHz - 1GHz Vertical Polarity Measured Emissions

Operator: Eric Lifsey

17650\012016\Run06\RE\RxSpuriousBTRadio\17650-15\Receive

01:10:06 PM, Saturday, January 23, 2016

Power: 230/50

Aggregator Bluetooth

EUT: OmniSystem Aggregator

Project Number: 17650-15

Client: Virtuix

≤ 1GHz Vertical Antenna Polarity Measured Emissions

Table 7.3.2: Radiated Spurious Emissions, Receive Mode, Below 1 GHz, Horizontal Polarity

Professional Testing, EMI, Inc.										
Test Method:		ANSI C63.4–2003: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).								
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits								
Section:		15.209								
Test Date(s):		1/20/2016			EUT Serial #:		0			
Customer:		Virtuix			EUT Part #:		0			
Project Number:		17650-15			Test Technician:		Eric Lifsey			
Purchase Order #:		NA			Supervisor:		Lisa Arndt			
Equip. Under Test:		PODS			Witness' Name:		Brian Olinger			
Radiated Emissions Test Results Data Sheet								Page: 1 of 1		
EUT Line Voltage:		230		VAC		EUT Power Frequency:		50		Hz
Antenna Orientation:		Horizontal				Frequency Range:		30MHz to 1GHz		
EUT Mode of Operation:					Receive Mode, Center Channel					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBμV)	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results	
87.9665	10	41	3.74	Quasi-peak	42.8	22.894	29.5	-6.6	Pass	
96.3784	10	58	3.66	Quasi-peak	41.9	23.78	33.1	-9.3	Pass	
136.742	10	12	3.77	Quasi-peak	40.1	22.862	33.1	-10.2	Pass	
137.85	10	229	3.65	Quasi-peak	41.2	23.925	33.1	-9.2	Pass	
887.008	10	0	2	Quasi-peak	21.4	26.046	35.6	-9.6	Pass	

Professional Testing, EMI, Inc

Radiated Emissions, 10m Distance

30MHz - 1GHz Horizontal Polarity Measured Emissions

Quasi-peak Limit Level

Corrected Peak Level

Recorded Peak Level

EUT Class B1

ETSI Receive Mode

Operator: Eric Lifsey

17650-012016-Run06-RE-Rx Spurious BTRadio Mode: Receive

01:10:06 PM, Saturday, January 23, 2016

Power: 230/50

Aggregator: Bluetooth

EUT: OmniSystem Aggregator

Project Number: 17650-15

Client: Virtuix

≤ 1GHz Horizontal Antenna Polarity Measured Emissions

Table 7.3.3: Radiated Spurious Emissions, Receive Mode, Above 1 GHz, Middle Channel, Vertical Polarity

Professional Testing, EMI, Inc.										
Test Method:		ANSI C63.4–2003: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).								
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits								
Section:		15.209								
Test Date(s):		1/20/2016				EUT Serial #:		0		
Customer:		Virtuix				EUT Part #:		0		
Project Number:		17650-15				Test Technician:		Eric Lifsey		
Purchase Order #:		NA				Supervisor:		Lisa Arndt		
Equip. Under Test:		PODS				Witness' Name:		Brian Olinger		
Radiated Emissions Test Results Data Sheet										
EUT Line Voltage:					230 VAC		EUT Power Frequency:		50 Hz	
Antenna Orientation:					Vertical		Frequency Range:		Above 1GHz	
EUT Mode of Operation:					Receive Mode, Center Channel					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBμV)	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results	
1380.39	3	196	0.6	Average	36.5	24.85	54.0	-29.1	Pass	
1676.97	3	178	0.6	Average	35.6	24.951	54.0	-29.0	Pass	
1831.56	3	228	0.6	Average	34.2	24.347	54.0	-29.6	Pass	
1996.3	3	263	0.6	Average	36.3	27.618	54.0	-26.3	Pass	

Professional Testing, EMI, Inc

Radiated Emissions, 3m Distance

1-18GHz Vertical Polarity Measured Emissions

▽

Average Limit Level

—

Corrected Average Level

—

Class B Limit Peak

—

Corrected Peak Peak

—

EMV Class B OP

—

ETSI Receive Mode

Operator: Eric Lifsey

17650/012016/Run06/RE/RxSpurious/BTRadio/Minimize/Receive

08:27:54 AM, Saturday, January 23, 2016

Power: 230/50

Aggregator Bluetooth

EUT: OmniSystem Aggregator

Project Number: 17650-15

Client: Virtuix

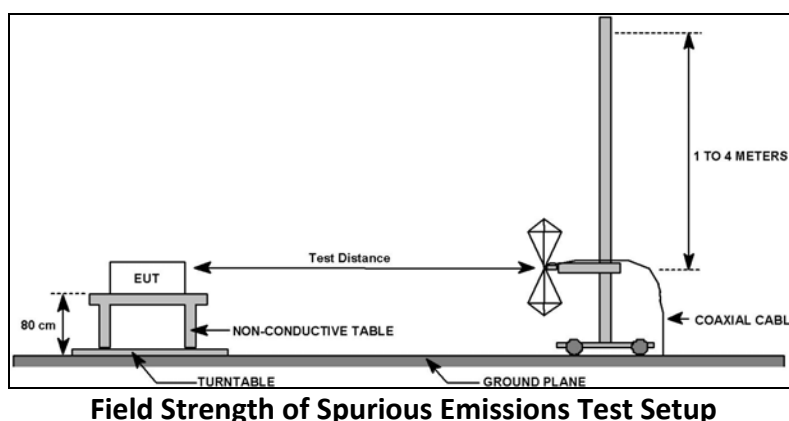
1 to 18 GHz Vertical Antenna Polarity Measured Emissions

7.0 Radiated Spurious Emissions, Transmit Mode

7.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The EUT was centered on a rotating turntable.

Spurious emissions below 1 GHz were measured with peak and quasi-peak detection with a resolution bandwidth of 120 kHz at a distance of 10 meters. Above 1 GHz the measurement distance was 3 meters with resolution bandwidth of 1 MHz and using peak and average detection. A diagram showing the test setup is given in the figure below.



7.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.209 // RSS-247 5.5, RSS-Gen 6.13	Field Strength of Radiated Spurious/Harmonic Emissions	20 Jan 2016 26 Jan 2016

7.3 Test Results

In all cases detector mode is peak, RBW 1 MHz, VBW 3 MHz. All peak emissions can be seen as being below the average or QP limits.

Averaging of the harmonic emissions by duty cycle factor yielded a result of -20.0 dB which is typical due to the short channel dwell time and high return to channel time of hopping radios. This factor can be applied by inspection of the peak plots appearing in the tables below.

The EUT satisfied the criteria. Recorded data is presented below.

Table 7.3.1: Radiated Spurious Emissions, Transmit Mode, Below 1 GHz, Three Channels, Vertical Polarity

Professional Testing, EMI, Inc.									
Test Method:	ANSI C63.4-2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).								
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits								
Section:	15.209								
Test Date(s):	1/20/2016	EUT Serial #:	0						
Customer:	Virtuix	EUT Part #:	0						
Project Number:	17650-15	Test Technician:	Eric Lifsey						
Purchase Order #:	NA	Supervisor:	Lisa Arndt						
Equip. Under Test:	PODS	Witness' Name:	Brian Olinger						
Radiated Emissions Test Results Data Sheet							Page: 1 of 1		
EUT Line Voltage:		230 VAC		EUT Power Frequency:		50 Hz			
Antenna Orientation:		Vertical		Frequency Range:		30MHz to 1GHz			
EUT Mode of Operation:				Transmit Mode, Modulated, 3 Channels/EUTs					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
36.0668	10	18	1.63	Quasi-peak	34.1	21.102	29.5	-8.4	Pass
37.3319	10	14	1.42	Quasi-peak	33.1	20.219	29.5	-9.3	Pass
46.1113	10	207	3.49	Quasi-peak	32.6	14.831	29.5	-14.7	Pass
137.839	10	124	2.94	Quasi-peak	30.3	19.202	29.5	-10.3	Pass
275.976	10	307	2.11	Quasi-peak	28.1	17.602	29.5	-11.9	Pass
899.438	10	109	3.78	Quasi-peak	21.3	20.993	29.5	-9.6	Pass

Professional Testing, EMI, Inc
Radiated Emissions, 10m Distance
30MHz - 1GHz Vertical Polarity Measured Emissions

Field Strength (dBµV/m)

60

50

40

30

20

10

0

10M

100M

1G

Operator: Eric Lifsey
1765012016Run08 RETxSpurious3 Ch BT Radio transmit, BT radio, three channel
08:31:20 AM, Monday, January 25, 2016

Unmodulated Laptop on USB

EUT: Omni System Aggregator
Project Number: 17650-15
Client: Virtuix

Quasi-peak Limit Level
Corrected Quasi-peak
Recorded Quasi-peak
Unmodulated Laptop on USB

PROFESSIONAL

1 GHz Vertical Antenna Polarity Measured Emissions

Table 7.3.2: Radiated Spurious Emissions, Transmit Mode, Below 1 GHz, Three Channels, Horizontal Polarity

Professional Testing, EMI, Inc.									
Test Method:		ANSI C63.4–2003: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).							
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits							
Section:		15.209							
Test Date(s):		1/20/2016			EUT Serial #:		0		
Customer:		Virtuix			EUT Part #:		0		
Project Number:		17650-15			Test Technician:		Eric Lifsey		
Purchase Order #:		NA			Supervisor:		Lisa Arndt		
Equip. Under Test:		PODS			Witness' Name:		Brian Olinger		
Radiated Emissions Test Results Data Sheet							Page: 1 of 1		
EUT Line Voltage:		230 VAC		EUT Power Frequency:		50 Hz			
Antenna Orientation:		Horizontal			Frequency Range:		30MHz to 1GHz		
EUT Mode of Operation:				Transmit Mode, Modulated, 3 Channels/EUTs					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBμV)	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
37.8039	10	5	3.56	Quasi-peak	23.6	8.338	29.5	-21.2	Pass
66.6925	10	107	2.26	Quasi-peak	25.3	4.463	29.5	-25.0	Pass
138.038	10	161	3.56	Quasi-peak	34.3	17.07	33.1	-16.0	Pass
275.965	10	24	3.62	Quasi-peak	30	19.482	35.6	-16.1	Pass
898.974	10	295	3.42	Quasi-peak	21.3	26.573	35.6	-9.0	Pass
947.835	10	142	3.33	Quasi-peak	21	26.174	35.6	-9.4	Pass

Professional Testing, EMI, Inc

Radiated Emissions, 10m Distance

30MHz - 1GHz Horizontal Polarity Measured Emissions

Operator: Eric Lifsey

17650-012016-Run08-RE-TxSpurious-3Ch-BT Radio Transmitter, BT radio, three channels

08:31:20 AM, Monday, January 25, 2016

Power: 230/50

Unmodulated; Laptop on USB

EUT: OmniSystem Aggregator

Project Number: 17650-15

Client: Virtuix

≤ 1GHz Horizontal Antenna Polarity Measured Emissions

Table 7.3.3: Radiated Spurious Emissions, Transmit Mode, 1 to 18 GHz, Three Channels, Vertical Polarity

Professional Testing, EMI, Inc.										
Test Method:		ANSI C63.4–2003: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).								
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits								
Section:		15.209								
Test Date(s):		1/20/2016			EUT Serial #:		0			
Customer:		Virtuix			EUT Part #:		0			
Project Number:		17650-15			Test Technician:		Eric Lifsey			
Purchase Order #:		NA			Supervisor:		Lisa Arndt			
Equip. Under Test:		PODS			Witness' Name:		Brian Olinger			
Radiated Emissions Test Results Data Sheet							Page: 1 of 1			
EUT Line Voltage:		230		VAC		EUT Power Frequency:		50		Hz
Antenna Orientation:		Vertical			Frequency Range:		Above 1GHz			
EUT Mode of Operation:					Transmit Mode, Modulated, 3 Channels/EUTs					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBμV)	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results	
7206	3	0	0.6	Peak	53.95	53.95	74.0	-20.0	Pass	
<div><div><div>Professional Testing, EMI, Inc</div><div>Radiated Emissions, 3m Distance</div><div>1-18GHz Vertical Polarity Measured Emissions</div></div><div><div><div><div>▽</div><div>Average Limit Level</div></div><div><div>—</div><div>Corrected Average Level</div></div><div><div>—</div><div>Peak Limit Level</div></div><div><div>—</div><div>Corrected Peak Level</div></div><div><div>—</div><div>EUT Transmit Spurious</div></div></div><div><div>Field Strength (dB μV/m)</div><div></div></div><div><div>Operator: Eric Lifsey</div><div>17650'012016'Run08'RETxSpurious'3Ch'BT radio, BT radio, three channels</div><div>05:16:59 PM, Wednesday, January 20, 2016</div><div>Power: 230/50</div><div>Unmodulated; Laptop on USB</div></div><div><div>EUT: OmniSystem Aggregator</div><div>Project Number: 17650-15</div><div>Client: Virtuix</div></div></div></div>										
1 to 18 GHz Vertical Antenna Polarity Measured Emissions										

Averaging of the harmonic emissions by duty cycle factor yielded a result of -20.0 dB which is typical due to the short channel dwell time and high return to channel time of hopping radios. This factor can be applied by inspection of the peak plots appearing in the table above.

Table 7.3.4: Radiated Spurious Emissions, Transmit Mode, 1 to 18 GHz, Three Channels, Horizontal Polarity

Professional Testing, EMI, Inc.										
Test Method:		ANSI C63.4–2003: “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz” (incorporated by reference, see §15.38).								
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits								
Section:		15.209								
Test Date(s):		1/20/2016				EUT Serial #:		0		
Customer:		Virtuix				EUT Part #:		0		
Project Number:		17650-15				Test Technician:		Eric Lifsey		
Purchase Order #:		NA				Supervisor:		Lisa Arndt		
Equip. Under Test:		PODS				Witness' Name:		Brian Olinger		
Radiated Emissions Test Results Data Sheet								Page: 1 of 1		
EUT Line Voltage:		230		VAC		EUT Power Frequency:		50		Hz
Antenna Orientation:		Horizontal				Frequency Range:		Above 1GHz		
EUT Mode of Operation:					Transmit Mode, Modulated, 3 Channels/EUTs					
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBμV)	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results	
7206	3	0	0.6	Peak	56.45	56.45	74.0	-17.5	Pass	

Professional Testing, EMI, Inc

Radiated Emissions, 3m Distance

1-18GHz Horizontal Polarity Measured Emissions

Average Limit Level

Corrected Average Level

Peak Limit Level

Corrected Peak Level

EMI - Class B - OIP3

EUT Transmit Spur

PROFESSIONAL

EMI TESTING

Operator: Eric Lifsey

17650\012016\Run08\RETxSpurious\3Ch\BTRadio\Transmit, BT radio, three channels

05:28:18 PM, Wednesday, January 20, 2016

Power: 230.50

Unmodulated; Laptop on USB

EUT: OmniSystemAggregator

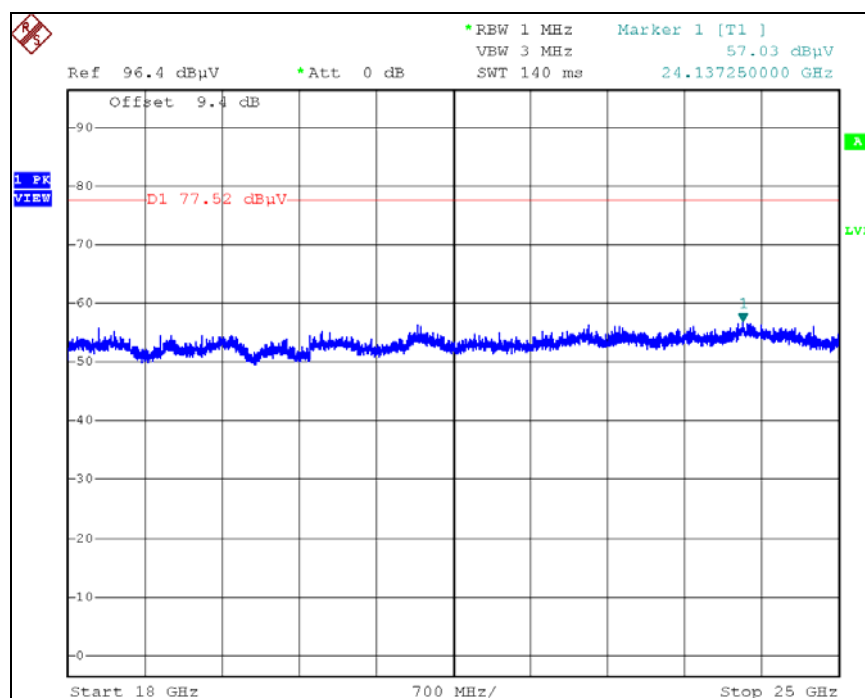
Project Number: 17650-15

Client: Virtuix

1 to 18 GHz Horizontal Antenna Polarity Measured Emissions

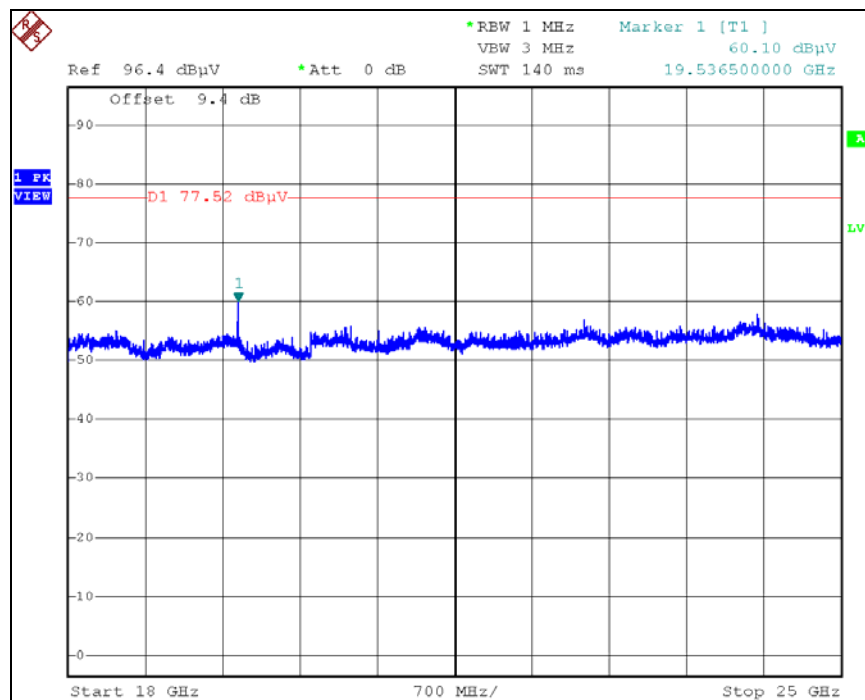
Averaging of the harmonic emissions by duty cycle factor yielded a result of -20.0 dB which is typical due to the short channel dwell time and high return to channel time of hopping radios. This factor can be applied by inspection of the peak plots appearing in the table above.

Table 7.3.5: Radiated Spurious Emissions, Transmit Mode, 18 to 26 GHz, Bottom Channel, Vertical & Horizontal Polarity



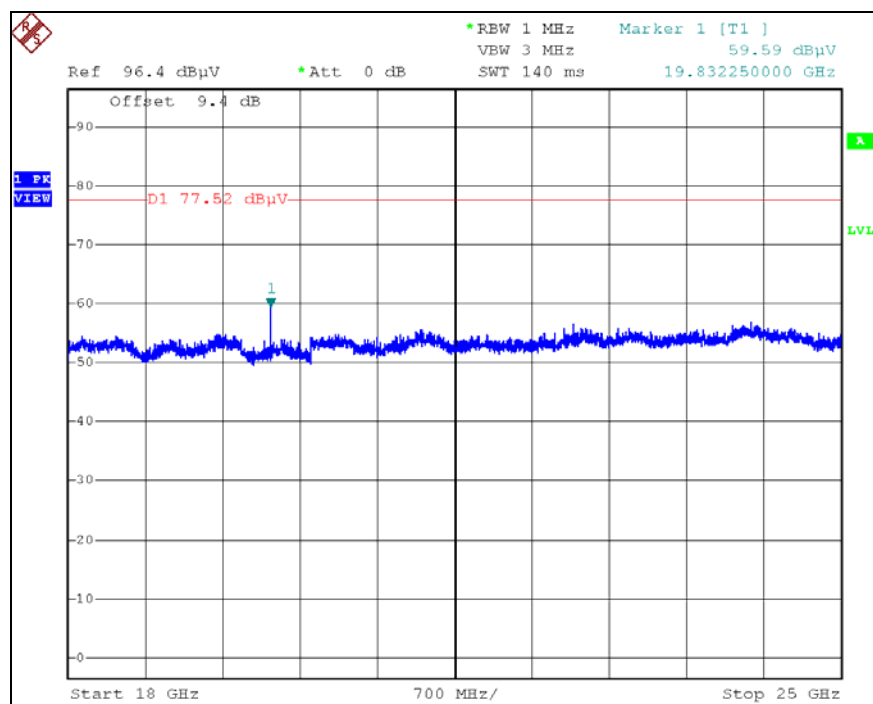
Low Channel, Max Hold of Both Polarities
Corrected for Gain/Loss, Limit as Shown for Distance 20 cm

Table 7.3.6: Radiated Spurious Emissions, Transmit Mode, 18 to 26 GHz, Middle Channel, Vertical & Horizontal Polarity



Middle Channel, Max Hold of Both Polarities
Corrected for Gain/Loss, Limit as Shown for Distance 20 cm

Table 7.3.7: Radiated Spurious Emissions, Transmit Mode, 18 to 26 GHz, Top Channel, Vertical & Horizontal Polarity



**High Channel, Max Hold of Both Polarities
 Corrected for Gain/Loss, Limit as Shown for Distance 20 cm**

8.0 Antenna Construction Requirements

The design was investigated for meeting the antenna construction requirements of the applicable rules.

8.1 Procedure

A direct examination of the antenna construction is performed and compared to rule criteria that prevent wireless device antennas from being modified by end users in ways that would void their authorization to use the device.

8.2 Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.203 // RSS-Gen 8.3	Antenna Construction	21 Mar 2016

8.3 Results

Table 9.3.1 Antenna Construction Details	
Antenna Manufacturer and Model	Specifications
Manufacturer: Johanson Technology, Inc. Model: P/N 2450AT18A100	Chip antenna. Peak gain: 0.5 dBi Peak* *The effect of gain is captured in the radiated measurements.

- The antenna is internal only to the device.
- The antenna is soldered component on the circuit board.
- There is no antenna connector.

The antenna design above satisfies the requirements of the rules.

9.0 Equipment and Bandwidths

9.1 Equipment for Radiated Power, Band Edge and Spurious Emissions 30 MHz to 18 GHz

Professional Testing, EMI, Inc.					
Test Method:		ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).			
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits			
Section:		15.209			
Test Date(s):		1/20/2016	EUT Serial #:	0	
Customer:		Virtuix	EUT Part #:	0	
Project Number:		17650-15	Test Technician:	Eric Lifsey	
Purchase Order #:		NA	Supervisor:	Lisa Arndt	
Equip. Under Test:		PODS	Witness' Name:	Brian Olinger	
Radiated Emissions Test Equipment List					
Tile! Software Version:		4.2.A, May 23, 2010, 08:38:52 AM			
Test Profile:		2015 Rad Emissions_ClassA - LowPRF_072715.til or 2015 Rad Emissions_ClassB - LowPRF_072715.til			
Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Braden	N/A	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	2/5/2017
1890	HP	8447F	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	2/1/2018
1937	Agilent	E4440A	Spectrum Analyzer, 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	12/15/2016
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	1/25/2017
C027D	none	RG214	Cable Coax, N-N, 25m	none	10/1/2016
1327	EMCO	1050	Controller, Antenna Mast	none	N/A
0942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1969	HP	11713A	Attenuator/Switch Driver	3748A04113	N/A
1509B	Braden	N/A	TDK 10M Chamber, VSWR > 1 GHz	DAC-012915-005	3/14/2017
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/11/2018
C030	none	none	Cable Coax, N-N, 30m	none	10/1/2016
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	2/25/2017

9.2 Equipment for Bandwidth and Duty Cycle Timings

Asset #	Manufacturer	Model #	Description	Calibration Due
ALN-077	Rohde & Schwarz	FSP-30	Spectrum Analyzer	16 Dec 2016

9.3 Equipment for 18 to 25 GHz Emission Measurement

Asset #	Manufacturer	Model #	Description	Calibration Due
ALN-077	Rohde & Schwarz	FSP-30	Spectrum Analyzer	16 Dec 2016
1974	Agilent	83017A	Microwave Amplifier	17 Dec 2017
1542	AH Systems	SAS-572	Horn Antenna, Standard Gain, 20 dB	CNR

9.4 Measurement Bandwidths, Radiated

Radiated Emissions Spectrum Analyzer Bandwidth and Measurement Time - Peak Scan				
Frequency Band Start (MHz)	Frequency Band Stop (MHz)	6 dB Bandwidth (kHz)	Number of Ranges Used	Measurement Time per Range
0.009	0.15	0.3	2	Multiple Sweeps
0.15	30	9	6	Multiple Sweeps
30	1000	120	2	Multiple 800 mS Sweeps
1000	6000	1000	2	Multiple Sweeps
6000	18000	1000	2	Multiple Sweeps
18000	26500	1000	2	Multiple Sweeps

***Notes:**

1. The settings above are specifically calculated for the E4440A series of spectrum analyzers, which have 8,000 data points per range.
2. The measurement receiver resolution bandwidth setting was 300 Hz for quasi-peak measurements from 9-150 kHz.
3. The measurement receiver resolution bandwidth setting was 9 kHz for quasi-peak measurements from 0.15-30 MHz.
4. The measurement receiver resolution bandwidth setting was 120 kHz for quasi-peak measurements from 30-1000 MHz.
5. The measurement receiver resolution bandwidth setting was 1 MHz for average measurements from 1-18 GHz.

Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1: Summary of Measurement Uncertainties for Site 45

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Mains Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Telecom Conducted Emissions	150 kHz to 30 MHz	N/A	2.8
Radiated Emissions	30 to 1,000 MHz	10 m	4.8
	1 to 18 GHz	3 m	5.7

End of Report

(This page intentionally left blank.)