LS RESEARCH, LLC
WIRELESS PRODUCT DEVELOPMENT
ACCREDITED TESTING CERT #1255.01
W66 N220 Commerce Court ● Cedarburg, WI 53012 ● USA
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TEST REPORT # 311256 B
LSR Job #: C-1283

Compliance Testing of:
900 MHz Transceiver with Dipole Antenna

Test Date(s):
September 23, 27, 28, October 4, November 8, 10, 2011, October 4, 2012

Prepared For:
LS Research, LLC
W66 N220 Commerce Ct
Cedarburg, WI 53012

In accordance with:
Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247
Industry Canada (IC) RSS 210 Annex 8
Frequency Hopping Spread Spectrum (FHSS) Operating in the
Frequency Band 902-928 MHz

This Test Report is issued under the Authority of:

Signature: Peter Feilen Date: 10/17/12

Test Report Reviewed by: Adam Alger, EMC Engineer	Tested by: Peter Feilen, EMC Engineer.
Signature: Adam O Alger Date: 10/16/12	Signature: Peter Feilen Date: 10/4/12

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EXHIBIT 1. INTRODUCTION

1.1 - Scope

References:	FCC Part 15, Subpart C, Section 15.247 and 15.209 FCC Part 2, Section 2.1043 paragraph (b)1. RSS GEN and RSS 210 Annex 8
Title:	FCC : Telecommunication – Code of Federal Regulations, CFR 47, Part 15. IC : Low-power License-exempt Radio-communication Devices (All Frequency Bands): Category I Equipment
Purpose of Test:	To gain FCC and IC Certification Authorization for Low-Power License-Exempt Transmitters.
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute 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 9 kHz to 40 GHz.
Environmental Classification:	Commercial, Industrial or Business Residential

1.2 – Normative References

Please reference Appendix B for test standards followed.

1.3 - LS Research, LLC Test Facility

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025, 2005 "General Requirements for the Competence of Calibration and Testing Laboratories".

LS Research, LLC's scope of accreditation includes all test methods listed herein, unless otherwise noted. A copy of the accreditation may be accessed on our web site: www.lsr.com. Accreditation status can be verified at A2LA's web site: www.a2la2.net.

1.4 – Location of Testing

All testing was performed at the following location utilizing the facilities listed below, unless otherwise noted.

LS Research, LLC
W66 N220 Commerce Court
Cedarburg, Wisconsin, 53012 USA,

List of Facilities Located at LS Research, LLC:

Compact Chamber
Semi-Anechoic Chamber
Open Area Test Site (OATS)

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. All test equipment is calibrated in accordance with A2LA standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	LS Research, LLC
Address:	W66 N220 Commerce Ct
Contact Name:	Bill Steinike

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	SiFLEX01
Model Number:	SiFLEX01
Serial Number:	SF01A2003

2.3 - Associated Antenna Description

An articulating dipole antenna with u.fl to reverse-gendered SMA connector, gain +2 dBi, is utilized.

2.4 - EUT'S Technical Specifications

EUT Frequency Range (in MHz)	903-926.6 MHz
Maximum Conducted Output Power (in dBm)	24.5 dBm
Minimum Conducted Output Power (in dBm)	24.5 dBm
Field Strength at 3 meters	126.2 dBuV/m
Occupied Bandwidth (99% BW)	496 kHz
Type of Modulation	FSK
Emission Designator	496kFXD
EIRP (in mW)	446.68 mW
Transmitter Spurious (worst case) at 3 meters	47.3 dBuV/m
Receiver Spurious (worst case) at 3 meters	52.3 dBuV/m
Receiver Bandwidth	203 kHz
Receiver Sensitivity	-100 dBm
Stepped (Y/N)	No
Step Value:	N/A
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Microprocessor Model #	CC430F6137IRGC
Antenna Information	
Detachable/non-detachable	Detachable
Type	Dipole
Gain (in dBi)	+2.0 dBi
EUT will be operated under FCC Rule Part(s)	15.247
EUT will be operated under RSS Rule Part(s)	RSS 210
Modular Filing	☒ Yes ☐ No
Portable or Mobile?	Mobile

RF Technical Information:

Type of Evaluation (check one)		SAR Evaluation: Device Used in the Vicinity of the Human Head
		SAR Evaluation: Body-worn Device
	X	RF Evaluation

If RF Evaluation checked above, test engineer to complete the following:

Evaluated against exposure limits: ☒ General Public Use ☐ Controlled Use
Duty Cycle used in evaluation: 100 %
Standard used for evaluation: OET 65
Measurement Distance: 20 cm
RF Value: 0.889 ☐ V/m ☐ A/m ☒ W/m^2
☐ Measured ☐ Computed ☒ Calculated

2.5 - Product Description

The SiFLEX01 module is a high performance 900MHz radio based on the Texas Instruments CC430 combined with the CC1190 front-end in a cost effective footprint, and is adaptable to many different applications.

The CC1190 is a companion IC that works in conjunction with the radio in the CC430. The CC1190 is a range extender that integrates a Power Amplifier (PA), a Low Noise Amplifier (LNA), switches, and RF matching in a single package. The CC1190 is core component on the module and is controlled via control signals from the CC430.

Note: Unique firmware, which cannot be altered by the end user, was used for all testing.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	15-35 ºC
Humidity:	30-60%
Pressure:	645-795 mmHg

3.2 - Applicability & Summary Of EMC Emission Test Results

FCC and IC Paragraph	Test Requirements	Compliance (Yes/No)
FCC : 15.207 IC : RSS GEN sect. 7.2.2	Power Line Conducted Emissions Measurements	Yes
FCC : 15.247 (a)(1)(i) IC : RSS 210 A8.1 (a)	20 dB Bandwidth	Yes
FCC : 15.247(b) & 1.1310 IC : RSS 210 A8.4	Maximum Output Power	Yes
FCC : 15.247(i), 1.1307, 1.1310, 2.1091 & 2.1093 IC : RSS 102	RF Exposure Limit	Yes
FCC :15.247(c) IC : RSS 210 A8.5	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC:15.247 (a)(1)(i) IC: RSS 210 (b)	Carrier Frequency Separation	Yes
FCC:15.247 (a)(1)(i),(ii),(iii) IC: RSS 210 (c),(d),(e)	Number of hopping channels	Yes
FCC:15.247 (a)(1)(i),(ii),(iii) IC: RSS 210 (c),(d),(e)	Time of occupancy (Dwell Time)	Yes
FCC : 15.247(c), 15.209 & 15.205 IC : RSS 210 A8.2(b), section 2.2, 2.6 and 2.7	Transmitter Radiated Emissions	Yes

3.3 - Modifications Incorporated In The EUT For Compliance Purposes

☒ None ☐ Yes (explain below)

3.4 - Deviations & Exclusions From Test Specifications

☒ None ☐ Yes (explain below)

Note: Data presented is dated more than 1 year old. Data has been re-reviewed and the testing in the report is valid.

EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the requirements as described within the specification of FCC Title 47, CFR Part 15.247, and Industry Canada RSS-210, Issue 8 (2010), Section Annex 8 (section A8.1) for a Frequency Hopping Spread Spectrum (FHSS) Transmitter.

Note: 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 Title 47, CFR FCC Part 15, RSS GEN and ANSI C63.4-2003. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber. The EUT was operated in continuous modulated transmit mode for final testing using power as provided by a bench DC supply. 3 separate units were provided for testing on 3 different channels.

The applicable limits apply at a 3 meter distance. Measurements above 4 GHz were performed at a 1.0 meter separation distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of three (3) standard channels: low (903.0 MHz), middle (914.6 MHz) and high (926.6 MHz) to comply with FCC Part 15.31(m). The channels and operating modes were set via laptop computer using customer specific test code and test program.

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 10000 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 pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Bi-conical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 10 GHz. The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities.

The EUT was rotated along three orthogonal axes during the investigations to find the highest emission levels.

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 resolution bandwidths as prescribed in ANSI C63.4.

5.4 - Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.247 and Canada RSS-210, Issue 8 (2010), Annex 8 for a FHSS transmitter. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

5.5 - Calculation of Radiated Emissions Limits

The maximum peak output power of an intentional radiator in the 902 to 928 MHz band, as specified in Title 47 CFR 15.247 and RSS 210 is 1 Watt. The harmonic and spurious RF emissions, as measured in any 100 kHz bandwidth, as specified in 15.247 (d) and RSS 210 A8.5, shall be at least 20 dB below the measured power of the desired signal, and must also meet the requirements described in 15.205(c) for FCC and section 2.2, 2.6 and 2.7 of RSS 210 for IC.

The following table depicts the general radiated emission limits above 30 MHz. These limits are obtained from Title 47 CFR, Part 15.209, for radiated emissions measurements. These limits were applied to any signals found in the 15.205 restricted bands. The mentioned limits correspond to those limits listed in RSS 210 section 2.7.

Frequency (MHz)	3 m Limit μV/m	3 m Limit (dBμV/m)	1 m Limit (dBμV/m)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-24,000	500	54.0	63.5

Sample conversion of field strength (μV/m to dBμV/m):
dBμV/m = 20 log $_{10}$ (100)= 40 dBμV/m (from 30-88 MHz)

For measurements made at 1.0 meter, a 9.5 dB correction has been invoked.

960 MHz to 10,000 MHz
500μV/m or 54.0 dB/μV/m at 3 meters
54.0 + 9.5 = 63.5 dB/μV/m at 1 meter

Generic sample of reported data for 200MHz:

Raw Data + Antenna Factor + Cable Factor = Reported Data

18.2 dBμV/m + 15.8 dB + 1.45 dB = 35.45 dBμV/m

5.6 - Radiated Emissions Test Data Chart

Frequency Range Inspected: 30 MHz to 10000 MHz

Manufacturer:	LS Research, LLC						
Date(s) of Test:	September 22,23,28, November 8, 2011						
Project Engineer:	Peter Feilen						
Test Engineer(s):	Peter Feilen						
Voltage:	3.3 VDC						
Operation Mode:	Continuous transmit, modulated mode						
Environmental Conditions in the Lab:	Temperature: 71° F Relative Humidity: 32 %						
EUT Power:		Single Phase ___VAC		3 Phase ___VAC			
		Battery	X	Other: Bench DC Supply			
EUT Placement:		80cm non-conductive table		10cm Spacers			
EUT Test Location:	X	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS			
Measurements:		Pre-Compliance		Preliminary		Final	
Detectors Used:	X	Peak	X	Quasi-Peak	X	Average	

The following table depicts the level of significant spurious radiated RF emissions found (other than the fundamentals and its harmonics):

Frequency (MHz)	Height (m)	Azimuth (degree)	Quasi Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
85.1	2.05	257	21.05	40.0	19.0	H	SIDE
296.9	1.00	0	25.57	46.0	20.4	H	SIDE
742.0	1.35	183	26.56	46.0	19.4	H	SIDE
960.5	1.42	16	43.13	54.0	10.9	H	SIDE

Note:

1. H: Horizontal, V: Vertical, F: Flat.

RADIATED EMISSIONS DATA CHART (continued)

The following table depicts the level of significant radiated harmonic emissions seen on Channel Low (903.0 MHz):

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
2708.985	1.00	0	46.9	42.5	54.0	11.5	Vertical	Side
3611.98	1.00	224	48.5	42.1	54.0	11.9	Horizontal	Vertical
4514.975	1.00	331	49.4	41.2	54.0	12.8	Vertical	Side
5417.97	1.00	0	60.1	52.1	63.5	11.4	Horizontal	Vertical
8126.955	1.03	281	59.1	45.6	63.5	17.9	Vertical	Flat
9029.95	1.02	218	52.9	41.7	63.5	21.9	Horizontal	Vertical

The following table depicts the level of significant radiated harmonic emissions seen on Channel Middle (914.6 MHz):

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
2743.9293	1.37	0	47.6	43.2	54.0	10.8	Horizontal	Side
3658.5724	1.00	256	48.1	41.5	54.0	12.5	Horizontal	Vertical
4573.2155	1.00	346	46.3	36.2	54.0	17.8	Vertical	Side
7317.1448	1.00	307	61.0	48.5	63.5	15.0	Vertical	Flat
8231.7879	1.00	264	61.4	47.3	63.5	16.2	Vertical	Flat
9146.431	1.00	207	53.0	41.0	63.5	22.5	Horizontal	Flat

The following table depicts the level of significant radiated harmonic emissions seen on Channel High (926.6 MHz):

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
2779.8627	1.09	161	42.8	36.9	54.0	17.1	Horizontal	Side
3706.4836	1.00	223	49.8	42.7	54.0	11.3	Horizontal	Vertical
4633.1045	1.42	315	54.7	47.3	54.0	6.7	Vertical	Side
7412.9672	1.07	82	63.7	51.3	63.5	12.3	Vertical	Flat
8339.5881	1.03	294	57.0	44.5	63.5	19.0	Vertical	Flat

Notes:

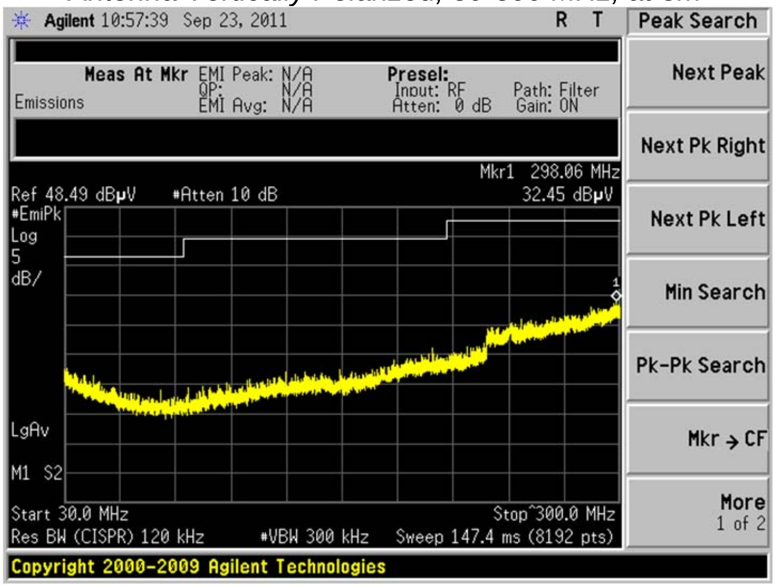
1. A Quasi-Peak Detector was used in measurements below 1 GHz. To ensure the peak emissions did not exceed 20 dB above the limits a peak detector was used. A peak detector with video averaging was used for measurements above 1 GHz.
2. Measurements above 5 GHz were made at 1 meters of separation from the EUT. Limits have been corrected to reflect the change in measurement distance.
3. H: Horizontal, V: Vertical, F: Flat, S: Side.

5.7 - Screen Captures - Radiated Emissions Test

These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and a video averaged Peak detector function is utilized when measuring frequencies above 1 GHz.

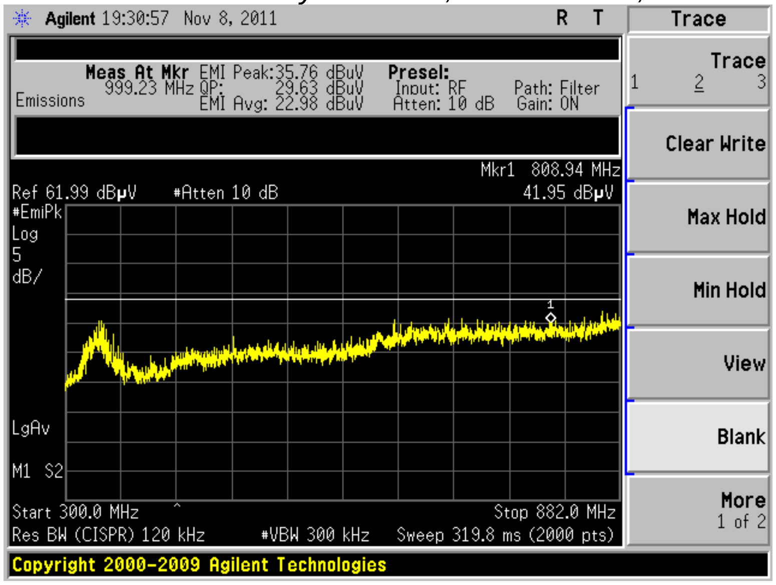
The signature scans shown here are from worst-case emissions, as measured on channels 903 MHz, 914.6 MHz, or 926.6 MHz, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Antenna Vertically Polarized, 30-300 MHz, at 3m



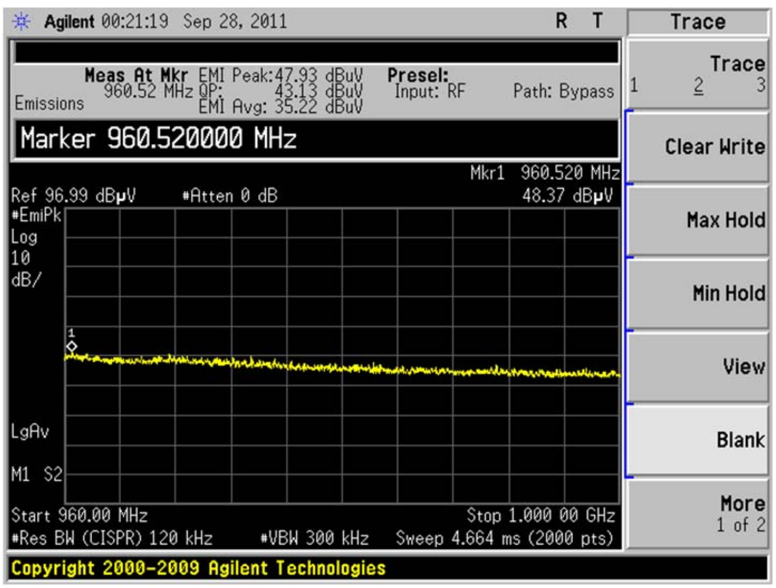
Screen Captures - Radiated Emissions Testing – Transmit Mode (continued)

Antenna Horizontally Polarized, 300-882 MHz, at 3m



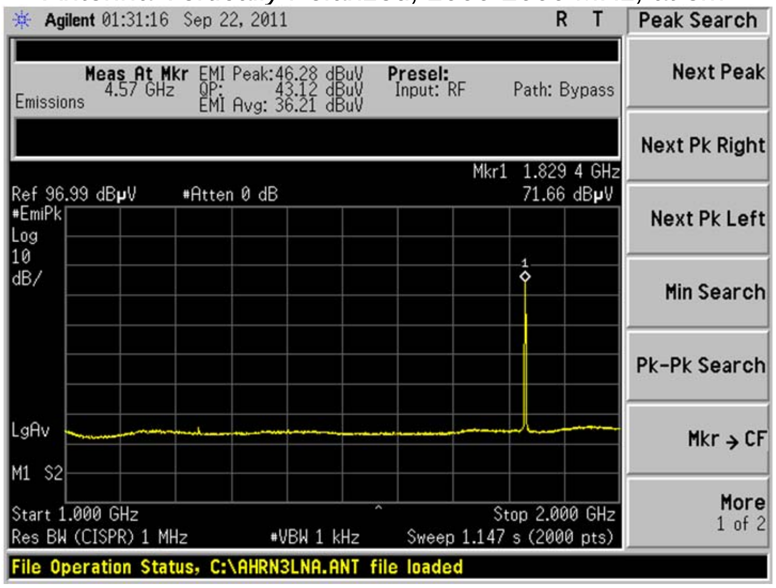
Note: The frequency range 882-902 MHz and 926-960 MHz is in the Band-edge section (Exhibit 8).

Antenna Horizontally Polarized, 960-1000 MHz, at 3m

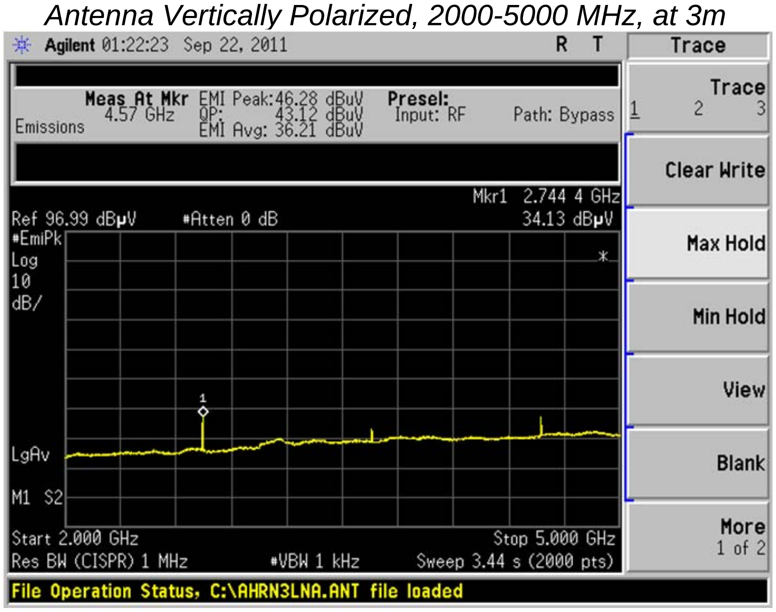


Screen Captures - Radiated Emissions Testing – Transmit Mode (continued)

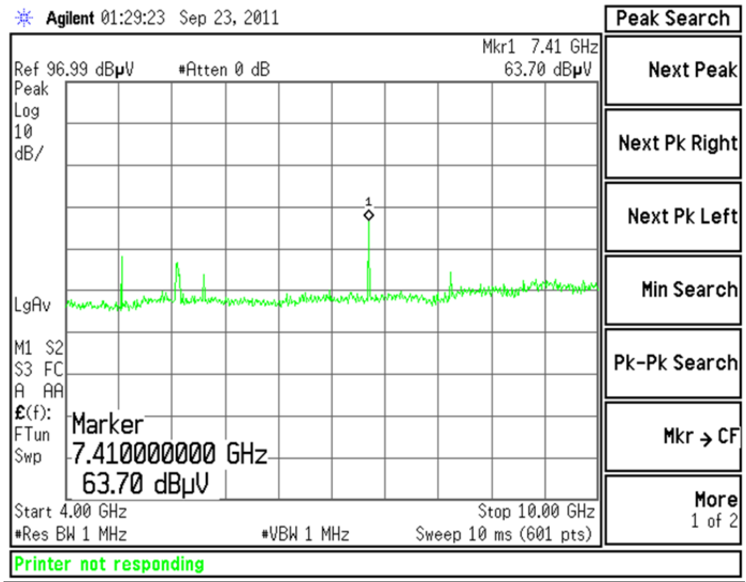
Antenna Vertically Polarized, 1000-2000 MHz, at 3m



Antenna Vertically Polarized, 2000-5000 MHz, at 3m



Antenna Vertically Polarized, 4000-10000 MHz, at 1m



5.9 - Receive Mode Testing

Per the requirements of RSS-210 and CFR 47 part 15, the EUT was placed in continuous receive mode and the radiated spurious emissions were measured and compared to the limits stated in RSS-Gen Section 4.10 and CFR 47 15.109.

The test setup, procedure, and equipment utilized were identical to that described in sections 5.1, 5.2, and 5.3 of this document.

Measurement data and screen captures from the receive tests are presented below:

Frequency (MHz)	Height (m)	Azimuth (degree)	Quasi-Peak Reading (dBµV/m)	Quasi-Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
299.0	1.00	0	25.0	46.0	21.0	H	side
992.48	1.00	0	30.1	54.0	23.9	H	side
3839.4	1.00	0	27.2	54.0	26.8	H	side
389.04	1.00	0	35.2	46.0	10.8	H	side

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Average Reading (dBµV/m)	E-Field Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
5486.7	1.01	0	62.9	61.8	63.5	1.7	V	S

Notes:

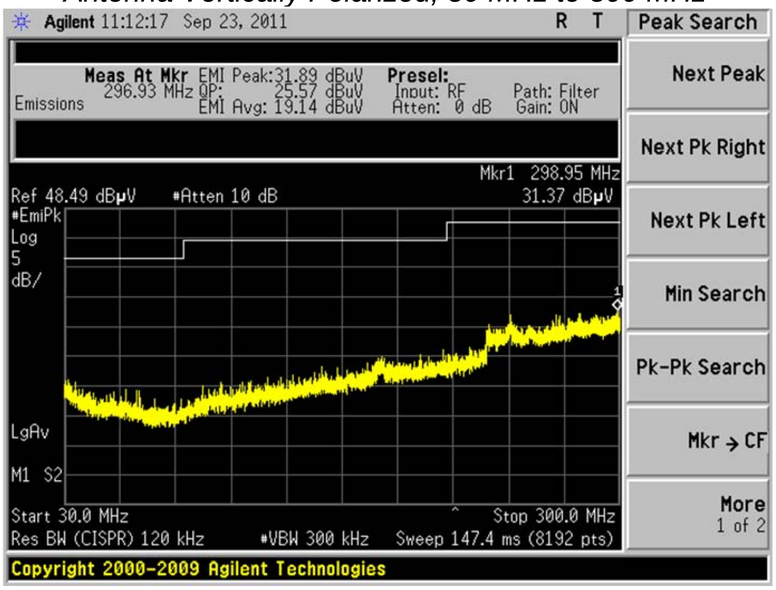
1. A Quasi-Peak Detector was used in measurements below 1 GHz. To ensure the peak emissions did not exceed 20 dB above the limits a peak detector was used. A peak detector with video averaging was used for measurements above 1 GHz.
2. Measurements above 4 GHz were made at 1 meters of separation from the EUT.
3. H: Horizontal, V: Vertical, F: Flat, S: Side.

5.10 - Screen Captures - Radiated Emissions Testing – Receive Mode

These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and a video averaged Peak detector function is utilized when measuring frequencies above 1 GHz.

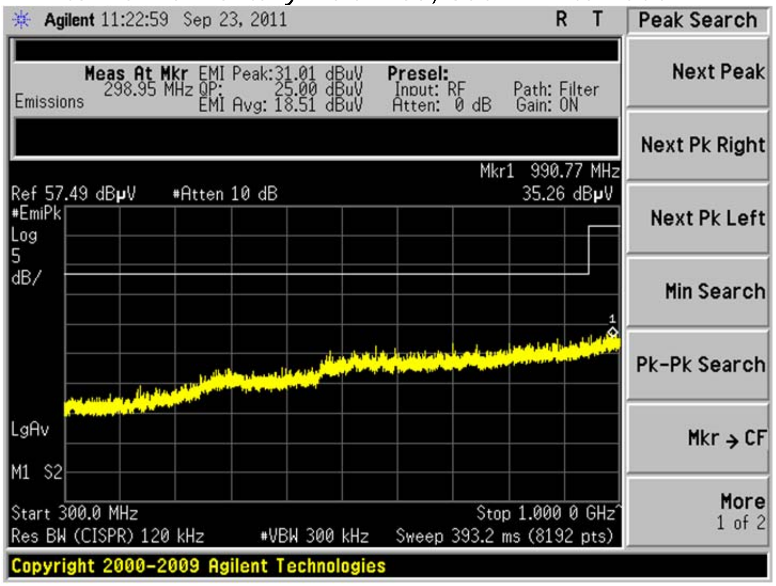
The signature scans shown here are from worst-case emissions, as measured on channels 903.0 MHz, 914.6 MHz, or 926.6 MHz, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Antenna Vertically Polarized, 30 MHz to 300 MHz



Screen Captures - Radiated Emissions Testing – Receive Mode (continued)

Antenna Horizontally Polarized, 300 MHz to 1000 MHz



Antenna Vertically Polarized, 1000 MHz to 4000 MHz

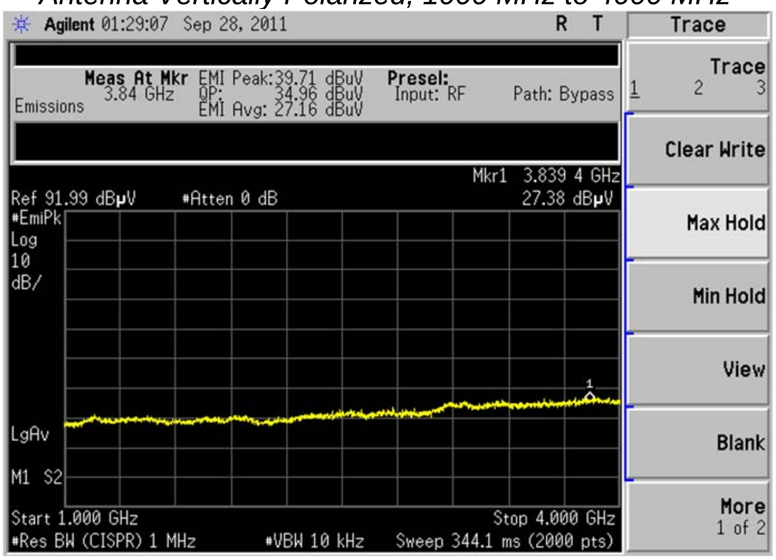


EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

6.1 - Test Setup

The test area and setup are in accordance with ANSI C63.4-2003 and with Title 47 CFR, FCC Part 15, Industry Canada RSS-210 and RSS GEN. The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The EUT's power cable was plugged into a 50Ω (ohm), 50/250 μH Line Impedance Stabilization Network (LISN). The AC power supply of 120V was provided 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 LISN was connected to a 10 dB Attenuator-Limiter, and then to the EMI Receiver. The EMCO 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 and continuous receive 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.

An Enercell brand off-the-shelf AC-DC power supply was used during the test to supply the EUT with voltage.

6.3 - Test Equipment Utilized

Please see Appendix A.

6.4 - Test Results

The EUT was found to **MEET** the Conducted Emission requirements of FCC CFR 47 Part **15.207** and **15.107**, Conducted Emissions. See the Data Charts and Graphs for more details of the test results. By virtue of meeting the requirements of FCC, the EUT also meets the requirements of IC **RSS 210** and **RSS GEN**.

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

Frequency Range inspected: 150 KHz to 30 MHz
Test Standard: FCC 15.207 Class B
IC RSS GEN 7.2.2

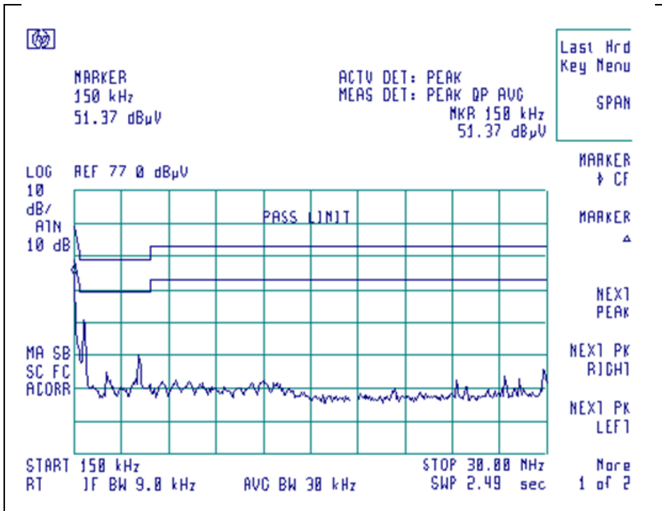
Manufacturer:	LS Research, LLC					
Date(s) of Test:	October 4, 2012					
Project Engineer:	Peter Feilen					
Voltage:	3.6VDC Nominal Voltage					
Operation Mode:	Continuous transmit and Continuous receive					
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %					
Test Location:						Chamber
EUT Placed On:	X	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	X	Final
Detector Used:		Peak	X	Quasi-Peak	X	Average

Frequency (MHz)	Line	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµV)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)
0.151	1	27.900	65.945	38.045	20.600	55.945	35.345
0.150	2	27.600	66.000	38.400	19.600	56.000	36.400

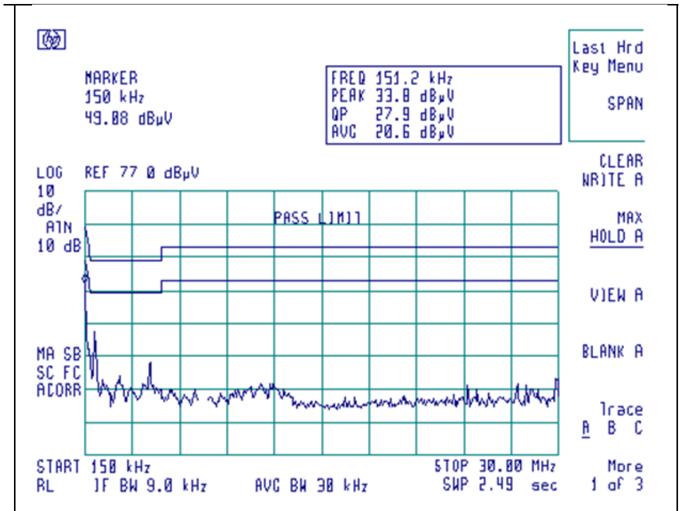
Notes:
1) *The emissions listed are characteristic of the power supply used, and did not change by the EUT.*
2) *The EUT exhibited similar emissions in transit and receive modes*
3) *All other emissions were better than 20 dB below the limits.*

6.7 - 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 emissions must meet both the Quasi-peak limit and the Average limit as described in 47 CFR 15.207 and RSS GEN 7.2.2 (Table 2).



Line 1



Line 2

EXHIBIT 7. OCCUPIED BANDWIDTH

7.1 - Limits

For a frequency Hopping system in the 902 to 928 MHz band, the 20 dB bandwidth shall not exceed 500 kHz for FCC CFR 47 15.247 (a)(1)(i) and IC RSS 210 A8.1. (c).

7.2 - Method of Measurements

Public notice DA 00-705 was observed for measurement guidance. The transmitter output was connected to the Spectrum Analyzer. The bandwidth of the fundamental frequency was measured with the Spectrum Analyzer using 30 kHz RBW and VBW=300 kHz.

For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to a spectrum analyzer. An attenuator was placed in series with the cable to protect the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, allowing direct measurements, without the need for any further corrections. A spectrum analyzer was used with the resolution bandwidth set to 1 kHz for this portion of the tests. The EUT was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used in peak-hold mode while measurements were made, as presented in the chart below.

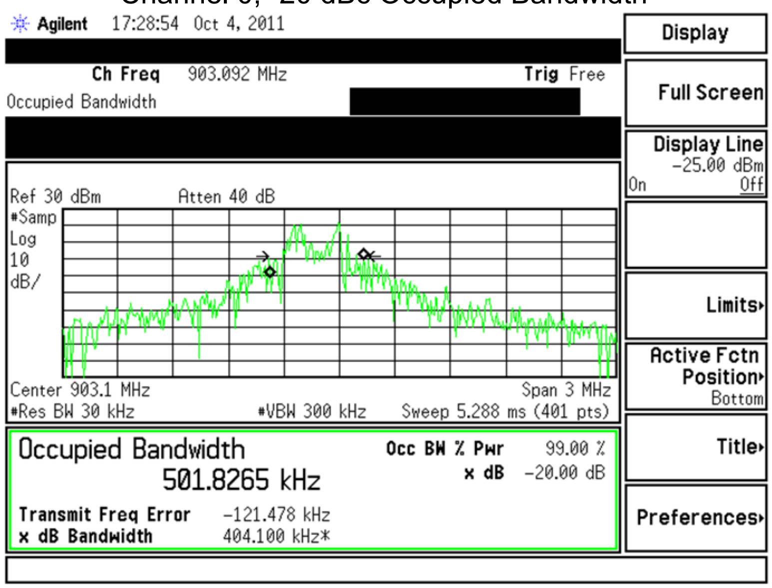
From this data, the closest measurement (20 dB bandwidth) when compared to the specified limit, is 496 kHz, which is below the maximum of 500 kHz.

7.3 - Test Data

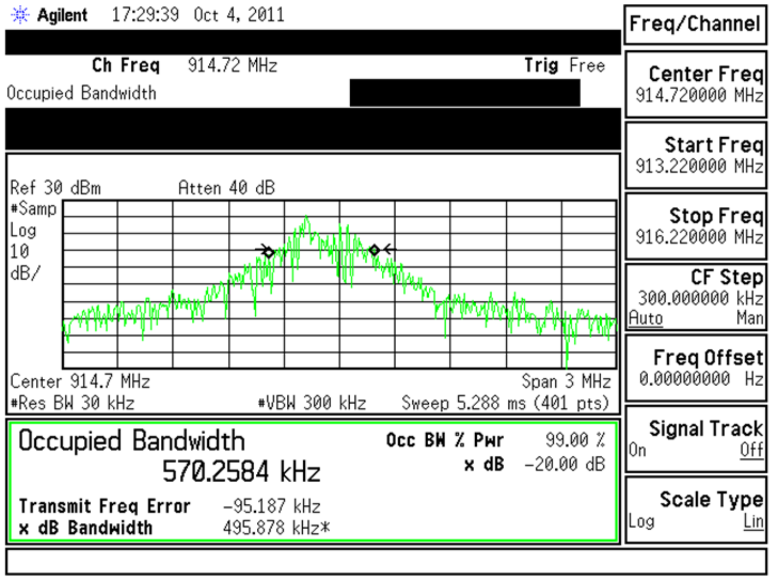
Channel	Center Frequency (MHz)	Measured 99% Occ. BW (kHz)	Measured -20 dBc Occ. BW (kHz)	Maximum - 20 dBc Limit (kHz)	Margin (kHz)
0	903.0	502	404	500	96
14	914.6	570	496	500	4
28	926.6	497	427	500	73

7.4 - Screen Captures - Occupied Bandwidth

Channel 0, -20 dBc Occupied Bandwidth



Channel 14, -20 dBc Occupied Bandwidth



Channel 28, -20 dBc Occupied Bandwidth

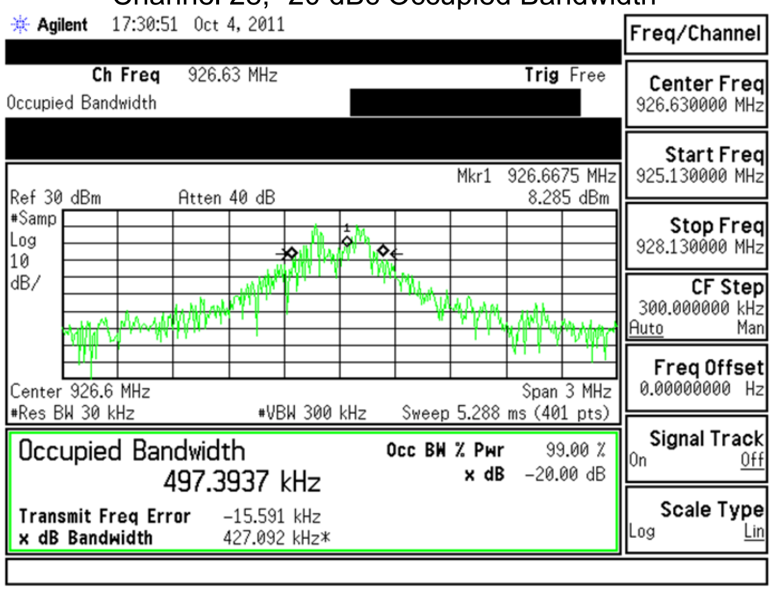
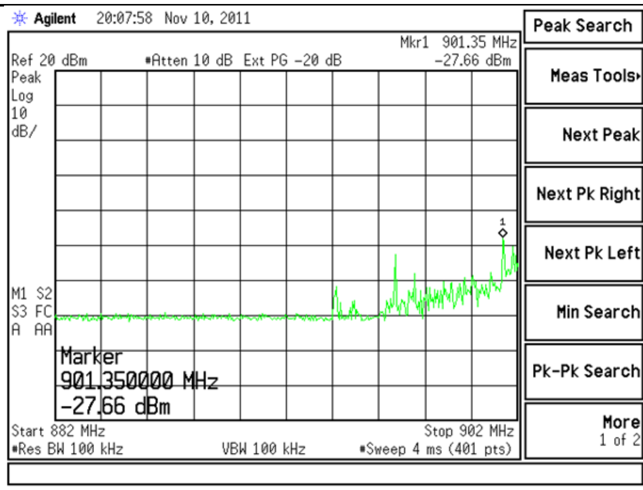


EXHIBIT 8. BAND EDGE MEASUREMENTS

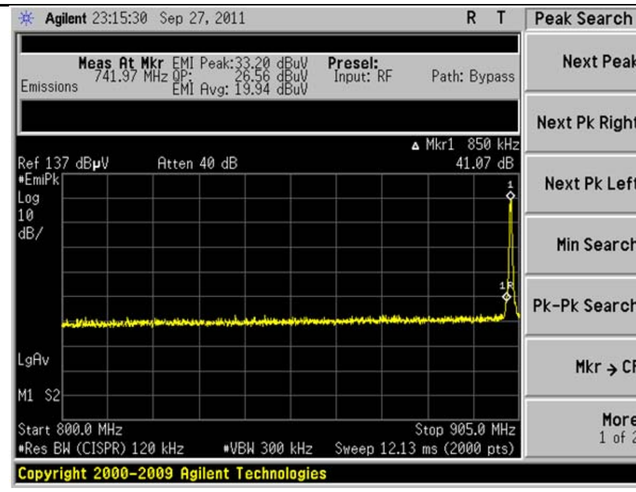
8.1 - Method of Measurements

FCC 15.209(b) and 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the Band-Edges where the intentional radiator operates. Also, RSS 210 Section 2.2 requires that unwanted emissions meet limits listed in tables 2 and 3 of the same standard and also to the limits in the applicable annex. The following screen captures demonstrate compliance of the intentional radiator at the 902 MHz to 928 MHz Band-Edges. The EUT was operated in continuous transmit mode with continuous modulation, with internally generated data as the modulating source. The EUT was operated at the lowest channel for the investigation of the lower Band-Edge, and at the highest channel for the investigation of the higher Band-Edge.

Screen Capture Demonstrating Compliance at the Lower Band-Edge

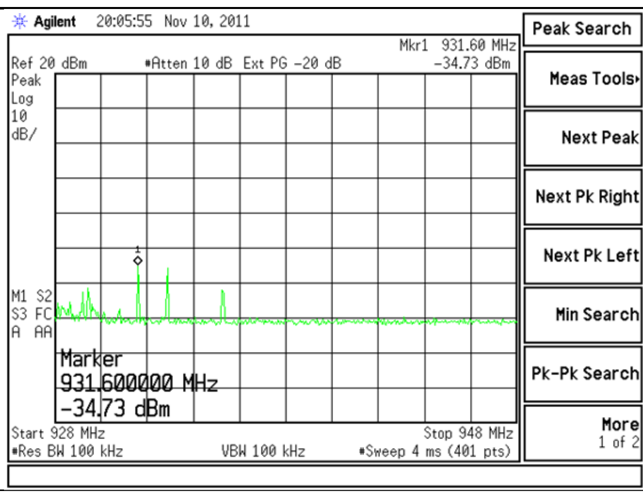


Conducted Lower Bandedge

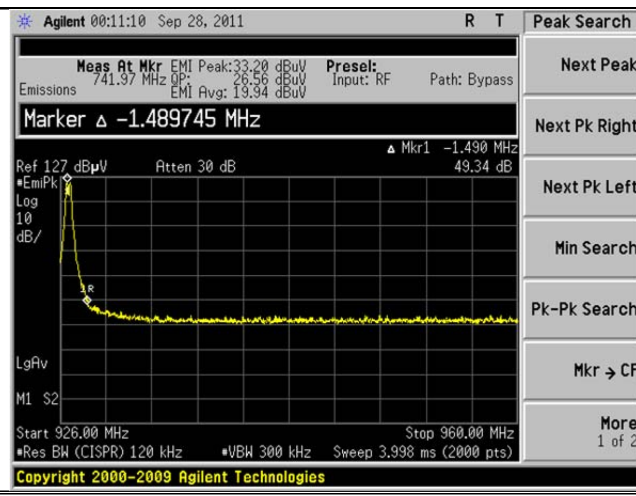


Radiated Lower Bandedge

Screen Capture Demonstrating Compliance at the Upper Band-Edge



Conducted Upper Bandedge



Radiated Upper Bandedge

EXHIBIT 9. POWER OUTPUT (CONDUCTED)

9.1 - Method of Measurements

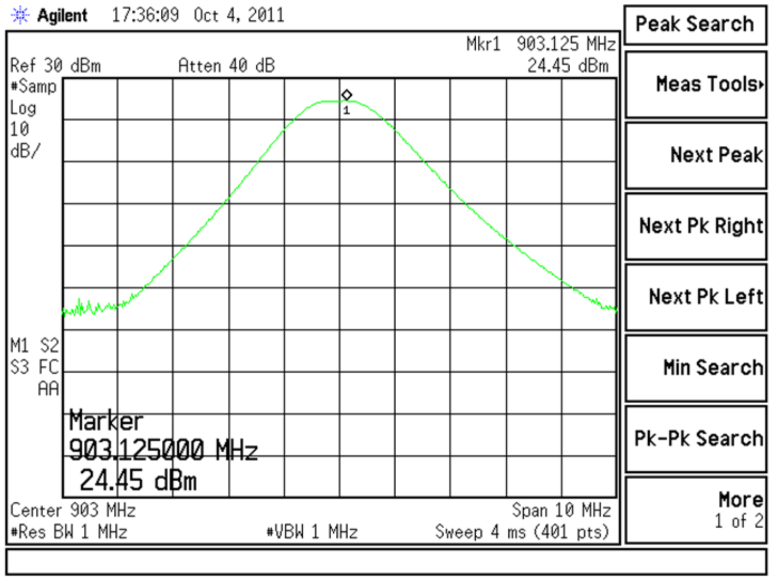
Public notice DA 00-705 was observed for measurement guidance. The conducted RF output power of the EUT was measured at the antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, allowing direct measurements without the need for any further corrections. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with resolution bandwidths set to 1 MHz and a span of 10 MHz with measurements from a peak detector presented in the chart below.

9.2 - Test Data

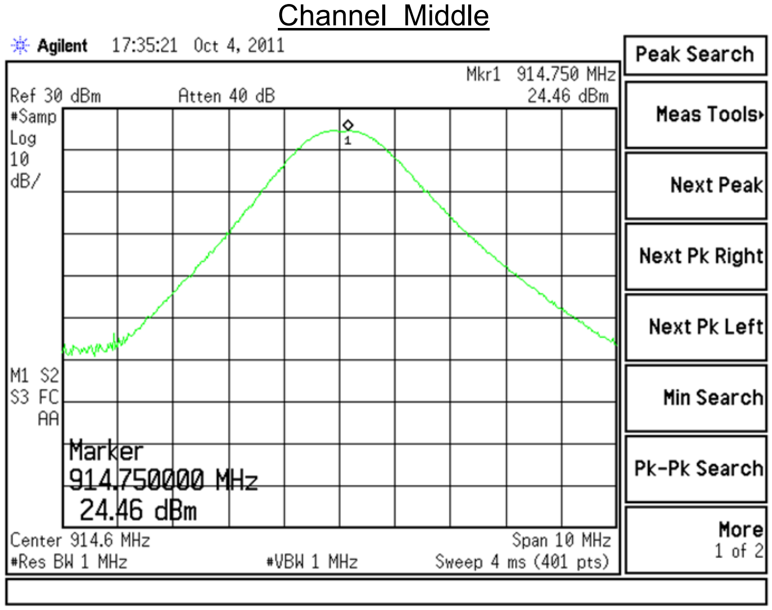
CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
LOW	903.0	30.0	24.5	4.5
MIDDLE	914.6	30.0	24.5	4.5
HIGH	926.6	30.0	24.5	4.5

9.3 - Screen Captures – Power Output (Conducted)

Channel Low



Channel Middle



Channel High

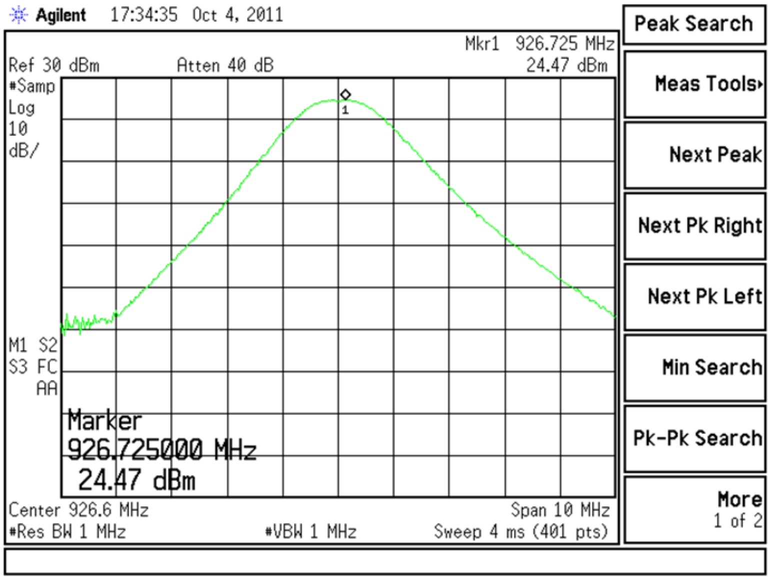


EXHIBIT 10. CONDUCTED SPURIOUS EMISSIONS: 15.247(d)

10.1 - Limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 db below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

10.2 – Conducted Harmonic And Spurious RF Measurements

FCC Part 15.247(d) and IC RSS 210 A8.5 both require a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. Public notice DA 00-705 was observed for measurement guidance. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, thereby allowing direct readings of the measurements made without the need for any further corrections. A spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

Conducted harmonics:

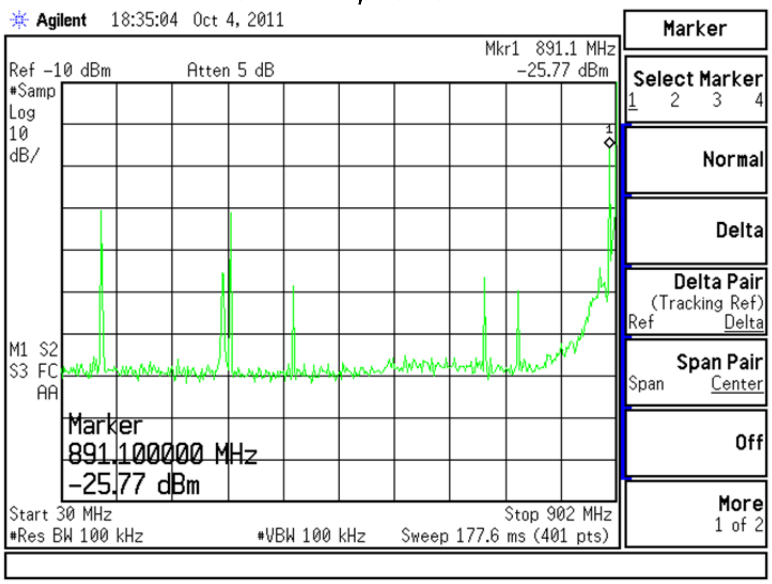
Freq	903	914.6	926.6
2fo	-13.88	-15.91	-17.81
3fo	-1.49	-0.1	-0.02
4fo	-63.78	-66.7	-71.26
5fo	Note 1	Note 1	-71.93
6fo	Note 1	Note 1	Note 1
7fo	Note 1	Note 1	Note 1
8fo	Note 1	Note 1	Note 1
9fo	Note 1	Note 1	Note 1
10fo	Note 1	Note 1	Note 1

Conducted spurious emissions:

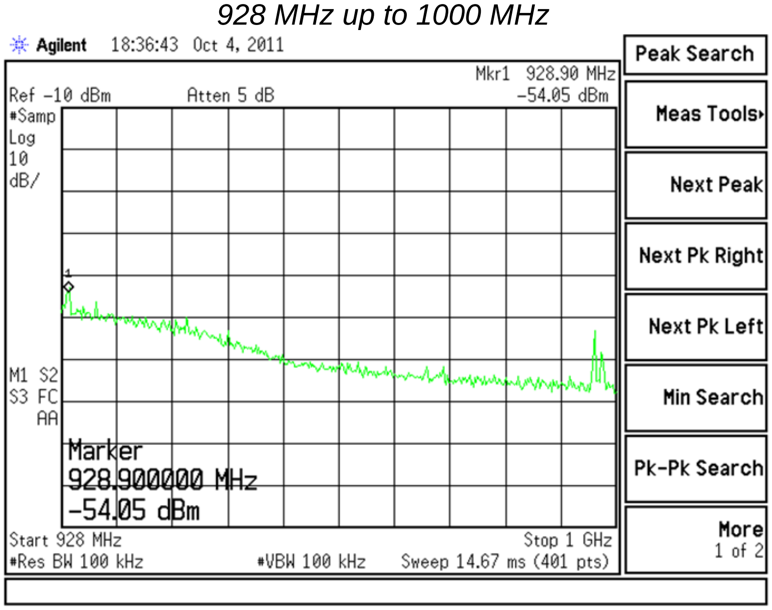
Freq(MHz)	Chan	level(dBm)
494.3	28	-37.0
354.8	28	-51.6
952.7	28	-48.0
2777.5	28	-56.3
2732.5	14	-14.4
1337.5	14	-57.7
128.1	14	-41.8
93.2	0	-43.1
296.0	0	-41.0
891.1	0	-25.7
928.9	0	-54.1
997.1	0	-63.3
2080.0	0	-52.9

10.3- Screen Captures – Spurious Conducted Emissions

30 MHz up to 902 MHz



928 MHz up to 1000 MHz



1000 MHz up to 10000 MHz

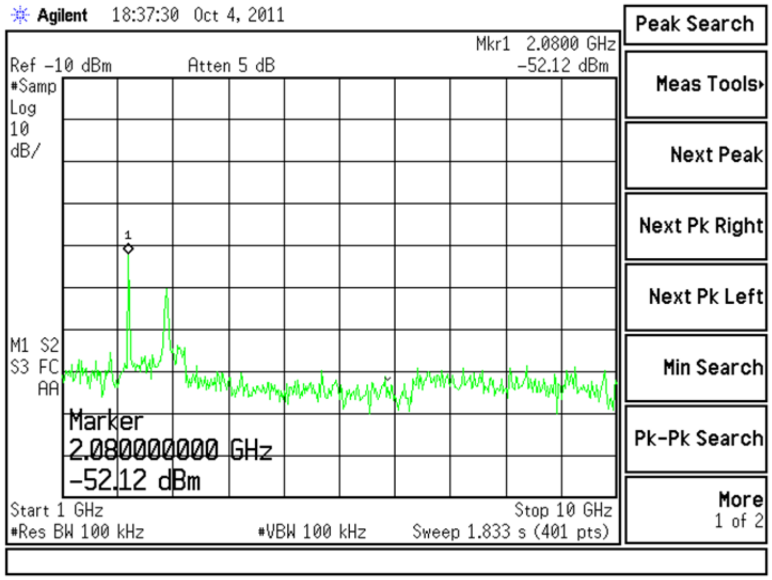


EXHIBIT 11. FREQUENCY & POWER STABILITY OVER VOLTAGE VARIATIONS

Public notice DA 00-705 was observed for measurement guidance. For measurements of the frequency and power stability, the transmitter was powered by an external bench-type variable power supply. A Spectrum Analyzer was used to measure the frequency at the appropriate frequency markers and also the output power at the antenna port.

2.8 VDC		3.3 VDC		3.8 VDC		
Power	Frequency	Power	Frequency	Power	Frequency	Channel
23.39	903.0925	24.32	903.0925	25.31	903.0925	0
23.48	914.7425	24.43	914.75	25.17	914.75	14
23.38	926.725	24.37	926.725	25.11	926.72	28

max	min	freq drift (Hz)	Channel
903.093	903.093	0	0
914.750	914.743	0.0075	14
926.725	926.720	0.005	28

The power was then cycled On/Off to observe system response. No unusual response was observed, the emission characterizes were well behaved, and the system returned to the same state of operation as before the power cycle.

The maximum shift in frequency is better than 100 ppm in the 2400 MHz to 2483.5 MHz band.

EXHIBIT 12. CHANNEL PLAN AND SEPARATION

Public notice DA 00-705 was observed for measurement guidance. A spectrum analyzer was used with a resolution bandwidth of 100 kHz to measure the channel separation of the EUT.

The minimum and maximum channel-separations measured for this device are 650 kHz and 3.56 MHz respectively. The maximum occupied bandwidth of the device, as reported in the previous section is 496 kHz.

The minimum channel separation limit as stated in FCC CFR 47 15.247 and IC RSS210 is 25 kHz or the 20dB bandwidth of the hopping channel, whichever is greater.

The minimum number of channels limit as stated in FCC CFR 47 15.247 and IC RSS210 is 50 channels for channel bandwidth less than 250 kHz and 25 channels for channel bandwidth greater than 250 kHz.

The following plots describe this spacing, and also establish the channel separation and plan.

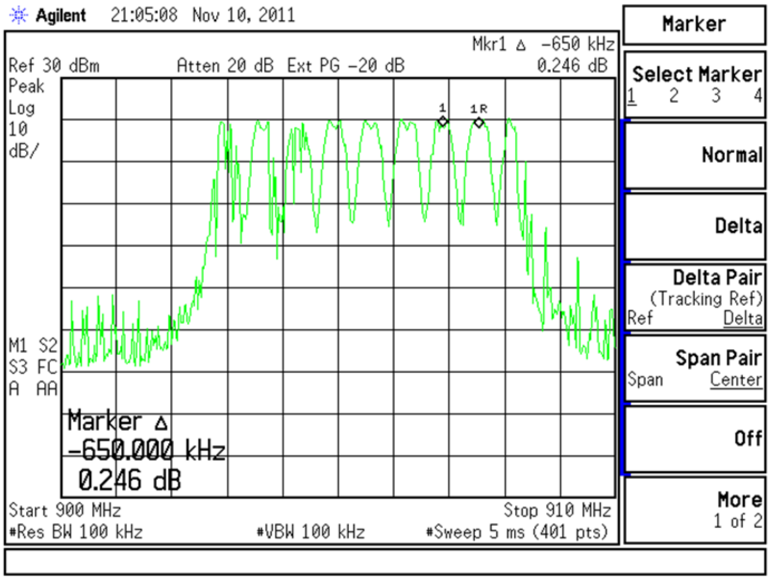
RANGE (MHz)	NUMBER OF CHANNELS PER CAPTURE	Max separation (Hz)
900 - 910	9.0	65000
910 - 920	14.0	65000
920 - 930	6.0	3560000

Total Channels	29
Max separation	3560000 Hz
Min Separation	65000 Hz

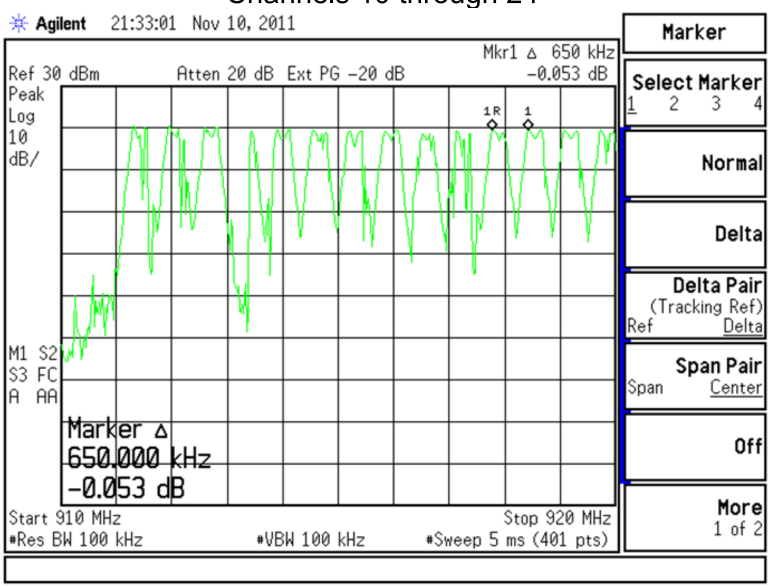
Total number of channels = 29

12.1 - Screen Captures – Channel Separation

Channels 1 through 9



Channels 10 through 24



Screen Captures – Channel Separation *(continued)*

Channels 24 through 29

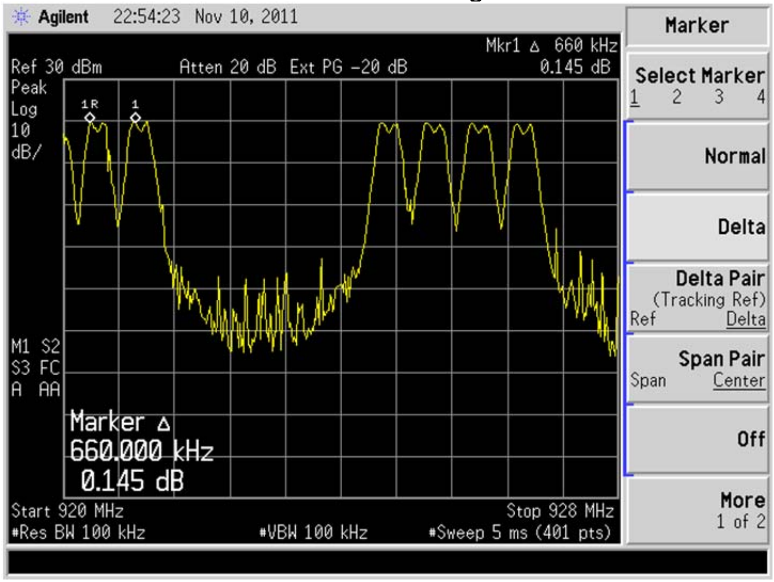


EXHIBIT 13. CHANNEL OCCUPANCY

Part 15.247(a)(1) requires a channel occupancy, for this device, of no more than 400 milliseconds in a 10 second window. The channel occupancy for this EUT was measured using a spectrum analyzer, set to zero-span at the frequency of interest. With the analyzer in peak-hold mode, the transmission lengths can be measured by adjusting the sweep rate of the analyzer. A suitable sweep rate was used to measure the channel occupancy at the low, mid and high channels.

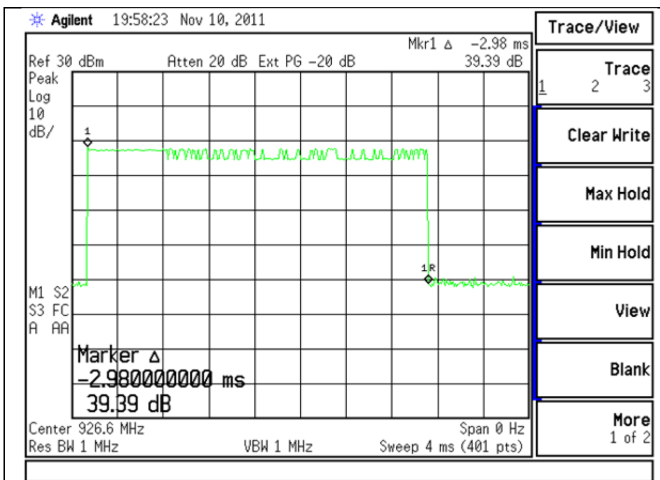
The longest time any transmission will occur on a single channel is 3.48 milliseconds. In a 10 second window, each channel has 3 transmission cycles. The maximum occupancy in a 10 second window is calculated by multiplying 3 transmission cycles by 3.48 milliseconds transmission duration per cycle, to arrive at 10.44 milliseconds total occupancy. This means the device is within tolerance, transmitting 10.44 ms, which is less than the maximum allowable of 400 ms in 10 second period.

Greatest Occupancy Observed

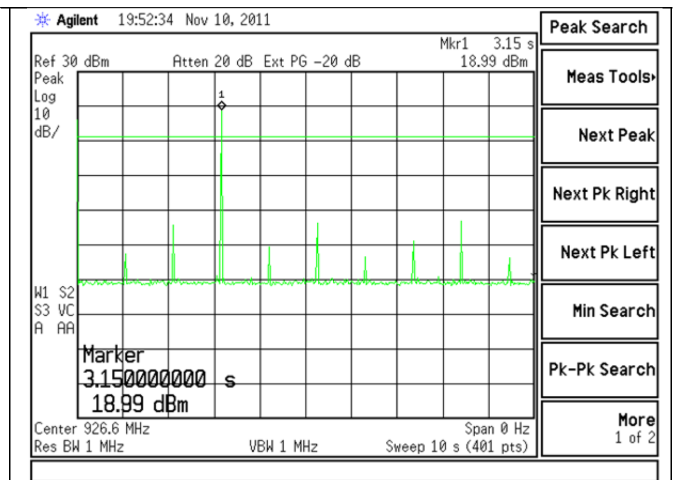
Channel	Frequency (MHz)	Total Occupancy in 10 seconds (ms)	Occupancy in 400 ms window (ms)
High	926.6	8.94	2.98

Plots of Greatest Channel Occupancy

Channel High Occupancy



4 ms window



10 seconds window

Note: High channel data provided as an example. Low, middle and high channels are similar.

EXHIBIT 14. EQUAL CHANNEL USAGE AND PSEUDORANDOM HOPPING SEQUENCE.

This system uses the spread spectrum technique of frequency hopping. The carrier frequency changes many times per second. As required by the FCC, each channel is guaranteed not be used more than 400 ms in a 10 second window. Also all channels are used equally by the system and every device within the system. For this reason at 29 channels are used and all devices must channel hop.

The channel sets implemented are a list of channels a radio will cycle through as part of its frequency hopping. Each channel set available consists of the same 29 channels in pseudo-random order. The sets are created as orthogonal as possible to minimize the amount of interference between radios using different channel sets. The channel set used by a gateway is determined by the least significant byte of the 2 byte identifier (configured via the gateway GUI). The gateway forwards the channel set to the sensors when they join the gateway's system via the Network Initialization Vector (NIV). The channel gets implemented are defined in the following table.

{0, 3, 20, 5, 4, 22, 19, 18, 13, 11, 23, 12, 16, 2, 1, 8, 15, 27, 9, 24, 10, 26, 28, 14, 6, 7, 17, 25, 21}
{10, 22, 16, 17, 24, 3, 2, 27, 13, 26, 6, 23, 9, 8, 7, 25, 18, 20, 28, 21, 11, 15, 4, 5, 12, 14, 0, 1, 19}
{12, 15, 2, 26, 4, 1, 10, 19, 9, 27, 25, 6, 28, 17, 16, 20, 18, 21, 3, 7, 8, 5, 24, 14, 13, 22, 11, 23, 0}
{18, 5, 22, 14, 3, 24, 2, 9, 10, 23, 19, 12, 16, 25, 1, 13, 4, 8, 0, 28, 7, 21, 17, 20, 27, 6, 26, 15, 11}
{3, 13, 1, 27, 25, 7, 15, 5, 14, 28, 24, 23, 10, 19, 8, 17, 2, 12, 21, 9, 26, 4, 18, 6, 20, 0, 16, 22, 11}
{17, 7, 1, 16, 24, 3, 6, 9, 25, 0, 11, 2, 10, 21, 28, 5, 23, 8, 14, 18, 19, 4, 20, 22, 13, 27, 26, 15, 12}
{2, 9, 22, 19, 5, 13, 24, 18, 4, 7, 27, 23, 16, 10, 12, 25, 6, 11, 14, 8, 15, 28, 20, 0, 3, 17, 21, 1, 26}
{0, 22, 4, 11, 18, 21, 8, 12, 3, 6, 5, 28, 1, 2, 17, 25, 15, 16, 20, 19, 26, 7, 24, 14, 9, 13, 23, 27, 10}
{16, 23, 24, 19, 22, 25, 10, 8, 26, 11, 20, 6, 21, 1, 9, 7, 17, 5, 0, 13, 12, 15, 28, 14, 2, 18, 3, 27, 4}
{1, 2, 5, 19, 23, 16, 4, 22, 21, 8, 11, 0, 14, 15, 26, 25, 20, 3, 28, 10, 7, 9, 12, 17, 27, 6, 24, 18, 13}
{14, 8, 12, 7, 20, 18, 3, 10, 5, 25, 1, 0, 4, 15, 2, 13, 17, 28, 24, 22, 19, 6, 16, 9, 27, 11, 23, 21, 26}
{26, 28, 22, 24, 3, 11, 13, 27, 7, 25, 16, 8, 15, 10, 6, 19, 4, 14, 20, 23, 17, 1, 21, 5, 2, 12, 18, 0, 9}
{6, 10, 20, 16, 1, 19, 9, 25, 21, 15, 27, 22, 12, 5, 26, 14, 3, 18, 4, 17, 13, 8, 7, 28, 23, 24, 0, 2, 11}
{22, 10, 11, 7, 18, 27, 19, 3, 6, 1, 24, 20, 25, 2, 23, 4, 16, 5, 14, 26, 17, 21, 13, 28, 15, 9, 0, 12, 8}
{6, 10, 28, 0, 17, 19, 9, 7, 23, 13, 14, 12, 8, 1, 22, 4, 5, 16, 26, 3, 2, 15, 24, 11, 21, 20, 27, 18, 25}
{10, 19, 21, 3, 1, 26, 22, 28, 27, 6, 23, 4, 15, 24, 16, 7, 2, 25, 8, 12, 14, 9, 13, 5, 20, 0, 11, 17, 18}

Note: The information in this section is provided by the manufacturer.

EXHIBIT 15. RECEIVER SYNCHRONIZATION AND RECEIVER INPUT BANDWIDTH.

Sensors will resynchronize with the gateway once every second. They will synchronize to the gateway via the beacon message sent out on regular intervals by the gateway. The synchronization will be done just before the sensor is to transmit data to the gateway. This will ensure that the open communication window between the gateway and sensors will be as closely coordinated as possible.

To achieve this all sensors are put into a sleep mode in a systematic way within the communication protocol. By synchronizing the duty cycle which the radios in the battery powered sensors are turned on, the system can limit the power used by allowing the whole system to sleep in a coordinated manner. This is implemented first by keeping tight timing as described above. All devices can then sleep during the time periods where no communication is taking place, wake up on a time based interval, re-synchronize to the Gateway Beacon and TX/RX any data that needs to pass within the system. On each beacon message interval the channel used for communications is changed by incrementing the index of the channel selector to the next channel in the hop channel set selected for this network.

Note: The information in this section is provided by the manufacturer.

APPENDIX A – Test Equipment List

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 30-Aug-2011 | Type Test : Radiated Emissions | Job # : C-1283

Prepared By: Peter | Customer : LSR | Quote #: 311256

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	6/7/2010	6/7/2011	Active Calibration
2	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/7/2010	6/7/2011	Active Calibration
3	EE 960158	RF Preselecter	Agilent	N9039A	MY46520110	6/7/2010	6/7/2011	Active Calibration
4	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	11/10/2009	11/10/2010	Active Calibration
5	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	12/22/2009	12/22/2010	Active Calibration
6	AA 960150	Bicon Antenna	ETS	3110B	0003-3346	11/3/2009	11/3/2010	Active Calibration
7	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	12/28/2009	12/28/2010	Active Calibration
8	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	9/22/2010	9/22/2011	Active Calibration
9	AA 960156	900MHz High Pass Filter	KWM	HPF-L-14185	unknown	6/4/2010	6/4/2011	Active Calibration

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 30-Aug-2011 | Type Test : Conducted Radio | Job # : C-1283

Prepared By: | Customer : LSR | Quote #: 311256

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	9/22/2010	9/22/2011	Active Calibration

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 4-Oct-2012 | Type Test : Conducted Emissions | Job # : C-1283

Prepared By: | Customer : LSR | Quote #: 311256

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960072	Transient Limiter	HP	11947A	3107A02515	9/20/2012	9/20/2013	Active Calibration
2	AA 960008	LISN	EMCO	3816/2NM	9701-1057	1/3/2012	1/3/2013	Active Calibration
3	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	11/22/2011	11/22/2012	Active Calibration
4	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	11/22/2011	11/22/2012	Active Calibration
5	EE 960001	Multimeter	HP	971A	JP36004055	3/12/2012	3/12/2013	Active Calibration

Project Engineer: Peter Feiten   Quality Assurance: ____________

APPENDIX B – Test Standards: CURRENT PUBLICATION DATES RADIO

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2003		
ANSI C63.10	2009		
CISPR 11	2009-05	2009-12 P	
CISPR 16-1-1 Note 1	2010-01		
CISPR 16-1-2 Note 1	2003	2004-04	2006-07
CISPR 22	2008-09		
CISPR 24	1997-09	2001-07	2002-10
EN 55011	2009		
FCC 47 CFR, Parts 0-15, 18, 90, 95	2009		
FCC Public Notice DA 00-1407	2000		
FCC ET Docket # 99-231	2002		
FCC Procedures	2007		
ICES 003	2004-02		
RSS GEN	2007-06		
RSS 210	2007-06		

APPENDIX C - Uncertainty Statement

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k=2.

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*
Absolute Conducted Emissions	*Agilent PSA/ESA Series*	*1.38 dB*
AC Line Conducted Emissions	*Shielded Room/EMCO LISN*	*3.20 dB*
Radiated Immunity	*3 Volts/Meter in 3-Meter Chamber*	*2.05 Volts/Meter*
Conducted Immunity	*3 Volts level*	*2.33 V*
EFT Burst, Surge, VDI	*230 VAC*	*54.4 V*
ESD Immunity	*Discharge at 15kV*	*3200 V*
Temperature/Humidity	*Thermo-hygrometer*	*0.64° / 2.88 %RH*