W66 N220 Commerce Court ● Cedarburg, WI 53012 ● USA
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ENGINEERING TEST REPORT # TR316050 Rx
LSR Job #: C- 2391

Compliance Testing of:

Sterling-LWB

Test Date(s):

2/10/16 – 4/18/16

Prepared For:

Attn: Josh Bablitch
LSR
W66 N220 Commerce Court
Cedarburg, WI 53012

This Test Report is issued under the Authority of: Coty Hammerer, EMC Engineer Signature: Coty Hammerer Date: 5-4-16	
Test Report Reviewed by: Adam Alger, Quality Systems Engineer – Test Services Signature: Date: 5-4-16	**Project Engineer:** Coty Hammerer, EMC Engineer Signature: Coty Hammerer Date: 5-4-16

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EXHIBIT 1. INTRODUCTION

1.1 Scope

References:	CFR Title 47 FCC Part 15
Purpose of Test:	To demonstrate compliance to the requirements of CFR 47 FCC part 15, RSS GEN, and ICES-003
Test Procedures:	Radiated emissions measurements were conducted in accordance with ANSI C63.4
Environmental Classification:	**Residential**

1.2 Normative references

Publication	Title
ANSI C63.4	American National Standard for Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9kHz to 40 GHz
ICES-003	Information Technology Equipment (ITE)- Limits and methods of measurements
RSS GEN	General Requirements for Compliance of Radio apparatus
CFR Title 47 FCC Part 15	Radio Frequency Devices

1.3 LS Research, LLC in Review

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01

Federal Communications Commission (FCC) – USA

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948
FCC Registration Number: 90756

Industrie Canada Industry Canada

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-2
On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-3

1.4 Location Of Testing

All testing was performed at LS Research, LLC, W66 N220 Commerce Court, Cedarburg, Wisconsin, 53012 USA, utilizing the facilities listed below, unless otherwise noted.

List of Facilities Located at LS Research, LLC:

- Semi-Anechoic Chamber

1.5 Test Equipment Utilized

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 Client Information

Manufacturer Name:	LSR
Address:	W66 N220 Commerce Court Cedarburg, WI 53012
Contact Name:	Josh Bablitch

2.2 Equipment Under Test (EUT) information

The following information has been supplied by the applicant.

Product Name:	Sterling-LWB
Model Number:	Sterling-LWB
Serial Number:	WLAN: 23, Bluetooth: 26 (Conducted Testing) WLAN: 15, Bluetooth: 29 (Radiated Testing)

2.3 EUT's Technical Specififcations

Additional Information:

Operating Voltage	3.0 – 3.6 VDC
EUT will be operated under FCC part(s) and/or IC Rule	FCC: CFR 47 part 15 IC: ICES-003, RSS GEN

2.4 Product Description

The Sterling-LWB is a multi-standard module with support for WLAN (802.11 b/g/n), and Bluetooth V2.1 and Bluetooth 4.0 & 4.1 with multiple antenna options.

Chip Antenna: Johanson Part # 2450AT18D0100 Peak Gain 1.5 dBi

U.FL Antenna port utilizes the following antenna options:

LSR 2.4 GHz Dipole Antenna 2dBi
LSR 2.4 GHz FlexPIFA 2dBi
LSR 2.4 GHz FlexNotch 2dBi

EXHIBIT 3. EUT OPERATING CONDITIONS DURING TEST

3.1 Climate test conditions

Temperature:	70-74° Fahrenheit
Humidity:	30-42%
Pressure:	729-742mmHg

3.2 Applicability and summary of EMC emissions test results

FCC part 15 Test Requirements	Compliance (yes/no)
Power Line Conducted Emissions Measurements	Yes
Unintentional Radiated Emissions	Yes

3.3 Modifications incorporated in the EUT for compliance purposes

☒ **None** ☐ **Yes (explain below)**

3.4 Deviations and exclusions from test specifications

☒ **None** ☐ **Yes (explain below)**

EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the emissions requirements as described within the specification of Code of Federal Regulation (CFR) title 47 FCC part 15 and ICES-003.

If some emissions are seen to be within 3 dB of their respective limits:
As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

LS Research, LLC certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 Test Setup

The test setup was assembled in accordance with ANSI C63.4. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 3-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber.

The EUT was powered with a generic DC supply providing 3.6 VDC.

5.2 Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive material in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 200 MHz, and a Log Periodic Antenna was used to measure emissions from 200 MHz to 1000 MHz. Measurements above 1GHz were performed using a double ridged horn antenna and standard gain horn antenna was used for measurements above 18GHz. The maximum radiated RF emissions were found by raising and lowering the sense antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities and rotating the EUT on a turntable. For measurements above 1 GHz the “cone of radiation”, as refered to in ANSI C63.4, was maintained

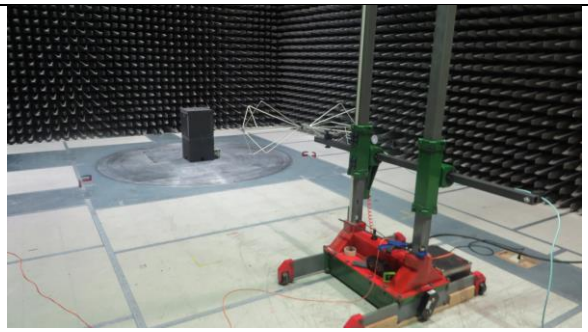
5.3 Test Equipment Utilized

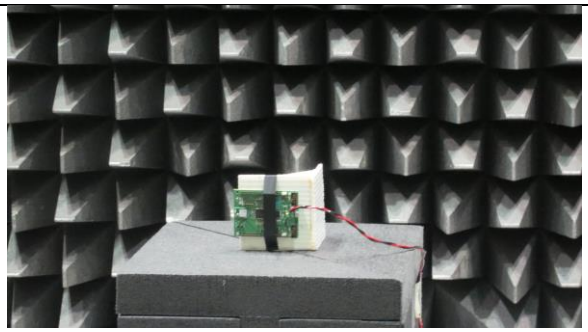
A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at an IEC/ISO 17025 accredited calibration laboratory, traceable to the SI standard. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and an EMI Receiver. The resulting correction factors and the cable loss factors from these calibrations were entered into the EMI Receiver database. As a result, the data taken from the EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading. The EMI Receiver was operated with a resolution bandwidth of 120 kHz for measurements below 1 GHz (video bandwidth of 1.2 MHz), and a bandwidth of 1 MHz for measurements above 1 GHz (video bandwidth of 3 MHz).

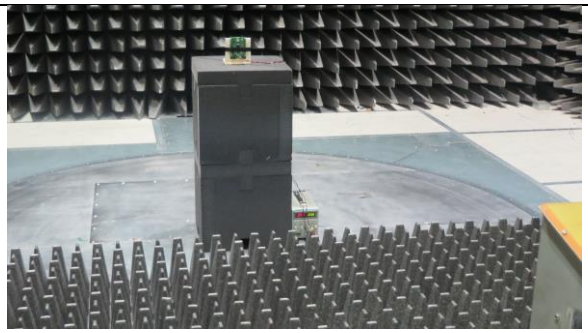
5.4 Test Results

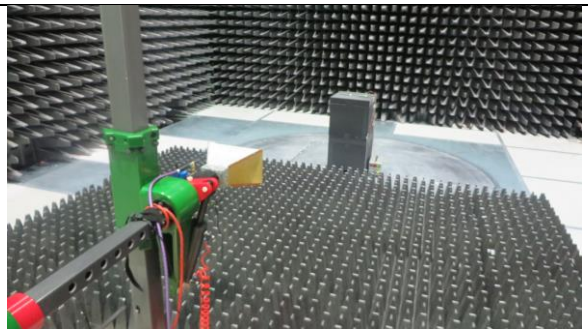
The EUT was found to **MEET** the Radiated Emissions requirements of CFR 47 part 15.109 class B and Industry Canada ICES-003 class B. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

5.5 Test Setup Photos – Radiated Emissions Test









5.6 Calculations of radiated emissions limits

The following table depicts the Class **B** limits.

CFR 47 part 15.109 and RSS GEN/ICES003

Frequency (MHz)	3 m Limit μV/m	3 m Limit (dBμV/m)
30-88	100	40.0
88-216	150	43.0
216-960	200	46.0
960-40,000	500	54.0

Example:

E in dBμV/m = 20log(E in μV/m)
= 20log (100 μV/m)
E = 40.0 dBμV/m

Reported data:

For both fundamental and spurious emissions measurement, the data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBμV/m) + Antenna correction Factor + Cable factor (dB) + Miscellaneous factors when applicable (dB) – amplification factor when applicable (dB).

Example of reported data at 200 MHz:

Reported Measurement data = 18.2 (raw receiver measurement) + 15.8 (antenna factor) + 1.45 (cable factor) = 35.45 (dBμV/m).

5.7 Data Chart- Radiated emissions test

Manufacturer:	LSR					
Date(s) of Test:	2/10/16 – 4/18/16					
Project Engineer(s):	Coty Hammerer					
Test Engineer(s):	Coty Hammerer/Kimberly Bay					
Voltage:	3.6VDC					
Operation Mode:	Continuous receive					
Environmental Conditions in the Lab:	Temperature: 70-74° F Relative Humidity: 30-42 %					
EUT Power:		Single Phase 120 VAC		3 Phase ___VAC		
		Battery		X	Other: 3.6VDC	
EUT Placement:	X	80cm non-conductive table			10cm Spacers	
EUT Test Location:	X	3 Meter Semi-Anechoic FCC Listed Chamber			3/10m OATS	
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:	X	Peak	X	Quasi-Peak	X	Average

The following table depicts the level of significant spurious radiated RF emissions found:

WLAN

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Quasi-Peak Reading (dBµV/m)	Average Reading (dBµV/m)	Peak Limit (dBµV/m)	Quasi-Peak Limit (dBµV/m)	Average Limit (dBµV/m)	Peak Margin (dB)	Quasi-Peak Margin (dB)	Average Margin (dB)	Antenna Polarity	Channel	EUT orientation
76.60	1.00	0.00	N/A	29.60	N/A	N/A	40.00	N/A	N/A	10.40	N/A	V	Mid	Flat
400.00	1.00	202.00	N/A	35.70	N/A	N/A	46.00	N/A	N/A	10.30	N/A	H	Mid	Flat
3660.00	1.00	316.50	46.29	N/A	42.48	74.00	N/A	54.00	27.71	N/A	11.52	H	Mid	Flat
3660.00	2.46	211.25	47.85	N/A	44.40	74.00	N/A	54.00	26.15	N/A	9.60	V	Mid	Flat
7311.00	1.66	327.25	47.85	N/A	42.15	74.00	N/A	54.00	26.15	N/A	11.85	V	Mid	Flat
7238.00	2.29	166.5	48.71	N/A	43.83	74.00	N/A	54.00	25.30	N/A	10.17	V	Mid	Flat
7386.00	2.42	214.25	48.30	N/A	43.77	74.00	N/A	54.00	25.70	N/A	10.23	V	Mid	Flat
7310.00	1.01	306.5	46.30	N/A	39.74	74.00	N/A	54.00	27.70	N/A	14.26	H	Mid	Vert.

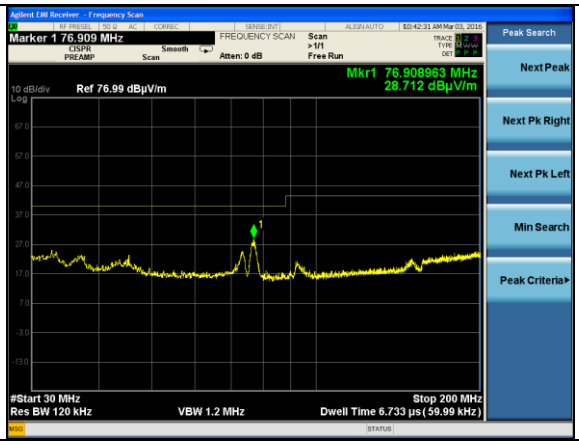
Bluetooth

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Quasi-Peak Reading (dBµV/m)	Average Reading (dBµV/m)	Peak Limit (dBµV/m)	Quasi-Peak Limit (dBµV/m)	Average Limit (dBµV/m)	Peak Margin (dB)	Quasi-Peak Margin (dB)	Average Margin (dB)	Antenna Polarity	Channel	EUT orientation
76.42	1.00	296.75	N/A	29.80	N/A	N/A	40.00	N/A	N/A	10.20	N/A	V	Mid	Vert.
2410.00	1.00	100.00	44.25	N/A	30.05	74.00	N/A	54.00	29.75	N/A	23.95	V	Low	Vert.
2450.00	1.00	0.00	40.28	N/A	27.54	74.00	N/A	54.00	33.72	N/A	26.46	V	Low	Vert.
2413.00	1.00	0.00	32.23	N/A	27.26	74.00	N/A	54.00	41.77	N/A	26.74	H	Low	Side
2464.00	1.00	0	39.87	N/A	27.66	74.00	N/A	54.00	34.13	N/A	26.34	H	Low	Flat
2410.00	1.00	0	44.67	N/A	30.12	74.00	N/A	54.00	29.33	N/A	23.88	V	Low	Flat

5.8 Screen Captures - Radiated Emissions Testing

These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, while both peak and average function is utilized for emissions above 1000 MHz. The plots below represent the worst emissions in each frequency range.

WLAN
30 to 200 MHz



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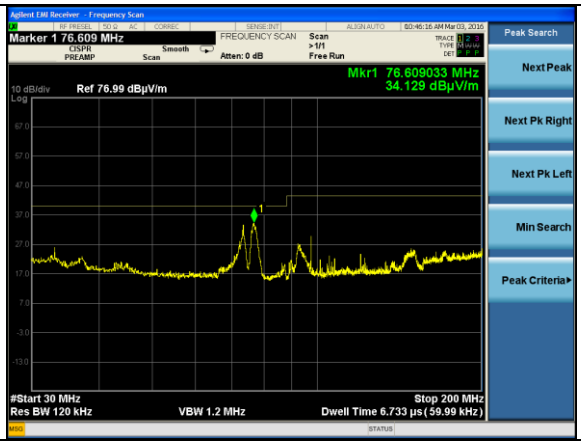
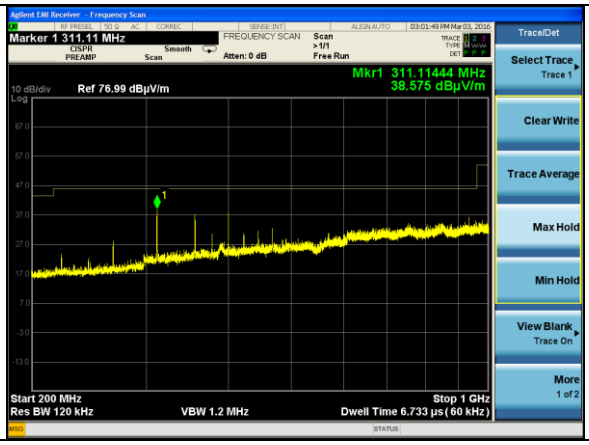


Vertical

200 to 1000 MHz



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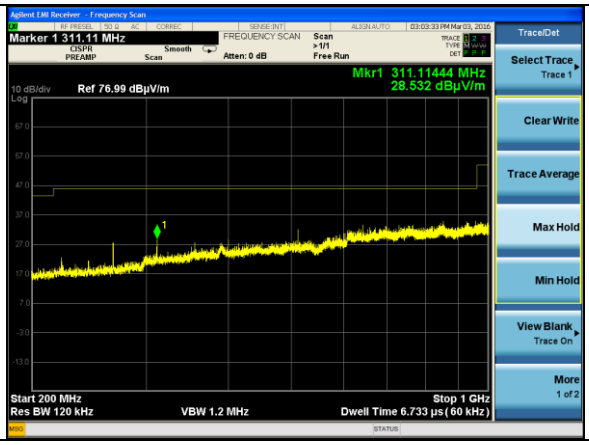
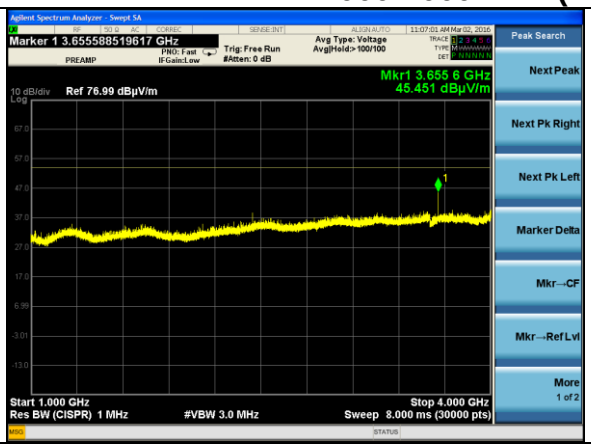


Vertical

1000-4000 MHz (Average Limit Shown)



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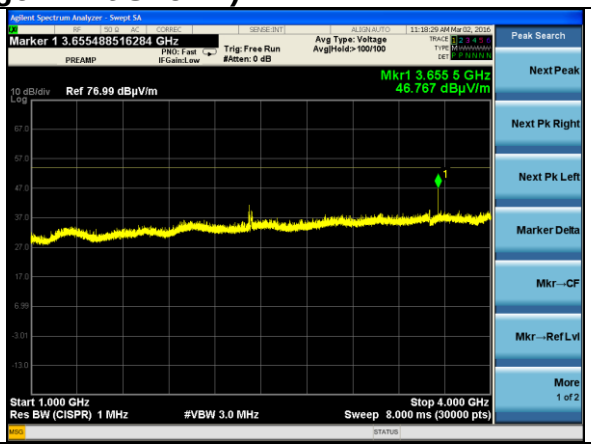
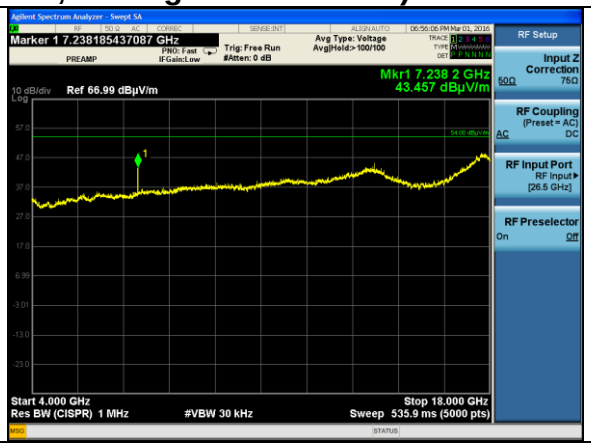


Vertical

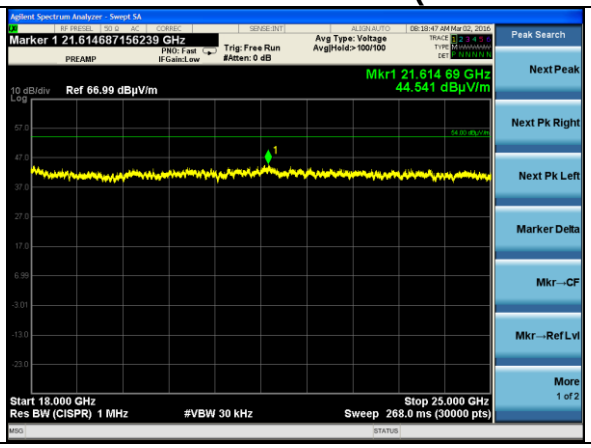
4000-18000 MHz (Reduced bandwidth, Average Limit Shown)

Horizontal

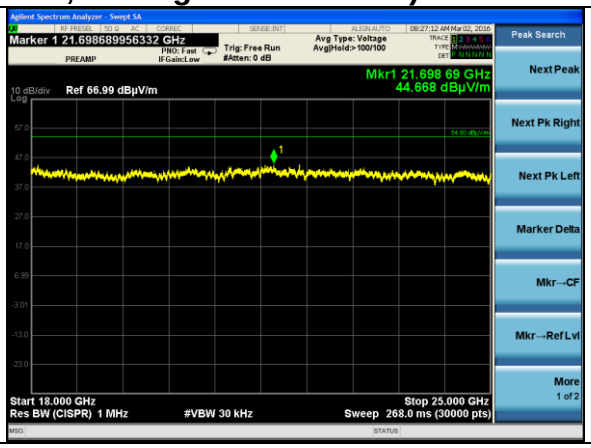


Vertical

18000-25000 MHz (Reduced bandwidth, Average Limit Shown)

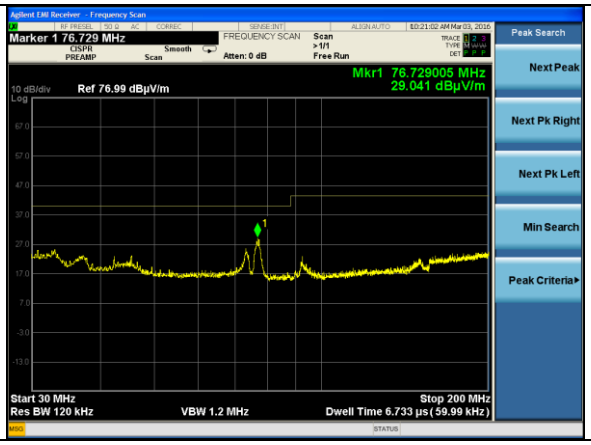


Horizontal



Vertical

Bluetooth
30 to 200 MHz



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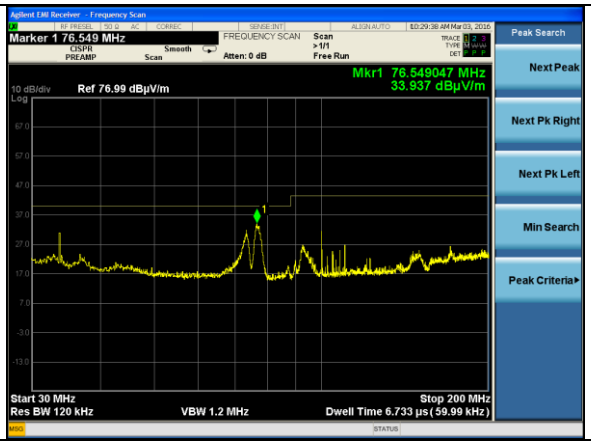
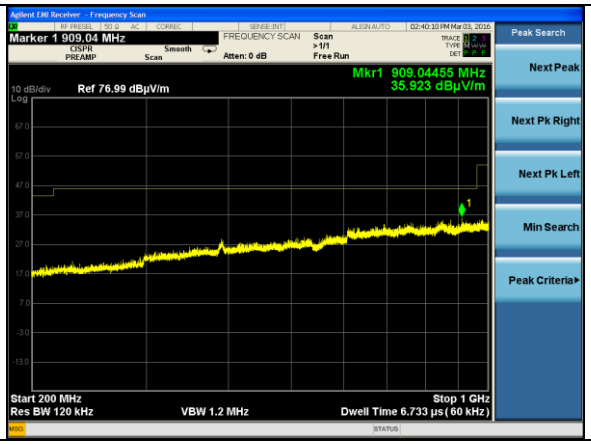


Vertical

200 to 1000 MHz



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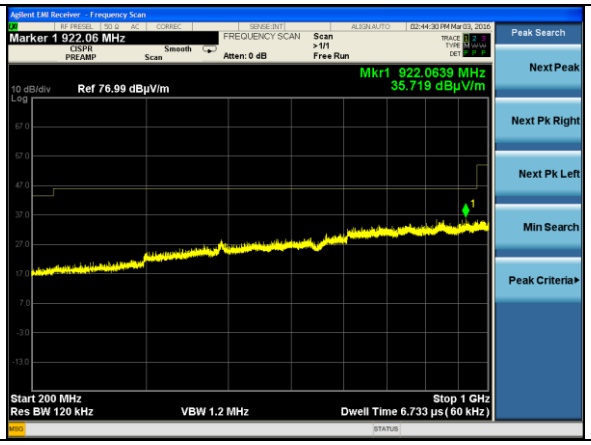


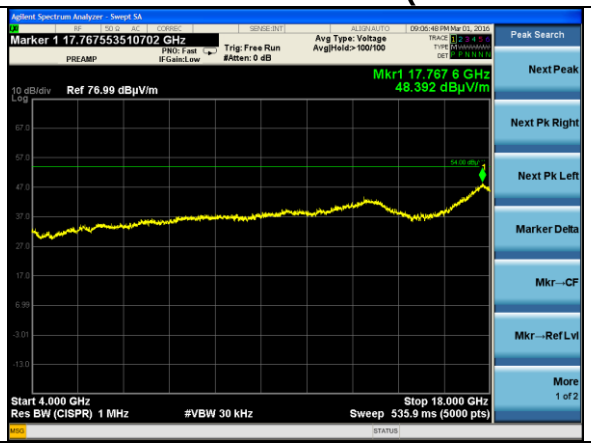
Vertical

1000-4000 MHz (Average Limit Shown)

Horizontal

Vertical

4000-18000 MHz (Reduced bandwidth, Average Limit Shown)



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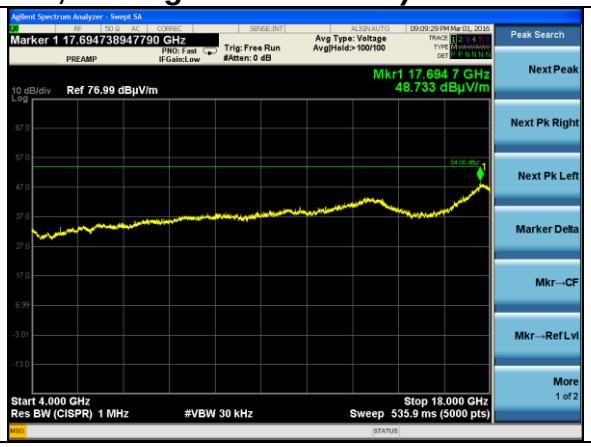
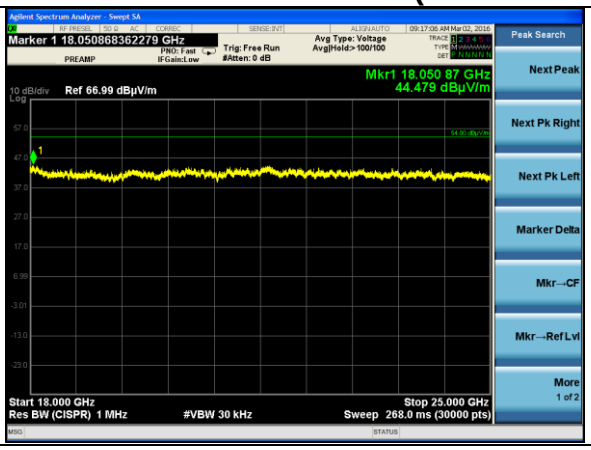


Vertical

18000-25000 MHz (Reduced bandwidth, Average Limit Shown)



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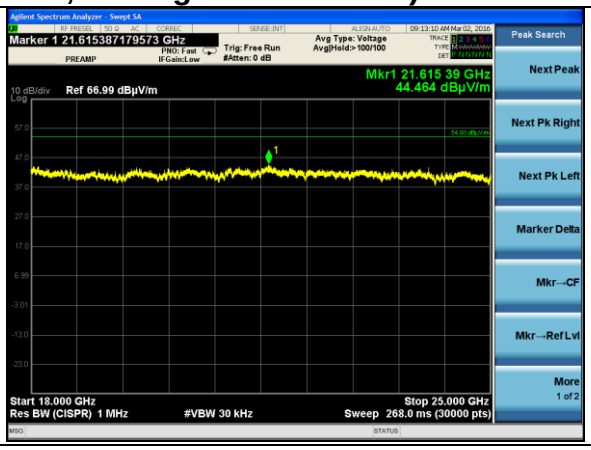


Vertical

EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

6.1 Test Setup

The test area and setup are in accordance with ANSI C63.4 and with Title 47 CFR, FCC Part 15, Industry Canada RSS GEN. The EUT was placed on a non-conductive table, with a height of 80 cm above the reference ground plane. The power supply was then plugged into a 50Ω (ohm), Line Impedance Stabilization Network (LISN). A generic AC-DC Adapter was used to supply of 3.3VDC via an appropriate broadband EMI Filter, and then to the LISN line input. Final readings were then taken and recorded. After the EUT was setup and connected to the LISN, the RF Sampling Port of the EMI receiver System. The LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral).

6.2 Test Procedure

The EUT was investigated in continuous modulated transmit mode for this portion of the testing. The appropriate frequency range and bandwidths were selected on the EMI Receiver, and measurements were made. The bandwidth used for these measurements is 9 kHz, as specified in CISPR 16-1, Section 1, Table 1, for Quasi-Peak and Average detectors in the frequency range of 150 kHz to 30 MHz. Final readings were then taken and recorded.

6.3 Test Equipment Utilized

A list of the test equipment and accessories utilized for the Conducted Emissions test is provided in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. Calibrations of the LISN and Limiter were performed at an IEC/ISO 17025 accredited calibration laboratory, traceable to the SI standard. All cables are calibrated and checked periodically for conformance. The emissions are measured on the EMI System, which has automatic correction for all factors stored in memory and allows direct readings to be taken.

6.4 Test Results

The EUT was found to **MEET** the Conducted Emission requirements of FCC Part 15.107 and ICES-003 Class B. See the Data Charts and Graphs for more details of the test results.

6.5 FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBµV)		Measuring Bandwidth
	Quasi-Peak	Average	
0.150 -0.50 *	66-56	56-46	RBW = 9 kHz VBW ≥ 9 kHz for QP VBW = 1 Hz for Average
0.5 – 5.0	56	46	
5.0 – 30	60	50	
* The limit decreases linearly with the logarithm of the frequency in this range.			

6.6 CONDUCTED EMISSIONS TEST DATA CHART

Manufacturer:	LSR					
Date(s) of Test:	4/16/16					
Project Engineer:	Coty Hammerer					
Test Engineer:	Coty Hammerer					
Voltage:	3.3VDC					
Operation Mode:	Continuous Receive					
Environmental Conditions in the Lab:	Temperature: 70-74° F Relative Humidity: 32-42%					
Test Location:	X	AC Mains Test area				Chamber
EUT Placed On:	X	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:		Peak	X	Quasi-Peak	X	Average

Note: Data used for this test is leveraged from the TX conducted data, which represents the worst-case emissions. Emissions are independent of channel.

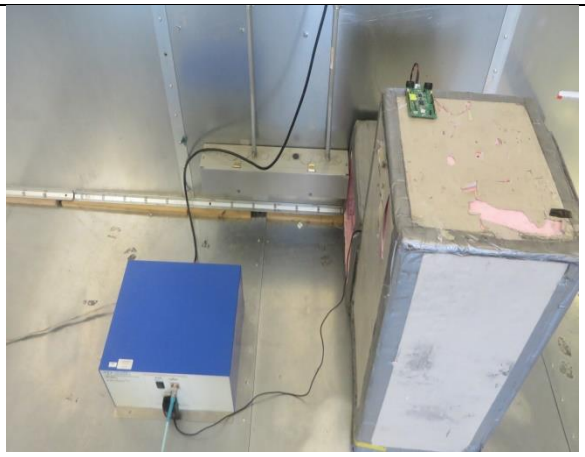
WLAN

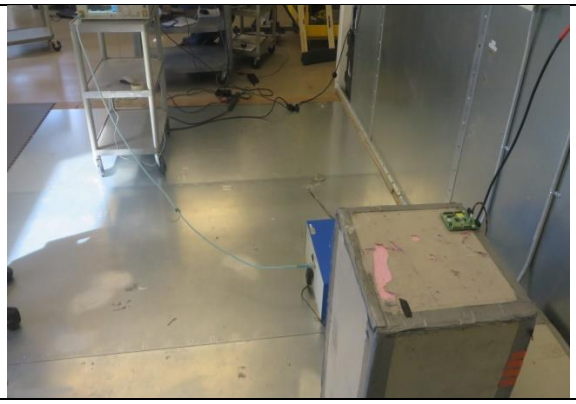
Line	Frequency (MHz)	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµV)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Notes
1	0.20	44.60	63.83	19.23	31.50	53.83	22.33	Tx
1	0.62	40.70	56.00	15.30	30.00	46.00	16.00	Tx
1	0.20	46.50	63.62	17.12	36.20	53.62	17.42	Tx
2	0.20	41.90	63.62	21.72	26.50	53.62	27.12	Tx
2	0.67	41.40	56.00	14.60	25.10	46.00	20.90	Tx
2	0.27	41.30	61.24	19.94	27.30	51.24	23.94	Tx

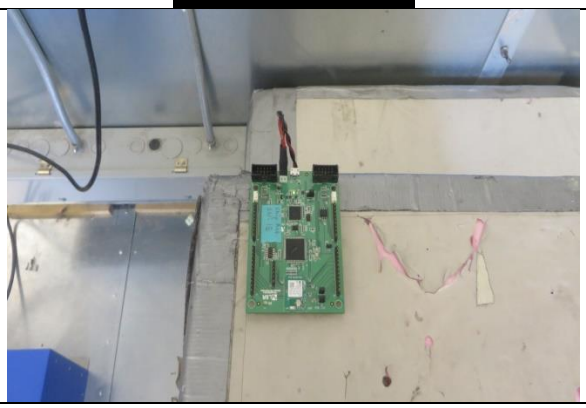
Bluetooth

Line	Frequency (MHz)	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµV)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Notes
1	0.15	40.50	66.00	25.50	28.30	56.00	27.70	Tx
1	0.63	33.60	56.00	22.40	25.50	46.00	20.50	Tx
1	0.16	39.80	65.42	25.62	28.70	55.42	26.72	Tx
2	0.62	34.00	56.00	22.00	24.90	46.00	21.10	Tx
2	0.16	33.00	65.73	32.73	19.90	55.73	35.83	Tx
2	0.16	34.70	65.47	30.77	21.60	55.47	33.87	Tx

6.7 Test Setup Photo(s) – Conducted Emissions Test



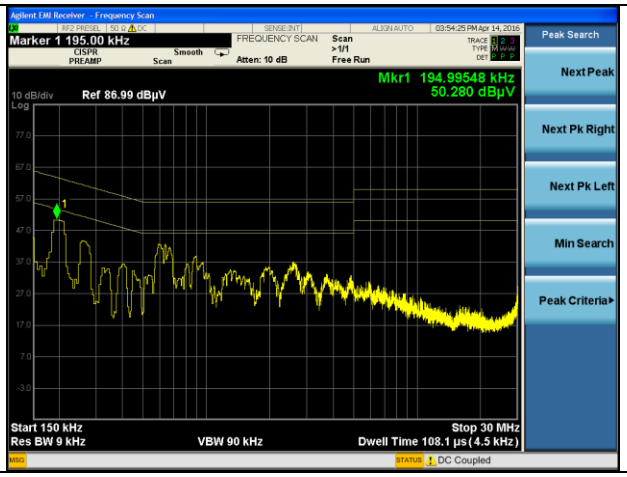




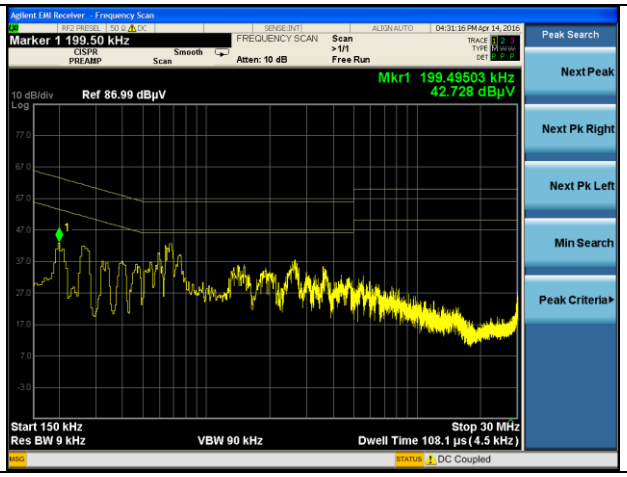
6.8 Screen Captures – Conducted Emissions Test

These screen captures represent Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized. The plots below represent the worst-case emissions.

WLAN

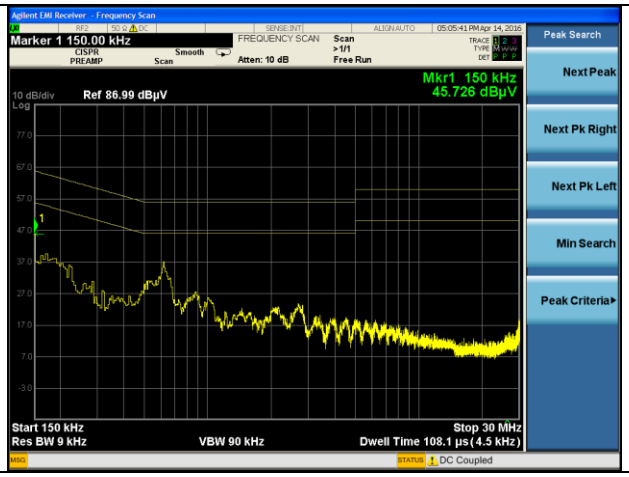


Line 1

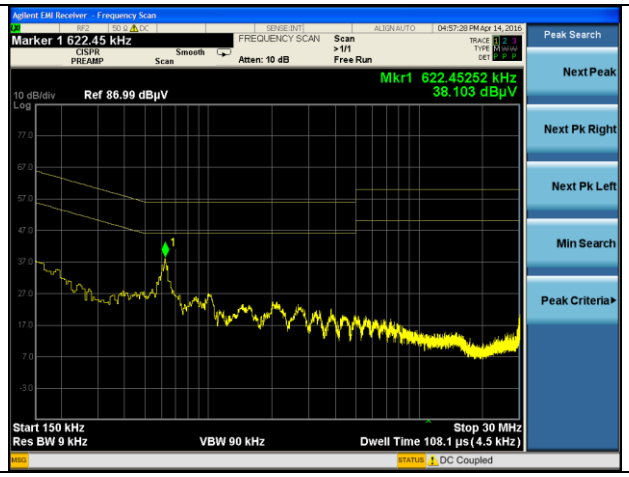


Line 2

Bluetooth



Line 1



Line 2

APPENDIX A: Test Equipment List

Date: 11-Feb-2016 Type Test: Radiated Measurements Job #: C-2391

Prepared By: Coty Hammerer Customer: LSR Quote #: 316050

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960153	2.4GHz High Pass Filter	KWM	HPF-L-14186	7272-04	4/15/2015	4/15/2016	Active Calibration
2	EE 960159	0.8 - 21GHz LNA	Mini-Circuits	ZVA-213X-S+	40201429	2/4/2016	2/4/2017	Active Calibration
3	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	2/4/2016	2/4/2017	Active Calibration
4	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	Verification	Verification	System
5	AA 960162	EM Series Cable	MegaPhase	EM26-S1S1-120	12024301 001	6/30/2015	6/30/2016	Active Calibration
6	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/6/2015	5/6/2016	Active Calibration
7	EE 960077	DC Power Supply	GW Instek	GPS-3030DD	EJ810521	Verification	Verification	System
8	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	1/14/2016	1/14/2017	Active Calibration
9	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	3/31/2016	3/31/2017	Active Calibration
10	Rental	Horn Antenna 18-40 GHz	AH Systems, Inc	SAS-574	193	11/30/2015	11/30/2016	Active Calibration

Date: 14-Apr-2016 Type Test: Conducted Emissions Job #: C-2391

Prepared By: Coty Hammerer Customer: LSR Quote #: 316050

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960162	LISN - 15A	COM-POWER	LI-215A	191969	7/24/2015	7/24/2016	Active Calibration
2	EE 960077	DC Power Supply	GW Instek	GPS-3030DD	EJ810521	Verification	Verification	System
3	EE 960088	8GHz MXE Spectrum Analyzer	Agilent	N9038A	MY51210138	2/24/2016	2/24/2017	Active Calibration

Project Engineer: Coty Hammerer Quality Assurance:

APPENDIX B: Test Standards

STANDARD #	DATE	Am. 1	Am. 2
CFR 47 part 15	2016		
ANSI C63.4	2014		
RSS GEN	2014		
ICES-003	2016		

APPENDIX C: Uncertainty Statement

Table of Expanded Uncertainty Values, (K=2) for Specified Measurements

Measurement Type	*Particular Configuration*	*Uncertainty Values*
Radiated Emissions	*3 – Meter chamber, Biconical Antenna*	*4.82 dB*
Radiated Emissions	*3-Meter Chamber, Log Periodic Antenna*	*4.88 dB*
Radiated Emissions	*3-Meter Chamber, Horn Antenna*	*4.85 dB*
Radiated Emissions	*10-Meter OATS, Biconical Antenna*	*4.32 dB*
Radiated Emissions	*10-Meter OATS, Log Periodic Antenna*	*3.63 dB*
AC Line Conducted Emissions	*Shielded Room/EMCO LISN*	*3.20 dB*
Temperature/Humidity	*Thermo-hygrometer*	*0.64° / 2.88 %RH*