LS RESEARCH, LLC
Wireless Product Development

W66 N220 Commerce Court ● Cedarburg, WI 53012 USA ● Phone: 262.375.4400 ● Fax: 262.375.4248 ● www.lsr.com

ENGINEERING TEST REPORT # 313136 A
LSR Job #: C-1724

Compliance Testing of:
TiWi-uB1

Test Date(s):
August 6,8,9,12,15 2013

Prepared For:
LS Research, LLC.
Attn: Josh Bablitch
W66 N220 Commerce Court
Cedarburg, WI 53012

This Test Report is issued under the Authority of: Adam Alger, EMC Engineer

Signature: Date: 8-20-13

Test Report Reviewed by:
Ryan M. Urness, Quality and Operations Manager
Signature: Date: 8-19-13

Report by:
Adam Alger, EMC Engineer

Signature: Date: 8-19-13

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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 August 2013 the EUT was tested and MEETS the following requirements:

FCC and IC Paragraph	Test Requirements	Compliance (Yes/No)
FCC:15.247 (a)(2) IC: RSS 210 A8.2 (a)	6 dB Bandwidth of a Digital Modulation System	Yes
FCC : 15.247(b) & 1.1310 IC : RSS 210 A8.4	Maximum Output Power	Yes
FCC:15.247 (e) IC: RSS 210 A8.2 (b)	Power Spectral Density of a Digital Modulation System	Yes
FCC :15.247(d) IC : RSS 210 A8.5	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC : 15.247(d), 15.209, 15.205 IC: RSS 210 A8.5, section 2.2	Transmitter Radiated Emissions	Yes
FCC : 2.1055 (d)	Frequency Stability	Yes
FCC : 15.207 IC : RSS GEN sect. 7.2.4	Power Line Conducted Emissions Measurements	Yes

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:	LS Research, LLC.
Address:	W66 N220 Commerce Ct. Cedarburg, WI 53012
Contact Person:	Josh Bablitch

3.1 Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	TiWi-uB1
Model Number:	TiWi-uB1
Serial Number:	Trace Antenna Unit (1CBA8C1B8B35); U.FL Unit (1CBA8C1B8C65)
FCC ID	TFB-BT2
IC Number	5969A-BT2

3.2 Product Description

The TiWi-uB1 Module is a radio module that implements a Bluetooth Low Energy (BLE) transceiver.
This module uses a hybrid trace antenna and an off board U.FL option for +2 dBi peak gain Dipole antenna.

3.3 Modifications Incorporated In the EUT for Compliance Purposes

None noted at time of test

3.4 Deviations & Exclusions from Test Specifications

None noted at time of test

3.5 Additional Information

The channels used for test were 2402 MHz (low), 2440 MHz (mid), and 2480 MHz (high). The radio is programmed via a Chipcon AS (SOC_BB 1.1) board with USB cable connected to computer running TiWi Bluetooth Eval Tool Version 4.0.0.0. Once programmed the module is removed from the programming board and powered with a DC bench supply.

4.0 Conditions of Test

Environmental:

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

Mains Voltage: 120VAC 60Hz
DC Supply to module: 3.3 VDC (nominal)

5.0 Test Equipment

All test equipment is calibrated by a calibration laboratory accredited 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.

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

6.0 Conformance Summary

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.

<u>If some emissions are seen to be within 3 dB of their respective limits</u>:
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 : 6-Aug-2013 Type Test : RF Conducted Job # : C-1724

Prepared By: Adam Customer : LSR Quote #: 313136

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960143	Phaseflex	Gore	EKD01D01048.0	5546519	6/14/2013	6/14/2015	Active Calibration
2	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/28/2013	5/28/2014	Active Calibration

Project Engineer: Quality Assurance:

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 6-Aug-2013 Type Test : AC Mains Emissions Job # : C-1724

Prepared By: Adam A Customer : LSR Quote #: 313136

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960084	LISN - 15A	COM-POWER	LI-215A	191920	2/6/2013	2/6/2014	Active Calibration
2	AA 960031	Transient Limiter	HP	11947A	3107A01708	9/2/2012	9/2/2013	Active Calibration
3	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	2/11/2013	2/11/2014	Active Calibration
4	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	2/11/2013	2/11/2014	Active Calibration

Project Engineer: Quality Assurance:

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 6-Aug-2013 Type Test : Radiated Emissions Job # : C-1724

Prepared By: Adam A Customer : LSR Quote #: 313136

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	2/11/2013	2/11/2014	Active Calibration
2	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	2/11/2013	2/11/2014	Active Calibration
3	AA 960158	Double Ridge Horn Antenna	EMCO	3117	109300	3/28/2013	3/28/2014	Active Calibration
4	EE 960159	0.8 - 21GHz LNA	Mini-Circuits	ZVA-213X-S+	740411007	3/28/2013	3/28/2014	Active Calibration
5	AA 960153	2.4GHz High Pass Filter	KWM	HPF-L-14186	7272-04	4/1/2013	4/1/2014	Active Calibration
6	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	1/29/2013	1/29/2014	Active Calibration
7	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/28/2013	5/28/2014	Active Calibration
8	AA 960004	Log Periodic Antenna	EMCO	93146	9512-4276	9/17/2012	9/17/2013	Active Calibration
9	AA 960150	Bicon Antenna	ETS	3110B	0003-3346	12/12/2012	12/12/2013	Active Calibration
10	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	2/1/2013	2/1/2014	Active Calibration
11	EE 960146	Std. Gain Horn Ant. w/preamp	Adv. Micro / EMC	WLA622-4 / 3160-09	123001	9/26/2012	9/26/2013	Active Calibration

Project Engineer: Quality Assurance:

Appendix B – Test Data
B.1 – RF Conducted Emissions

Manufacturer	LS Research, LLC
Test Location	LS Research, LLC
Rule Part	FCC Part 15.247 / RSS-210 Annex 8
General Measurement Procedure	FCC KDB 558074 D01 DTS Meas Guidance v03r01 ANSI C63.10-2009 Section 6.7
General Description of Measurement	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.

B.1.1 – RF Conducted – Fundamental Bandwidth

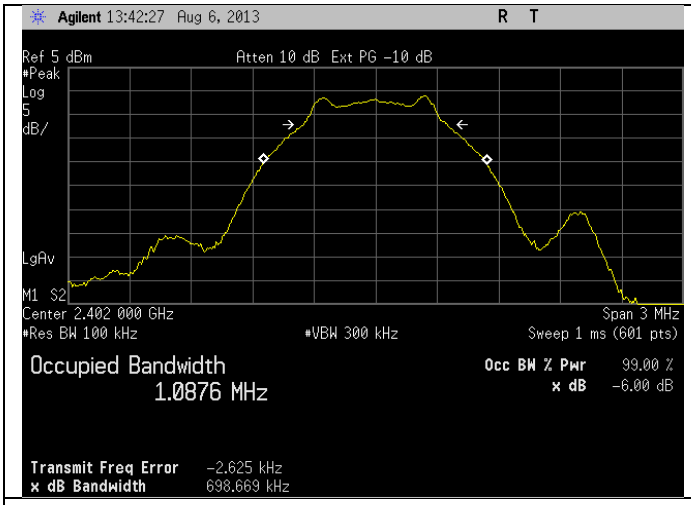
Manufacturer	LS Research, LLC
Date	8-6-13
Operator	Adam A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Rule Part	FCC Part 15.247 / RSS-210 A8
Specific Measurement Procedure	FCC KDB 558074 Section 8.0 DTS bandwidth ANSI C63.10-2009 Section 6.9 RSS-GEN Section 4.6
Additional Description of Measurement	Peak detector used
Additional Notes	Continuous transmit modulated used for this test.

Table

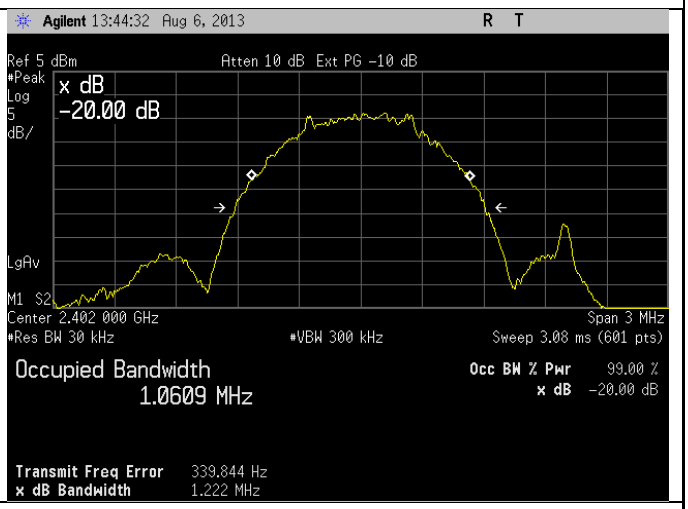
Frequency (MHz)	6 dB DTS BW (kHz)	99 % BW (MHz)	20 dB BW (MHz)
2402	698.6	1.06	1.22
2440	697.6	1.06	1.21
2480	709.5	1.06	1.21

Plots

Low Channel – 2402 MHz

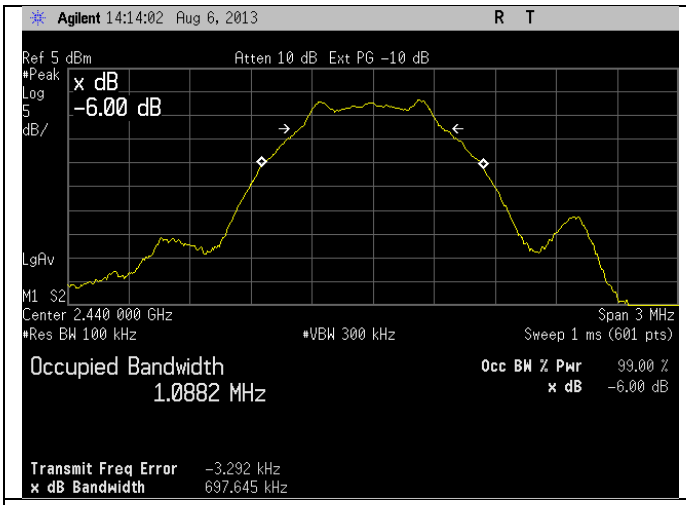


6 dB DTS BW

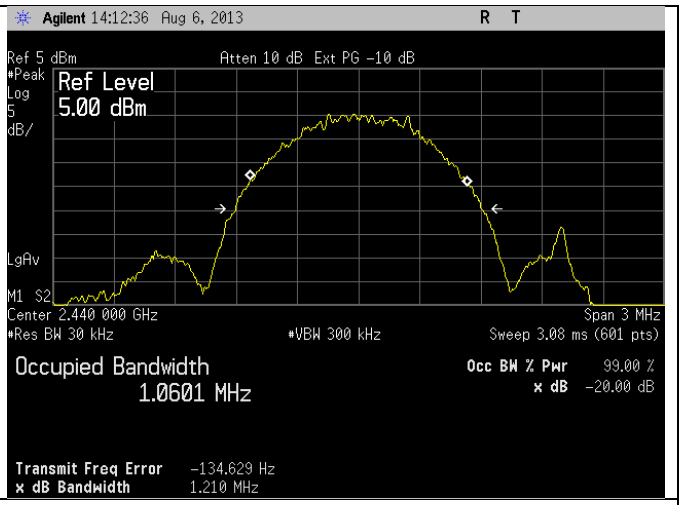


99% BW

Mid Channel – 2440 MHz

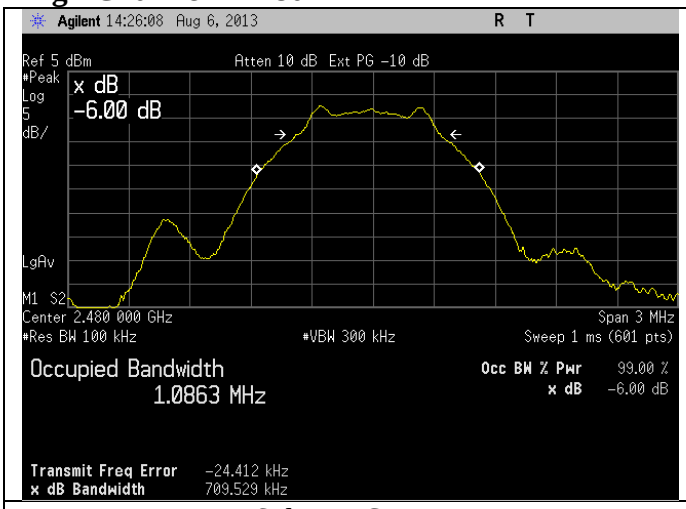


6 dB DTS BW

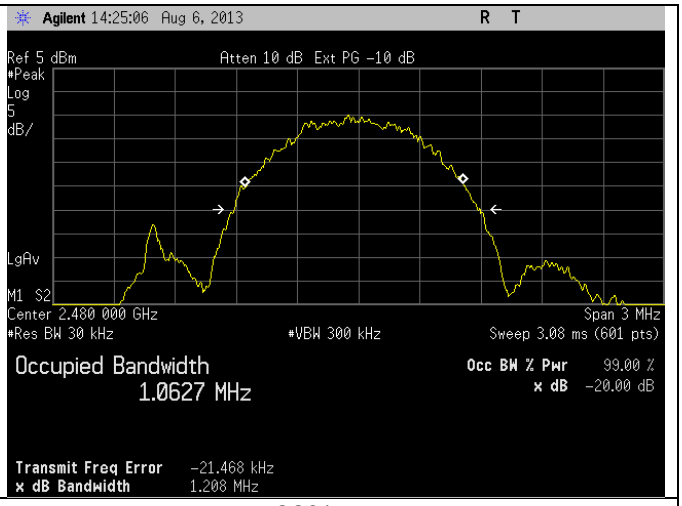


99% BW

High Channel – 2480 MHz



6 dB DTS BW



99% BW

B.1.2 – RF Conducted – Fundamental Power and Spectral Density

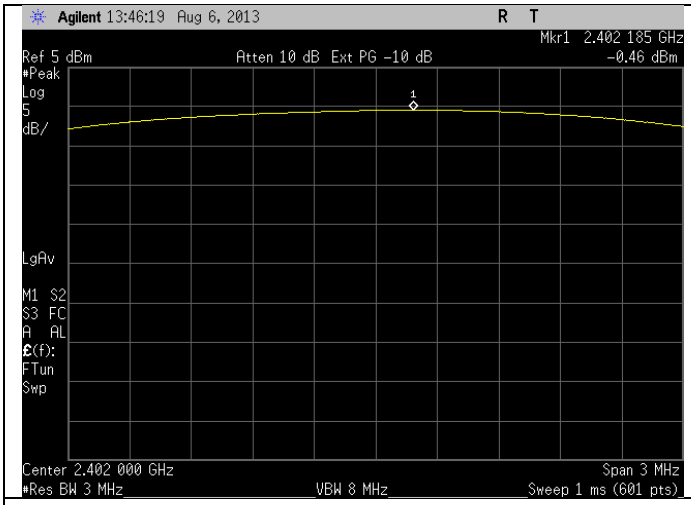
Manufacturer	LS Research, LLC
Date	8-6-13
Operator	Adam A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Rule Part	15.247 / RSS-210 A8
Specific Measurement Procedure	FCC KDB 558074 Section 9.1.1 – Maximum peak conducted output power FCC KDB 558074 Section 10.2 – Peak PSD
Additional Description of Measurement	3 kHz resolution bandwidth used for Peak Power Spectral Density measurement
Additional Notes	Sample Calculation: Margin (dB) = Limit – Measured level Continuous transmit modulated used for this test.

Table

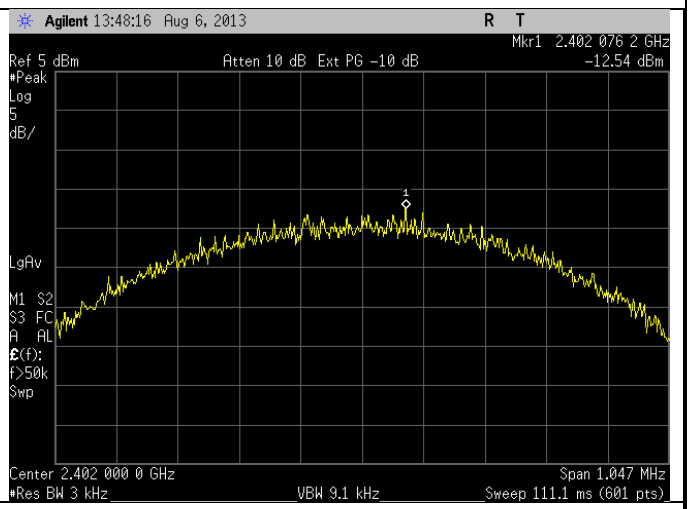
Frequency (MHz)	Power (dBm)	PKPSD (dBm)	Limit (dBm)	Margin (dB)
2402	-0.46	-12.54	8	20.54
2440	-1.07	-12.94	8	20.94
2480	-1.83	-14.00	8	22.00

Plots

Low Channel – 2402 MHz

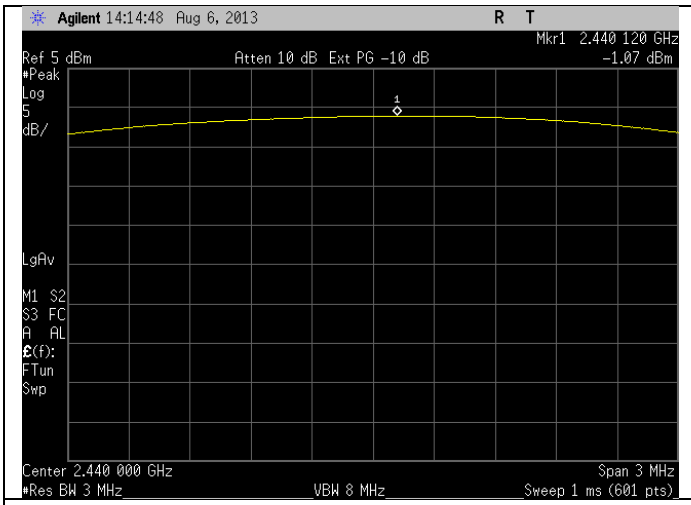


Peak Output Power

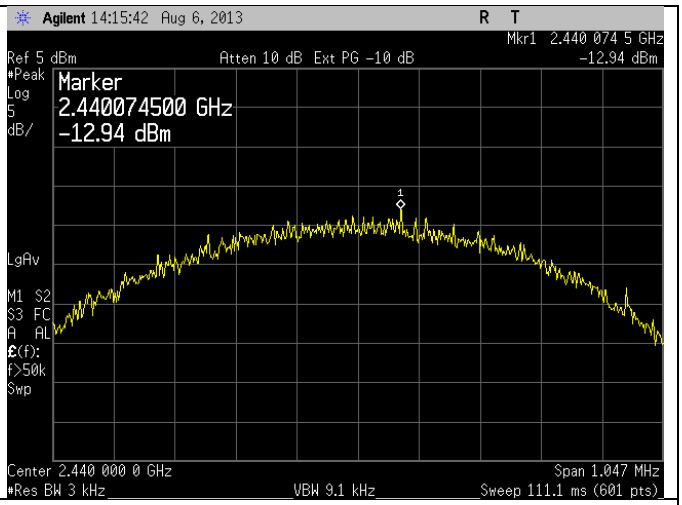


Peak Power Spectral Density

Mid Channel – 2440 MHz

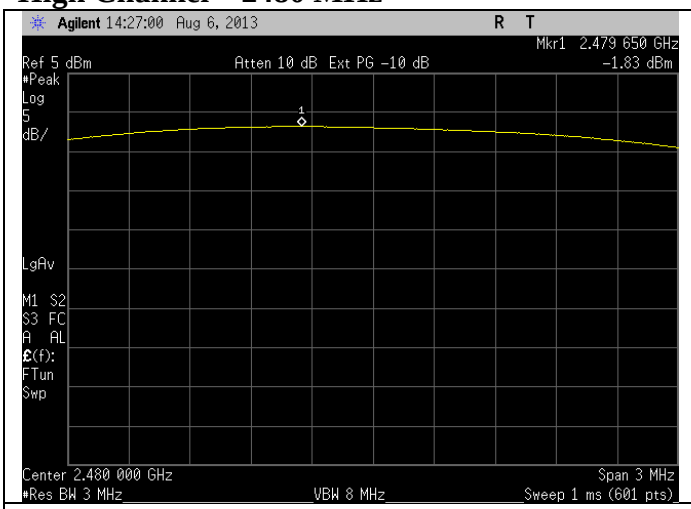


Peak Output Power

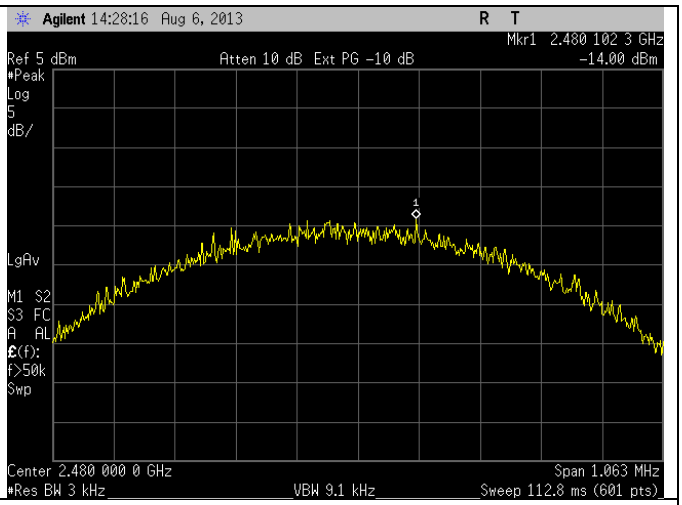


Peak Power Spectral Density

High Channel – 2480 MHz



Peak Output Power



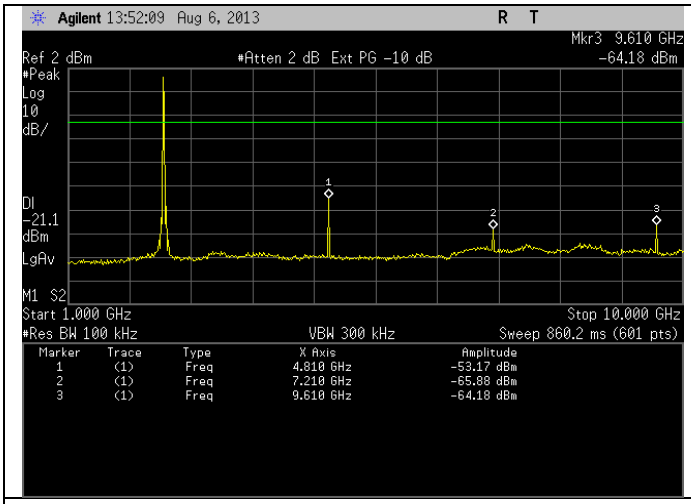
Peak Power Spectral Density

B.1.3 – RF Conducted – Spurious

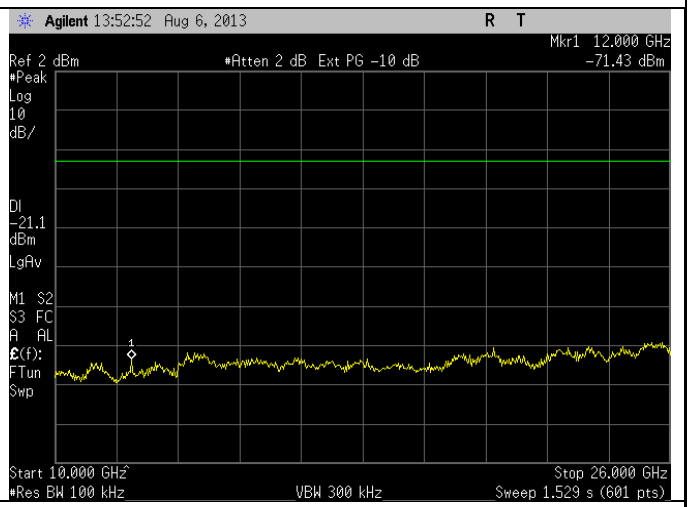
Manufacturer	LS Research, LLC
Date	8-6-13
Operator	Adam A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Rule Part	15.247 / RSS-210 A8
Specific Measurement Procedure	FCC KDB 558074 Section 11.0 – Emissions in non-restricted frequency bands
Additional Description of Measurement	RF Conducted Measurement
Additional Notes	No Emissions found to be within 30 dB of limit Continuous transmit modulated used for this test.

Plots start next page

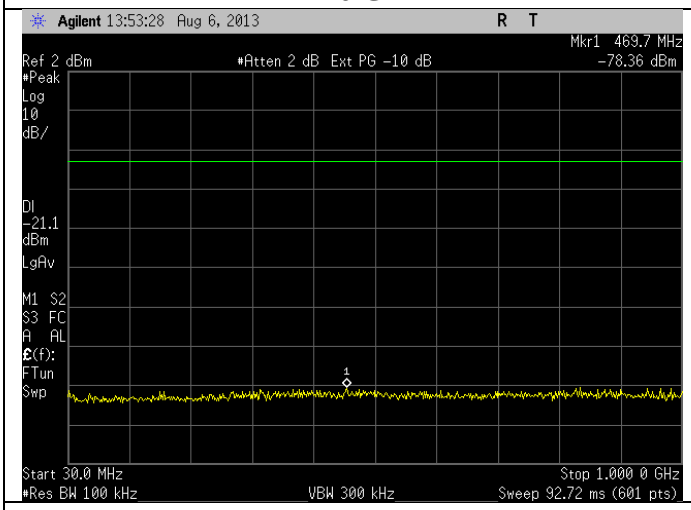
Low Channel – 2402 MHz



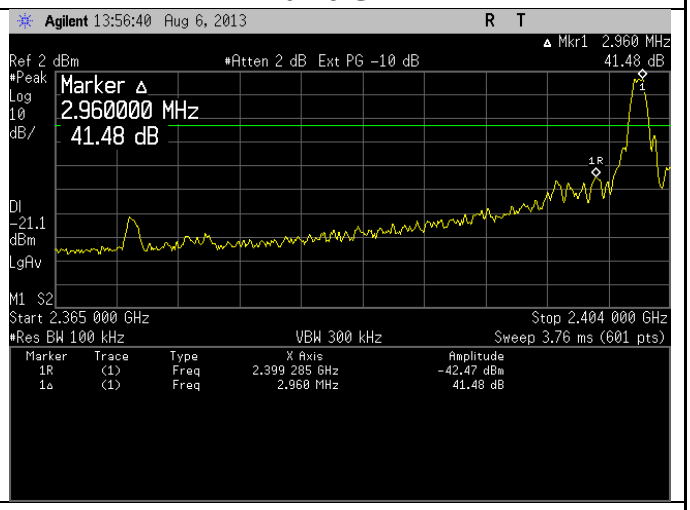
1 - 10 GHz



10-26 GHz

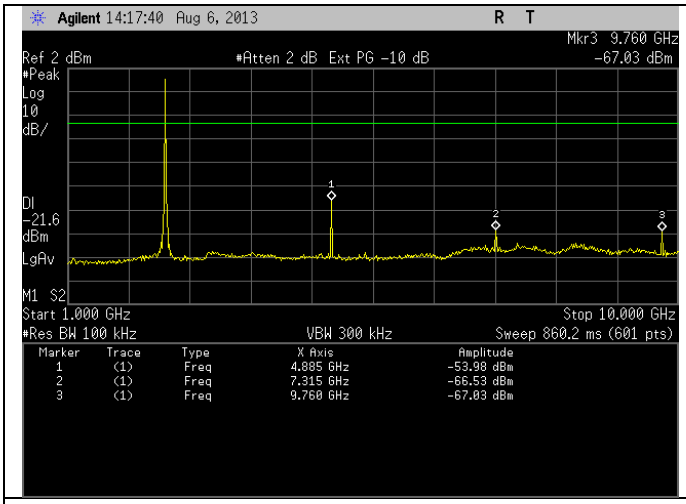


30-1000 MHz

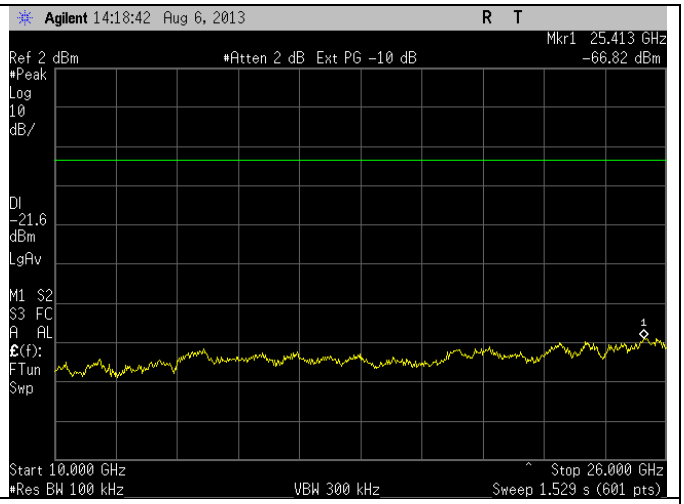


Band-Edge

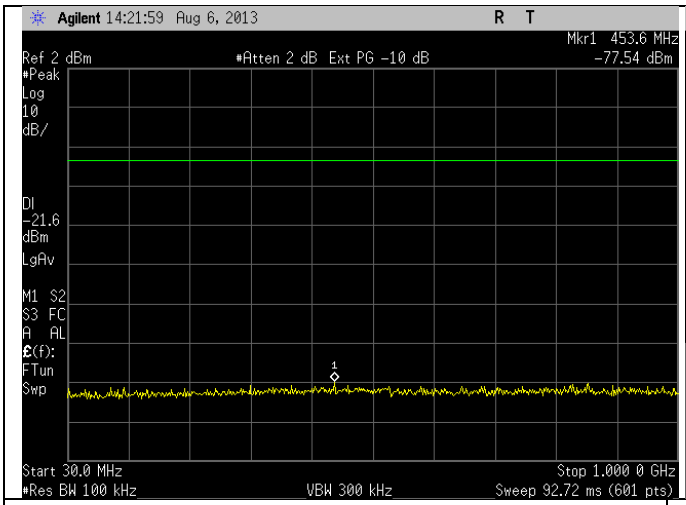
Mid Channel – 2440 MHz



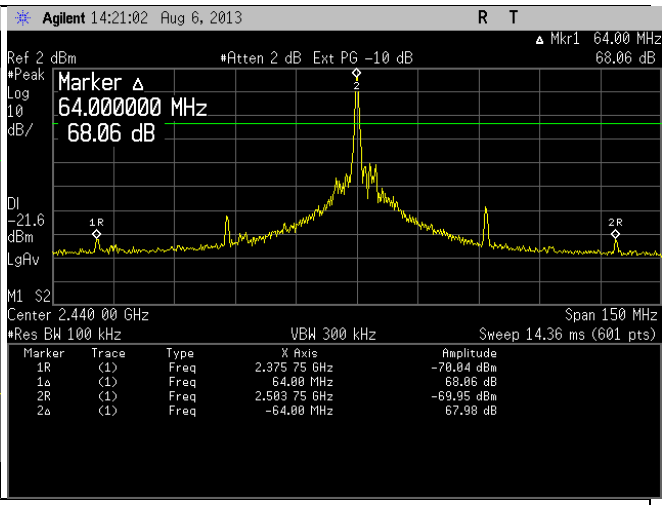
1 – 10 GHz



10-26 GHz

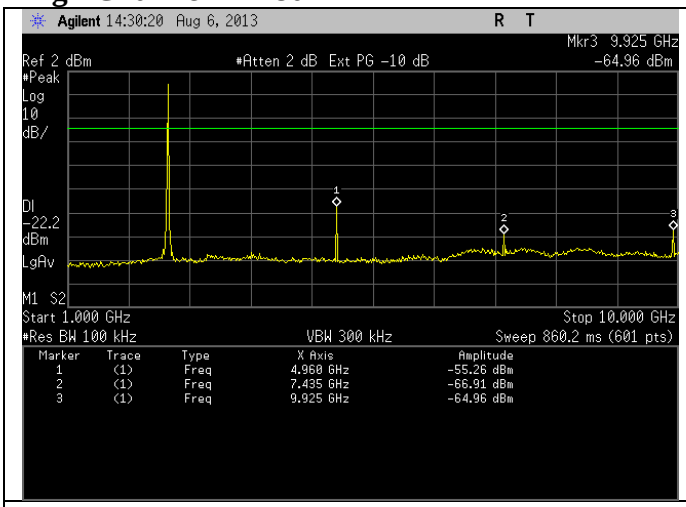


30-1000 MHz

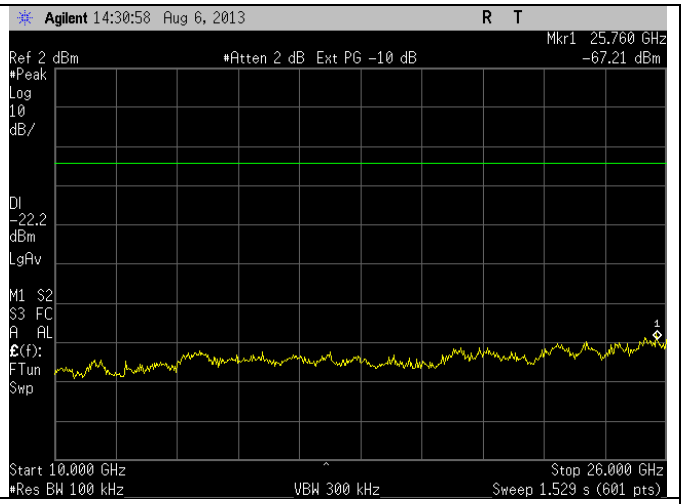


Band-edges

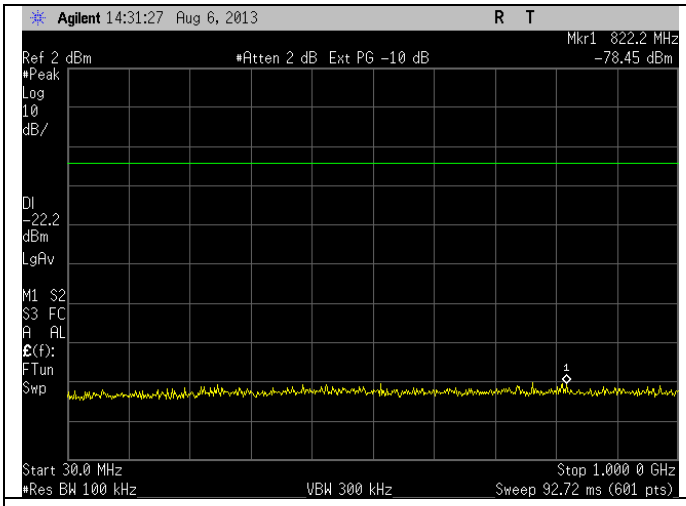
High Channel – 2480 MHz



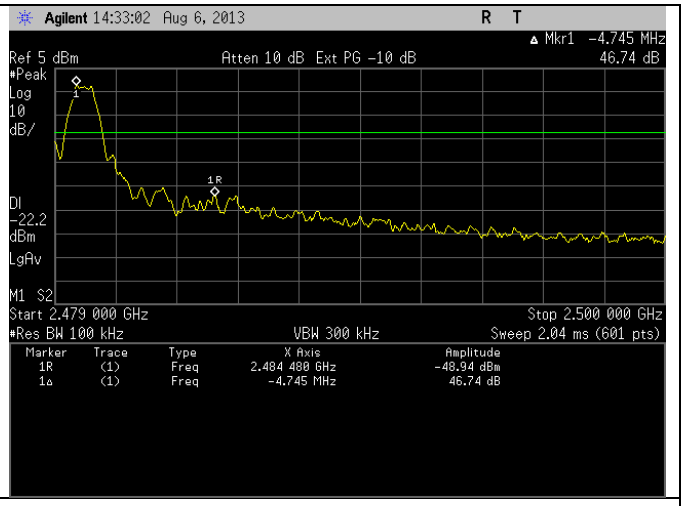
1 – 10 GHz



10 – 26 GHz



30 – 1000 MHz



Band-Edge

B.1.3 – RF Conducted – Emissions in Restricted Bands

Manufacturer	LS Research, LLC
Date	8-6-13 and 8-15-13
Operator	Adam A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Rule Part	15.247 / RSS-210 A8
Specific Measurement Procedure	FCC KDB 558074 Section 12.0 – Emissions in restricted frequency bands Section 12.2 – Antenna-port conducted measurements Section 12.2.4 - Peak power measurement procedure Section 12.2.5.1 - Trace averaging with continuous EUT transmission at full power
Additional Description of Measurement	RF Conducted Measurement
Additional Notes	1. Continuous transmit modulated used for this test. 2. Supplied Dipole gain of +2.0 dBi used as maximum antenna gain.

Sample Calculation:

Margin (dB) = Limit – Emission

E = EIRP -20log D + 104.8

EIRP = conducted output power (dBm) + maximum antenna gain (dBi) + ground reflection factor (dB)

EIRP = -51.73 +2 + 0 = -49.73

E = (-49.73) – 20*log (3) +104.8 = 45.53

Band-edge Restricted Bands

Channel (MHz)	Peak Emission (dBm)	Average Emission (dBm)
2402	-51.73	-61.06
2480	-42.45	-50.44

Channel (MHz)	Peak Emission (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Average Emission (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
2402	45.53	74	28.47	36.20	54	17.80
2480	54.81	74	19.19	46.82	54	7.18

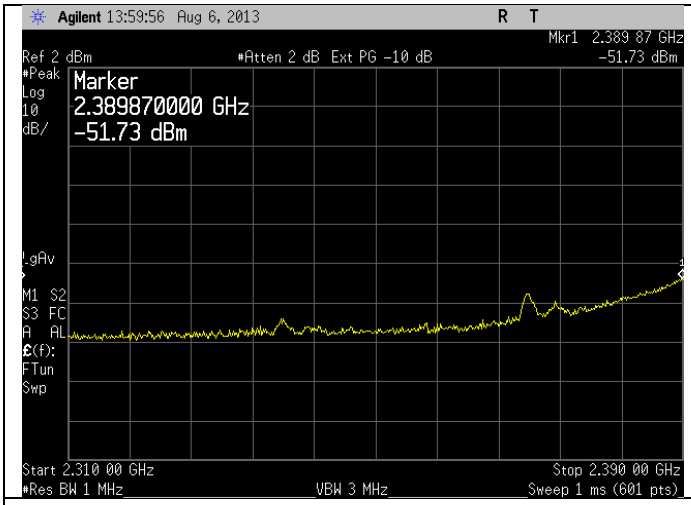
Harmonics in Restricted Bands

Frequency (MHz)	Peak Emission (dBm)	Average Emission (dBm)
4804	-49.51	-52.37
4880	-51.20	-54.05
4960	-52.51	-55.65

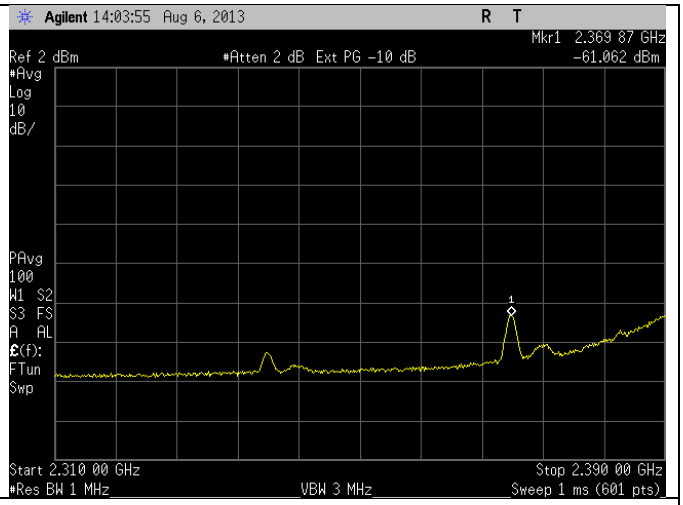
Frequency (MHz)	Peak Emission (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Average Emission (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
4804	47.75	74	26.25	44.89	54	9.11
4880	46.05	74	27.95	43.21	54	10.79
4960	44.75	74	29.25	41.61	54	12.39

RF Conducted Band-edges in Restricted Bands

Low Channel – 2402 MHz

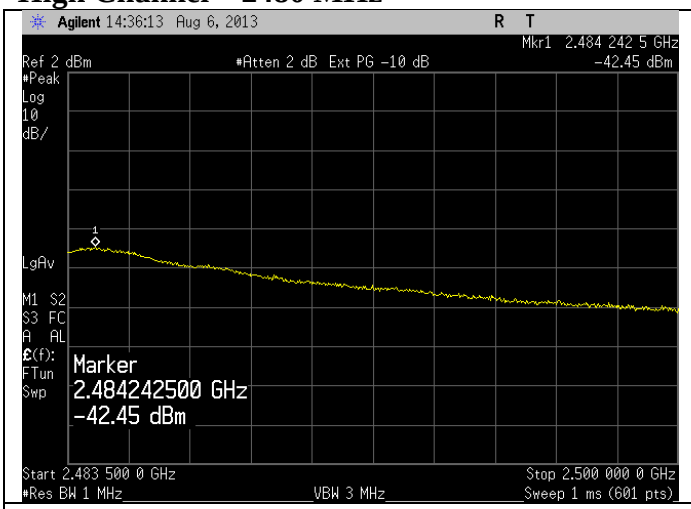


Lower Restricted Band (Peak)

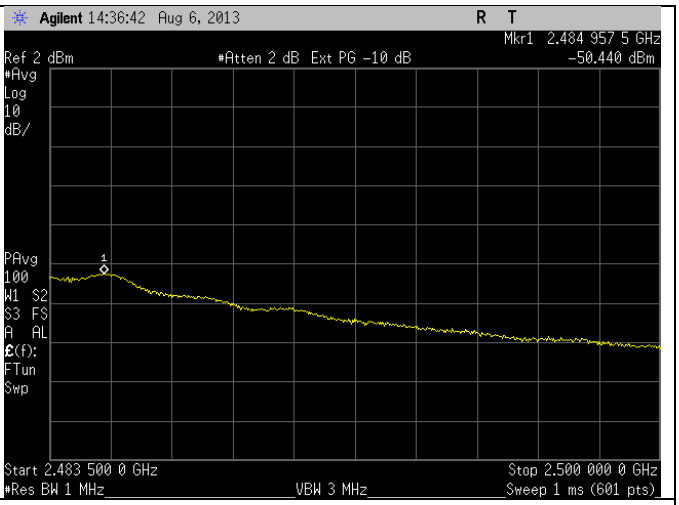


Lower Restricted Band (Average)

High Channel – 2480 MHz



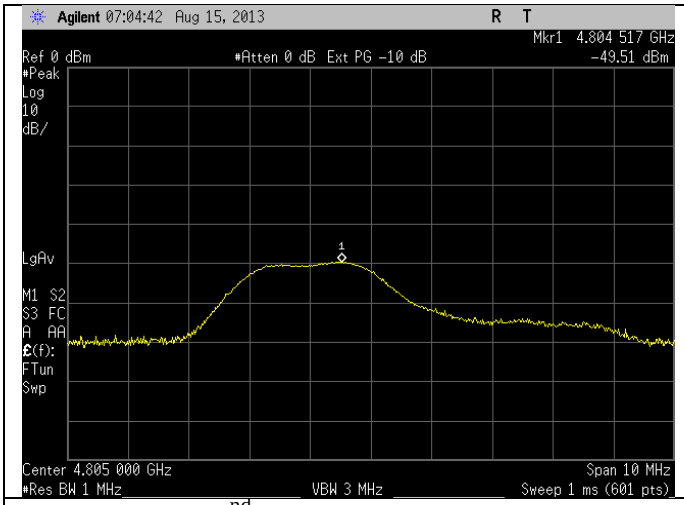
Upper Restricted Band (Peak)



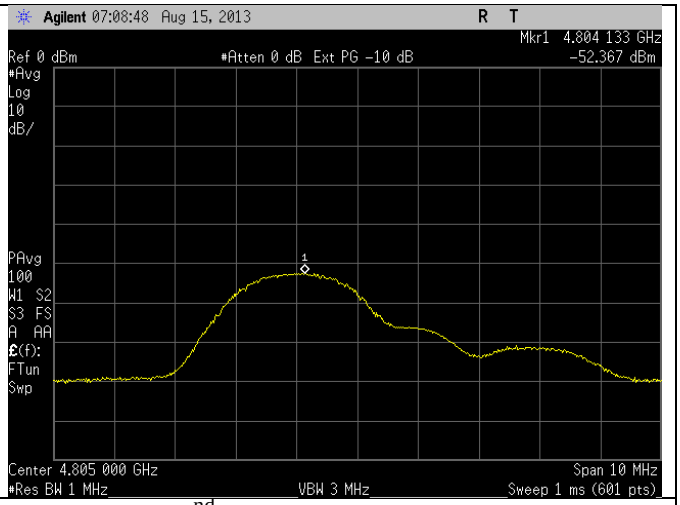
Upper Restricted Band (Average)

RF Conducted Harmonics in Restricted Bands

Low Channel – 2402 MHz

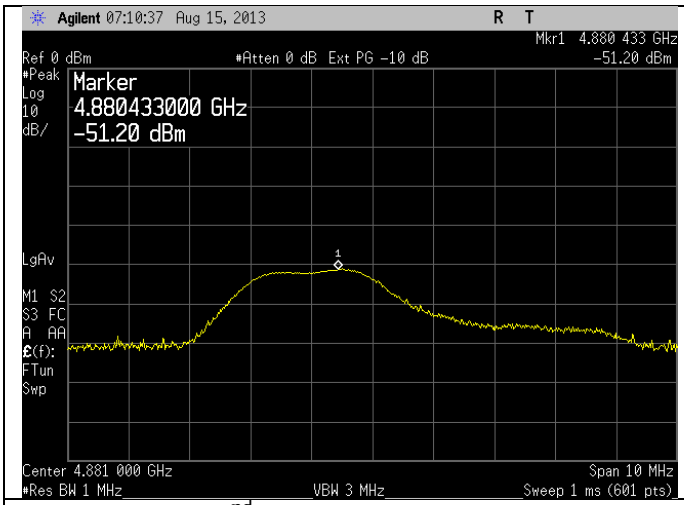


2nd Harmonic (Peak)

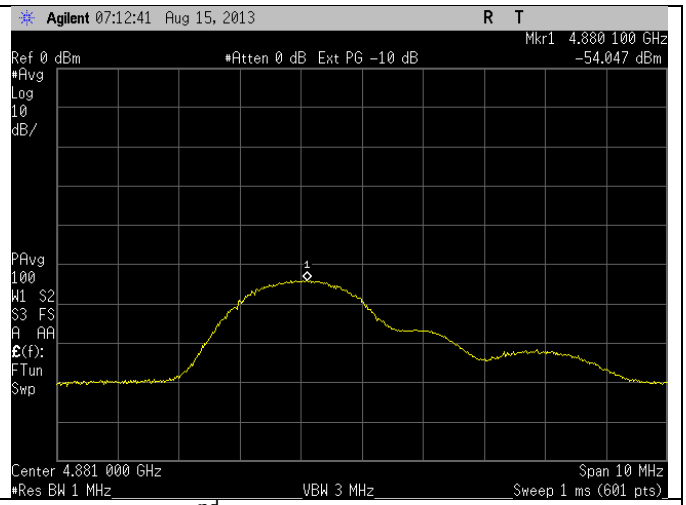


2nd Harmonic (Average)

Mid Channel – 2440 MHz

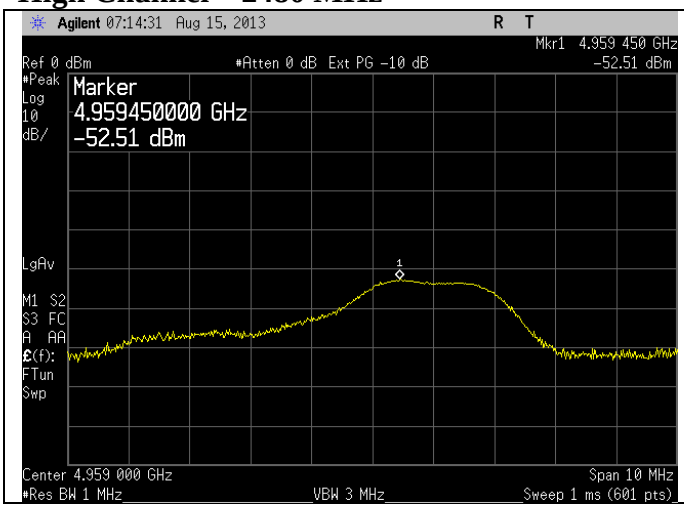


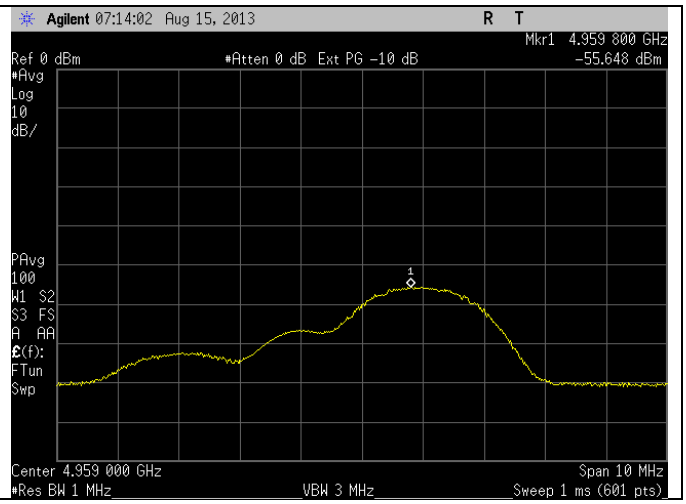
2nd Harmonic (Peak)



2nd Harmonic (Average)

High Channel – 2480 MHz





B.2 – Radiated Emissions

Rule Part(s)	FCC: 15.247 / 15.205 / 15.209 IC: RSS-210 A8 / RSS-210 Section 2.2			
Measurement Procedure	ANSI C63.4 - 2003 ANSI C63.10 – 2009 FCC KDB 558074 D01 DTS Meas Guidance v03r01			
Test Location	LS Research, LLC - FCC Listed 3 meter Semi-Anechoic Chamber			
Test Distance	See data section			
EUT Placement	80 cm height non-conductive table above reference ground plane			
Frequency Range of Measurement	Biconical: 30-300 MHz	Log Periodic Dipole Array: 300-1000 MHz	Double-Ridged Waveguide Horn: 1-18 GHz	Standard Gain Horn: 18-25 GHz
Measurement Detectors	30-1000MHz RBW: 120 kHz VBW: 300 kHz		1 - 25 GHz: RBW : 1MHz VBW: 3 MHz Peak / 10 Hz Average	
Description of Measurement	1) The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are preformed. The data is gathered and reported as the corrected values. 2) The EUT is placed on a non-conductive pedestal centered on a turn-table in the test location with the antenna at the test distance from the EUT 3) Maximum radiated RF emissions are determined by rotation of azimuth and scanning the sense antenna between 1 and 4 meters in height using both horizontal and vertical antenna polarities. Maximized levels are manually noted at degree values of azimuth and at sense antenna height.			
Example Calculations	Reported Measurement data = Raw receiver measurement + Antenna Correction Factor + Cable factor (dB) - amplification factor (when applicable) + Additional factor (when applicable)			

FCC Part 15.209 / IC RSS-210 Section 2.7 Limits:

Frequency (MHz)	3 m Limit (µV/m)	3 m Limit (dBµV/m)	Type
30-88	100	40.0	Quasi-Peak
88-216	150	43.5	Quasi-Peak
216-960	200	46.0	Quasi-Peak
Above 960	500	54.0	Average (>1 GHz)

B.2.1 – Radiated Band-Edge Restricted Bands

Manufacturer	LS Research, LLC
Date	8-9-13 and 8-12-13
Operator	Adam A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Rule Part	15.247/ 15.205 / 15.209
Measurement Procedure	ANSI C63.4 - 2003 ANSI C63.10 - 2009 FCC KDB 558074 12.2.7 Radiated Spurious emission test
Test Distance	3 meter (1-4 GHz)
EUT Placement	80 cm height non-conductive table centered on turn-table
Detectors	Peak; RBW 1MHz VBW 3 MHz (10Hz VBW for average measurements)
Additional Notes	1) Tested in the worst case of continuous transmit modulated mode with EUT in three orthogonal orientations at maximum power. 2) EUT maximized in azimuth and antenna height with maximum results reported. 3) Tested two units; Trace antenna unit and U.FL unit with matched terminated antenna per FCC KDB 558074 Section 12.2.7

Example Calculation:

FCC 15.209 Peak Limit @ 3 meter (dBµV/m) – Peak Reading (dBµV/m) = Peak Margin

FCC 15.209 Average Limit @ 3 meter (dBµV/m) –Average Reading (dBµV/m) = Average Margin

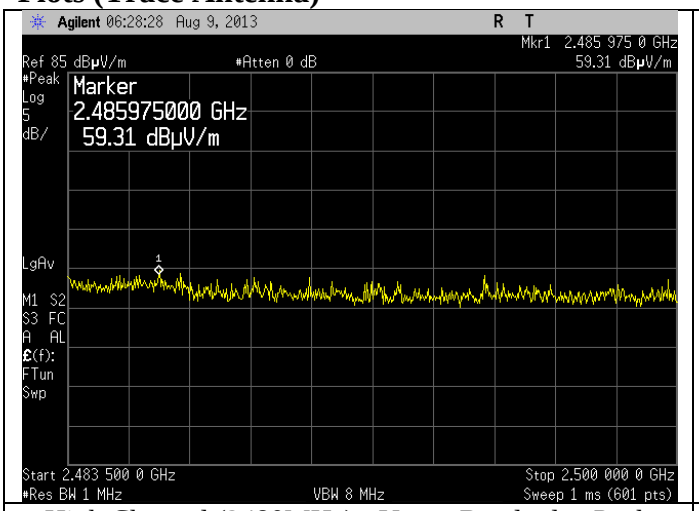
Data Table (Trace Antenna)

Channel (MHz)	Peak Emission (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Average Emission (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
2402	57.73	74	16.27	44.42	54	9.58
2480	59.31	74	14.69	47.43	54	6.57

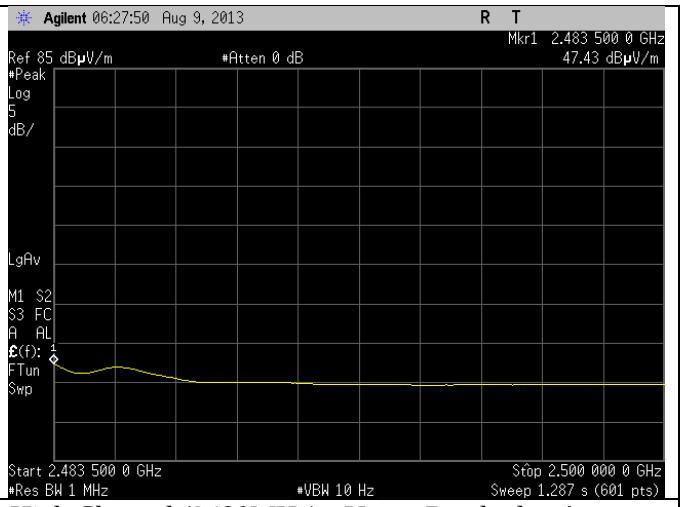
Data Table (Terminated Antenna)

Channel (MHz)	Peak Emission (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Average Emission (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
2402	45.95	74	28.05	33.22	54	20.78
2480	46.88	74	27.12	33.97	54	20.03

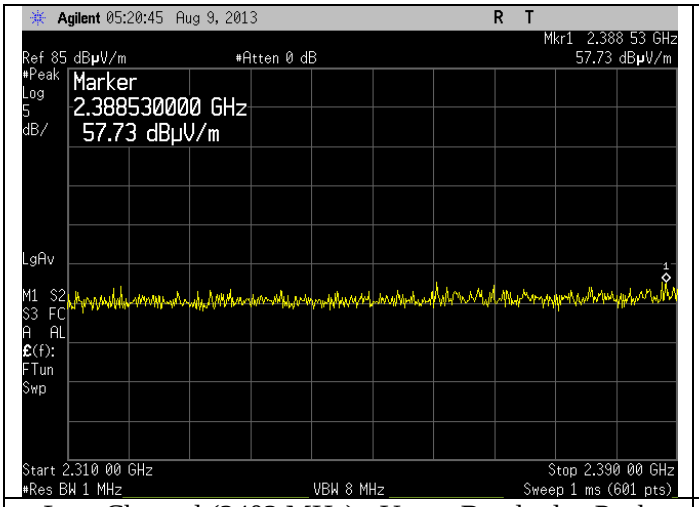
Plots (Trace Antenna)



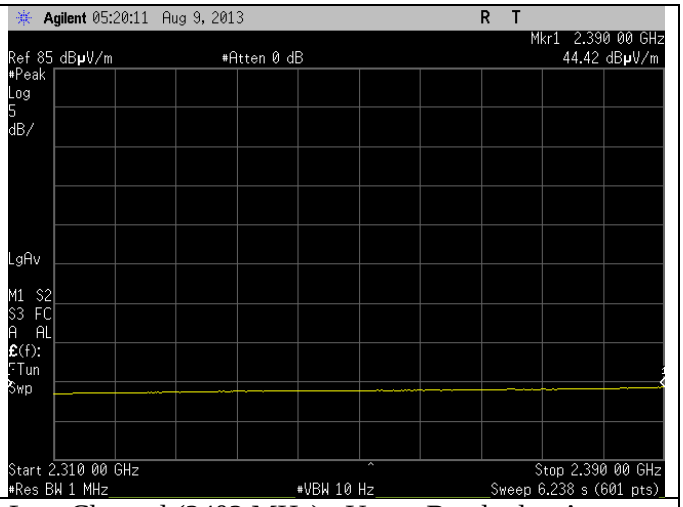
High Channel (2480MHz) - Upper Band-edge Peak



High Channel (2480MHz) - Upper Band-edge Average

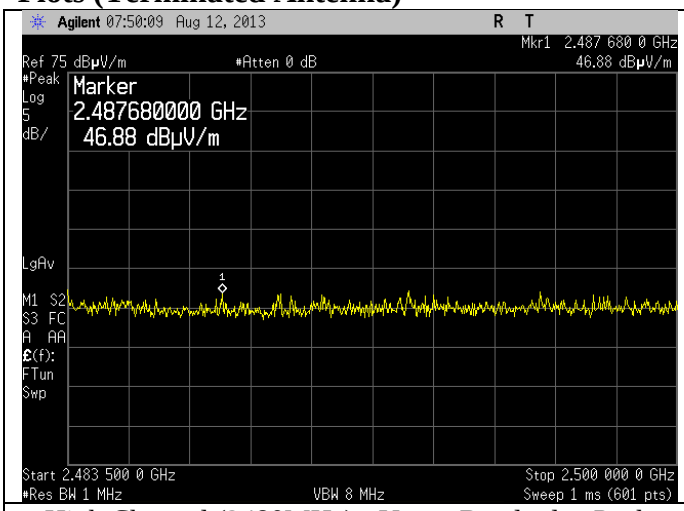


Low Channel (2402 MHz) - Upper Band-edge Peak

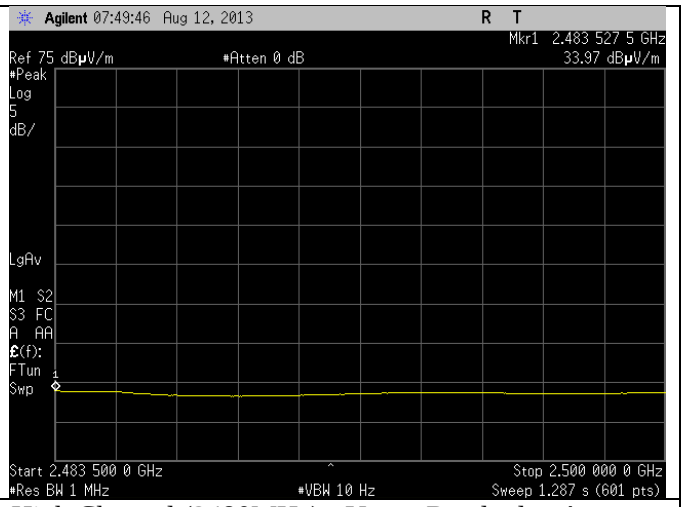


Low Channel (2402 MHz) - Upper Band-edge Average

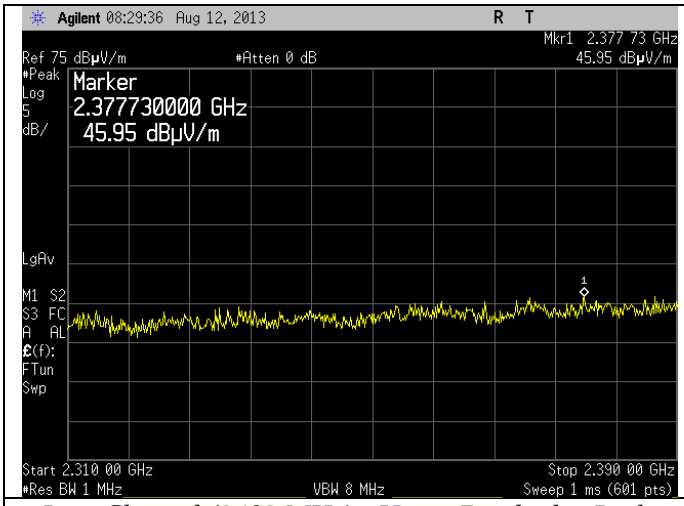
Plots (Terminated Antenna)



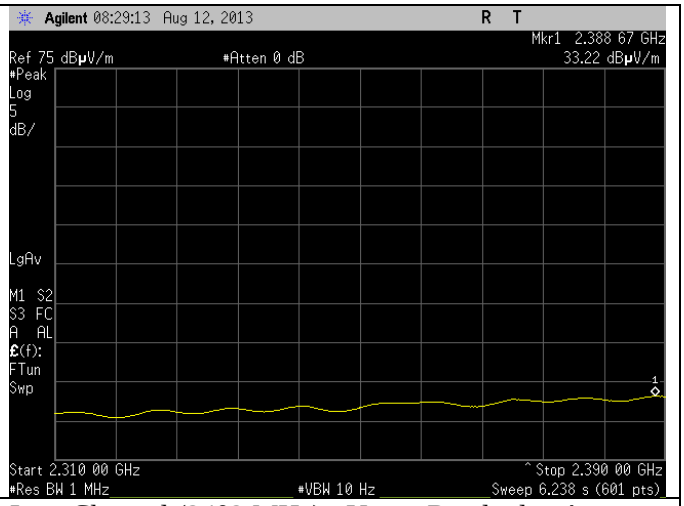
High Channel (2480MHz) - Upper Band-edge Peak



High Channel (2480MHz) - Upper Band-edge Average



Low Channel (2402 MHz) - Upper Band-edge Peak



Low Channel (2402 MHz) - Upper Band-edge Average

B.2.2 – Radiated Harmonics in Restricted Bands

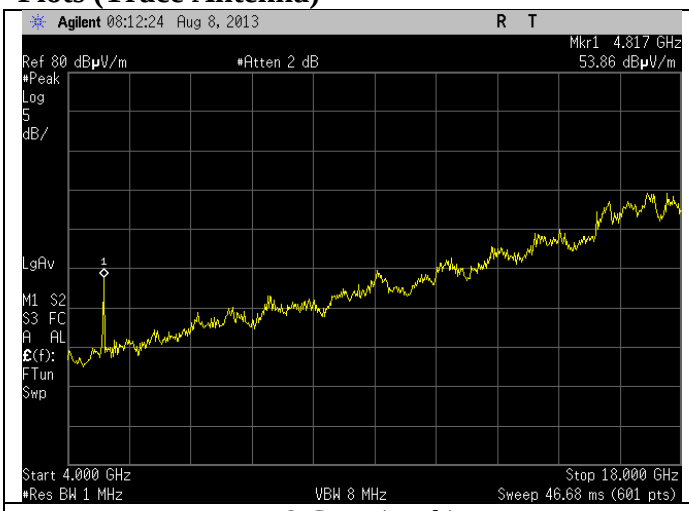
Manufacturer	LS Research, LLC
Date	8-8-13 and 8-15-13
Operator	Adam A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Rule Part	15.247/ 15.205 / 15.209
Measurement Procedure	ANSI C63.4 - 2003 ANSI C63.10 - 2009
Test Distance	1 meter 4-25 GHz
EUT Placement	80 cm height non-conductive table centered on turn-table
Detectors	RBW 1 MHz; Peak; VBW 3 MHz / Average VBW (10Hz)
Additional Notes	1) Tested in continuous transmit modulated mode with EUT in three orientations at maximum power. 2) Maximum results reported. 3) Tested at 1 meter test distance so a distance correction factor of 9.5 added to 3 meter limit 4) Tested two units; Trace antenna unit and U.FL unit with matched terminated antenna per FCC KDB 558074 Section 12.2.7

Example Calculation:
FCC 15.209 Peak Limit @ 1 meter (dBµV/m) – Peak Reading (dBµV/m) = Margin (dB)
FCC 15.209 Average Limit @ 1 meter (dBµV/m) – Average Reading (dBµV/m) = Margin (dB)

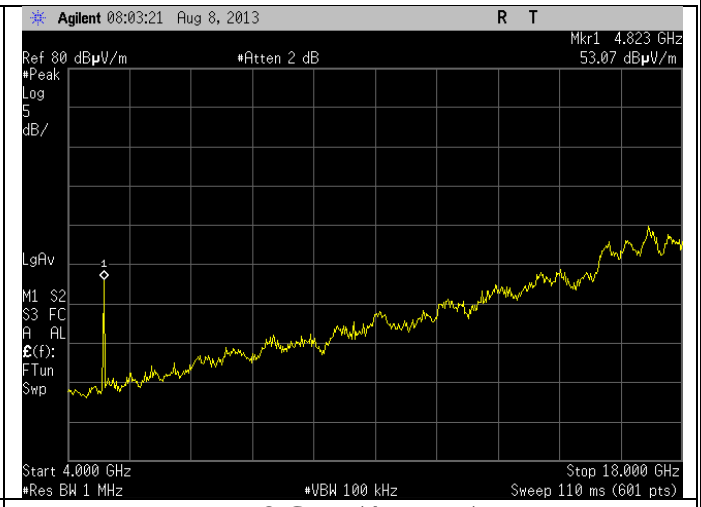
Data Table (Trace Antenna)

Frequency (MHz)	EUT orientation	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Avg Limit (dBµV/m)	Avg Margin (dB)
4804	Vertical	Vertical	100	92	51.44	47.24	83.50	32.06	63.50	16.26
		Horizontal	111	84	51.77	48.09		31.73		15.41
	Horizontal	Vertical	100	43	51.73	48.35		31.77		15.15
		Horizontal	100	55	54.91	52.89		28.59		10.61
	Flat	Vertical	104	168	52.76	49.09		30.74		14.41
		Horizontal	100	199	52.11	48.24		31.39		15.26
4880	Vertical	Vertical	102	46	51.22	46.48	83.50	32.28	63.50	17.02
		Horizontal	114	47	53.19	50.00		30.31		13.50
	Horizontal	Vertical	111	11	52.79	48.99		30.71		14.51
		Horizontal	101	60	53.62	50.12		29.88		13.38
	Flat	Vertical	103	160	51.86	47.98		31.64		15.52
		Horizontal	100	159	52.56	49.01		30.94		14.49
4960	Vertical	Vertical	100	21	51.31	47.67	83.50	32.19	63.50	15.83
		Horizontal	106	1	52.59	48.49		30.91		15.01
	Horizontal	Vertical	100	166	52.72	48.95		30.78		14.55
		Horizontal	102	41	53.72	51.05		29.78		12.45
	Flat	Vertical	102	170	53.61	50.76		29.89		12.74
		Horizontal	100	145	54.73	52.07		28.77		11.43

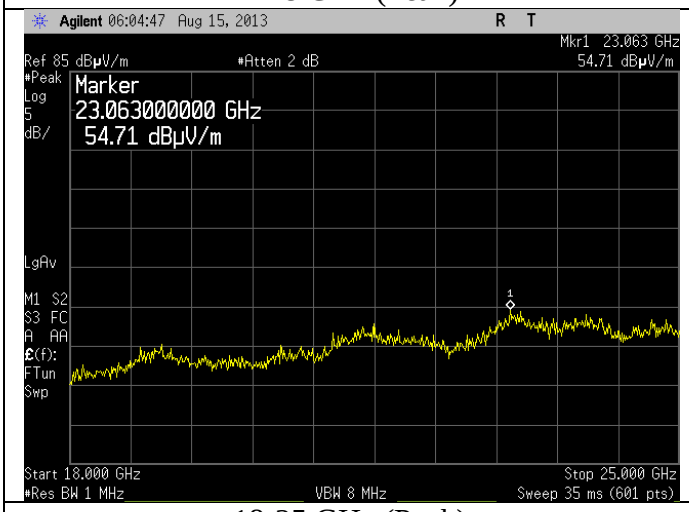
Plots (Trace Antenna)



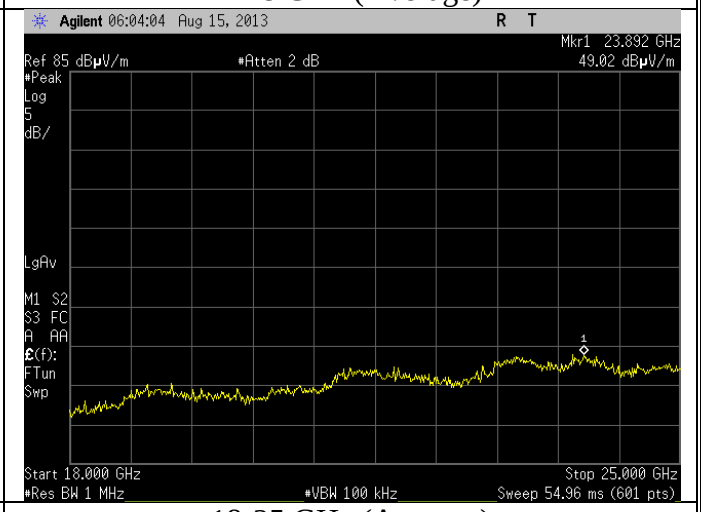
4-18 GHz (Peak)



4-18 GHz (Average)



18-25 GHz (Peak)

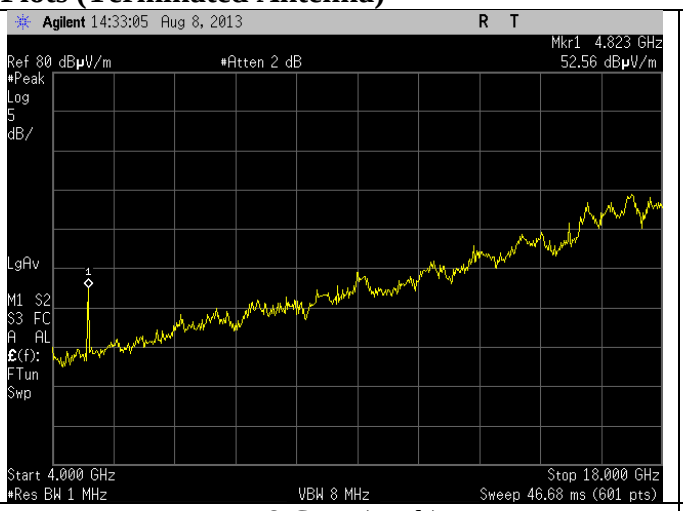


18-25 GHz (Average)

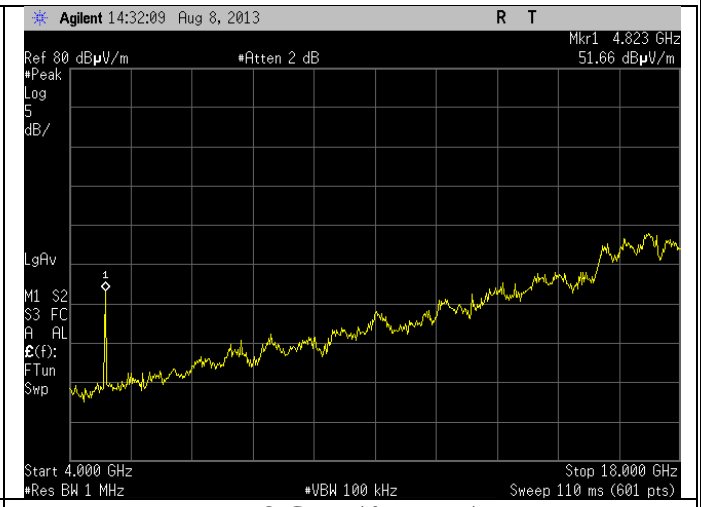
Data Table (Terminated Antenna)

Frequency (MHz)	EUT orientation	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Avg Limit (dBµV/m)	Avg Margin (dB)
4804	Vertical	Vertical	100	98	51.75	46.33	83.50	31.75	63.50	17.17
		Horizontal	107	333	52.92	47.62		30.58		15.88
	Horizontal	Vertical	104	12	52.20	48.50		31.30		15.00
		Horizontal	100	60	53.69	51.12		29.81		12.38
	Flat	Vertical	100	268	53.56	49.17		29.94		14.33
		Horizontal	100	263	51.98	46.25		31.52		17.25
4880	Vertical	Vertical	100	101	52.72	47.55	83.50	30.78	63.50	15.95
		Horizontal	107	99	53.14	47.67		30.36		15.83
	Horizontal	Vertical	111	35	52.26	45.97		31.24		17.53
		Horizontal	100	73	54.02	48.93		29.48		14.57
	Flat	Vertical	103	263	52.16	46.55		31.34		16.95
		Horizontal	100	263	51.60	45.14		31.90		18.36
4960	Vertical	Vertical	100	104	52.43	47.51	83.50	31.07	63.50	15.99
		Horizontal	106	96	52.96	47.63		30.54		15.87
	Horizontal	Vertical	100	310	51.80	43.58		31.70		19.92
		Horizontal	104	136	53.52	48.24		29.98		15.26
	Flat	Vertical	102	271	52.08	46.44		31.42		17.06
		Horizontal	100	265	51.66	45.39		31.84		18.11

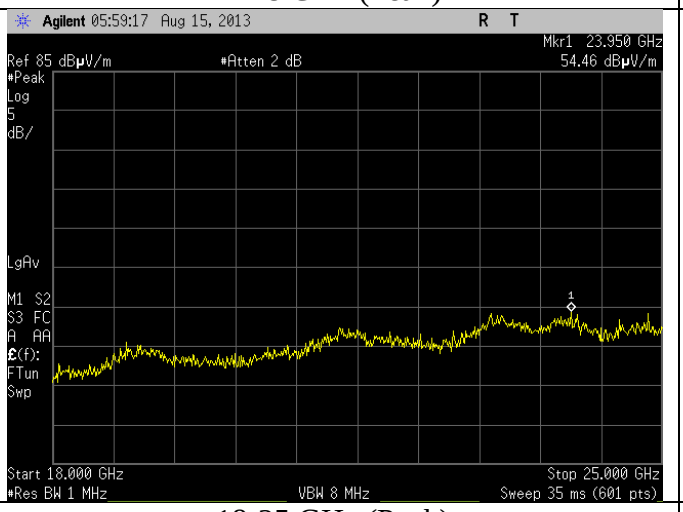
Plots (Terminated Antenna)



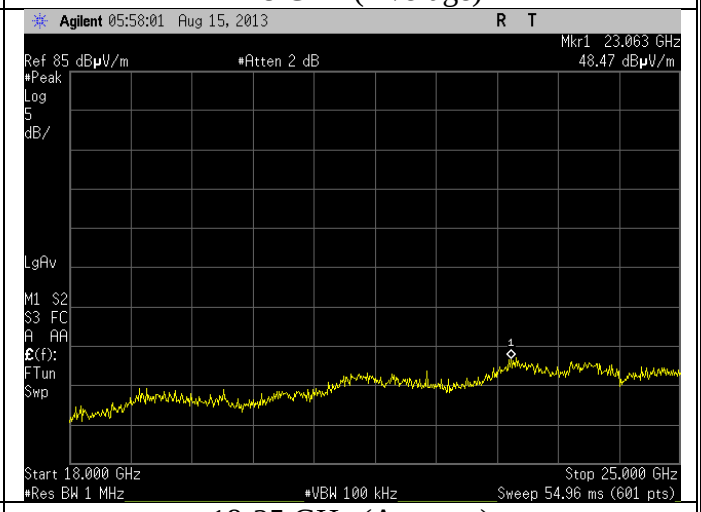
4-18 GHz (Peak)



4-18 GHz (Average)



18-25 GHz (Peak)

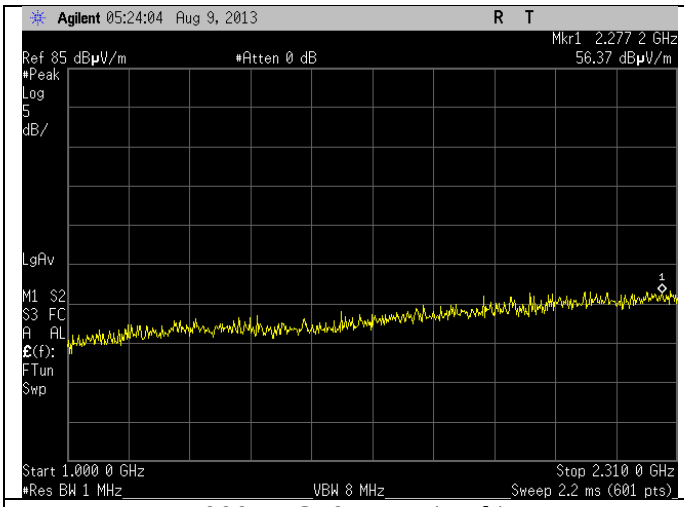


18-25 GHz (Average)

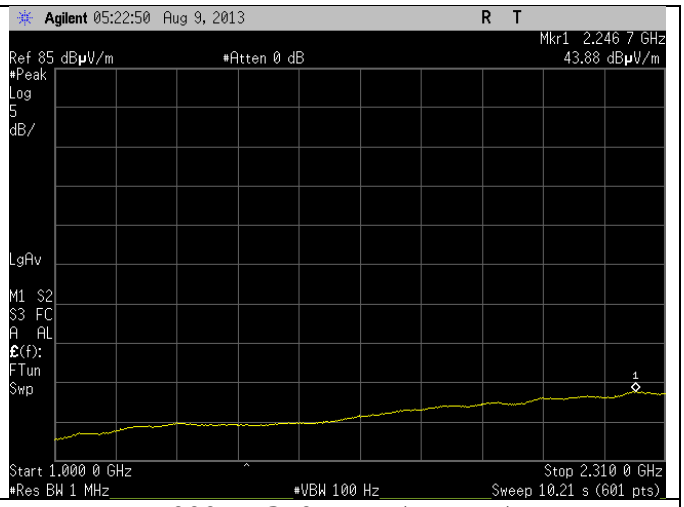
B.2.3 – Radiated Emissions Transmit Mode

Manufacturer	LS Research, LLC
Date	8-9-13 and 8-15-13
Operator	Adam A
Temp. / R.H.	20 - 25º C / 30-60% R.H.
Rule Part	15.247/ 15.205 / 15.209
Measurement Procedure	ANSI C63.4 - 2003 ANSI C63.10 - 2009
Test Distance	3 meter 30-4000 MHz
EUT Placement	80 cm height non-conductive table centered on turn-table
Detectors	Peak; RBW 1 MHz
Additional Notes	1) Tested in continuous transmit modulated mode with EUT in three orientations at maximum power. Worst case emissions reported. 2) Peak detector with max hold in vertical and horizontal antenna polarizations 3) No emissions found associated with EUT on low, mid, and high channels 4) Tested two units; Trace antenna unit and U.FL unit with matched terminated antenna per FCC KDB 558074 Section 12.2.7

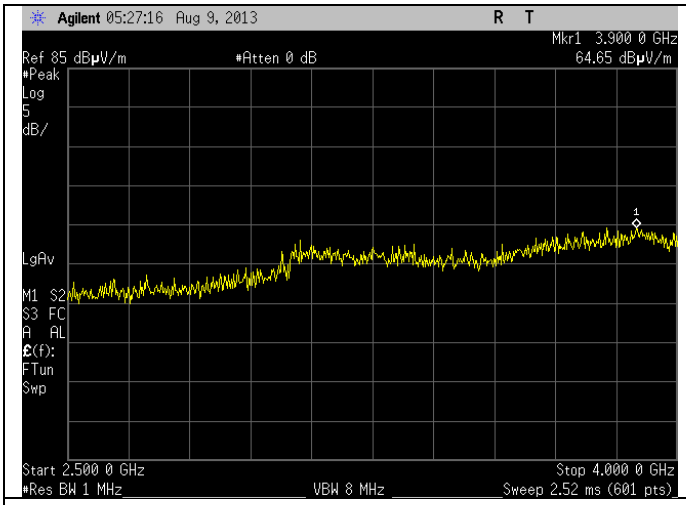
Example Calculation:



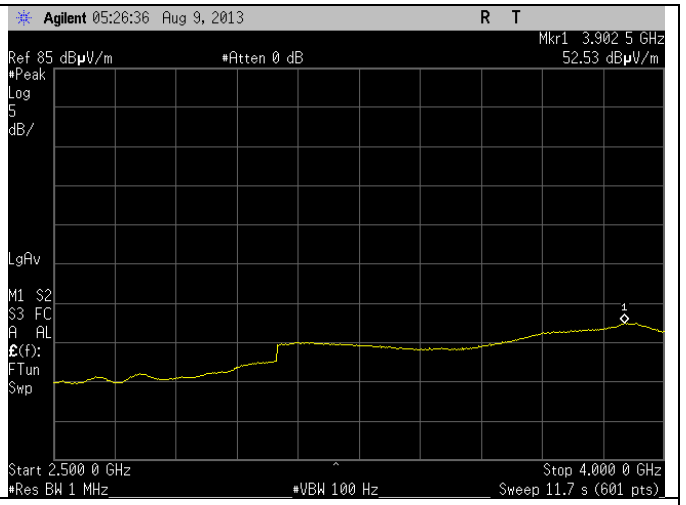
1000 – 2310 MHz (peak)



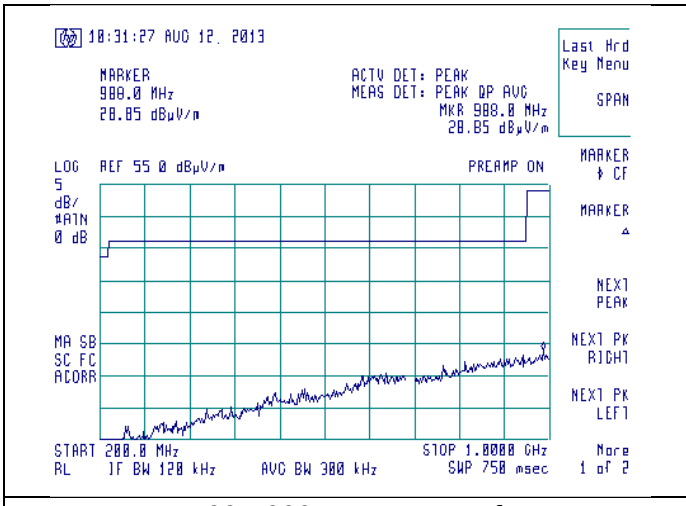
1000 – 2310 MHz (average)



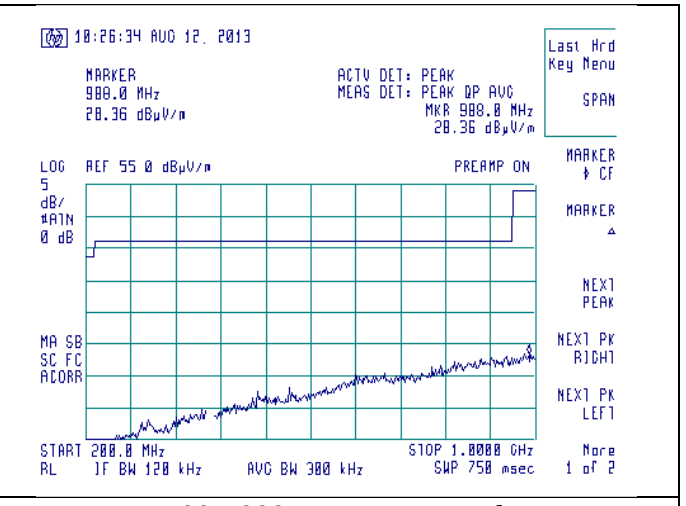
2500 – 4000 MHz (peak)



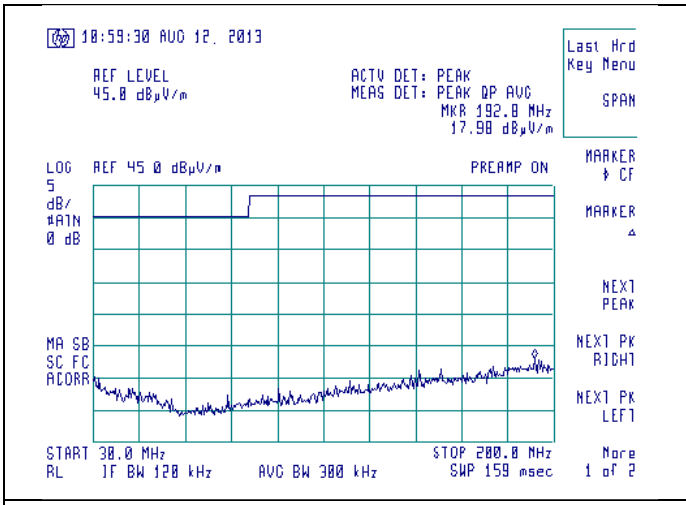
2500 – 4000 MHz (average)



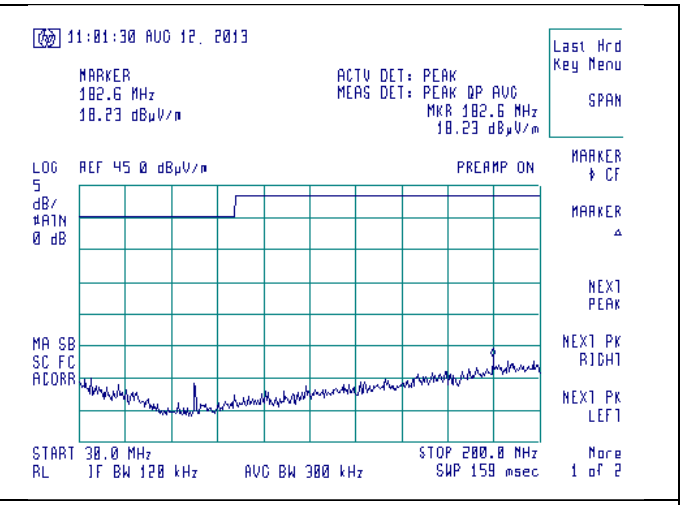
200-1000 MHz Vertical



200-1000 MHz Horizontal



30-200 MHz Vertical



30-200 MHz Horizontal

B3 – Frequency Stability

Manufacturer	LS Research, LLC
Operator	Adam A
Additional Notes	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 from the nominal. 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. Below is data showing stability of the fundamental frequency. Continuous transmit modulated used for this test with RF Conducted U.FL unit. EUT does not operate below 2.0 VDC

Channel (MHz)	Max (3.6 VDC)	Min (2.0 VDC)	freq drift (Hz)
2402	2401991521	2401997772	6688
2440	2439991130	2439997800	6670
2480	2479991160	2479996910	5920

B4 – AC Mains Conducted Emissions

Test Setup

The test area and setup are in accordance with ANSI C63.4-2003 and with Title 47 CFR, FCC Part 15, Industry Canada RSS-210 and RSS GEN. The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The EUT's power cable was plugged into a Line Impedance Stabilization Network (LISN). The AC power supply of 120V was provided via an appropriate broadband EMI Filter, and then to the LISN line input. Final readings were then taken and recorded. After the EUT was setup and connected to the LISN, the RF Sampling Port of the LISN was connected to a 10 dB Attenuator-Limiter, and then to the EMI Receiver. The LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral).

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 was as specified for Quasi-Peak and Average detectors in the frequency range of 150 kHz to 30 MHz. Final readings were then taken and recorded.

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
0.5 – 5.0	56	46	
5.0 – 30	60	50	
* The limit decreases linearly with the logarithm of the frequency in this range.			

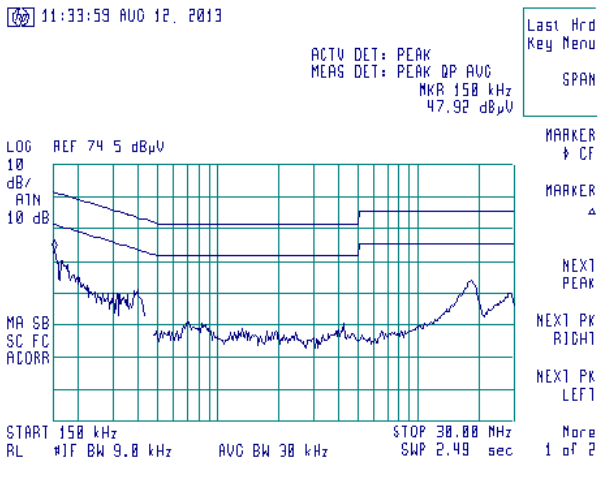
Test Data

Manufacturer:	LS Research, LLC					
Date(s) of Test:	8-12-13					
Test Engineer:	Adam A					
Voltage:	120 VAC 60Hz Off-the-shelf AC-DC supply with 3.3 VDC to module					
Operation Mode:	Continuous transmit modulated used for this test (trace antenna unit)					
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:	X	Peak		Quasi-Peak		Average

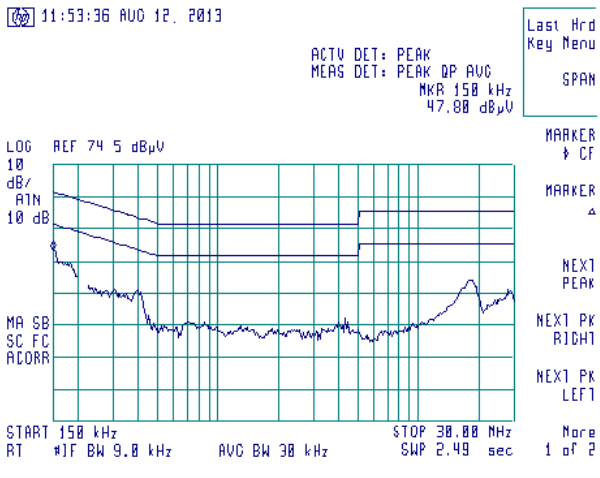
Sample Calculation:
Margin (dB) = Limit (dBµV) – Reading (dBµV)

Frequency (MHz)	Line	Peak Reading (dBµV)	Average Limit (dBµV)	Margin (dB)
0.150	1	46.79	56.00	9.21
0.170	1	44.52	54.96	10.44
0.390	1	35.25	48.07	12.82
18.32	2	38.42	50.00	11.58
28.74	2	34.59	50.00	15.41
0.180	2	42.67	54.49	11.82

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

Appendix C - 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 D - References

Publication	Year	Title
FCC CFR Parts 0-15	2013	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 v03r01	2013	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

END OF REPORT

Date	Version	Comments	Person
8-19-13	V0	Initial Draft Release	Adam A
8-20-13	V1	Final Release	Adam A