MEASUREMENT AND TEST REPORT

VERSION 1.01

Report Prepared for: Rainforest Automation Inc.
34 W 7th Avenue
Vancouver, BC
V5Y 1L6
Canada

Equipment Under Test (EUT): Model: RFA-Z109 EAGLE

FCC ID: YCXRFA-Z109
IC Certification number: 8919A-RFAZ109

FCC Rule Part(s): Part 15B, 15C
Industry Canada Rule Part(s) RSS-210

Tested by: Island Compliance Services Inc.
6454 Fitzgerald Road
Courtenay, BC
V9J 1N7

Prepared By	Authorized By
A. Horel (Technical Writer) 	A. Eadie (Sr. EMC Eng.) 

Note: This test report has been prepared for the Applicant and device described herein. It may not be duplicated or used in part without prior written consent from Island Compliance Services Inc.

FCC OATS registration number: 386117
Industry Canada OATS registration number: 9578B-1

Revision History

Version	Date	Author	Comment
1.0	05/02/2012	A. Horel	Original Release
1.01	19/02/2012	A.Horel	Cover Page and Header: Model Name updated p.20 – p.21 Radiated Spurious Emissions Band Edge data added p.22 – p.23: Spurious Emissions data and plot updated p.25 - p.26: Power Line Conducted Emissions data and plots updated

1.1 CONTENTS

2 SUMMARY OF TEST RESULTS

The equipment under test was found to comply with the test standards and criteria outlined herein.

Test Description	Reference Specification FCC	Reference Specification Industry Canada	Result	Comment
RF Peak Power Output	FCC Subpart C 15.247(b) (3)	RSS 210 Issue 8 A8.4(4)	Complies	
Occupied Bandwidth 6dB Bandwidth	FCC Subpart C 15.247 (a) (2)	RSS 210 Issue 8 A8.2(a)	Complies	
Occupied Bandwidth 20dB Bandwidth	N/A	RSS-Gen Issue 3 4.6.1	Complies	
Power Spectral Density	FCC Subpart C 15.247(e)	RSS 210 Issue 8 A8.2(b)	Complies	
Conducted Spurious Emissions	FCC Subpart C 15.247(d)	RSS 210 Issue 8 A8.5	Complies	
Conducted Spurious Emissions Band Edge	FCC Subpart C 15.247(d)	RSS 210 Issue 8 A8.5	Complies	
Duty Cycle Correction factor	FCC Subpart C 15.35(c)	RSS-Gen Issue 3 4.5	Complies	
Radiated Spurious Emissions Band Edge	FCC Subpart C 15.209(a) 15.205(a)	RSS 210 Issue 8 2.5, A8.5	Complies	
Radiated Spurious Emissions (TX and RX)	FCC Subpart C 15.247, 15.205 FCC Subpart B 15.109	RSS 210 Issue 8 2.5, A8.5 RSS Gen Issue 3 Section 4.10 and section 6 for RX ICES-003 Issue 4	Complies	
Power line Conducted Emission	FCC Subpart C 15.207 (a) FCC Subpart B 15.107	RSS-Gen Issue 3 7.2.4 Ices-003 Issue 4	Complies	

2.1 ENVIRONMENTAL CONDITIONS

Description	Reading
Indoor Temperature	18-21°C
Indoor Humidity	39-40%
Outdoor Temperature	5-6°C
Outdoor Humidity	80 – 90%

2.2 STANDARD TEST CONDITIONS AND ENGINEERING PRACTICES

Except as noted herein, the following conditions and procedures were observed during the testing:

CFR 47, FCC rules Part 15 subpart C, ANSI C63.4 (2003), Public Notice DA 00-705, DTS procedures KDB 558074, IC standards RSS-GEN and RSS0210. ANSI C63.4-2003 or later, was used for all test procedures as required by RSS-Gen I3 2010, Section 4.1. Deviations, modification or clarifications (if any) to above mentioned documents are described herein.

Measurement results, unless otherwise noted, are worst-case measurements.

3 GENERAL EQUIPMENT SPECIFICATIONS

Item	Description
Manufacturer	Rainforest Automation
Model Number	RFA-Z109 EAGLE
Function	Energy Monitoring Unit
Power Supply Input	5V from USB 5V power source or a 5V AC/DC adapter regulated down to 3.3V
Power Output	0.04345 W
Antenna Gain/Type	4.4 dBi Max
Channel Spacing	5 MHz
Frequency Range	2405-2480 MHz
Modulation	0-QPSK

3.1 AUXILIARY EQUIPMENT

Equipment	Description
N/A	

3.2 ENGINEERING CHANGES TO PRODUCTION UNIT

N/A

4 RF PEAK POWER OUTPUT

Test Name	Reference Specification	Result	Notes
RF Peak Power Output	15.247(b)(3) A8.4 (4)	Complies	

4.1 TEST METHOD

RSS-Gen Issue 3 4.8 and FCC Publication 558074, Section 15.247(b) – 2. Set the RBW ≥ EBW. Set VBW ≥ 3 x RBW. Set span = zero. Sweep time = auto couple. Detector = peak. Trace mode = max hold. Allow trace to fully stabilize. Use peak marker function to determine the peak amplitude level within the fundamental emission.

4.2 DATA

Channel	Tuned Frequency (GHz)	Peak Power (dBm)	CF (dB)	Corrected (dBm)	Limit (dBm)
Low (11)	2.405	15.05	0	15.05	30
Mid (18)	2.440	16.29	0	16.29	30
High (26)	2.480	16.38	0	16.38	30

4.3 PLOT(S)

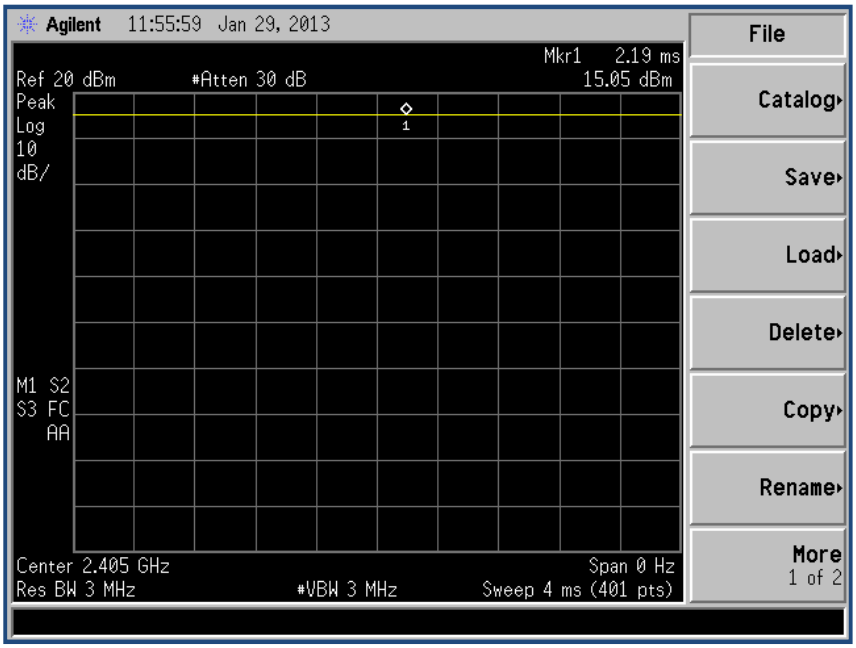


FIGURE 1 - PEAK OUTPUT POWER, LOW CHANNEL

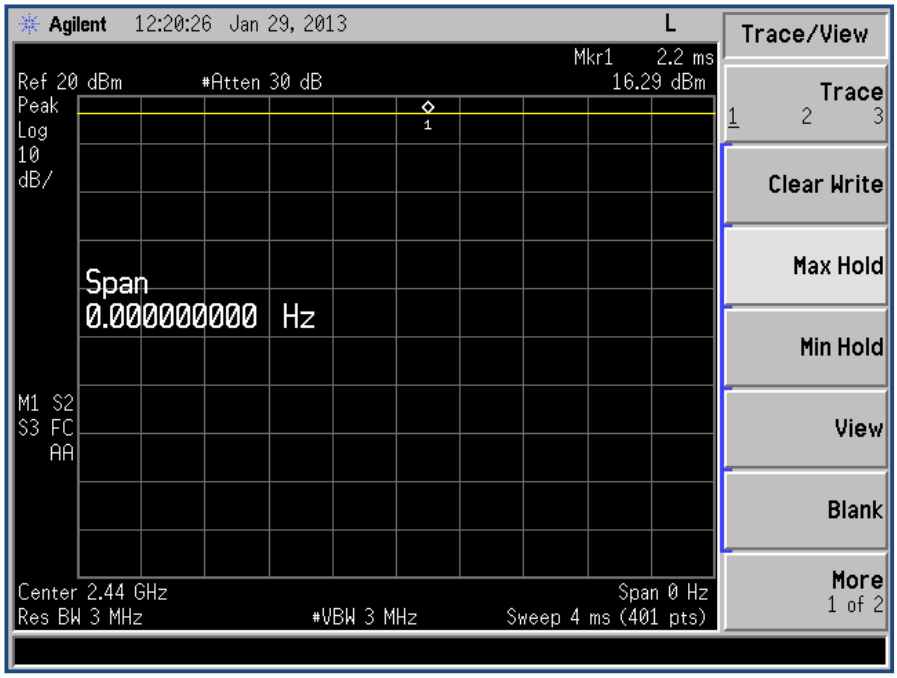


FIGURE 2 - PEAK POWER, MID CHANNEL

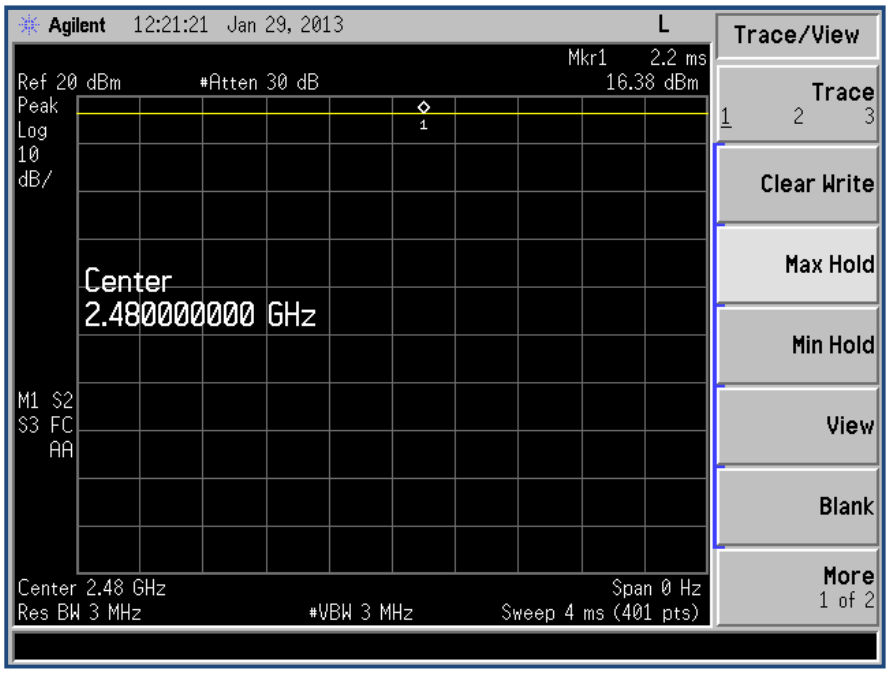


FIGURE 3 - PEAK POWER, HIGH CHANNEL

4.4 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	29/01/2013

5 OCCUPIED BANDWIDTH

Test Description	Reference Specification	Result	Notes
Occupied Bandwidth 6dB and 20dB	15.247(a) A8.2(a) 4.6.1	Complies	

5.1 TEST METHOD

RSS-Gen Issue 4.6.1 and FCC Publication 558074, Section 15.247(a) (2) – Emission Bandwidth (EBW) -
Method: Set RBW=1-5% of the emission bandwidth (EBW), VBW=≥ 3 x RBW, Detector=Peak, Trace mode=max hold, Sweep=auto couple, allow trace to stabilize. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower) that are attenuated by 6 dB to the maximum level measured in the fundamental emission. Compare the resultant bandwidth with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is 1-5%.

Test performed with modulation ON and 100% duty cycle

5.2 DATA

Channel	Frequency (GHz)	20dB Bandwidth (MHz)	6dB Bandwidth (MHz)
Low (11)	2.405	2.28	1.568
Mid (18)	2.440	2.33	1.604
High (26)	2.480	2.39	1.634

5.3 PLOTS

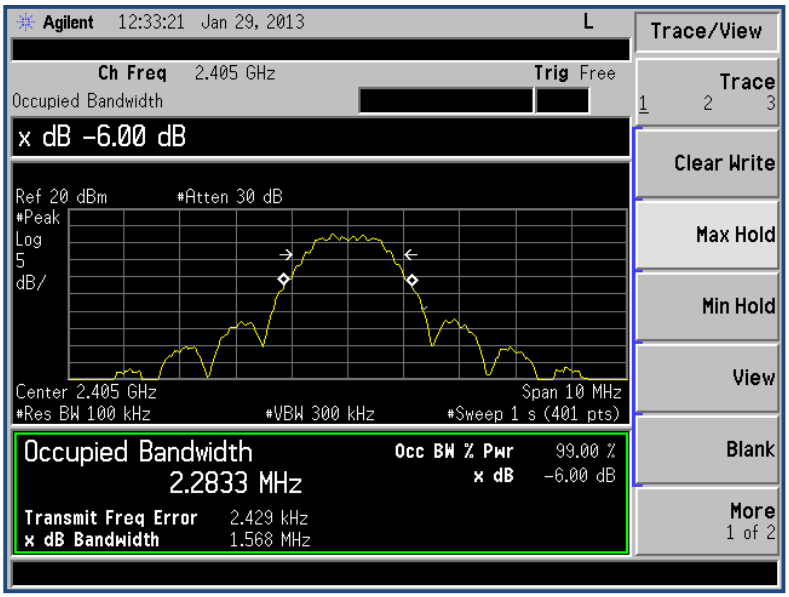


FIGURE 4 - LOW CHANNEL OCCUPIED BANDWIDTH (20DB)

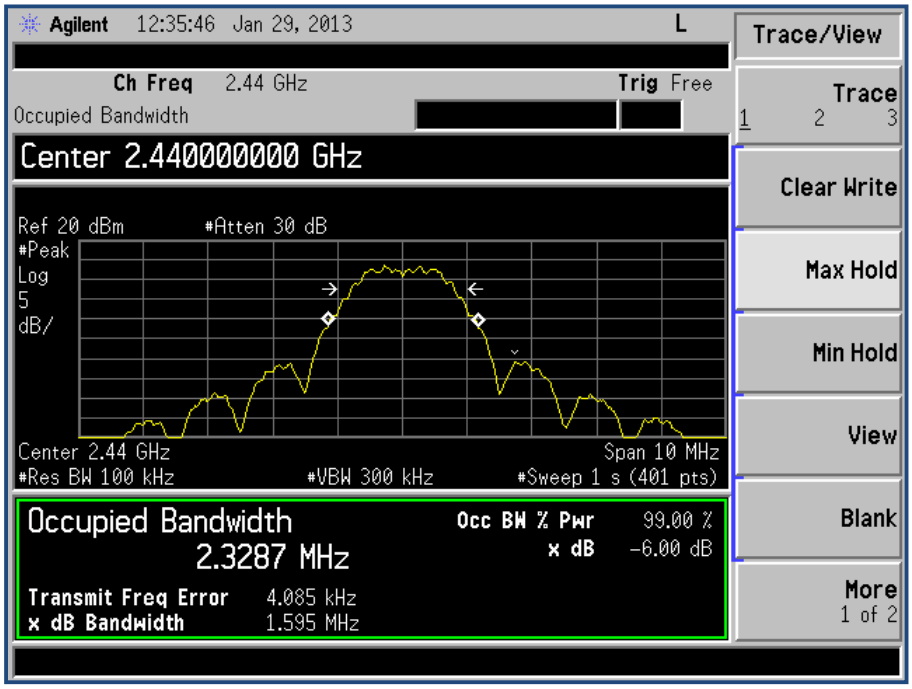


FIGURE 5 – MID CHANNEL OCCUPIED BANDWIDTH (20DB)

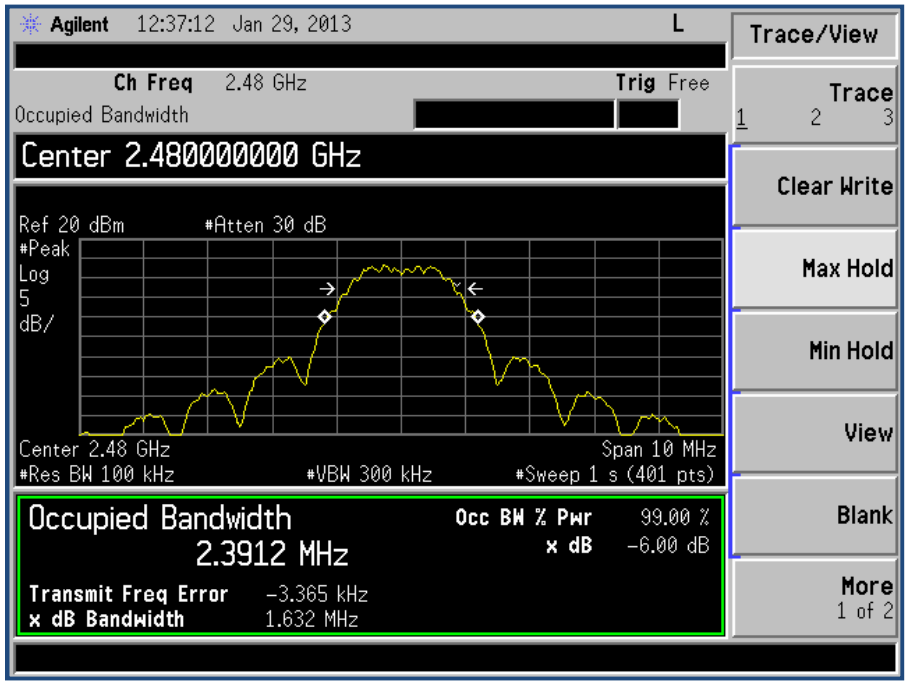


FIGURE 6 - HIGH CHANNEL OCCUPIED BANDWIDTH (20DB)

5.4 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	01/29/2013

6 POWER SPECTRAL DENSITY

Test Description	Reference Specification	Result	Notes
Power Spectral Density	15.247(e) A8.2 (b)	Complies	maximum measured power spectral density: -1.69

6.1 TEST METHOD

RSS-210 Issue 8 and FCC Publication 558074, Section 15.247(e) - Maximum Power Spectral Density Level in the Fundamental Emission (PSD) – Method: RBW = 100 kHz, VBW ≥ 300 kHz, Span=5-30 % greater than the EBW, Detector= peak, Sweep time = auto couple, Trace mode = max hold, allow trace to fully stabilize. The peak marker function is used to determine the maximum power level in any 100 kHz band segment within the fundamental EBW. The observed power level is scaled to an equivalent value in 3 kHz by adjusting (reducing) the measured power by a bandwidth correction factor (BWCF) where BWCF = 10log (3 kHz/100kHz) = -15.2 dB.

6.2 LIMITS

15.247(e) specifies a conducted power spectral density (PSD) limit of 8 dBm in any 3 kHz band segment within the fundamental EBW during any time interval of continuous transmission.

6.3 DATA

Channel	Frequency (GHz)	Pk Power (dBm)	CF (dB)	PSD (dBm)
Low (11)	2.405	12.41	-15.2	-2.79
Mid (18)	2.440	13.51	-15.2	-1.69
High (26)	2.480	13.32	-15.2	-1.88

Note: All final reported values are corrected values

6.4 PLOTS

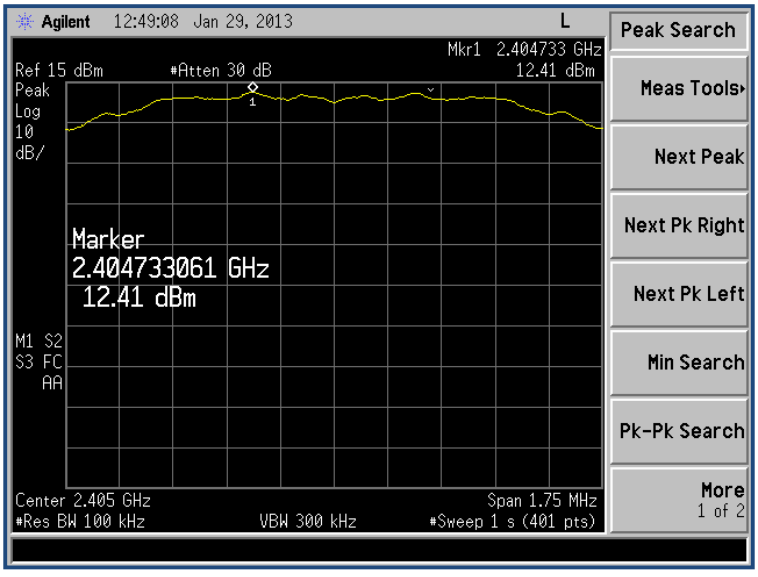


FIGURE 7 – PEAK POWER (LOW CHANNEL)

6.5

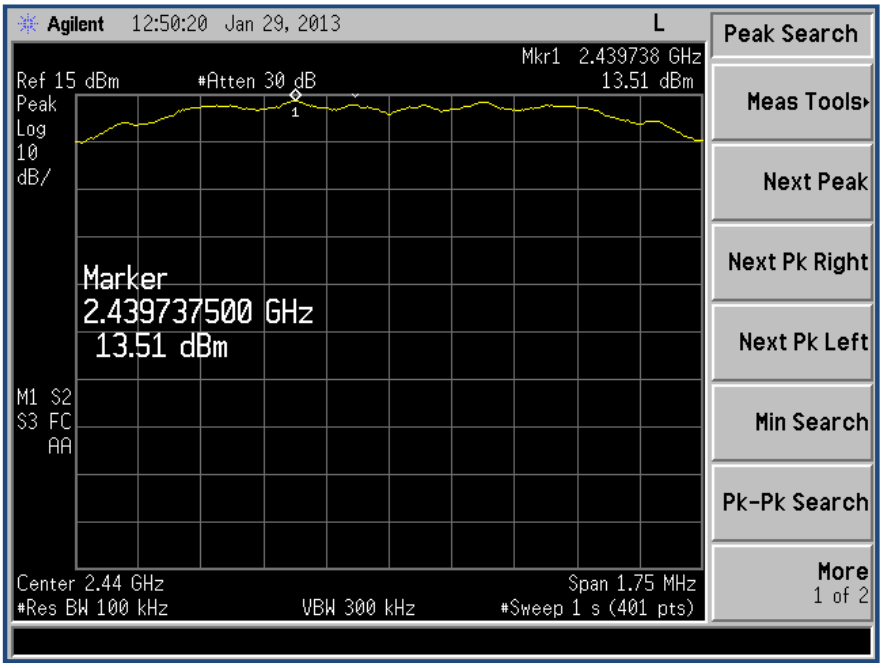


FIGURE 8 - PEAK POWER (MID CHANNEL)

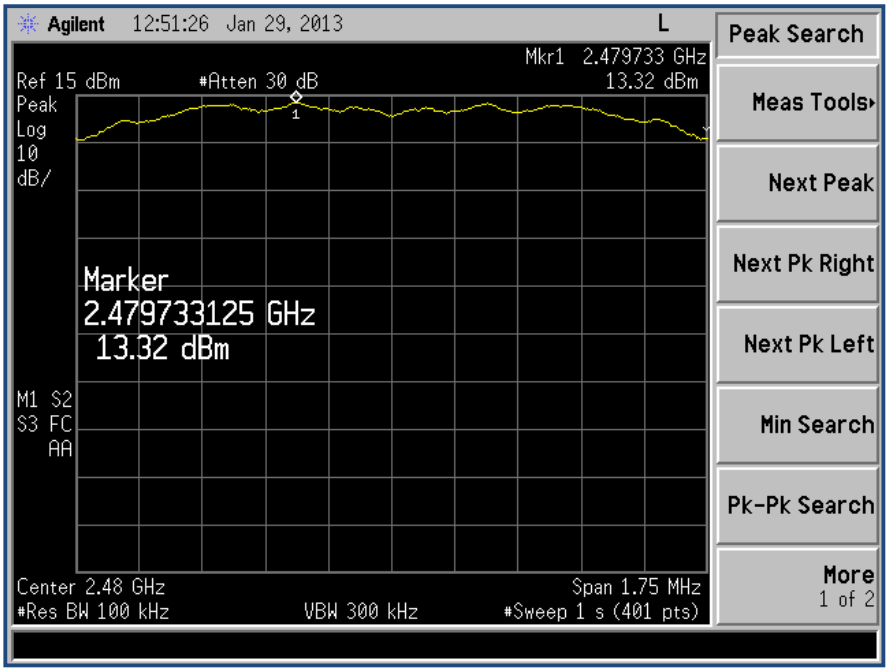


FIGURE 9 - PEAK POWER (HIGH CHANNEL)

6.6 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	29/01/2013

7 CONDUCTED SPURIOUS EMISSIONS

Test Description	Reference Specification	Result	Notes
Conducted Spurious Emissions	15.247(c) A8.5	Complies	

7.1 TEST METHOD

RF conducted as per FCC Publication 558074
RSS-210 Issue 8 A8.5

7.2 LIMITS

15.247(c) In any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in 15.205(a), must also comply with the radiated emission limits specified in 15.209(1) (see 15.205(c)).

7.3 DATA

Channel	Harmonic4 (dBc)	Harmonic5 (dBc)	Harmonic6 (dBc)	Limit (dBc)	Result
Low (11)	-46.04	-42.60	-49.86	-20	Complies
Mid (18)	-48.62	**-40.38**	-47.49	-20	Complies
High (26)	-49.45	-51.81	-52.44	-20	Complies

Note: worst case harmonic: -40.38

7.4 PLOTS

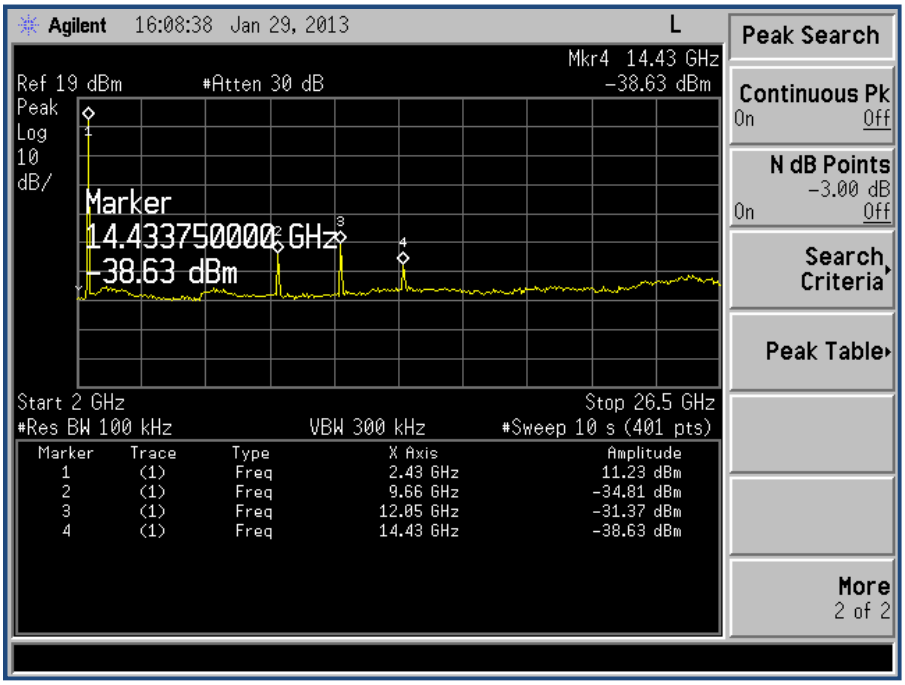


FIGURE 10 – LOW CHANNEL SUPRIOUS, 2-10GHZ

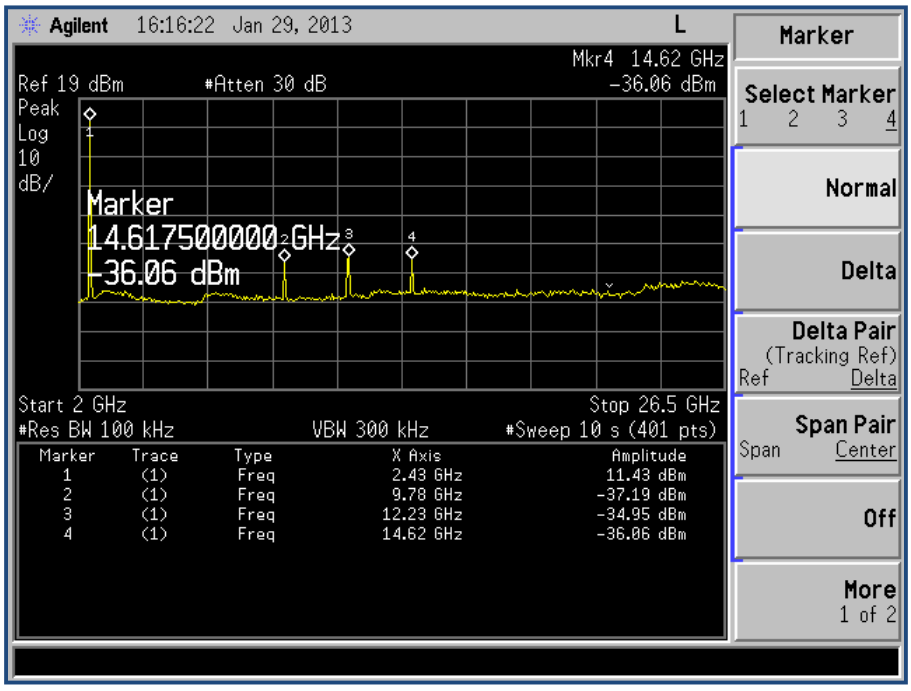


FIGURE 11 - MID CHANNEL SPURIOUS 2-10GHZ

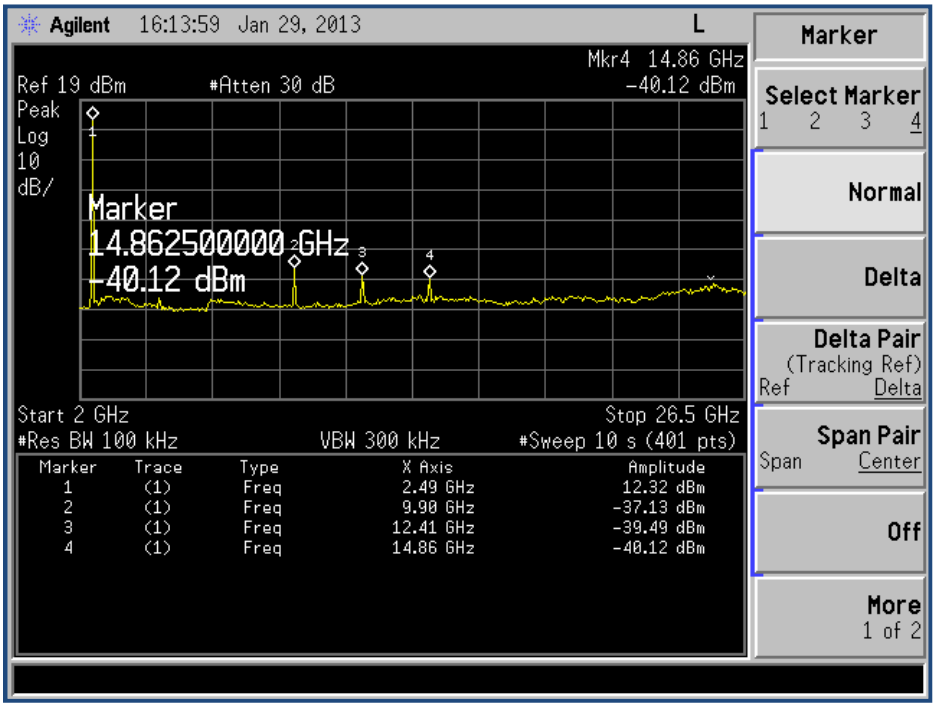


FIGURE 12 - HIGH CHANNEL SPURIOUS 2-10GHZ

7.5 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	29/01/2013

8 CONDUCTED SPURIOUS EMISSIONS BANDEDGE

Test Description	Reference Specification	Limit	Result	Notes
Band Edge Compliance	15.247(d) A8.1	>20dBc, 74dBuV/m pk	Complies	

8.1 TEST METHOD

Using the marker-delta method outlined in DA 00-705 an in-band field strength measurement of the fundamental emission using the RBW and detector function required by C63.4 and FCC Rules for the frequency being measured was undertaken. A spectrum analyzer span was chosen that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. The delta measurement is then subtracted from the field strengths measured. The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance as required by Section 15.205.

8.2 LIMITS

15.247(d) 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.

8.3 DATA

An in-band field strength measurement taken at 3m, with RBW = 1MHz, VBW = 1MHz and in peak detection mode resulted in a corrected peak fundamental measurement of 110.4 dBuV/m

Using the marker-delta method outlined in DA 00-705, band edge emissions were well below the 74dBuV/m peak limits for restricted bands.

Spurious Emission Frequency (MHz)	Pk Fundamental Radiated Ampl. (dBuV)	Band Edge Emission Level (dBc)	Band Edge Corrected Value (dBuV/m)	Limit	Margin (dB)	Result
2377.8	110.4	56.2	54.2	>20dBc, 74 dBuV/m pk	19.8	Complies
2484	109.2	38.3	70.9	>20dBc, 74 dBuV/m pk	3.1	Complies

8.4 PLOTS

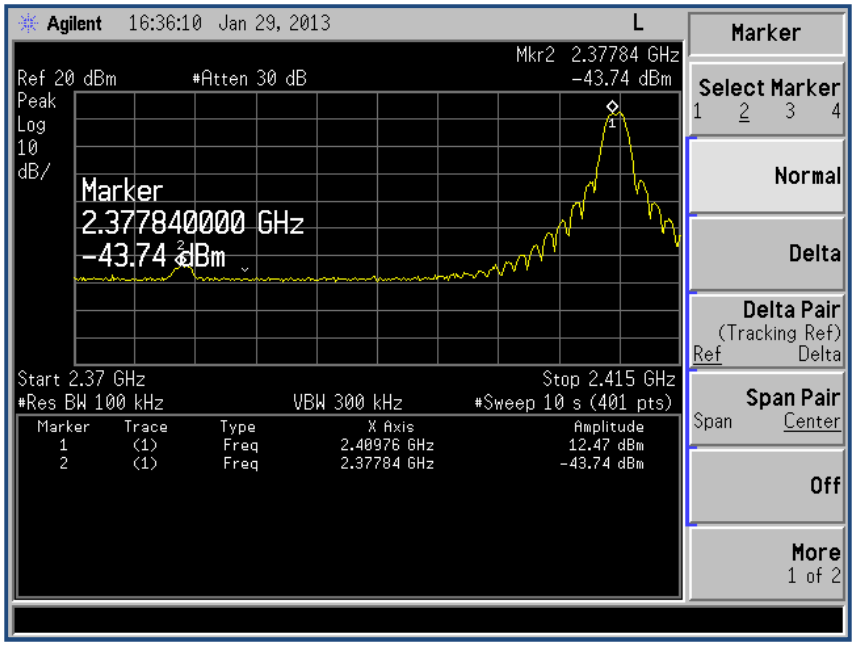


FIGURE 13 - LOWER BANDEDGE (2370-2415)

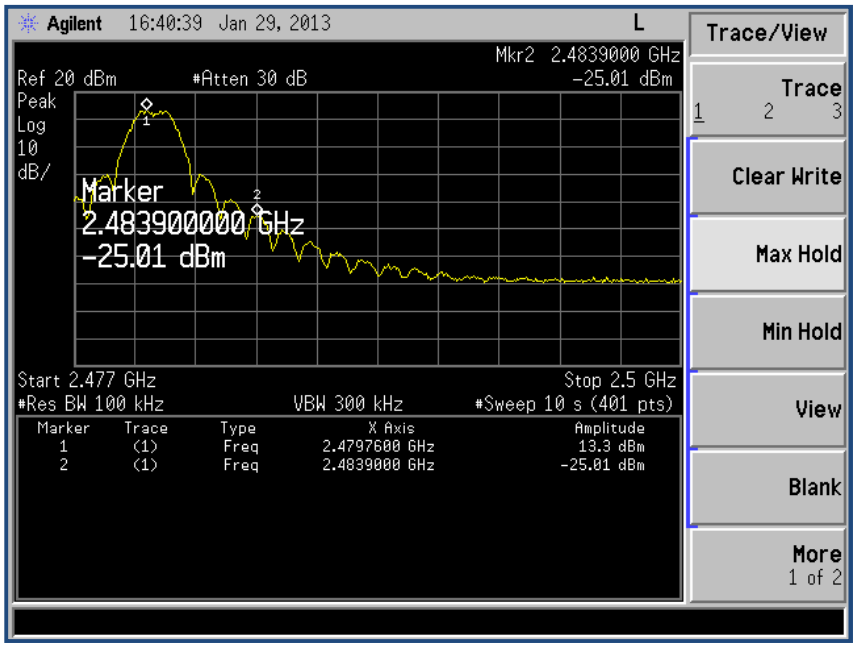


FIGURE 14 - UPPER BANDEDGE (2477 - 2500)

8.5 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	29/01/2013

9 DUTY CYCLE CORRECTION FACTOR

Test Description	Reference Specification	Result
Duty Cycle Correction Factor	15.35(c) RSS-Gen Issue 3 4.5	Duty cycle correction factor = 20*log(0.822/8.160) = -19.94 dB

9.1 TEST METHOD

As per FCC 15.35 with spectrum analyzer in Zero span mode the EUT was tuned to Low channel (Ch Mid) with 10% duty cycle operating mode as the worst case of EUT normal operation per client.

9.2 TEST LIMITS

15.35 (c) Unless otherwise specified, e.g. §15.255(b), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

9.3 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	29/01/2013

10 RADIATED SPURIOUS EMISSIONS BAND EDGE

10.1 TEST PROCEDURE

The EUT is placed on a non-conducive turntable on the 3m OATS. An in-band field strength measurement of the fundamental emissions using RBW and detector function for the frequency being measured. Repeated with average detector. Spectrum analyzer span is chosen that encompasses both the peak and the fundamental emissions and the band edge emissions under investigation. Analyzer is set, RBW to 1% of total span (never less than 30kHz) with a video bandwidth equal to or greater than the RBW. Peak levels of the fundamental emissions and the relevant band edge emissions are recorded. Stored trace is observed and amplitude delta between the peak of fundamental and band edge emissions are measured. Delta is subtracted from field strengths, these measurements are used to determine compliance.

10.2 SUMMARY OF TEST RESULTS

Test Description	Reference Specification	Result	Notes
Radiated Spurious Emissions Band Edge	FCC Subpart C 15.209(a) 15.205(a) RSS 210 Issue 8 2.5, A8.5	Complies	

10.2.1 SUMMARY OF 15.205 LIMITS

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
[1]0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	[2]
13.36–13.41			

FIGURE 15 - RESTRICTED BANDS

10.3 DATA

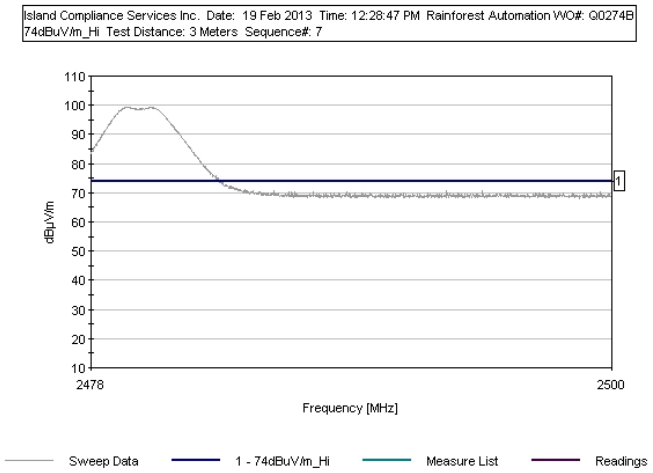


FIGURE 16 - UPPER BAND EDGE – HI CHANNEL, RBW=1M, VBW=3M

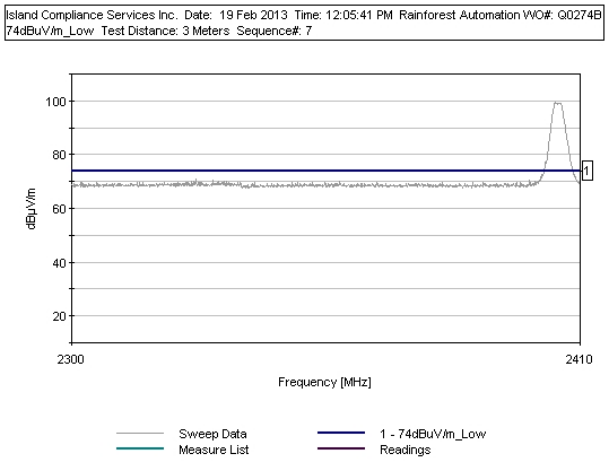


FIGURE 17 - LOWER BAND EDGE - LOW CHANNEL, RBW=1M, VBW=3M

The restricted bands were investigated using both peak and average detectors (with 54dBuV/m limit). Where applicable, RBW was reduced to lower the noise floor to assist in identifying emissions. No emissions were found above the noise floor in the restricted bands.

10.4 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	12/02/2013

11 RADIATED SPURIOUS EMISSIONS

11.1 TEST PROCEDURE

The EUT is placed on a non-conducive turntable on the 3m OATS. Exploratory measurements are made using a suitable antenna positioned within 1m of the EUT. Notable emissions are maximized and final measurements are taken if the initial results are within 20 dB of the permissible limit. The EUT is placed at nonconductive plate at the turntable center. For each suspected frequency, the turntable is rotated 360 degrees and antenna is scanned from 1 to 4 m. This is repeated for both horizontal and vertical receive antenna polarizations. The emissions less than 20 dB below the permissible value are reported.

The measurement results are obtained as described below:

E [µV/m] = URX + ATOT

Where URX is receiver reading and ATOT is total correction factor including cable loss, antenna factor and preamplifier gain (ATOT = LCABLES + AF - GPREAMP).

11.2 SUMMARY OF TEST RESULTS

Test Description	Reference Specification	Result	Notes
Radiated Spurious Emissions	15.209(a) 15.205(a) A8.5	Complies	

11.2.1 SUMMARY OF 15.205 LIMITS

See Figure 15 above.

11.3 DATA

No.	Freq (MHz)	Rdng (dBuV)	Corrected (dBuV/m)	Spec (dBuV/m)	Margin (dB)	Polarity	Antenna Height
1	47.838M	25.7	32.8	40.0	-7.2	Vert	100
2	924.925M	11.1	38.2	46.0	-7.8	Horiz	155
3	626.250M	14.0	37.2	46.0	-8.8	Horiz	150
4	185.888M	22.0	33.1	43.5	-10.4	Vert	100
5	132.000M	21.2	31.4	43.5	-12.1	Horiz	118
6	257.925M	14.3	28.5	46.0	-17.5	Horiz	131

11.4 EMISSIONS PLOT

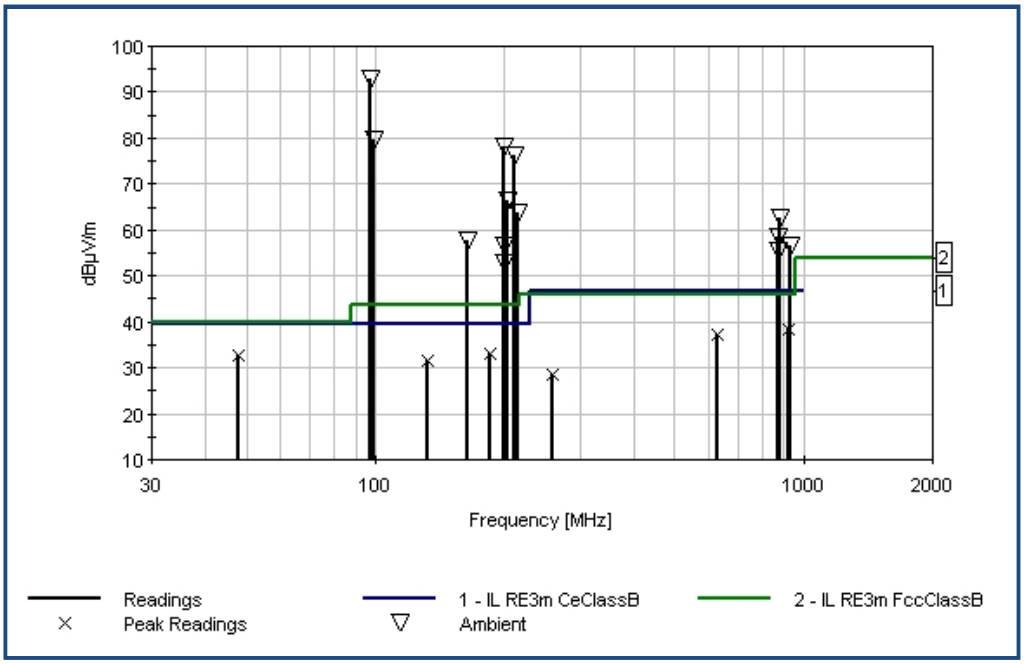


FIGURE 18 - SPURIOUS EMISSIONS PLOT

11.5 ADDITIONAL INFORMATION

Description	Comment
Test Engineer	A. Eadie
Test Date	12/02/2013

12 POWER LINE CONDUCTED EMISSIONS

12.1 TEST METHOD

For the duration of the conducted emissions test, the power cord of the EUT was connected to the main power outlet of the LISN. The LISN in turn is connected to an AC power source. Exploratory tests of the EUT are performed by varying modes and cable positioning. Maximizing procedures are performed on the highest emission readings from the EUT

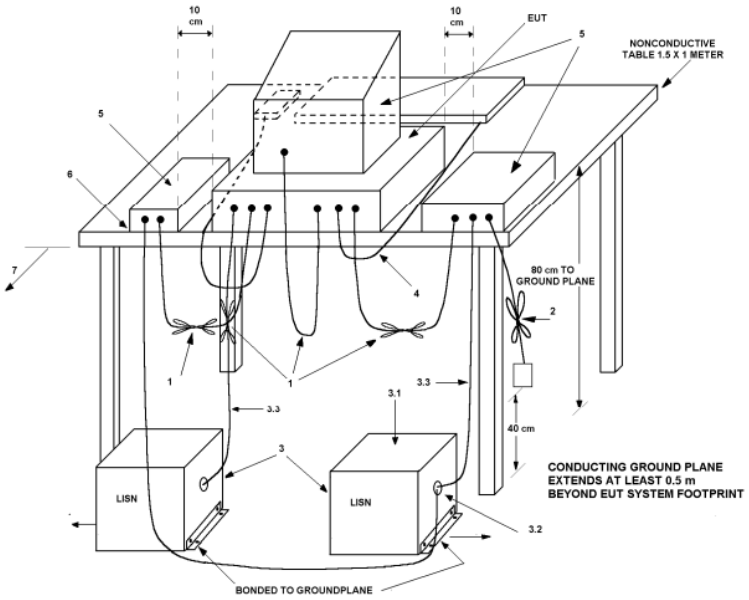


TABLE 1 - TEST ARRANGEMENT FOR CONDUCTED EMISSIONS OF TABLETOP EQUIPMENT

12.2 LIMITS AS PER 15.207

Frequency of emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66-56*	56-46*
0.5-5	56	46
5-30	60	50

TABLE 2 – CONDUCTED EMISSION LIMITS

12.3 LINE RESULTS PLOT 120V

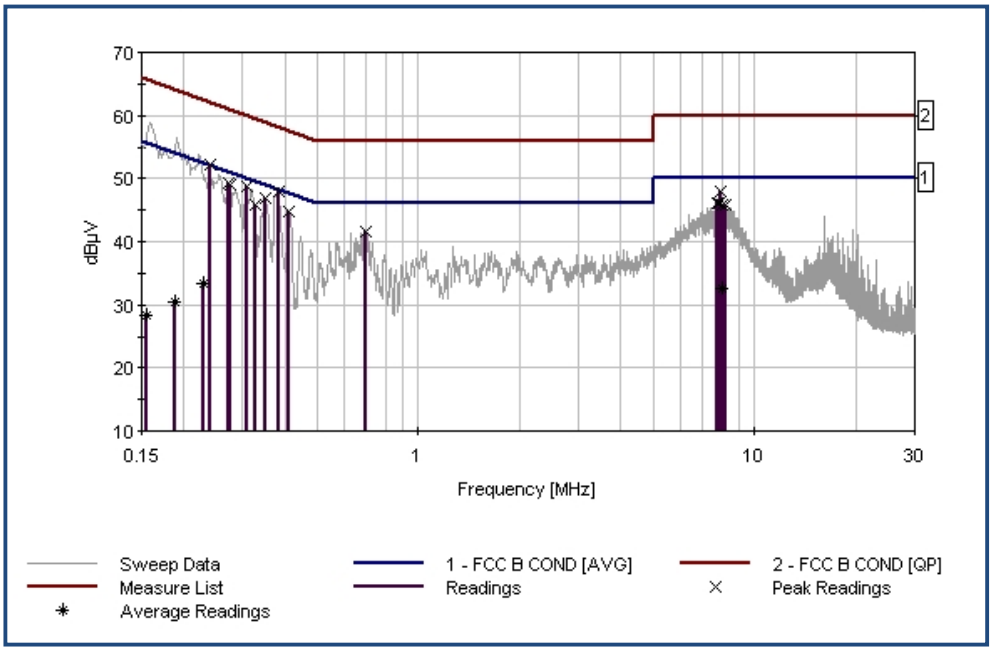


FIGURE 19 - CONDUCTED EMISSIONS PLOT – LINE 120V

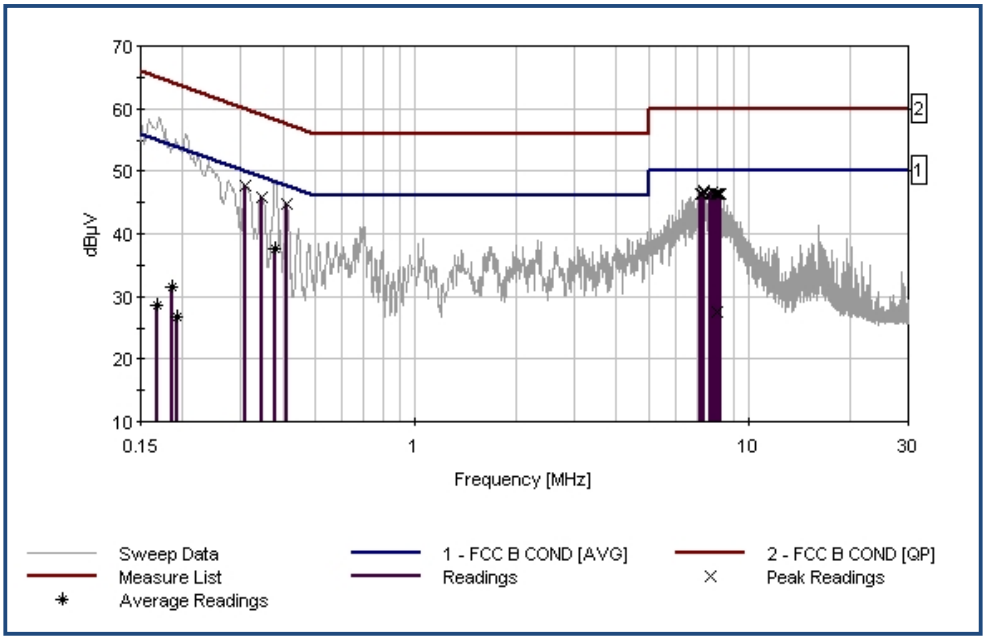


FIGURE 20 - CONDUCTED EMISSIONS PLOT – NEUTRAL 120V

12.4 Measurement Data, Line 120V

No.	Freq (MHz)	Rdng (dBuV)	Corrected (dBuV)	Spec (dBuV)	Margin (dB)	Polarity
1	382.706k	37.9	48.0	58.2	-10.2	Line
2	308.167k	38.7	48.8	60.0	-11.2	Line
3	275.443k	39.0	49.1	61.0	-11.9	Line
4	7.924M	37.9	48.0	60.0	-12.0	Line
5	326.347k	35.7	45.8	59.5	-13.7	Line
6	8.059M	35.8	45.9	60.0	-14.1	Line

12.5 Measurement Data, Neutral 120V

No.	Freq (MHz)	Rdng (dBuV)	Corrected (dBuV)	Spec (dBuV)	Margin (dB)	Polarity
1	409.976k	34.6	44.7	57.6	-12.9	Neutral
2	344.528k	35.8	45.9	59.1	-13.2	Neutral
3	7.346M	36.5	46.6	60.0	-13.4	Neutral
4	8.113M	36.4	46.5	60.0	-13.5	Neutral
5	8.231M	36.4	46.5	60.0	-13.5	Neutral
6	7.987M	36.2	46.3	60.0	-13.7	Neutral

12.6 Additional Information

Description	Comment
Test Engineer	A. Eadie
Test Date	12/02/2013

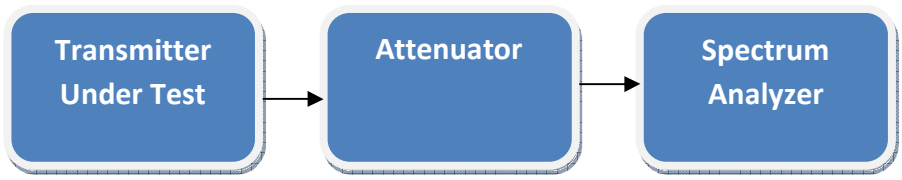
13 TEST EQUIPMENT

All applicable test equipment will be calibrated in accordance with ANSI Standard NCSL Z540-1 or other NIST traceable calibration standard. Equipment is calibrated on a 2 year cycle or according to the manufacturer's recommendations.

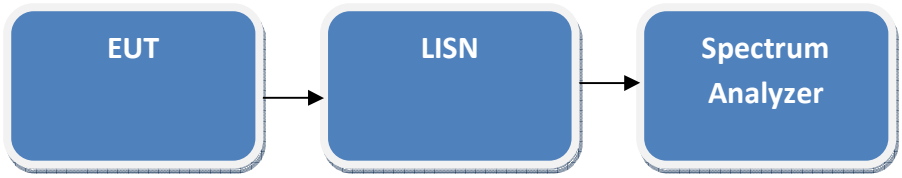
Manufacturer	Description	Model	Serial Number	Cal/Char Due Date D/M/Y
Agilent	Spectrum Analyzer	E4407B	US4142960	10/10/2014
Electro Metrics	Line Impedance Stabilization Network	EM-7823	115037	31/10/2013
Electro Metrics	Hybrid Antenna	EM-3141	9902-1141	07/12/2014
AH Systems	Horn Antenna	SAS-571	1242	18/11/2013

14 Test Diagrams

14.1 Conducted RF Test Setup



14.2 Power line conducted Emissions Test Setup



14.3 Radiated Emissions Test Setup