LS RESEARCH LLC
Wireless Product Development
ACCREDITED
TESTING CERT #1255.01
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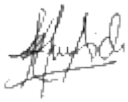
TEST REPORT # 313179 B
LSR Job #: C-1818

Compliance Testing of:
E0150-MOD

Test Date(s):
March 20th, April 25th 2012, October 11th to November 11th 2013

Prepared For:
Attention: Chris Cartile
Nikon Metrology Canada Inc.
Integrated Systems and Technologies
13-55 Fleming Dr.
Cambridge, Ontario, Canada
NIT 2A9

This Test Report is issued under the Authority of:
Khairul Aidi Zainal, Senior EMC Engineer.

Signature:  Date: 11/27/13

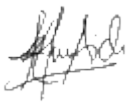
Test Report Reviewed by:	Project Engineer:
Ryan Urness, Laboratory Quality and Operations manager.	Khairul Aidi Zainal, Senior EMC Engineer.
Signature:  Date: 11/26/13	Signature:  Date: 11/13/13

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EXHIBIT 1. INTRODUCTION

1.1 - Scope

References:	FCC Part 15, Subpart C, Section 15.247 RSS GEN issue 3 and RSS 210 issue 8 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:	Radiated 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:	Residential

1.2 – Normative References

Publication	Year	Title
47 CFR, Parts 0-15 (FCC)	2013	Code of Federal Regulations - Telecommunications
RSS 210 Issue 8 Annex 8	2010-12	Low-power License-exempt Radio-communication Devices (All Frequency Bands): Category I Equipment
ANSI C63.4	2003	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.
ANSI 63.10	2009	American National Standard For Testing Unlicensed Wireless devices.
FCC DA 00-705	2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

1.3 - LS Research, LLC Test Facility

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) as conforming 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. Accreditation status can be verified at A2LA’s web site: www.a2la.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 by a calibration laboratory accredited to the requirements of ISO/IEC 17025, and traceable to SI standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	Nikon Metrology Canada Inc. Integrated Systems and Technologies
Address:	13-55 Fleming Dr., Cambridge, Ontario, Canada
Contact Name:	Chris Cartile

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	E0150-MOD
Model Number:	E0150-MOD
Serial Number:	SN081201, 010502

2.3 - Associated Antenna Description

The antenna associated with the module is an Ethertronics Prestta™ WLAN Embedded Antenna. The antenna is a multi-band antenna that operates in the 2.4GHz, 4.9GHz, 5.2GHz and the 5.8GHz bands.

The antenna performance is as listed:

WLAN a/b/g/n + Japan Antenna (GHz)	2.390-2.490 b, g	4.900-5.100 Japan	5.150-5.350 a	5.70-5.900 a
Peak Gain	-0.6dBi	2.5dBi	4.5dBi	3.5dBi
Average Efficiency	55%	71%	75%	65%
VSWR Match	3.0:1 max	2.5:1 max	2.5:1 max	3.0:1 max
Feed Point Impedance	50 Ω unbalanced (other if required)			

2.4 - EUT'S Technical Specifications

EUT Frequency Range (in MHz)	2402 MHz to 2480MHz
RF Power in Watts	☒ Conducted Measurement ☐ EIRP
Minimum(Watts):	GFSK = 0.0083 EDR 2 = 0.0085 EDR 3 = 0.0097
Maximum(Watts):	GFSK = 0.0086 EDR 2 = 0.0087 EDR 3 = 0.0102
Occupied Bandwidth (99% and 20dB)	20dB (kHz): GFSK = 884 EDR2 = 1380 EDR3 = 1380 99%(kHz): GFSK = 857 EDR2 = 1220 EDR3 = 1220
Type of Modulation	GFSK, QPSK
Emission Designator	GFSK: 857kFXD EDR2: 1M22FXD EDR3: 1M22FXD
Transmitter Spurious (worst case radiated) at 3 meters	47.6 dBµV/m at 3m at 4960 MHz
Stepped (Y/N)	N
Step Value:	N/A
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Antenna Information	
Detachable/non-detachable	Yes
Type	Isolated Magnetic Dipole stamped metal antenna ™.
Gain	-0.6
EUT will be operated under FCC Rule Part(s)	Title 47 part 15.247
EUT will be operated under RSS Rule Part(s)	RSS 210
Modular Filing	☐ Yes ☒ No
Portable or Mobile?	Portable

2.5 - Product Description

The module is a multi-standard module with support for WLAN (802.11 a/b/g/n), Bluetooth 2.1+EDR and Bluetooth 4.0 (LE).

Proprietary LS Research software was used to control functionality of the module. The test softwares are:

1. TiWi WLAN eval tool V2.1.0.0 for controlling WLAN functions.
2. TiWi BT Eval tool 930-0030-R4.0 for controlling Bluetooth functions.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	70-71° F
Humidity:	34-38%
Pressure:	729-742mmHg

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) 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(d) IC : RSS 210 A8.5	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC:15.247 (a)(1)(iii) 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(b) IC : RSS 210 A8.2(b), section 2.2, 2.6 and 2.7	Transmitter Radiated Emissions in the restricted bands	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), Annex 8 (section 8.1).

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 ANSI C63.4 per the requirements of Title 47, CFR FCC Part 15 and RSS GEN. 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 transmit modulated mode for final testing. The EUT is powered via a bench DC supply.

Using the LS Research 'TiWi Bluetooth Eval Tool', the test sample was operated on one of three (3) standard channels: low (2402 MHz), middle (2440 MHz) and high (2480 MHz) to comply with FCC Part 15.31(m).

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 Biconical Antenna was used to measure emissions from 30 MHz to 200 MHz, and a Log Periodic Antenna was used to measure emissions from 200 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 18 GHz while a standard gain horn antenna was used in the 18 GHz to 25 GHz range. The maximum radiated RF emissions between 30 MHz to 4 GHz were found by raising and lowering the sense antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. Between 4 GHz to 25 GHz, the sense antenna was raised and lowered between 1 and 1.8 meters in height.

The EUT was positioned in 3 orthogonal orientations.

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 a calibration laboratory accredited to ISO 17025, and are traceable to SI standards. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and an EMI Receiver. The resulting correction factors and the cable loss factors from these calibrations were entered into the EMI Receiver database. **As a result, the data taken from the EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading.** The EMI Receiver was operated with a resolution bandwidth of 120 kHz for measurements below 1 GHz (video bandwidth of 300 kHz), and a bandwidth of 1 MHz for measurements above 1 GHz (video bandwidth of 1 MHz).

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 an 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 and reported data

Reported data:

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

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

Generic example of reported data at 200 MHz:

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

As specified in 15.247 (d) and RSS 210 A8.5, radiated emissions that fall within the restricted band described in 15.205(c) for FCC and section 2.2 of RSS 210 for IC, must comply with the general emissions limit.

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 GEN.

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):
To convert 100 µV/m to dBµV/m,

dBµV/m = 20 $\log_{10}$ (100)= 40 dBµV/m (from 30-88 MHz)

5.6 - Radiated Emissions Test Data Chart

Manufacturer:	Nikon Metrology, Inc					
Date(s) of Test:	Oct 29th to 31st 2013					
Project Engineer(s):	Khairul Aidi Zainal					
Test Engineer(s):	Khairul Aidi Zainal					
Voltage:	3.6 VDC					
Operation Mode:	continuous transmit, modulated					
Environmental Conditions in the Lab:	Temperature: 70-71° F Relative Humidity: 34-38%					
EUT Power:		Single Phase 120VAC		3 Phase ___VAC		
	X	Battery		Other: Bench DC supply		
EUT Placement:	**X**	80cm non-conductive pedestal		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

Table of emissions other than harmonics of the transmitter.

Frequency (MHz)	Antenna	EUT	Height (m)	Azimuth (°)	Peak (dBµV/m)	Q.Peak (dBµV/m)	Average (dBµV/m)	Peak limit (dBµV/m)	Q.Peak limit (dBµV/m)	Average limit (dBµV/m)	Peak margin (dB)	Q.Peak margin (dB)	Average margin (dB)	Notes
300.0	H	V	1.00	0	23.3	17.8	11.3	N/A	46.0	N/A	N/A	28.2	N/A	1
933.1	H	V	1.00	0	33.1	27.6	20.9	N/A	46.0	N/A	N/A	18.5	N/A	1
210.4	V	V	1.00	150	24.5	19.1	10.6	N/A	40.0	N/A	N/A	20.9	N/A	
133.0	H	V	1.00	0	28.5	22.4	16.4	N/A	43.0	N/A	N/A	20.6	N/A	1
85.5	V	V	1.00	0	35.5	30.6	21.8	N/A	40.0	N/A	N/A	9.4	N/A	2
130.4	V	V	1.00	313	29.9	24.5	17.8	N/A	40.0	N/A	N/A	15.5	N/A	2

Notes:

1. Measurements of system noise floor
2. Emission does not change with channel. May be a function of the power supply used.
3. Measurement above 4 GHz performed at 1m separation distance.

RADIATED EMISSIONS DATA CHART (continued)

The following table depicts the level of significant radiated **harmonic** emissions of channel 2402 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
4804	1.00	297	55.1	47.8	63.5	15.8	Horizontal	Side
12010	1.00	131	55.3	44.9	63.5	18.6	Horizontal	Flat
19216	1.00	53	54.0	42.2	63.5	21.3	Horizontal	Side

The following table depicts the level of significant radiated **harmonic** emissions of channel 2440 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
4880	1.03	299	57.4	54.4	63.5	9.1	Horizontal	Side
7320	1.06	54	55.7	50.8	63.5	12.7	Horizontal	Flat
12200	1.00	135	60.6	52.8	63.5	10.7	Horizontal	Flat
19520	1.00	291	53.1	41.1	63.5	22.4	Horizontal	Side

The following table depicts the level of significant radiated **harmonic** emissions of channel 2480 MHz in the restricted band:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4960	1.14	37	60.0	57.1	63.5	6.4	Horizontal	Vertical
7440	1.00	32	51.7	44.7	63.5	18.8	Horizontal	Vertical
12400	1.00	44	55.8	44.5	63.5	19.0	Vertical	Flat
19840	1.00	288	50.6	39.1	63.5	24.4	Horizontal	Side
22320	Note 3				63.5			

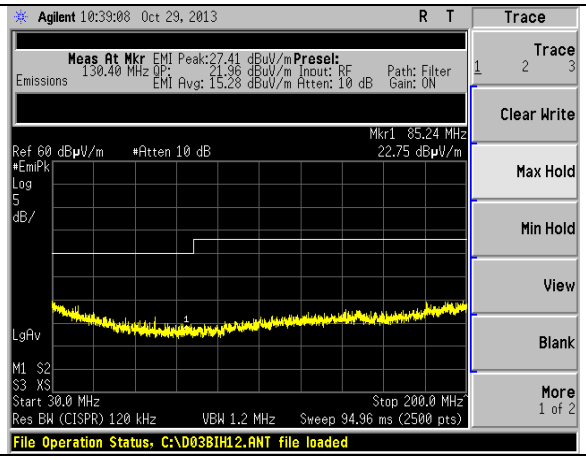
Notes:

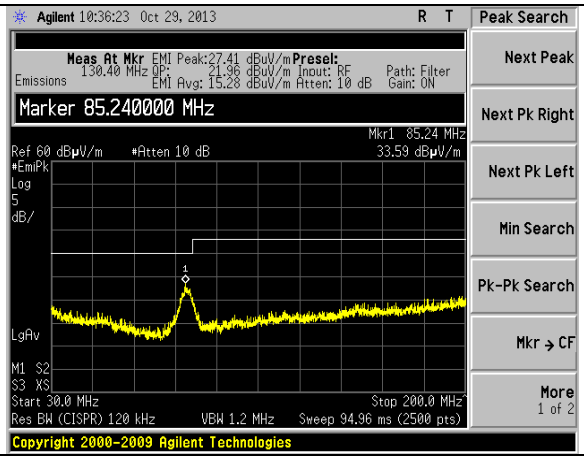
1. Measurements above 4 GHz were made at 1 meter separation distance from the EUT.
2. Refer to exhibit 5.5 on explanation of how data is reported.
3. Measurements of system noise floor

5.8 – Screen Captures of Radiated emissions.

The screen captures represent worst case emissions.

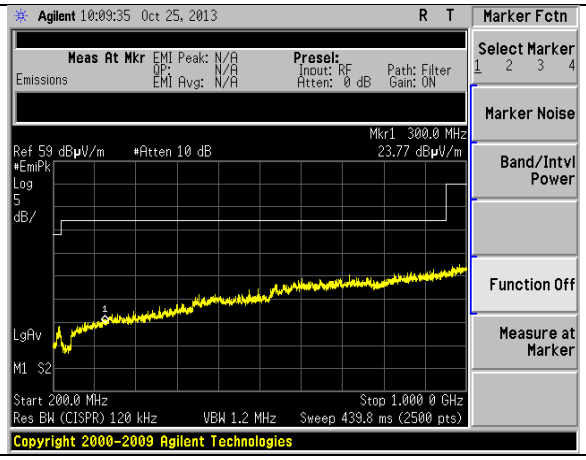
30MHz to 200MHz, 3m distance

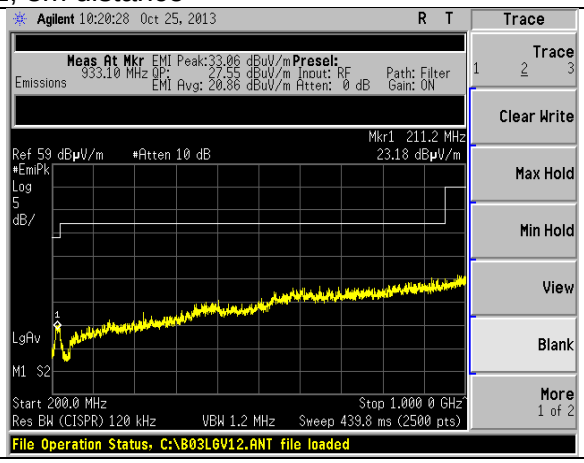




Horizontal Polarization	Vertical Polarization

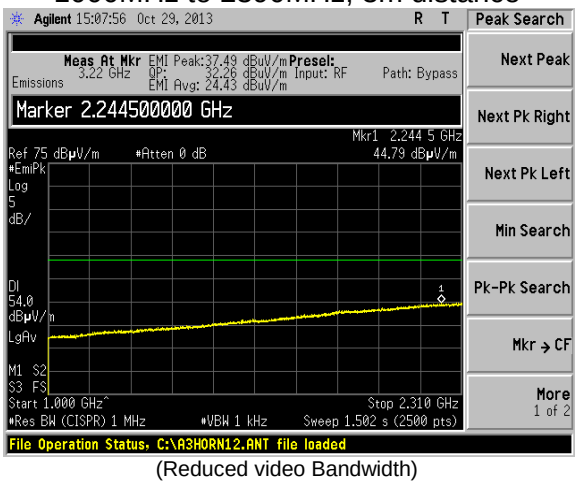
200MHz to 1000MHz, 3m distance





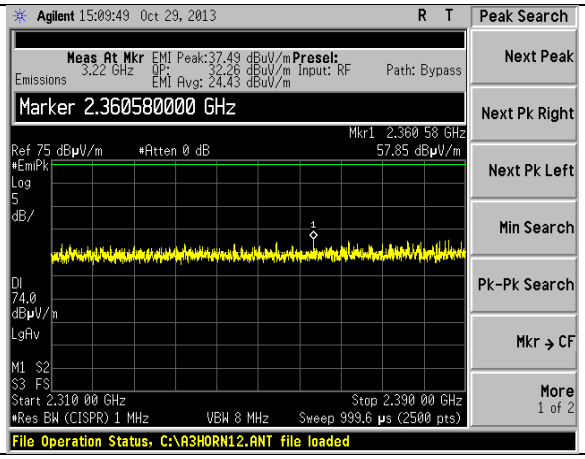
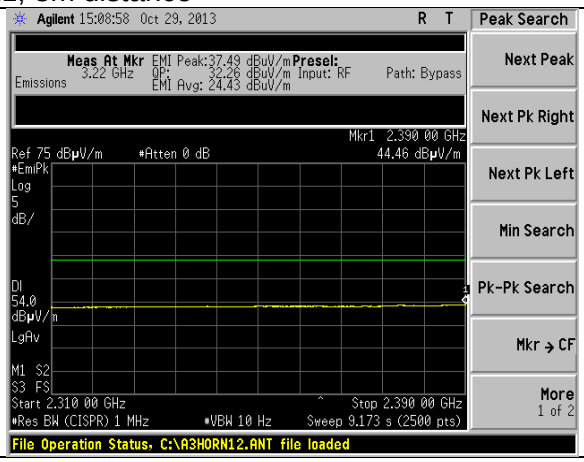
Horizontal Polarization	Vertical Polarization

1000MHz to 2390MHz, 3m distance

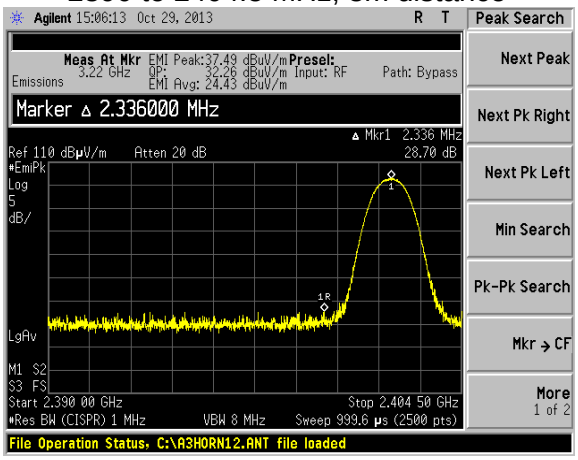


(Reduced video Bandwidth)

2310MHz to 2390MHz, 3m distance

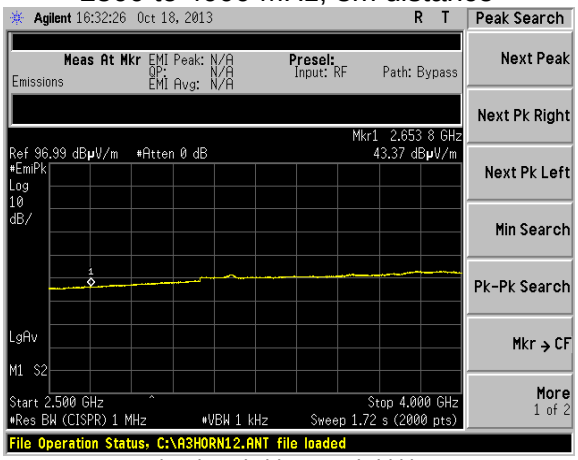
	
Peak	Average

2390 to 2404.5 MHz, 3m distance



Note: Fundamental Emission included in capture to determine -20 dBc requirement at bandedge

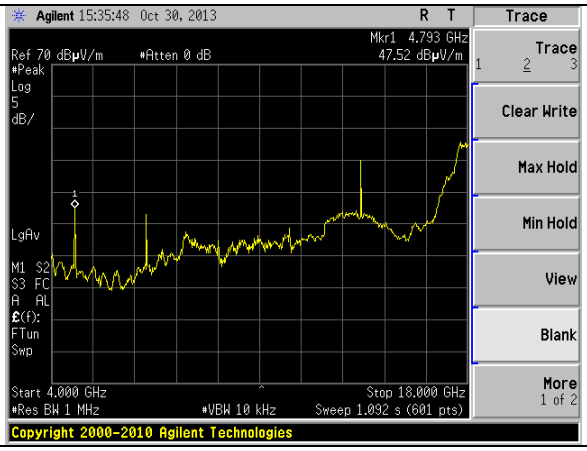
2500 to 4000 MHz, 3m distance

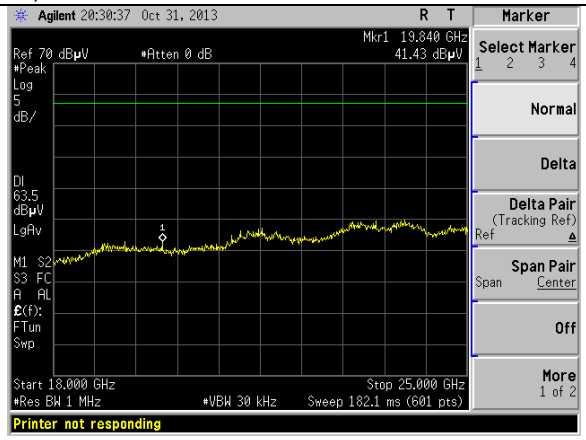


(Reduced video Bandwidth)

Note: The range 2483.5 to 2500 MHz is in section 8 of this report (band-Edges)

4000 MHz to 25000 MHz, 1m distance.





4000 MHz to 18000 MHz	18000 MHz to 25000 MHz

(Reduced video Bandwidth)

EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

6.1 Test Setup

The test area and setup are in accordance with ANSI C63.4 per Title 47 CFR, FCC Part 15, 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 was connected to a USB port of a generic laptop and set to transmit. The Generic laptop power supply was then 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 EMI receiver System. 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 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.

This test was performed on the EUT while it was powered using an off-the-shelf wall AC to DC power supply. The DC power supply is a CUI Stack class 2 transformer model number 41-9-650D which outputs 9VDC, 650mA. The 9 VDC was then regulated (Onsemi RB850) to 3.3 VDC.

6.3 Test Equipment Utilized

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

6.4 Test Results

The EUT was found to **MEET** the Conducted Emission requirements of FCC Part 15.207 and RSS GEN 7.2.2 for Conducted Emissions for an Intentional Radiator. See the Data Charts and Graphs for more details of the test results.

6.5 FCC Limits of Conducted Emissions at the AC Mains Ports

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

6.6 CONDUCTED EMISSIONS TEST DATA CHART

Frequency Range inspected: 150 KHz to 30 MHz

Manufacturer:	LS Research					
Date(s) of Test:	April 25th 2012					
Project Engineer:	Khairul Aidi Zainal					
Test Engineer:	Mike Hintzke					
Voltage:	120 VAC					
Operation Mode:	Continuous transmit, modulated					
Environmental Conditions in the Lab:	Temperature: 71° F Relative Humidity: 40%					
Test Location:	X	AC Mains Test area				Chamber
EUT Placed On:	X	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:		Peak	X	Quasi-Peak	X	Average

		Quasi-Peak			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)
0.150	L1	35.2	66.0	30.8	5.2	56.0	50.8
0.302	L1	32.2	60.2	28.0	10.7	50.2	39.5
1.106	L1	27.2	56.0	28.8	-2.7	46.0	48.7
0.150	L2	34.6	66.0	31.4	4.9	56.0	51.1
0.416	L2	20.0	57.5	37.5	-7.0	47.5	54.5
0.295	L2	30.0	60.4	30.4	0.6	50.4	49.8
1.025	L2	27.6	56.0	28.4	-2.4	46.0	48.4
0.618	L2	22.1	56.0	33.9	17.7	46.0	28.3

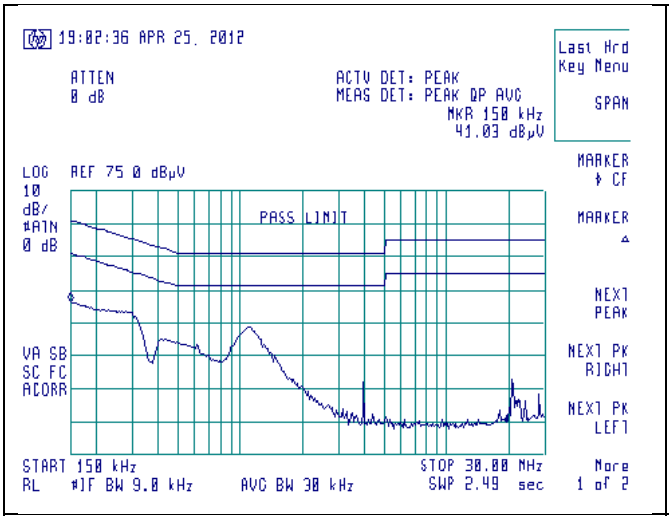
Notes:

1) The emissions listed are characteristic of the power supply used, and did not change by the EUT.

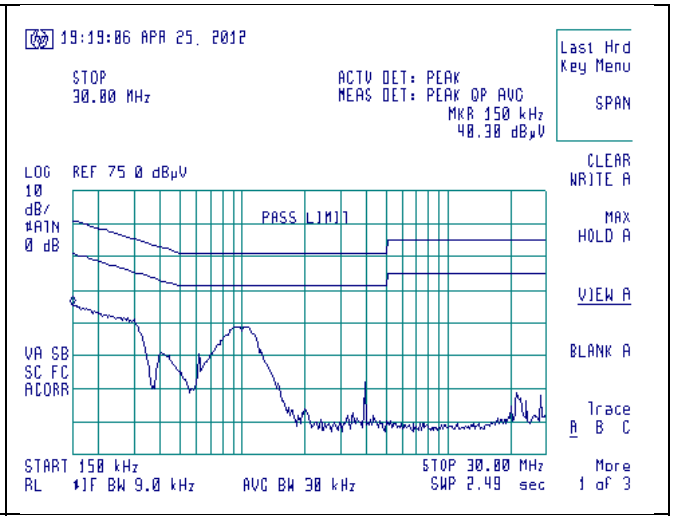
6.7 Test Setup Photo(s) – Conducted Emissions Test

6.8 Screen Captures – Conducted Emissions Test

These screen captures represent Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized. The 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 an FHSS system operating in the 2400 to 2483.5 MHz band, there are no limits for 20dB bandwidth.

7.2 - Method of Measurements

Industry Canada (IC RSS GEN 4.6.1) requires the measurement of the 99% bandwidth while CFR 47 part 15.247 requires the measurement of the 20dB bandwidth. 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 there by allowing direct measurements, without the need for any further corrections. The EUT was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. A bandwidth measurement function that is built into the spectrum analyzer was used to measure the bandwidths.

7.3 - Test Data

A. GFSK

Mode	Channel	Frequency (MHz)	20 dB BW (kHz)	99 % BW (kHz)
GFSK	1	2402	884.2	854.8
	19	2440	883.9	855.4
	39	2480	884.1	857.2

B. EDR2

Mode	Channel	Frequency (MHz)	20 dB BW (kHz)	99 % BW (kHz)
EDR2	1	2402	1.37	1.22
	19	2440	1.37	1.22
	39	2480	1.38	1.22

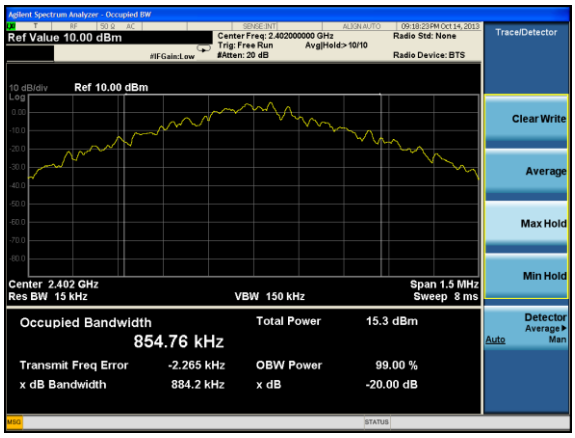
C. EDR3

Mode	Channel	Frequency (MHz)	20 dB BW (kHz)	99 % BW (kHz)
EDR3	1	2402	1.35	1.22
	19	2440	1.35	1.22
	39	2480	1.36	1.22

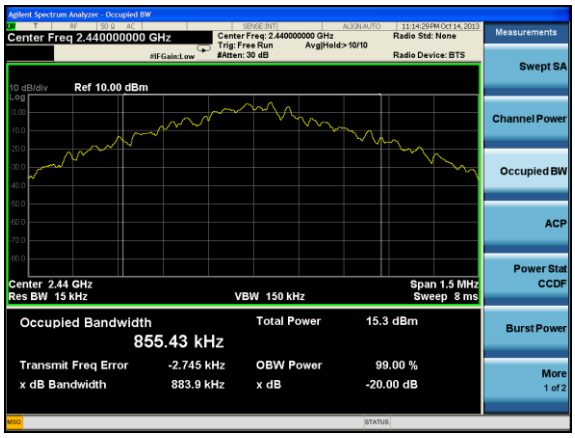
7.4 – Screen Captures

A. GFSK

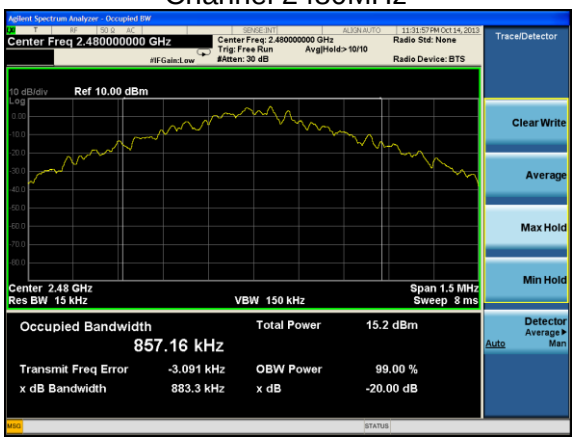
Channel 2402MHz



Channel 2440MHz

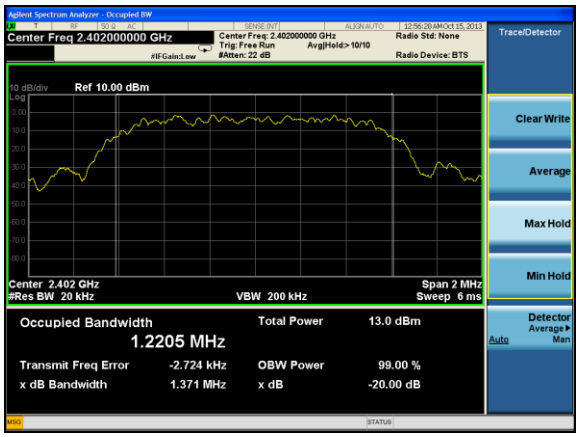


Channel 2480MHz

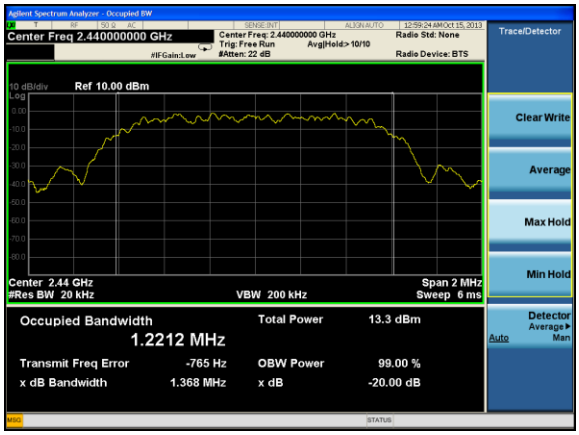


B. EDR2

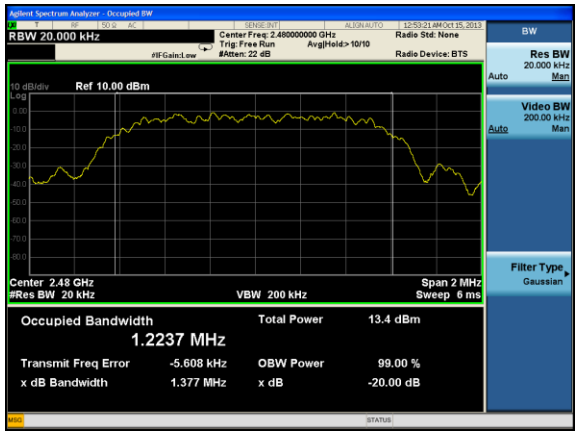
Channel 2402MHz



Channel 2440MHz

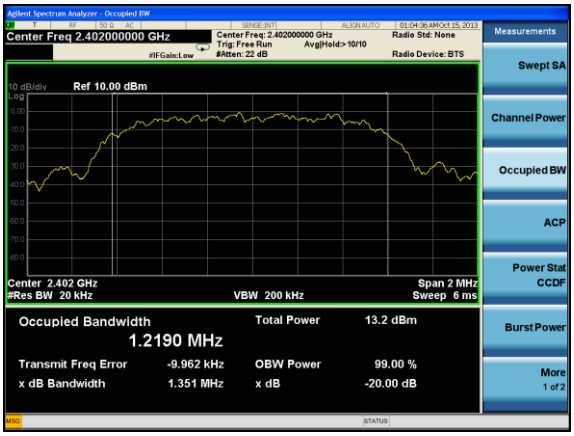


Channel 2480MHz

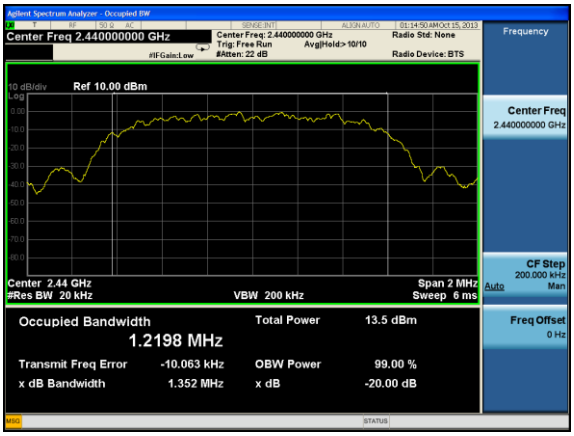


C. EDR3

Channel 2402MHz



Channel 2440MHz



Channel 2480MHz

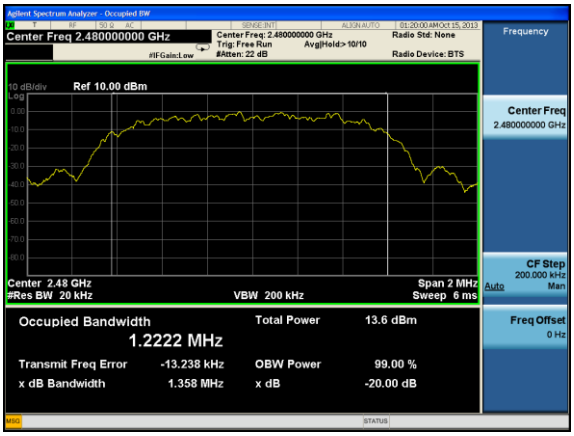


EXHIBIT 8. BAND EDGE MEASUREMENTS

8.1 - Method of Measurements

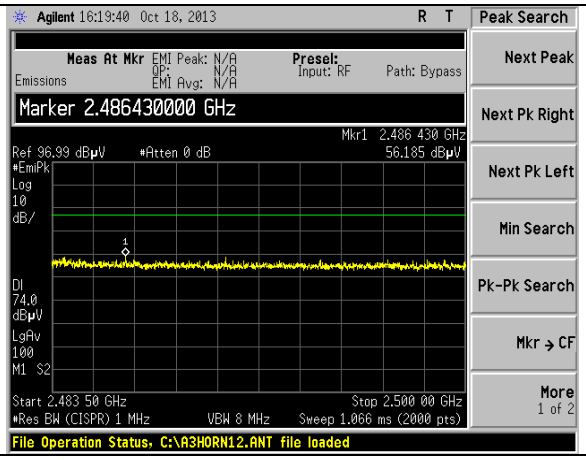
FCC 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the Band-Edges where the intentional radiator operates. Also, RSS 210 Section 2.2 requires that unwanted emissions meet limits listed in RSS GEN and also to the limits in the applicable annex. The following screen captures demonstrate compliance of the intentional radiator at the 2400 – 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.

The Band-edge measurements were performed radiated and conducted. The conducted measurement of band-edge was performed to satisfy FCC 15.247(d). The radiated measurements were performed to satisfy the conditions of 15.205 restricted bands.

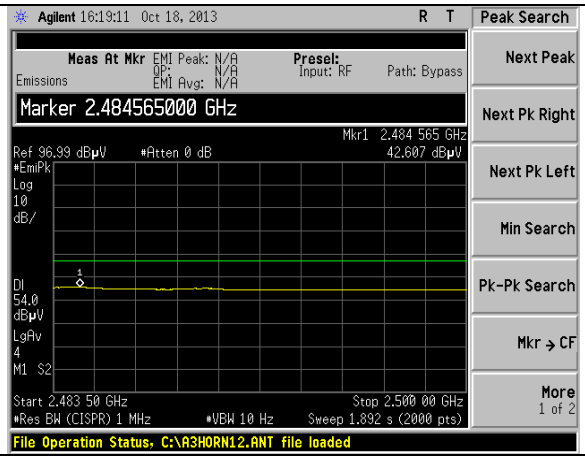
Conducted measurements of the spurious emission were performed with a measurement bandwidth of 100 kHz while radiated measurements were performed with a measurement bandwidth of 1 MHz.

8.2. Band-Edge captures.

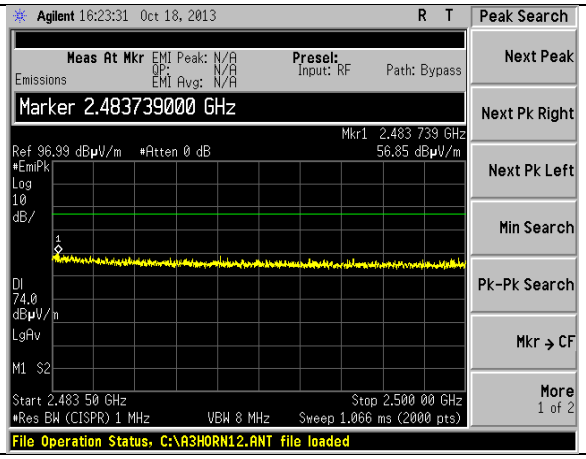
Radiated Band-edge restricted band (2483.5 to 2500 MHz):



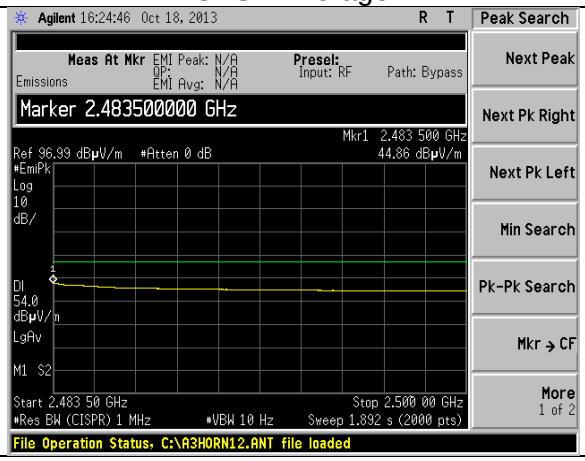
GFSK Peak



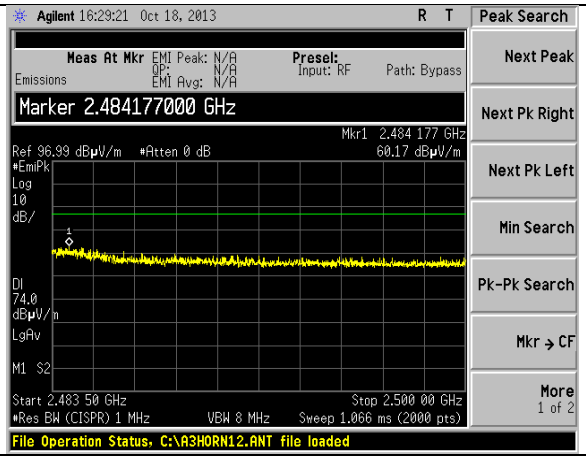
GFSK Average



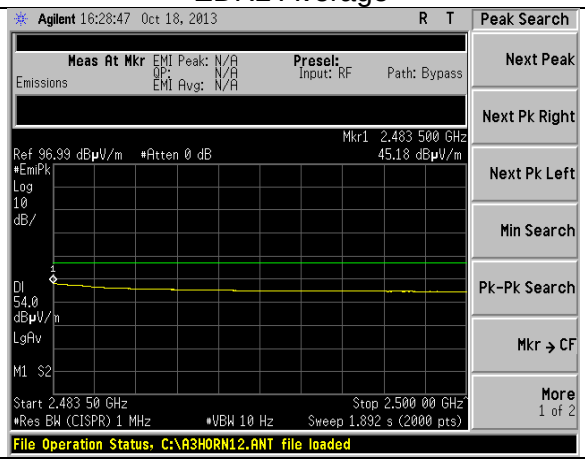
EDR2 Peak



EDR2 Average



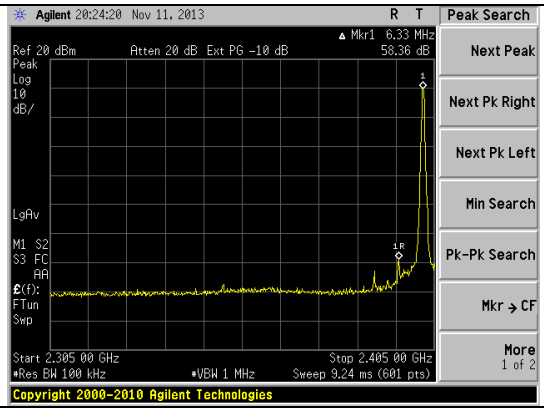
EDR3 Peak



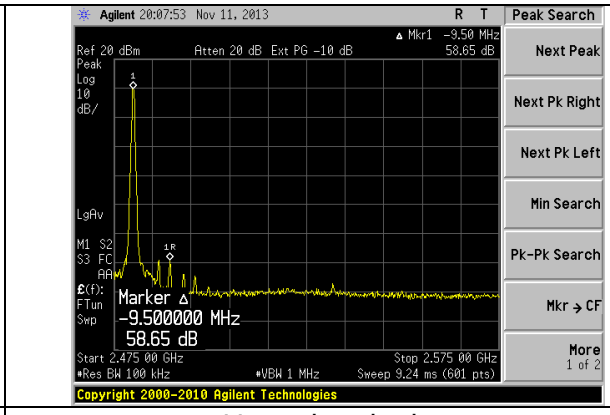
EDR3 Average

Conducted Band-edge:

A. GFSK

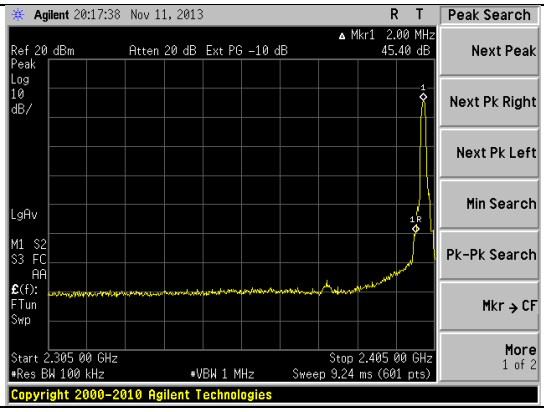


Lower band edge

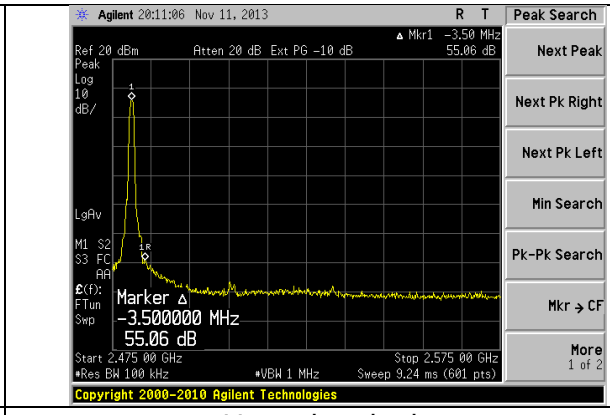


Upper band edge

B. EDR2

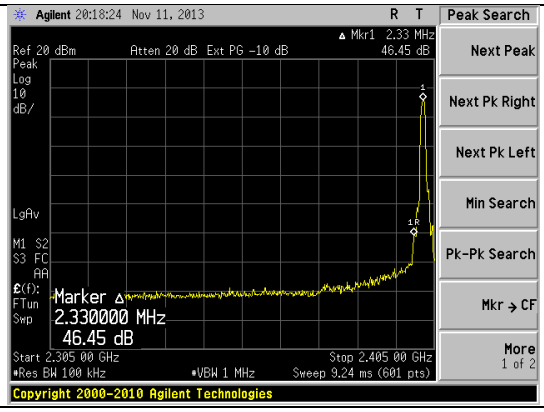


Lower band edge

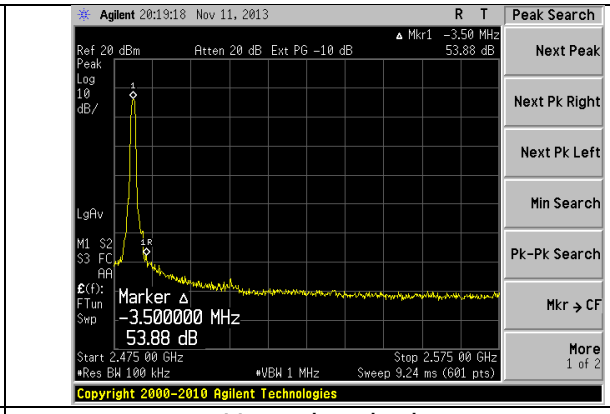


Upper band edge

C. EDR3

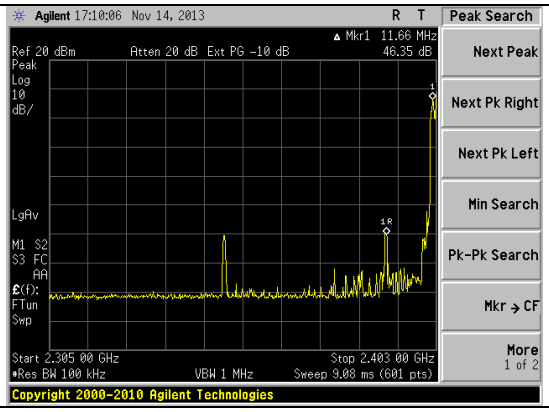


Lower band edge

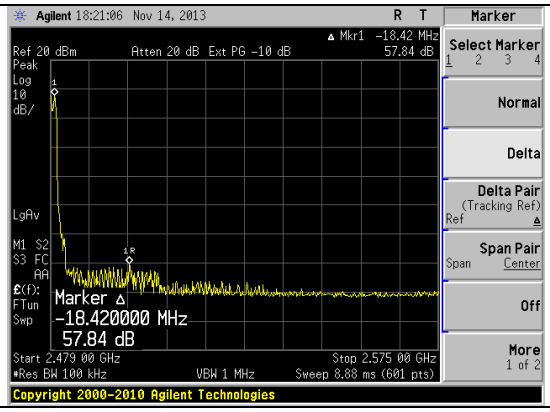


Upper band edge

D. Hopping mode.



Lower band edge



Upper band edge

EXHIBIT 9. POWER OUTPUT (CONDUCTED): 15.247(b)

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 there by 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 the appropriate resolution bandwidth, with measurements from a peak detector presented in the chart below.

9.2 - Test Data

A. GFSK

Mode	Channel	Frequency (MHz)	Power (dBm)
GFSK	1	2402	9.19
	19	2440	9.32
	39	2480	9.24

B. EDR2

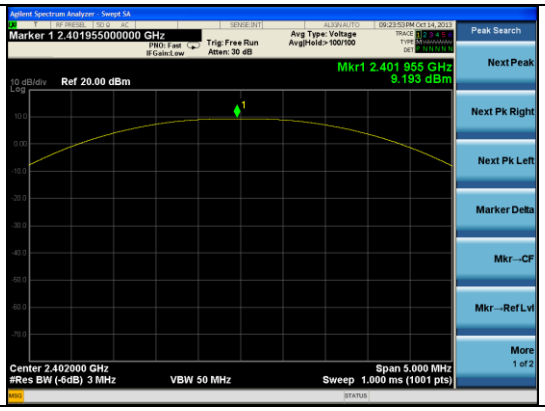
Mode	Channel	Frequency (MHz)	Power (dBm)
EDR2	1	2402	9.31
	19	2440	9.42
	39	2480	9.29

C. EDR3

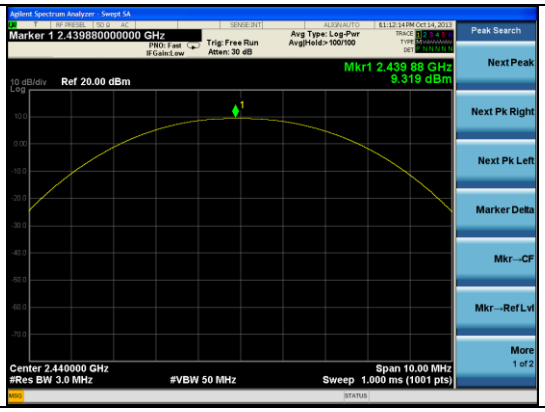
Mode	Channel	Frequency (MHz)	Power (dBm)
EDR3	1	2402	10.10
	19	2440	10.00
	39	2480	9.88

9.3 – Screen Captures

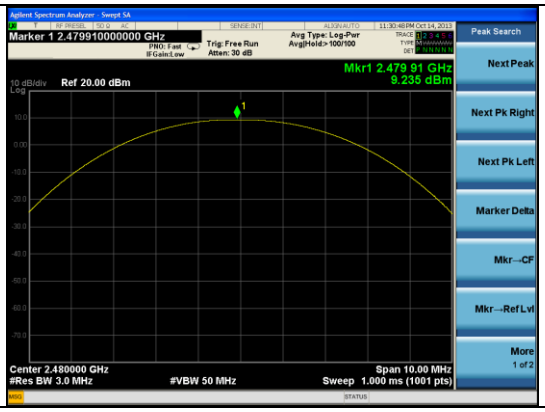
A. GFSK



Low Channel

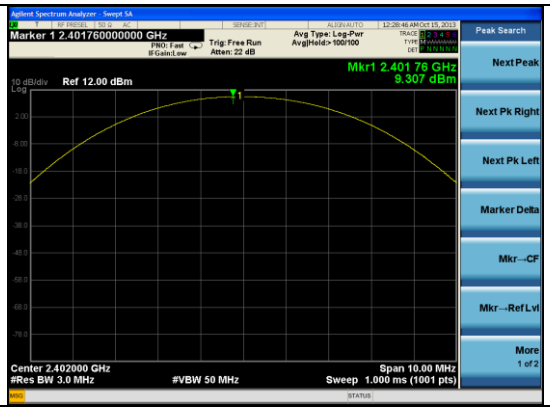


Middle Channel

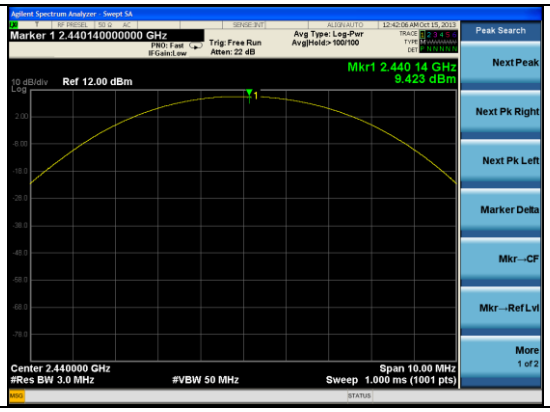


High Channel

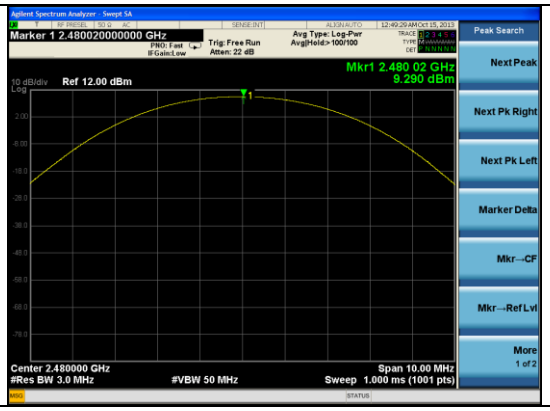
B. EDR2



Low Channel

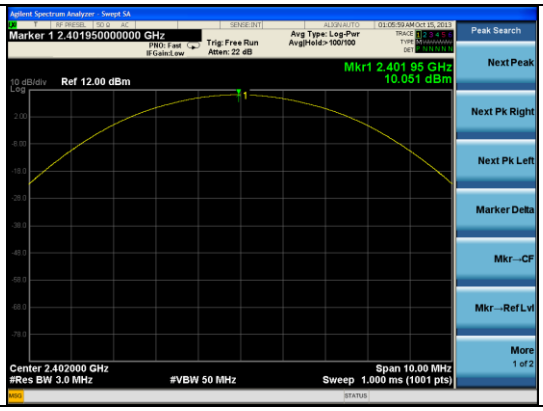


Middle Channel

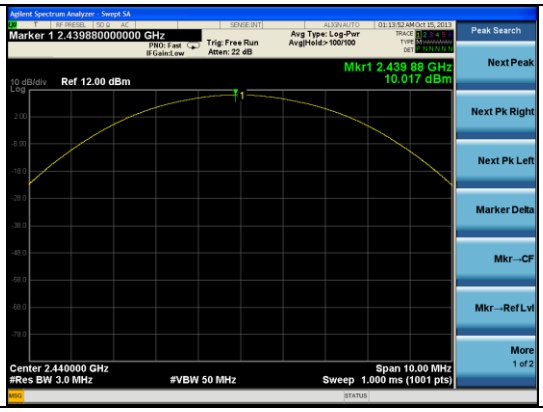


High Channel

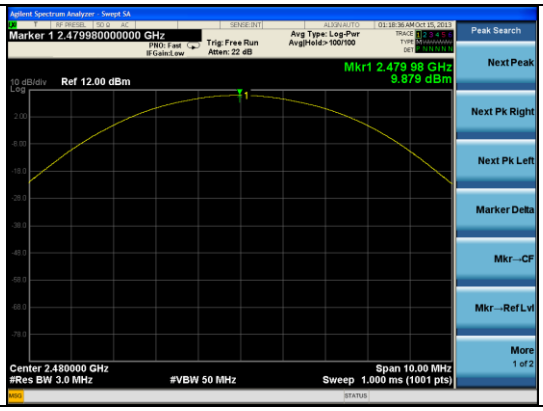
C. EDR3



Low Channel



Middle Channel



High Channel

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.

10.3 - Test Data

Conducted Spurious Emissions

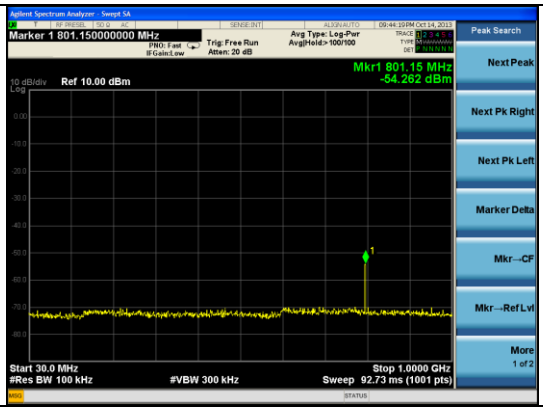
Channel	Frequency (MHz)	Amplitude (dBm)
1	800.15	-54.3
1	1602	-46.4
1	2000	-60.3
1	2802.8	-63.7
1	3202.5	-59.2
40	813.76	-65.1
40	1627.2	-51.0
40	2033.2	-60.4
40	2492.4	-62.7
40	2846.4	-67.0
40	3252.8	-66.2
40	826.2	-54.3
39	1653.8	-45.8
39	2066.8	-59.9

Conducted Harmonics

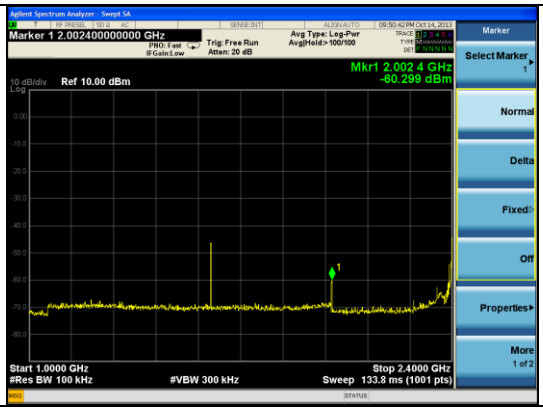
Freq\Chan	1\2402	40\2440	79\2480
fo	9.1	9.1	9.1
2fo	-52.0	-49.3	-52.8
3fo	-55.3	-59.1	-61.6
4fo	NF	NF	-75.5
5fo	-61.3	-60.4	-61.2
6fo	-49.0	-58.0	-60.7
7fo	NF	-71.2	-68.6
8fo	-61.7	-64.2	-64.8
9fo	NF	-70.9	NF
10fo	NF	NF	-69.5

Data shown is that of GFSK mode being worst case.

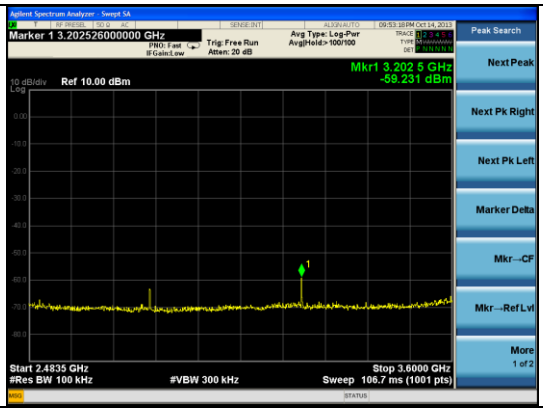
A. Low Channel



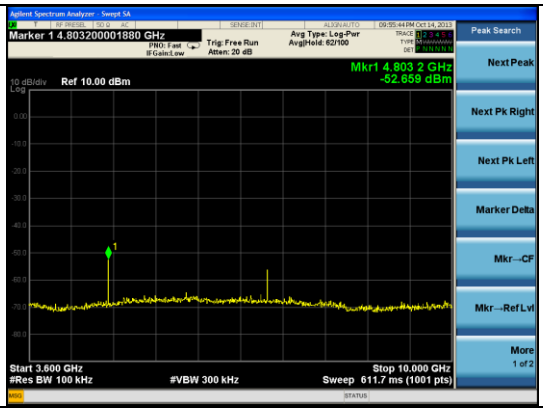
30 to 1000MHz



1000 to 2400 MHz



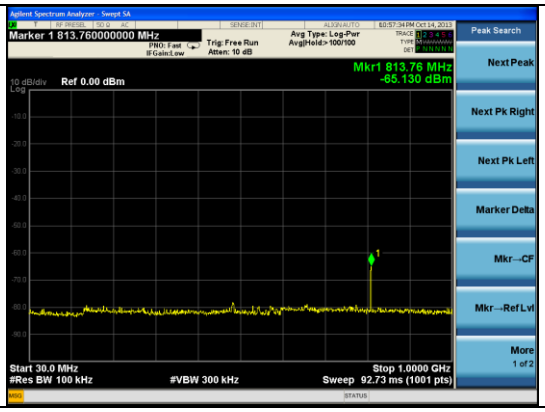
2483.5 to 3600 MHz



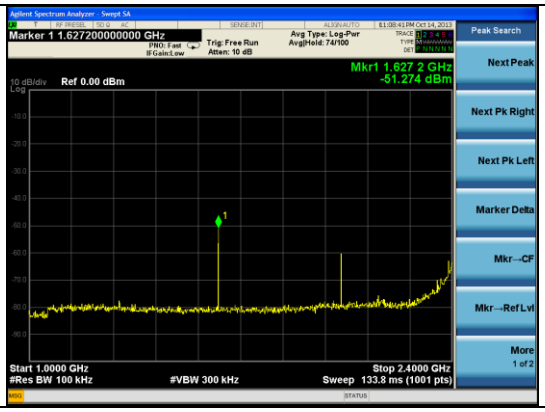
3600 to 10000

10000 to 25000

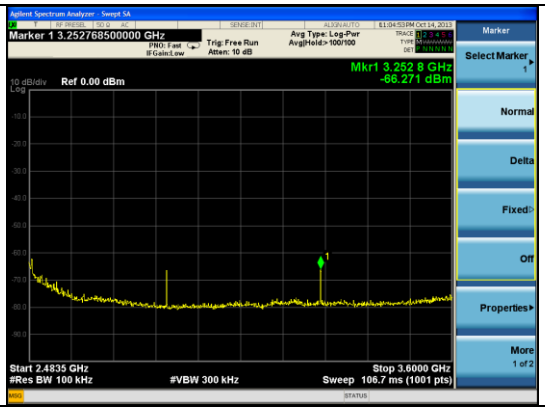
B. Middle Channel



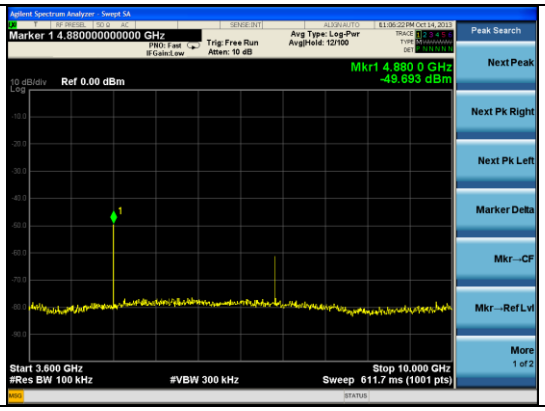
30 to 1000MHz



1000 to 2400 MHz



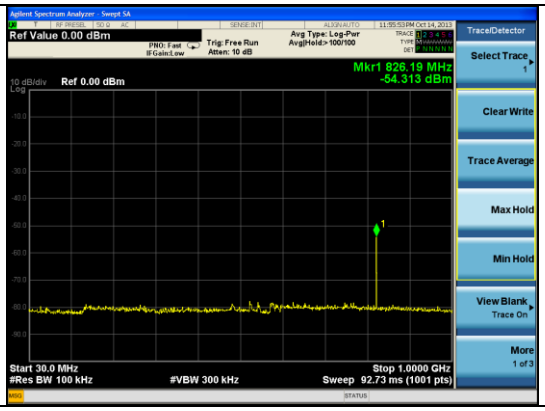
2483.5 to 3600 MHz



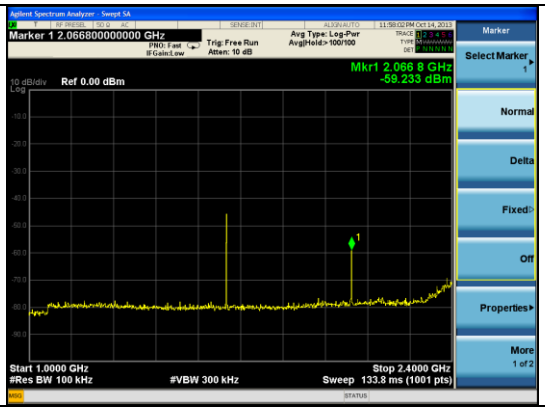
3600 to 10000

10000 to 25000

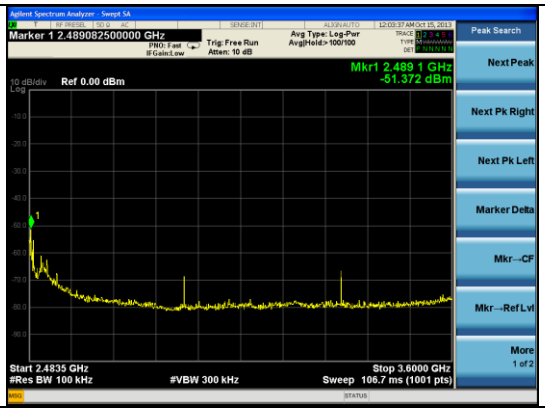
C. High Channel



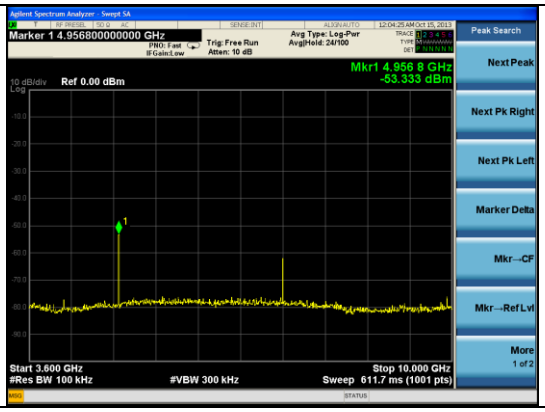
30 to 1000MHz



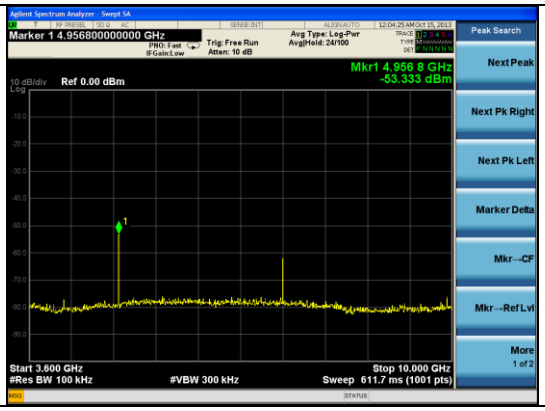
1000 to 2400 MHz



2483.5 to 3600 MHz



3600 to 10000



10000 to 25000

EXHIBIT 11. FREQUENCY & POWER STABILITY OVER VOLTAGE VARIATIONS

The power and frequency stability of the device was examined as a function of the input voltage available to the EUT. A Spectrum Analyzer was used to measure the RF output power and frequency at the appropriate frequency markers. Power was supplied by an external bench-type DC power supply and was varied ±15% from the nominal.

BLUETOOTH

	3.06 VDC		3.60 VDC		4.14 VDC			
	POWER (dBm)	FREQUENCY (Hz)	POWER (dBm)	FREQUENCY (Hz)	POWER (dBm)	FREQUENCY (Hz)	FREQ DRIFT (Hz)	Pout DRIFT (dBm)
LOW CHANNEL	9.4	2402000459	9.4	2402000479	9.4	2402000479	20	0.0
MID CHANNEL	9.4	2440000560	9.4	2440000560	9.4	2440000539	21	0.0
HIGH CHANNEL	9.2	2480000580	9.2	2480000560	9.2	2480000539	41	0.1

WLAN 2.4 GHZ

	3.06 VDC		3.60 VDC		4.14 VDC			
	POWER (dBm)	FREQUENCY (Hz)	POWER (dBm)	FREQUENCY (Hz)	POWER (dBm)	FREQUENCY (Hz)	FREQ DRIFT (Hz)	Pout DRIFT (dBm)
LOW CHANNEL	6.1	2412000969	6.4	2412000990	6.2	2412000990	21	0.3
MID CHANNEL	6.6	2437000920	6.7	2437000940	6.6	2437000960	40	0.1
HIGH CHANNEL	6.5	2462000939	6.6	2462000960	6.7	2462000960	21	0.3

WLAN 5.7 GHZ

	3.06 VDC		3.60 VDC		4.14 VDC			
	POWER (dBm)	FREQUENCY (Hz)	POWER (dBm)	FREQUENCY (Hz)	POWER (dBm)	FREQUENCY (Hz)	FREQ DRIFT (Hz)	Pout DRIFT (dBm)
LOW CHANNEL	3.8	5745002200	4.0	5745002300	4.0	5745002340	140	0.3
MID CHANNEL	2.7	5785002280	3.0	5785002360	3.2	5785002280	80	0.5
HIGH CHANNEL	2.1	5825002160	2.4	5825002220	2.6	5825002320	160	0.4

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

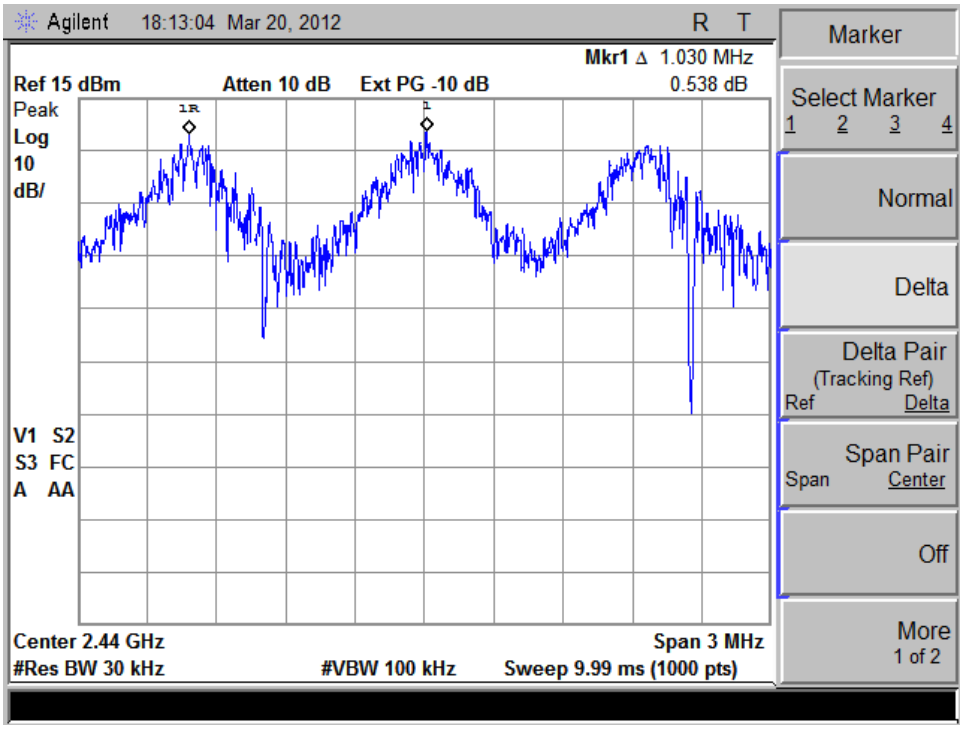
EXHIBIT 12. CHANNEL PLAN AND SEPARATION

A spectrum analyzer was used with a resolution bandwidth of 30 kHz to measure the channel separation of the EUT.

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

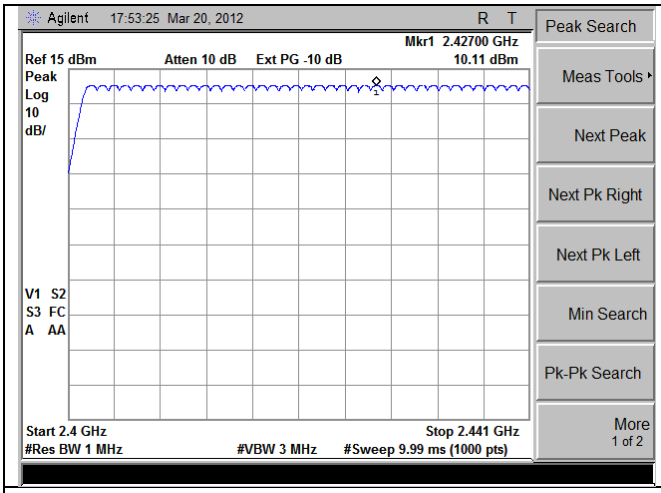
12.1 - Screen Captures

Channel Spacing

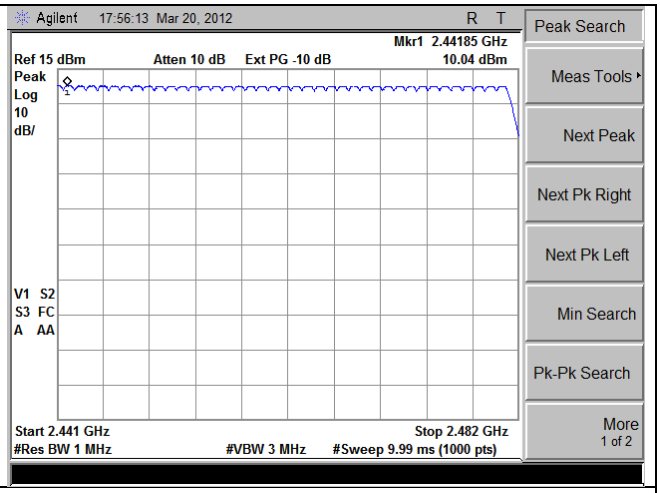


Channel separation = 1.030 MHz

Channel Plan



39 Channels



40 Channels

Number of channels = <u>79 Channels</u>

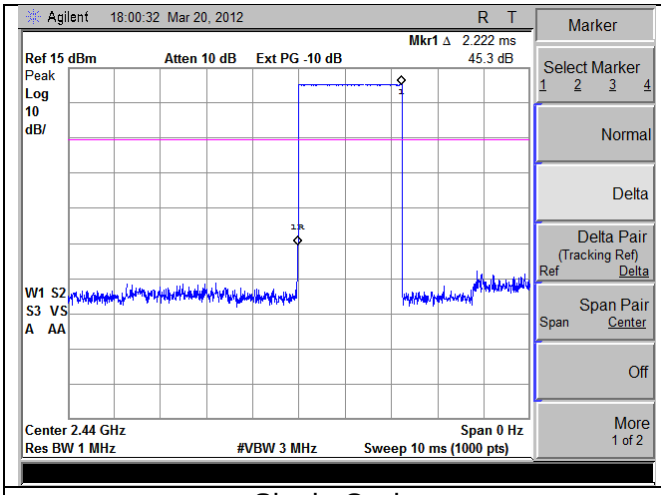
EXHIBIT 13. CHANNEL OCCUPANCY.

Part 15.247(a)(1) requires a channel occupancy, for this device, of no more than 400 milliseconds in a 31.6 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.

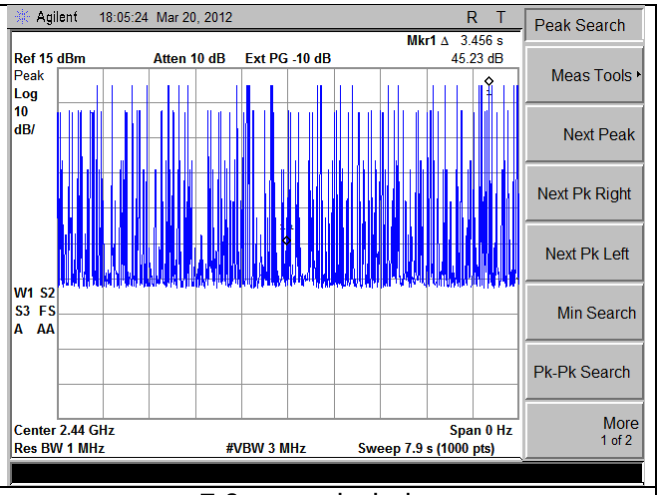
The longest time any transmission will occur on a **single channel is 2.22 milliseconds**. In a 7.9 second window, each channel has 33 transmission cycles. The maximum occupancy in a 31.6 second window is calculated by multiplying 132 transmission cycles by 2.22 milliseconds transmission duration per cycle, to arrive **at 290 milliseconds total occupancy**.

Plots of Channel Occupancy

Channel Occupancy



Single Cycle



7.9 second window

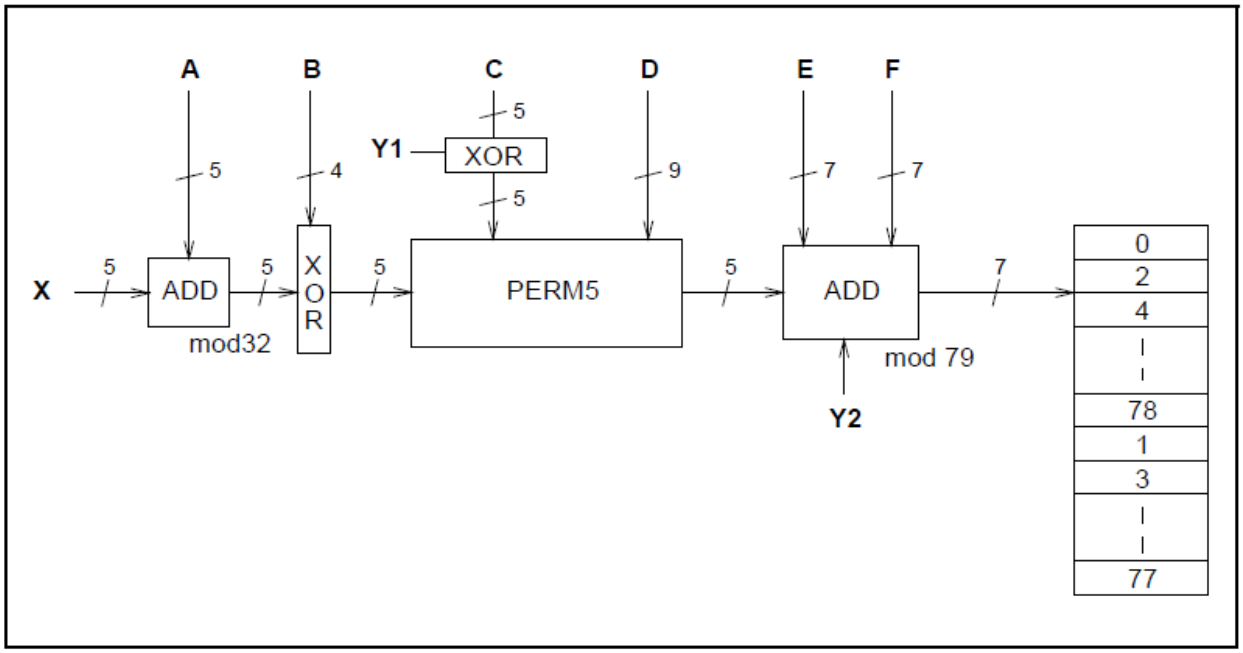
EXHIBIT 14. EQUAL CHANNEL USAGE AND PSEUDORANDOM HOPPING SEQUENCE.

By virtue of being an IEEE 802.15 Bluetooth device, the EUT is inherently compliant to the requirements.

EXHIBIT 15. RECEIVER SYNCHRONIZATION AND INPUT BANDWIDTH.

By virtue of being an IEEE 802.15 Bluetooth device, the EUT is inherently compliant to the requirements.

Bluetooth devices use a hopping kernel to generate a hopping map. The figure below represents the basic hop selection kernel for the hop system. The output of the adder addresses a bank of 79 registers. The registers are loaded with the synthesizer code words corresponding to the hop frequencies 0 to 78. Note that the upper half of the bank contains the even hop frequencies, whereas the lower half of the bank contains the odd hop frequencies.



The X input determines the phase in the 32-hop segment, whereas Y1 and Y2 selects between master-to-slave and slave-to-master. The inputs A to D determine the ordering within the segment, the inputs E
and F determine the mapping onto the hop frequencies. The kernel addresses a register containing the RF channel indices. This list is ordered so that first all even RF channel indices are listed and then all odd hop frequencies. In this way, a 32-hop segment spans about 64 MHz and visits these hops in a pseudo-random order. Next, a different 32-hop segment is chosen, etc. When the basic channel hopping sequence is selected, the output constitutes a pseudo-random sequence that slides through the 79 hops. The principle is depicted below:

APPENDIX A – Test Equipment List

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 8-Oct-2013 Type Test : Radiated measurements Job # : C-1818

Prepared By: Aidi Zainal Customer : Nikon Metrology Quote #: 313179

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	9/5/2013	9/5/2014	Active Calibration
2	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	9/5/2013	9/5/2014	Active Calibration
3	EE 960158	RF Preselecter	Agilent	N9039A	MY46520110	9/5/2013	9/5/2014	Active Calibration
4	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	1/29/2013	1/29/2014	Active Calibration
5	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	6/10/2013	6/10/2014	Active Calibration
6	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	12/10/2012	12/10/2013	Active Calibration
7	AA 960150	Bicon Antenna	ETS	3110B	0003-3346	12/12/2012	12/12/2013	Active Calibration
8	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/28/2013	5/28/2014	Active Calibration
9	AA 960153	2.4GHz High Pass Filter	KWM	HPF-L-14186	7272-04	4/1/2013	4/1/2014	Active Calibration
10	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	2/1/2013	2/1/2014	Active Calibration
11	EE 960087	44GHz EXA Spectrum Analyzer	Agilent	N9010A	MY53400296	10/27/2013	10/27/2014	Active Calibration
12	EE 960161	26.5-40GHz LNA	Ducommun Techno	ALN-33144030	1103717-01	9/24/2013	9/24/2014	Active Calibration
13	AA 960161	Highpass Filter	K&L Microwave	11SH10-8000	2	12/24/2013	12/24/2014	Active Calibration
14	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/1/2011	7/1/2013	Syatem
15	EE 960146	Std. Gain Horn Ant. w/preamp	Adv. Micro / EMCO	WLA622-4 / 3160-09	123001	9/24/2013	9/24/2014	Active Calibration
16	AA 960137	Standard Gain Horn Ant.	EMCO	3160-10	69259	10/4/2011	10/4/2014	Active Calibration
17	AA 960160	UTiFLEX Cable	Micro-Coax	UFC142A-0-0720-2002(	218652-001	9/24/2013	9/24/2014	Active Calibration

Project Engineer: Quality Assurance: Peter Fiden

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 8-Oct-2013 Type Test : Conducted measurements Job # : C-1818

Prepared By: Aidi Zainal Customer : Nikon Metrology Quote #: 313179

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	8/7/2013	8/7/2014	Active Calibration
2	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/1/2011	7/1/2013	System
3	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/28/2013	5/28/2014	Active Calibration
4	AA 960143	Phaseflex	Gore	EKD01D01048.0	5546519	6/14/2013	6/14/2015	Active Calibration
5	AA 960160	UTiFLEX Cable	Micro-Coax	UFC142A-0-0720-2002(	218652-001	9/24/2013	9/24/2014	Active Calibration

Project Engineer: Quality Assurance:

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 20-Dec-2011 Type Test : AC mains Job # : C-1371

Prepared By: Aidi Customer : LSR Quote #: 311362

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	11/22/2011	11/22/2012	Active Calibration
2	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	11/22/2011	11/22/2012	Active Calibration
3	AA 960072	Transient Limiter	HP	11947A	3107A02515	11/2/2011	11/2/2012	Active Calibration
4	AA 960075	LISN	EMCO	3810/2NM	9612-1710	9/19/2011	9/19/2012	Active Calibration

Project Engineer: Aidi Quality Assurance: Mike Hintzke

APPENDIX B – Test Standards: CURRENT PUBLICATION DATES RADIO

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2003		
ANSI C63.10	2009		
FCC 47 CFR, Parts 0-15	2013		
FCC Public Notice DA 00-705	2000		
RSS GEN	2010		
RSS 210	2010		

APPENDIX C - Uncertainty Statement

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

Measurement Type	*Particular Configuration*	*Uncertainty Values*
Radiated Emissions	*3 – Meter chamber, Biconical Antenna*	*4.82 dB*
Radiated Emissions	*3-Meter Chamber, Log Periodic Antenna*	*4.88 dB*
Radiated Emissions	*3-Meter Chamber, Horn Antenna*	*4.85 dB*
Radiated Emissions	*10-Meter OATS, Biconical Antenna*	*4.32 dB*
Radiated Emissions	*10-Meter OATS, Log Periodic Antenna*	*3.63 dB*
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*