LS RESEARCH, LLC
Wireless Product Development

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ENGINEERING TEST REPORT # 312065
LSR Job #: C-1438

Compliance Testing of:
FreeStar Pro Zigbee Module

Test Date(s):
April and May 2012

Prepared For:
California Eastern Laboratories
4590 Patrick Henry Drive
Santa Clara, CA 95054-1817

In accordance with:
Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247
Industry Canada (IC) RSS-210 Annex 8
Digital Transmission System (DTS) Operating
In the Frequency Band 2400-2483.5 MHz

Class 2 Permissive Change Report

Intentional Radiators

This Test Report is issued under the Authority of:
Signature:

Date: 5-17-12

Test Report Reviewed by:	**Report by:**
Khairul Aidi Zainal, Senior EMC Engineer	Adam Alger
Signature: Date:5-17-12	Signature: Date: 5-16-12

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LS Research, LLC in Review

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

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

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

Federal Communications Commission (FCC) – USA

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

Industrie Canada Industry Canada

Canada

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-212 – Issue 1
File Number: IC 3088-A
On file, 3 and 10 Meter OATS based on RSS-212 – Issue 1
File Number: IC 3088

U. S. Conformity Assessment Body (CAB) Validation

Validated by the European Commission as a U. S. Competent Body operating under the U. S./EU, Mutual Recognition Agreement (MRA) operating under the European Union Electromagnetic Compatibility –Council Directive 2004/108/EC (formerly 89/336/EEC, Article 10.2).
Date of Validation: January 16, 2001

Validated by the European Commission as a U.S. Notified Body operating under the U.S. /EU, Mutual Recognition Agreement (MRA) operating under the European Union Telecommunication Equipment – Council Directive 99/5/EC, Annex V.
Date of Validation: November 20, 2002
Notified Body Identification Number: 1243

1.0 Summary of Test Report

In April and May 2012 the CEL FreeStar Pro Zigbee module was tested and MEETS the following requirements. The purpose of these tests is to request a Class II permissive change to FCC ID: W7Z-FSTARPRO and IC: 8254A-FSTARPRO, to add an antenna. See permissive change request letter for full description of changes.

Rule	Description	Procedure	Compliant	Note
FCC: 15.247(b) IC: RSS-210 A8.4	Conducted Output Power	ANSI C63.4-2003 FCC KDB558074	Yes	2
FCC: 15.247(d) IC: RSS-210 A8.5	Radiated Emissions at Band-edge	ANSI C63.4-2003 FCC KDB558074	Yes	1
FCC: 15.247(d) IC: RSS-210 A8.5	Radiated Harmonics	ANSI C63.4-2003 FCC KDB558074	Yes	1
FCC: 15.247(d) IC: RSS-210 A8.5	Radiated Emissions	ANSI C63.4-2003 FCC KDB558074	Yes	1
FCC: 15.109 IC: RSS-GEN	Receiver radiated Emissions	ANSI C63.4-2003	Yes	1
FCC: 2.1091 IC: RSS-102 2.5.1	RF Exemption Calculation	FCC KDB447498 RSS-102	Yes	None

Note 1: Tested in three orthogonal positions and two EUT antenna orientations.
Note 2: RF Conducted measurement at antenna terminal.

2.0 Test Facilities

All testing was performed at:

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

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to the requirements of 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.

3.0 Client Information

Manufacturer Name:	California Eastern Laboratories, Inc.
Address:	4590 Patrick Henry Drive, Santa Clara, CA 95054-1817
Contact Person:	Dave Wilde

3.1 Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	FreeStar Pro Zigbee Module
Model Number:	ZFSM-201-1
Serial Number:	Lot: 0851B S/N: ES0405
FCC ID	W7Z-FSTARPRO
IC Number	8254A-FSTARPRO

3.2 Product Description

For the class II permissive change, the antenna used with the module is a Nearson Half-Wave dipole Whip antenna (Model S181AH-2405S) with a five inch MMCX to RPSMA connector.
Information from testing dipole antenna:

Frequency Range (MHz)	2405-2480
RF Power In Watts (conducted)	Max: 0.012; Min: 0.0008
Max Conducted Output Power (dBm)	10.86
Field Strength at 3 meters (dBµV/m)	N/A
Occupied Bandwidth 99%	Note 1
Type of Modulation	O-QPSK
Emission Designator	Note 1
Transmitter Spurious (worst case) at 3 meters	43.90 dBµV/m average (extrapolated)
Stepped (Y/N)	No
Step Value	N/A
Frequency Tolerance %,Hz, ppm	Note 1
Microprocessor Model #	MC13224
Antenna: Detachable / Non-detachable	Detachable
Antenna: Type	Dipole
Antenna Gain (From data sheet)	2 dBi
FCC Rule Part	Title 47 Part 15.247
Industry Canada Rule Part	RSS-210 Issue 8 2010
Modular Filing	Class II Permissive Change
RF Exposure Type	Mobile
Receiver Spurious (worst case) at 3 meters	51.92 dBµV/m peak (extrapolated, noise floor)

Note 1: Not changed from original report.

3.3 Modifications Incorporated In the EUT for Compliance Purposes

Note 1:

Band-edge measurements at power setting 6 caused a non-compliant condition therefore power setting 4 (channels 11-25) and power setting 1(channel 26) with duty cycle correction was implemented.

Note 2:

There were radiated harmonic tests at power setting 6 prior to the reduction of power for band-edge compliance. Radiated harmonic data taken at the higher power setting 6 has been determined worst case and the data was adjusted for duty cycle correction.

Class II permissive change tested channels / power settings / power used with dipole antenna:

Channel	Frequency MHz	Power Setting	Power dBm
11	2405	4	10.86
18	2440	4	9.51
25	2475	4	8.14
26	2480	1	-0.94

Note: Channels 11-25 are power setting 4.

Original filing tested channels / power settings / power used with inverted F trace antenna:

Channel	Frequency MHz	Power Setting	Power dBm
11	2405	4	10.52
12	2410	4	11.37
13	2415	6	20.66
18	2440	6	20.56
25	2475	6	19.48
26	2480	1	-1.17

3.4 Deviations & Exclusions from Test Specifications

The conducted output power was verified at power setting 4. Other conducted tests such as emission bandwidth, power spectral density and conducted spurious emissions will not be affected by the change in antenna and therefore were not measured for this class II permissive change. AC mains conducted will also not be affected by adding the new antenna.

4.0 Conditions of Test

Environmental:

Temperature: 20-25º C
Relative Humidity: 30-60%
Atmospheric Pressure: 86-106 kPa

Mains Voltage:

3.3VDC from bench supply

5.0 Additional Information

The EUT was programmed from a laptop computer with CEL's proprietary control program. Once programmed the radio was powered from a bench supply at 3.3VDC.

6.0 Test Equipment

All test equipment is calibrated by a calibration laboratory accredited by A2LA to the requirements of ISO 17025. For a complete list of test equipment and calibration dates, see Appendix A. Unless otherwise noted, resolution bandwidth of measuring instrument used during testing for given frequency range, see below. For average measurements above 1000MHz the video bandwidth is set at 10Hz.

Frequency Range	Resolution Bandwidth
9 kHz – 150 kHz	200 Hz
150 kHz – 30 MHz	9 kHz
30 MHz – 1000 MHz	120 kHz
Above 1000 MHz	1 MHz

7.0 Declaration of Conformity

The EUT was found to MEET the requirements as described within the specification of FCC Title 47, CFR Part 15.247 (2011) and Industry Canada RSS-210, Issue 8 (2010)

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.

Appendix A – Test Equipment

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date: 19-Apr-2012 Type Test: Spurious Emissions Job #: C-1438

Prepared By: Adam Customer: CEL Quote #: 312065

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2012	5/9/2013	Active Calibration
2	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	1/6/2012	1/6/2013	Active Calibration
3	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/1/2011	6/1/2012	Active Calibration
4	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	1/6/2012	1/6/2013	Active Calibration
5	AA 960154	2.4GHz High Pass Filter	KWM	HPF-L-14186	7272-02	6/10/2011	6/10/2012	Active Calibration
6	EE 960146	Std. Gain Horn Ant. w/preamp	Adv. Micro	WLA622-4	123001	11/3/2011	11/3/2012	Active Calibration

Project Engineer: Adam Quality Assurance: Aidi

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date: 19-Apr-2012 Type Test: Conducted Power Output Job #: C-1438

Prepared By: Adam Customer: CEL Quote #: 312065

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2012	5/9/2013	Active Calibration
2	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/1/2011	6/1/2012	Active Calibration

Project Engineer: Adam Quality Assurance: Aidi

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date: 19-Apr-2012 Type Test: Radiated Emissions Job #: C-1438

Prepared By: Adam Customer: CEL Quote #: 312065

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/6/2011	6/6/2012	Active Calibration
2	EE 960158	RF Preselecter	Agilent	N9039A	MY46520110	6/11/2011	6/11/2012	Active Calibration
3	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	6/6/2011	6/6/2012	Active Calibration
4	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	6/10/2011	6/10/2012	Active Calibration
5	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	11/15/2011	11/15/2012	Active Calibration

Project Engineer: Adam Quality Assurance: Aidi

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date: 19-Apr-2012 Type Test: Band-Edge Job #: C-1438

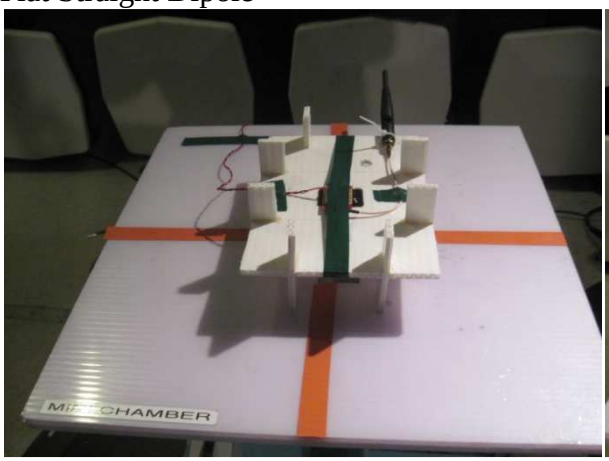
Prepared By: Adam Customer: CEL Quote #: 312065

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/6/2011	6/6/2012	Active Calibration
2	EE 960158	RF Preselecter	Agilent	N9039A	MY46520110	6/11/2011	6/11/2012	Active Calibration
3	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	1/6/2012	1/6/2013	Active Calibration

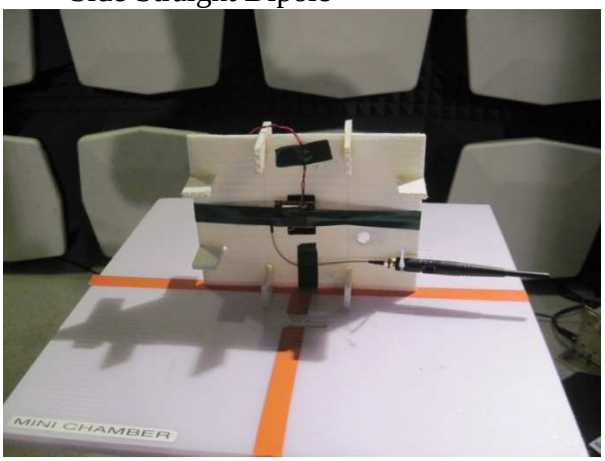
Project Engineer: Adam Quality Assurance: Aidi

Appendix B – Setup Photos

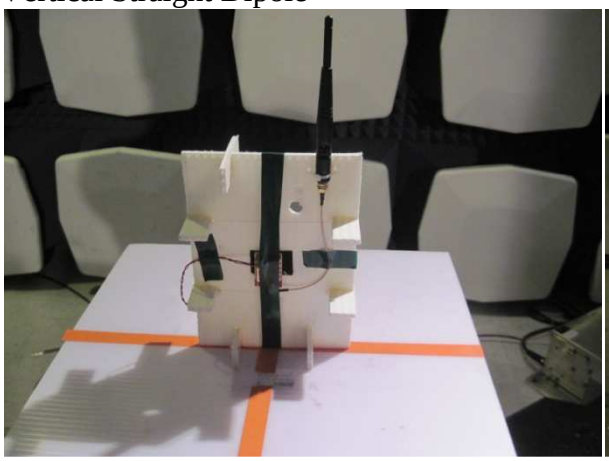
Flat Straight Dipole



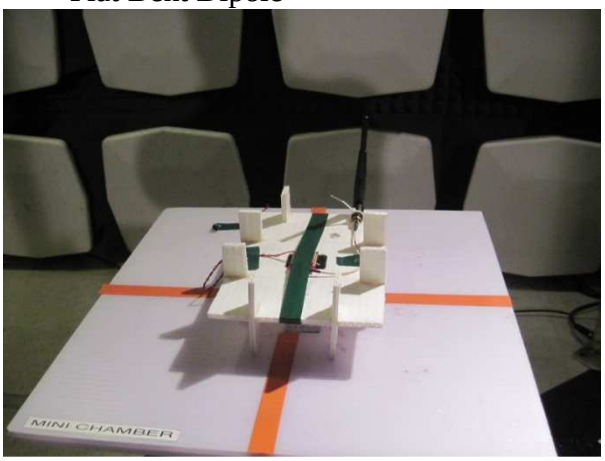
Side Straight Dipole



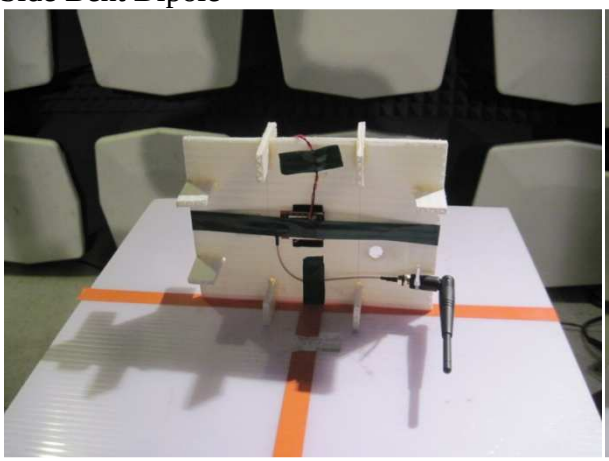
Vertical Straight Dipole



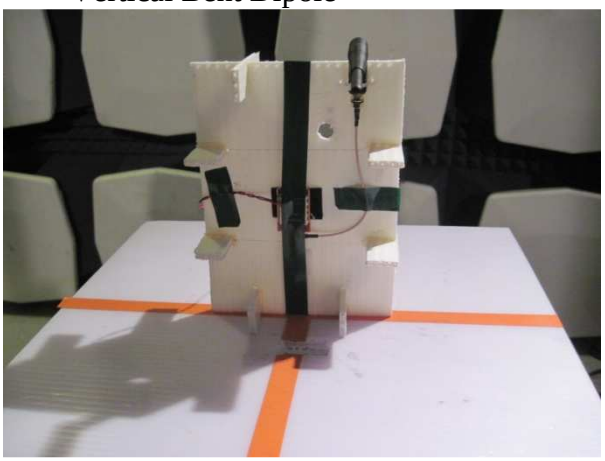
Flat Bent Dipole



Side Bent Dipole



Vertical Bent Dipole



Appendix C – Test Data

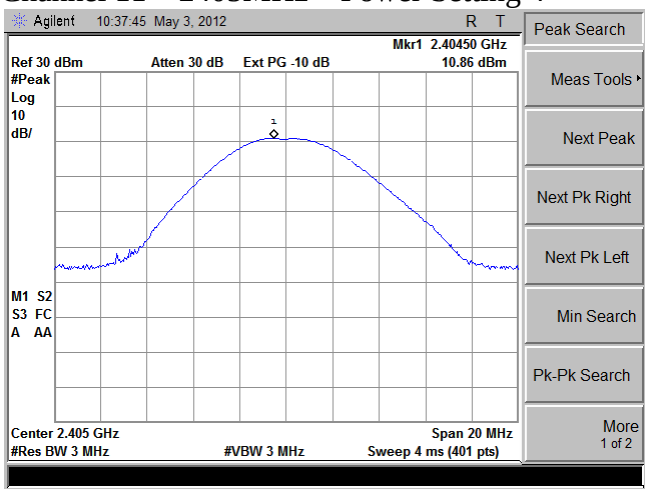
C.1 – RF Conducted Emissions

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.
The measurements were made using FCC KDB 558074 D01 DTS Meas Guidance v01 1-18-2012 and ANSI C63.10-2009 Section 6.7.

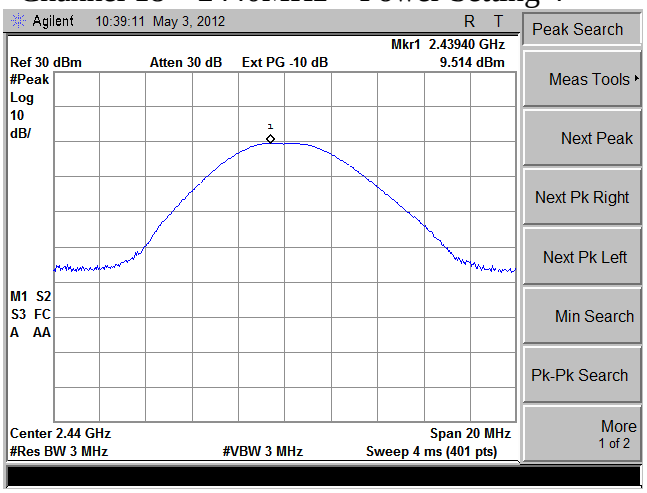
Summary of Results

Channel	Frequency MHz	Power Setting	Power dBm
11	2405	4	10.86
18	2440	4	9.51
25	2475	4	8.14
26	2480	1	-0.94

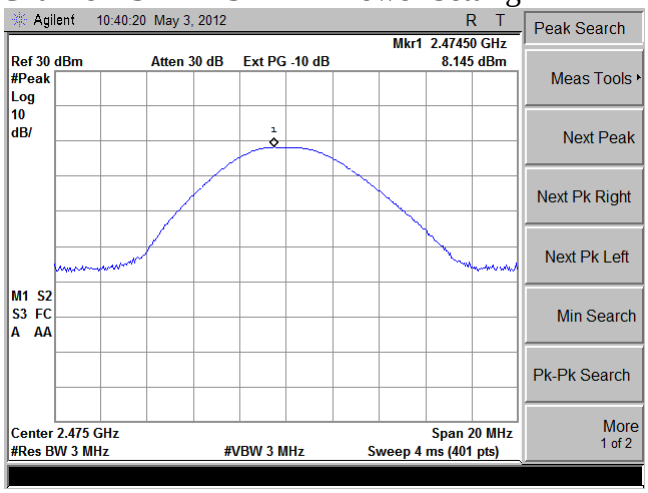
Channel 11 – 2405MHz – Power Setting 4



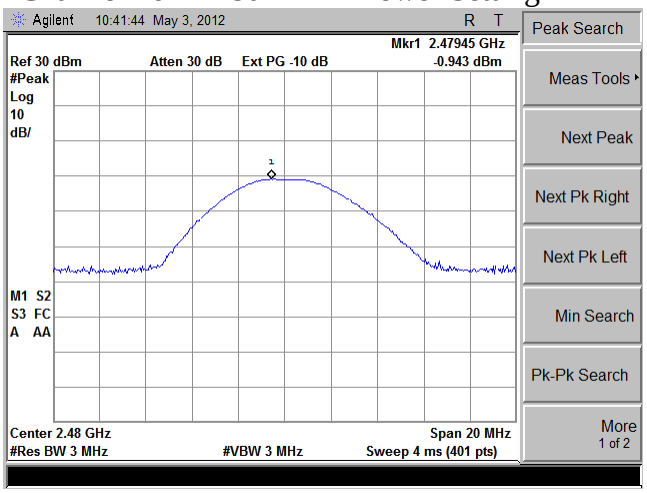
Channel 18 – 2440MHz – Power Setting 4



Channel 25 – 2475MHz – Power Setting 4



Channel 26 – 2480MHz – Power Setting 1



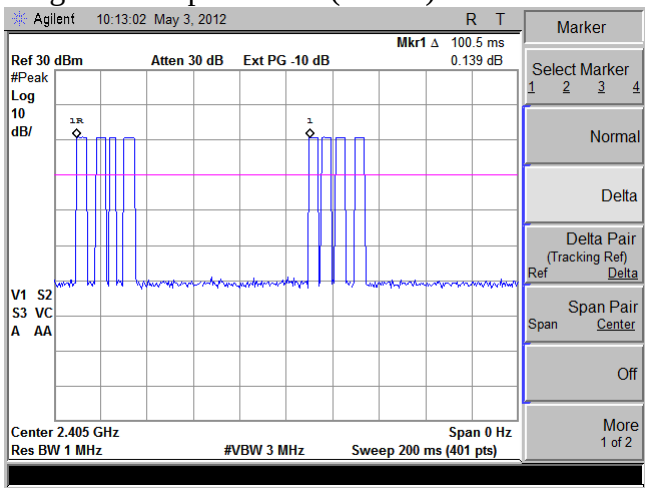
Duty Cycle Correction

Measurement Method: ANSI C63.10 – 2009 Section 7.5

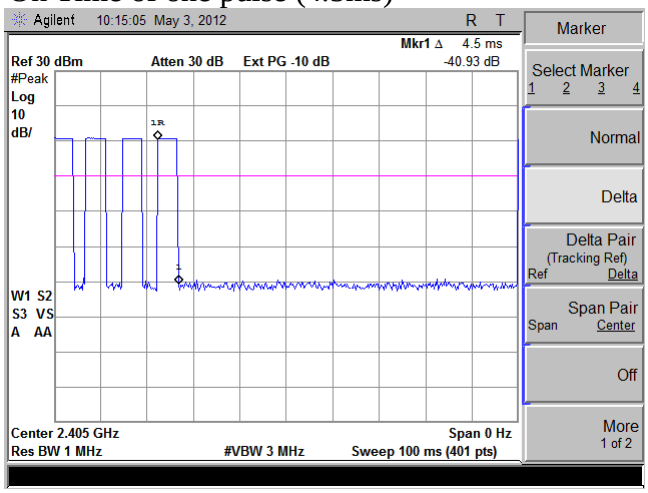
20*log(18/100)= -14.9

Duty Cycle Correction 14.9 dB

Length of one pulse train (100ms)



On Time of one pulse (4.5ms)



C.2 – Radiated Emissions

The test setup was assembled in accordance with Title 47, CFR FCC Part 15, RSS GEN and ANSI C63.4-2003.
Radiated RF measurements were performed on the EUT placed on an 80cm high non-conductive pedestal 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 40 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. Measurements above 4 GHz are performed at 1 meter separation distance.

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 A8.2 (b), radiated emissions that fall within the restricted band described in 15.205(c) for FCC and section 2.2, 2.6 and 2.7 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 210 section 2.7.

Frequency (MHz)	3 m Limit (μV/m)	3 m Limit (dBμV/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-10,000	500	54.0

Note: Limits are rounded to the nearest tenth of a dB.

Radiated Harmonics in Restricted Bands

Low Channel (11; 2405 MHz) Power Setting 4

Straight Dipole Highest Emission

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4810	1.00	165	48.14	83.5	35.4	14.9	33.24	63.5	30.3	Vertical	Vertical	none
12025	1.00	0	51.68	83.5	31.8	14.9	36.78	63.5	26.7	N/A	N/A	Noise Floor
19240	1.00	0	53.21	83.5	30.3	14.9	38.31	63.5	25.2	N/A	N/A	Noise Floor

Mid Channel (18; 2440 MHz) Power Setting 6

Straight Dipole Highest Emission

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4880	1.01	255	61.92	83.5	21.6	14.9	47.02	63.5	16.5	Vertical	Vertical	none
7320	1.00	255	64.53	83.5	19.0	14.9	49.63	63.5	13.9	Horizontal	Flat	none
12200	1.00	13	67.93	83.5	15.6	14.9	53.03	63.5	10.5	Horizontal	Flat	none
19520	1.06	98	58.93	83.5	24.6	14.9	44.03	63.5	19.5	Horizontal	Vertical	none

High Channel (25; 2475 MHz) Power Setting 6

Straight Dipole Highest Emission

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4950	1.00	227	64.41	83.5	19.1	14.9	49.51	63.5	14.0	Vertical	Vertical	none
7425	1.01	252	67.81	83.5	15.7	14.9	52.91	63.5	10.6	Horizontal	Flat	none
12375	1.00	22	64.06	83.5	19.4	14.9	49.16	63.5	14.3	Horizontal	Flat	none
19800	1.00	106	61.15	83.5	22.4	14.9	46.25	63.5	17.3	Horizontal	Vertical	none
22275	1.00	232	56.67	83.5	26.8	14.9	41.77	63.5	21.7	Horizontal	Side	none

Higher Channel (26; 2480 MHz) Power Setting 1

Straight Dipole Highest Emission

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4960	1.03	82	50.28	83.5	33.2	14.9	35.38	63.5	28.1	Vertical	Side	none
7440	1.00	0	49.47	83.5	34.0	14.9	34.57	63.5	28.9	N/A	N/A	Noise Floor
12400	1.00	0	53.47	83.5	30.0	14.9	38.57	63.5	24.9	N/A	N/A	Noise Floor
19840	1.00	0	53.21	83.5	30.3	14.9	38.31	63.5	25.2	N/A	N/A	Noise Floor
22320	1.00	0	54.68	83.5	28.8	14.9	39.78	63.5	23.7	N/A	N/A	Noise Floor

Radiated Harmonics in Restricted Bands

Low Channel (11; 2405 MHz) Power Setting 4

Bent Dipole Highest Emission

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4810	1.05	196	53.18	83.5	30.3	14.9	38.28	63.5	25.2	Horizontal	Flat	none
12025	1.00	0	51.68	83.5	31.8	14.9	36.78	63.5	26.7	N/A	N/A	Noise Floor
19240	1.00	0	53.21	83.5	30.3	14.9	38.31	63.5	25.2	N/A	N/A	Noise Floor

Mid Channel (18; 2440 MHz) Power Setting 6

Bent Dipole Highest Emission

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4880	1.01	77	61.79	83.5	21.7	14.9	46.89	63.5	16.6	Vertical	Flat	none
7320	1.08	166	65.96	83.5	17.5	14.9	51.06	63.5	12.4	Horizontal	Flat	none
12200	1.00	14	68.34	83.5	15.2	14.9	53.44	63.5	10.1	Horizontal	Flat	none
19520	1.00	92	58.22	83.5	25.3	14.9	43.32	63.5	20.2	Horizontal	Vertical	none

High Channel (25; 2475 MHz) Power Setting 6

Bent Dipole Highest Emission

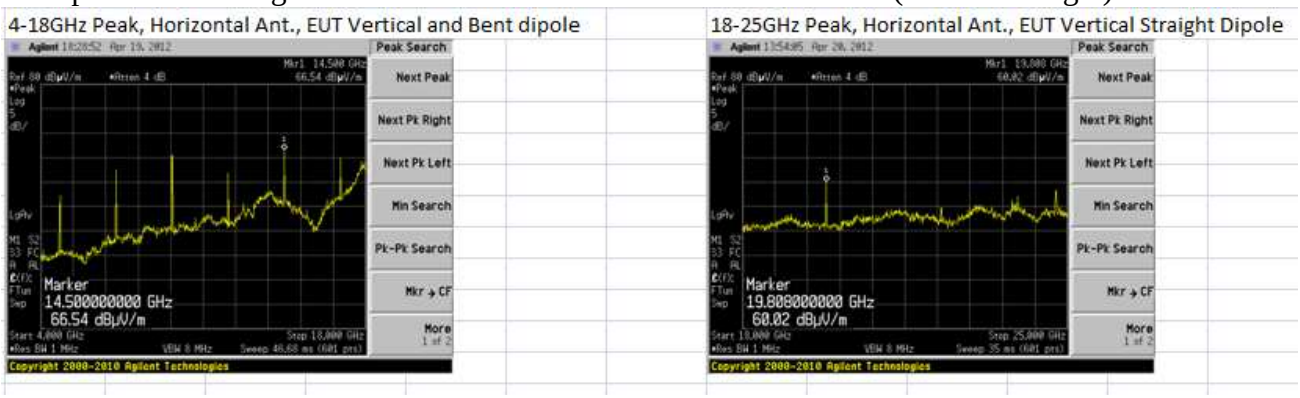
Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4950	1.00	298	64.89	83.5	18.6	14.9	49.99	63.5	13.5	Vertical	Flat	none
7425	1.06	230	67.33	83.5	16.2	14.9	52.43	63.5	11.1	Horizontal	Flat	none
12375	1.00	22	63.74	83.5	19.8	14.9	48.84	63.5	14.7	Horizontal	Flat	none
19800	1.00	241	58.10	83.5	25.4	14.9	43.20	63.5	20.3	Horizontal	Vertical	none
22275	1.00	145	57.03	83.5	26.5	14.9	42.13	63.5	21.4	Horizontal	Flat	none

Higher Channel (26; 2480 MHz) Power Setting 1

Bent Dipole Highest Emission

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Duty Cycle Correction (dB)	Avg Value (dBµV/m)	Avg Limit (dBµV/m)	Average Margin (dB)	Antenna Polarity	EUT orientation	Comment
4960	1.03	84	50.14	83.5	33.4	14.9	35.24	63.5	28.3	Vertical	Side	none
7440	1.00	0	49.47	83.5	34.0	14.9	34.57	63.5	28.9	N/A	N/A	Noise Floor
12400	1.00	0	53.47	83.5	30.0	14.9	38.57	63.5	24.9	N/A	N/A	Noise Floor
19840	1.00	0	53.21	83.5	30.3	14.9	38.31	63.5	25.2	N/A	N/A	Noise Floor
22320	1.00	0	54.68	83.5	28.8	14.9	39.78	63.5	23.7	N/A	N/A	Noise Floor

Example Plot showing radiated harmonics 4-25GHz tested at 1 meter (Power setting 6)



Radiated Band-edge in Restricted Bands

EUT maximized in:
Three orientations (side, flat, vertical)
Bent and straight transmit dipole
Vertical and horizontal receive antenna
360 degrees table azimuth

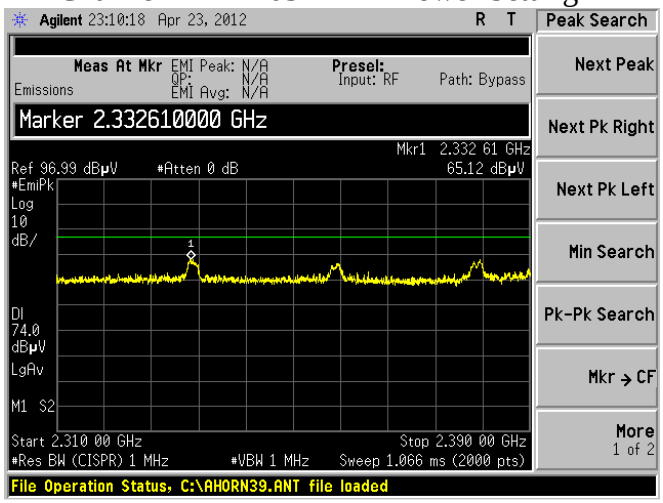
Worst Case Orientation Reported: Side with Straight Dipole - Horizontal Receive Antenna

Example Calculation:
Peak Limit – Peak Reading = Peak Margin
Peak Reading – Duty Cycle = Calculated Average
Average Limit – Calculated Average = Average Margin

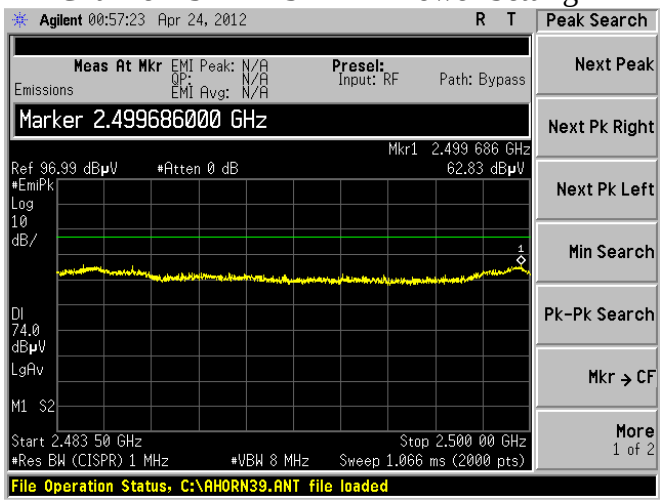
Channel	Fundamental Frequency (MHz)	Band-Edge	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dBµV/m)	Duty Cycle (dB)	Calculated Average (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
11	2405	Lower	65.12	74	8.9	14.9	50.22	54	3.8
25	2475	Upper	62.83	74	11.2	14.9	47.93	54	6.1
26	2480	Upper	61.62	74	12.4	14.9	46.72	54	7.3

Radiated Band-edge in Restricted Bands

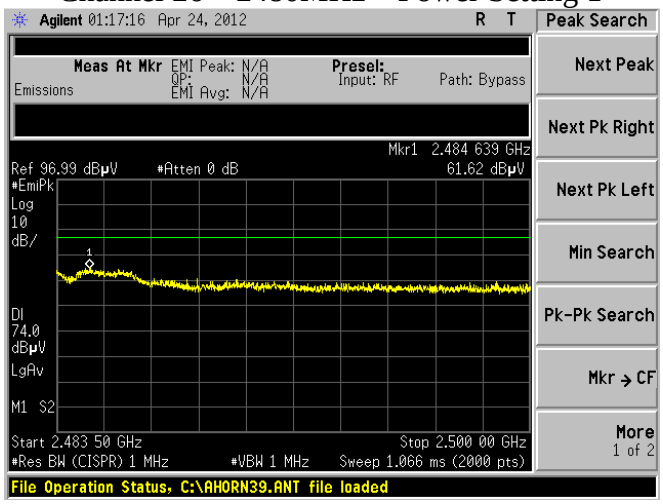
Channel 11 – 2405MHz – Power Setting 4



Channel 25 – 2475MHz – Power Setting 4



Channel 26 – 2480MHz – Power Setting 1

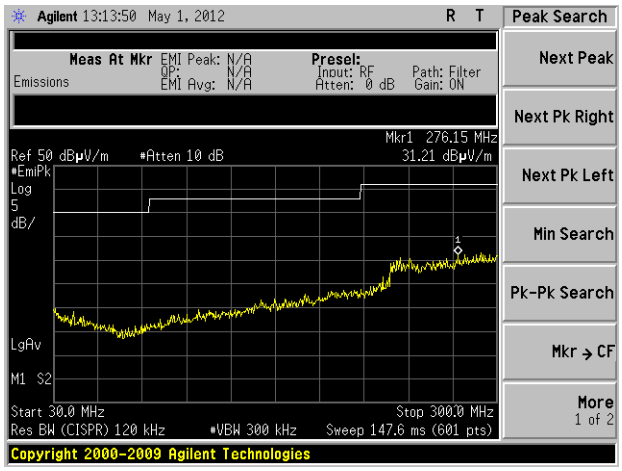


Radiated Emissions 30-1000MHz (15.209)

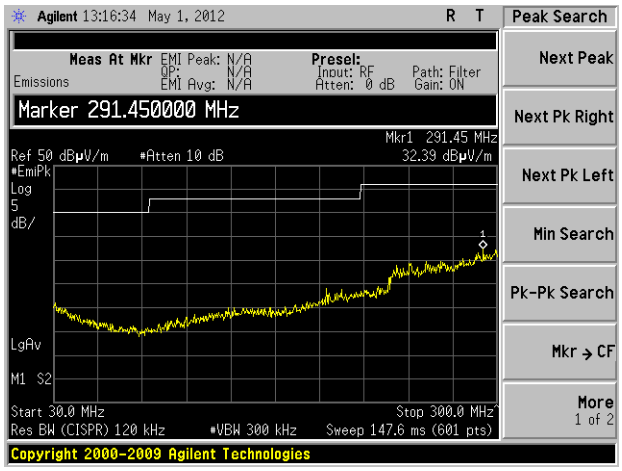
Manufacturer	CEL, Inc.
Date	May 1 & 10, 2012
Operator	Adam A
Temperature	20 - 25º C
Humidity	30 – 60%
Test Voltage	3.3 VDC from bench supply
Test Location	LS Research, LLC - FCC Listed 3 meter Semi-Anechoic Chamber
Test Distance	3 meter
EUT Placement	80 cm height non-conductive table
Measurements	Final
Detectors	Quasi-Peak
Additional Notes	1) Peak Emission Compared to quasi-peak limit 2) Tested in transmit continuous modulated signal low, mid, and high channel and 3 orthogonal orientations with straight and bent dipole. 3) No change of frequencies of emissions between channels 4) Data table contains emissions from transmit mode that fell into restricted bands. 5) Plots show locations of restricted bands and emissions in and out of restricted bands. Only emissions in restricted bands are compared to restricted band limits. All other emissions meet the requirements of FCC Part 15.247 (d).

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation	EUT Antenna	EUT Channel
408.0	1.00	280	40.68	46.0	5.3	Horizontal	Flat	Straight	Low
960.0	1.00	210	45.31	54.0	8.7	Horizontal	Flat	Straight	Low
408.0	1.13	177	34.61	46.0	11.4	Vertical	Flat	Straight	Low
960.0	1.60	0	38.89	54.0	15.1	Vertical	Flat	Straight	Low
408.0	1.00	101	41.81	46.0	4.2	Horizontal	Flat	Bent	Low
960.0	1.00	195	45.78	54.0	8.2	Horizontal	Flat	Bent	Low
960.0	1.11	233	42.77	54.0	11.2	Vertical	Flat	Bent	Low
408.0	1.16	154	36.89	46.0	9.1	Vertical	Flat	Bent	Low
408.0	1.00	213	41.58	46.0	4.4	Horizontal	Side	Straight	Low
960.0	1.00	207	49.02	54.0	5.0	Horizontal	Side	Straight	Low
408.0	1.16	200	42.31	46.0	3.7	Vertical	Side	Straight	Low
960.0	1.00	91	43.99	54.0	10.0	Vertical	Side	Straight	Low
408.0	1.00	190	40.66	46.0	5.3	Horizontal	Side	Bent	Low
960.0	1.00	281	49.55	54.0	4.5	Horizontal	Side	Bent	Low
960.0	1.27	96	45.81	54.0	8.2	Vertical	Side	Bent	Low
408.0	1.23	190	42.74	46.0	3.3	Vertical	Side	Bent	Low
408.0	1.00	258	42.02	46.0	4.0	Horizontal	Vertical	Straight	Low
960.0	1.00	10	45.59	54.0	8.4	Horizontal	Vertical	Straight	Low
408.0	1.16	69	44.78	46.0	1.2	Vertical	Vertical	Straight	Low
960.0	1.00	261	47.81	54.0	6.2	Vertical	Vertical	Straight	Low
408.0	1.00	55	41.59	46.0	4.4	Horizontal	Vertical	Bent	Low
960.0	1.00	226	46.46	54.0	7.5	Horizontal	Vertical	Bent	Low
960.0	1.00	0	46.3	54.0	7.7	Vertical	Vertical	Bent	Low
408.0	1.10	68	44.56	46.0	1.4	Vertical	Vertical	Bent	Low

30-300MHz Vertical

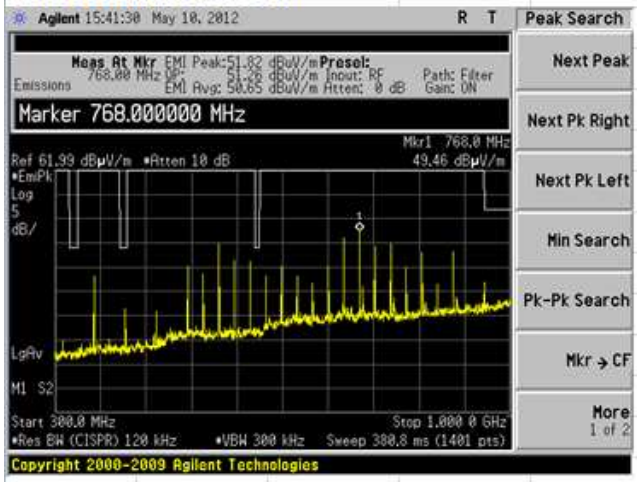


30-300MHz Horizontal



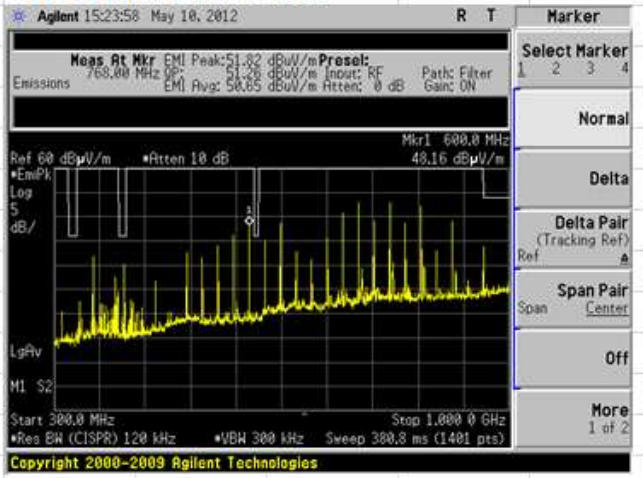
Low Channel (2405MHz), Flat, Straight Dipole

300-1000MHz Vertical



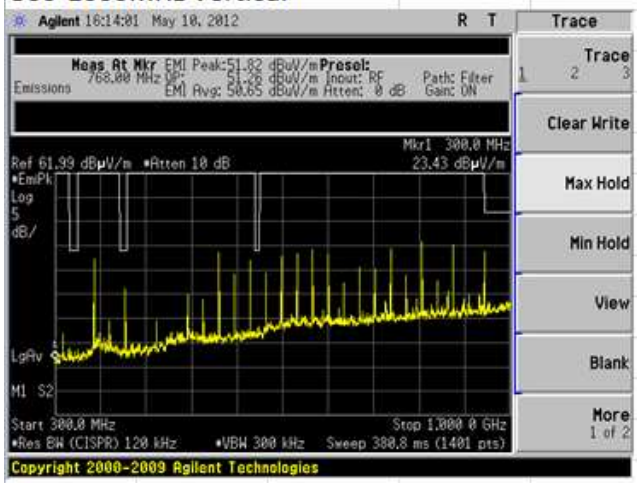
Low Channel (2405MHz), Flat, Straight Dipole

300-1000MHz Horizontal



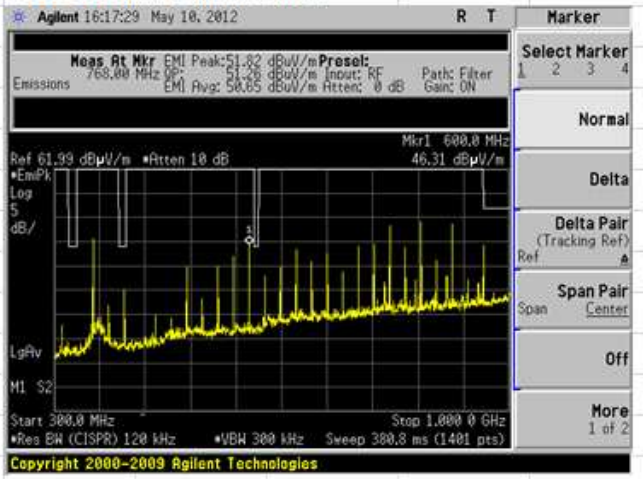
Mid Channel (2440MHz), Flat, Bent Dipole

300-1000MHz Vertical



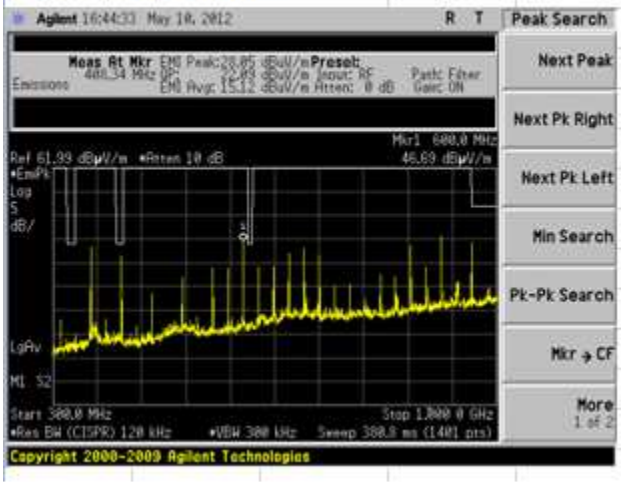
Mid Channel (2440MHz), Flat, Bent Dipole

300-1000MHz Horizontal



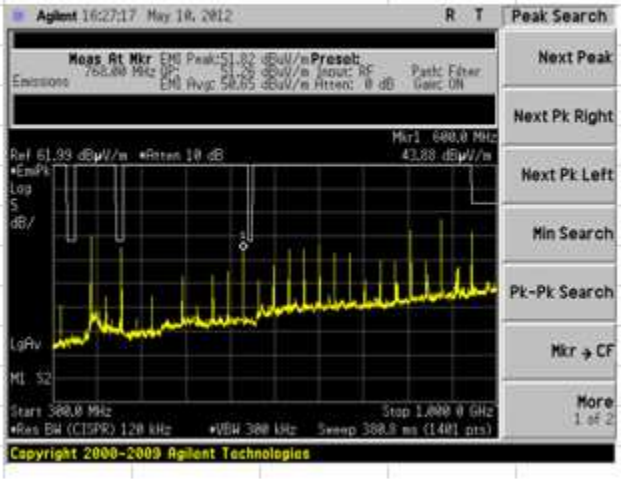
High Channel (2440MHz), Flat, Bent Dipole

300-1000MHz Vertical



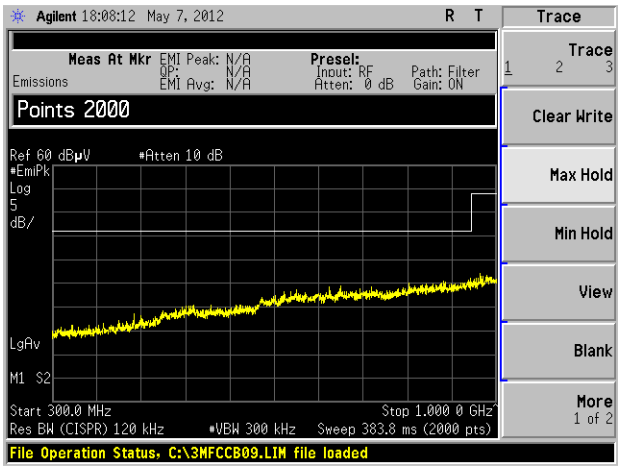
High Channel (2440MHz), Flat, Bent Dipole

300-1000MHz Horizontal

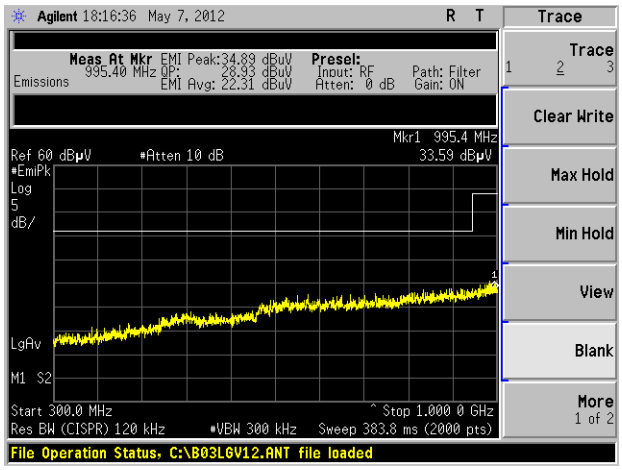


Receive Mode (15.109)
No Emissions Found

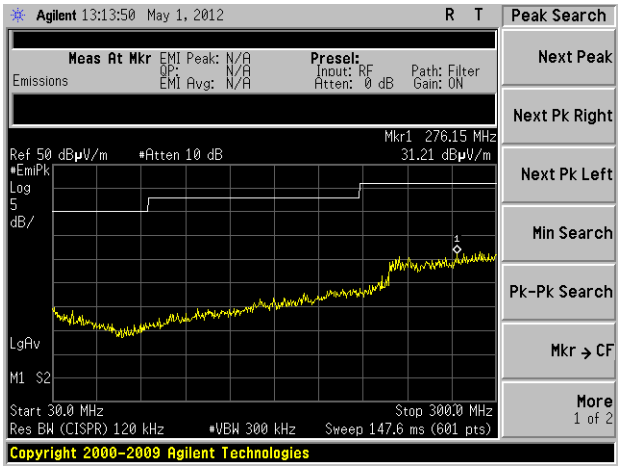
Horizontal



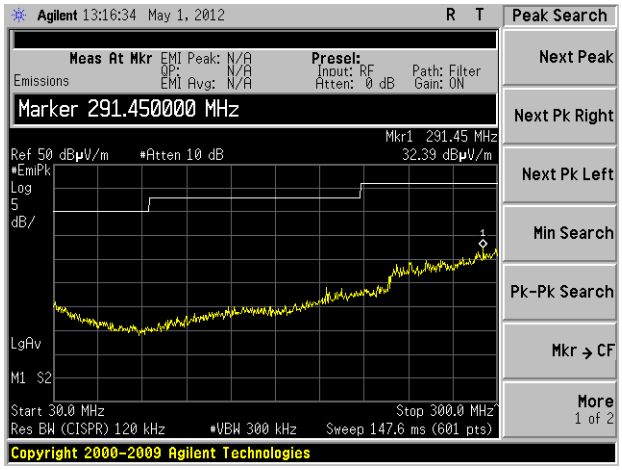
Vertical



30-300MHz Vertical



30-300MHz Horizontal



1-18GHz Receive mode, Vertical and Horizontal
EUT flat, side, vertical with bent and straight dipole, low, mid, high channel
No emissions found
Tested at 1 meter; Peak meets average limit

Appendix D - Uncertainty Summary

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

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

Measurement Type	Particular Configuration	Uncertainty Values
Radiated Emissions	3 – Meter chamber, Biconical Antenna	4.82 dB
Radiated Emissions	3-Meter Chamber, Log Periodic Antenna	4.88 dB
Radiated Emissions	3-Meter Chamber, Horn Antenna	4.85 dB
Radiated Emissions	10-Meter OATS, Biconical Antenna	4.32 dB
Radiated Emissions	10-Meter OATS, Log Periodic Antenna	3.63 dB
Absolute Conducted Emissions	Agilent PSA/ESA Series	1.38 dB
AC Line Conducted Emissions	Shielded Room/EMCO LISN	3.20 dB
Radiated Immunity	3 Volts/Meter in 3-Meter Chamber	2.05 Volts/Meter
Conducted Immunity	3 Volts level	2.33 V
EFT Burst, Surge, VDI	230 VAC	54.4 V
ESD Immunity	Discharge at 15kV	3200 V
Temperature/Humidity	Thermo-hygrometer	0.64°/ 2.88 %RH

Appendix E - References

Publication	Year	Title
FCC CFR Parts 0-15	2011	Code of Federal Regulations – Telecommunications
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.
RSS-210 Annex 8	2010	Low-power License-exempt Radio communication Devices (All Frequency Bands): Category I Equipment
RSS-GEN Issue 3	2010	General Requirements and Information for the Certification of Radio Apparatus
ANSI C63.10	2009	American National Standard for Testing Unlicensed Wireless Devices
FCC KDB 558074 D01 DTS Meas Guidance v01	1-18-2012	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

Appendix F – RF Exposure Exemption

The following exemption calculations are based on a RF Conducted measurement of 10.86 dBm.
Output power dBm (conducted): 10.86 dBm = 12.2 mW

The output power is much lower than the 60/f (GHz) mW threshold as defined in FCC KDB 447498.
60/2.405 GHz = 24.95mW

The output power is less than 20mW and exempt from evaluation as stated in Industry Canada RSS-102 section 2.5.1.

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:	10.86	(dBm)
Maximum peak output power at antenna input terminal:	12.190	(mW)
Antenna gain(typical):	2	(dBi)
Maximum antenna gain:	1.585	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2405	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)
Power density at prediction frequency:	0.003844	(mW/cm^2)
Maximum allowable antenna gain:	26.2	(dBi)
Margin of Compliance at 20 cm =	24.2	dB

END OF REPORT

Date	Version	Comments	Person
5-16-12	V0	Initial Draft Release	Adam A
5-17-12	V1	Minor clarifications and grammar fixes after review	Adam A
5-30-12	V2	Change of model number	Adam A