LS RESEARCH, LLC
WIRELESS PRODUCT DEVELOPMENT
ACCREDITED
TESTING CERT #1255.01
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TEST REPORT # 311282
LSR Job #: C-1305

Compliance Testing of:
2.4GHz Radio with Dipole Antenna, Mobile Mark Antenna & Multi-Mode Emitter Antenna

Test Date(s):
September 20-21, October 14, December 13/14, 2011

Prepared For:
Global Traffic Technologies, LLC
7800 Third Street North
BLDG 100
Saint Paul, MN 55128

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 2400-2483.5 MHz

This Test Report is issued under the Authority of:

Signature: Thomas T. Smith Date: 3/21/2012

Test Report Reviewed by:	Tested by:
Signature: Thomas T. Smith Date: 3/21/2012	Peter Feilen, EMC Engineer Signature: Peter Feilen Date: 3/21/2012

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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 see Appendix B

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:	Global Traffic Technologies
Address:	7800 Third Street North, Bldg 100, Saint Paul, MN 55120
Contact Name:	Chuck Meyer

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	Next Gen GPS Radio
Model Number:	OPTICOMGPS2
Serial Number:	11490037

2.3 - Associated Antenna Description

There are three possible antennas associated to the 2.4GHz radio. They are:
A.) HOW TSEN # S-00101 Dipole Antenna
B.) Mobile Mark #DM2-2400/1575Antenna
C.) Laird #MAF94192

2.4 - EUT'S Technical Specifications

EUT Frequency Range (in MHz)	2401.02-2476.80 MHz
Minimum (in W)	0.501 W
Maximum (in W)	0.575W
Occupied Bandwidth (99% BW)	967 kHz
Type of Modulation	FSK
Emission Designator	967KF1D
Transmitter Spurious (worst case) at 3 meters	51.2 dBuV/m @ 3m, @ 3864 MHz See page 17
Receiver Spurious (worst case) at 3 meters	49.7 dBuV/m @ 3m, @ 2366 MHz See page 22
Receiver Bandwidth	1.1 MHz
Receiver Sensitivity	-86 dBm
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Microprocessor Model # (if applicable)	OMAPL138BZCE3
Antenna Information	
Detachable/non-detachable	Detachable
Type	A.) HOW TSEN # S-00101 Dipole B.) Mobile Mark #DM2-2400/1575 *C.) Laird #MAF94192*
Gain (in dBi)	A.) 2.62 dBi B.) 2.50 dBi C.) 3.50 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: 2.563 ☒ W/m^2 ☐ V/m ☐ A/m
☒ Measured ☐ Computed ☐ Calculated

2.5 - Product Description

The GPS based priority control system uses a proprietary 2.4 GHz FHSS/TDMA transceiver to transfer data between any vehicles, and traffic intersection controllers within radio range.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	20-25 ˚C
Humidity:	35-50 % R.H.

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	N/A
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)

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 (2401.02 MHz), middle (2440.96 MHz) and high (2476.80 MHz) to comply with FCC Part 15.35. The channels and operating modes were controlled via laptop PC.

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 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 18 GHz. A standard gain horn was used from 18 to 25 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 2400 to 2483.5 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

Sample Calculation using correction factors from the device

Raw Receiver Data + Antenna Factor + Cable Factor + = Reported Value
Generic example of reported data at 258 MHz:
Reported Measurement data = 20.7 (raw receiver measurement) + 12.9 (antenna factor) + 1.4 (cable factor) = 35.0 dBμV

5.6 - Radiated Emissions Test Data Chart

Frequency Range Inspected: 30 MHz to 25000 MHz

Manufacturer:	Global Traffic Technologies, LLC					
Date(s) of Test:	September 20,21, October 14, Dec 13,14, 2011					
Project Engineer:	Peter Feilen					
Voltage:	3.3VDC					
Operation Mode:	Continuous transmit, modulated mode					
EUT Power:		Single Phase ___VAC		3 Phase ___VAC		
		Battery	X	Other: Bench DC Supply		
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 (other than the fundamentals and its harmonics):

Frequency (MHz)	Height (m)	Azimuth (degree)	EFI Reading (dBµV/m)	EFI Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation (Board and Antenna)
258.0	1.00	200	35.0	46.0	11.0	v	side
258.0	1.00	223	36.0	46.0	10.0	v	f
300.0	1.00	0	28.4	46.0	17.6	h	f
909.3	1.39	231	42.8	46.0	3.2	H	F
516.1	1.00	334	39.8	46.0	6.2	V	F
516.1	1.00	190	40.8	46.0	5.2	V	V
417.8	1.82	57	36.5	46.0	9.5	H	V
3864.2	1.00	0	51.18	54.0	2.8	V	S
3830.4	1.00	0	51.06	54.0	2.9	H	S
2270.7	1.00	0	43.65	54.0	10.4	V	side
300.0	1.00	186	36.62	46.0	9.4	V	side
221.0	1.00	0	30.19	46.0	15.8	V	side
74.3	1.00	0	23.44	40.0	16.6	V	side
73.7	1.00	67	25.15	40.0	14.9	V	V
258.0	1.00	256	31.57	46.0	14.4	V	V
122.9	1.20	116	27.71	43.5	15.8	V	V
73.7	1.00	0	24.58	40.0	15.4	V	V
122.9	1.00	135	27.38	43.5	16.1	V	V
172.1	1.00	59	26.32	43.5	17.2	V	V
300.0	1.00	178	40.62	46.0	5.4	V	V
258.0	1.22	0	30.96	46.0	15.0	H	side
122.9	1.02	161	28.37	43.5	15.1	V	side
73.8	1.00	16	24.01	40.0	16.0	V	side
368.6	1.00	0	35.57	46.0	10.4	H	V
909.3	1.09	189	40	46.0	6.0	H	V
300.0	1.00	186	39.83	46.0	6.2	V	V
442.4	1.00	132	35.6	46.0	10.4	V	V
300.0	1.00	167	40	46.0	6.0	V	side
540.7	2.03	283	35.56	46.0	10.4	V	side
749.6	1.00	348	38.06	46.0	7.9	H	side
540.7	1.84	21	30.95	46.0	15.1	H	side
983.0	2.02	0	34.79	54.0	19.2	H	side
982.9	1.00	197	38.08	54.0	15.9	H	F
958.4	1.00	172	36.44	46.0	9.6	H	H
442.6	1.19	343	37.92	46.0	8.1	V	H
983.0	1.00	130	39.58	54.0	14.4	V	H
2260.4	1.00	0	43.6	54.0	10.4	H	NORMAL/V
3844.5	1.00	0	51.12	54.0	2.9	V	NORMAL/V
3731.7	1.00	0	50.55	54.0	3.5	H	NORMAL/V
442.4	1.15	19	38.79	46.0	7.2	V	NORMAL/V
300.0	1.64	125	37.21	46.0	8.8	V	NORMAL/V
909.3	1.17	0	40.41	46.0	5.6	V	NORMAL/V
258.0	1.00	92	35.42	46.0	10.6	V	NORMAL/V
221.1	1.00	0	33.48	46.0	12.5	V	NORMAL/V

RADIATED EMISSIONS DATA CHART (continued)

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

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty-Cycle Adjusted Reading (dBuV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4801.6	1.04	2	66	62.5	32.1	63.5	31.4	Vertical	Vertical
12004.0	1	323	71.1	60.3	29.9	63.5	33.6	Horizontal	Side
19206.4	1	328	58.3	52.6	22.2	63.5	41.3	Vertical	Flat

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

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty-Cycle Adjusted Reading (dBuV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4882	1.02	354	67.7	64.8	34.4	63.5	29.1	Vertical	Vertical
7323	1.04	4	74.5	68.1	37.7	63.5	25.8	Vertical	Vertical
12205	1.02	325	73.4	63.5	33.1	63.5	30.4	Horizontal	Side
19528	1.00	197	57.5	52.2	21.8	63.5	41.7	Vertical	Flat

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

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty-Cycle Adjusted Reading (dBuV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4953	1.25	339	68.7	65.7	35.3	63.5	28.2	Vertical	Vertical
7430	1.07	198	73.9	68.0	37.6	63.5	25.9	Vertical	Vertical
12384	1	50	67.3	59.4	29.0	63.5	34.5	Horizontal	Side
19814	1	17	57.0	48.0	17.6	63.5	45.9	Vertical	Vertical
22291	1	9.3	54.2	49.4	19.0	63.5	44.5	Horizontal	Side

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. Limits have been corrected to reflect the change in measurement distance.
3. Measurement at receiver system noise floor.
4. Margin Calculation: Margin = (Average Limit – Duty-Cycle Adjusted Reading)

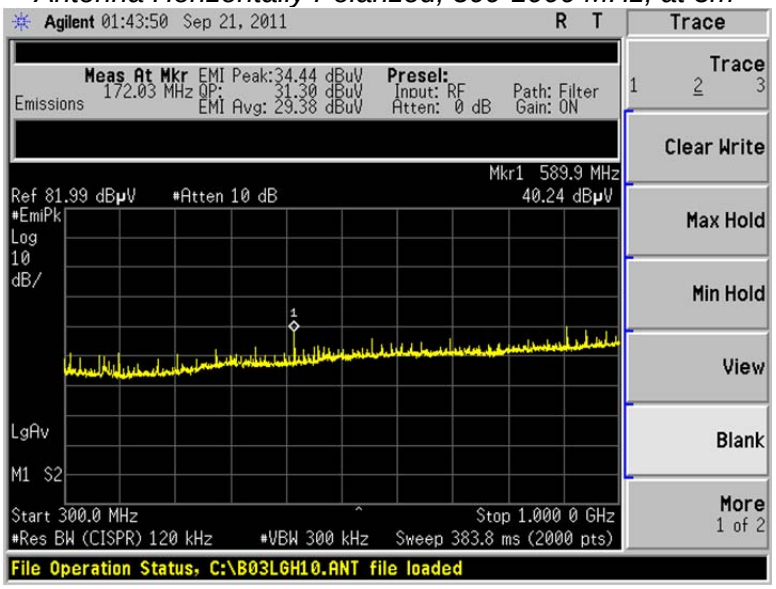
5.8 - Screen Captures - Radiated Emissions Test

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 2401.02 MHz, 2440.96 MHz, or 2476.80 MHz, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

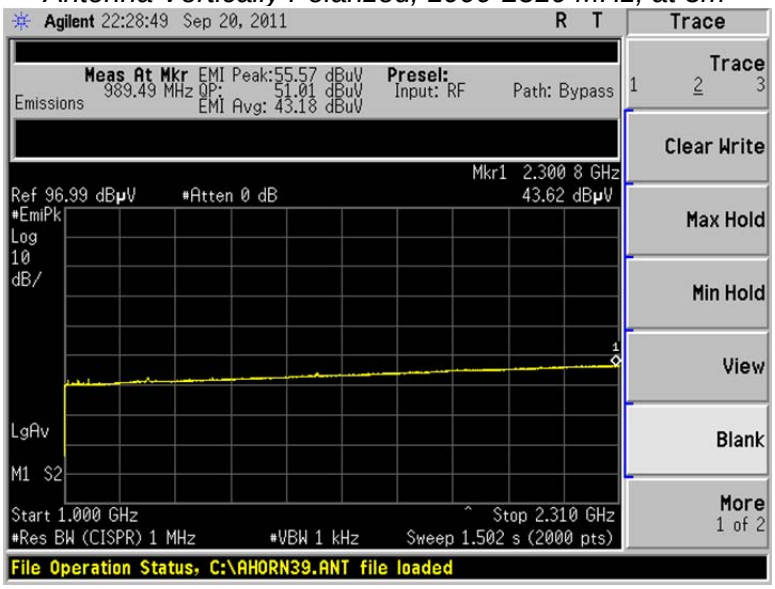
Antenna Vertically Polarized, 30-300 MHz, at 3m

Antenna Horizontally Polarized, 300-1000 MHz, at 3m



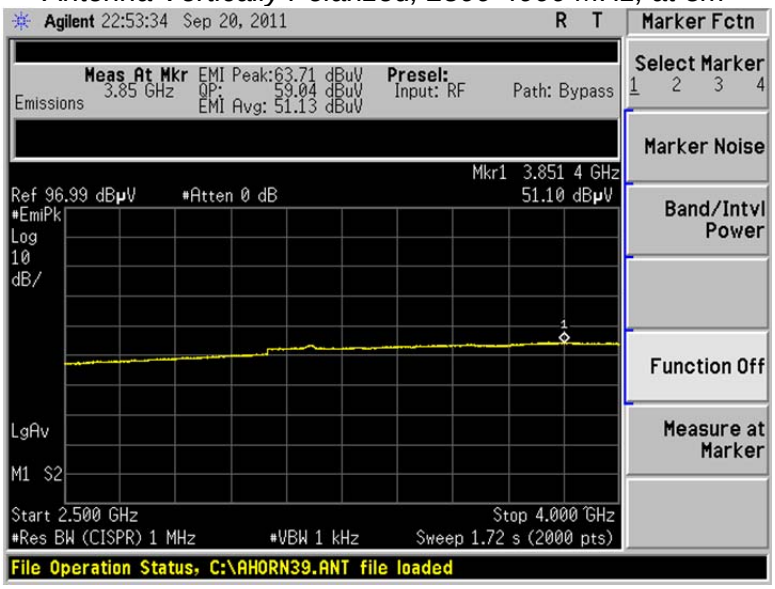
Screen Captures (continued)

Antenna Vertically Polarized, 1000-2310 MHz, at 3m



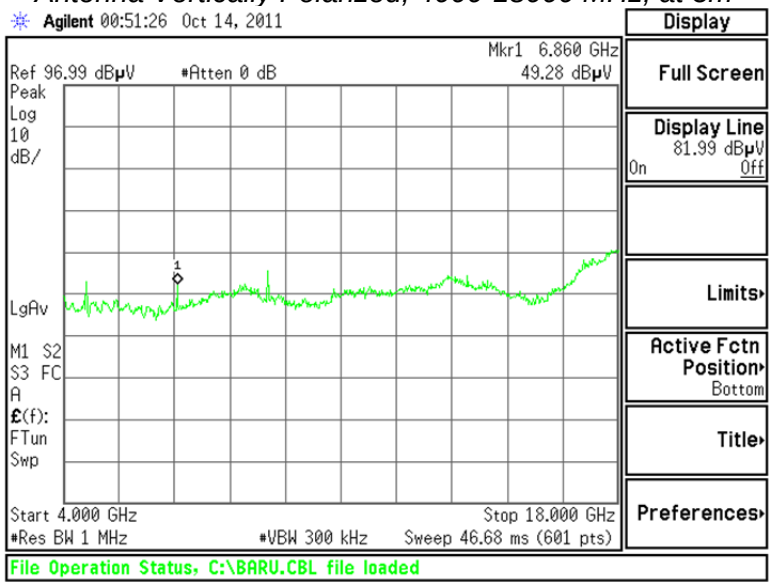
Note: The frequency range 2310-2390 MHz and 2483.5-2500.0 MHz is in the Band-edge section (Exhibit 8).

Antenna Vertically Polarized, 2500-4000 MHz, at 3m

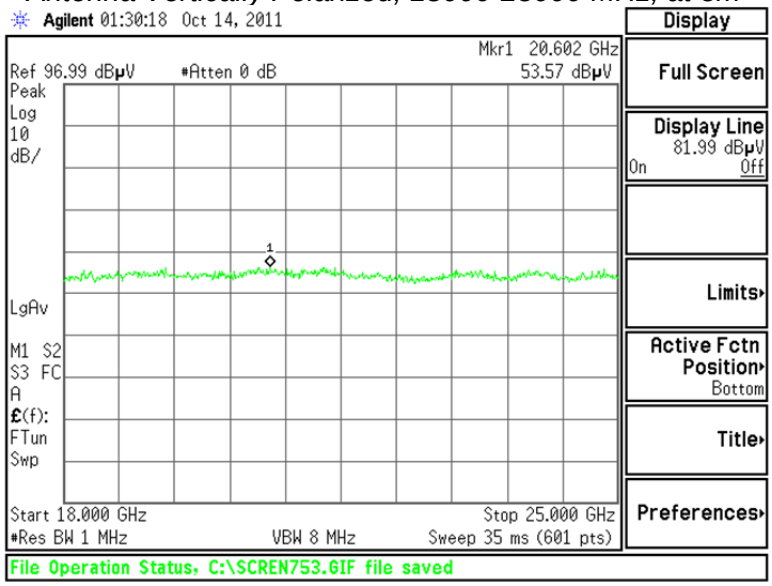


Screen Captures (continued)

Antenna Vertically Polarized, 4000-18000 MHz, at 3m



Antenna Vertically Polarized, 18000-25000 MHz, at 3m



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)	EFI Reading (dBµV/m)	EFI Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
2366.2	1.08	155	48.1	54.0	5.9	H	side
2366.2	1.23	63	48.01	54.0	6.0	V	side
2366.2	1.00	220	47.9	54.0	6.1	V	vertical
2366.2	1.49	0	44.5	54.0	9.5	H	vertical
2366.3	1.00	237	46.3	54.0	7.7	V	flat
2366.2	1.17	279	47.8	54.0	6.2	H	flat
2366.2	1.08	183	48.1	54.0	5.9	H	side
2366.2	1.00	5	46.28	54.0	7.7	v	side
2366.2	1.00	246	47.28	54.0	6.7	v	vertical
2366.2	2.07	0	44.4	54.0	9.6	h	vertical
2366.2	1.06	154	49.7	54.0	4.3	h	side/antenna on side
1007.6	1.00	334	32.67	54.0	21.3	h	vertical board/vertical ant
516.1	1.82	125	36.5	46.0	9.5	h	side/antenna on side
565.4	1.00	233	35.68	46.0	10.3	v	side/antenna on side
516.0	1.00	165	35.39	46.0	10.6	v	side/antenna on side
368.6	1.58	0	28.26	46.0	17.7	v	side/antenna on side
221.0	1.00	0	28.38	46.0	17.6	v	side/antenna on side
240.0	1.02	29	31.06	46.0	14.9	v	side/antenna on side
17900.0	1.00	0	49.57	63.5	13.9	H	side
4372.5	1.00	311	53.33	63.5	10.2	H	side
4915.3	1.00	294	46.17	63.5	17.3	V	side
4915.3	1.13	45	51.9	63.5	11.6	H	side
17900.0	1.00	0	49.49	63.5	14.0	H	side
4915.2	1.04	44	52.51	63.5	11.0	H	side

Notes:

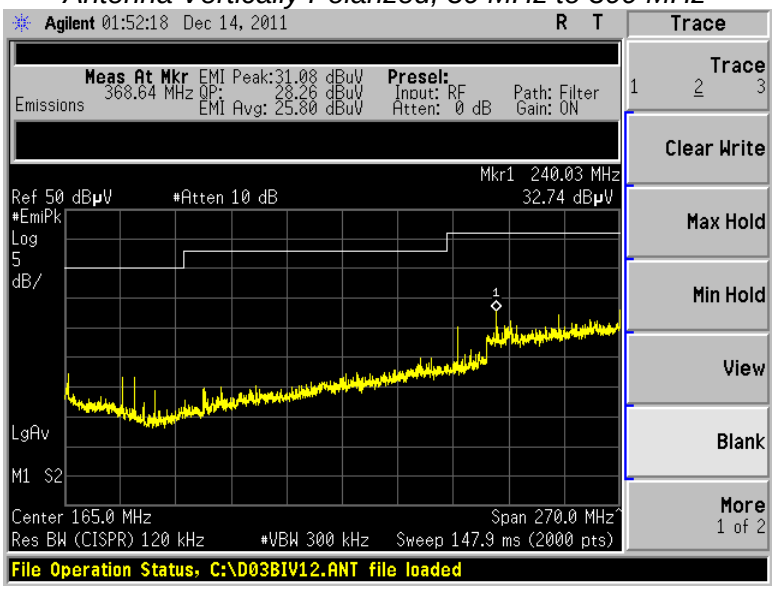
1. A Quasi-Peak Detector was used in measurements below 1 GHz. To ensure the peak emissions did not exceed 20 dB above the limits a peak detector was used. A peak detector with video averaging was used for measurements above 1 GHz.
2. Measurements above 4 GHz were made at 1 meters of separation from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

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.

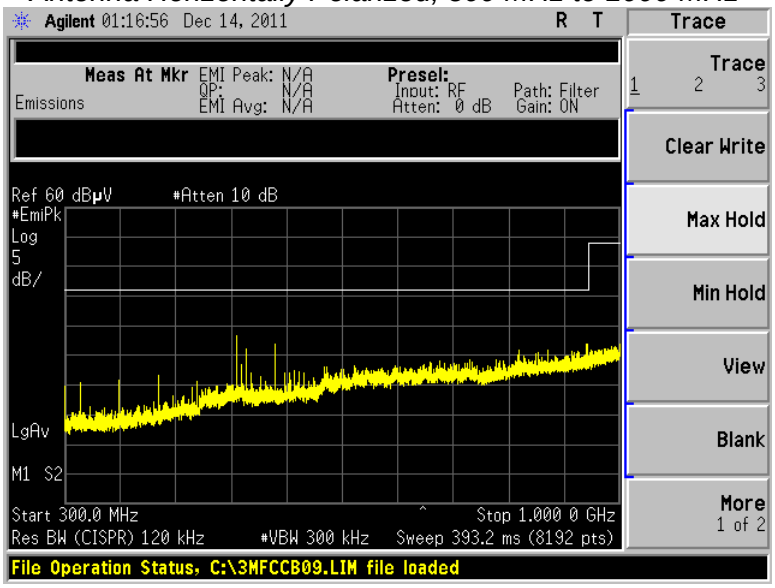
The signature scans shown here are from worst-case emissions, as measured on channels 2401.02 MHz, 2440.96 MHz, or 2476.80 MHz, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Antenna Vertically Polarized, 30 MHz to 300 MHz

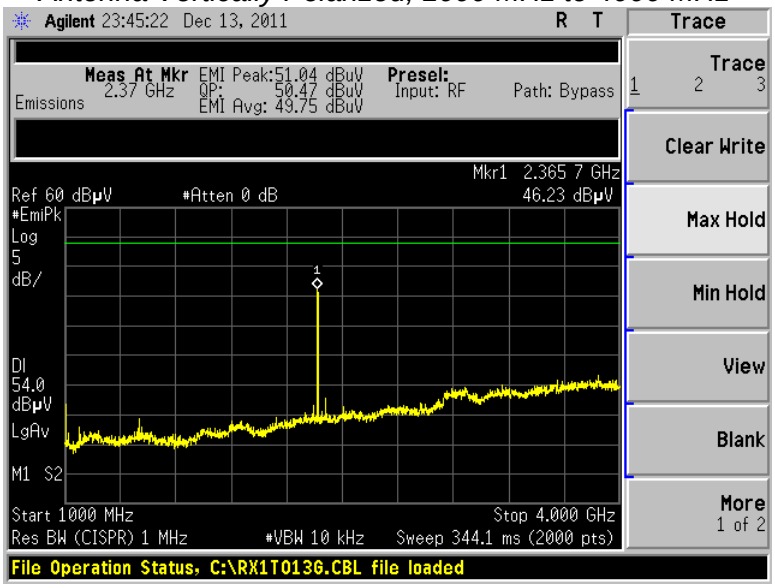


Screen Captures - Radiated Emissions Testing - Receive Mode (continued)

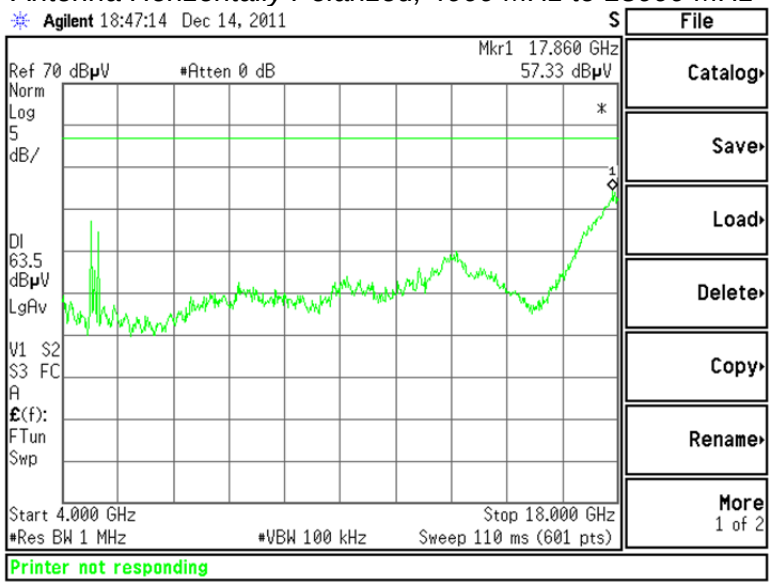
Antenna Horizontally Polarized, 300 MHz to 1000 MHz



Antenna Vertically Polarized, 1000 MHz to 4000 MHz



Antenna Horizontally Polarized, 4000 MHz to 18000 MHz



Antenna Horizontally Polarized, 18000 MHz to 25000 MHz

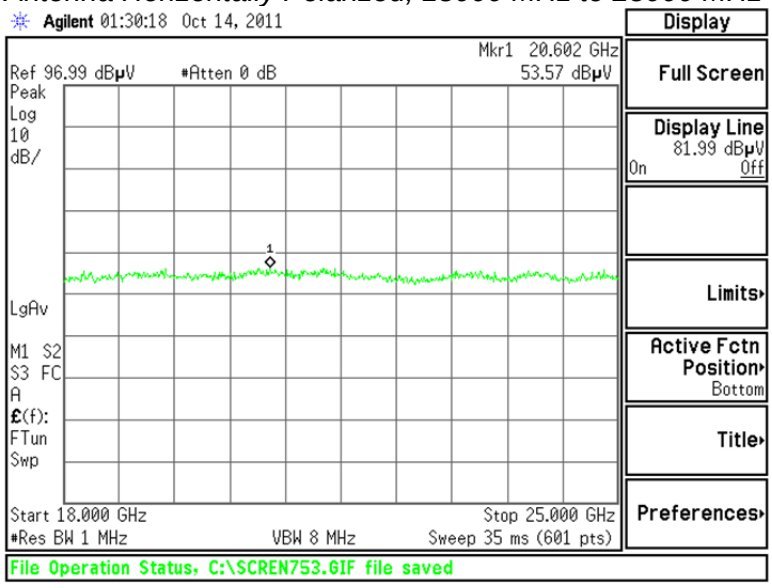


EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

This test is not applicable as the EUT will only be supplied with voltage derived from a host board with voltage regulation on-board. The host board will contain other elements of a final system, independent of this module. DC Power was supplied for all test purposes, relative to the voltage supplied to the module on the host board.

EXHIBIT 7. OCCUPIED BANDWIDTH

7.1 - Requirement

For a frequency hopping system in the 2400 to 2483.5 MHz band, channel separation shall be at minimum 25 kHz or the 20 dB bandwidth, for transmitters with a conducted power of greater than .125W. Therefore, the 20 dB bandwidth must be measured, to test channel separation requirement.

7.2 - Method of Measurements

The transmitter output was connected to the Spectrum Analyzer. The bandwidth of the fundamental frequency was measured with the Spectrum Analyzer using 10 kHz RBW and VBW=30 kHz. Measurements were made in accordance to ANSI C63.10 measurement methodology.

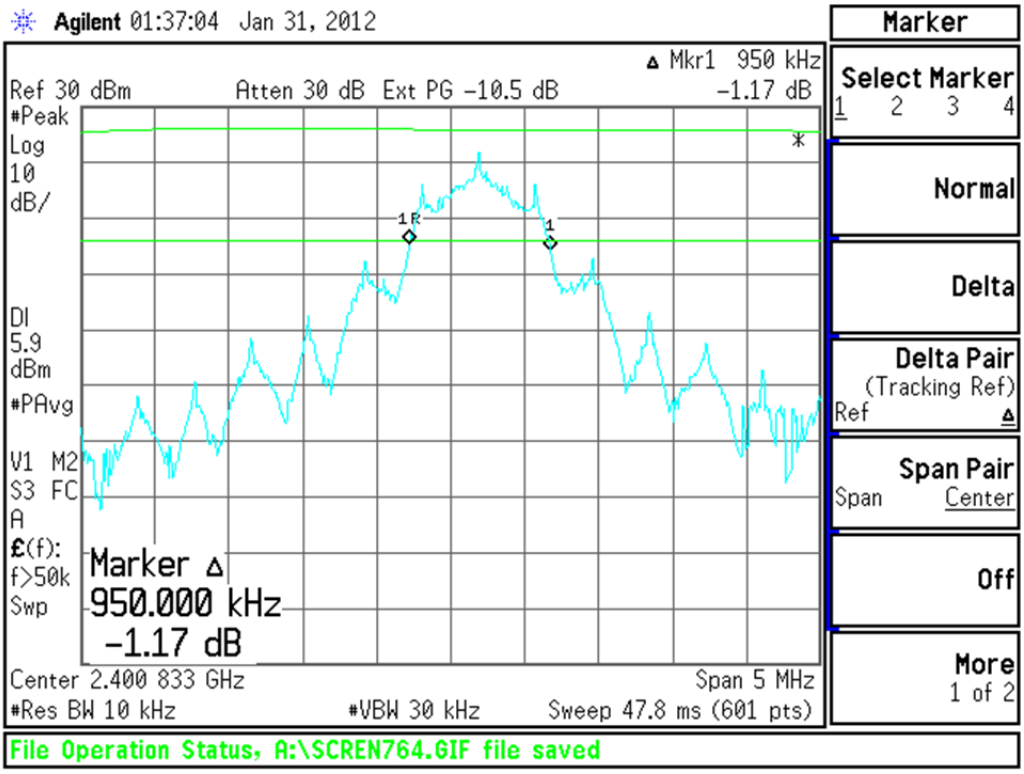
For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to a spectrum analyzer. An attenuator was placed in series with the cable to protect the spectrum analyzer. The loss from the cable and the attenuator were 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.

7.3 - Test Data

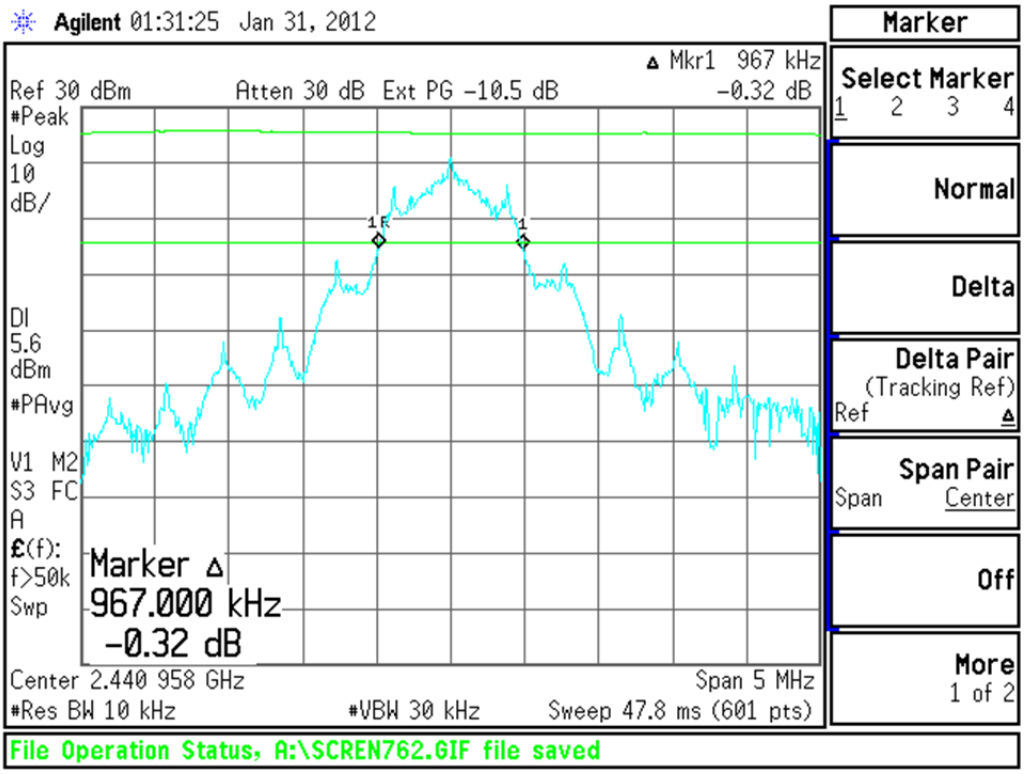
Channel	Center Frequency (MHz)	Measured -20 dBc Occ. BW (kHz)
Low	2401.02	950
Middle	2440.96	967
High	2476.80	900

7.4 - Screen Captures - Occupied Bandwidth

Low Channel -20 dBc Occupied Bandwidth



Middle Channel -20 dBc Occupied Bandwidth



Channel high -20 dBc Occupied Bandwidth

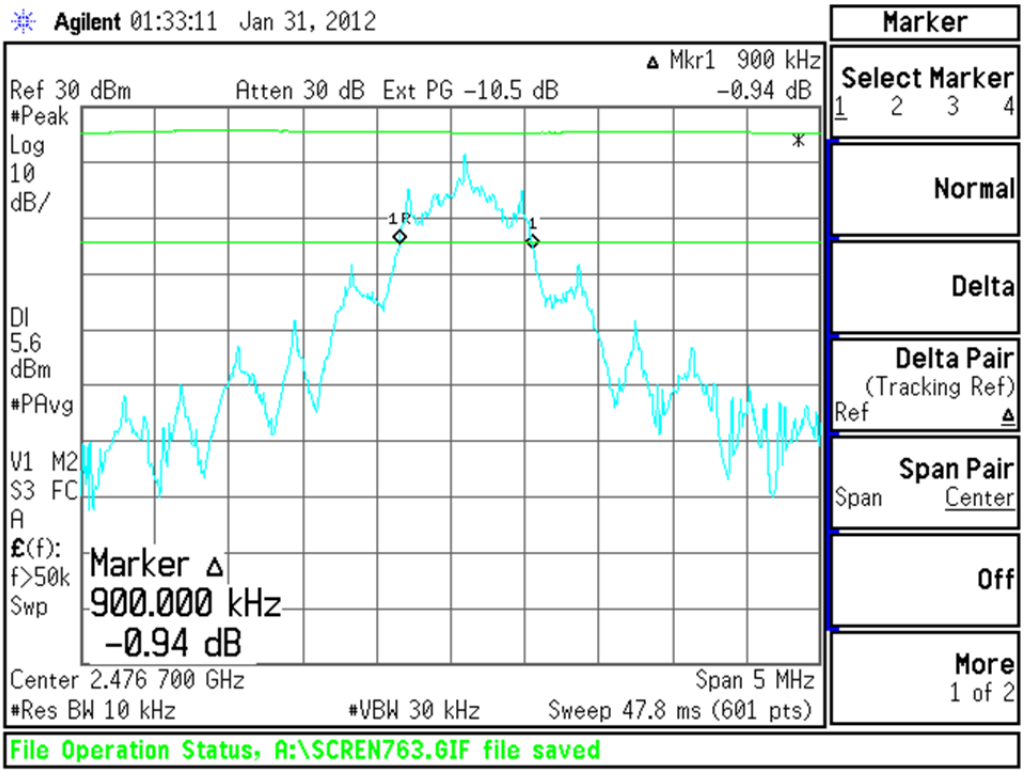
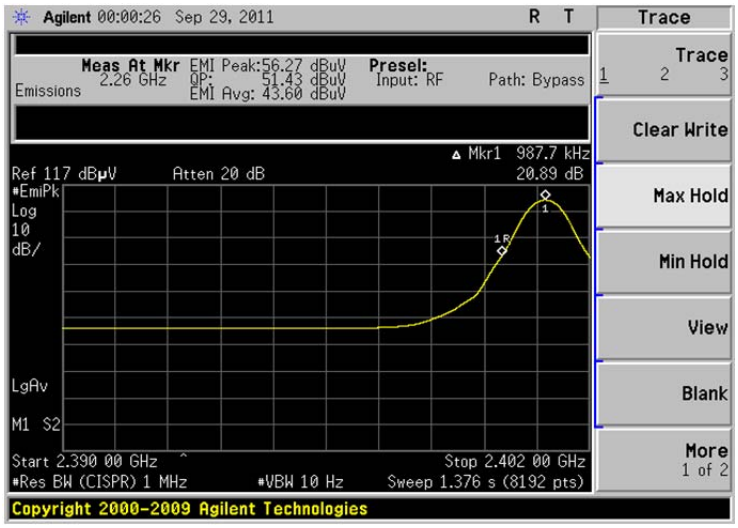


EXHIBIT 8. BAND EDGE MEASUREMENTS

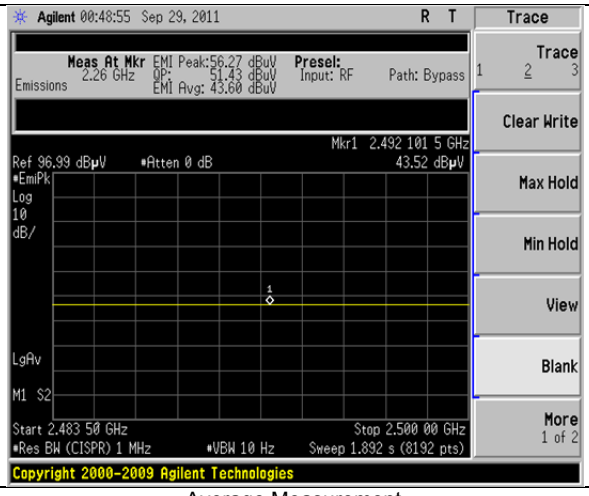
8.1 - Method of Measurements

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 2400 MHz to 2483.5 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.

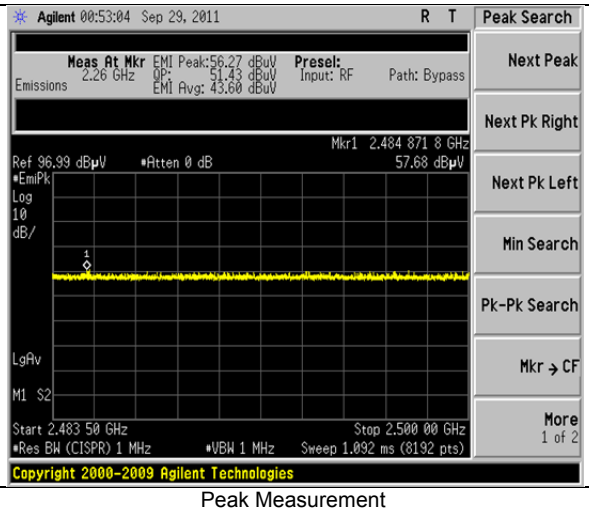
Screen Capture Demonstrating Compliance at the Lower Band-Edge; >20 dBc @ 2400 MHz



Screen Capture Demonstrating Compliance at the Higher Band-Edge, 2483.5-2500 MHz



Average Measurement



Peak Measurement

EXHIBIT 9. POWER OUTPUT (CONDUCTED)

9.1 - Method of Measurements

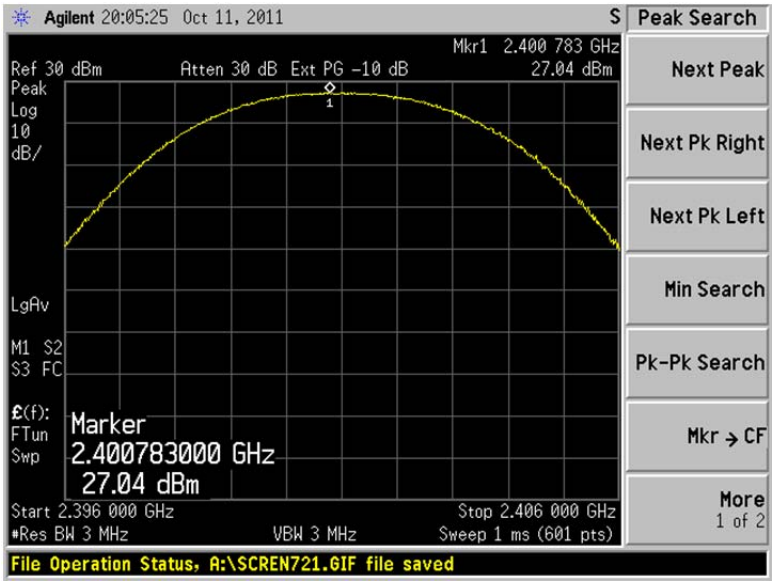
The conducted RF output power of the EUT was measured at the antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, allowing direct measurements without the need 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 3 MHz and a span of 10 MHz, with measurements from a peak detector presented in the chart below.

9.2 - Test Data

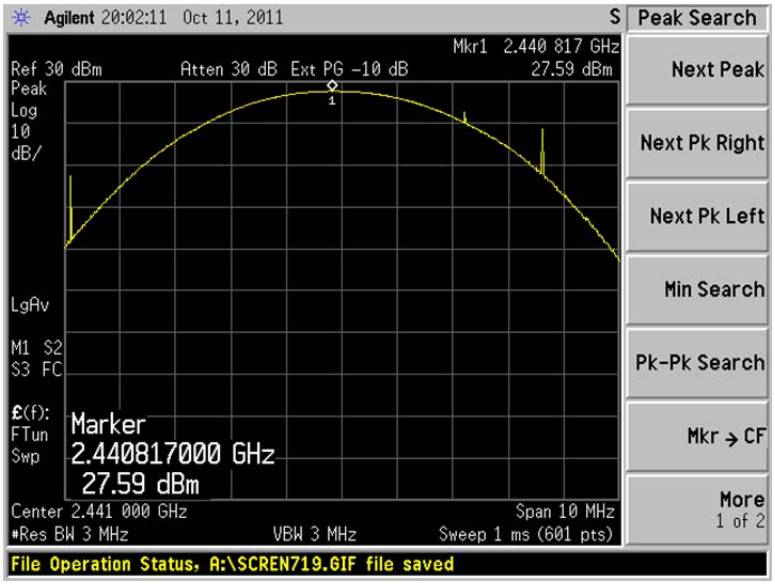
CHANNEL	CENTER FREQ (MHz)	LIMIT (dBm)	MEASURED POWER (dBm)	MARGIN (dB)
LOW	2401.02	30.0	27.0	3.0
MIDDLE	2440.96	30.0	27.6	2.4
HIGH	2476.80	30.0	27.2	2.8

9.3 - Screen Captures – Power Output (Conducted)

Channel Low



Channel Middle



Channel High

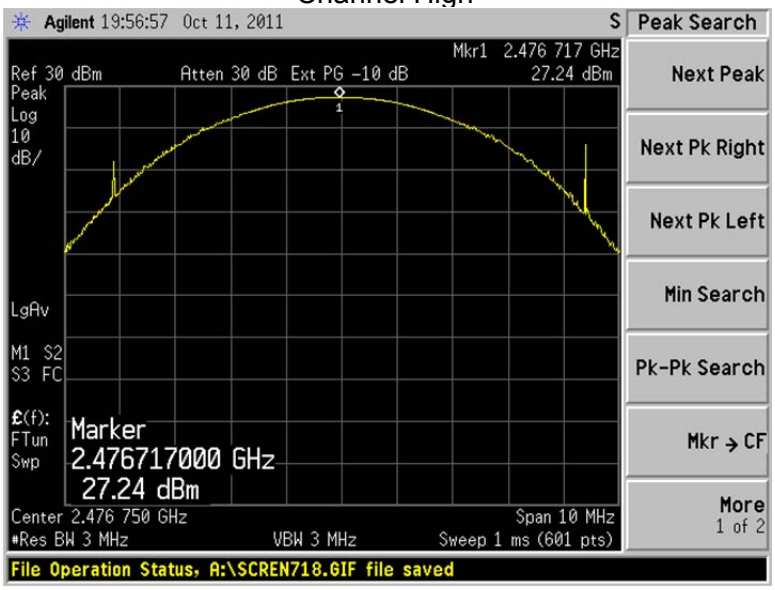


EXHIBIT 10. CONDUCTED SPURIOUS EMISSIONS: 15.247(d)

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. 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:

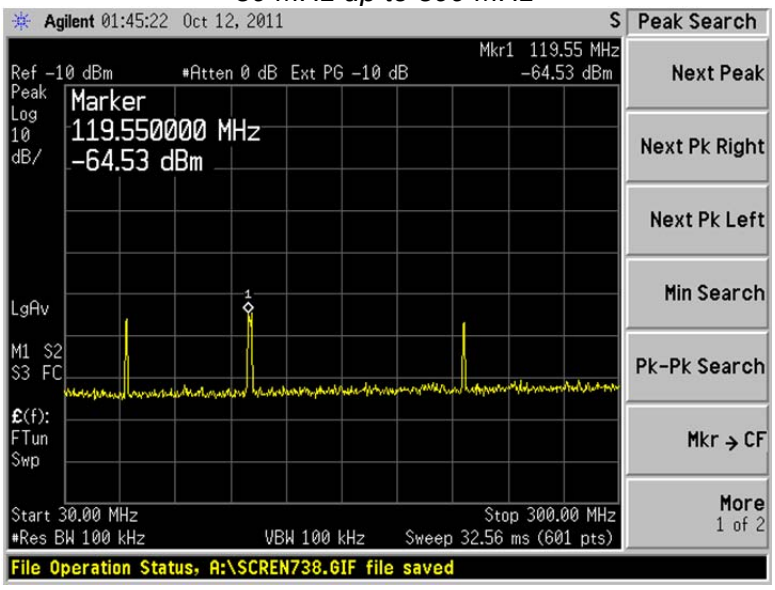
Harmonic/Chan	2401.02	2440.96	2476.80
2	-65.7	-58.9	-55.8
3	-50.5	-52.8	-48.3
4	-76.3	-70.4	-65.7
5	-74.3	-74.6	-76.8
6	NF	NF	NF
7	NF	NF	NF
8	NF	NF	NF
9	NF	NF	NF
10	NF	NF	NF

Conducted spurious emissions:

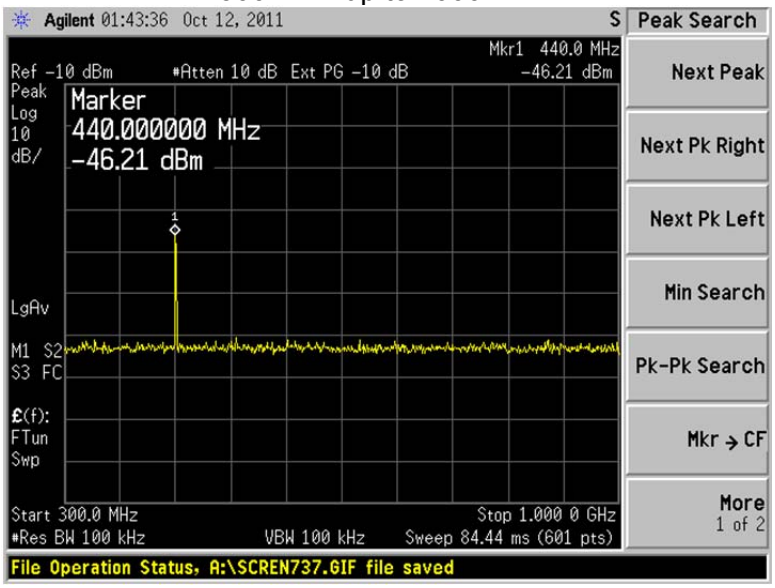
Freq(MHz)	Chan	level(dBm)
154.65	40	-64.96
280.65	40	-66.27
480.80	40	-43.79
2330.00	40	-41.79
219.45	40	-62.73
7319.00	40	-52.29
23925.00	40	-65.32
9160	1	-64.79
2290	1	-70.97
7206	1	-47.80
2290.3	1	-41.90
440	1	-46.21
119.55	1	-64.28
120.9	1	-63.74

10.3- Screen Captures – Spurious Radiated Emissions

30 MHz up to 300 MHz

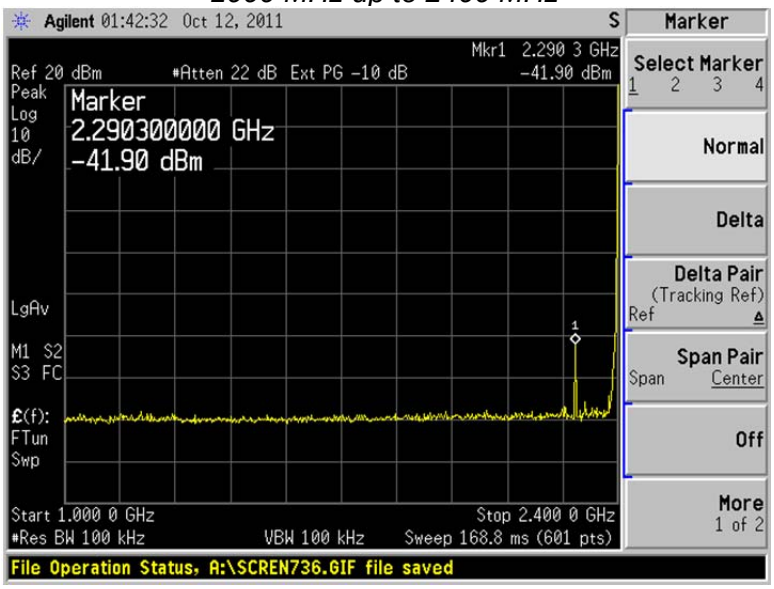


300 MHz up to 1000 MHz

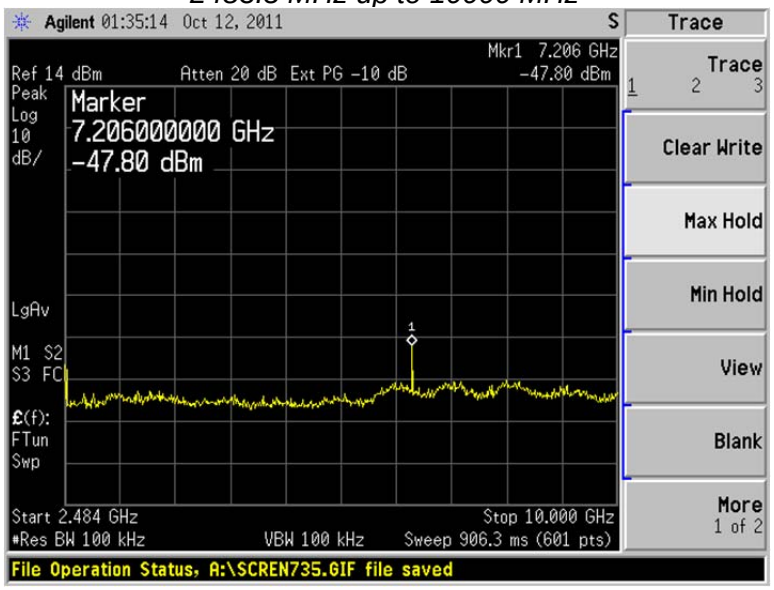


Spurious Radiated Emissions (continued)

1000 MHz up to 2400 MHz



2483.5 MHz up to 10000 MHz



Spurious Radiated Emissions (continued)

10000 MHz up to 25000 MHz

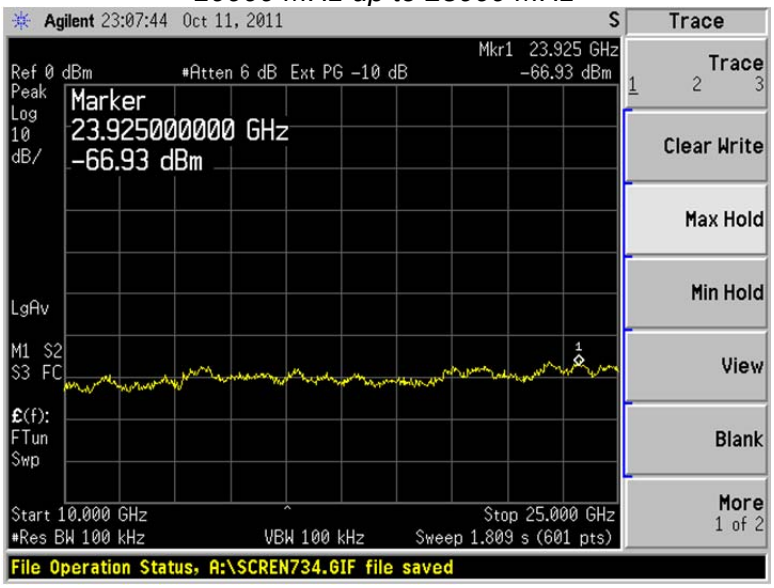


EXHIBIT 11. FREQUENCY & POWER STABILITY OVER VOLTAGE VARIATIONS

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.

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 **160 kHz** which is better than 100 ppm in the 2400 MHz to 2483.5 MHz band.

2.8 VDC		3.3 VDC		3.8 VDC		
Power	Frequency	Power	Frequency	Power	Frequency	Channel
20.48	2400.863000	27.04	2400.903000	25.48	2400.973000	1
20.16	2440.837000	27.60	2440.903000	26.61	2440.997000	40
19.98	2476.683000	27.20	2476.775000	26.91	2476.813000	75

EXHIBIT 12. CHANNEL PLAN AND SEPARATION

A spectrum analyzer was used with a resolution bandwidth of 100 kHz to measure the channel separation of the EUT.

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 15 channels.

This EUT uses 75 channels and has a minimum and maximum channel-separation measured for this device as 1017 kHz and 1033 kHz respectively. The maximum occupied bandwidth of the device, as reported in the previous section is 967 kHz.
Therefore, the requirements are met, as the minimum number of channels is satisfied, and the channel separation is greater than the maximum 20 dB occupied bandwidth.

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

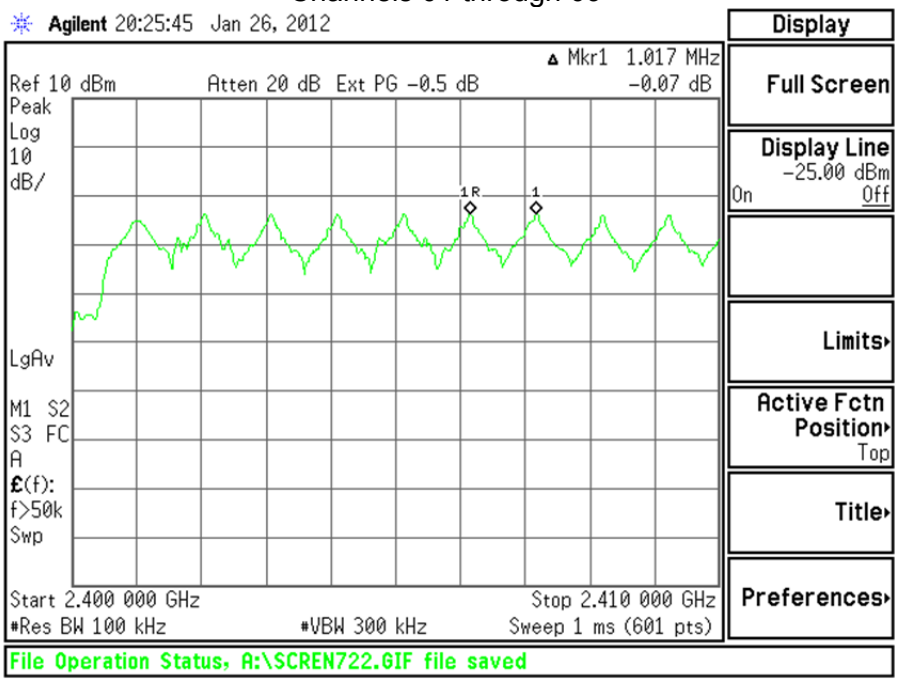
RANGE (MHz)	NUMBER OF CHANNELS PER CAPTURE	Max separation (kHz)
2400-2410	9.0	1017
2410-2420	10	1033
2420-2430	10	1033
2430-2441.5	11	1033
2441.5-2450.7	9	1033
2450.7-2461	10	1033
2461-2470	9	1017
2470-2483.5	7	1035

Total Channels	75
Max separation	1035
Min Separation	1017

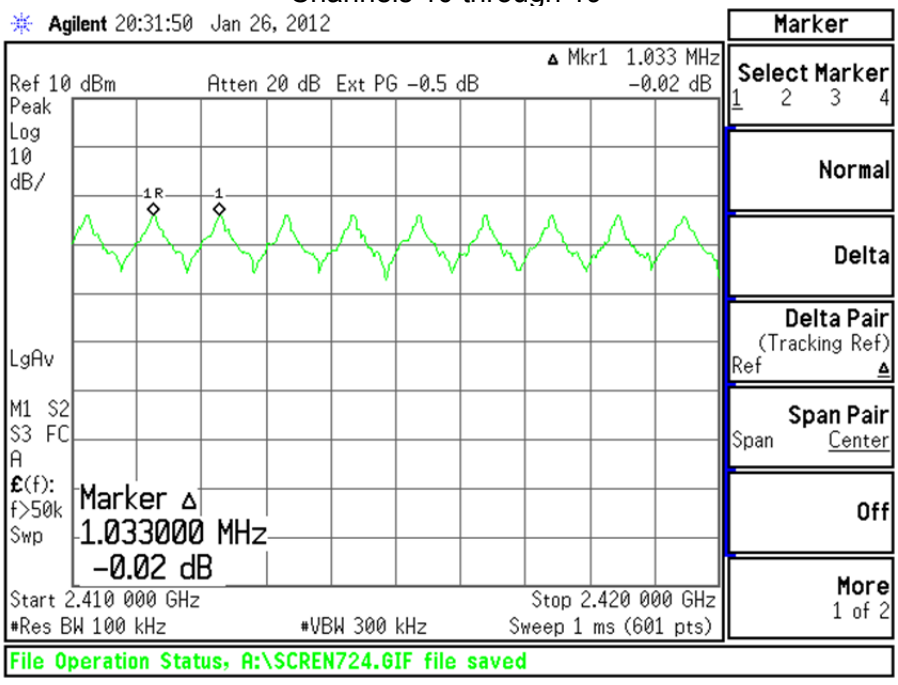
Total number of channels = 75

12.1 - Screen Captures – Channel Separation

Channels 01 through 09

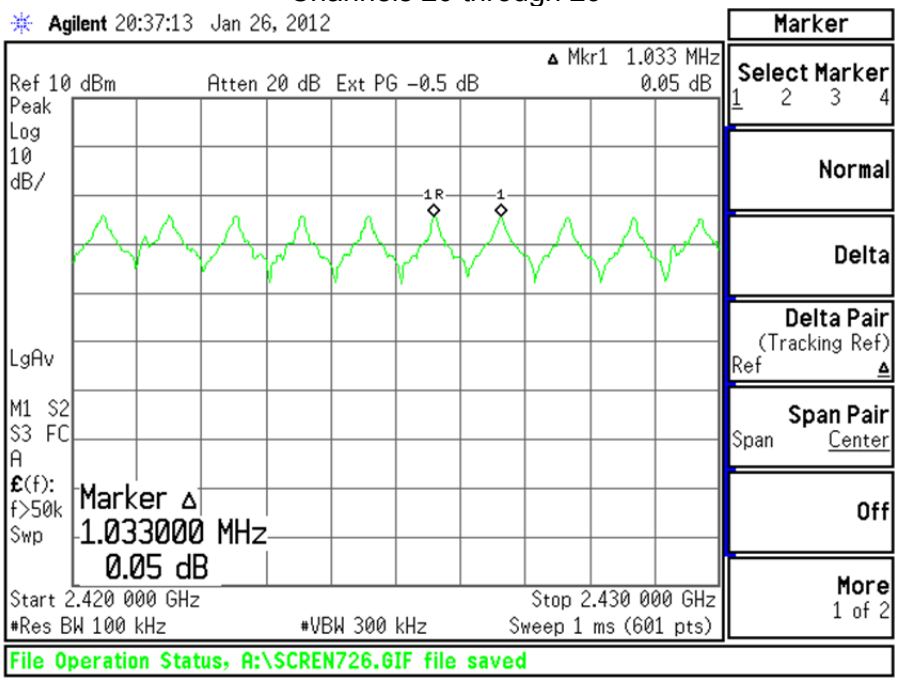


Channels 10 through 19

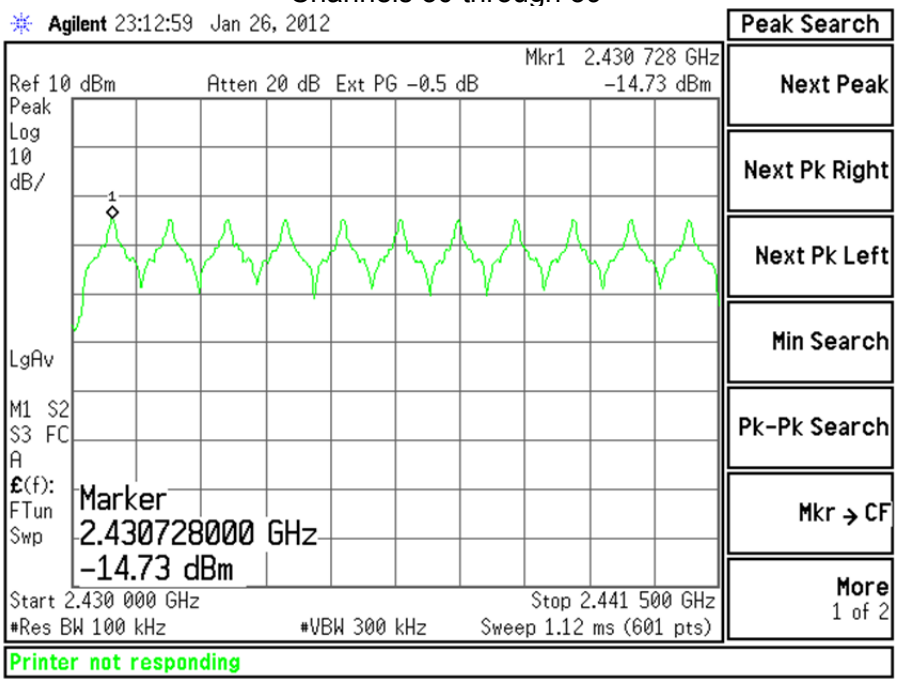


Screen Captures – Channel Separation *(continued)*

Channels 20 through 29

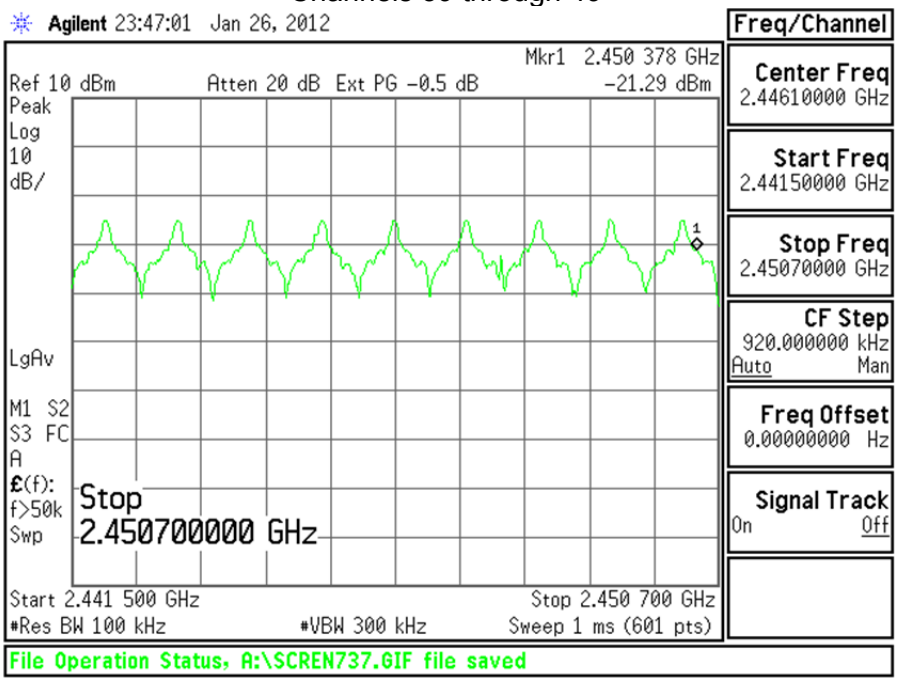


Channels 30 through 39

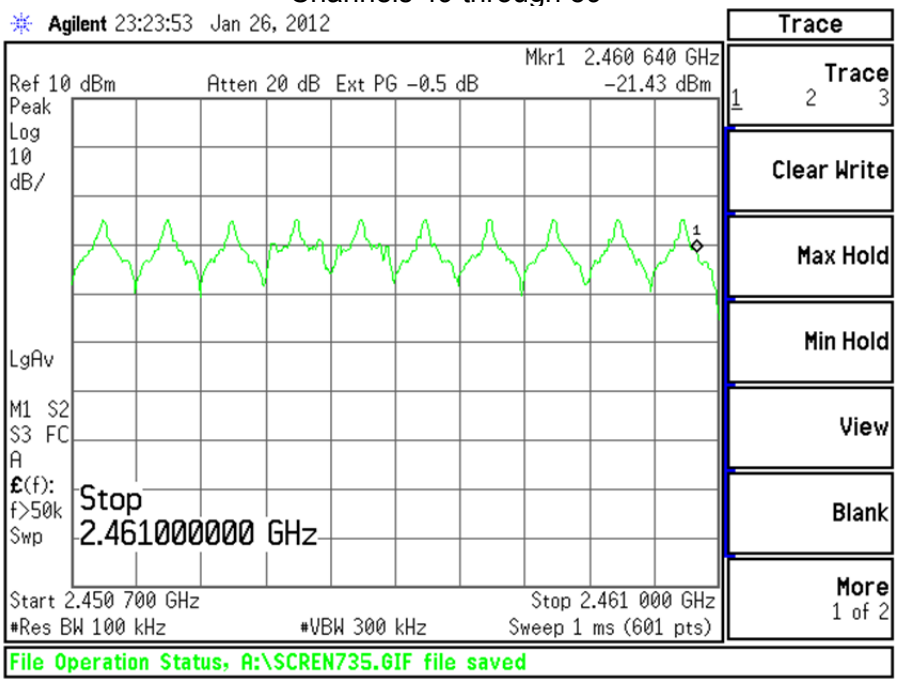


Screen Captures – Channel Separation *(continued)*

Channels 39 through 49

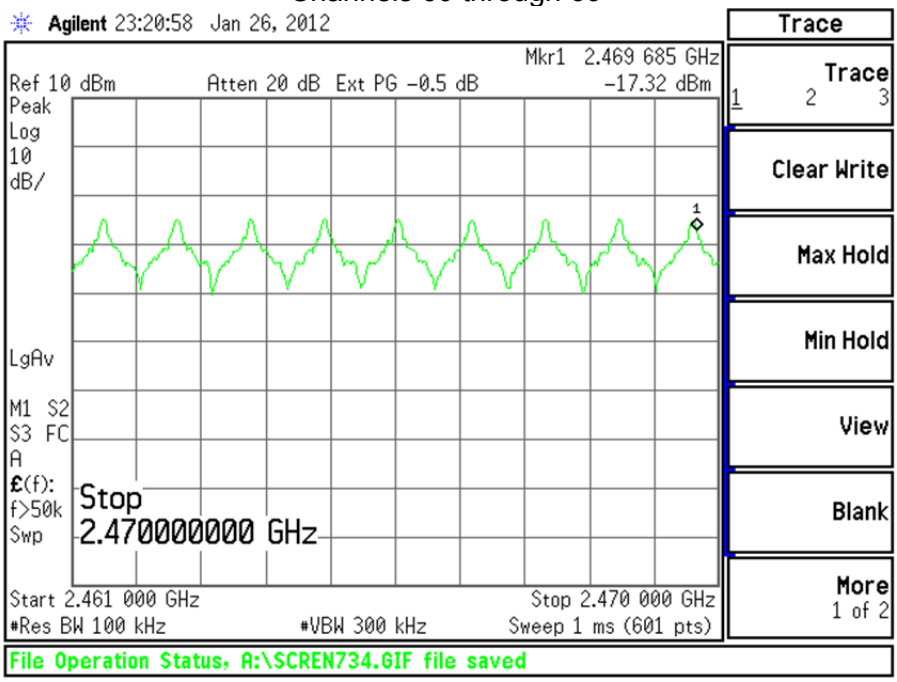


Channels 49 through 59



Screen Captures – Channel Separation *(continued)*

Channels 60 through 69



Channels 69 through 75

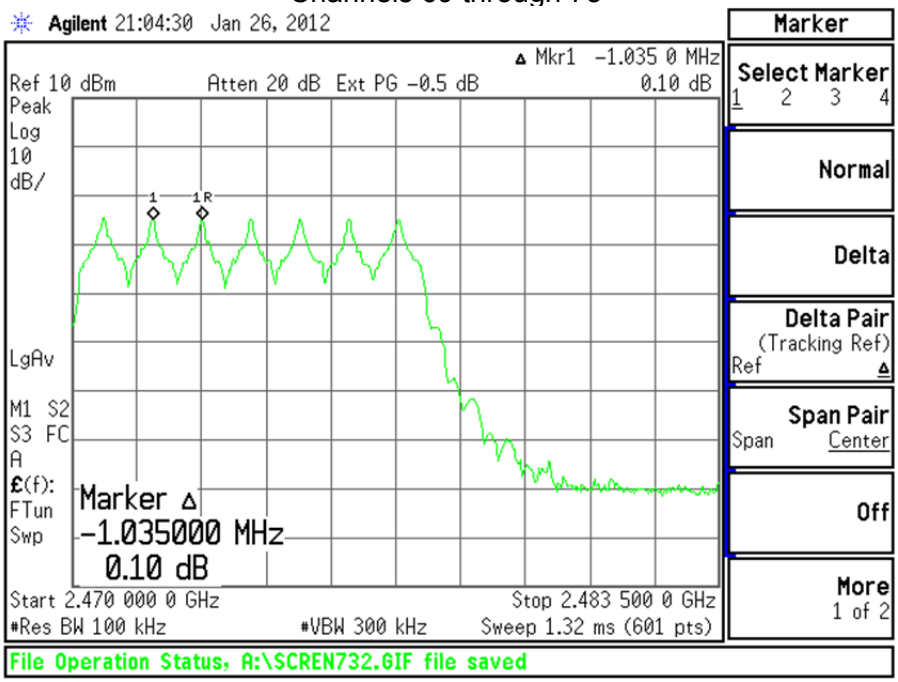


EXHIBIT 13. CHANNEL OCCUPANCY

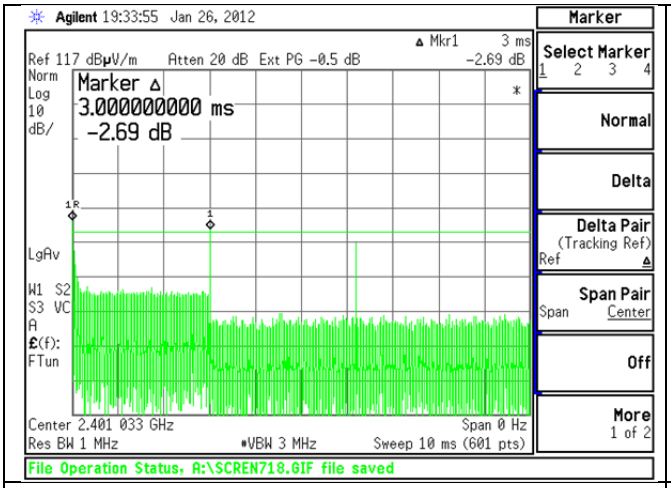
Part 15.247(a)(1) requires a channel occupancy, for this device, of no more than 400 milliseconds in a 30 second window. The channel occupancy for this EUT was measured using a spectrum analyzer, set to zero-span at the frequency of interest. With the analyzer in peak-hold mode, the transmission lengths 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 3.0 milliseconds. In a 30 second window, each channel has 1 transmission cycle. The maximum occupancy in a 30 second window is calculated by multiplying 1 transmission cycle by 3.0 milliseconds transmission duration per cycle, to arrive at 3.0 milliseconds total occupancy.

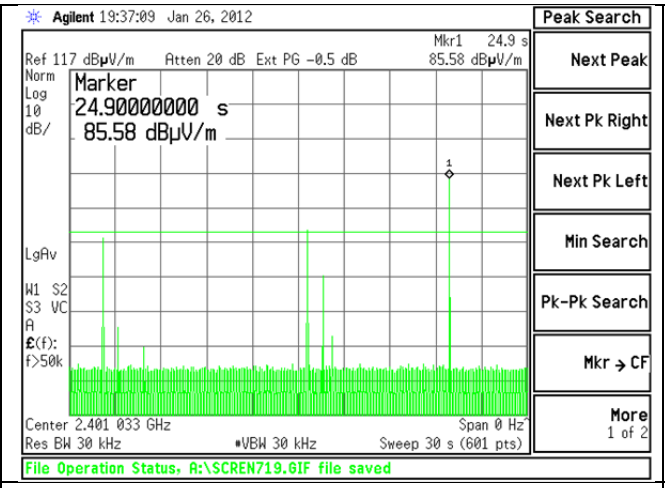
Channel	Frequency (MHz)	Total Occupancy in 20 seconds (ms)	Occupancy in 10 ms window (ms)
Low	2401.02	3 ms	3 ms
Middle	2440.96	3 ms	3 ms
High	2476.80	3 ms	3 ms

Plots of Channel Occupancy

Low Channel Occupancy

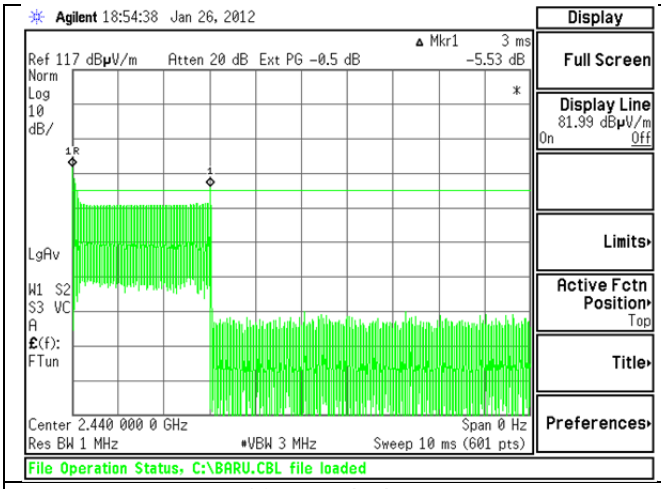


10 ms window

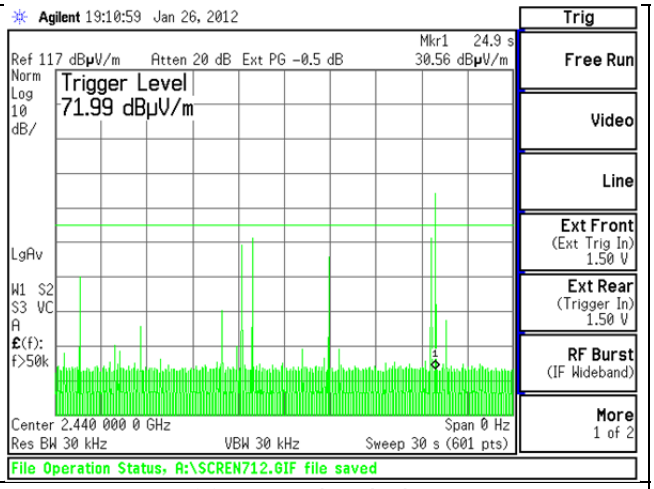


30 seconds window

Middle Channel Occupancy

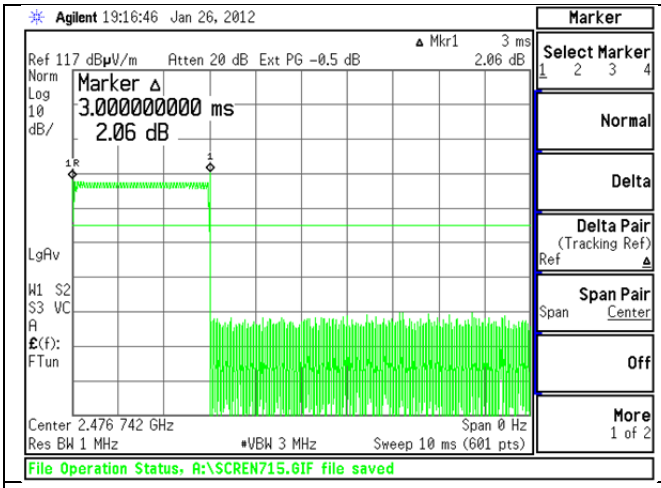


10 ms window

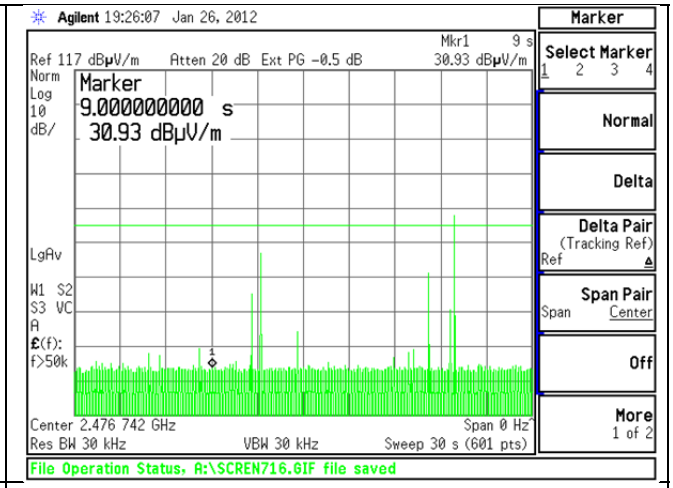


30 seconds window

Channel High Occupancy



10 ms window



30 seconds window

EXHIBIT 14. EQUAL CHANNEL USAGE AND PSEUDORANDOM HOPPING SEQUENCE.

A new hop channel is selected every 333ms.

2	50	58
4	52	6
8	60	10
48	42	12
46	44	40
62	38	64
14	16	66
18	32	20
68	22	30
72	1	74
34	36	24
28	26	3
70	53	5
55	59	9
49	7	47
51	11	45
61	13	63
41	39	15
43	65	19
37	67	69
17	21	73
31	29	33
71	75	27
35	25	23
56	57	54

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

EXHIBIT 15. RECEIVER SYNCHRONIZATION AND RECEIVER INPUT BANDWIDTH.

The receiver input bandwidth is 1.1 MHz.

The receiver is a dual conversion design with a FSK discriminator based demodulator. The discriminator output is connected to an A/D converter.

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 : 24-Jan-2012 Type Test : Radiated Emissions Job # : C-1305

Prepared By: Peter Customer : GTT Quote #: 311282

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960158	RF Preselecter	Agilent	N9039A	MY46520110	6/11/2011	6/11/2012	Active Calibration
2	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/6/2011	6/6/2012	Active Calibration
3	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	6/6/2011	6/6/2012	Active Calibration
4	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	4/27/2011	4/27/2012	Active Calibration
5	AA 960158	Double Ridge Horn Antenna	EMCO	3117	109300	9/21/2011	9/21/2012	Active Calibration
6	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	11/15/2011	11/15/2012	Active Calibration
7	AA 960150	Bicon Antenna	ETS	3110B	0003-3346	11/15/2011	11/15/2012	Active Calibration
8	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	1/4/2011	1/4/2012	Active Calibration

Project Engineer: Peter Fielen Quality Assurance:

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 24-Jan-2012 Type Test : Conducted Radio Emissions Job # : C-1305

Prepared By: Peter Customer : GTT Quote #: 311282

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	4/25/2011	4/25/2012	Active Calibration
2	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/1/2011	6/1/2012	Active Calibration

Project Engineer: Peter Fielen Quality Assurance:

APPENDIX B – Test Standards: CURRENT PUBLICATION DATES RADIO

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2003		
ANSI C63.10	2009		
RSS 210	2010-12		
CISPR 11	2009-05	2009-12 P	
RSS GEN	2007-06		
FCC 47 CFR, Parts 0-15, 18,	2009		
FCC Procedures	2007		
FCC Public Notice DA 00-705	2000		
EN 55011	2009		

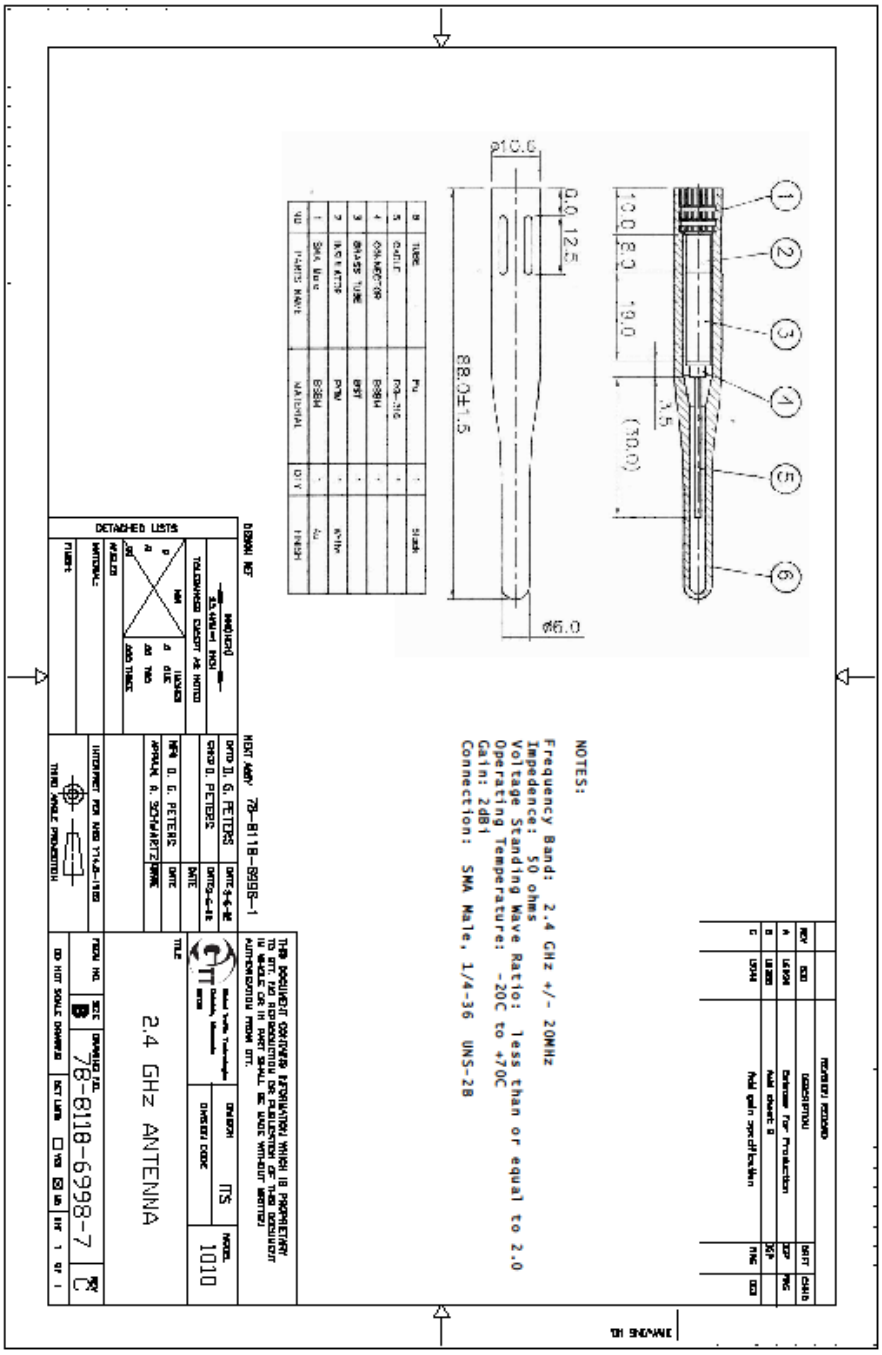
APPENDIX C - Uncertainty Statement

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	4.24 dB
Radiated Emissions	3-Meter Chamber, Log Periodic Antenna	4.8 dB
Radiated Emissions	10-Meter OATS, Biconical Antenna	4.18 dB
Radiated Emissions	10-Meter OATS, Log Periodic Antenna	3.92 dB
Conducted Emissions	Shielded Room/EMCO LISN	1.60 dB
Radiated Immunity	3 Volts/Meter in 3-Meter Chamber	1.128 Volts/Meter
Conducted Immunity	3 Volts level	1.0 V

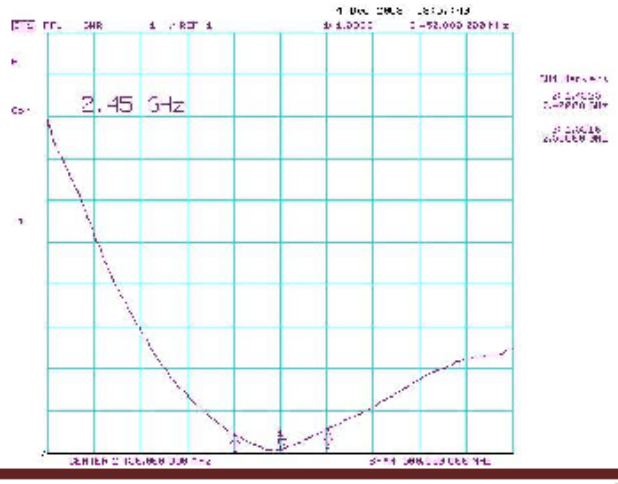
APPENDIX D - Antenna Specification(s)



S-001-1 2D pattern

2008 12 04

Date/Time	2008.12.15
Measurement space	9mX4mX3.6m
Product No.	S-001-1
Temp. / Humidity	20°C / 55%
Network analyzer	Agilent 50MHz-20GHz 8720ET



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S-001-1 2D pattern

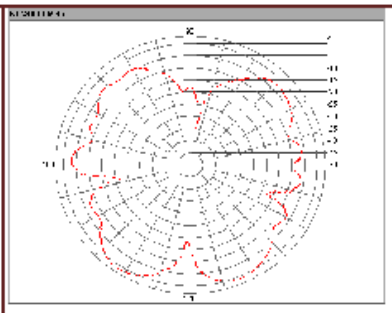
2008 12 04

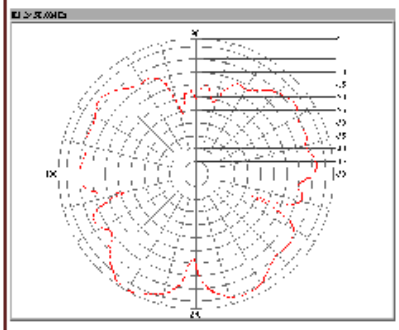
E Plane

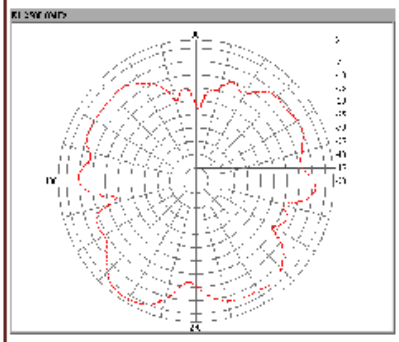
2400MHz	E1
Max Gain (dBi)	1.4
Max Gain@Angle (degree)	236
Min Gain (dBi)	-35.18
Min Gain@Angle (degree)	82
Average Gain (dBi)	-4.75
-3dB Angle L (degree)	250.1
-3db Angle R (degree)	224.5
HPB (degree)	25.6
FBR (dB)	4.62

2450MHz	E1
Max Gain (dBi)	2.62
Max Gain@Angle (degree)	238
Min Gain (dBi)	-26.99
Min Gain@Angle (degree)	338
Average Gain (dBi)	-4.52
-3dB Angle L (degree)	251.97
-3db Angle R (degree)	229.6
HPB (degree)	22.37
FBR (dB)	10.28

2500MHz	E1
Max Gain (dBi)	1.59
Max Gain@Angle (degree)	236
Min Gain (dBi)	-23.25
Min Gain@Angle (degree)	87
Average Gain (dBi)	-5.37
-3dB Angle L (degree)	251.53
-3db Angle R (degree)	225.6
HPB (degree)	25.93
FBR (dB)	7.8







S-001-1 2D pattern

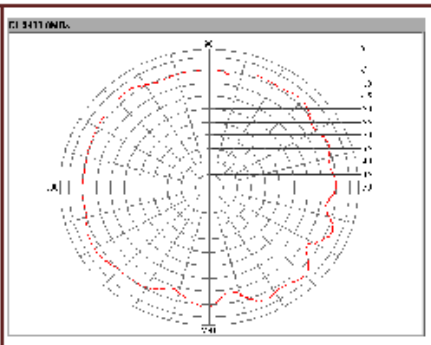
2008 12 04

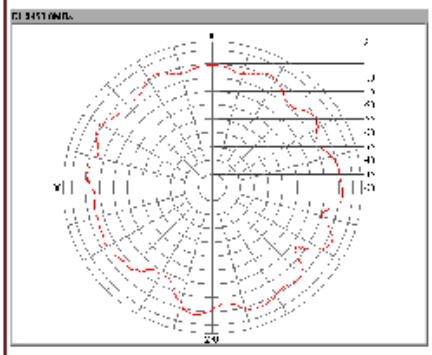
H Plane

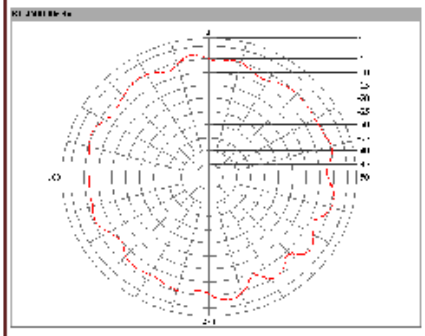
2400MHz	H
Max Gain (dBi)	-1.94
Max Gain@Angle (degree)	315
Min Gain (dBi)	-9.3
Min Gain@Angle (degree)	327
Average Gain (dBi)	-4.7
-3dB Angle L (degree)	321.7
-3db Angle R (degree)	288.38
HPB (degree)	33.32
FBR (dB)	1

2450MHz	H
Max Gain (dBi)	-3.01
Max Gain@Angle (degree)	335
Min Gain (dBi)	-13.7
Min Gain@Angle (degree)	245
Average Gain (dBi)	-6.28
-3dB Angle L (degree)	340.63
-3db Angle R (degree)	329.27
HPB (degree)	11.36
FBR (dB)	0.99

2500MHz	H
Max Gain (dBi)	-2.7
Max Gain@Angle (degree)	279
Min Gain (dBi)	-10.24
Min Gain@Angle (degree)	217
Average Gain (dBi)	-5.87
-3dB Angle L (degree)	286.97
-3db Angle R (degree)	269.52
HPB (degree)	17.44
FBR (dB)	0.5







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APPENDIX E – Duty-Cycle Justification

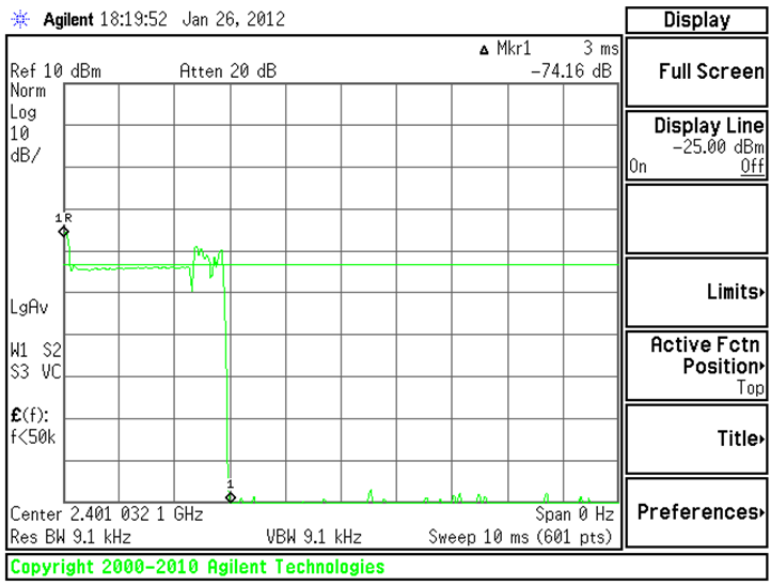
Average (Relaxation) Factor

Average Factor = 20* Log_{10} (Worst Case EUT On-time over _X_ ms time window)

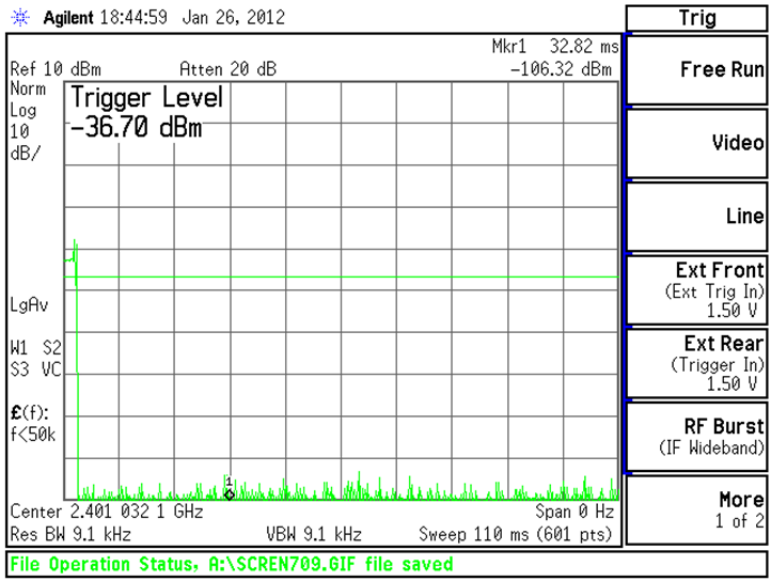
The transmit packet occupies 3 ms of time, within any 100 ms window. Therefore, the relaxation factor allowance is calculated as:

Average Factor = 20* Log_{10} (3 / 100 ms) = - 30.46

A relaxation factor of 30.46 dB would be allowable for this product.



A single transmission, with an on-time of 3 ms.



Period greater than 100 ms demonstrated.