



W66 N220 Commerce Court • Cedarburg, WI 53012
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TEST REPORT #: 311291
LSR Job #: C-1311

Compliance Testing of:
TiWi-SL

Test Date(s):
October 1st – 21st, 2011

Prepared For:
LS Research
W66 N220 Commerce Court
Cedarburg, WI 53012

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

This Test Report is issued under the Authority of:
Shane Rismeyer, EMC Engineer

Signature: 

Date: 11/23/11

Quality Assurance by:
Peter Feilen, EMC Engineer

Signature:  Date: 11/21/11

Project Engineer:
Shane Rismeyer, EMC Engineer

Signature:  Date: 11/14/11

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EXHIBIT 1. INTRODUCTION

1.1 - Scope

References:	FCC Part 15, Subpart C, Section 15.247 and 15.209 FCC Part 2, Section 2.1043 paragraph (b)1. RSS GEN and RSS 210 Annex 8
Title:	FCC : Telecommunication – Code of Federal Regulations, CFR 47, Part 15. IC : Low-power License-exempt Radio-communication Devices (All Frequency Bands): Category I Equipment
Purpose of Test:	To gain FCC and IC Certification Authorization for Low- Power License-Exempt Transmitters.
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
Environmental Classification:	Commercial, Industrial or Business Residential

1.2 – Normative References

Publication	Title
47 CFR, Parts 0-15 (FCC)	Code of Federal Regulations - Telecommunications
RSS 210 Annex 8	Low-power License-exempt Radio- communication Devices (All Frequency Bands): Category I Equipment
ANSI C63.4	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
CISPR 16-1-1	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus.
CISPR 16-2-1	Specification for radio disturbance and immunity measuring apparatus and methods. Part 201: Conducted disturbance measurement.
FCC Public Notice DA 00-1407	Part 15 Unlicensed Modular Transmitter Approval
FCC ET Docket No. 99-231	Amendment to FCC Part 15 of the Commission's Rules Regarding Spread Spectrum Devices.
FCC Procedures	Measurement of Digital Transmission Systems operating under Section 15.247.

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1.3 - 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



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

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EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 - Client Information

Manufacturer Name:	LS Research, LLC
Address:	W66 N220 Commerce Court
Contact Name:	Josh Bablitch

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	TiWi-SL
Model Number:	TiWi-SL
Serial Number:	N/A

2.3 - Associated Antenna Description

See Appendix D for antenna data sheets.

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2.4 - EUT'S Technical Specifications

EUT Frequency Range (in MHz)	2412-2462
EIRP (in mW)	
Minimum:	212.8
Maximum:	353.2
Occupied Bandwidth (99% BW)	16.3 MHz for 54 Mbps 14.3 MHz for 1Mbps
Type of Modulation	64-QAM/QPSK
Emission Designator	16M3D1D(54Mbps)/14M3G1D(1Mbps)
Transmitter Spurious (worst case) at 3 meters	50.42 dB μ V/m
Receiver Spurious (worst case) at 3 meters	53.30 dB μ V/m
Stepped (Y/N)	Yes
Step Value:	(1/8)dB
Frequency Tolerance %, Hz, ppm	+/- 20ppm
Microprocessor Model # (if applicable)	n/a (System on a chip radio is CC3000)
Antenna Information	
Detachable/non-detachable	Non-detachable (chip)/detachable(dipole)
Type	Chip/Dipole
Gain (in dBi)	0.5 (chip)/2.0 (diploe)
EUT will be operated under FCC Rule Part(s)	15.247
EUT will be operated under RSS Rule Part(s)	210
Modular Filing	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Portable or Mobile?	Mobile

RF Technical Information:

Type of Evaluation (check one)	<input type="checkbox"/>	SAR Evaluation: Device Used in the Vicinity of the Human Head
	<input type="checkbox"/>	SAR Evaluation: Body-worn Device
	<input checked="" type="checkbox"/>	RF Evaluation

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

Evaluated against exposure limits: General Public Use Controlled Use

Duty Cycle used in evaluation: 100 %

Standard used for evaluation: OET 65

Measurement Distance: \geq 20 cm

RF Value: 0.111 V/m A/m mW/cm²

Measured Computed Calculated

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2.5 - Product Description

The TiWi module is a module with support for WLAN (802.11 b/g/n)

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EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	70 °F
Humidity:	40%
Pressure:	650 mmHg

3.2 - Applicability & Summary Of EMC Emission Test Results

FCC and IC Paragraph	Test Requirements	Compliance (Yes/No)
FCC : 15.207 IC : RSS GEN sect. 7.2.2	Power Line Conducted Emissions Measurements	Yes
FCC : 15.247(a)(2) IC : RSS 210 A8.2(a)	6 dB Bandwidth of a Digital Modulation System	Yes
IC : RSS GEN section 4.6.1	20 dB Bandwidth	Yes
FCC : 15.247(b) & 1.1310 IC : RSS 210 A8.4	Maximum Output Power	Yes
FCC : 15.247(i), 1.1307, 1.1310, 2.1091 & 2.1093 IC : RSS 102	RF Exposure Limit	Yes
FCC :15.247(c) IC : RSS 210 A8.5	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC : 15.247(d) IC : RSS 210 A8.2(b)	Transmitted Power Spectral Density of a Digital Modulation System	Yes
FCC : 15.247(c), 15.209 & 15.205 IC : RSS 210 A8.2(b), section 2.2, 2.6 and 2.7	Transmitter Radiated Emissions	Yes

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

3.3 - Modifications Incorporated In the EUT for Compliance Purposes

None Yes (explain below)

For the chip antenna the power level was set to 16.5 on Channel 11 in order to pass Upper Band Edge.

3.4 - Deviations & Exclusions from Test Specifications

None Yes (explain below)

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EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the requirements as described within the specification of FCC Title 47, CFR Part 15.247, and Industry Canada RSS-210, Issue 7 (2010), Section Annex 8 (section 8.2) for a Digital Spread Spectrum (DTS) Transmitter.

Note: If some emissions are seen to be within 3 dB of their respective limits; as these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

LS Research, LLC certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

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EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 - Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15, RSS GEN and ANSI C63.4. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber. The EUT was operated in modulated mode using power as provided by a laboratory bench supply. The unit has the capability to operate on 11 channels, controllable via laptop PC.

The applicable limits apply at a 3 meter distance. Measurements above 4 GHz were performed at a 1.0 meter separation distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of three (3) standard channels: low (2412 MHz), middle (2440 MHz) and high (2462 MHz) to comply with FCC Part 15.31(m). The channels and operating modes were changed using a PC.

5.2 - Test Procedure

Radiated RF measurements were performed on the EUT in 3 meter Semi-Anechoic and Compact Semi-Anechoic FCC listed Chambers. 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. For the lower frequency ranges the EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber with the antenna mast placed so that the separation distance between the antenna and EUT was 3 meters. A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, 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 4 GHz in the 3 meter Semi-Anechoic Chamber. The remaining measurements were taken in the Compact Semi-Anechoic Chamber at a separation distance of 1 meter. The Double-Ridged Waveguide Horn Antenna used from 4 GHz to 18 GHz and a Standard Gain Horn Antenna was used from 18 GHz to 25 GHz. The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. The EUT was rotated along three orthogonal axes during the investigations to find the highest emission levels.

5.3 - Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. The Agilent E4445A EMI Receiver was operated with a resolution bandwidth of 120 kHz for measurements below 1 GHz (video bandwidth of 300 kHz), and a bandwidth of 1 MHz for measurements above 1 GHz (video bandwidth of 1 MHz). From 4 GHz to 25 GHz, an Agilent E4446A Spectrum Analyzer was used.

5.4 - Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.247 and Canada RSS-210, Issue 7 (2010), Annex 8 for a DTS transmitter. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

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5.5 - Calculation of Radiated Emissions Limits

The maximum peak output power of an intentional radiator in the 2400-2483.5 MHz band, as specified in Title 47 CFR 15.247 (b)(3) and RSS 210 A8.4 is 1 Watt. The harmonic and spurious RF emissions, as measured in any 100 kHz bandwidth, as specified in 15.247 (d) and RSS 210 A8.2 (b), shall be at least 20 dB below the measured power of the desired signal, and must also meet the requirements described in 15.205(c) for FCC and section 2.2, 2.6 and 2.7 of RSS 210 for IC.

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 $\mu\text{V/m}$	3 m Limit (dB $\mu\text{V/m}$)	1 m Limit (dB $\mu\text{V/m}$)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-24,000	500	54.0	63.5

Sample conversion of field strength ($\mu\text{V/m}$ to dB $\mu\text{V/m}$):

$$\text{dB}\mu\text{V/m} = 20 \log_{10} (100) = 40 \text{ dB}\mu\text{V/m} \text{ (from 30-88 MHz)}$$

For measurements made at 1.0 meter, a 9.5 dB correction has been invoked.

$$\begin{aligned} &960 \text{ MHz to } 10,000 \text{ MHz} \\ &500\mu\text{V/m or } 54.0 \text{ dB}\mu\text{V/m at } 3 \text{ meters} \\ &54.0 + 9.5 = 63.5 \text{ dB}\mu\text{V/m at } 1 \text{ meter} \end{aligned}$$

Reported data is the raw data corrected for all applicable factors such as antenna factors, cable loss, etc.

Sample reported data at 240.8 MHz:

Raw Data + Antenna Factor + Cable Factor = Reported Data

$$4.33 \text{ dB}\mu\text{V/m} + 18.10 \text{ dB} + 1.20 \text{ dB} = 23.63 \text{ dB}\mu\text{V/m}$$

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5.6 - Radiated Emissions Test Data Chart

3 Meter Measurements of Electromagnetic Radiated Emissions

Test Standard: 47CFR, Part 15.205 and 15.247(DTS)

RSS 210 A8, sections 2.2, 2.6 and 2.7

Frequency Range Inspected: 30 MHz to 25000 MHz

Manufacturer:	LSR				
Date(s) of Test:	10/12/11-10/19/11				
Test Engineer(s):	Shane Rismeyer and Peter Feilen				
Voltage:	3.3 VDC				
Operation Mode:	Modulated				
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %				
EUT Power:	<input checked="" type="checkbox"/>	Single Phase 3.3VDC		3 Phase ___ VAC	
		Battery		Other:	
EUT Placement:	<input checked="" type="checkbox"/>	80cm non-conductive table		10cm Spacers	
EUT Test Location:	<input checked="" type="checkbox"/>	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS	
Measurements:		Pre-Compliance		Preliminary	<input checked="" type="checkbox"/> Final
Detectors Used:	<input checked="" type="checkbox"/>	Peak	<input checked="" type="checkbox"/>	Quasi-Peak	<input checked="" type="checkbox"/> Average

The following table depicts the level of significant spurious radiated RF emissions found:

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (degrees)	Quasi-Peak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
240.8	Vertical/Side	1.00	0	23.63	46.0	22.4
62.2	Vertical/Side	1.00	0	23.57	40.0	16.4
999.2	Vertical/Side	1.00	0	29.19	54.0	24.8
3860.4	Horizontal/Side	1.20	90	50.42	54.0	3.6
246.4	Vertical/Vertical	1.00	0	25.82	46.0	20.2
317.0	Horizontal/Vertical	1.00	330	22.14	46.0	23.9
997.5	Vertical/Vertical	1.00	0	29.39	54.0	24.6

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RADIATED EMISSIONS DATA CHART (continued)

The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 1 for the Chip Antenna (1Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
12059.2	V/Flat	119.9	76	57.12	52.10	63.50	11.40
7236.0	V/Flat	114.8	46	53.50	49.42	63.50	14.08
14472.0	V/Vertical	110.2	7	59.76	55.90	63.50	7.60
4824.0	V/Vertical	107.2	147	57.75	54.98	63.50	8.52

The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 7 for the Chip Antenna (1Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
12210.0	V/Flat	120.1	52	58.30	52.86	63.50	10.64
4884.0	H/Flat	119.3	174	55.42	52.52	63.50	10.98
7325.9	V/Flat	110.9	51	51.52	49.86	63.50	13.64

The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 11 for the Chip Antenna (1Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
4924.1	V/Side	111.5	98	55.04	51.67	63.50	11.8
7386.4	H/Vertical	109.8	233	54.47	51.40	63.50	12.10

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The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 1 for the Chip Antenna (54Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
7236.0	H/Vertical	102.0	344	54.09	49.57	63.50	13.93

The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 11 for the Chip Antenna (54Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
7385.8	H/Vertical	103.0	225	54.02	50.53	63.50	13.03

The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 1 for the Dipole Antenna (1Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
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7236.0	H/Vertical	101.4	331	57.24	53.93	63.50	9.63
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The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 7 for the Dipole Antenna (1Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
4883.9	H/Side	102.9	170	53.34	49.99	63.50	13.51
7325.8	H/Flat	109.6	322	58.92	53.03	63.50	10.53
12210.0	H/Vertical	113.1	62	60.46	55.34	63.50	8.24

The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 11 for the Dipole Antenna (1Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
4923.8	H/Flat	117.2	107	54.16	49.64	63.50	13.94
7386.1	H/Side	108.8	114	59.32	53.59	63.50	9.91
12312.0	V/Side	106.7	336	57.13	51.15	63.50	12.35

The following table depicts the level of significant radiated RF harmonic emissions seen on Channel 7 for the Dipole Antenna (54Mbps):

Frequency (MHz)	Ant./EUT Polarity	Height (cm)	Azimuth (degrees)	Peak (dB μ V/m)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
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7326.2	V/Flat	127.1	261	56.07	52.95	63.50	10.55
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Notes:

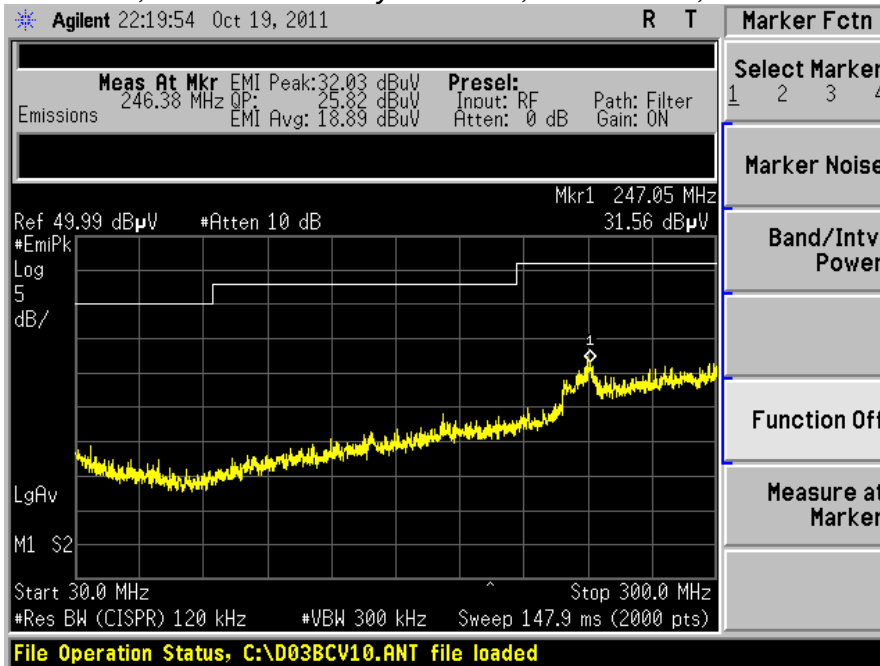
1. A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak as well as an Average Detector was used in measurements above 1 GHz. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits.
2. Measurements above 4 GHz were made at 1 meters of separation from the EUT.
3. Measurements that were greater than 15 dB are not show in the tables.

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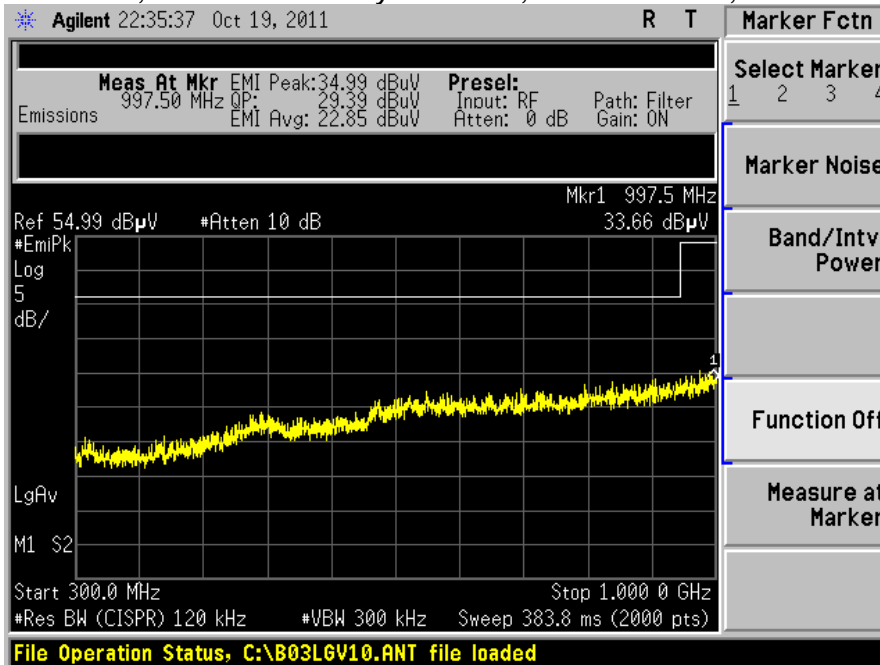
5.7 - Screen Captures - Radiated Emissions Test

These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and an Average detector function is utilized when measuring frequencies above 1 GHz.

Channel 7, Antenna Vertically Polarized, 30-300 MHz, at 3m



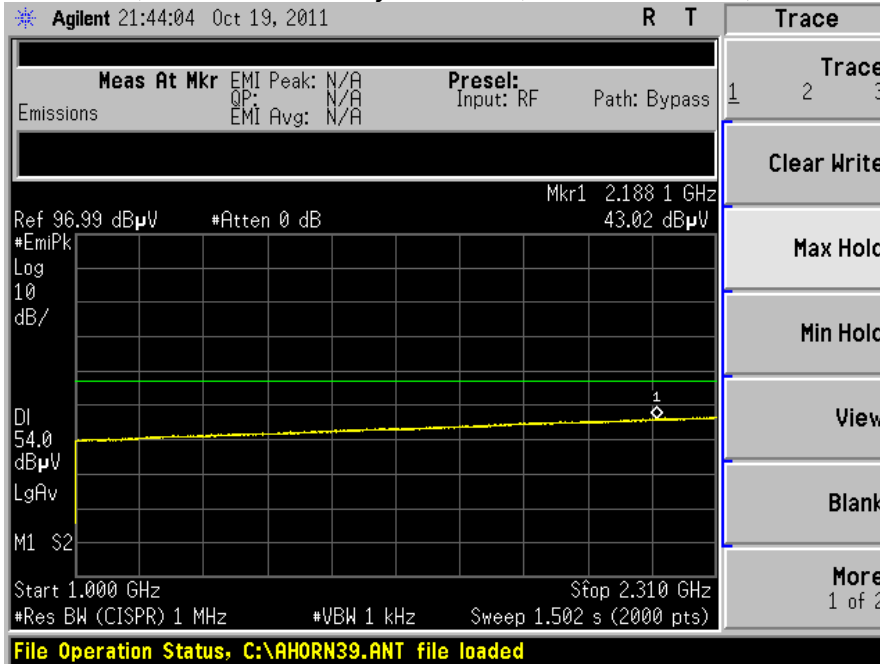
Channel 7, Antenna Vertically Polarized, 300-1000 MHz, at 3m



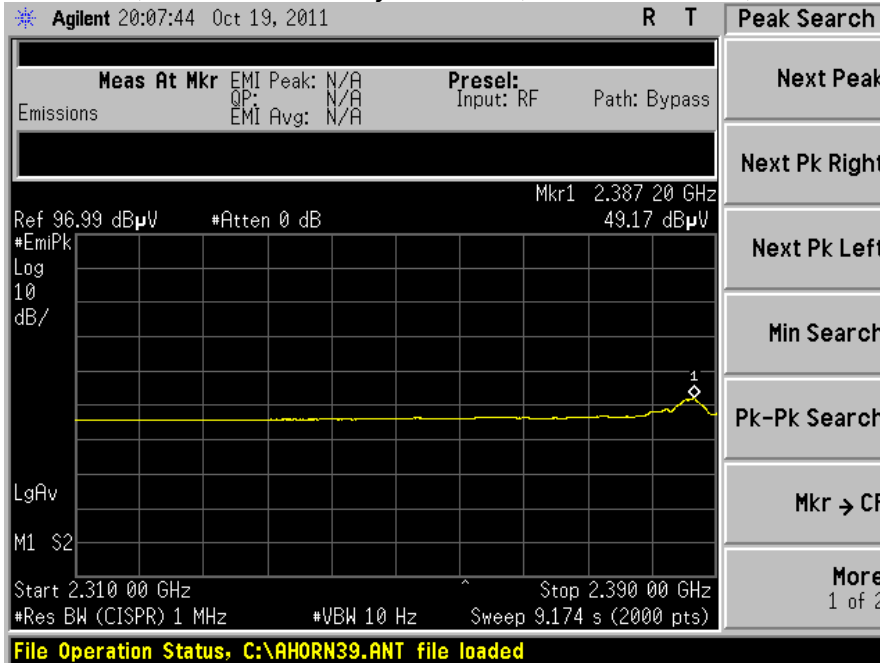
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Screen Captures - Radiated Emissions Testing (continued)

Channel 7, Antenna Vertically Polarized, 1000-2310 MHz, at 3m



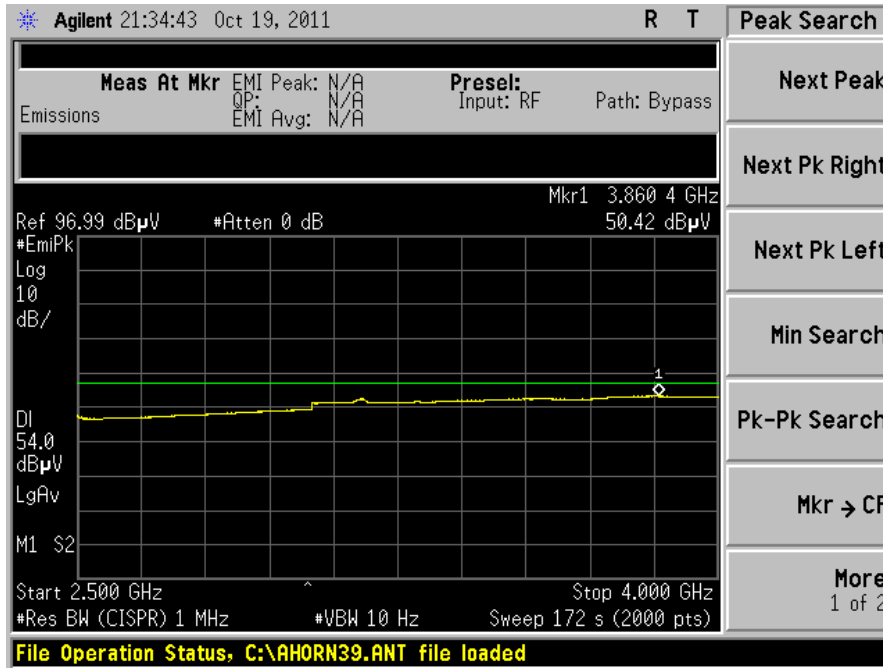
Channel 7, Antenna Vertically Polarized, 2310-2390 MHz, at 3m



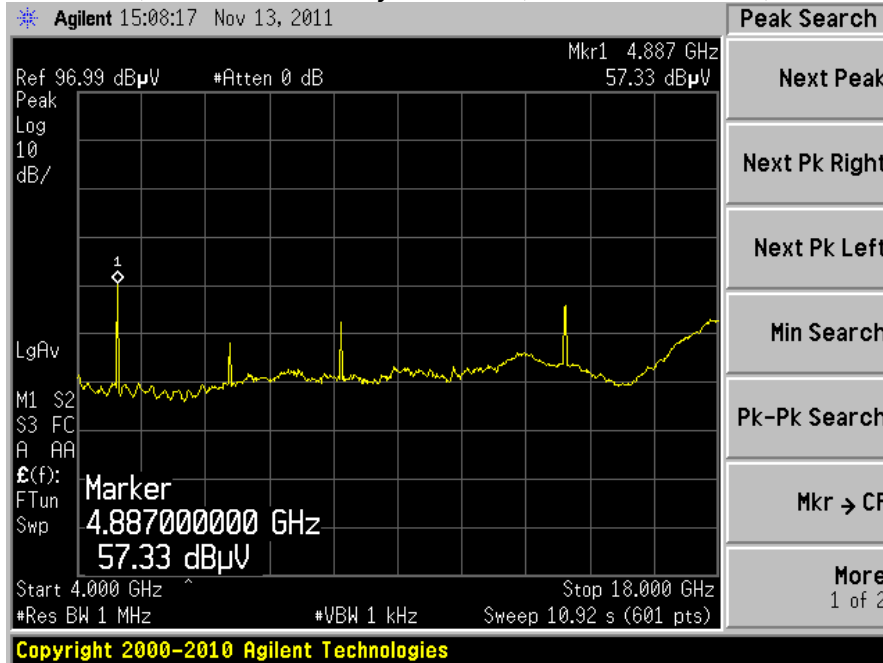
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Screen Captures - Radiated Emissions Testing (continued)

Channel 7, Antenna Vertically Polarized, 2500-4000 MHz, at 3m



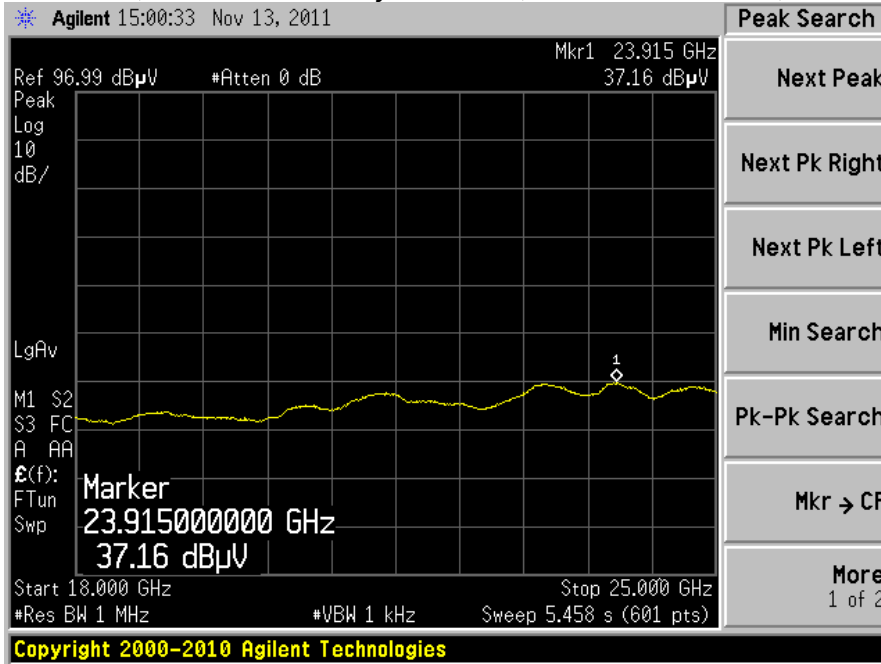
Channel 7, Antenna Vertically Polarized, 4000-18000 MHz, at 1m



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Screen Captures - Radiated Emissions Testing (continued)

Channel 7, Antenna Vertically Polarized, 18000-25000 MHz, at 1m



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

5.8 - Receive Mode Testing

Per the requirements of RSS-210, the EUT was placed in continuous receive mode and the radiated spurious emissions were measured and compared to the limits stated in RSS-Gen Section 4.10.

The test setup, procedure, and equipment utilized were identical to that described in sections 5.1, 5.2, and 5.3 of this document.

Measurement data and screen captures from the receive tests are presented below:

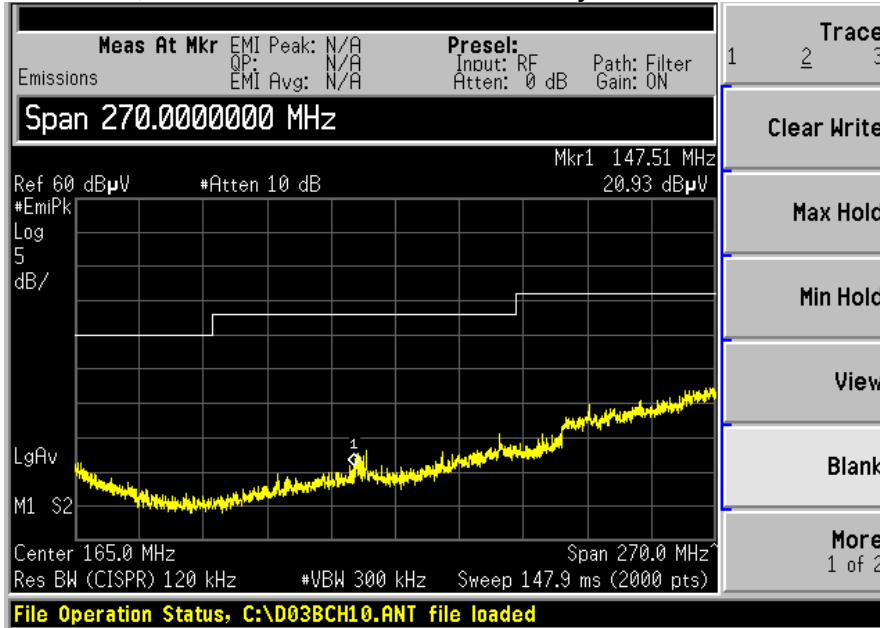
Frequency (MHz)	Height (m)	Azimuth (degree)	Reading (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Antenna Polarity	EUT orientation
9847.9	1.01	216	62.8	63.5	0.7	Vertical	Flat
298.0	1.00	0	29.4	47.0	17.6	Vertical	Flat
998.9	1.00	0	34.1	54.0	19.9	Vertical	Flat

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

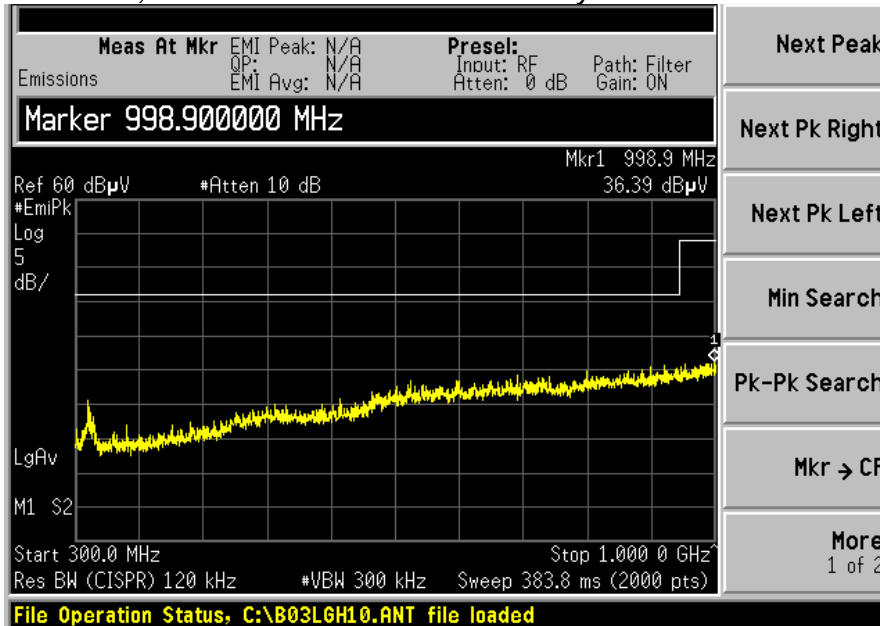
5.9 - Screen Captures - Radiated Emissions Testing - Receive Mode

These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and an Average detector function is utilized when measuring frequencies above 1 GHz.

Channel 7, 30-300 MHz Antenna Horizontally Polarized



Channel 7, 300-1000 MHz Antenna Vertically Polarized



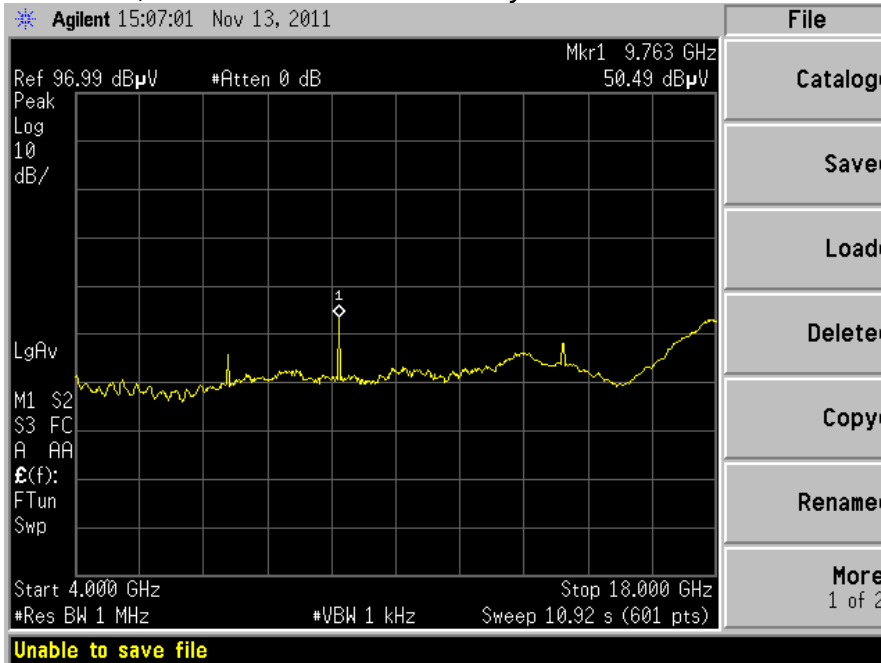
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Screen Captures - Radiated Emissions Testing – Receive Mode (continued)

Channel 7, 1-4 GHz Antenna Horizontally Polarized



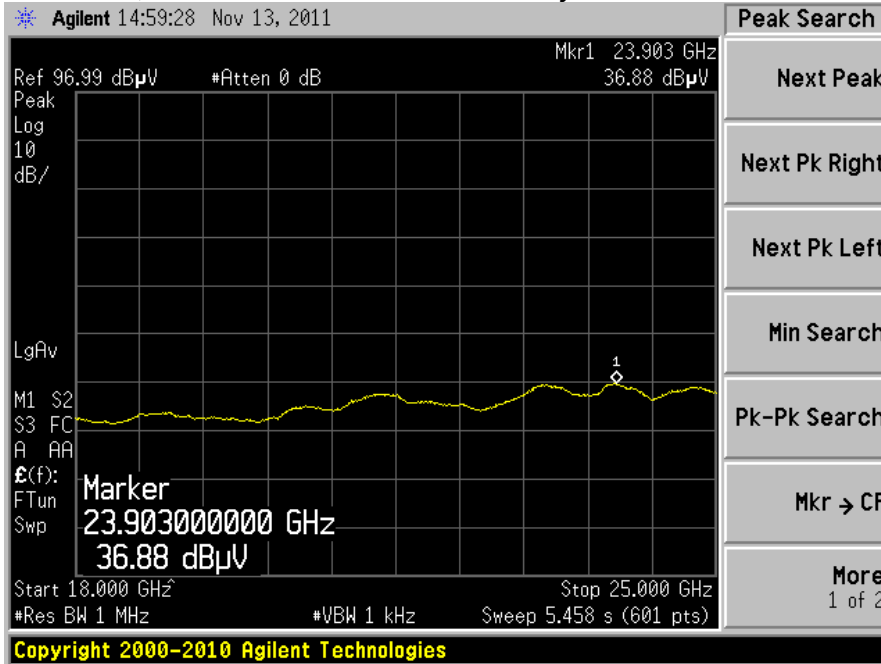
Channel 7, 4-18 GHz Antenna Vertically Polarized



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Screen Captures - Radiated Emissions Testing – Receive Mode (continued)

Channel 7, 18-25 GHz Antenna Horizontally Polarized



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

6.1 - 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 50 Ω (ohm), 50/250 μ H Line Impedance Stabilization Network (LISN). The AC power supply of 120V was provided inside the 3 Meter Semi-Anechoic Chamber 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 HP 8546A EMI Receiver. The EMCO LISN used has the ability to terminate the unused port with a 50 Ω (ohm) load when switched to either L1 (line) or L2 (neutral).

6.2 - Test Procedure

The EUT was investigated in continuous modulated transmit mode for this portion of the testing. The appropriate frequency range and bandwidths were selected on the EMI Receiver, and measurements were made. The bandwidth used for these measurements is 9 kHz, as specified in CISPR 16-1, Section 1, Table 1, for Quasi-Peak and Average detectors in the frequency range of 150 kHz to 30 MHz. Final readings were then taken and recorded.

6.3 - Test Equipment Utilized

A list of the test equipment and accessories utilized for the Conducted Emissions test is provided in Appendix A.

6.4 - Test Results

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

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

6.5 - FCC Limits of Conducted Emissions at the AC Mains Ports

The follow table represents the limits for Conducted Emissions Class B taken from CFR 15.207:

Frequency Range (MHz)	Quasi-Peak Limit (dBµV)	Average Limit (dBµV)
0.150 -0.50 *	66-56	56-46
0.5 – 5.0	56	46
5.0 – 30	60	50
* The limit decreases linearly with the logarithm of the frequency in this range.		

Sample calculation for the limits in the 0.15 to 0.5 MHz:

$$\text{Limit} = -19.12 (\text{Log}_{10} (F [\text{MHz}] / 0.15 [\text{MHz}])) + 66.0 \text{ dB}\mu\text{V}$$

For a frequency of 200 kHz for example:

$$\text{Quasi-Peak Limit (F=200 kHz)} = -19.12 (\text{Log}_{10} (0.2[\text{MHz}] / 0.15 [\text{MHz}])) + 66.0 \text{ dB}\mu\text{V}$$

$$\text{Quasi-Peak Limit (F=200 kHz)} = 63.6 \text{ dB}\mu\text{V}$$

$$\text{Average Limit (F=200 kHz)} = -19.12 (\text{Log}_{10} (0.2[\text{MHz}]/0.15[\text{MHz}])) + 56.0 \text{ dB}\mu\text{V}$$

$$\text{Average Limit (F = 200 kHz)} = 53.6 \text{ dB}\mu\text{V}$$

Reported data is the raw data corrected for all applicable factors such as antenna factors, cable loss, etc.

Sample reported data at 0.602 MHz:

Raw Data + Antenna Factor (LISN) + Transient Limiter= Reported Data

$$17.9 \text{ dB}\mu\text{V} + 1.0 \text{ dB} + 10.2 \text{ dB} = 29.1 \text{ dB}\mu\text{V}$$

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

6.6 – Conducted Emissions Test Data Chart

Frequency Range inspected: 150 KHz to 30 MHz

Test Standard: FCC 15.207 Class B

IC RSS GEN 7.2.2

Manufacturer:	LSR				
Date(s) of Test:	11/13/11				
Test Engineer:	Shane Rismeyer				
Voltage:	3.3VDC				
Operation Mode:	Modulated				
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %				
Test Location:	<input checked="" type="checkbox"/>	Other			Chamber
EUT Placed On:	<input checked="" type="checkbox"/>	40cm from Vertical Ground Plane			10cm Spacers
	<input checked="" type="checkbox"/>	80cm above Ground Plane			Other:
Measurements:		Pre-Compliance		Preliminary	<input checked="" type="checkbox"/> Final
Detector Used:		Peak	<input checked="" type="checkbox"/>	Quasi-Peak	<input checked="" type="checkbox"/> Average

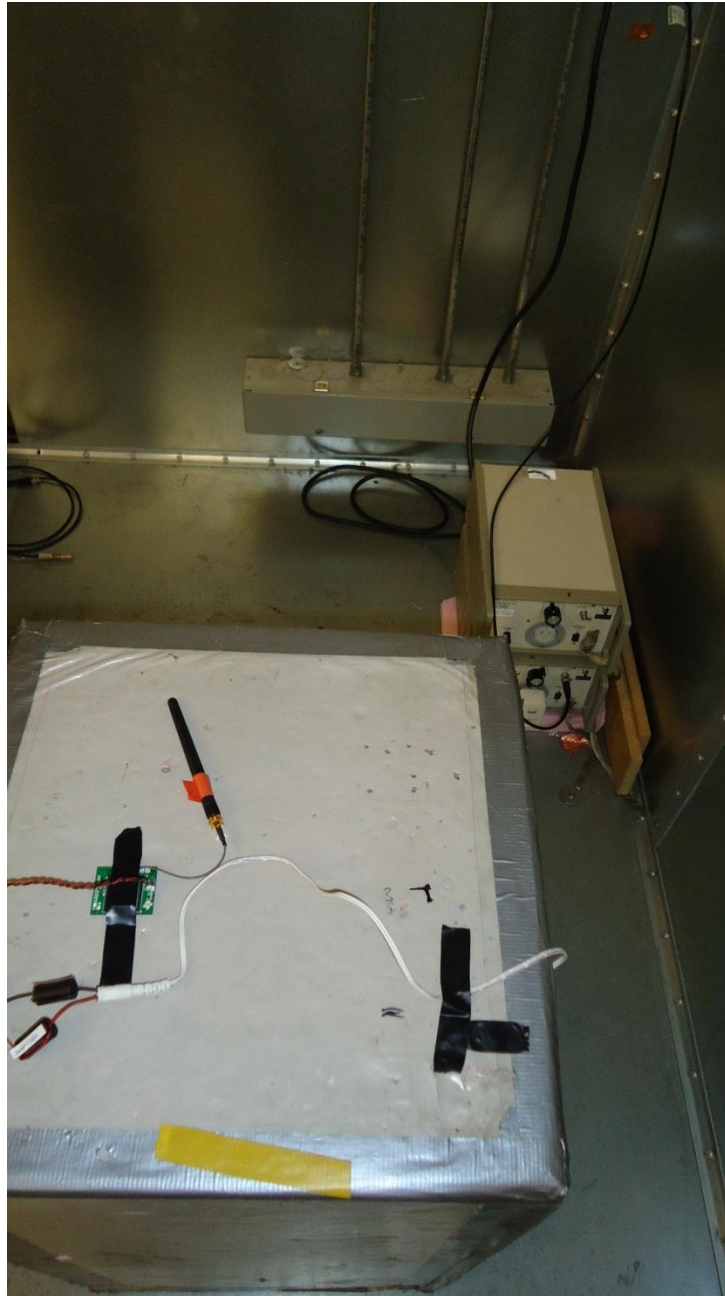
Frequency (MHz)	Line	QUASI-PEAK			AVERAGE		
		Reading (dBµV)	Limit (dBµ V)	Margin (dB)	Reading (dBµV)	Limit (dBµ V)	Margin (dB)
0.602	L1	29.1	56.0	26.9	23.1	46.0	22.9
0.599	L2	27.8	56.0	28.2	22.4	46.0	23.6

Notes:

- 1) All other emissions were better than 20 dB below the limits.
- 2) The EUT exhibited similar emissions in transmit and receive modes, and across the Low, Middle and High channels tested.

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

6.7 - Test Setup Photo(s) - Conducted Emissions Test

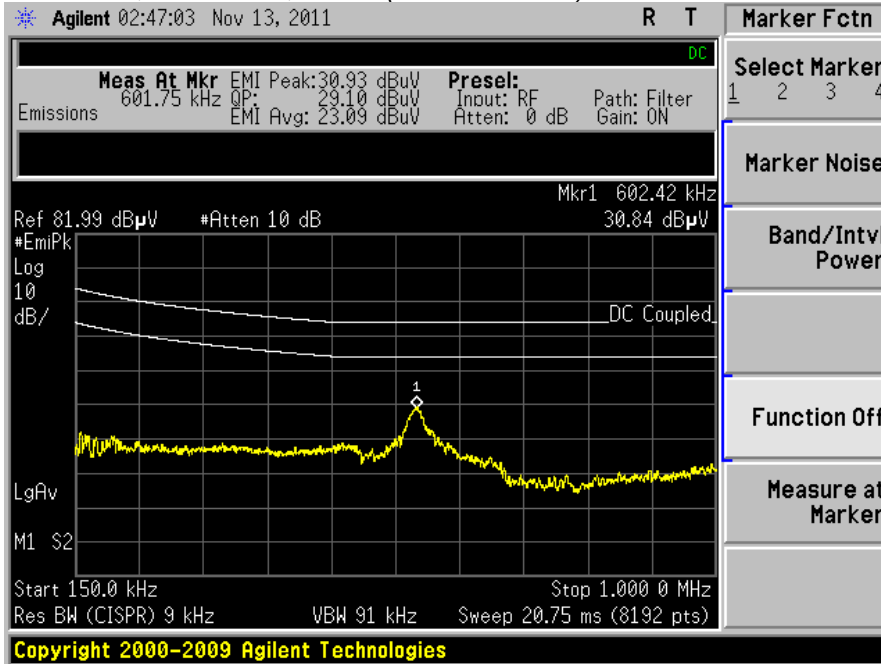


Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

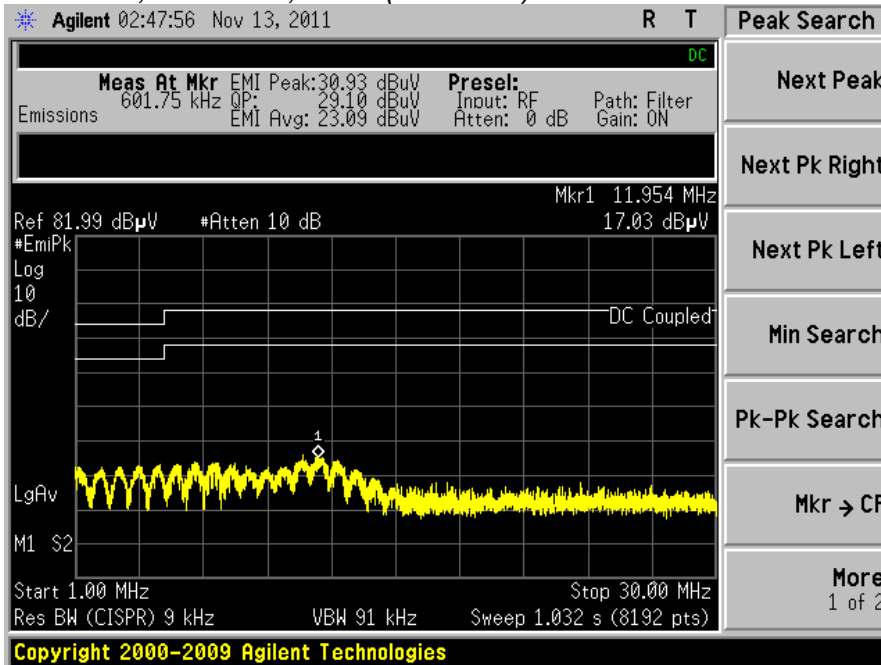
6.8 - Screen Captures - Conducted Emissions Test

These screen captures represent Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized. The emissions must meet both the Quasi-peak limit and the Average limit as described in 47 CFR 15.207 and RSS GEN 7.2.2 (Table 2).

Channel 7, 2442 MHz, Line 1(150-1000 kHz)

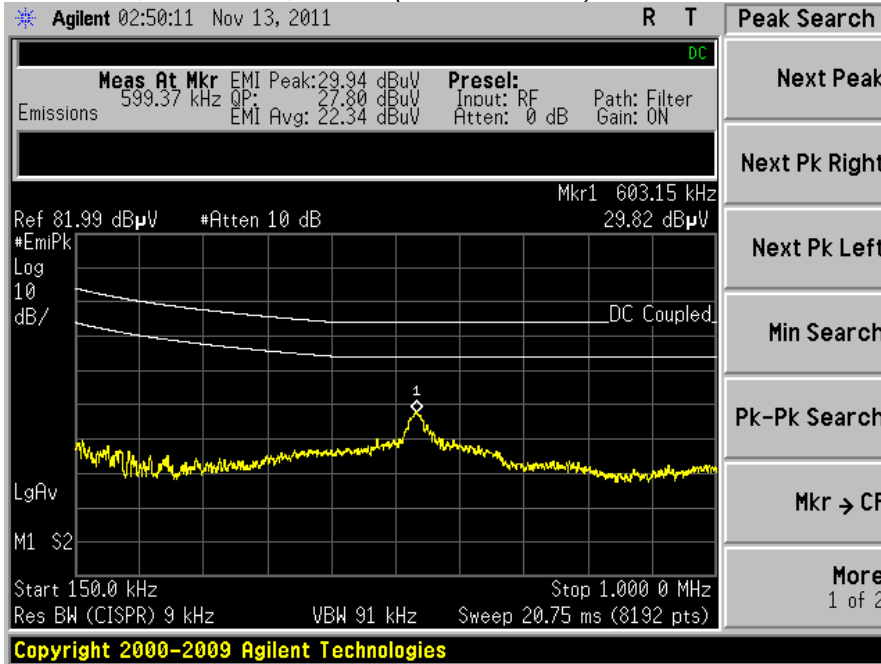


Channel 7, 2442 MHz, Line 1(1-30 MHz)

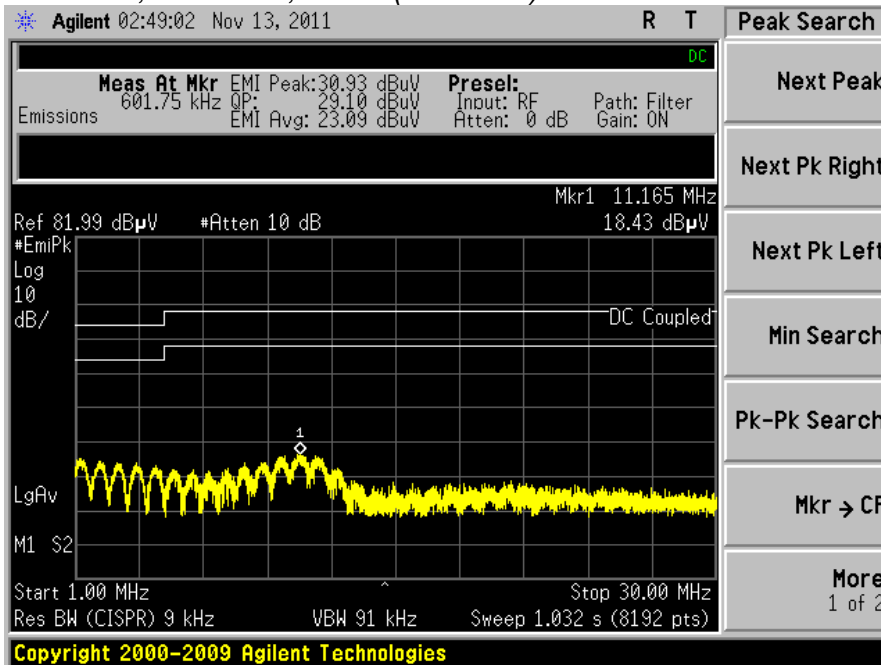


Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7, 2442 MHz, Line 2 (150-1000 kHz)



Channel 7, 2442 MHz, Line 2 (1-30 MHz)



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

EXHIBIT 7. OCCUPIED BANDWIDTH

7.1 - Limits

For a Digital Modulation System, the 6 dB bandwidth shall be at least 500 kHz.

7.2 - Method of Measurements

Refer to ANSI C63.4 and FCC Procedures for Digital Transmission Systems operating under 15.247.

The transmitter output was connected to the Spectrum Analyzer. The bandwidth of the fundamental frequency was measured with the Spectrum Analyzer using 510/470kHz RBW and VBW=3/4 MHz depending on the data rate.

The bandwidth requirement found in FCC Part 15.247(a)(2) and RSS 210 A8.2(a) requires a minimum -6dBc occupied bandwidth of 500 kHz. In addition, Industry Canada (IC RSS GEN 4.6.1) requires the measurement of the -20dBc occupied bandwidth. For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to the Agilent E4446A 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, thereby 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 spectrum analyzer was used in peak-hold mode while measurements were made, as presented in the chart below.

7.3 - Test Equipment List

A complete list of test equipment that was used for this test can be found in Appendix A.

7.4 - Test Data

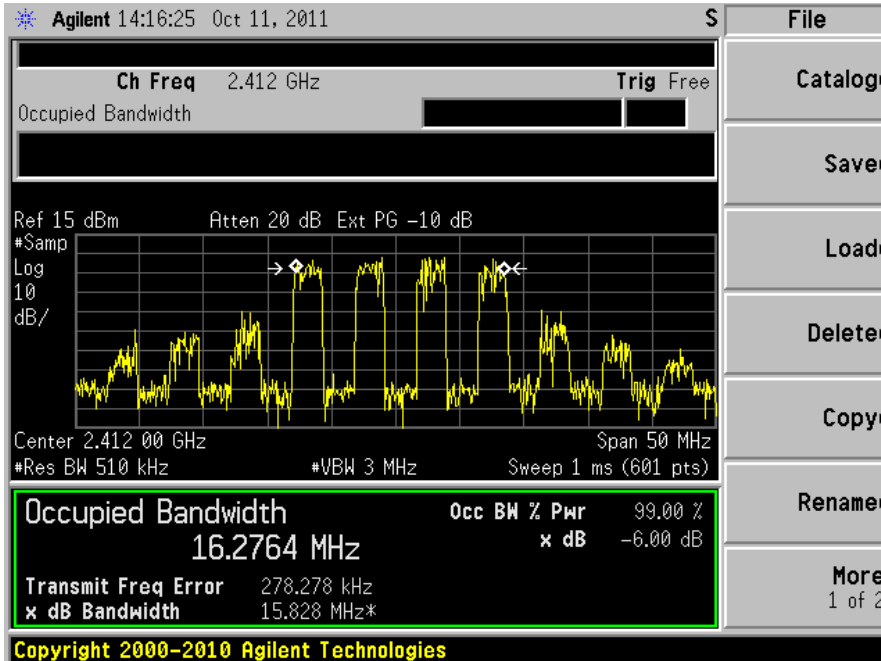
Channel	Center Freq (MHz)	-6 dBc OBW (MHz)	-20 dBc OBW (MHz)	Data Rate (Mbps)
1	2412	15.83	16.28	54
7	2442	15.01	16.13	54
11	2462	13.79	16.30	54
1	2412	8.38	14.10	1
7	2442	9.65	14.05	1
11	2462	9.61	14.33	1

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

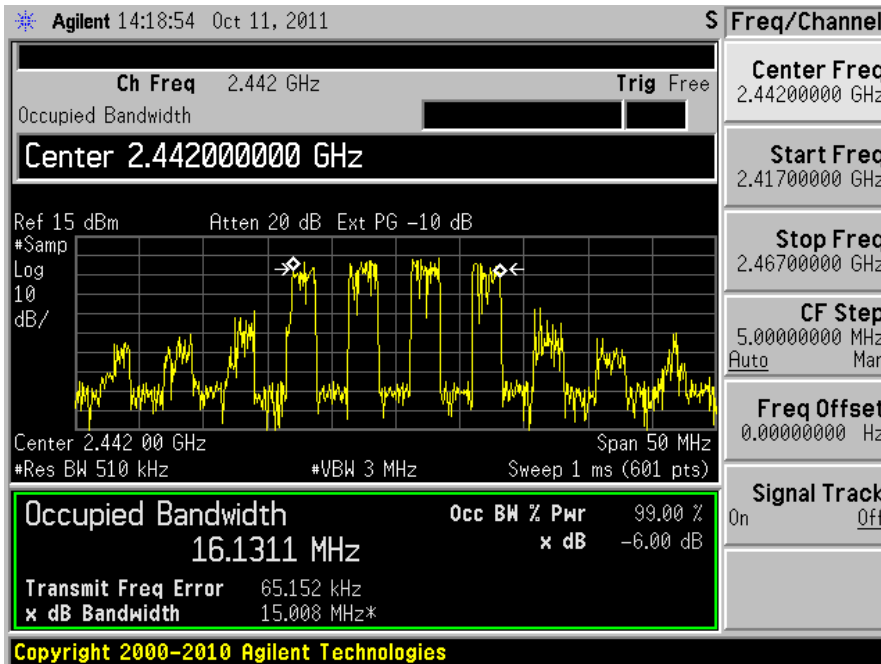
7.5 - Screen Captures - Occupied Bandwidth

Captures for 54Mbps Data Rate

Channel 1

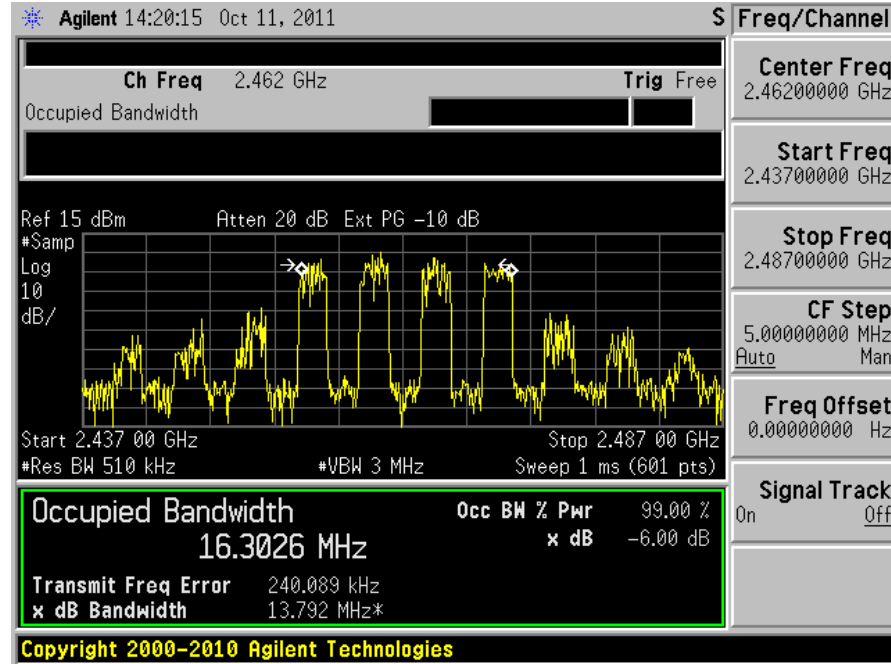


Channel 7



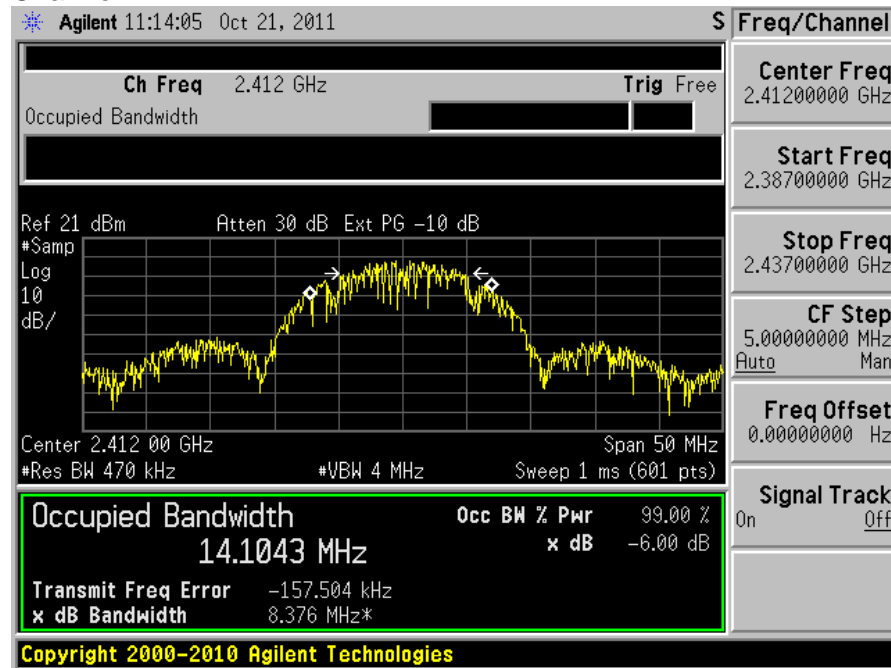
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 11



Captures for 1Mbps Data Rate

Channel 1



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7

Agilent 11:13:28 Oct 21, 2011

Ch Freq 2.442 GHz Trig Free

Occupied Bandwidth

Ref 21 dBm Atten 30 dB Ext PG -10 dB

#Samp Log 10 dB/

Start 2.417 00 GHz Stop 2.467 00 GHz

#Res BW 470 kHz #VBW 4 MHz Sweep 1 ms (601 pts)

Occupied Bandwidth	Occ BW % Pwr	99.00 %
14.0487 MHz	x dB	-6.00 dB
Transmit Freq Error		-91.832 kHz
x dB Bandwidth		9.652 MHz*

Copyright 2000-2010 Agilent Technologies

S Freq/Channel

Center Freq 2.44200000 GHz

Start Freq 2.41700000 GHz

Stop Freq 2.46700000 GHz

CF Step 5.00000000 MHz
Auto Man

Freq Offset 0.00000000 Hz

Signal Track On Off

Channel 11

Agilent 11:12:39 Oct 21, 2011

Ch Freq 2.462 GHz Trig Free

Occupied Bandwidth

Ref 21 dBm Atten 30 dB Ext PG -10 dB

#Samp Log 10 dB/

Start 2.437 00 GHz Stop 2.487 00 GHz

#Res BW 470 kHz #VBW 4 MHz Sweep 1 ms (601 pts)

Occupied Bandwidth	Occ BW % Pwr	99.00 %
14.3281 MHz	x dB	-6.00 dB
Transmit Freq Error		-151.147 kHz
x dB Bandwidth		9.612 MHz*

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S Measure

Meas Off

Channel Power

Occupied BW

ACP

Multi Carrier Power

Power Stat CCDF

More 1 of 2

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

EXHIBIT 8. BAND EDGE MEASUREMENTS

8.1 - Method of Measurements

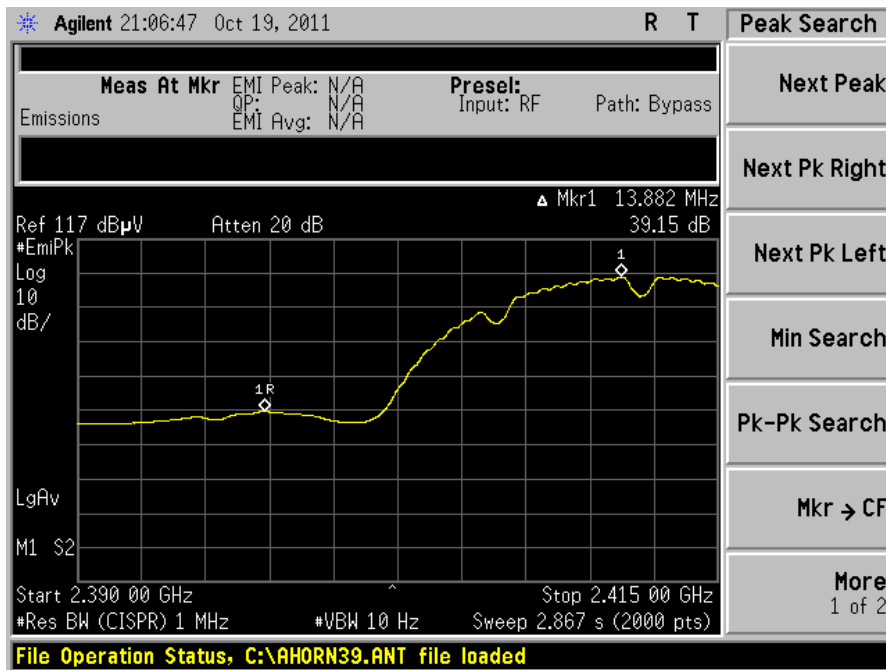
FCC 15.209(b) and 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the Band-Edges where the intentional radiator operates. Also, RSS 210 Section 2.2 requires that unwanted emissions meet limits listed in tables 2 and 3 of the same standard and also to the limits in the applicable annex. The following screen captures demonstrate compliance of the intentional radiator at the 2400-2483.5 MHz Band-Edges. The EUT was operated in continuous transmit mode with continuous modulation, with internally generated data as the modulating source. The EUT was operated at the lowest channel for the investigation of the lower Band-Edge, and at the highest channel for the investigation of the higher Band-Edge.

The Lower Band-Edge limit, in this case, would be -20 dBc with respect to the fundamental level.

The Upper Band-Edge limit, in this case, would be + 54 dB μ V/m at 3m.

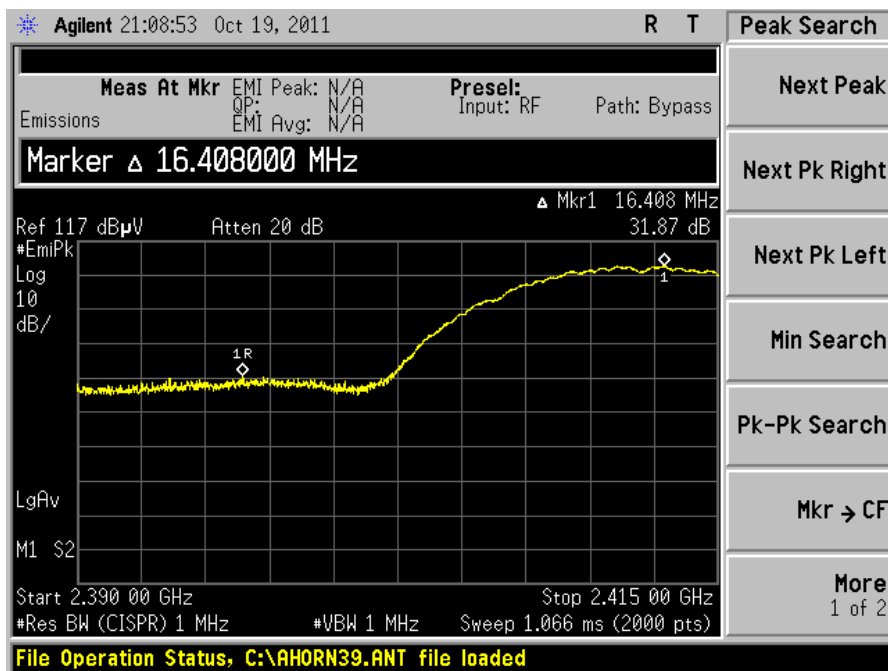
Screen Capture Demonstrating Compliance at the Lower Band-Edge

For Dipole Antenna 1Mbps Data Rate:



Average

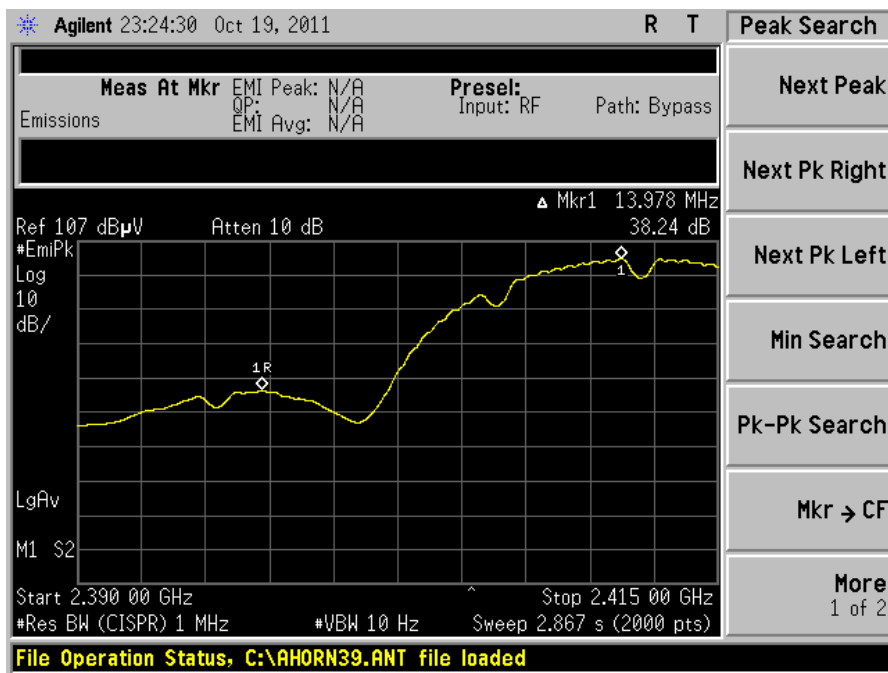
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311



- Peak Search
- Next Peak
- Next Pk Right
- Next Pk Left
- Min Search
- PK-Pk Search
- Mkr \rightarrow CF
- More 1 of 2

Peak

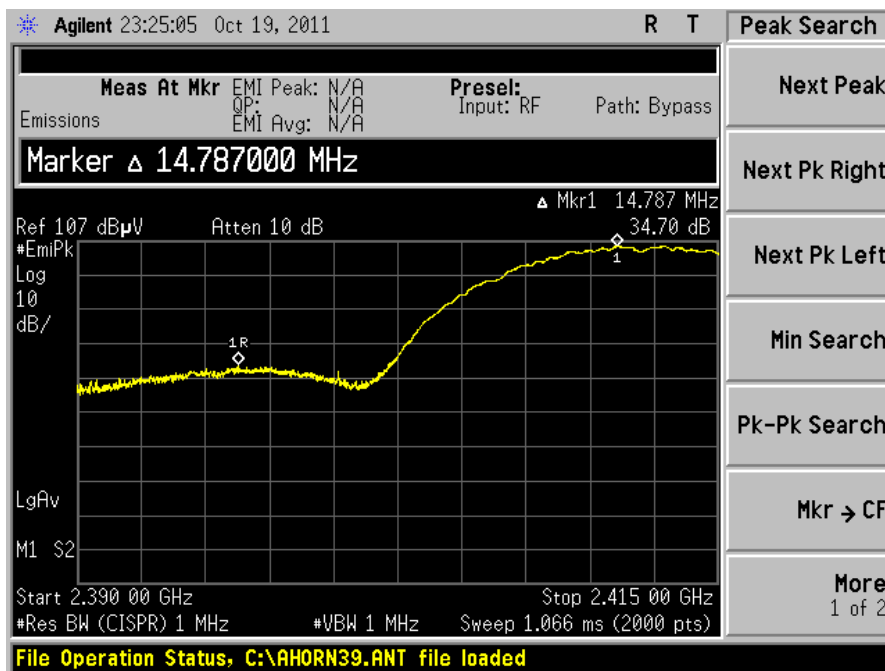
For Chip Antenna 1Mbps Data Rate:



- Peak Search
- Next Peak
- Next Pk Right
- Next Pk Left
- Min Search
- PK-Pk Search
- Mkr \rightarrow CF
- More 1 of 2

Average

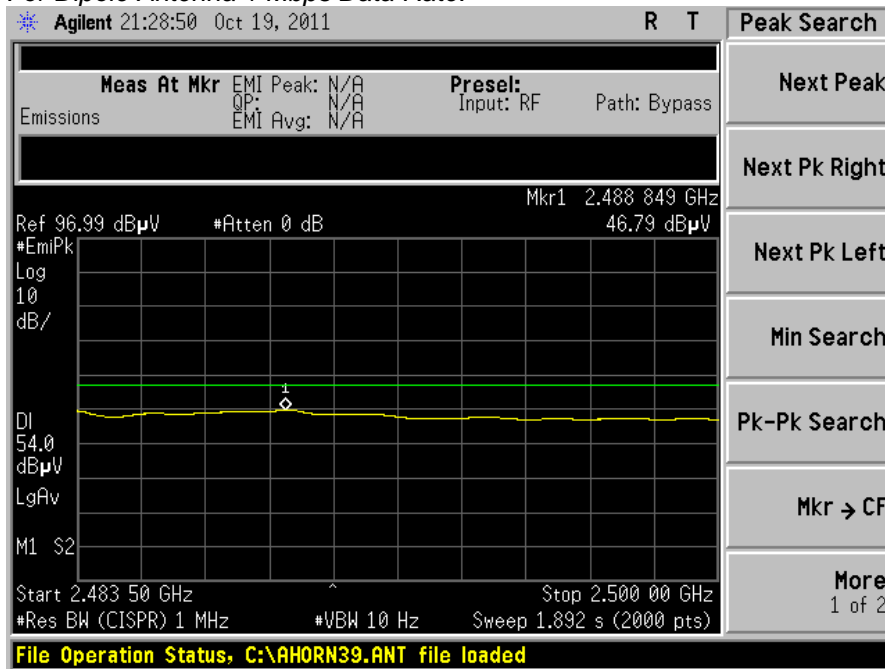
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311



Peak

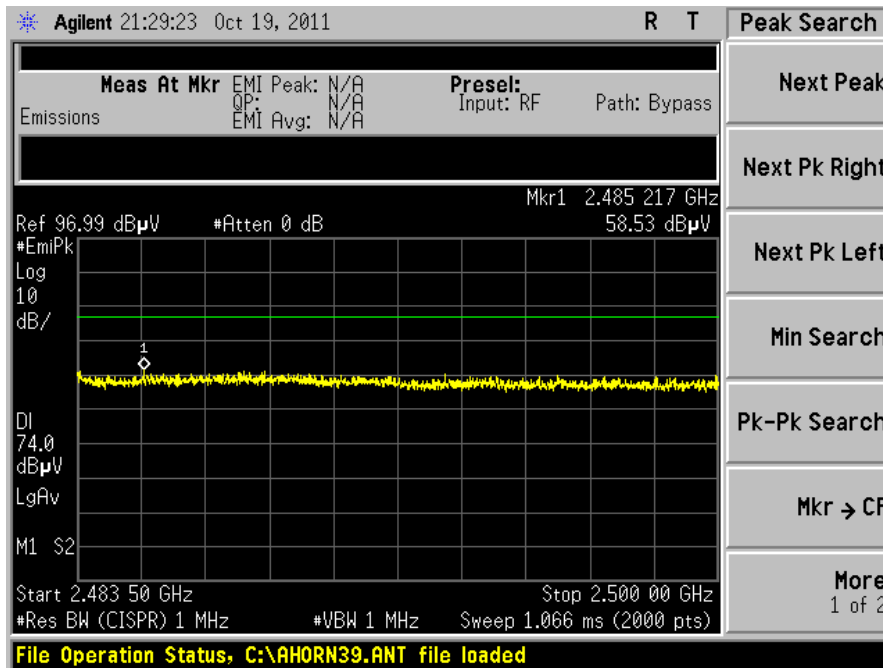
Screen Capture Demonstrating Compliance at the Higher Band-Edge

For Dipole Antenna 1 Mbps Data Rate:



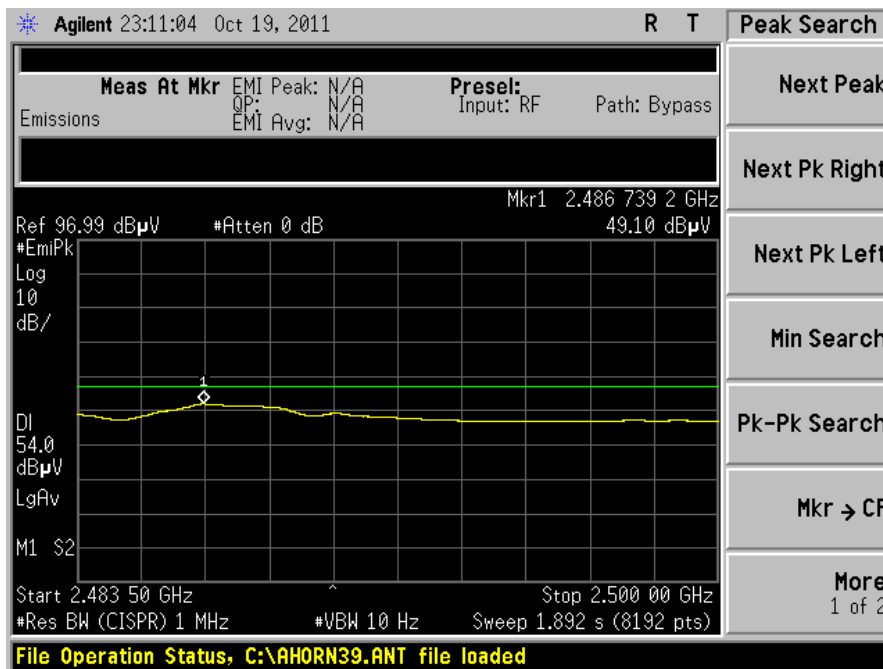
Average

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311



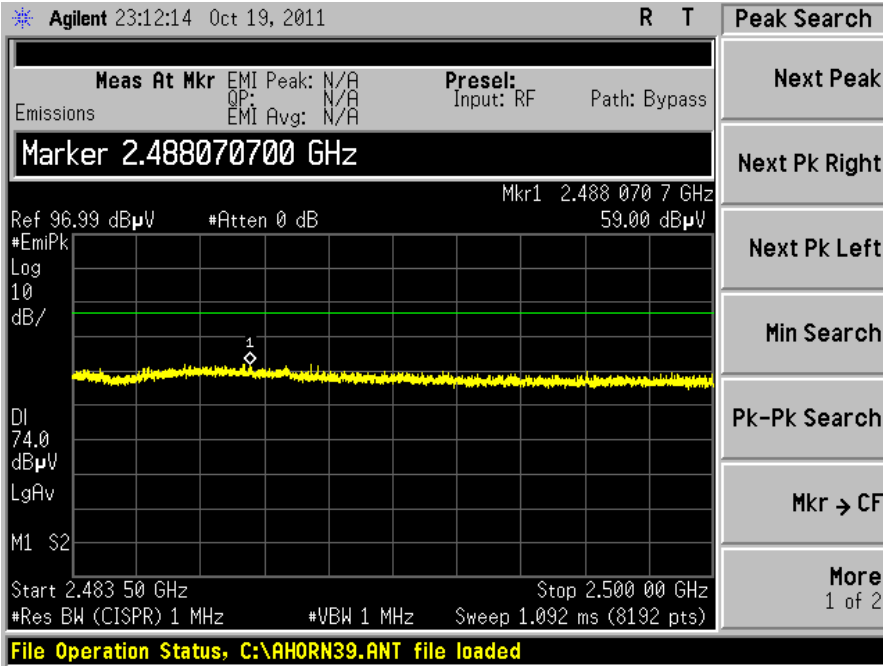
Peak

For Chip Antenna 1 Mbps Data Rate:



Average

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311



- Next Peak
- Next Pk Right
- Next Pk Left
- Min Search
- PK-Pk Search
- Mkr → CF
- More
1 of 2

Peak

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

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

9.1 - Method of Measurements

The conducted RF output power of the EUT was measured at the antenna port using a short RF cable. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with resolution and video bandwidths set to 8 MHz, and a span of 50 MHz, with measurements from a peak detector presented in the chart below.

9.2 - Test Equipment List

A complete list of test equipment that was used for this test can be found in Appendix A.

9.3 - Test Data

Channel	Freq. (MHz)	Data Rate (Mbps)	Limit (dBm)	Measured Power (dBm)	Corrected Power (dBm) ⁽¹⁾	Margin (dB)
1	2412	54	+30 dBm	21.24	24.33	5.67
7	2442	54	+30 dBm	20.70	23.79	6.21
11	2462	54	+30 dBm	20.19	23.28	6.72
1	2412	1	+30 dBm	18.70	25.48	4.52
7	2442	1	+30 dBm	18.47	25.25	4.75
11	2462	1	+30 dBm	18.54	25.32	4.68

Transmitter Channel	Freq. (MHz)	Data Rate (Mbps)	Peak Power at Antenna Terminal (dBm)	Conducted Power Limit (dBm)	Calculated EIRP (dBm) ⁽²⁾	EIRP Limit (dBm)	EIRP Margin (dBm)
1	2412	54	24.33	30.0	26.33	36.0	9.67
7	2442	54	23.79	30.0	25.79	36.0	10.21
11	2462	54	23.28	30.0	25.28	36.0	10.72
1	2412	1	25.48	30.0	27.48	36.0	8.52
7	2442	1	25.25	30.0	27.25	36.0	8.75
11	2462	1	25.32	30.0	27.32	36.0	8.68

⁽¹⁾For measurements of the fundamental power, because of spectral bandwidth a correction to the measured value is necessary. The receiver was set to maximum resolution and video bandwidths; RBW=VBW=8 MHz. The expected bandwidth of the device is 16.3 MHz at 54 Mbps data rate and 14.3 MHz at 1 Mbps data rate. Based on the receiver bandwidth and expected bandwidth of the device, an equation was used to calculate the reading if an appropriate RBW could be used. It is as follows for the 2412 MHz (54Mbps) measurement:

⁽²⁾ EIRP Calculation: EIRP = (Peak power at antenna terminal in dBm, using dipole antenna) + (EUT Antenna gain in dBi)

$$\text{Corrected Output Power value} = 10 \log \left(\frac{99\% \text{ Bandwidth}}{\text{Receiver Resolution BW}} \right) + \text{measured output power}$$

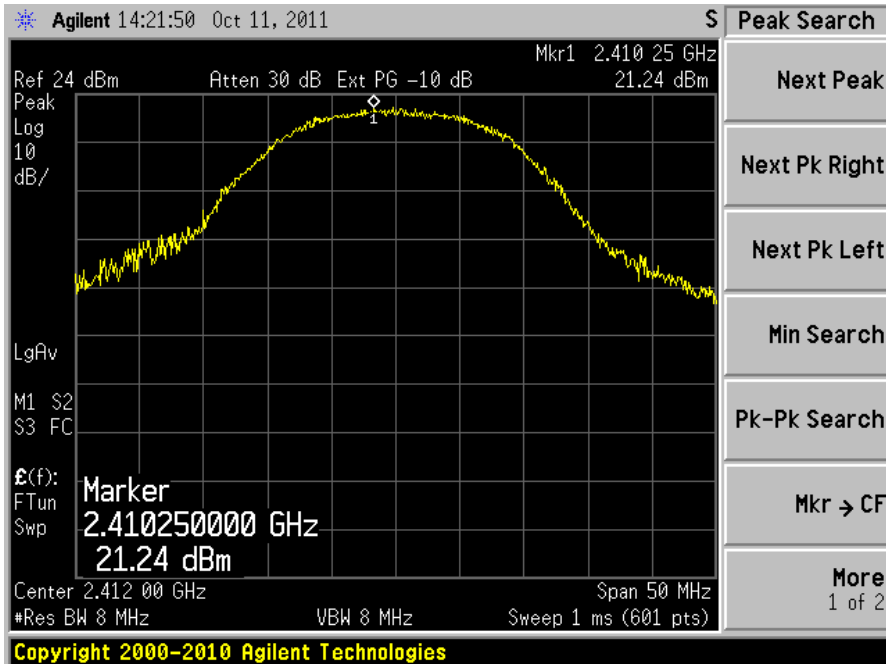
$$\text{Example corrected output power value: } 10 \log((16.3 \text{ MHz})/(8 \text{ MHz})) + 21.24 \text{ dBm} = 24.33 \text{ dbm}$$

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

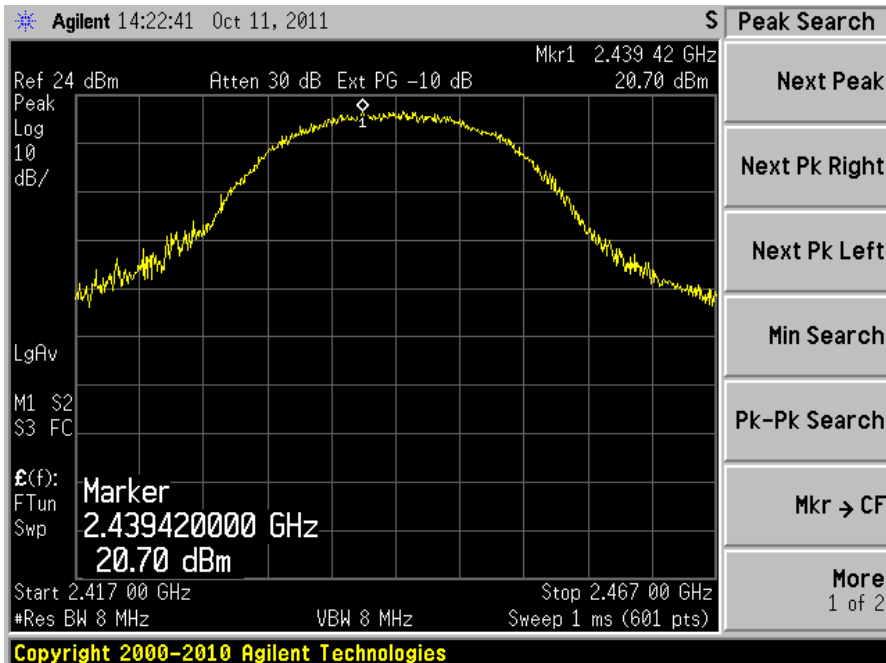
9.4 - Screen Captures - Power Output (Conducted)

Captures for 54 Mbps data rate

Channel 1

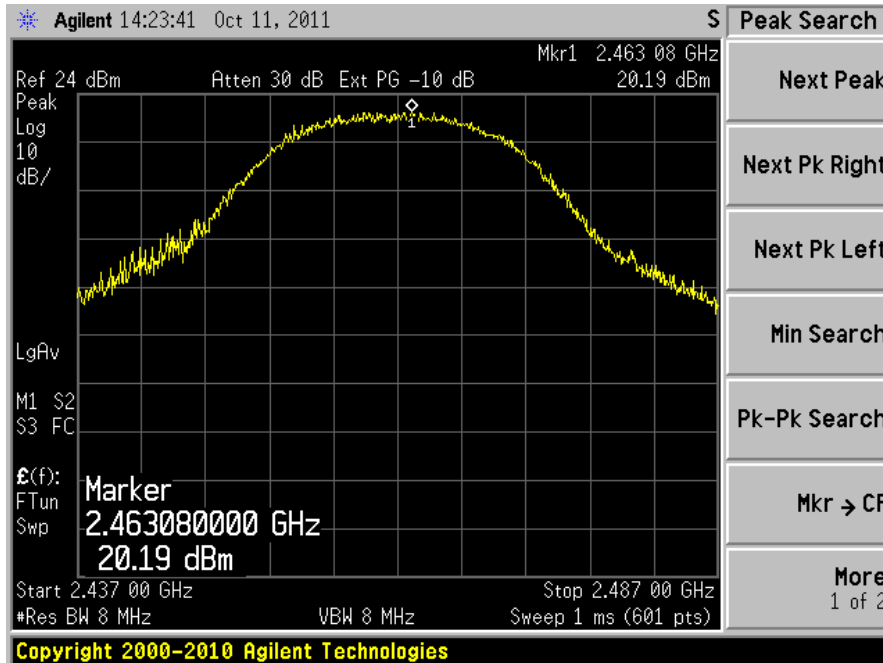


Channel 7



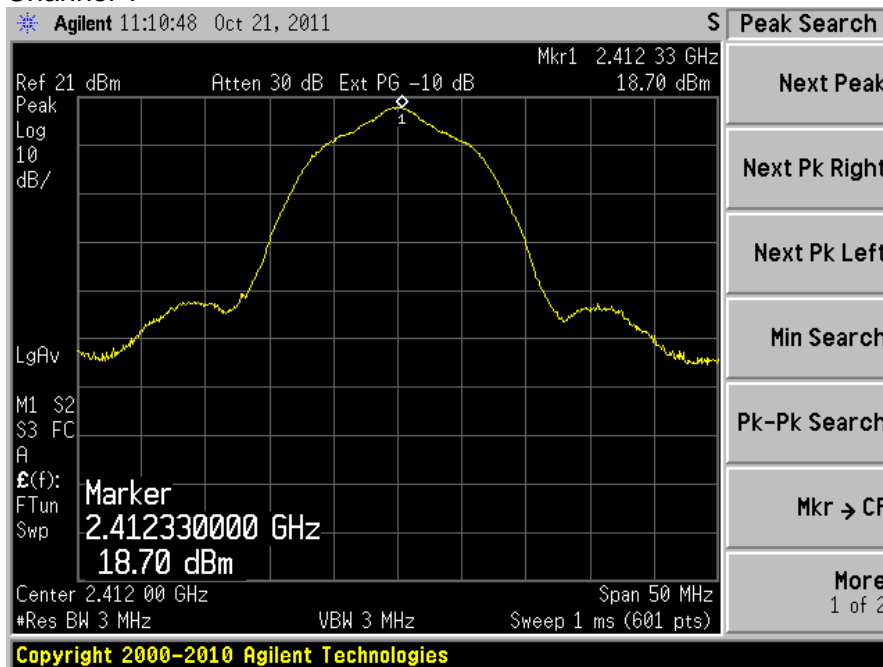
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 11



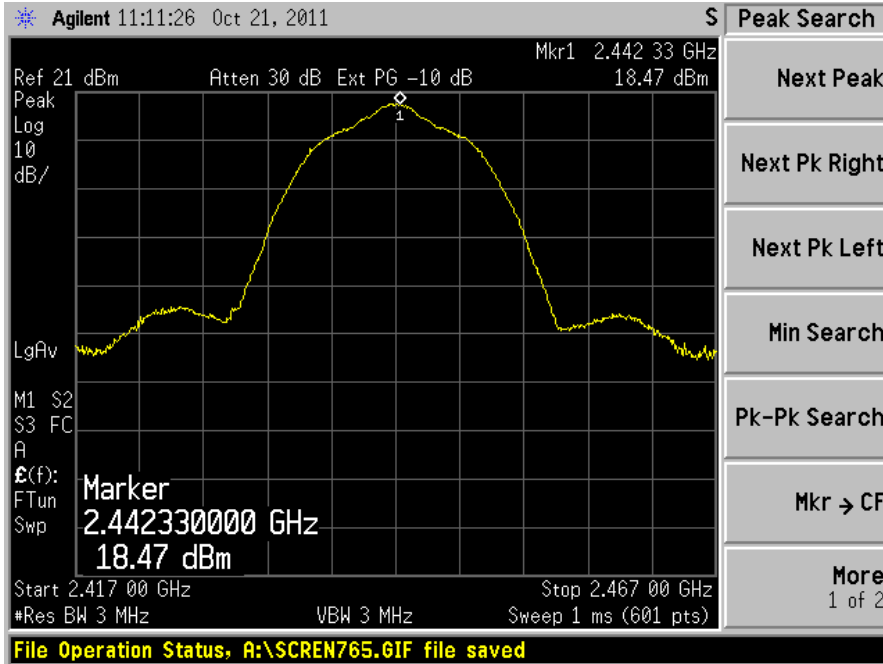
Captures for 1 Mbps data rate

Channel 1

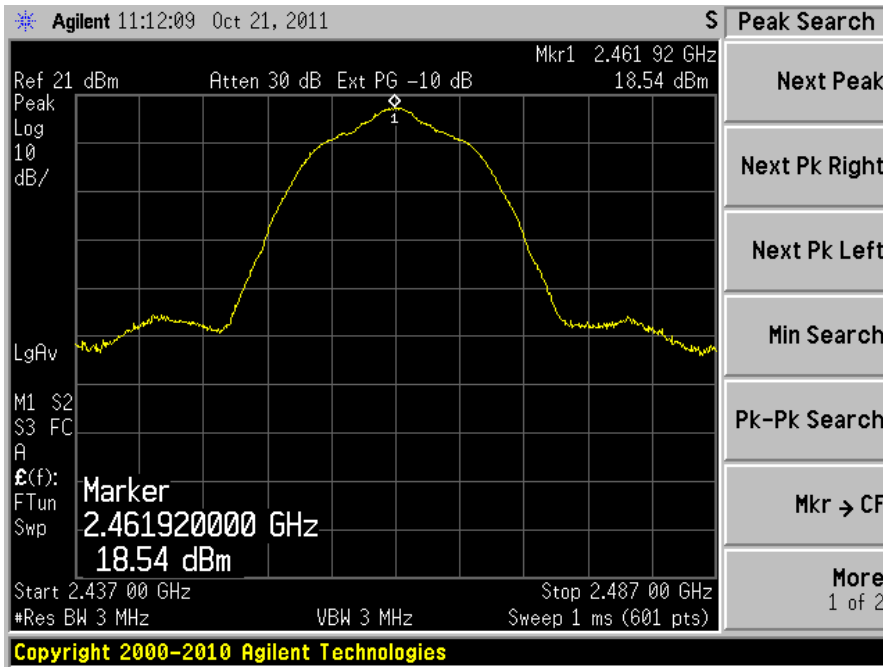


Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7



Channel 11



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

EXHIBIT 10. POWER SPECTRAL DENSITY: 15.247(e)

10.1 - Limits

For digitally modulate systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

In accordance with FCC Part 15.247(e) and RSS 210 A8.2(b), the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed using the noise-marker method built-in function of the Agilent E4446A spectrum analyzer. The peak output frequency for each representative frequency was scanned, with a narrow bandwidth, and reduced sweep, and a power density measurement was performed. The resultant density was then corrected to a 3 kHz bandwidth. The highest density was found to be no greater than -7.16 dBm, which is under the allowable limit by 15.16 dB.

10.2 - Test Equipment List

A complete list of test equipment can be found in Appendix A.

10.3 - Test Data

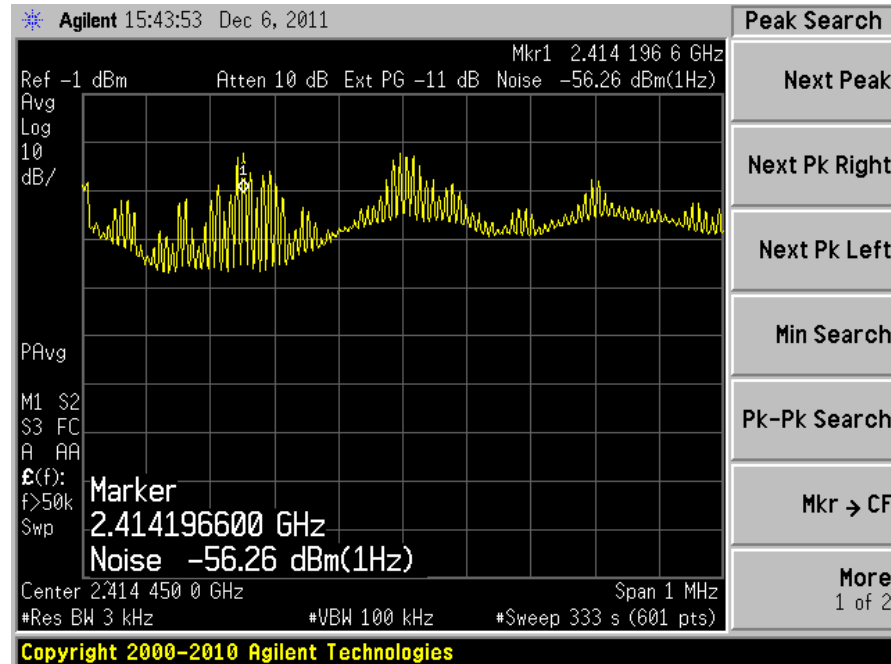
Channel	Center Frequency (MHz)	Measured Channel Power (dBm/Hz)	3 kHz Correction (dB)	Corrected Power Measurement (dBm/3kHz)	Limit (dBm)	Margin (dB)	Data Rate (Mbps)
1	2412	-59.36	35.0	-24.4	+8.0	32.4	54
7	2442	-59.41	35.0	-24.4	+8.0	32.4	54
11	2462	-59.9	35.0	-24.9	+8.0	32.9	54
1	2412	-42.16	35.0	-7.2	+8.0	15.2	1
7	2442	-49.5	35.0	-14.5	+8.0	22.5	1
11	2462	-49.1	35.0	-14.1	+8.0	22.1	1

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

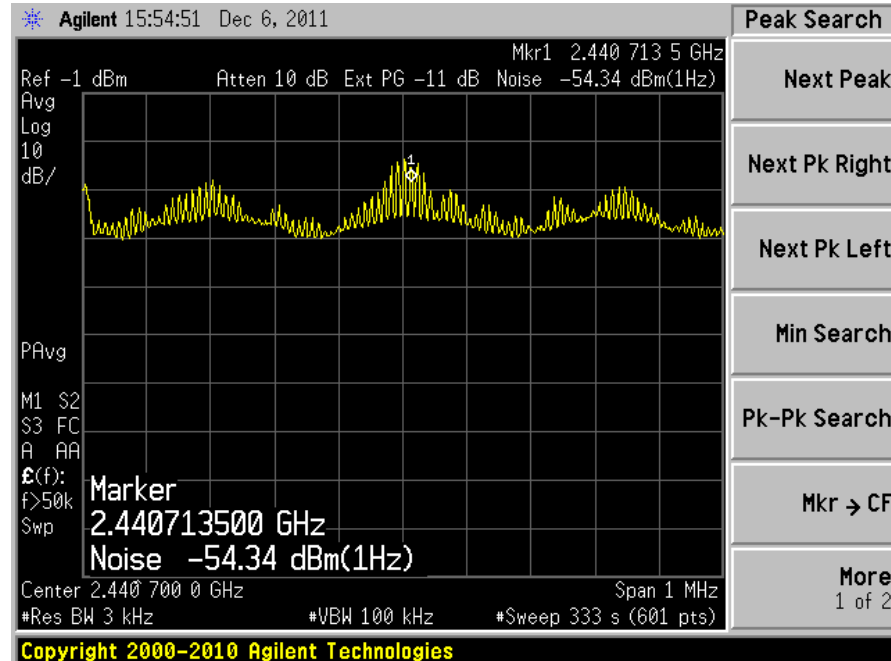
10.4 - Screen Captures - Power Spectral Density

Captures for 54 Mbps Data Rate

Channel 1

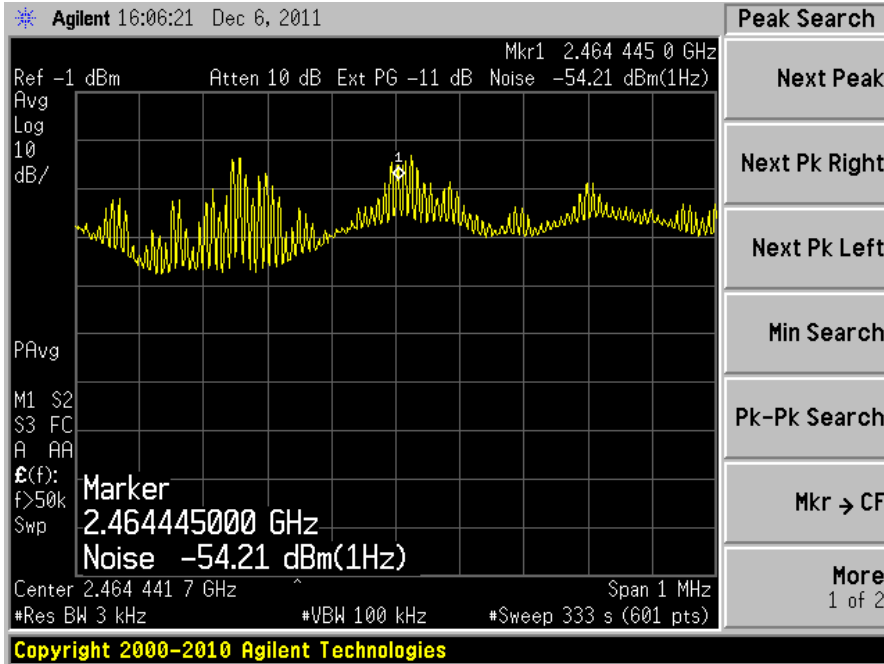


Channel 7



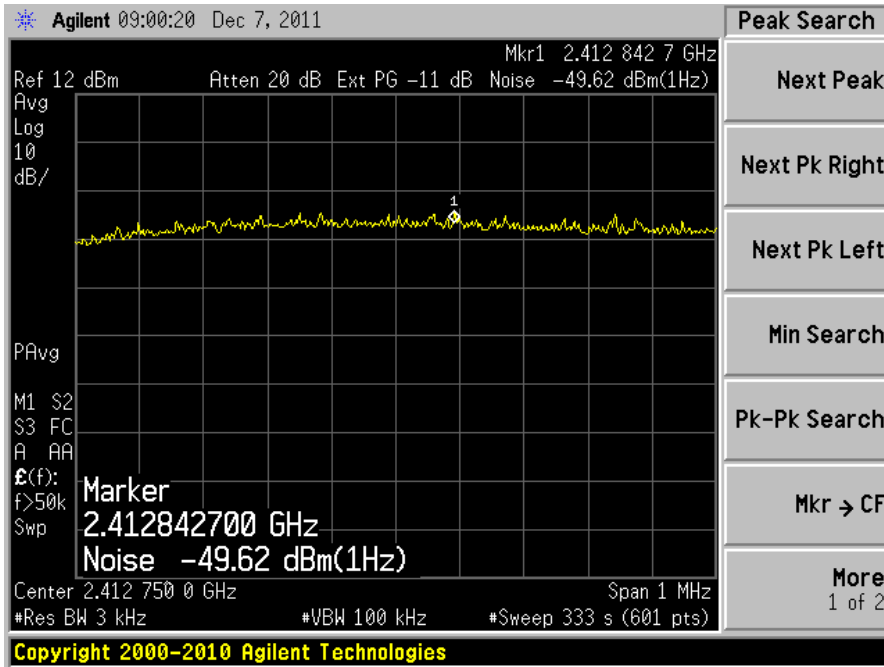
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 11



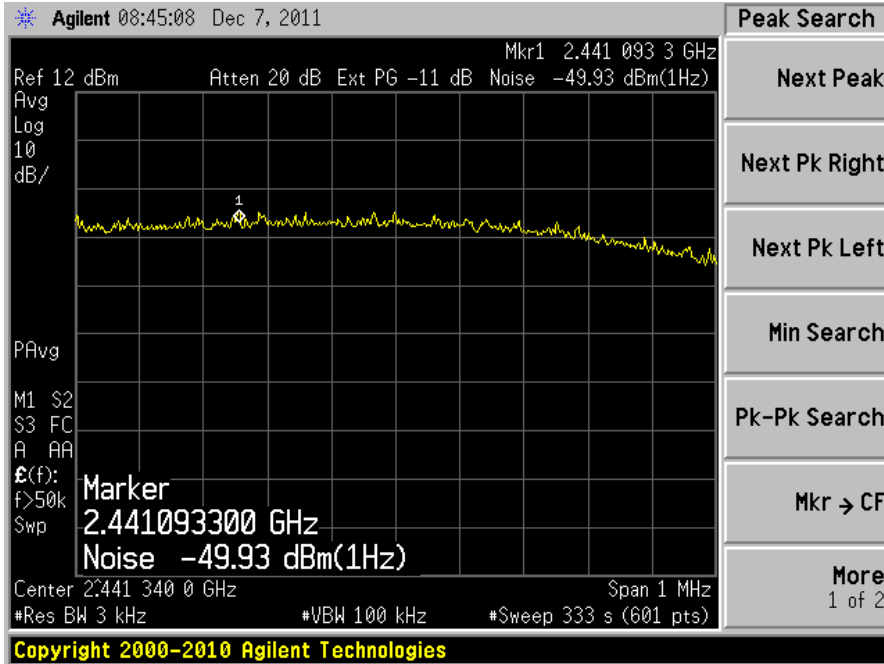
Captures for 1 Mbps Data Rate

Channel 1

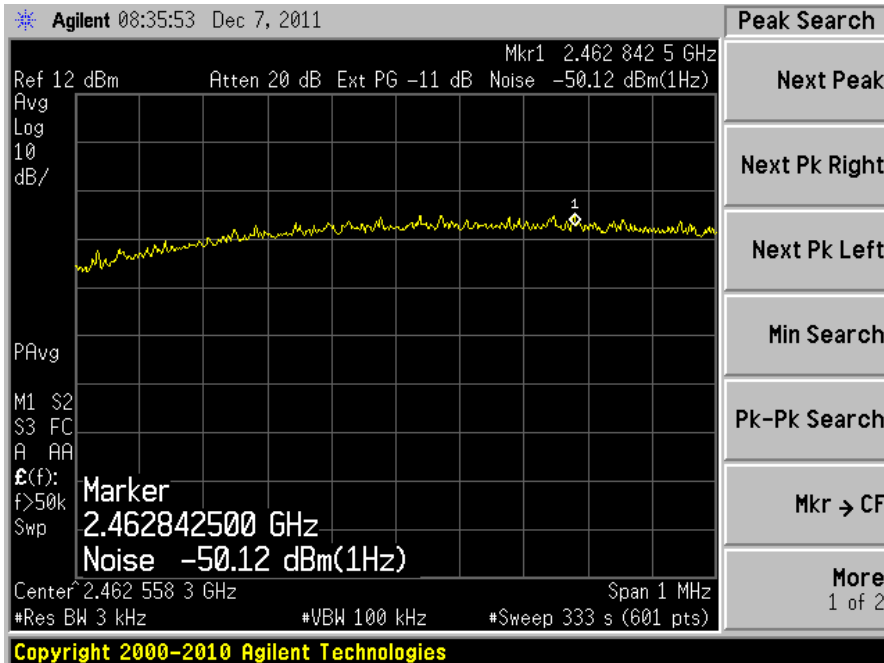


Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7



Channel 11



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

EXHIBIT 11. SPURIOUS CONDUCTED EMISSIONS: 15.247(d)

11.1 - Limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 db below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

FCC 47 CFR 15.205(a) – Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 – 0.110	162.0125 – 167.17	2310 – 2390	9.3 – 9.5
0.49 – 0.51	167.72 – 173.2	2483.5 – 2500	10.6 – 12.7
2.1735 – 2.1905	240 – 285	2655 – 2900	13.25 – 13.4
8.362 – 8.366	322 – 335.4	3260 – 3267	14.47 – 14.5
13.36 – 13.41	399.9 – 410	3332 – 3339	14.35 – 16.2
25.5 – 25.67	608 – 614	3345.8 – 3358	17.7 – 21.4
37.5 – 38.25	960 – 1240	3600 – 4400	22.01 – 23.12
73 – 75.4	1300 – 1427	4500 – 5250	23.6 – 24.0
108 – 121.94	1435 – 1626.5	5350 – 5460	31.2 – 31.8
123 – 138	1660 – 1710	7250 – 7750	36.43 – 36.5
149.9 – 150.05	1718.8 – 1722.2	8025 – 8500	Above 38.6
156.7 – 156.9	2200 – 2300	9000 – 9200	

Reported data is the raw data corrected for all applicable factors such as antenna factors, cable loss, etc.

Sample reported data at 2412 MHz:

Raw Data + Cable Factor = Reported Data

1.96 dBm + 0.58 dB = 2.54 dBm

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

11.2 - Conducted Harmonic And Spurious RF Measurements

FCC Part 15.247(d) and IC RSS 210 A8.5 both require a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable. An Agilent E4446A spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

No significant emissions could be noted within -40 dBc of the fundamental level for this product.

For 54 Mbps Data Rate:

Frequency	Channel 1 [dbm]	Channel 7 [dBm]	Channel 11 [dBm]
Fundamental	+2.54	+2.23	+2.17
2 nd Harmonic	-66.20	-66.94	-67.25
3 rd Harmonic	-64.42	-64.90	-63.65
4 th Harmonic	-61.43	-65.74	-68.46
5 th Harmonic	-67.93	-68.10	-69.83
6 th Harmonic	Note (1)	-71.39	-72.12
7 th Harmonic	Note (1)	-70.17	-72.26
8 th Harmonic	-66.26	-71.59	-72.24
9 th Harmonic	Note (1)	Note (1)	Note (1)
10 th Harmonic	Note (1)	Note (1)	Note (1)

Note 1): Measurement at system noise floor.

Spurious Conducted Emissions

Freq(MHz)	Channel	Level(dBm)
497.2	11	-67.85
479.4	7	-61.08
452	1	-60.24

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

For 1 Mbps Data Rate:

Frequency	Channel 1 [dbm]	Channel 7 [dBm]	Channel 11 [dBm]
Fundamental	+8.10	+7.99	+7.95
2 nd Harmonic	-41.93	-43.41	-44.38
3 rd Harmonic	-53.99	-56.10	-53.04
4 th Harmonic	-52.67	-53.68	-63.07
5 th Harmonic	-63.30	-62.10	-62.88
6 th Harmonic	-57.53	-57.83	-56.58
7 th Harmonic	-70.27	-70.77	-71.22
8 th Harmonic	-67.22	-68.92	-72.47
9 th Harmonic	Note (1)	Note (1)	Note (1)
10 th Harmonic	Note (1)	Note (1)	Note (1)

Note 1): Measurement at system noise floor.

Spurious Conducted Emissions

Freq(MHz)	Channel	Level(dBm)
502.1	11	-48.67
668.6	11	-63.79
452	1	-43.64
602.3	1	-64.69
481	7	-44.81
641.1	7	-62.17

11.3 - Test Equipment List

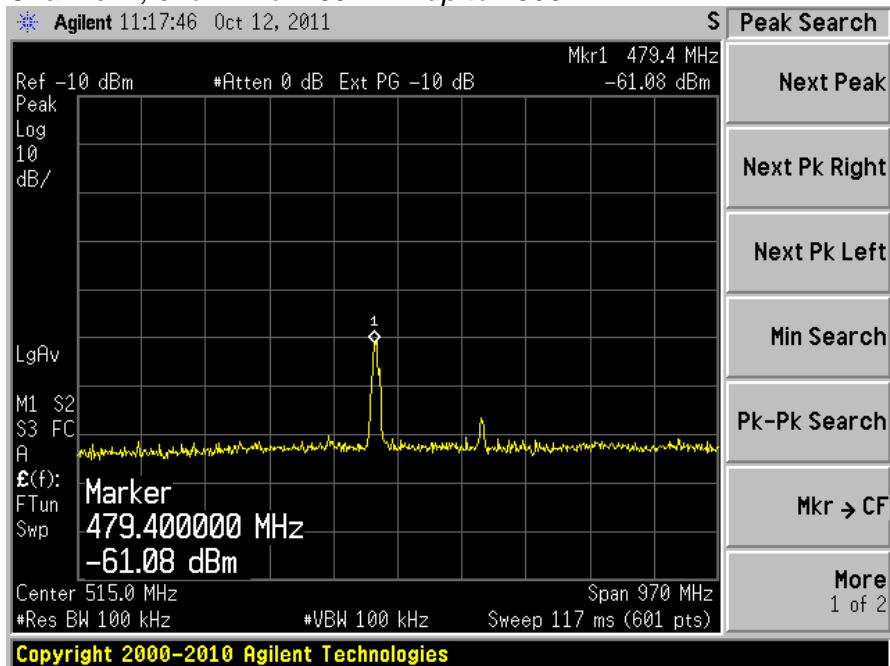
A complete list of test equipment that was used for this test can be found in Appendix A.

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

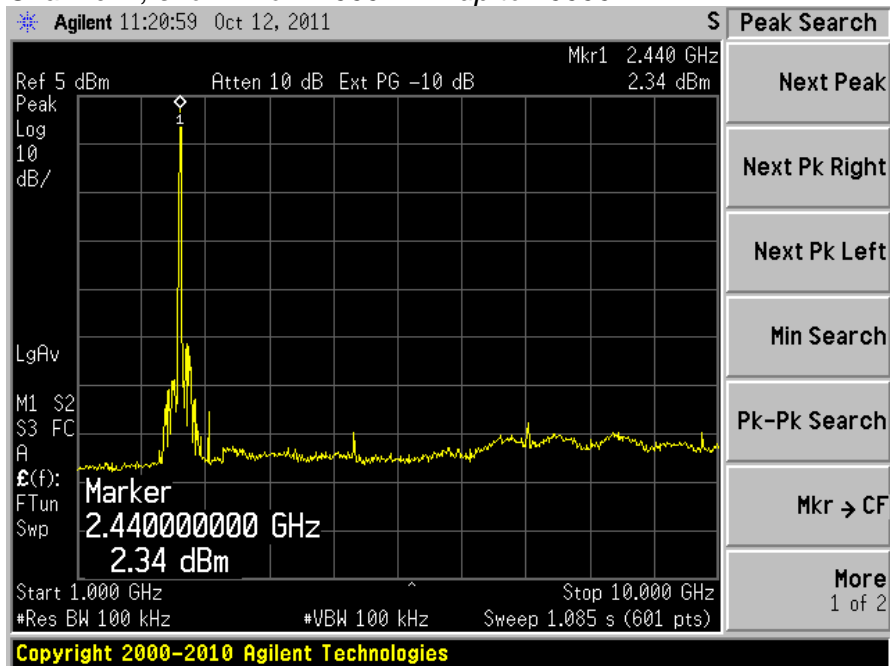
11.4 - Screen Captures – Spurious Radiated Emissions

For 54Mbps Data Rate:

Channel 7, shown from 30 MHz up to 1000 MHz

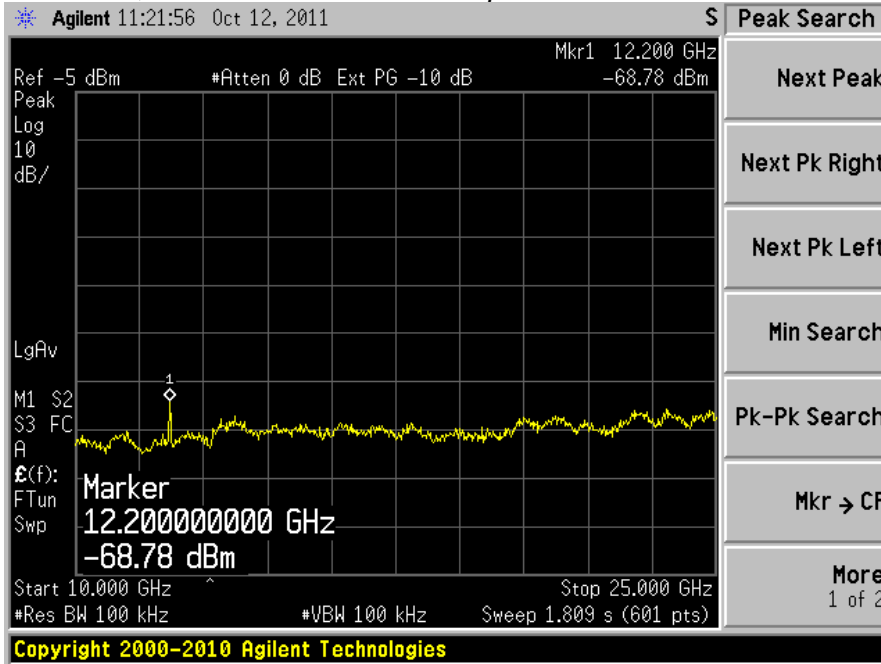


Channel 7, shown from 1000 MHz up to 10000 MHz



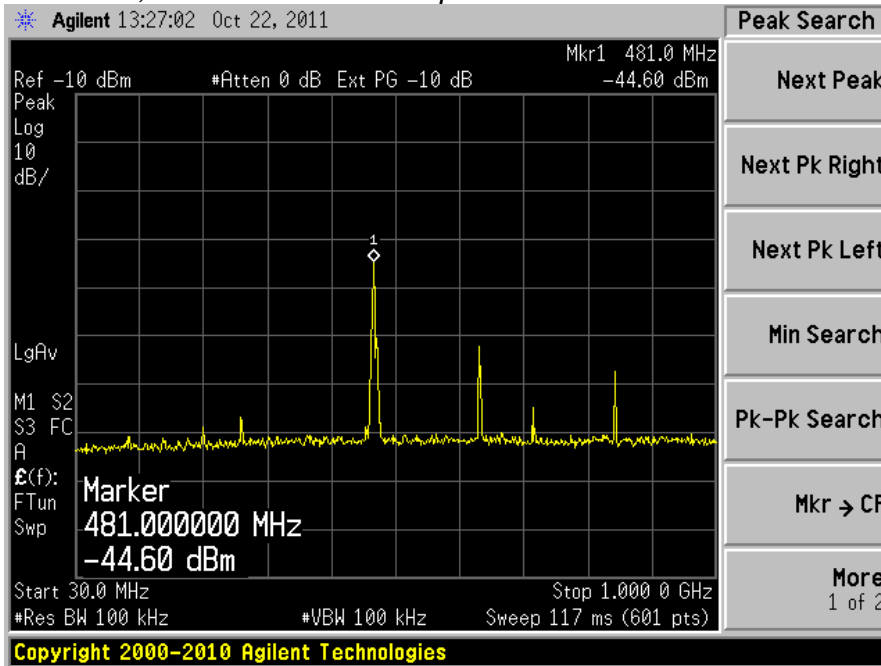
Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7, shown from 10000 MHz up to 25000 MHz



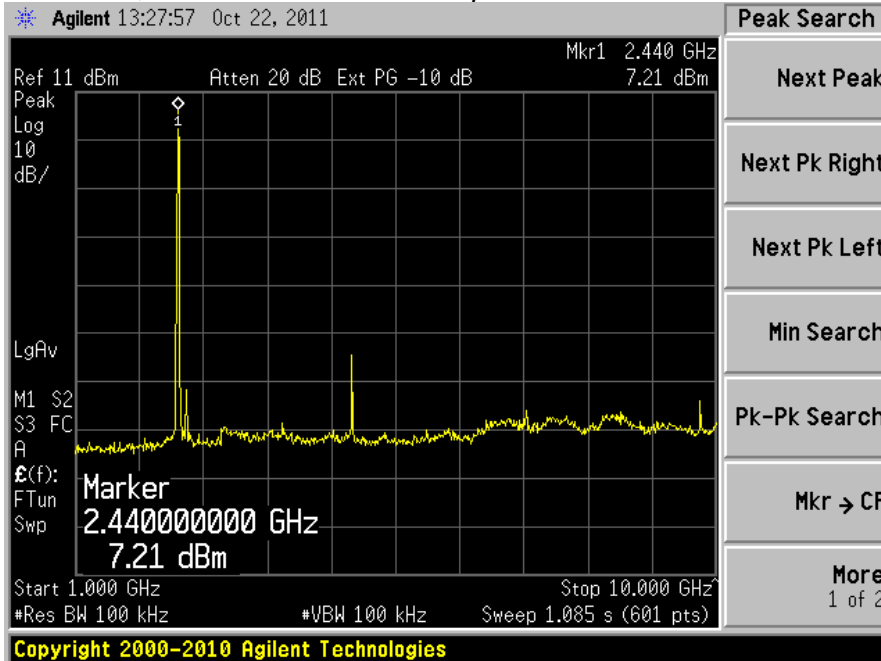
For 1Mbps Data Rate:

Channel 7, shown from 30 MHz up to 1000 MHz

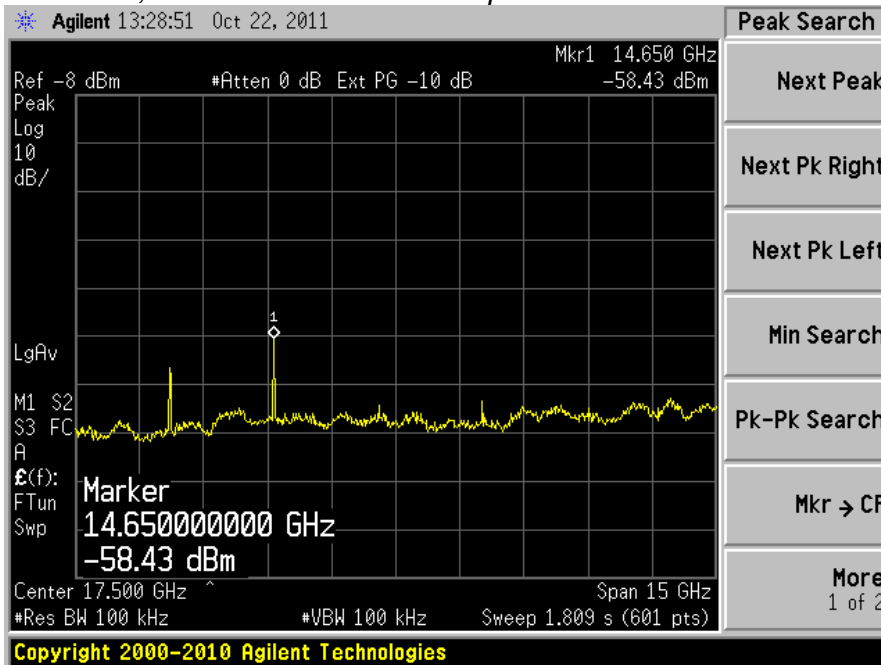


Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7, shown from 1000 MHz up to 10000 MHz

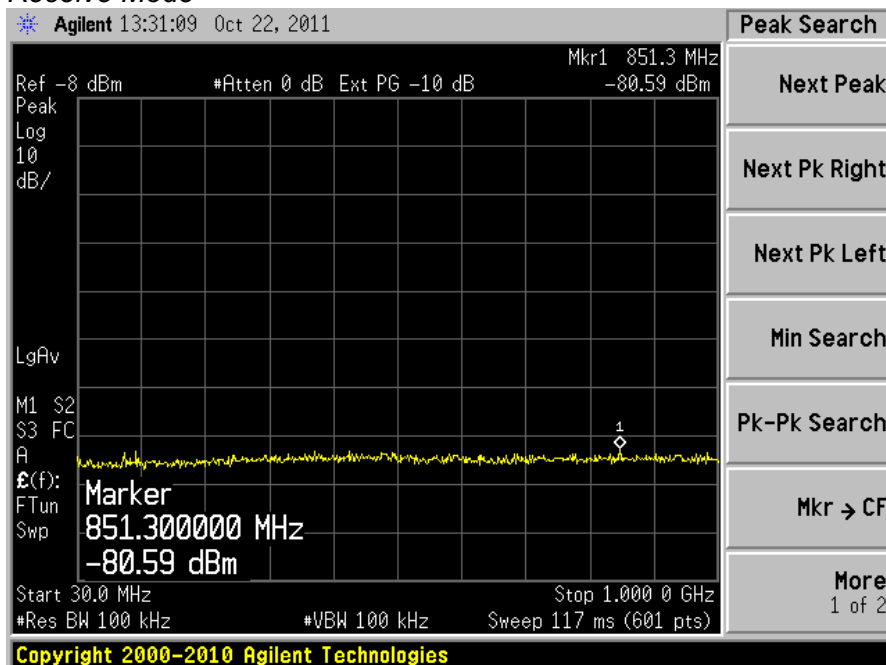


Channel 7, shown from 10000 MHz up to 25000 MHz

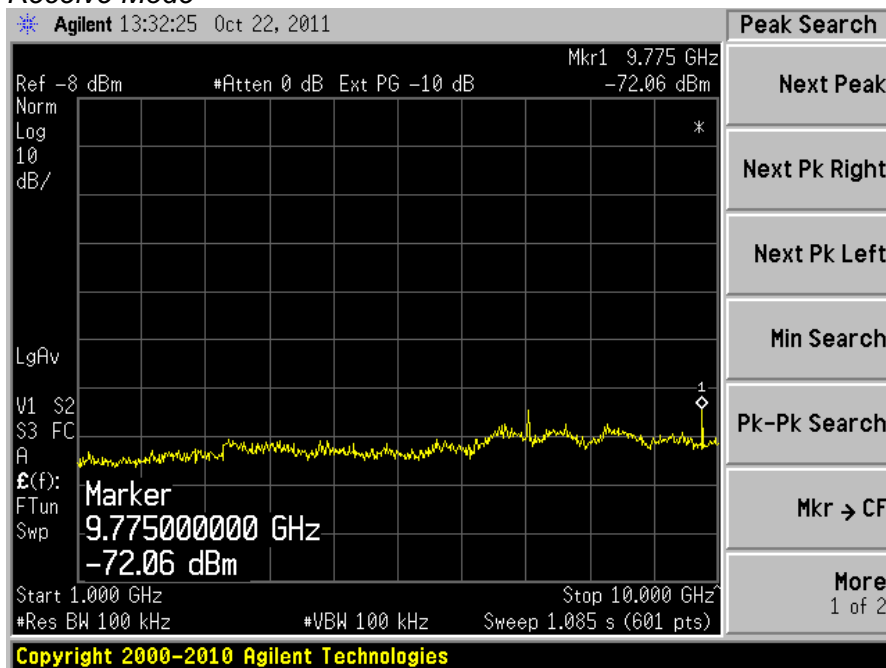


Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7, shown from 30 MHz up to 1000 MHz
Receive Mode

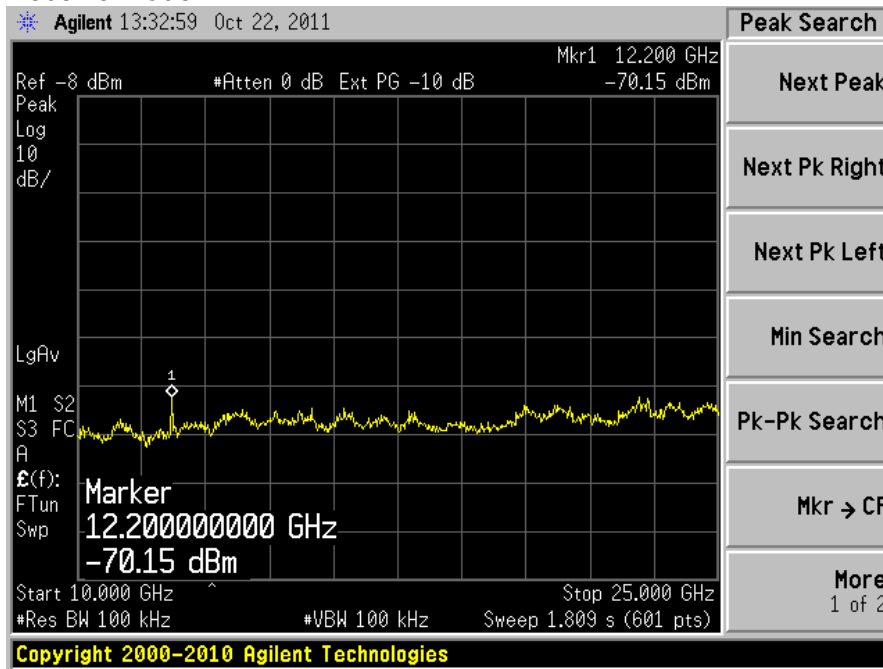


Channel 7, shown from 1000 MHz up to 10000 MHz
Receive Mode



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

Channel 7, shown from 10000 MHz up to 25000 MHz
Receive Mode



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

EXHIBIT 12. FREQUENCY & POWER STABILITY OVER VOLTAGE & TEMPERATURE VARIATIONS

A spectrum analyzer was used to measure the frequency at the appropriate frequency markers. For this test, the EUT was placed in continuous transmit CW mode. Power to the EUT was supplied by an external bench-type variable power supply. The frequency of operation was monitored using the spectrum analyzer with RBW=VBW=1 kHz settings while the voltage was varied. The RF Power Output of the EUT was also monitored in a separate test, also using a Spectrum Analyzer with RBW=VBW=3 MHz setting while the voltage was varied.

For 1Mbps Data Rate:

2.8VDC		3.3VDC		3.8VDC		
Power	Frequency	Power	Frequency	Power	Frequency	Channel
18.71	2411339400	18.63	2411339400	19.22	2411339400	1
18.12	2441597300	18.62	2441597300	18.79	2441597300	7
18.65	2462335700	19.77	2462335700	19.16	2462335700	11

Channel	max	min	freq drift (Hz)
1	2411339400	2411339400	0
7	2441597300	2441597300	0
11	2462335700	2462335700	0

For 54Mbps Data Rate:

2.8VDC		3.3VDC		3.8VDC		
Power	Frequency	Power	Frequency	Power	Frequency	Channel
16.27	2414445100	16.52	2414445100	16.53	2414445100	1
15.77	2440701700	16.87	2440712600	17.09	2440712600	7
15.74	2464444200	15.96	2464454300	16.17	2464454300	11

Channel	max	min	freq drift (Hz)
1	2414445100	2414445100	0
7	2440712600	2440701700	10900
11	2464454300	2464444200	10100

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

APPENDIX A – Test Equipment List



Date: 5-Oct-2011 Type Test: Radiated Emissions Job #: C-1311

Prepared By: Shane Rismeyer Customer: LSR Quote #: 311291

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960158	RF Preselector	Agilent	N9039A	MY46520110	6/11/2011	6/11/2012	Active Calibration
2	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/6/2011	6/6/2012	Active Calibration
3	EE 960130	Multi-Device Controller	ETS	2090	45968	XXX	XXX	Cal Not Required
4	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	10/19/2010	10/19/2011	Active Calibration
5	AA 960150	Bicon Antenna	ETS	3110B	0003-3346	10/19/2010	10/19/2011	Active Calibration
6	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	4/27/2011	4/27/2012	Active Calibration
7	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	1/4/2011	1/4/2012	Active Calibration
8	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	6/6/2011	6/6/2012	Active Calibration
9	EE 960146	Std. Gain Horn Ant. w/preamp	Adv. Micro	WLA622-4	123001	10/13/2010	10/13/2011	Active Calibration

Project Engineer: *Shane Rismeyer* Quality Assurance: *Peter Finken*



Date: 5-Oct-2011 Type Test: Conducted Measurements Job #: C-1311

Prepared By: Shane Rismeyer Customer: LSR Quote #: 311291

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960143	Phaseflex	Gore	EKD01D01048.0	5546519	6/1/2011	6/1/2012	Active Calibration
2	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	4/25/2011	4/25/2012	Active Calibration

Project Engineer: *Shane Rismeyer* Quality Assurance: *Peter Finken*



Date: 5-Oct-2011 Type Test: Conducted AC Emissions Job #: C-1311

Prepared By: Shane Rismeyer Customer: LSR Quote #: 311291

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960158	RF Preselector	Agilent	N9039A	MY46520110	6/11/2011	6/11/2012	Active Calibration
2	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/6/2011	6/6/2012	Active Calibration
3	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	6/6/2011	6/6/2012	Active Calibration
4	AA 960008	LISN	EMCO	3816/2NM	9701-1057	1/4/2011	1/4/2012	Active Calibration

Project Engineer: *Shane Rismeyer* Quality Assurance: *Peter Finken*

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

APPENDIX B – Test Standards: CURRENT PUBLICATION DATES RADIO

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2003		
ANSI C63.10	2009		
CISPR 11	2009-05	2009-12 P	
CISPR 12	2007-05		
CISPR 14-1	2005-11	2008-11	
CISPR 14-2	2001-11	2001-11	2008-05
CISPR 16-1-1 Note 1	2010-01		
CISPR 16-1-2 Note 1	2003	2004-04	2006-07
CISPR 22	2008-09		
CISPR 24	1997-09	2001-07	2002-10
EN 55011	2009		
EN 55014-1	2006		
EN 55014-2	1997		
EN 55022	2006	2007	
EN 60601-1-2	2007-03		
EN 61000-3-2	2006-05		
EN 61000-3-3	2008-12		
EN 61000-4-2	2009-05		
EN 61000-4-3	2006-07	2008-05	
EN 61000-4-4	2004		
EN 61000-4-5	2006-12		
EN 61000-4-6	2009-05		
EN 61000-4-8	1994	2001	
EN 61000-4-11	2004-10		
EN 61000-6-1	2007-02		
EN 61000-6-2	2005-12		
EN 61000-6-3	2007-02		
EN 61000-6-4	2007-02		
FCC 47 CFR, Parts 0-15, 18, 90, 95	2009		
FCC Public Notice DA 00-1407	2000		
FCC ET Docket # 99-231	2002		
FCC Procedures	2007		
ICES 001	2006-06		
ICES 002	2009-08		
ICES 003	2004-02		
IEC 60601-1-2 Note 1	2007-03		
IEC 61000-3-2	2005-11	2008-03	2009-02
IEC 61000-3-3	2008-06		
IEC 61000-4-2	2008-12		
IEC 61000-4-3	2008-04	2008-04	2009-12 FD

STANDARD #	DATE	Am. 1
IEC 61000-4-4	2004-07	2010-10
IEC 61000-4-5	2005-11	
IEC 61000-4-6	2008-10	
IEC 61000-4-8	2009-09	
IEC 61000-4-11	2004-03	
IEC 61000-6-1	2005-03	
IEC 61326-1	2006-06	
ISO 14982	1998-07	
MIL Std. 461E	1999-08	
RSS GEN	2007-06	
RSS 119	2007-06	
RSS 123	1999-11	
RSS 125	2000-03	
RSS 131	2003-07	
RSS 136	2002-10	
RSS 137	2009-02	
RSS 210	2007-06	
RSS 213	2005-12	
RSS 243	2010-02	
RSS 310	2007-06	
Updated on 08-23-11		
<i>Note 1: Test not on LSR Scope of Accreditation.</i>		

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

APPENDIX C - Uncertainty Statement

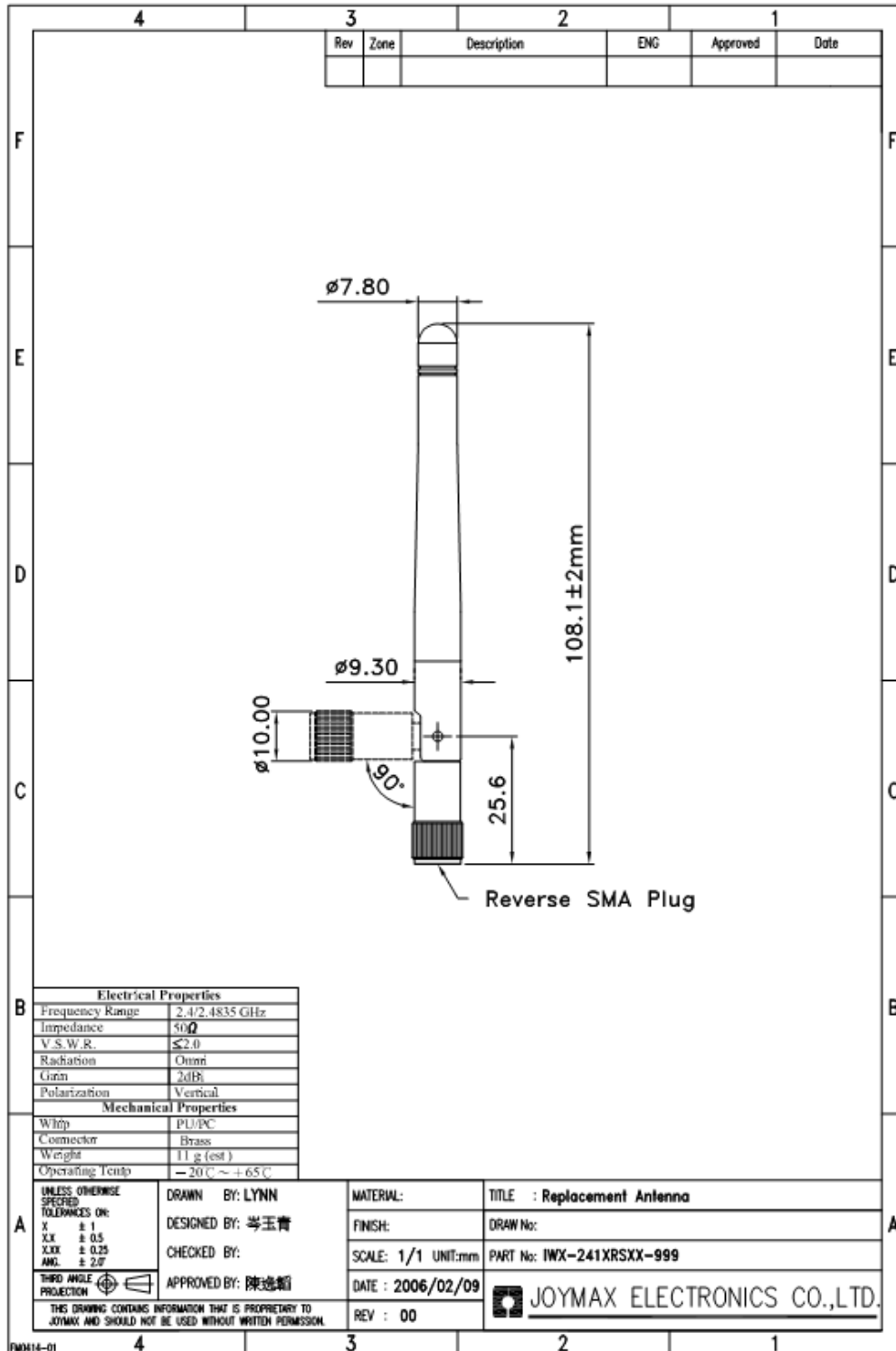
This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k=2.

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

Measurement Type	Particular Configuration	Uncertainty Values
Radiated Emissions	3 – Meter chamber, Biconical Antenna	4.24 dB
Radiated Emissions	3-Meter Chamber, Log Periodic Antenna	4.8 dB
Radiated Emissions	10-Meter OATS, Biconical Antenna	4.18 dB
Radiated Emissions	10-Meter OATS, Log Periodic Antenna	3.92 dB
Conducted Emissions	Shielded Room/EMCO LISN	1.60 dB
Radiated Immunity	3 Volts/Meter in 3-Meter Chamber	1.128 Volts/Meter
Conducted Immunity	3 Volts level	1.0 V

Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

APPENDIX D - Antenna Specification(s)



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311

"High Frequency Ceramic Solutions"

2.4 GHz WLAN, Home RF, Bluetooth Antenna

P/N 2450AT43B100

NEW with Ground Clearance Requirements Minimized

Detail Specification: 09/04/08

Page 1 of 4

General Specifications

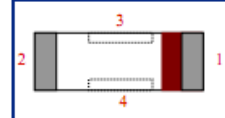
Part Number	2450AT43B100
Frequency Range	2400 - 2500 Mhz
Peak Gain	1.3 dBi typ. (XZ-V)
Average Gain	-0.5 dBi typ. (XZ-V)
Return Loss	9.5 dB min.

Input Power	2W max.
Impedance	50 Ω
Reel Quantity	1,000
Operating Temperature	-40 to +85°C
Storage Temperature	+5 to +35°C, Humidity: 45-75%RH, 12 mos. Max

P/N Suffix	Packaging Style	Bulk	Suffix = S	Eg. 2450AT43B100S
	Termination Style	T & R	Suffix = E	Eg. 2450AT43B100E
		100% Tin	Suffix = None	Eg. 2450AT43B100(E or S)
		Tin / Lead	Please consult Factory	

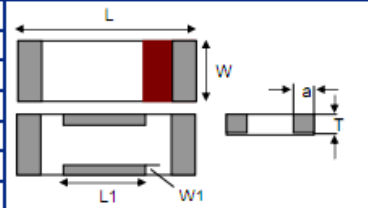
Terminal Configuration

No.	Function
1	Feed Point
2	NC
3	NC
4	NC



Mechanical Dimensions

	in	mm
L	0.276 ± 0.008	7.00 ± 0.20
W	0.079 ± 0.008	2.00 ± 0.20
L1	0.102 ± 0.008	2.60 ± 0.20
W1	0.020 ± 0.008	0.50 ± 0.20
T	0.079 +.004/-.008	2.00 +0.1/-0.2
a	0.020 ± 0.012	0.50 ± 0.30



Prepared For: LSR	Model Number: TiWi-SL	Report #: 311291
EUT: TiWi-SL	Serial Number: N/A	LSR Job #: C-1311