LS RESEARCH LLC
Wireless Product Development
ACCREDITED
TESTING CERT #1255.01
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TEST REPORT # 312122 A
LSR Job #: C-1479

Compliance Testing of:

PAIN External NeuroStimulator (ENS)

Test Date(s):

June 5th to 19th, 2012

Prepared For:
Medtronic
Attn: Mukul Jain
7000 Central Avenue NE MS RCC270
Minneapolis, MN 55432

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

Signature: Date: 9/11/12

Test Report Reviewed by:	Project Engineer:
Shane Rismeyer, EMC Engineer	Khairul Aidi Zainal, Senior EMC Engineer.
Signature: Date: 8/7/12	Signature: Date: 7/17/12

TABLE OF CONTENTS

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)	2012	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	10-2009	American National Standard For Testing Unlicensed Wireless devices.
FCC ET Docket No. 99-231	2002	Amendment to FCC Part 15 of the Commission's Rules Regarding Spread Spectrum 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 the SI standard.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	Medtronic
Address:	7000 Central Avenue NE MS RCC270, Minneapolis, MN 55432
Contact Name:	Mukul Jain (mukul.jain@medtronic.com)

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	PAIN External NeuroStimulator (ENS)
Model Number:	97725
Serial Number:	NLJ002306N

2.3 - Associated Antenna Description

The antenna used in the EUT is a PULSE Bluetooth/WLAN/WiFi Ceramic Chip Antenna part number W3008 with a peak gain of 2.2 dBi.

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 =0.0034 EDR 2 =0.0020 EDR 3 =0.0021
Maximum(Watts):	GFSK =0.0036 EDR 2 =0.0021 EDR 3 =0.0022
Occupied Bandwidth (99% and 20dB)	20dB: 1.13MHz 99%: 1.14MHz
Type of Modulation	GFSK, QPSK
Emission Designator	1M14FXD
Transmitter Spurious (worst case radiated) at 3 meters	47.8dBµV/m at 7440MHz
Stepped (Y/N)	N
Step Value:	N/A
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Antenna Information	
Detachable/non-detachable	Non-detacheable
Type	Ceramic Chip Antenna
Gain	2.2 dBi
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

RF Technical Information:

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

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

Evaluated against exposure limits: ☒ General Public Use ☐ Controlled Use
Duty Cycle used in evaluation: 100 %
Standard used for evaluation: OET 65
Measurement Distance: 20 cm
RF Value: **0.012** ☐ V/m ☐ A/m ☒ W/m^2

☐ Measured ☐ Computed ☒ Calculated

With a maximum EIRP of:

EIRP =5.6dBm + 2.2dBi = 7.8dBm = **6.02mW**

The EUT is exempt from SAR testing.

2.5 - Product Description

Neurostimulation therapy for chronic, intractable pain consists of electrical stimulation that interferes with the perception of pain by replacing the sensation of pain with the sensation of tingling/paresthesia. The function of the neurostimulation system is accomplished with a power source (neurostimulator), lead extension (depending on neurostimulation system used), and one or more leads. Mild electrical stimulation generated from the neurostimulator is transmitted through the lead to stimulate the targeted structure through electrodes located on the distal end of the lead. The neurostimulator parameters can be non-invasively adjusted by the physician via a clinician programmer. Patients can adjust stimulation within parameters that are determined and pre-set by the physician. The External Neurostimulator (ENS) device is used for screening patients to assess efficacy in a patient without having to undergo a full system implant. The existing device that performs this screening process will be replaced by the new ENS, along with accompanying components such as a clinician programmer and patient controller. The ENS provides a means to connect up to two (2), eight-conductor (8) extensions or two (2) eight-conductor (8) leads of 0.110 in connector spacing, up to four (4), four-conductor (4) extensions or four (4), four-conductor (4) leads of 0.170 in connector spacing. Upon identifying the ideal lead location for the intraoperative screening procedure in which the ENS would be used, the patient would go home wearing the ENS for a period of time to try out the therapy. The ENS is attached to the patient via surgical tape or an optional boot accessory that is taped to the body and holds the ENS in place via a pocket. This at-home screening period typically lasts five (5) to seven (7) days and up to thirty (30) days in some markets outside the United States. The ENS has similar stimulation capabilities to the Intellis (also known as the RS2) Implantable Neurostimulator, which is being developed in parallel to the ENS. The ENS has new features compared to the existing ENS such as constant current output, wireless telemetry with the clinician and patient programmers, and field steering capability.

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	N/A
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
The digital circuit portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class B Digital Devices (RSS GEN and RSS 210 of IC) and the associated Radio Receiver has also been tested and found to comply with Part 15, Subpart B – Radio Receivers (RSS GEN and RSS 210 of IC). The Receiver Test Report is available upon request.		

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 Title 47, CFR FCC Part 15, RSS GEN and ANSI C63.4. 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 using power as provided by 2 AAAA batteries. The unit has the capability to operate on 3 channels, controllable via a button on the EUT and via proprietary software called the "ENSTester". The modulations, modes and channels were changed via different script files.

The applicable limits apply at a 3 meter 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 (2402MHz), middle (2440MHz) and high (2480MHz) 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 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 while a standard gain horn antenna was used in the 18 GHz to 25 GHz range. The maximum radiated RF emissions between 30MHz 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 4GHz to 25GHz, the sense antenna was raised and lowered between 1 and 1.8 meters in height.

The EUT was positioned in 3 orthogonal orientations (refer to section 5.7 of this report).

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 the SI standard. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and an EMI Receiver. The resulting correction factors and the cable loss factors from these calibrations were entered into the EMI Receiver database. **As a result, the data taken from the EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading.** The EMI Receiver was operated with a resolution bandwidth of 120 kHz for measurements below 1 GHz (video bandwidth of 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:	Medtronic					
Date(s) of Test:	June 6th to 11th 2012					
Project Engineer(s):	Khairul Aidi Zainal					
Test Engineer(s):	Shane Rismeyer, Michael Hintzke, Adam Alger and Khairul Aidi Zainal					
Voltage:	3.0 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

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 Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4804	1.00	181	52.1	63.5	11.4	Horizontal	Vertical
7206						Note 1	
9608						Note 1	
12010	1.00	0	55.9	63.5	7.7	Noise Floor	
14412						Note 1 / Noise Floor	
16814						Note 1 / Noise Floor	
19216	1.00	0	51.0	63.5	12.6	Noise Floor	
21618						Note 1 / Noise Floor	
24020						Note 1 / Noise Floor	

Notes:

1. Emissions not in restricted band, greater than 20dB margin as compared to -20dBc.
2. Peak emissions compared to average limits.
3. Measurements above 4 GHz were made at 1 meter separation distance from the EUT.
4. Refer to exhibit 5.5 on explanation of how data is reported.

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 Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4880	1.00	233	54.1	63.5	9.4	Vertical	Vertical
7320	1.03	147	55.2	63.5	8.4	Horizontal	Side
9760						Note 1	
12200	1.00	0	56.7	63.5	6.8	Noise Floor	
14640						Note 1 / Noise Floor	
17080						Note 1 / Noise Floor	
19520	1.00	0	52.0	63.5	11.5	Noise Floor	
21960						Note 1 / Noise Floor	
24400						Note 1 / Noise Floor	

Notes:

1. Emissions not in restricted band, greater than 20dB margin as compared to -20dBc.
2. Peak emissions compared to average limits.
3. Measurements above 4 GHz were made at 1 meter separation distance from the EUT.
4. Refer to exhibit 5.5 on explanation of how data is reported.

The following table depicts the level of significant radiated **harmonic** emissions of channel 926.4 MHz in the restricted band:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4960	1.00	165	54.4	63.5	9.1	Vertical	Side
7440	1.04	181	57.3	63.5	6.2	Vertical	Vertical
9920						Note 1	
12400	1.00	0	56.8	63.5	6.7	Noise Floor	
14880						Note 1 / Noise Floor	
17360						Note 1 / Noise Floor	
19840	1.00	0	51.5	63.5	12.0	Noise Floor	
22320	1.00	0	52.5	63.5	11.0	Noise Floor	
24800						Note 1 / Noise Floor	

Notes:

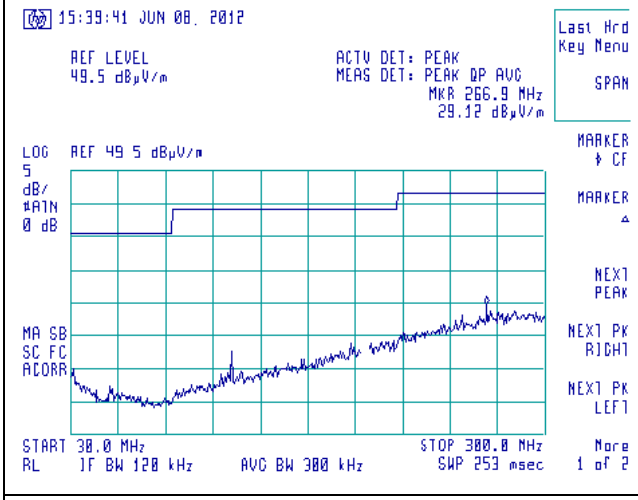
1. Emissions not in restricted band, greater than 20dB margin as compared to -20dBc.
2. Peak emissions compared to average limits.
3. Measurements above 4 GHz were made at 1 meter separation distance from the EUT.
4. Refer to exhibit 5.5 on explanation of how data is reported.

5.7 - Test Setup Photo(s) – Radiated Emissions Test

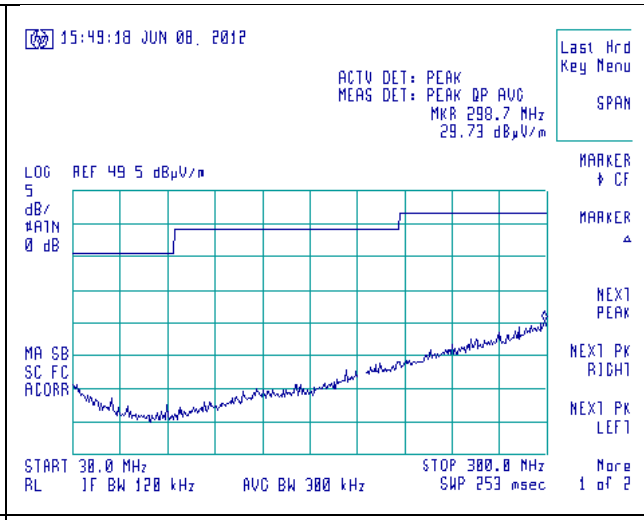
This section is not available

5.8 – Screen Captures of Radiated emissions.

30MHz to 300MHz

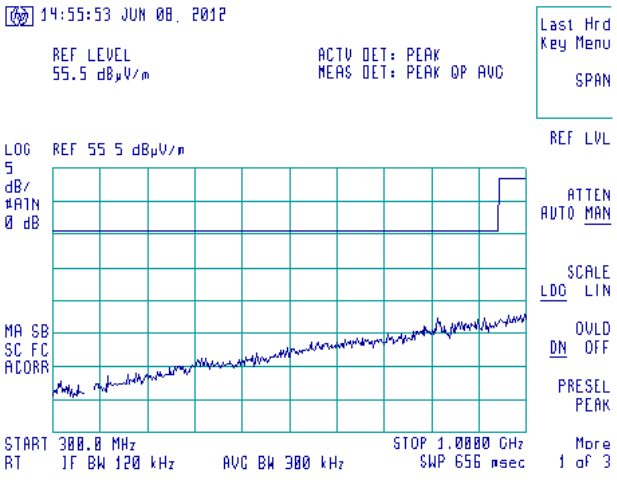


Horizontal Polarization

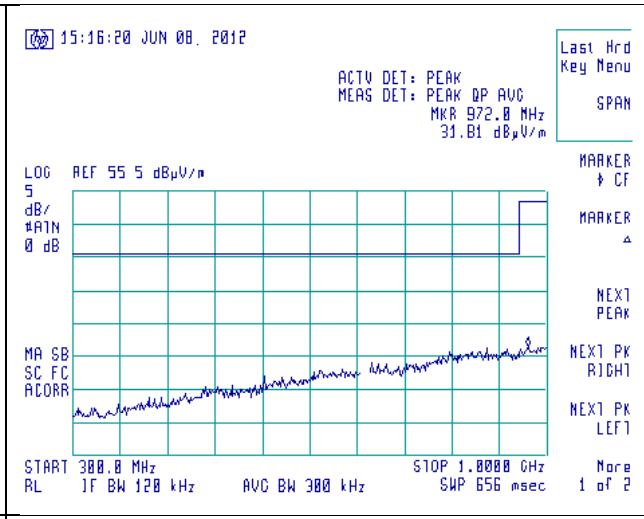


Vertical Polarization

300MHz to 1000MHz

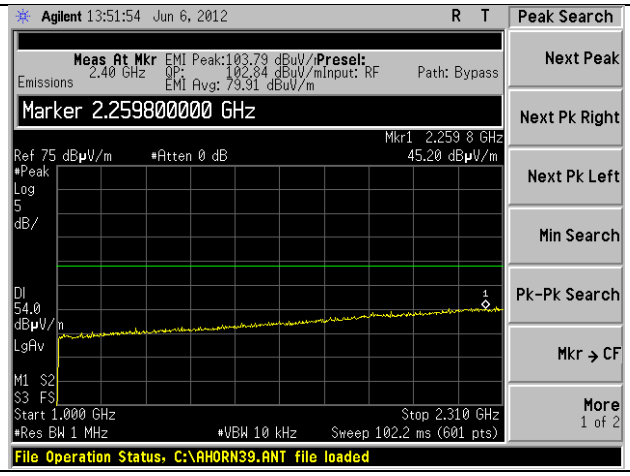


Horizontal Polarization

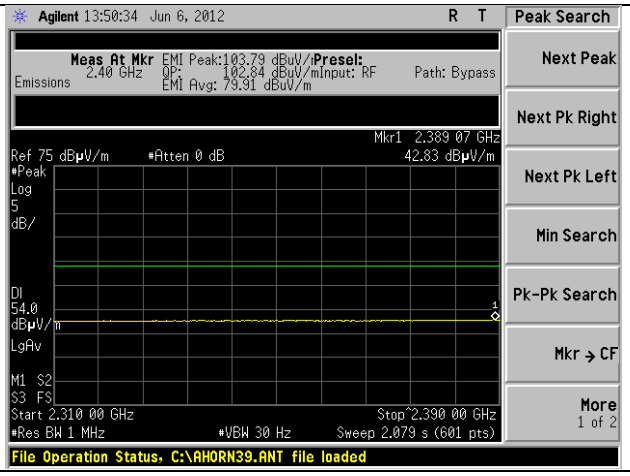


Vertical Polarization

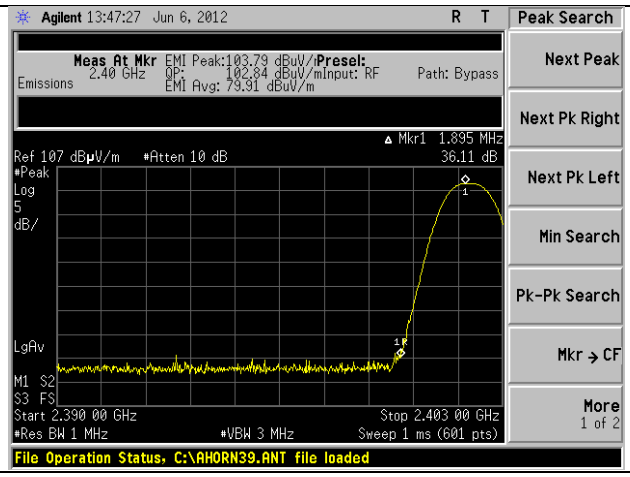
1000MHz to 2390MHz



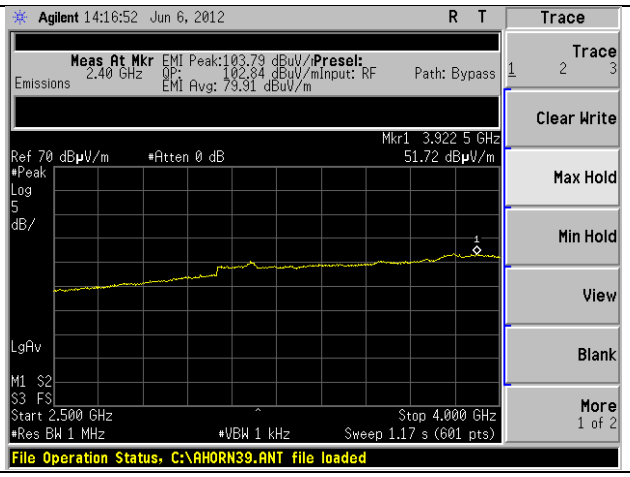
1000 to 2310 MHz



2300 to 2390 MHz



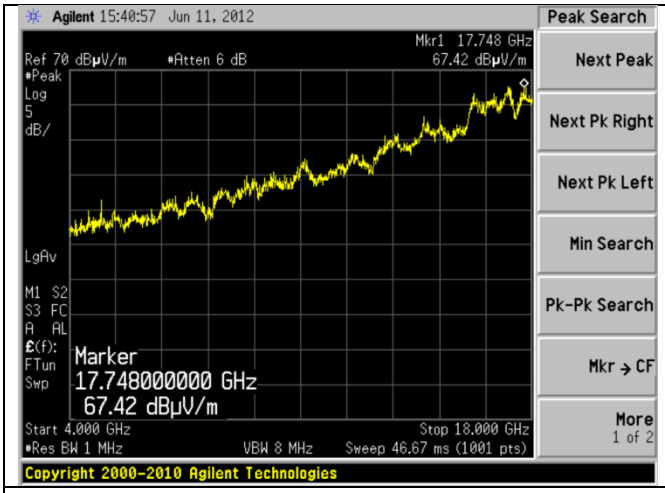
2390 to 2403 MHz



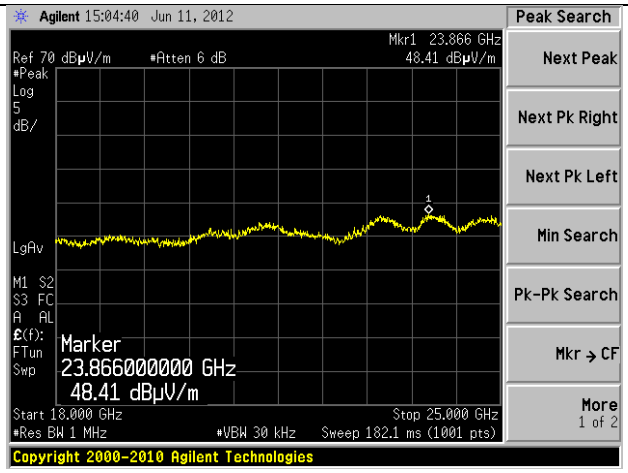
2500 to 4000 MHz

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

4000 MHz to 25000 MHz



4000 MHz to 18000 MHz



18000 MHz to 25000 MHz

EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

6.1 Test Setup

THIS TEST WAS NOT REQUIRED; THE EUT IS BATTERY POWERED.

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 99% bandwidths.

7.3 - Test Data

A. GFSK

Occupied bandwidth (kHz)		
Channel	20dB	99%
LOW	**739.00**	**851.47**
MIDDLE	**739.00**	**859.30**
HIGH	**736.00**	**864.18**

B. EDR2

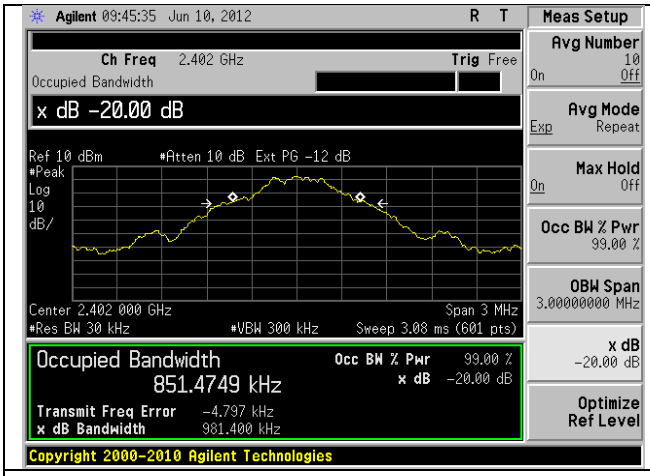
Occupied bandwidth (MHz)		
Channel	20dB	99%
LOW	1.115	1.136
MIDDLE	1.125	1.127
HIGH	1.130	1.133

C. EDR3

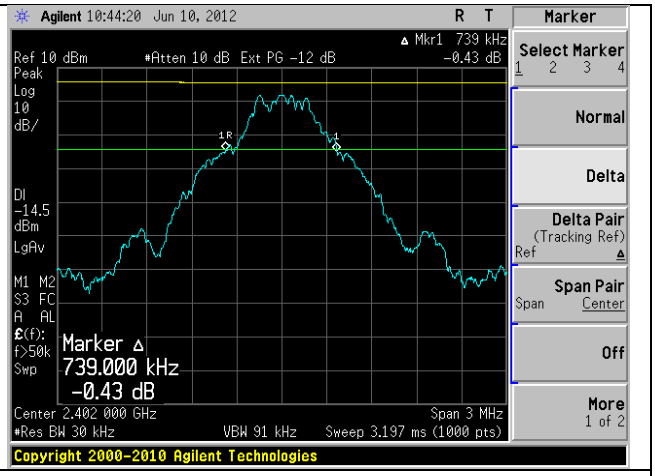
Occupied bandwidth (MHz)		
Channel	20dB	99%
LOW	1.105	1.115
MIDDLE	1.110	1.120
HIGH	1.100	1.121

7.4 – Screen Captures

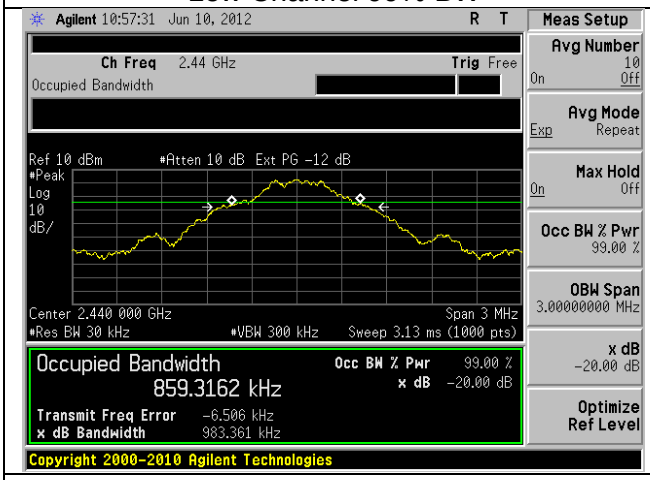
A. GFSK



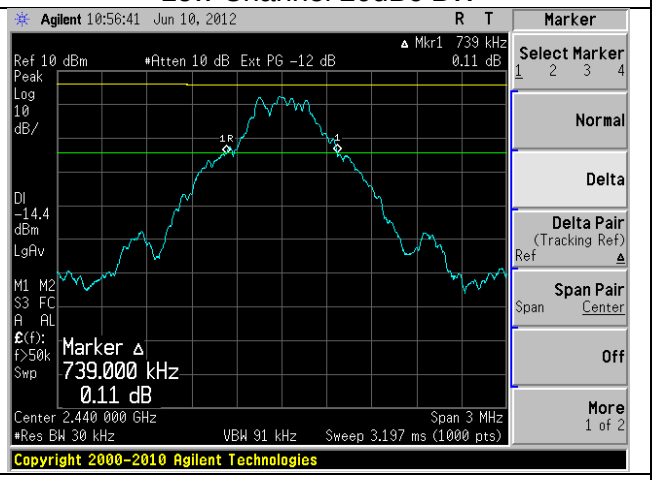
Low Channel 99% BW



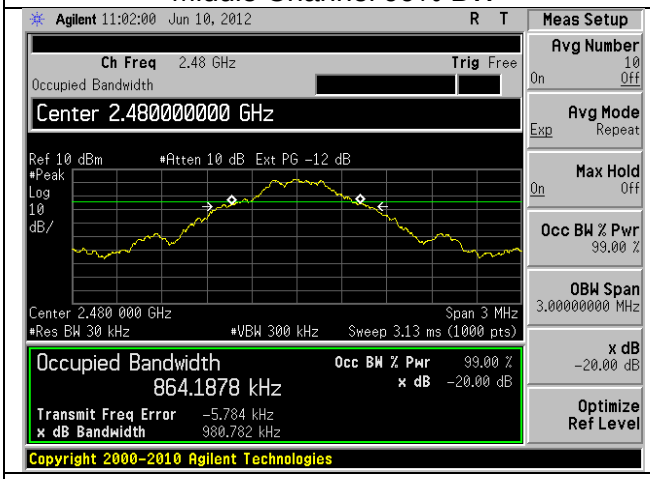
Low Channel 20dBc BW



Middle Channel 99% BW



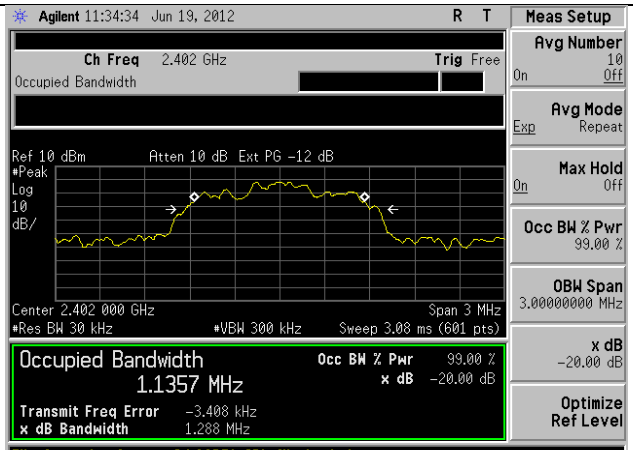
Middle Channel 20dBc BW



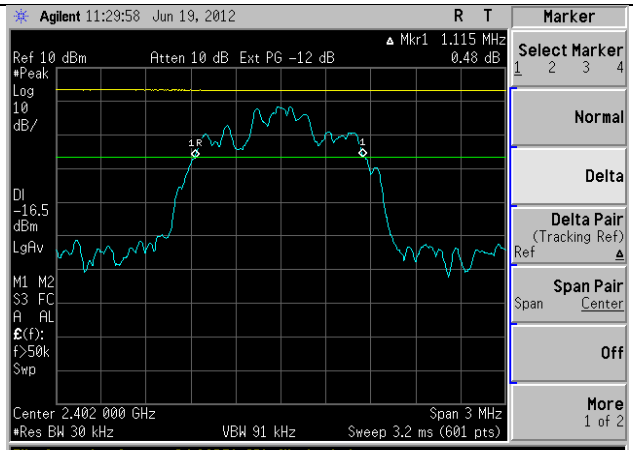
High Channel 99% BW

High Channel 20dBc BW

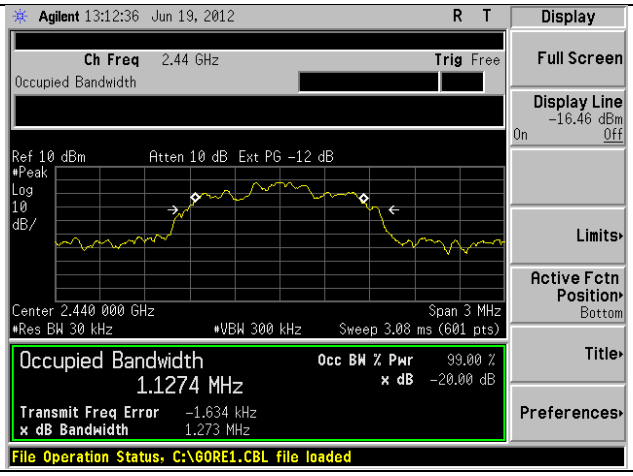
B. EDR2



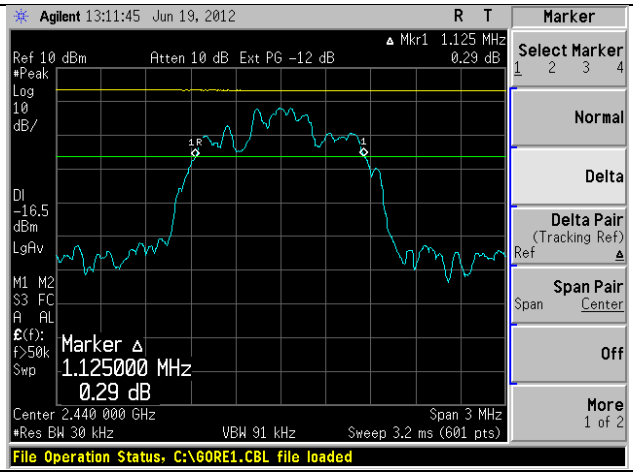
Low Channel 99% BW



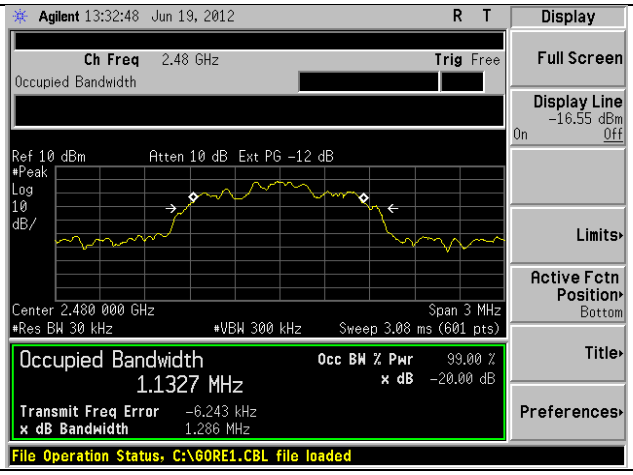
Low Channel 20dBc BW



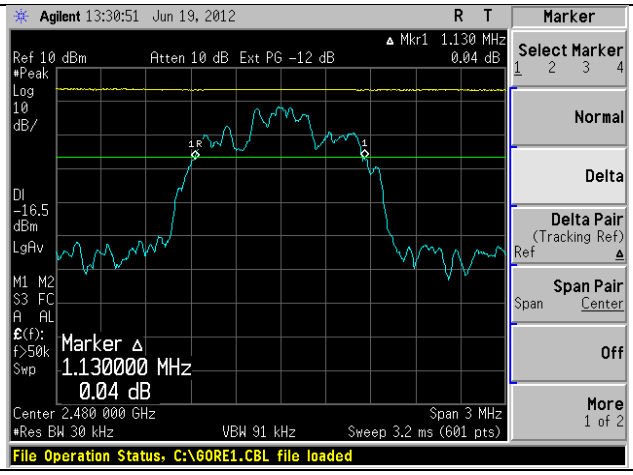
Middle Channel 99% BW



Middle Channel 20dBc BW

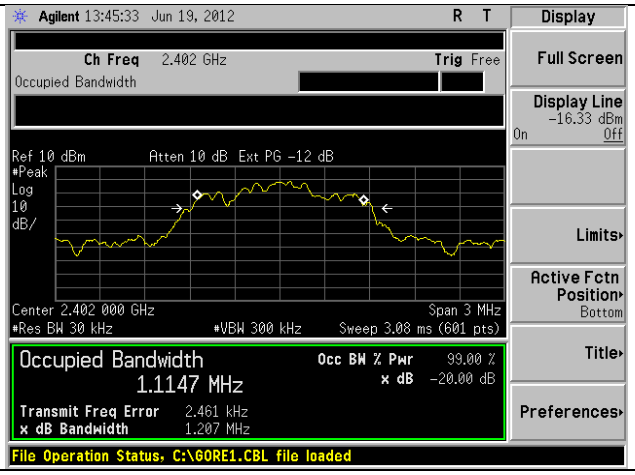


High Channel 99% BW

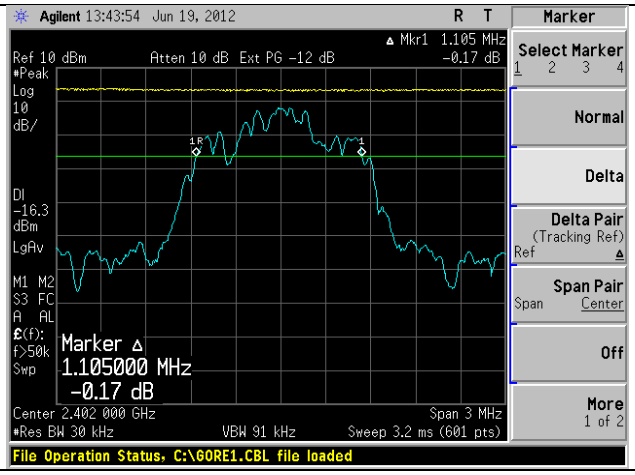


High Channel 20dBc BW

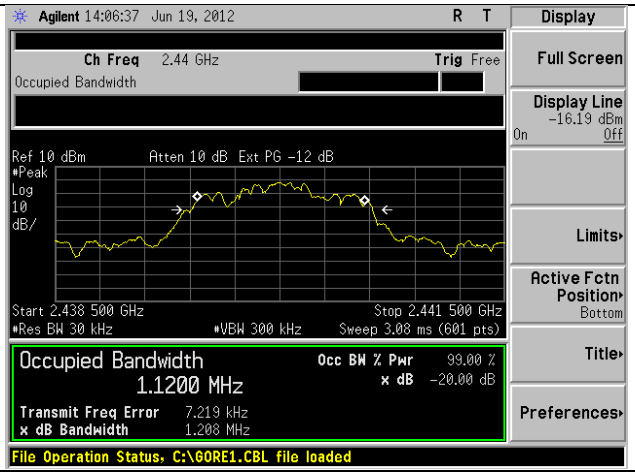
C. EDR3



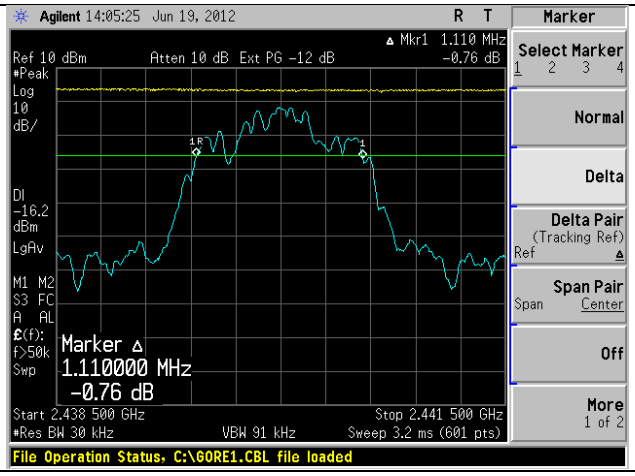
Low Channel 99% BW



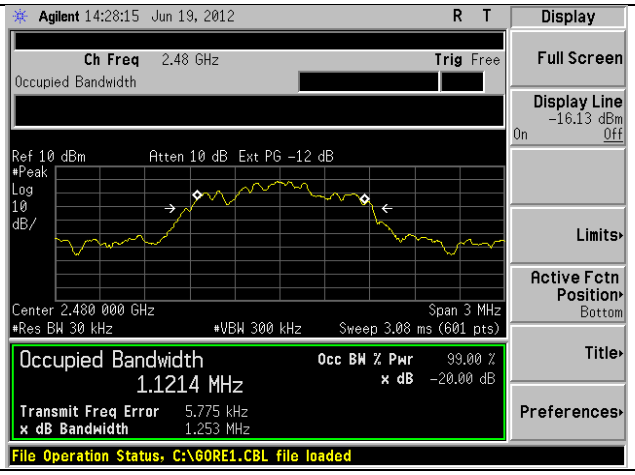
Low Channel 20dBc BW



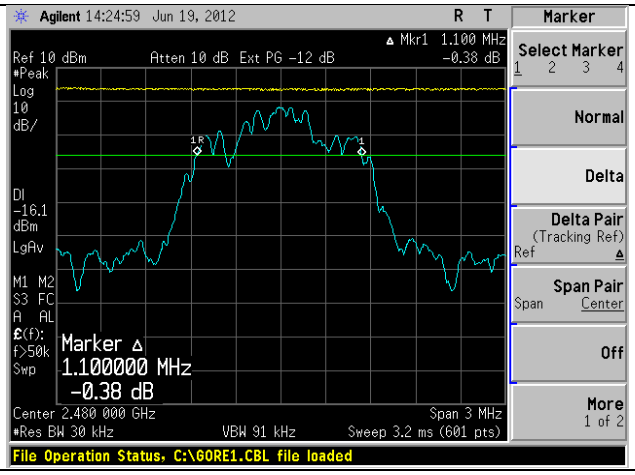
Middle Channel 99% BW



Middle Channel 20dBc BW



High Channel 99% BW



High Channel 20dBc BW

EXHIBIT 8. BAND EDGE MEASUREMENTS

8.1 - Method of Measurements

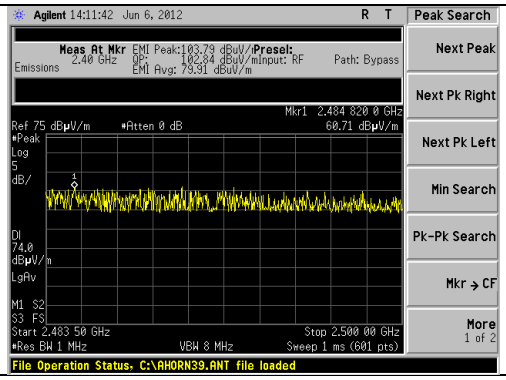
FCC 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the Band-Edges where the intentional radiator operates. Also, RSS 210 Section 2.2 requires that unwanted emissions meet limits listed in RSS GEN and also to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

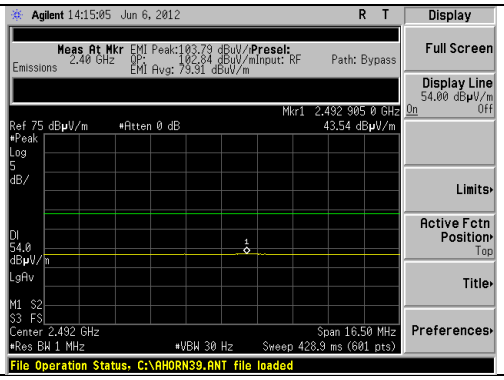
Conducted measurements of the spurious emission were performed with a measurement bandwidth of 100kHz while radiated measurements were performed with a measurement bandwidth of 1MHz.

8.2. Band-Edge captures.

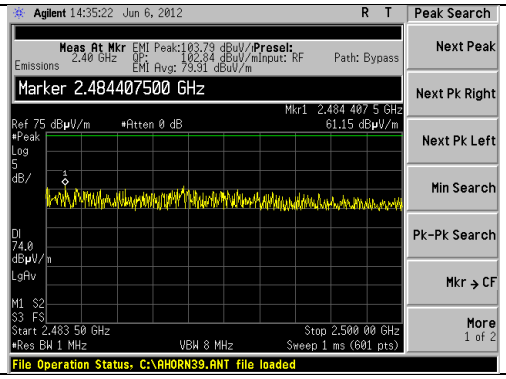
Radiated Band-edge restricted band (2483.5 to 2500 MHz):



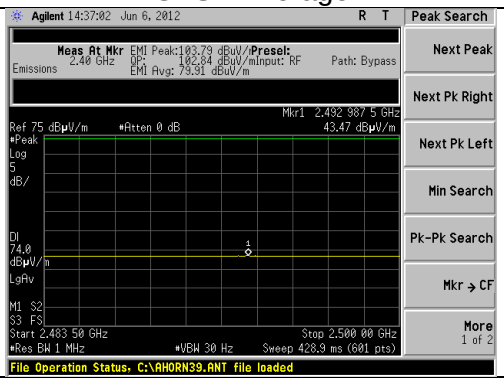
GFSK Peak



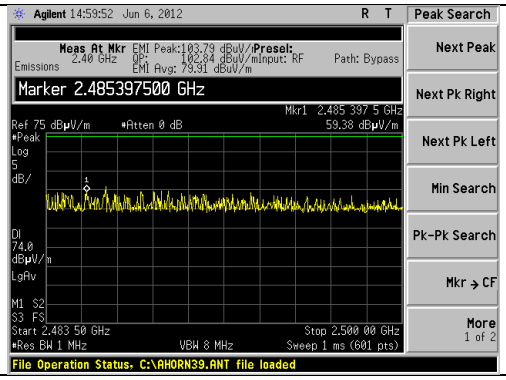
GFSK Average



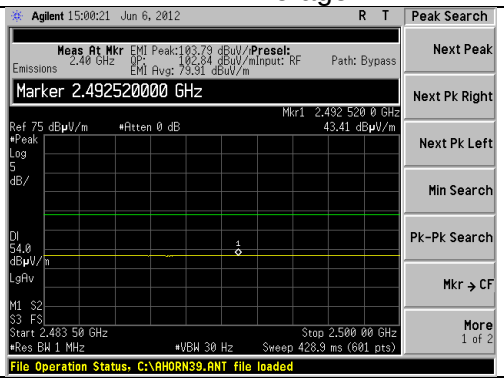
EDR2 Peak



EDR2 Average



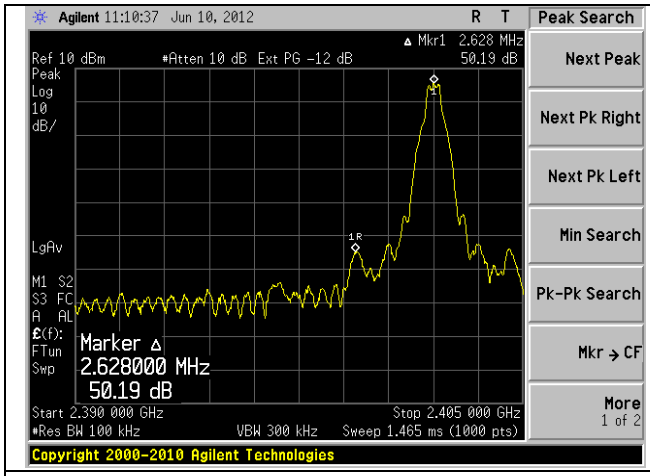
EDR3 Peak



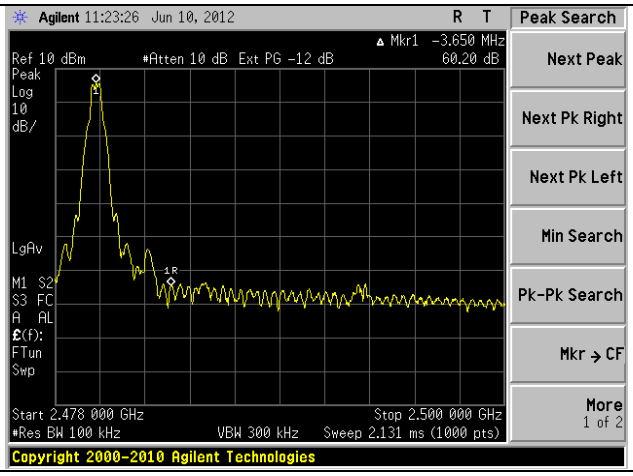
EDR3 Average

Conducted Band-edge:

A. GFSK

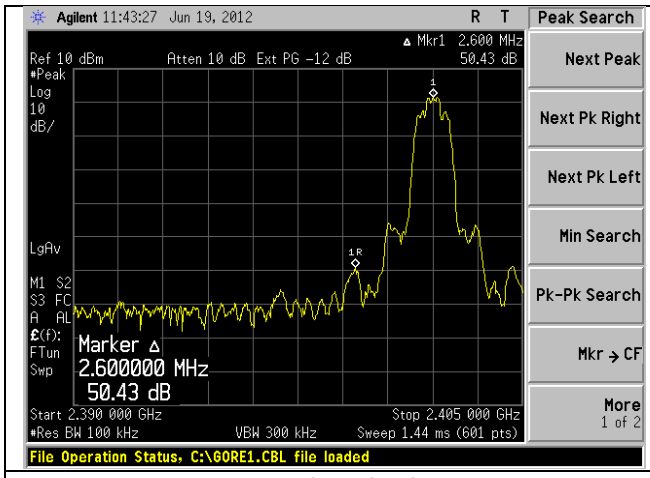


Lower band edge

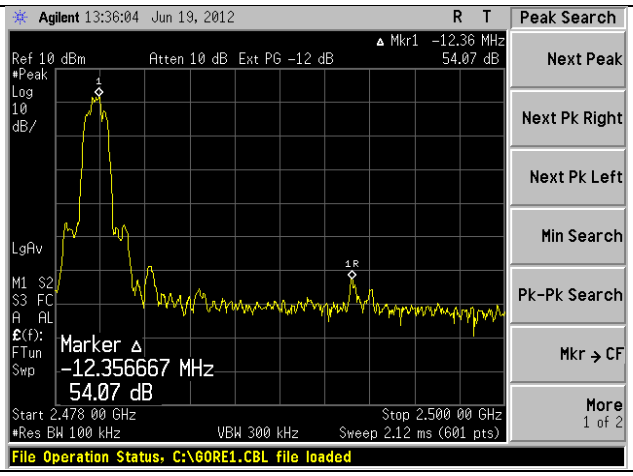


Upper band edge

B. EDR2

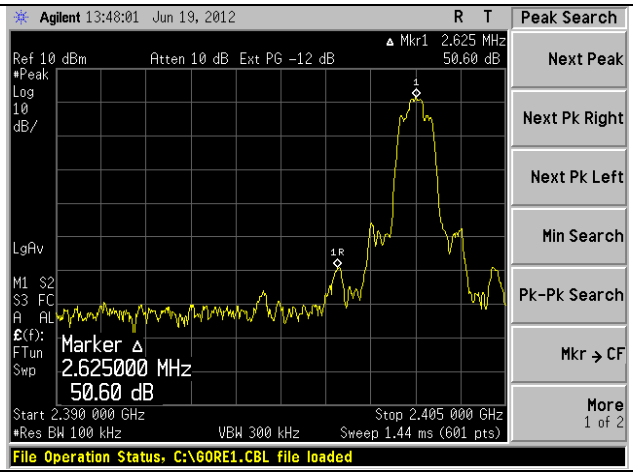


Lower band edge

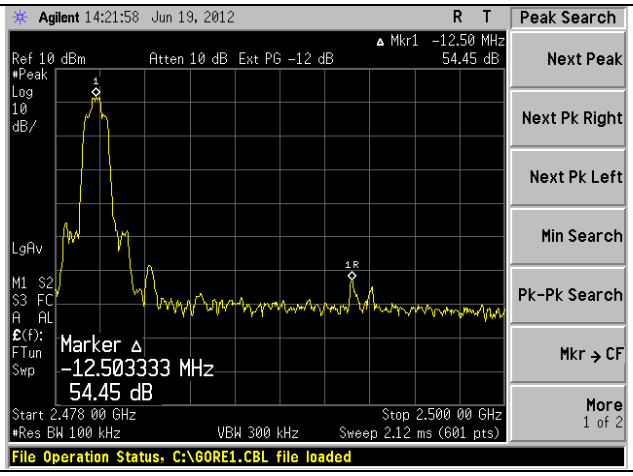


Upper band edge

C. EDR3

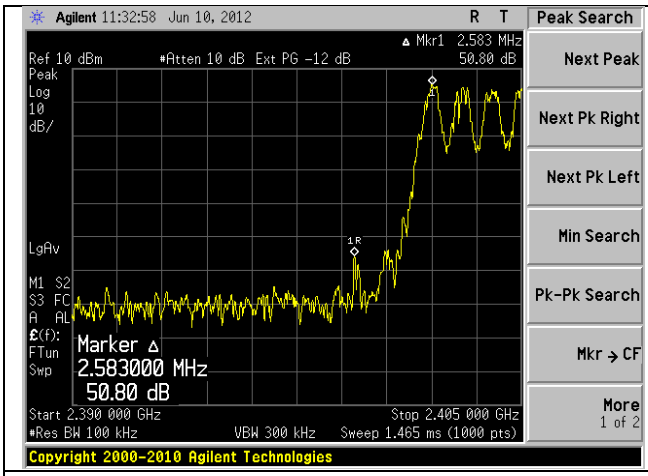


Lower band edge

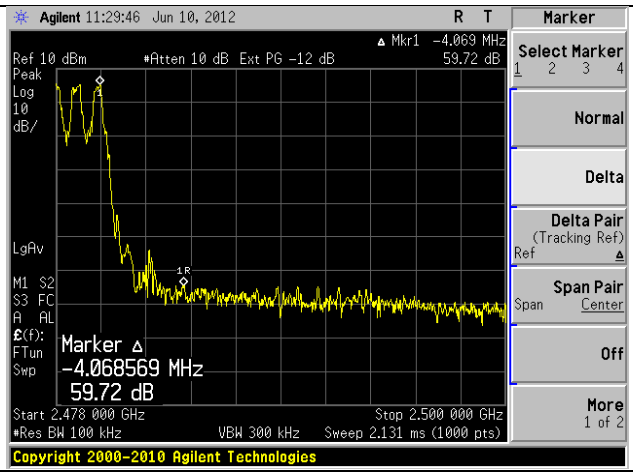


Upper band edge

D. Hopping mode.



Lower band edge



Upper band edge

Note:
The screen captures above are those of the EUT in GFSK mode, being used to represent all the other Bluetooth modulation.

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

Chan (MHz)	Power (dBm)	Power (Watts)	Limit (dBm)	Margin
2402.0	**5.3**	**0.0034**	30.0	24.7
2440.0	**5.6**	**0.0036**	30.0	24.4
2480.0	**5.6**	**0.0036**	30.0	24.4

B. EDR2

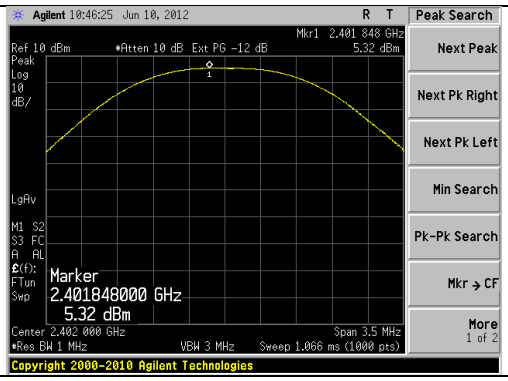
Chan (MHz)	Power (dBm)	Power (Watts)	Limit (dBm)	Margin
2402.0	**3.1**	**0.0020**	30.0	26.9
2440.0	**3.1**	**0.0020**	30.0	26.9
2480.0	**3.3**	**0.0021**	30.0	26.7

C. EDR3

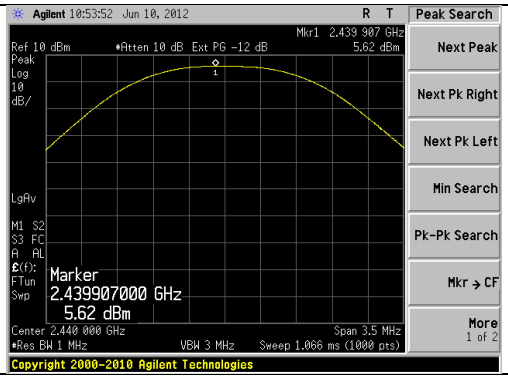
Chan (MHz)	Power (dBm)	Power (Watts)	Limit (dBm)	Margin
2402.0	**3.3**	**0.0021**	30.0	26.7
2440.0	**3.4**	**0.0022**	30.0	26.6
2480.0	**3.5**	**0.0022**	30.0	26.5

9.3 – Screen Captures

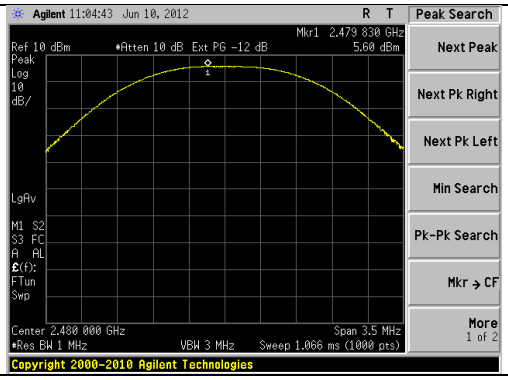
A. GFSK



Low Channel

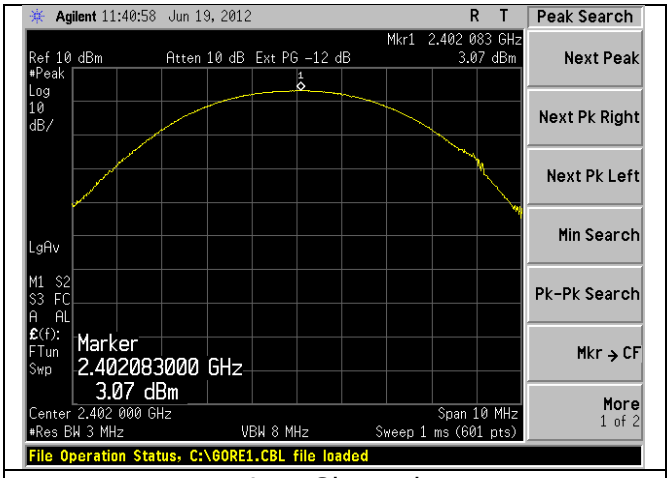


Middle Channel

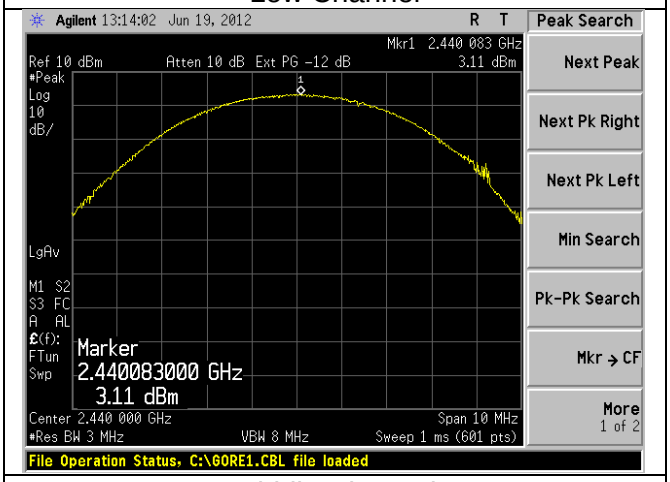


High Channel

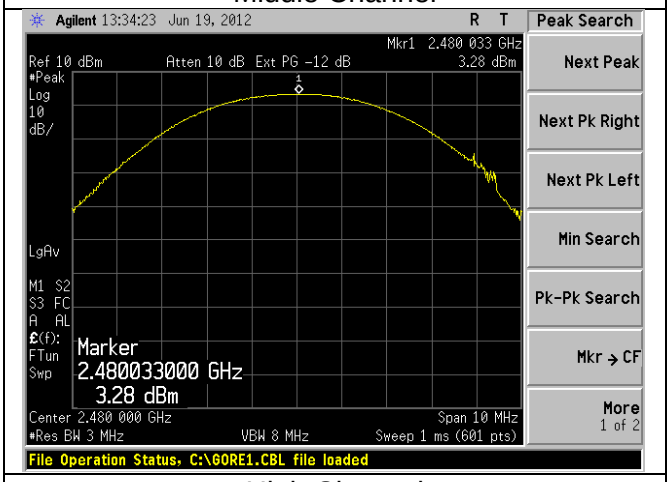
B. EDR2



Low Channel

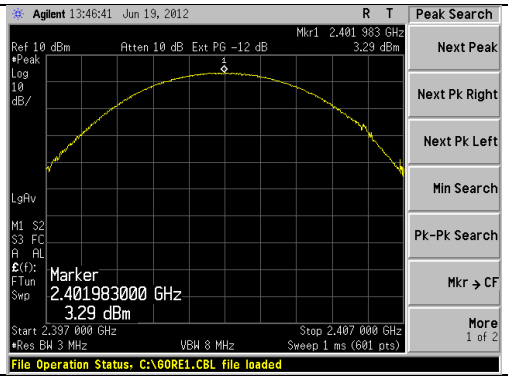


Middle Channel

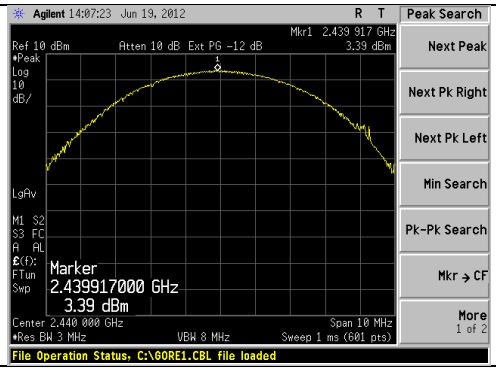


High Channel

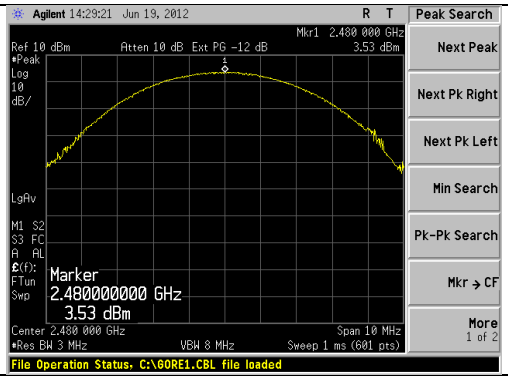
C. EDR3



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

A. GFSK

	Channel Low	Channel Middle	Channel High
Fundamental	5.2	5.3	5.5
2nd Harmonic	-36.6	-38.8	-39.3
3rd Harmonic	-56.1	-62.1	-62.4
4th Harmonic	Note 2	Note 2	Note 2
5th Harmonic	-60.9	-62.7	-64.1
6th Harmonic	-71.2	-64.3	Note 2
7th Harmonic	Note 2	Note 2	Note 2
8th Harmonic	Note 2	Note 2	Note 2
9th Harmonic	Note 2	Note 2	Note 2
10th Harmonic	Note 2	Note 2	Note 2

Note:
1. **All reported data are in dBm**.
2. **Spurious emission buried within system noise floor**.

B. EDR2

	Channel Low	Channel Middle	Channel High
Fundamental	1.2	1.2	1.2
2nd Harmonic	-40.8	-41.8	-42.6
3rd Harmonic	Note 2	Note 2	Note 2
4th Harmonic	Note 2	Note 2	Note 2
5th Harmonic	Note 2	Note 2	Note 2
6th Harmonic	Note 2	Note 2	Note 2
7th Harmonic	Note 2	Note 2	Note 2
8th Harmonic	Note 2	Note 2	Note 2
9th Harmonic	Note 2	Note 2	Note 2
10th Harmonic	Note 2	Note 2	Note 2

Note:
1. **All reported data are in dBm**.
2. **Spurious emission buried within system noise floor**.

C. EDR3

	Channel Low	Channel Middle	Channel High
Fundamental	1.5	1.3	1.6
2nd Harmonic	-39.9	-40.0	-40.5
3rd Harmonic	Note 2	Note 2	Note 2
4th Harmonic	Note 2	Note 2	Note 2
5th Harmonic	Note 2	Note 2	Note 2
6th Harmonic	Note 2	Note 2	Note 2
7th Harmonic	Note 2	Note 2	Note 2
8th Harmonic	Note 2	Note 2	Note 2
9th Harmonic	Note 2	Note 2	Note 2
10th Harmonic	Note 2	Note 2	Note 2

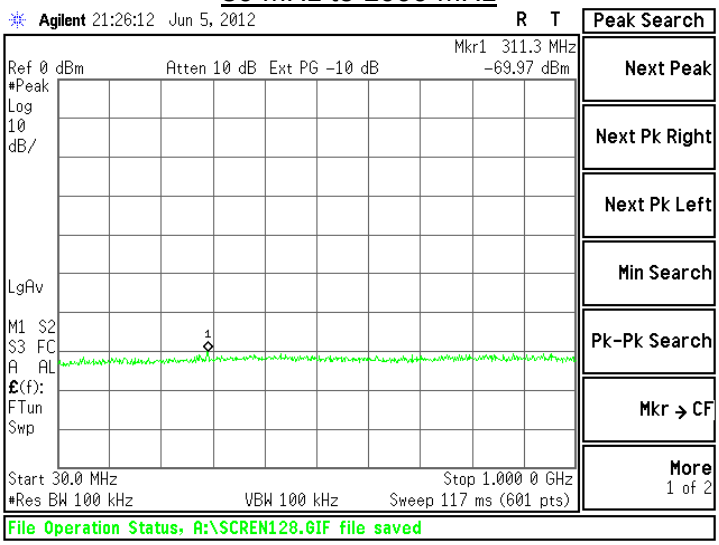
Note:

1. **All reported data are in dBm**.
2. **Spurious emission buried within system noise floor**.

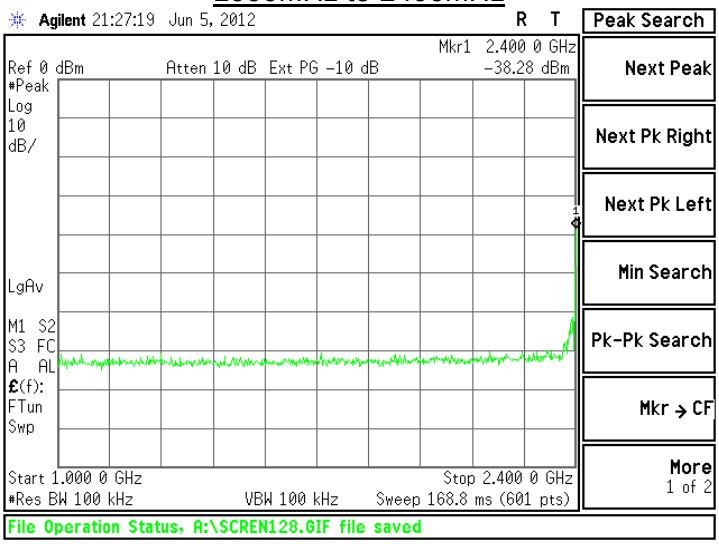
10.4 – Screen Captures – Spurious Radiated Emissions

The screen captures below are those of the EUT in GFSK mode (low channel), being used to represent all the other Bluetooth modulation and channels.

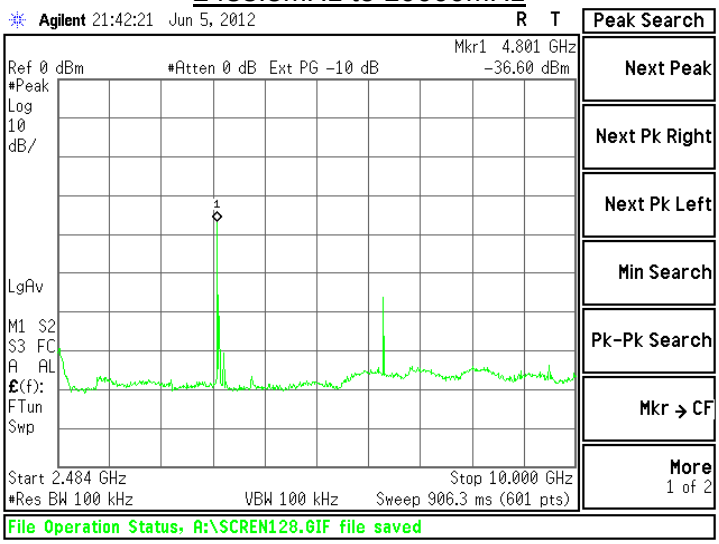
30 MHz to 1000 MHz



1000MHz to 2400MHz



2483.5MHz to 10000MHz



10000MHz to 25000MHz

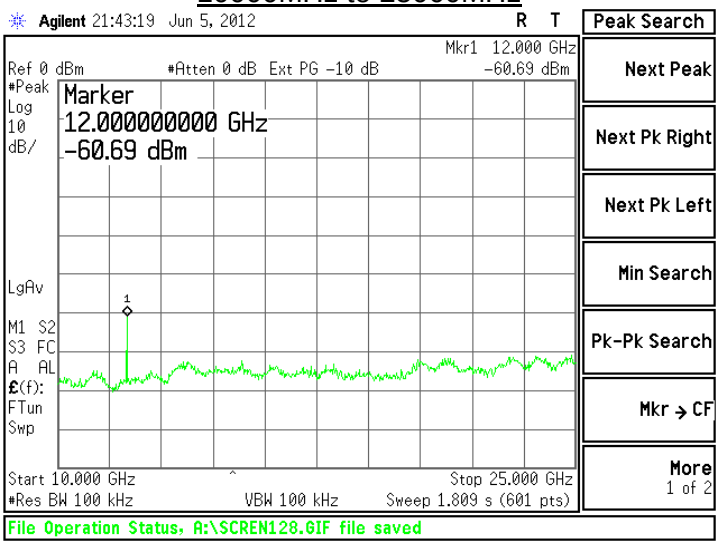


EXHIBIT 11. FREQUENCY & POWER STABILITY OVER VOLTAGE VARIATIONS

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 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.

2.55 VDC		3.0 VDC		3.45 VDC	
Power (dBm)	Frequency (Hz)	Power (dBm)	Frequency (Hz)	Power (dBm)	Frequency (Hz)
3.54	2403160450	3.53	2403160450	3.58	2403160700
3.64	2440160020	3.68	2440160220	3.68	2440160150
3.69	2480159940	3.69	2480160040	3.71	2480159910

Channel	max	min	freq drift (Hz)
Low	2403160700	2403160450	250
Middle	2440160220	2440160020	200
High	2480160040	2480159910	130

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 100 kHz to measure the channel separation of the EUT.

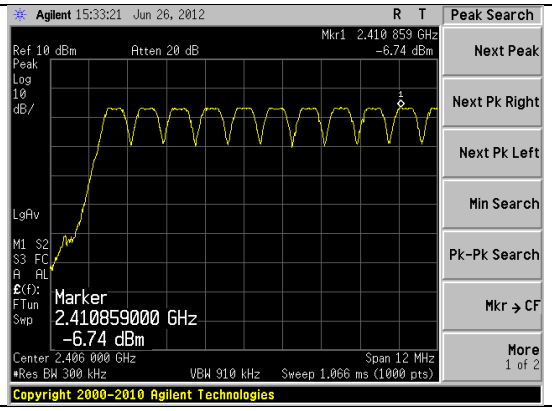
The channel separation measured for this device 958.5 kHz. The maximum 20dB bandwidth of the device, as reported in the previous section is 1130 kHz. The following plots describe this spacing, and also establish the channel separation and plan.

This EUT also satisfies the minimum number of hopping channels which is 15.

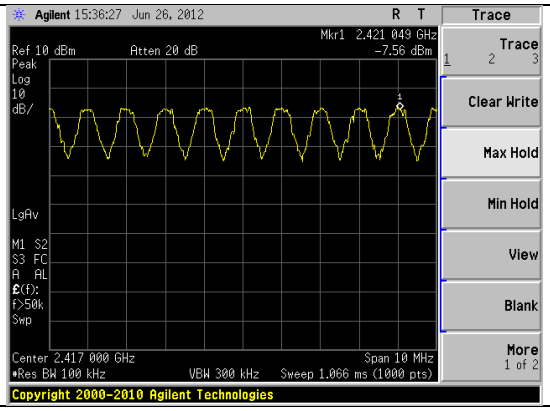
RANGE (MHz)	OF CHANNELS PER
2400-2412	10.5
2412-2422	10
2422-2432	10
2432-2442	10
2442-2452	10
2452-2462	10
2462-2472	10
2472-2483.5	8.5

Total Channels	79
CHAN SEPARATION	958.5 kHz

12.1 - Screen Captures – Channel Separation

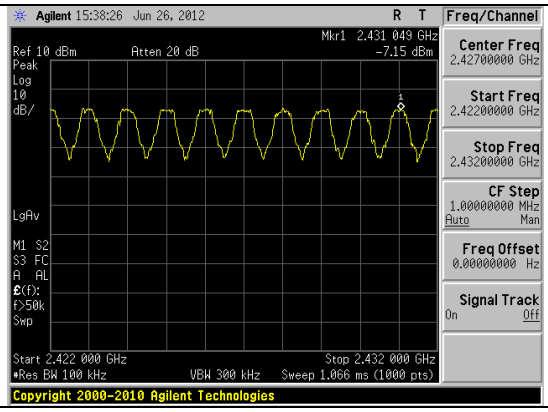


2400 – 2412 MHz

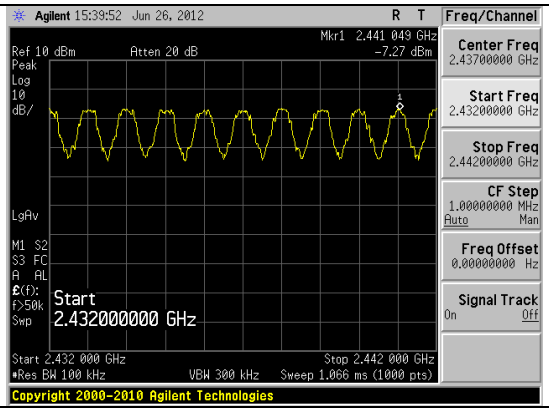


2412 – 2422 MHz

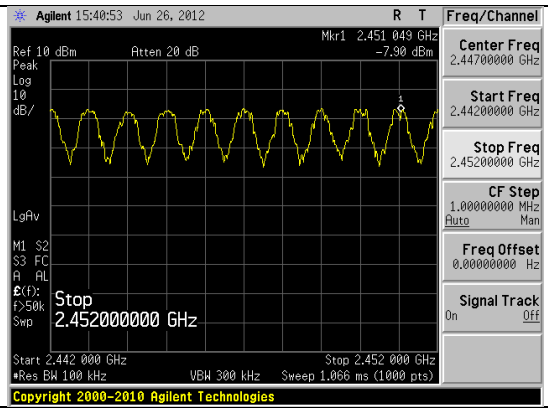
Screen Captures – Channel Separation *(continued)*



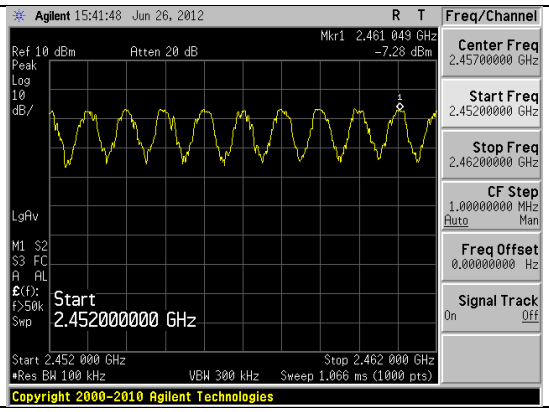
2422 – 2432 MHz



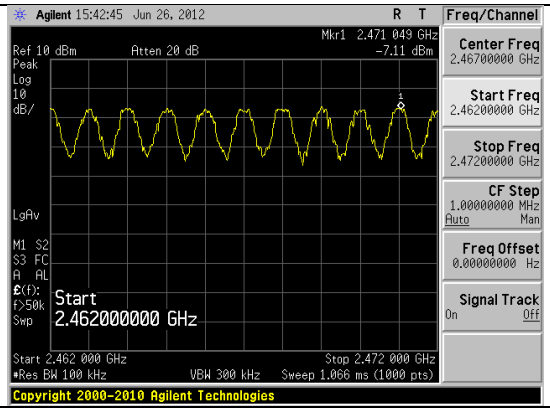
2432 – 2442 MHz



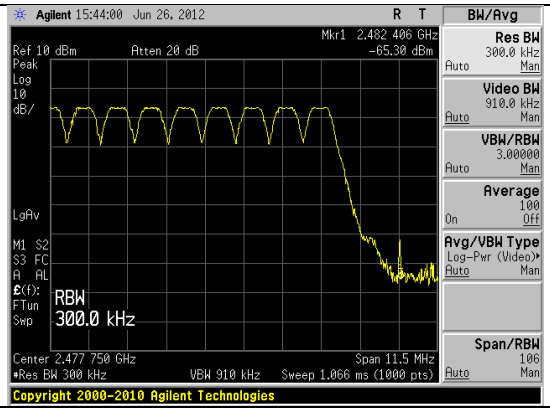
2442 – 2452 MHz



2452 – 2462 MHz



2462 – 2472 MHz



2472 – 2483.5 MHz

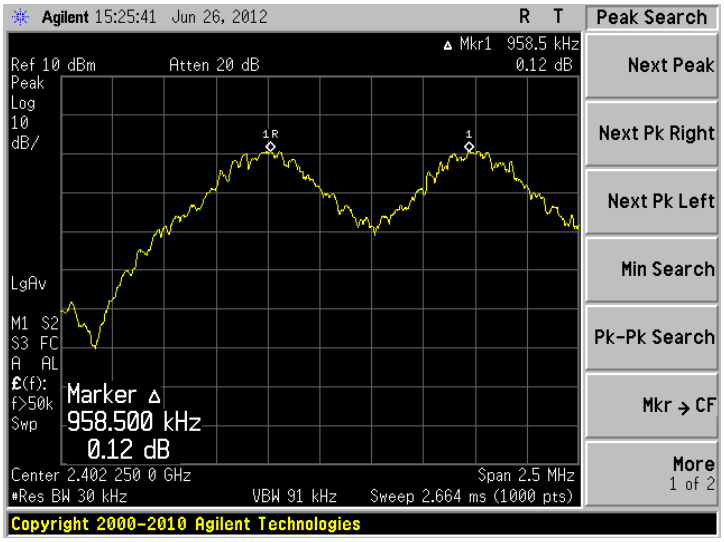


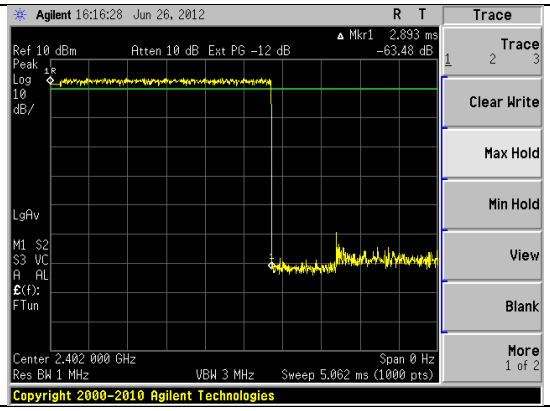
EXHIBIT 13. CHANNEL OCCUPANCY.

Part 15.247(a)(1)(i) requires an average 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 **2.89 ms**. The maximum occupancy in a **15.8 seconds** window is **57**(fifty seven) transmission cycle which translates to **164.73ms**. There are 2 15.8 seconds windows in a 31.6 second time span. Therefore the total occupancy in a 31.6 second time is

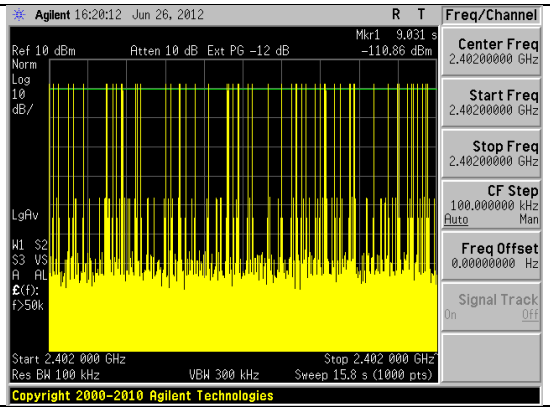
164.73s X 2 = **329.5ms**

13.1 Time occupancy captures.

Channel 2402MHz

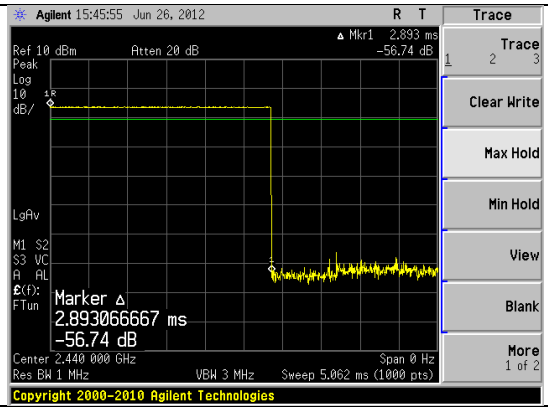


Single transmission

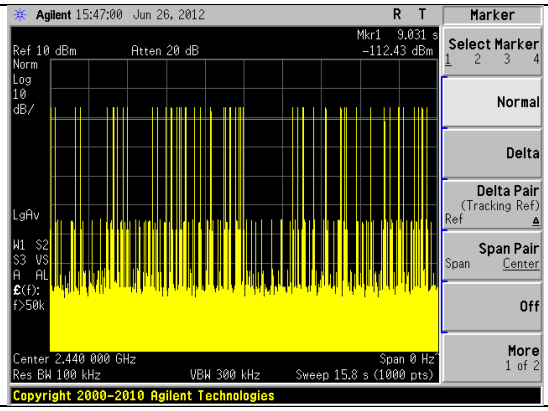


Maximum Occupancy in 15.8s

Channel 2440 MHz

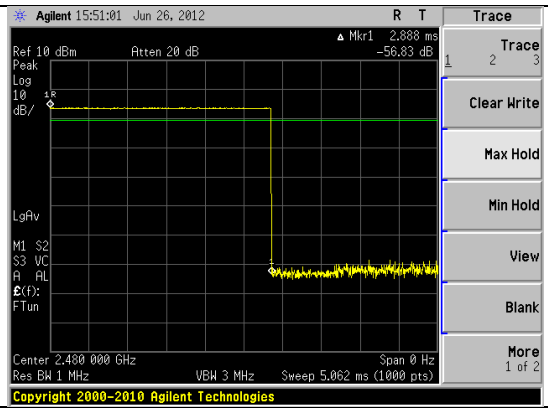


Single transmission

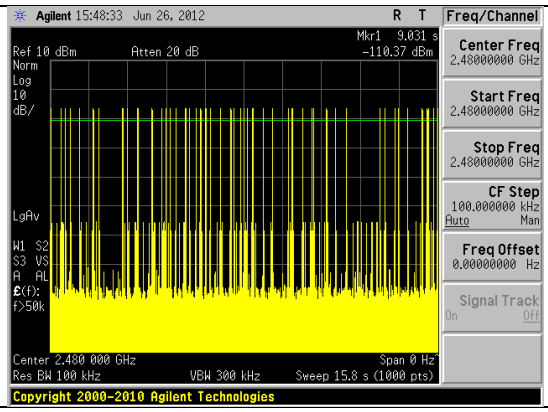


Maximum Occupancy in 15.8s

Channel 2480 MHz



Single transmission



Maximum Occupancy in 15.8s

EXHIBIT 14. EQUAL CHANNEL USAGE

The transceiver implemented in the EUT is a Bluetooth core specification V2.1 + EDR hence satisfies this requirement.

EXHIBIT 15. PSEUDORANDOM HOPPING SEQUENCE.

The transceiver implemented in the EUT is a Bluetooth core specification V2.1 + EDR hence satisfies this requirement.

EXHIBIT 16. RECEIVER SYNCHRONIZATION AND INPUT BANDWIDTH.

The transceiver implemented in the EUT is a Bluetooth core specification V2.1 + EDR hence satisfies this requirement.

EXHIBIT 17. MPE CALCULATIONS

The following MPE calculations are based on a maximum measured conducted RF power of +5.62 dBm as presented to the antenna. The peak gain of this antenna, based on the data sheet is 2.2 dBi.

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal:	5.62	(dBm)
Maximum peak output power at antenna input terminal:	3.648	(mW)
Antenna gain(typical):	2.2	(dBi)
Maximum antenna gain:	1.660	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2440	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)
Power density at prediction frequency:	0.001204	(mW/cm^2)
Maximum allowable antenna gain:	31.4	(dBi)
Margin of Compliance at 20 cm =	29.2	dB

APPENDIX A – Test Equipment List

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 5-Jun-2012 Type Test : Rad Measurements Job # : C-1479

Prepared By: AIDI Customer : Plexus Technology Group Quote #: 312122

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/11/2011	6/11/2012	Active Calibration
2	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	1/6/2012	1/6/2013	Active Calibration
3	EE 960158	RF Preselecter	Agilent	N9039A	MY46520110	6/11/2011	6/11/2012	Active Calibration
4	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2012	5/9/2013	Active Calibration
5	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	1/6/2012	1/6/2013	Active Calibration
6	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	1/6/2012	1/6/2013	Active Calibration
7	AA 960153	2.4GHz High Pass Filter	KWM	HPF-L-14186	7272-04	3/5/2012	3/5/2013	Active Calibration
8	EE 960146	Std. Gain Horn Ant. w/preamp	Adv. Micro	WLA622-4	123001	11/3/2011	11/3/2012	Active Calibration
9	AA 960150	Bicon Antenna	ETS	3110B	0003-3346	11/15/2011	11/15/2012	Active Calibration
10	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	11/15/2011	11/15/2012	Active Calibration
11	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	5/16/2012	5/16/2013	Active Calibration
12	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	11/22/2011	11/22/2012	Active Calibration
13	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	11/22/2011	11/22/2012	Active Calibration

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 5-Jun-2012 Type Test : Cond Measurements Job # : C-1479

Prepared By: Customer : Plexus Technology Group Quote #: 312122

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960143	Phaseflex	Gore	EKD01D01048.0	5546519	6/1/2011	6/1/2013	Active Calibration
2	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2012	5/9/2013	Active Calibration

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, 18, 90, 95	2012		
FCC Public Notice DA 00-1407	2000		
FCC ET Docket # 99-231	2002		
FCC Procedures	2007		
ICES 003	2004-02		
RSS GEN	2010		
RSS 210	2010		

Updated on 11-22-11 P=Project FD= Final Draft

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 – PLEXUS Instrument sheet.

The equipment table below lists the peripheral attachments used in the testing of the EUT.

Equipment Description	Plexus Identification Number
Breakout Board	BRKOUT_06
PAIN ENS	NLJ002306N
Bluetooth Dongle	BT_05
Conducted Measurement Cable	CM_CABLE_01
Quad Leads	BFT_LD_09 BFT_LD_10 BFT_LD_11 BFT_LD_12