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**TEST REPORT #: 311258**  
**LSR Job #: C-1285**

Compliance Testing of:

Tiwi-BLE

Test Date(s):

April 22, June 13, August 7-9, 24-31, Sept 8, 2010, and January 20-23, 2012

Prepared For:

LS Research

Attn: Brian Petted

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 D. Rismeyer, EMC Engineer

Signature: 

Date: 2/3/2012

**Quality Assurance by:**

Khairul Aidi Zainal, Senior EMC Engineer

Signature:  Date: 2/3/2012

**Project Engineer:**

Shane D. Rismeyer, EMC Engineer

Signature:  Date: 1/26/12

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# EXHIBIT 1. INTRODUCTION

## 1.1 - Scope

<b>References:</b>	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
<b>Title:</b>	FCC : Telecommunication – Code of Federal Regulations, CFR 47, Part 15. IC : Low-power License-exempt Radio-communication Devices (All Frequency Bands): Category I Equipment
<b>Purpose of Test:</b>	To gain FCC and IC Certification Authorization for Low- Power License-Exempt Transmitters.
<b>Test Procedures:</b>	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.
<b>Environmental Classification:</b>	Commercial, Industrial or Business Residential

## 1.2 – Normative References

Publication	Year	Title
47 CFR, Parts 0-15 (FCC)	2008-10	Code of Federal Regulations - Telecommunications
RSS 210 Annex 8	2007-06	Low-power License-exempt Radio- communication Devices (All Frequency Bands): Category I Equipment
ANSI C63.4	2009	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	2006-03 A1: 2006-09 A2: 2007-07	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus.
CISPR 16-2-1	2003 A1: 2004-04 A2: 2007-07	Specification for radio disturbance and immunity measuring apparatus and methods. Part 201: Conducted disturbance measurement.
FCC Public Notice DA 00-1407	2000	Part 15 Unlicensed Modular Transmitter Approval
FCC ET Docket No. 99-231	2002	Amendment to FCC Part 15 of the Commission's Rules Regarding Spread Spectrum Devices.
FCC Procedures	2007	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:

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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

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Federal Communications Commission (FCC) – USA

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948

FCC Registration Number: 90756

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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

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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
Address:	W66 N220 Commerce Court
Contact Name:	Brian Petted

### 2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	Tiwi-BLE
Model Number:	Tiwi-BLE
Serial Number:	031202

### 2.3 - Associated Antenna Description

#### Antenna Option 1:

A dipole antenna with dual orientation capability was used. This antenna has a peak gain of +4.3 dBi and is connected via SMA.

#### Antenna Option 2:

A PIFA with an average gain of -0.6dBi. It has a u.fl connector and is used for applications such as: Notebook Computers, Access Points, Industrial Handhelds, and WiFi enabled Televisions & Monitors.

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## 2.4 - EUT'S Technical Specifications

### Bluetooth BLE:

EUT Frequency Range (in MHz)	2402-2480 MHz
EIRP (in mW)	
Minimum:	9.57
Maximum:	10.12
Occupied Bandwidth (99% BW)	1.345 MHz
Type of Modulation	GFSK
Emission Designator	1M35G1D
Transmitter Spurious (worst case) at 3 meters	55.9 dBuV/m @ 4803.80 MHz
Receiver Spurious (worst case) at 3 meters	44.9 dBuV/m @ 3756.90 MHz
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Antenna Information	
Detachable/non-detachable	Detachable
Type	Dipole PIFA (trace)
Gain (in dBi)	Dipole: +4.3dbi average PIFA: -0.6 dBi average
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: 20 cm

RF Value: 0.005417     V/m     A/m     mW/cm<sup>2</sup>  
 Measured     Computed     Calculated

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**WLAN:**

EUT Frequency Range (in MHz)	2412-2462 MHz
RF Power (Watts)	1 Mbps data rate: 0.092683 W MCS7 data rate: 0.020277 W
Conducted Output Power (in dBm)	20.1 dBm at 1Mbps data rate 15.6 dBm at MCS7 data rate
Field Strength at 3 meters	Dipole: 121.50 dBuV/m @ 3m PIFA: 109.25 dBuV/m @ 3m
Occupied Bandwidth (99% BW)	1320 kHz at 1 Mbps data rate 1795 kHz at MCS7 data rate
Type of Modulation	FSK
Emission Designator	1M795D1D
EIRP (in mW)	Dipole and 1 mbps data rate: 134.90 mW Dipole and MCS7 data rate: 47.86 mW PIFA and 1 mbps data rate: 89.13 mW PIFA and MCS7 data rate: 31.62 mW
Transmitter Spurious (worst case)	39.7 dBuV/m at 3161 MHz
Receiver Spurious (worst case)	44.5 dBuV/m at 3756 MHz
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Antenna Information	
Detachable/non-detachable	Detachable
Type	Dipole
Gain (in dBi)	Dipole: +4.3 dBi average PIFA:-0.6 dBi average
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: 20 cm

RF Value: 0.54794     V/m     A/m     mW/cm<sup>2</sup>  
 Measured     Computed     Calculated

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## **2.5 - Product Description**

The TiWi module is a multi-standard module with support for WLAN (802.11 b/g/n), Bluetooth, Bluetooth BLE, FM broadcast receiver and FM transmitter.

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## EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

### 3.1 - Climate Test Conditions

Temperature:	15-35 °C
Humidity:	30-60%
Pressure:	725-745 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)

### 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 (2007), 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 normal mode, and final testing was performed using normal mode, using power as provided by a bench top supply set for 5 VDC. 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: WLAN: low (2412 MHz), middle (2437 MHz) and high (2462 MHz), and Bluetooth: low (2402 MHz), middle (2442 MHz) and high (2480 MHz) to comply with FCC Part 15.35. The channels and operating modes were changed using a PC.

## **5.2 - Test Procedure**

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 4 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. From 4 GHz to 25 GHz, the EUT was measured at a 1.0 meter separation, using a standard gain Horn Antenna and pre-amplifier, raising the antenna between 1 and 1.8m. 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 (2007), 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 $\mu\text{V}/\text{m}$	3 m Limit (dB $\mu\text{V}/\text{m}$ )	1 m Limit (dB $\mu\text{V}/\text{m}$ )
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 ( $\mu\text{V}/\text{m}$  to dB $\mu\text{V}/\text{m}$ ):

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

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

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

For measurements made at 0.3 meter, a 20 dB correction has been invoked.

$$\begin{aligned} & \text{960 MHz to 10,000 MHz} \\ & 500 \mu\text{V}/\text{m} \text{ or } 54.0 \text{ dB}\mu\text{V}/\text{m} \text{ at 3 meters} \\ & 54.0 + 20 = 74 \text{ dB}\mu\text{V}/\text{m} \text{ at 0.3 meters} \end{aligned}$$

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

Sample reported data for 200MHz:

Raw Data + Antenna Factor + Cable Factor = Reported Data

$$18.2 \text{ dB}\mu\text{V}/\text{m} + 15.8 \text{ dB} + 1.45 \text{ dB} = 35.45 \text{ dB}\mu\text{V}/\text{m}$$

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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

<b>Manufacturer:</b>	LS Research				
<b>Date(s) of Test:</b>	April 15, 22, May 6, June 13, August 8, 9, 24, 31, Sept. 8, 28, 29, 2010				
<b>Test Engineer(s):</b>	Peter Feilen, Tom Smith, Ryan Urness				
<b>Voltage:</b>	5 VDC and 3.3 VDC				
<b>Operation Mode:</b>	Continuous Transmit				
<b>Environmental Conditions in the Lab:</b>	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %				
<b>EUT Power:</b>	Single Phase	VAC		3 Phase	VAC
	Battery		X	Other: DC Bench Supply	
<b>EUT Placement:</b>	X	80cm non-conductive table		10cm Spacers	
<b>EUT Test Location:</b>	X	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS	
<b>Measurements:</b>		Pre-Compliance		Preliminary	X Final
<b>Detectors Used:</b>	X	Peak	X	Quasi-Peak	X Average

## WLAN DATA:

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

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (degrees)	Measured EFI (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
35.33	V/H	1.00	90	12.1	40.0	27.9
180.31	V/H	1.00	187	21.5	43.0	21.6
295.68	V/H	1.00	0	24.4	46.0	21.6
982.50	H/H	1.00	0	29.7	54.0	24.4
940.10	V/V	1.00	0	27.6	46.0	18.4
299.05	H/V	1.00	0	26.0	46.0	20.0
35.96	V/V	1.00	0	12.2	40.0	27.8
1224.38	V/S	1.00	0	34.3	54.0	19.7
1005.28	V/S	1.00	0	35.1	54.0	18.9
1178.32	H/V	1.00	0	34.8	54.0	19.2
1005.28	V/V	1.00	0	35.0	54.0	19.0
3161.09	H/V	1.00	0	39.7	54.0	14.3
2554.57	V/H	1.00	21	36.0	54.0	18.0

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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**:

Frequency (MHz)	Ant. Polarity	Height (meters)	Azimuth (degrees)	Peak (dB $\mu$ V/m)	Average (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
4824.00	Horizontal	1.16	346	51.9	47.0	63.5	16.5
14471.80	Horizontal	1.03	10	52.0	44.6	63.5	18.9
19296.00	Horizontal	1.00	0	49.8	47.3	63.5	16.2

The following table depicts the level of significant radiated RF harmonic emissions seen on **Channel 6**:

Frequency (MHz)	Ant. Polarity	Height (meters)	Azimuth (degrees)	Peak (dB $\mu$ V/m)	Average (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
4874.13	Horizontal	1.15	26.2	50.3	44.7	63.5	18.8
14622.00	Vertical	1.29	311.9	54.0	47.9	63.5	15.6

The following table depicts the level of significant radiated RF harmonic emissions seen on **Channel 11**:

Frequency (MHz)	Ant./EUT Polarity	Height (meters)	Azimuth (degrees)	Peak (dB $\mu$ V/m)	Average (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
4924.20	Vertical	1.08	85.6	50.4	44.9	63.5	18.6
14772.07	Vertical	1.16	194.6	54.4	49.3	63.5	14.2

Notes:

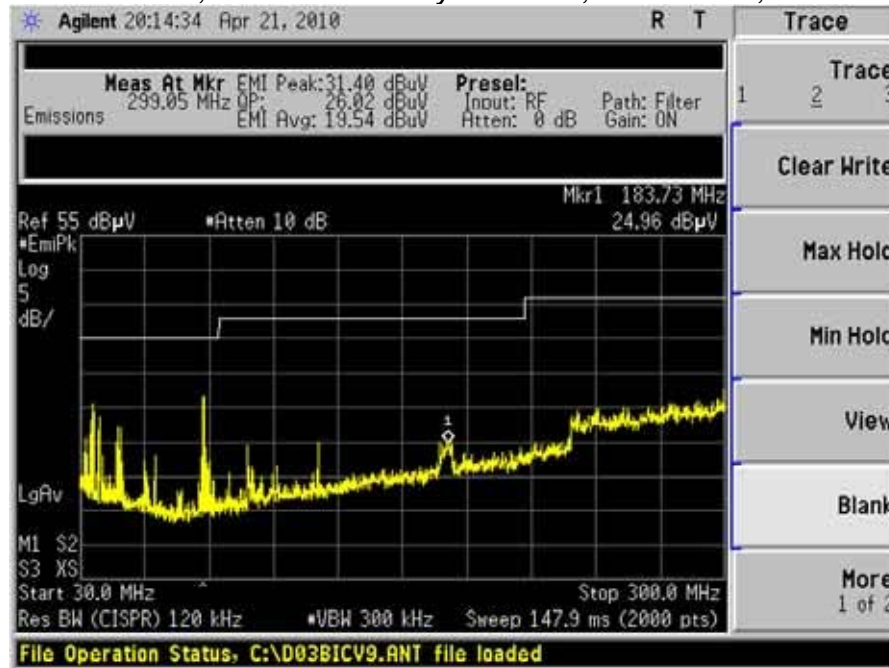
- A Peak as well as an Average Detector was used in measurements above 1 GHz. The peak detector was used to ensure the peak emissions did not exceed 20 dB above the limits.
- Measurements above 4 GHz were made at 1 meters of separation from the EUT.
- All other measurements were greater than 20 dB from the limit.

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

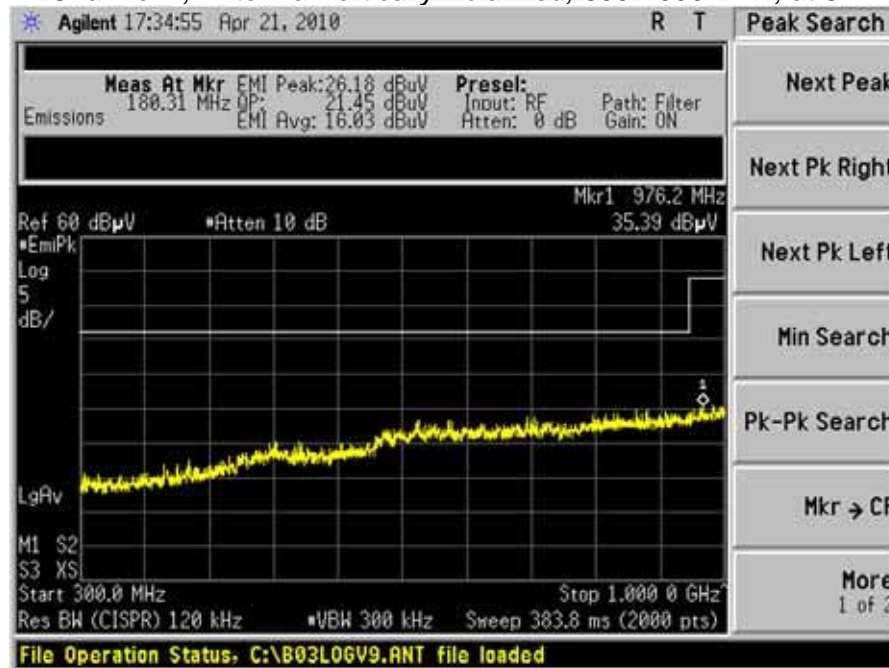
## 5.7 - Screen Captures - Radiated Emissions Test

Note: 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. The signature scans shown here are from worst-case emissions, as measured on channels 1, 6, or 11 of the WLAN radio, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Channel 1, Antenna Vertically Polarized, 30-300 MHz, at 3m



Channel 1, Antenna Vertically Polarized, 300-1000 MHz, at 3m



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

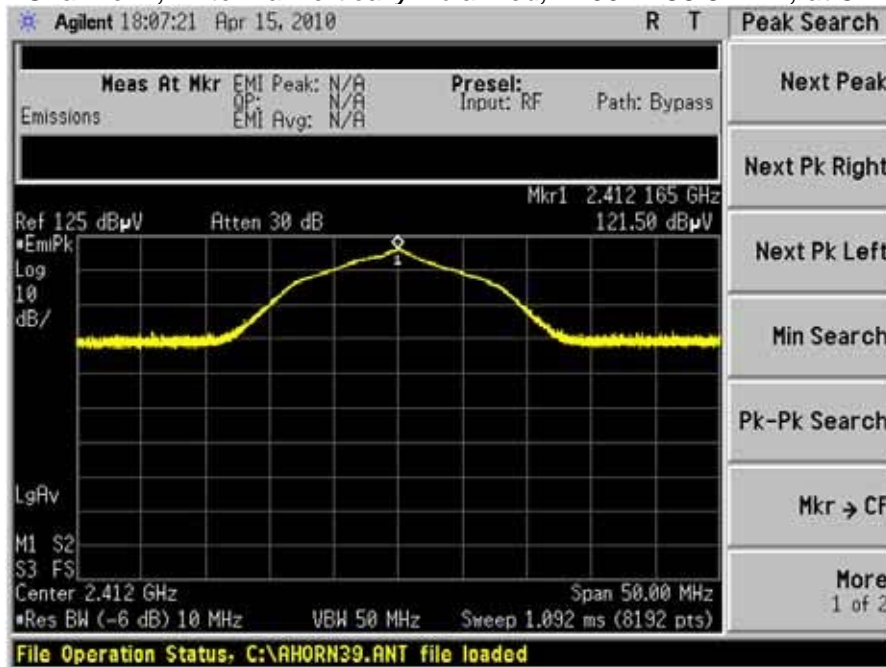


Screen Captures - Radiated Emissions Testing (continued)

Channel 1, Antenna Vertically Polarized, 1000-2310 MHz, at 3m



Channel 1, Antenna Vertically Polarized, 2400-2483.5 MHz, at 3m



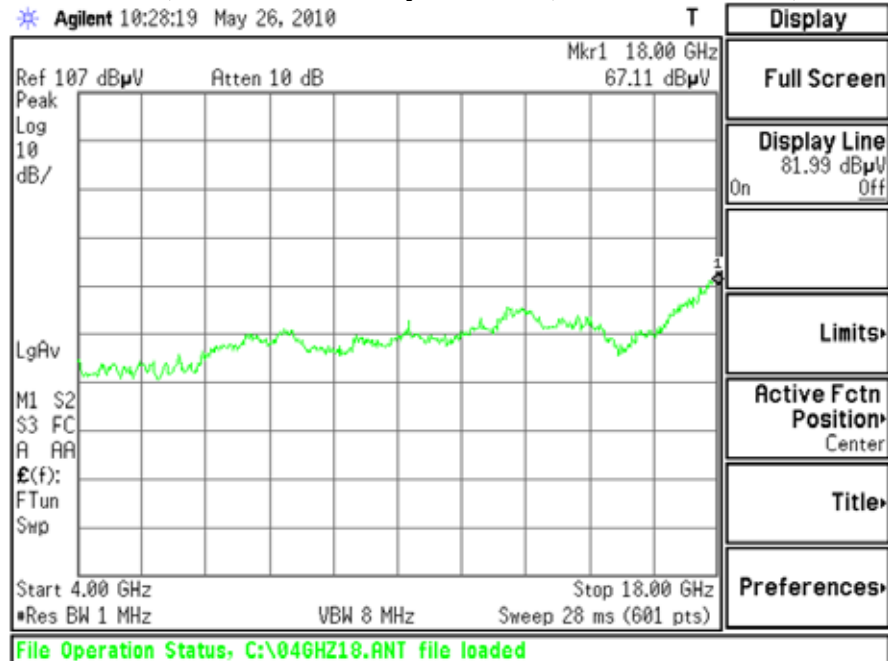
Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

Screen Captures - Radiated Emissions Testing (continued)

Channel 11, Antenna Vertically Polarized, 2484-4000 MHz, at 3m



Channel 11, Antenna Vertically Polarized, 4000-18000 MHz, at 1m

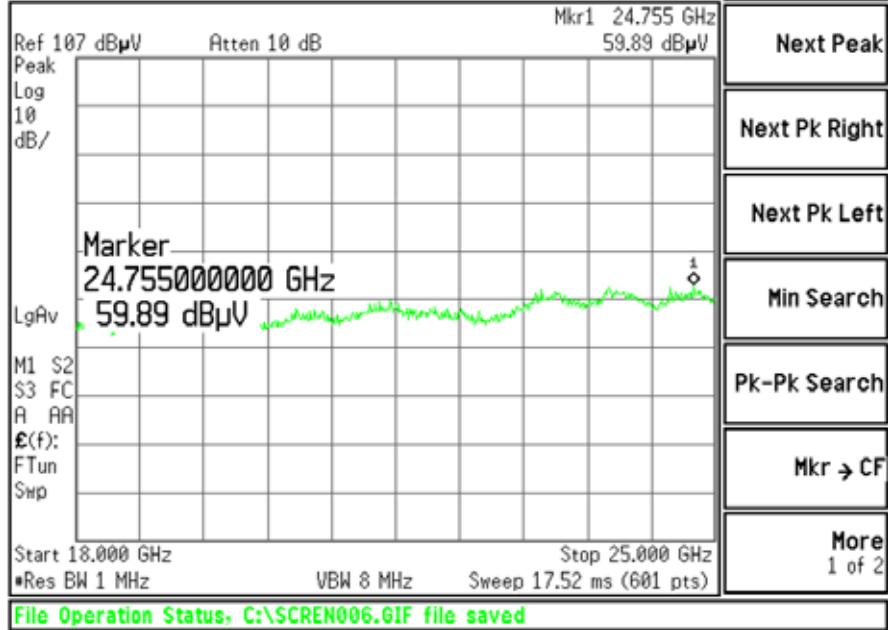


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

Screen Captures - Radiated Emissions Testing (continued)

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

Agilent 10:34:27 May 26, 2010



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

# BLUETOOTH DATA:

---

Dipole Antenna (Bent):

Frequency (MHz)	Ant. Polarity	Height (meters)	Azimuth (degrees)	Peak (dB $\mu$ V/m)	Average (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
4803.80	Horizontal	101.6	73	58.9	58.9	58.9	58.9
14411.15	Horizontal	109.7	299	60.6	60.6	60.6	60.6
4803.87	Vertical	101.2	94	57.5	57.5	57.5	57.5
14411.03	Vertical	108.2	118	54.3	54.3	54.3	54.3

Dipole Antenna (Straight):

Frequency (MHz)	Ant. Polarity	Height (meters)	Azimuth (degrees)	Peak (dB $\mu$ V/m)	Average (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
4804.35	Horizontal	101.8	336.3	61.8	59.9	63.5	3.6
14412.7	Horizontal	106.8	315.7	56.1	46.0	63.5	17.5
4803.87	Vertical	109.6	89.6	57.5	56.0	63.5	7.5

Notes:

- 1) Measurements above 4 GHz were made at 1 meters of separation from the EUT
- 2) A Quasi-Peak Detector was used in measurements below 1 GHz, and a Peak 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.
- 3) All other measurements were greater than 20 dB from limit.

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

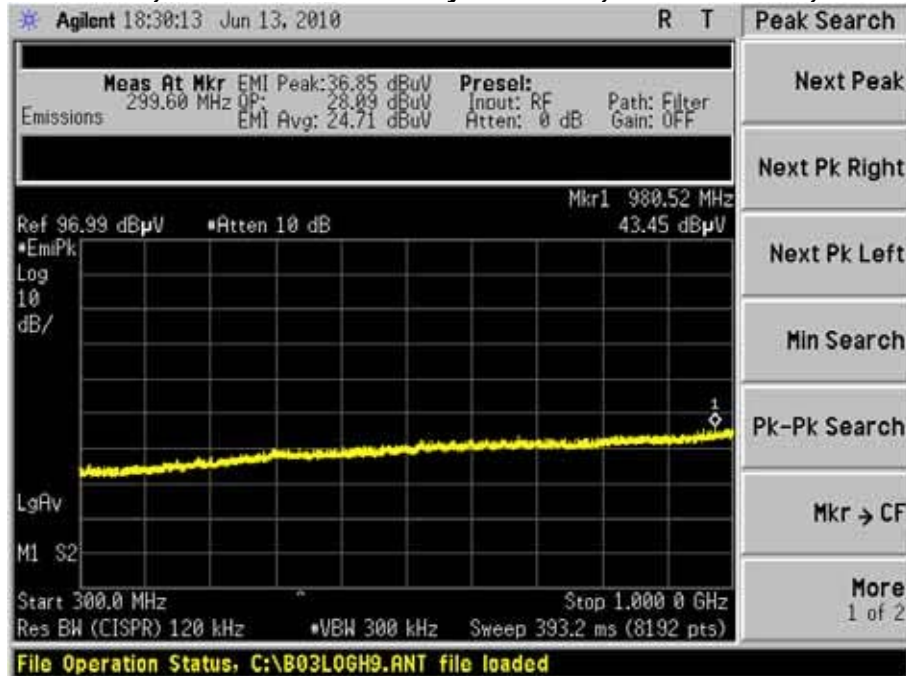
## Bluetooth with Dipole Antenna Screen Captures - Radiated Emissions Test

Note: 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. The signature scans shown here are from worst-case emissions, as measured on channels 1, 40, or 79 of the Bluetooth (BT) radio, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

### Channel 1, Antenna Vertically Polarized, 30-300 MHz, at 3m

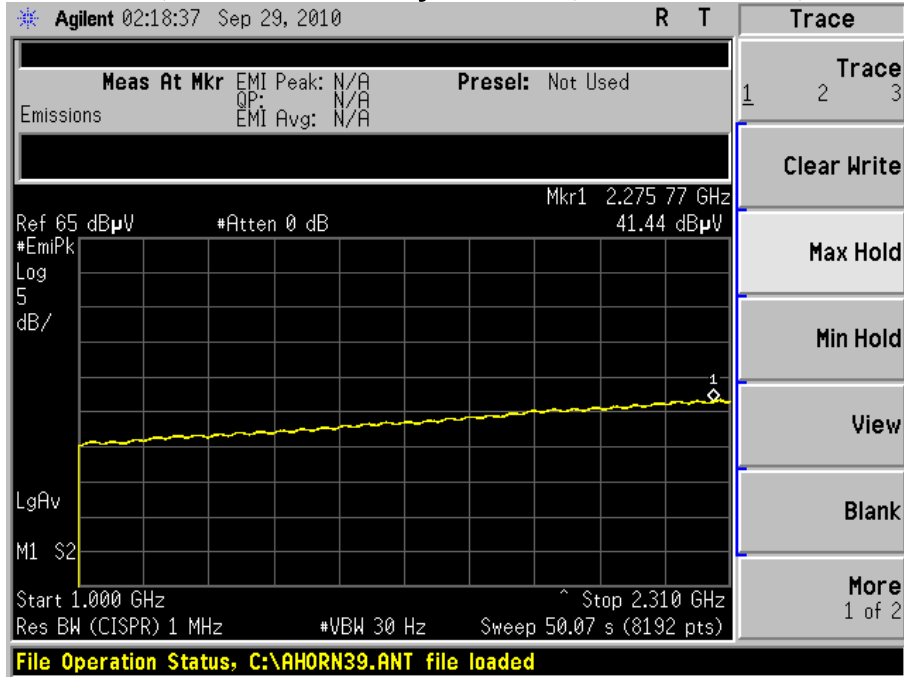


### Channel 1, Antenna Horizontally Polarized, 300-1000 MHz, at 3m

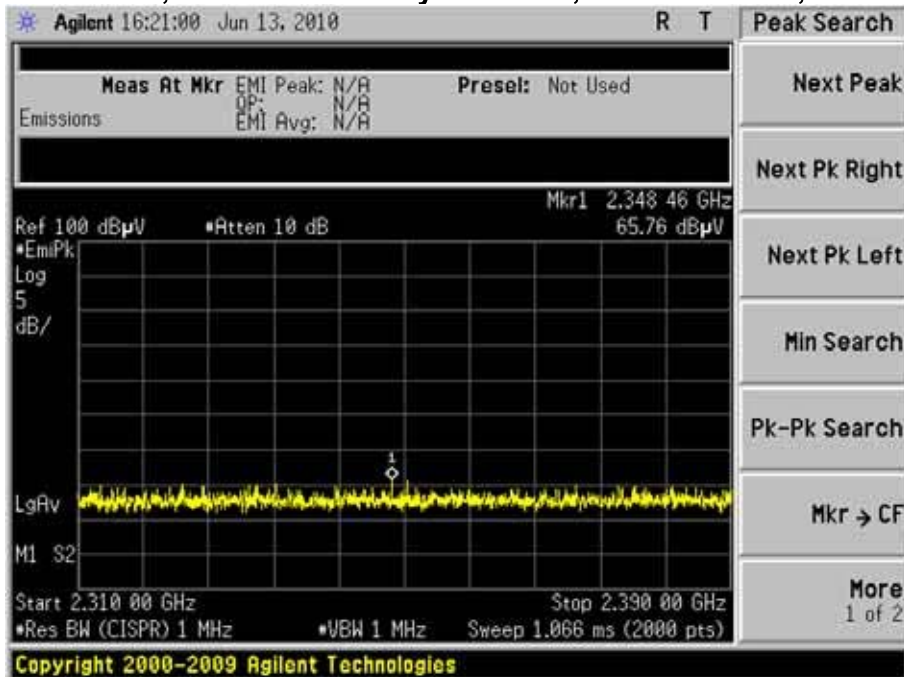


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Channel 1, Antenna Vertically Polarized, 1000-2310 MHz, at 3m**

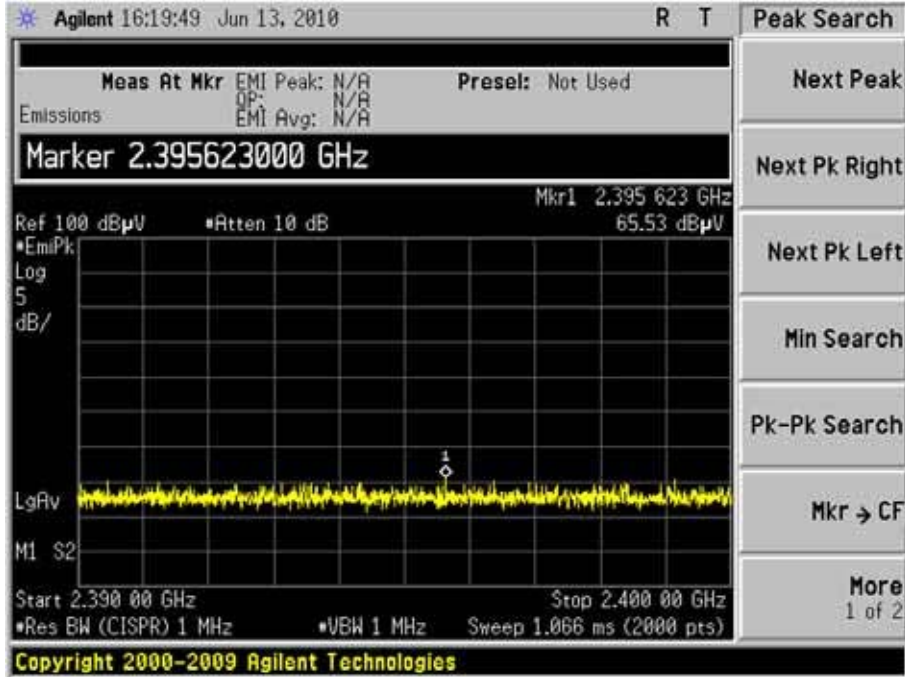


**Channel 1, Antenna Vertically Polarized, 2310-2390 MHz, at 3m**

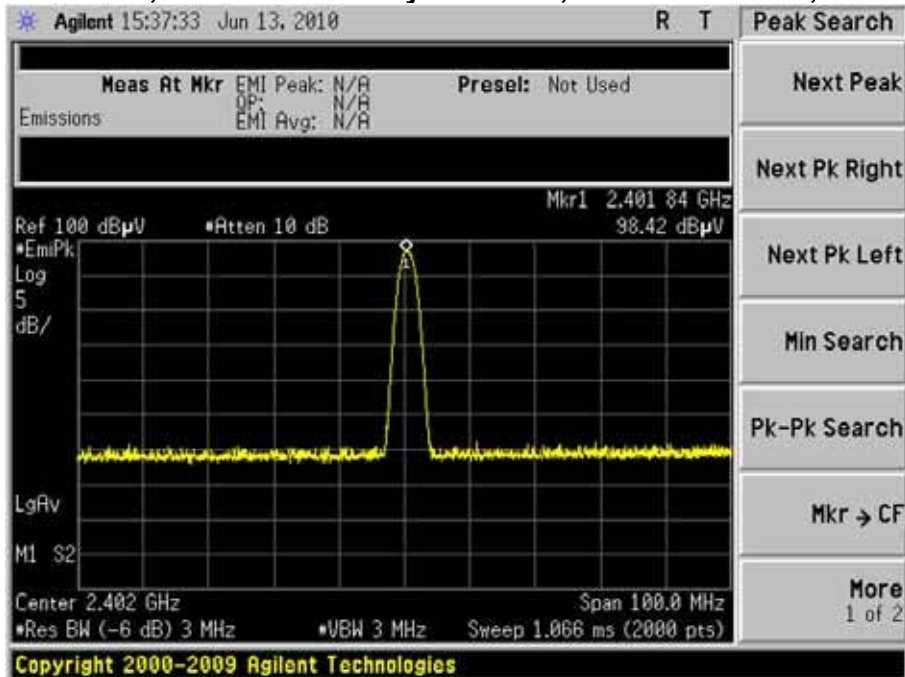


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Channel 1, Antenna Vertically Polarized, 2390-2400 MHz, at 3m**

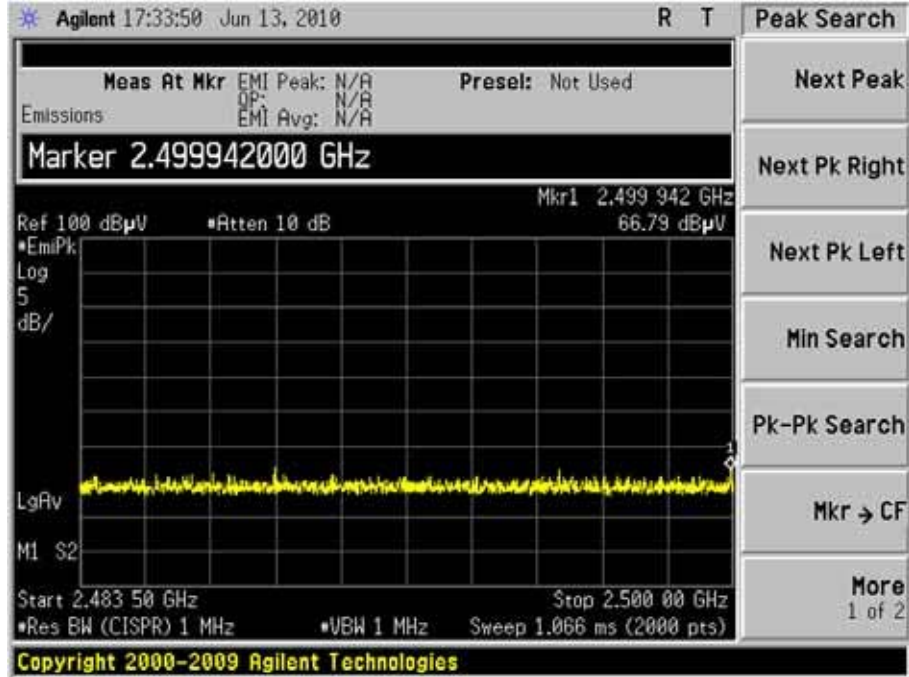


**Channel 1, Antenna Vertically Polarized, 2400-2483.5 MHz, at 3m**

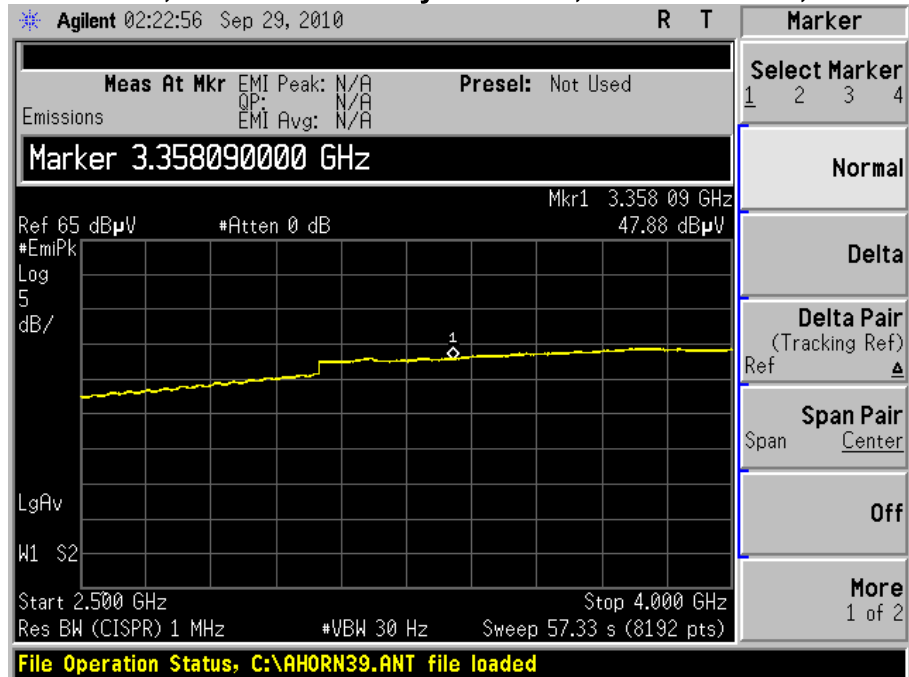


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Channel 1, Antenna Vertically Polarized, 2483.5-2500 MHz, at 3m**



**Channel 1, Antenna Vertically Polarized, 2500-4000 MHz, at 3m**



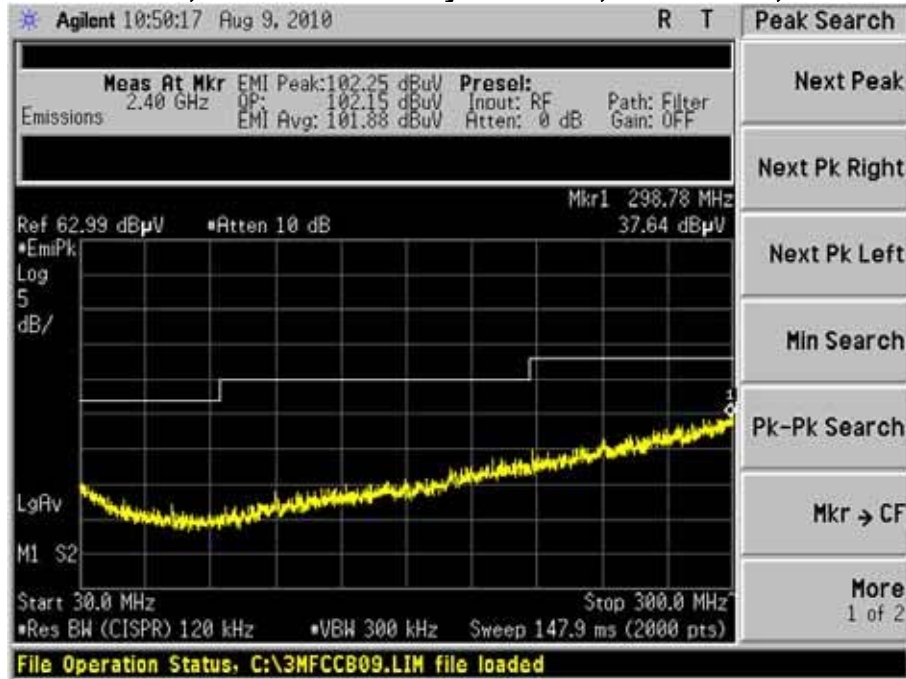
Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285



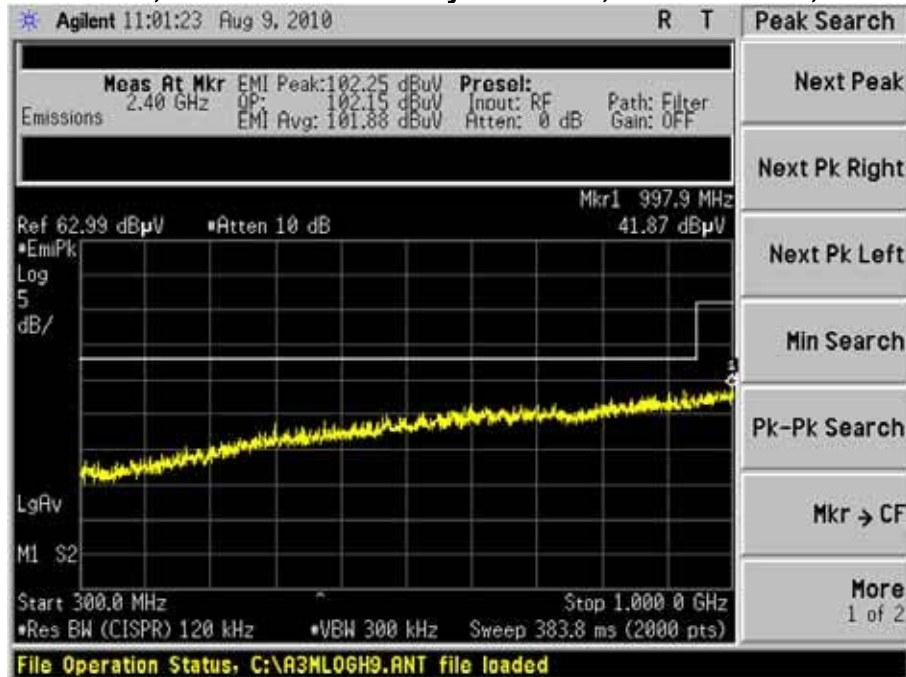
## Bluetooth with PIFA Antenna Screen Captures - Radiated Emissions Test

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. The signature scans shown here are from worst-case emissions, as measured on channels 1,40, or 79 of the Bluetooth (BT) radio, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

### Channel 1, Antenna Vertically Polarized, 30-300 MHz, at 3m

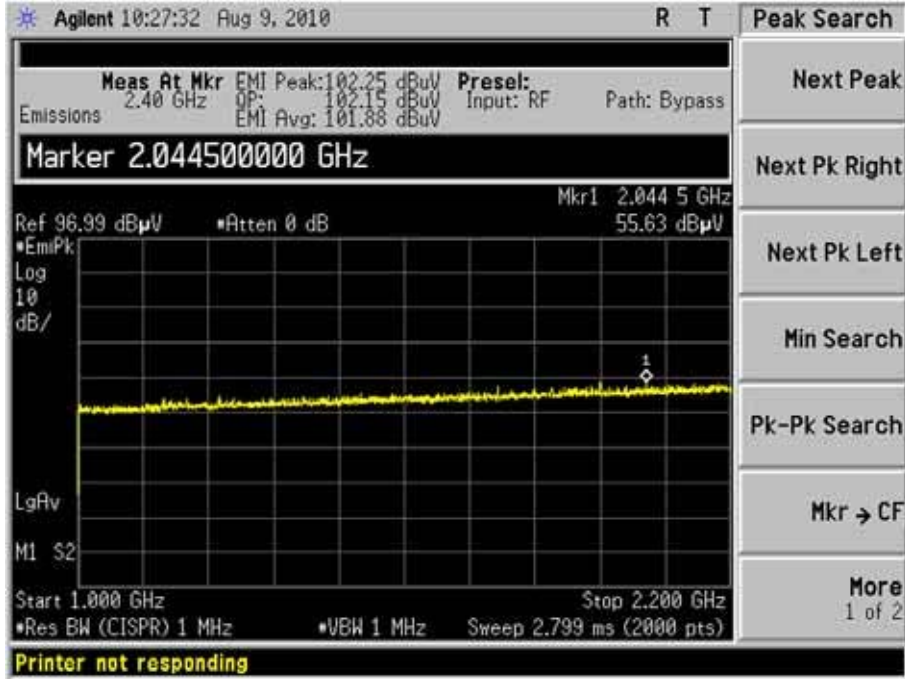


### Channel 1, Antenna Horizontally Polarized, 300-1000 MHz, at 3m

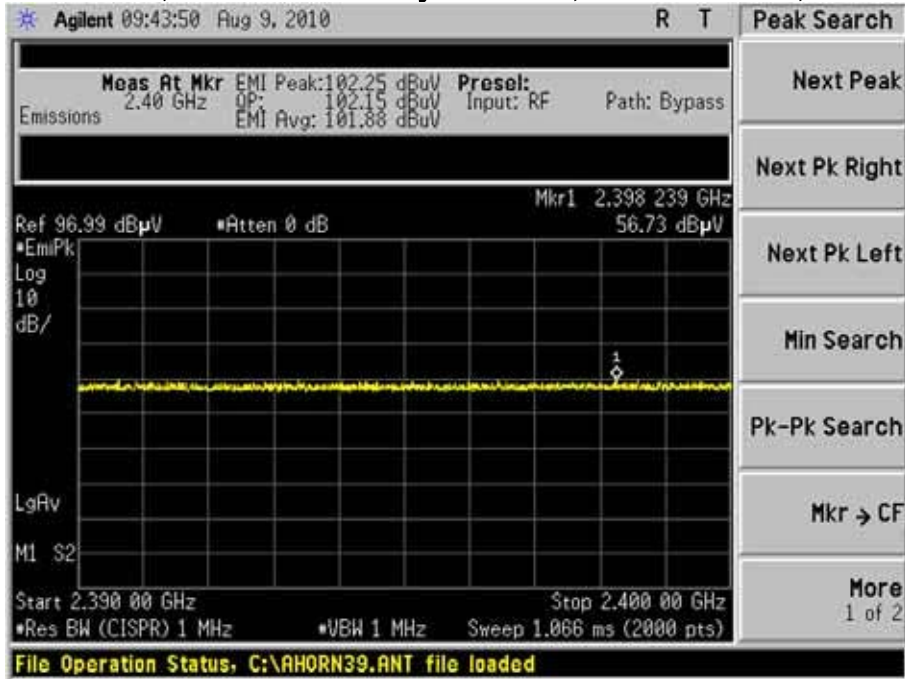


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Channel 1, Antenna Vertically Polarized, 1000-2200 MHz, at 3m**

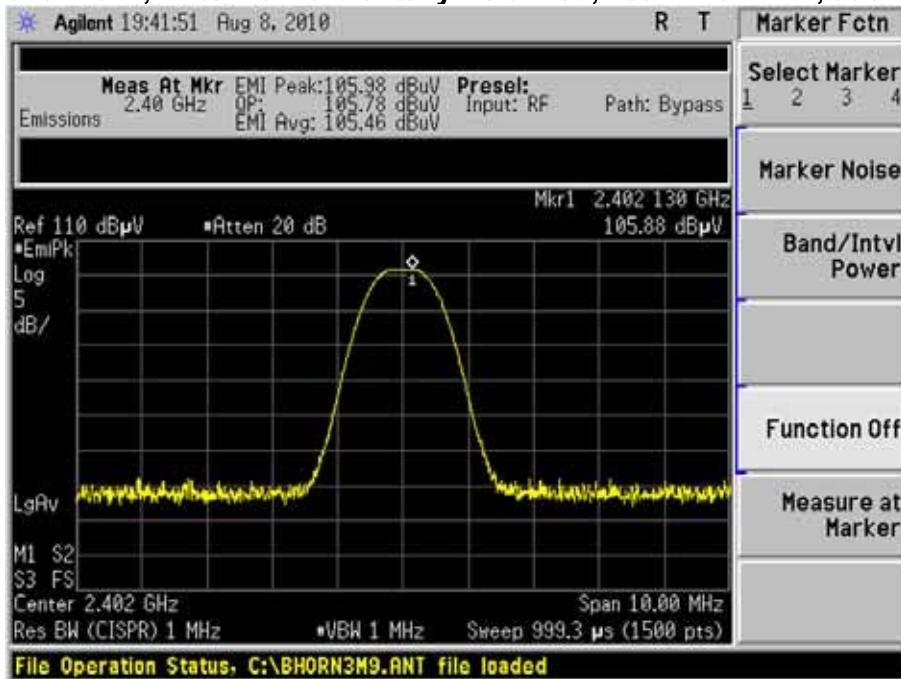


**Channel 1, Antenna Vertically Polarized, 2390-2400 MHz, at 3m**

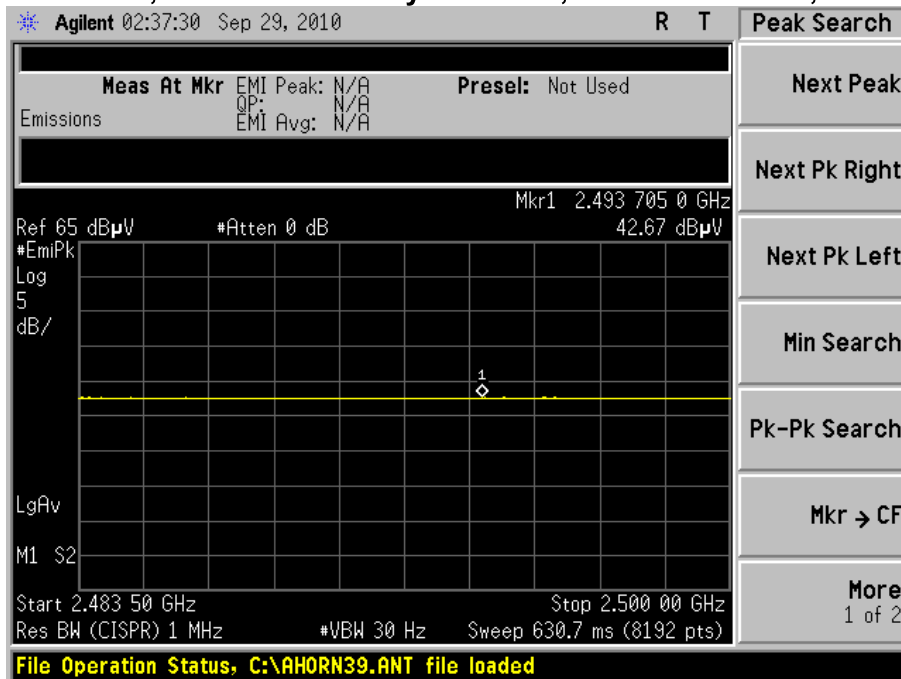


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Channel 1, Antenna Horizontally Polarized, 2397-2407 MHz, at 3m**

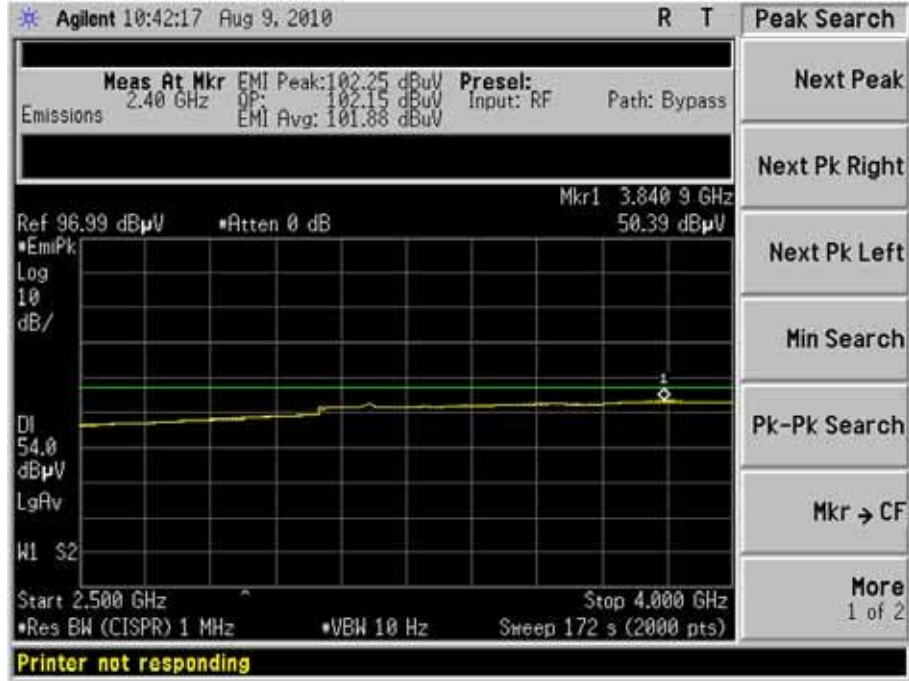


**Channel 1, Antenna Vertically Polarized, 2483.5-2500 MHz, at 3m**



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

Channel 1, Antenna Vertically Polarized, 2500-4000 MHz, Average, at 3m



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

## **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.

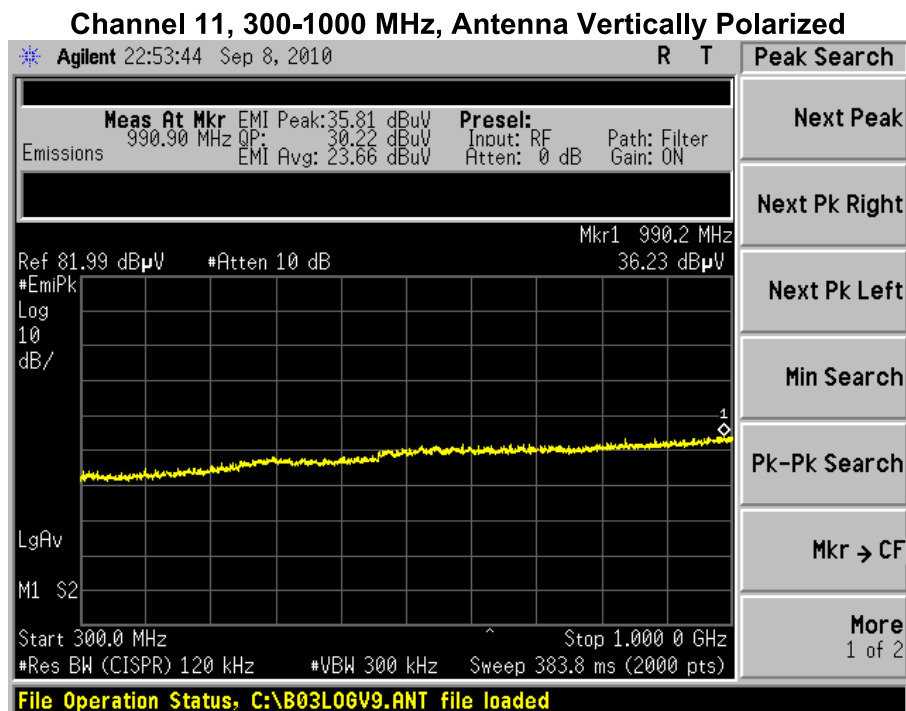
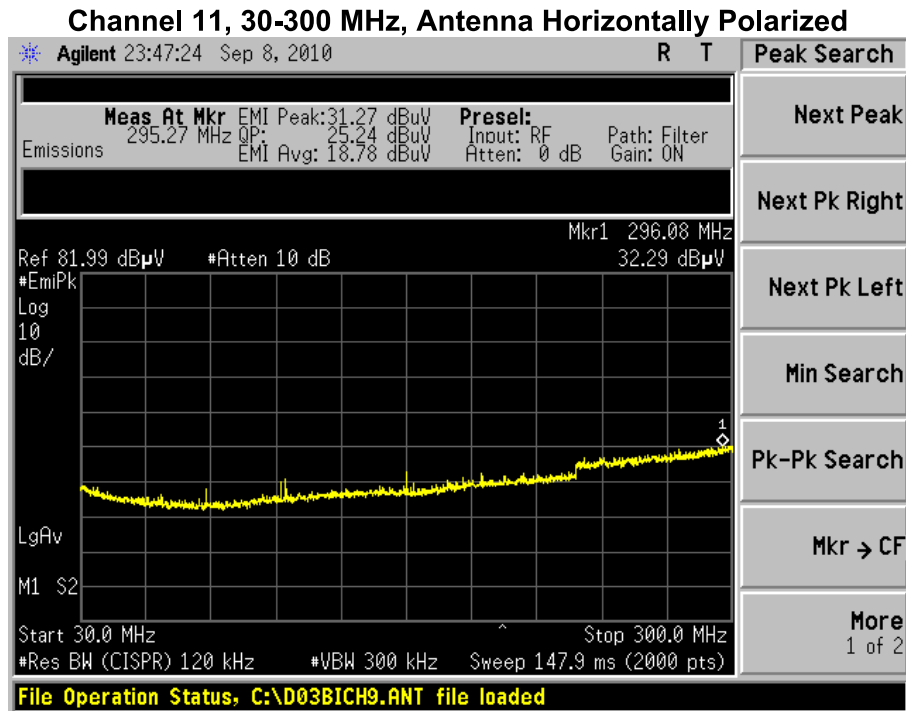
Measurement data and screen captures from the receive tests with the WLAN radio are presented below:

<b>Antenna</b>	<b>Frequency (MHz)</b>	<b>Height (m)</b>	<b>Azimuth (degree)</b>	<b>EFI Reading (dB<math>\mu</math>V/m)</b>	<b>Limit (dB<math>\mu</math>V/m)</b>	<b>Margin (dB)</b>	<b>Antenna Polarity</b>
Dipole	298.38	1.00	0	26.1	46.0	19.9	H
Dipole	2412.50	1.00	0	40.2	54.0	13.8	V
Dipole	3756.90	1.00	0	44.5	54.0	9.5	H
PIFA	59.32	1.00	0	9.8	40.0	30.2	V
PIFA	297.43	1.00	0	24.9	46.0	21.1	V
PIFA	295.27	1.00	0	25.2	46.0	20.8	H
PIFA	997.20	1.00	0	29.3	54.0	14.7	V
PIFA	3761.40	1.00	0	44.2	54.0	9.8	H

<b>Prepared For: LS Research</b>	<b>Model Number: TiWi-BLE</b>	<b>Report #: 311258</b>
<b>EUT: Tiwi-BLE</b>	<b>Serial Number: 031202</b>	<b>LSR Job #: C-1285</b>

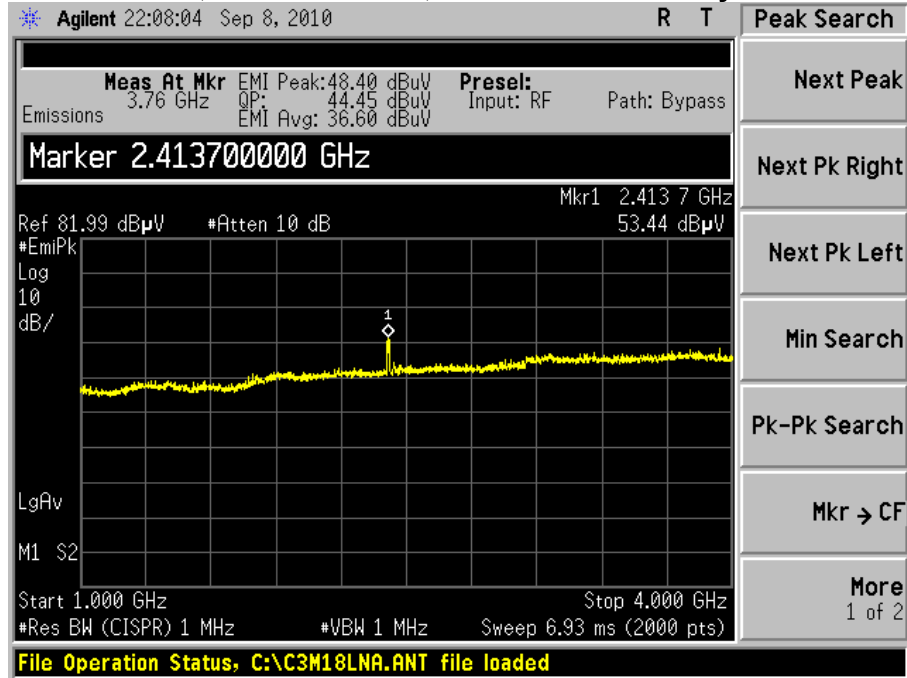
## 5.9 - Screen Captures - Radiated Emissions Testing - Receive Mode

Note: Data Taken with WLAN Radio and PIFA Antenna – WLAN Radio with Dipole antenna demonstrated similar results.



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

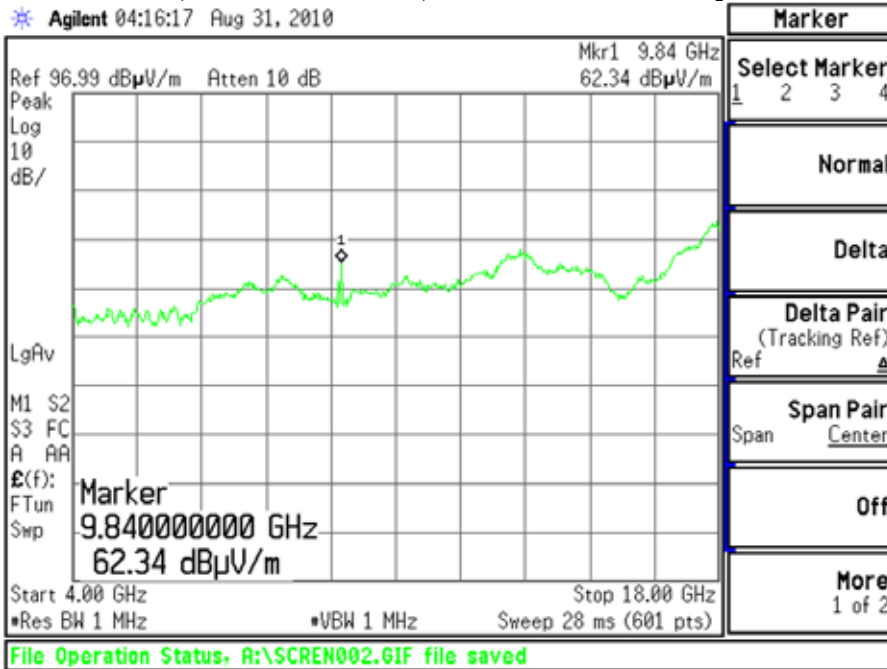
### Channel 11, 1000-4000 MHz, Antenna Horizontally Polarized



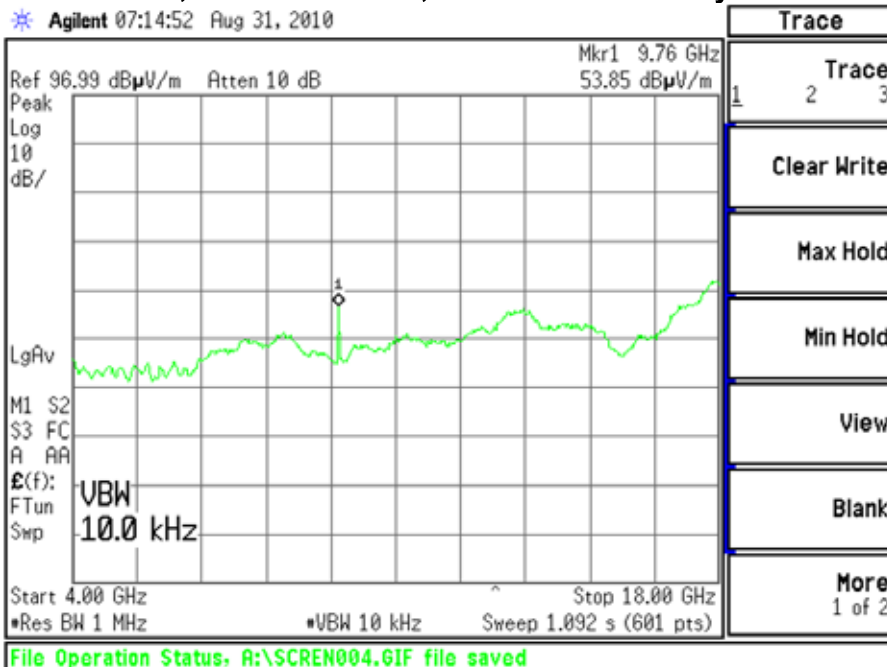
Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

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

**Channel 11, 4000-18000 MHz, Antenna Horizontally Polarized**



**Channel 11, 4000-18000 MHz, Antenna Horizontally Polarized**

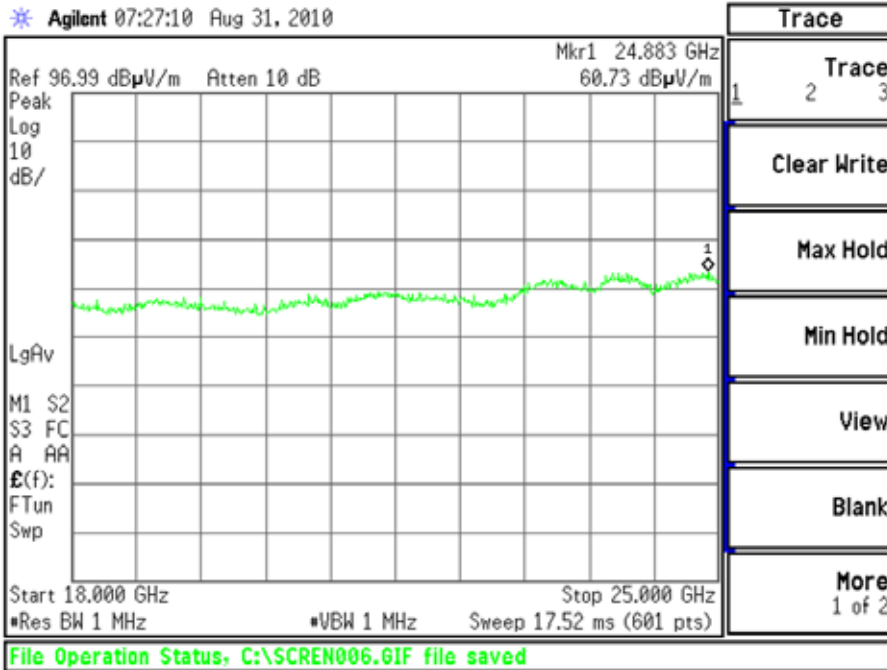


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285



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

**Channel 11, 18000-25000 MHz, Antenna Horizontally Polarized**

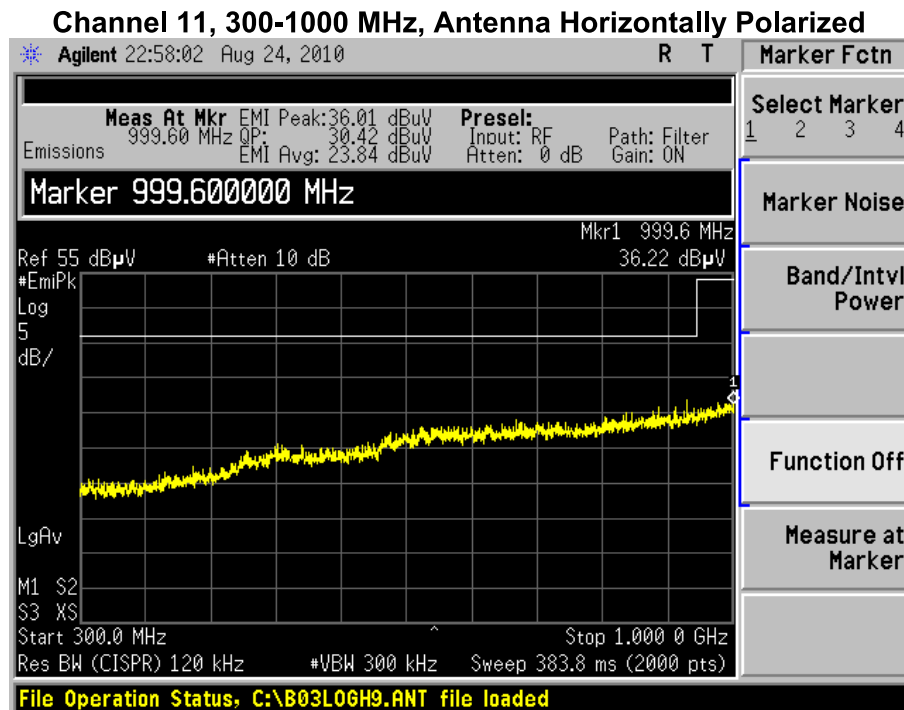
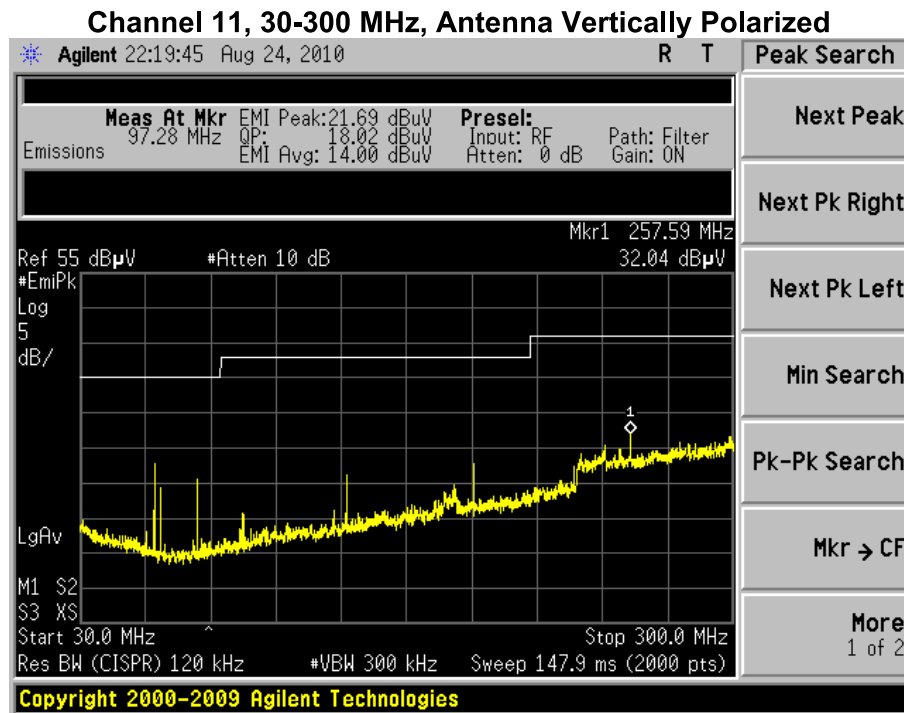


**Channel 11, 25000-40000 MHz, Antenna Horizontally Polarized**



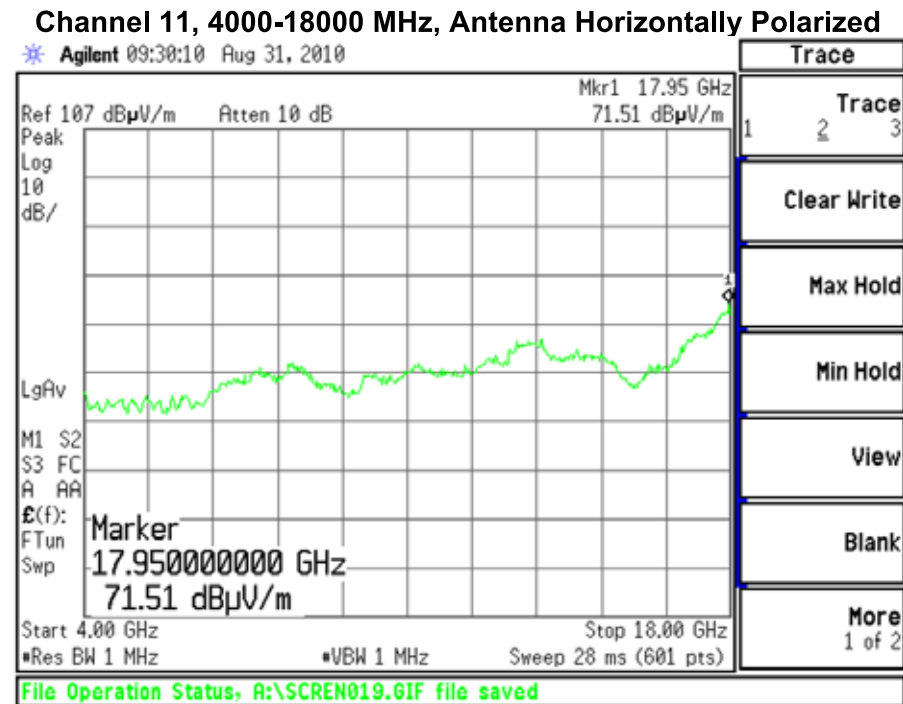
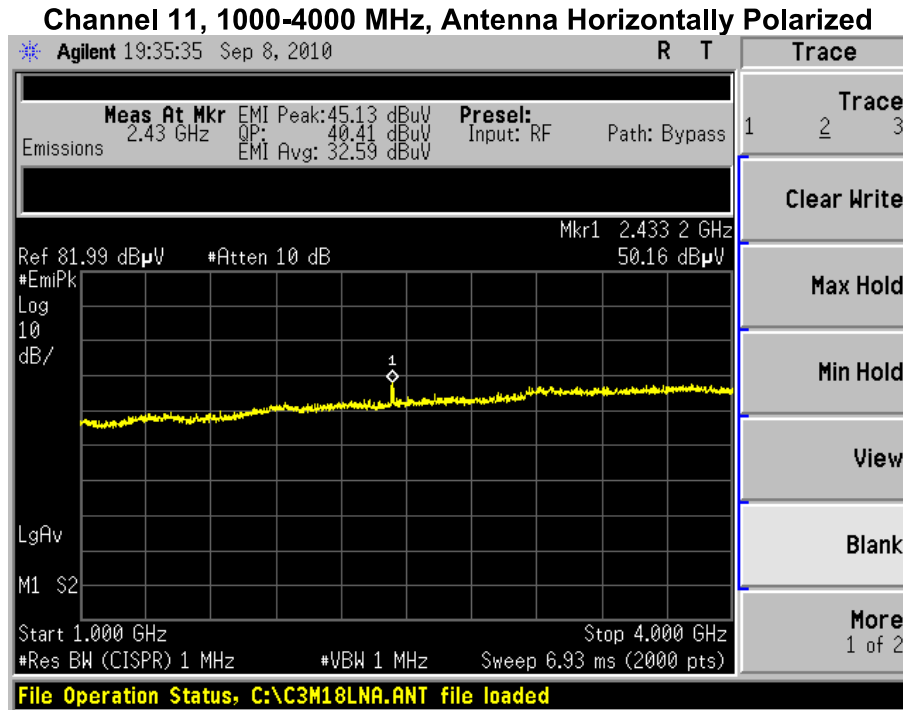
Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Screen Captures - Radiated Emissions Testing – Receive Mode (continued)**  
**BT Radio with PIFA Antenna – BT Radio with Dipole Antenna Produced Similar Results**



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

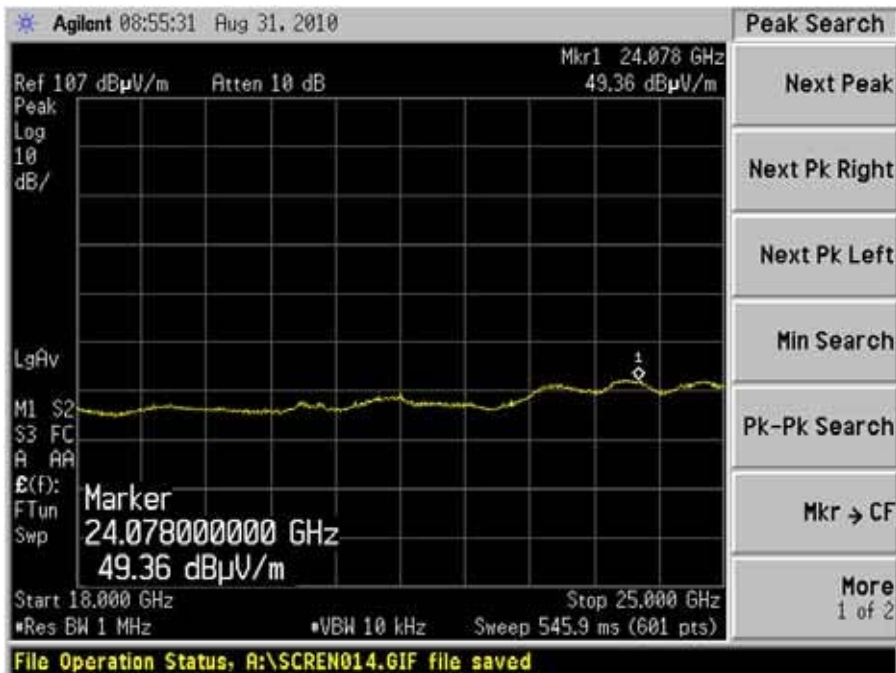
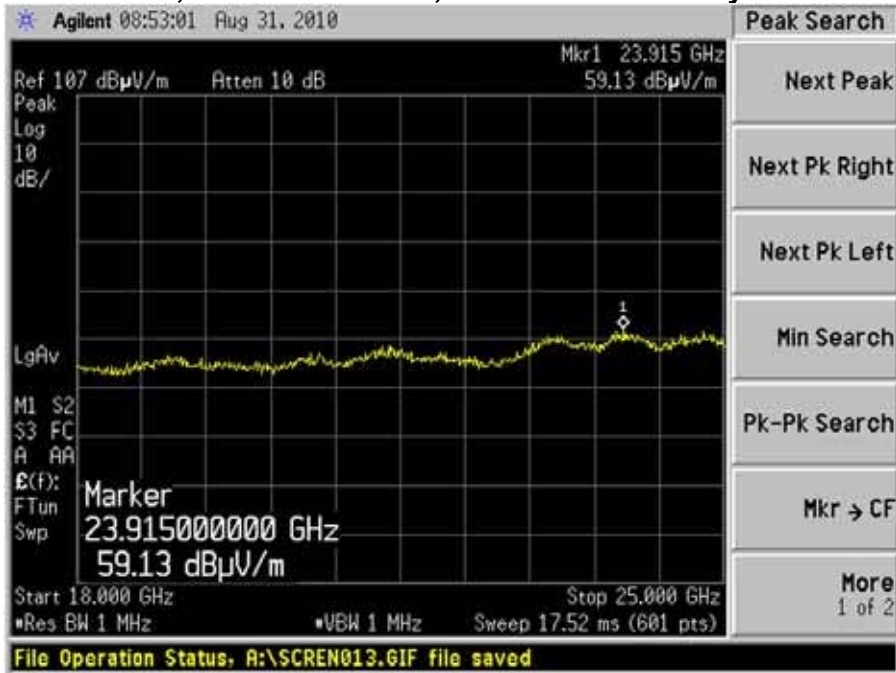
**Screen Captures - Radiated Emissions Testing – Receive Mode (continued)**



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

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

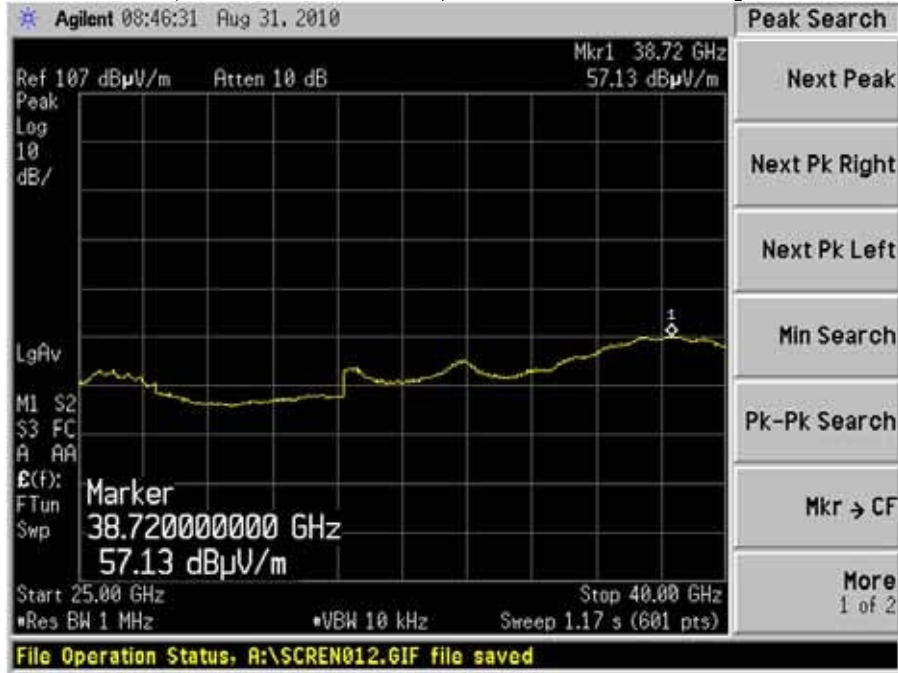
**Channel 11, 18000-25000 MHz, Antenna Horizontally Polarized**



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

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

**Channel 11, 25000-40000 MHz, Antenna Horizontally Polarized**



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

## 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 50Ω (ohm), 50/250 Ω 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 50Ω (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 and 15.107 Conducted Emissions for an Intentional Radiator as well as IC RSS 210 and RSS GEN. See the Data Charts and Graphs for more details of the test results.

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

## 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:

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

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

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

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

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

## 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

<b>Manufacturer:</b>	LS Research				
<b>Date(s) of Test:</b>	September 28, 2010				
<b>Test Engineer:</b>	Peter Feilen				
<b>Voltage:</b>	5VDC				
<b>Operation Mode:</b>	Continuous Transmit/Receive				
<b>Environmental Conditions in the Lab:</b>	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %				
<b>Test Location:</b>	<input checked="" type="checkbox"/>	Other			Chamber
<b>EUT Placed On:</b>	<input checked="" type="checkbox"/>	40cm from Vertical Ground Plane			10cm Spacers
	<input checked="" type="checkbox"/>	80cm above Ground Plane			Other:
<b>Measurements:</b>		Pre-Compliance		Preliminary	<input checked="" type="checkbox"/> Final
<b>Detector Used:</b>	<input checked="" type="checkbox"/>	Peak	<input checked="" type="checkbox"/>	Quasi-Peak	<input checked="" type="checkbox"/> Average

Frequency (MHz)	Radio	Line	QUASI-PEAK			AVERAGE		
			Reading (dBµV)	Limit (dBµV)	Margin (dB)	Reading (dBµV)	Limit (dBµV)	Margin (dB)
0.157	BT	TX1	29.03	65.62	36.59	6.89	55.62	48.73
0.161	BT	TX1	29.51	65.41	35.90	6.31	55.41	49.10
0.157	BT	TX2	28.8	65.62	36.82	6.53	55.62	49.09
0.154	BT	TX2	28.84	65.78	36.94	6.61	55.78	49.17
0.165	BT	RX2	16.57	65.21	48.64	4.51	55.21	50.70
0.167	BT	RX1	21.18	65.11	43.93	5.56	55.11	49.55
0.150	WLAN	TX1	39.01	66.00	26.99	20.77	56.00	35.23
0.165	WLAN	TX2	29.26	65.21	35.95	17.56	55.21	37.65
0.150	WLAN	RX2	30.14	66.00	35.86	18.23	56.00	37.77
0.172	WLAN	RX1	36.77	64.86	28.09	18.58	54.86	36.28

**Notes:**

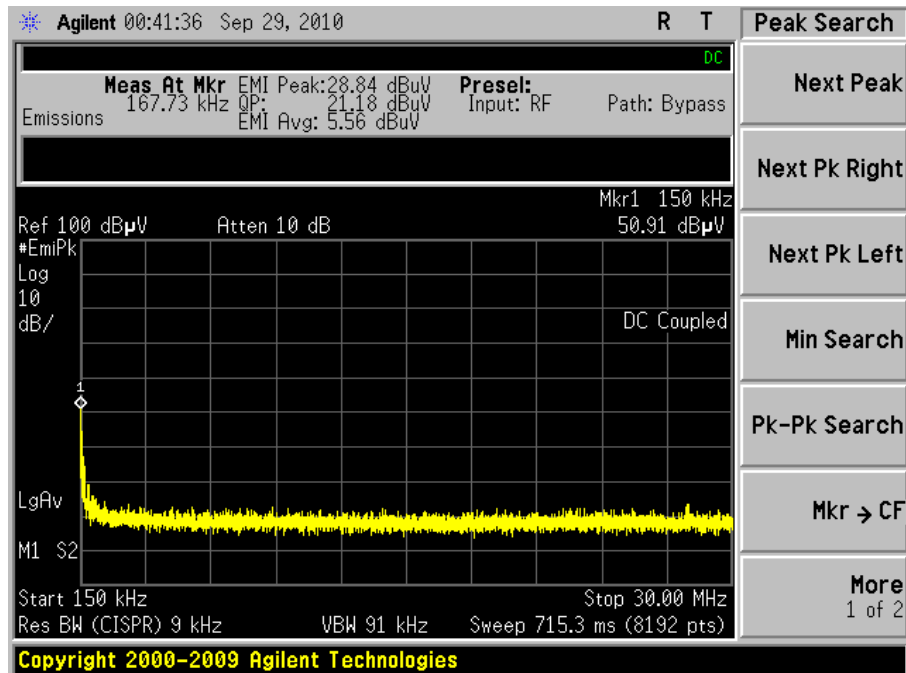
- 1) All other emissions were better than 20 dB below the limits.
- 2) The EUT exhibited similar emissions in transmit and receive modes, and across the Low, Middle and High channels tested.

<b>Prepared For:</b> LS Research	<b>Model Number:</b> TiWi-BLE	<b>Report #:</b> 311258
<b>EUT:</b> Tiwi-BLE	<b>Serial Number:</b> 031202	<b>LSR Job #:</b> C-1285

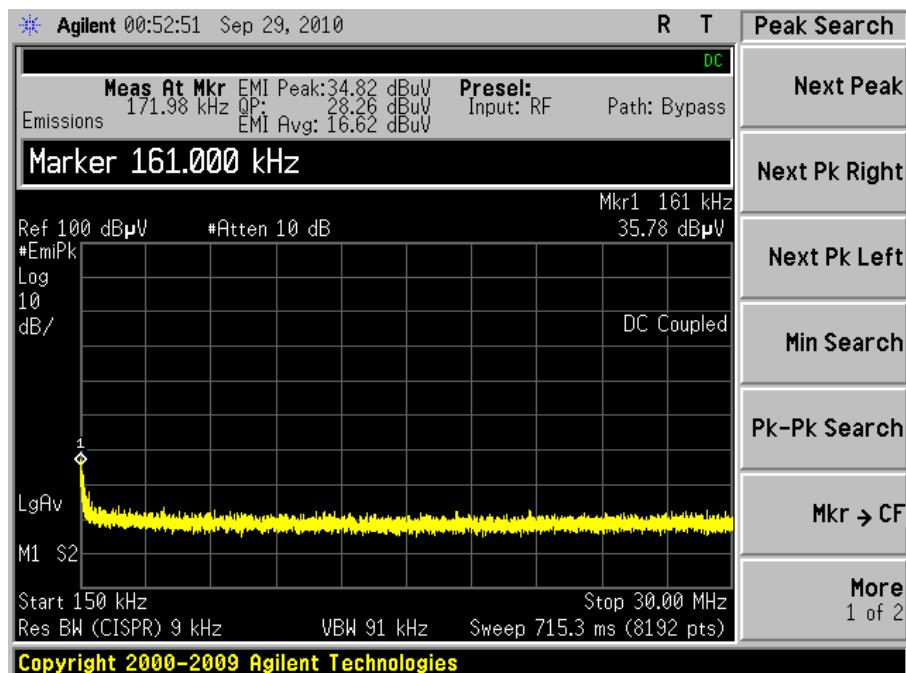


## 6.7 - Screen Captures - Conducted Emissions Test

### WLAN Transmit Mode:



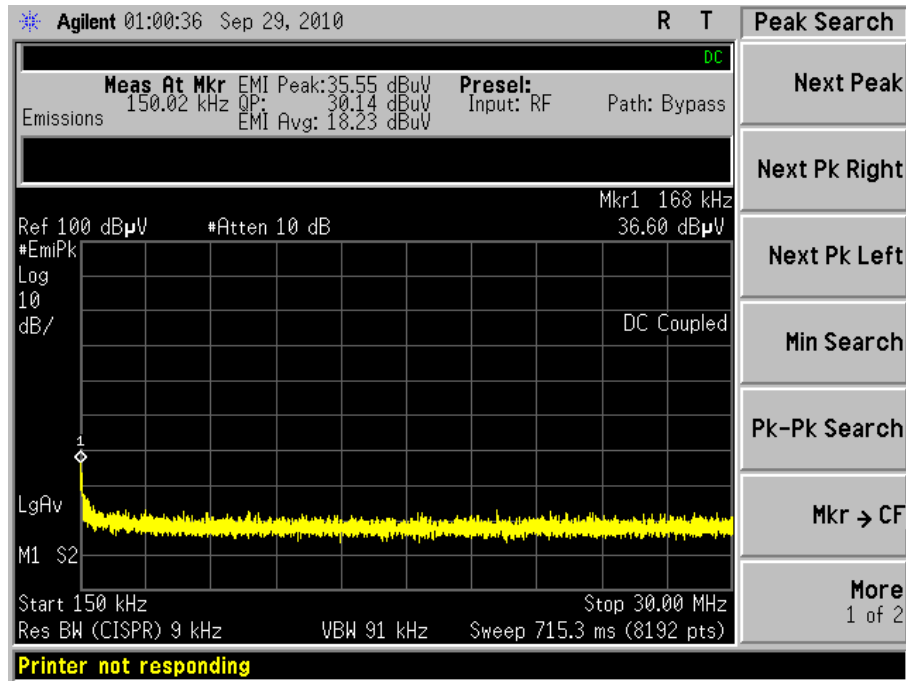
LINE 1



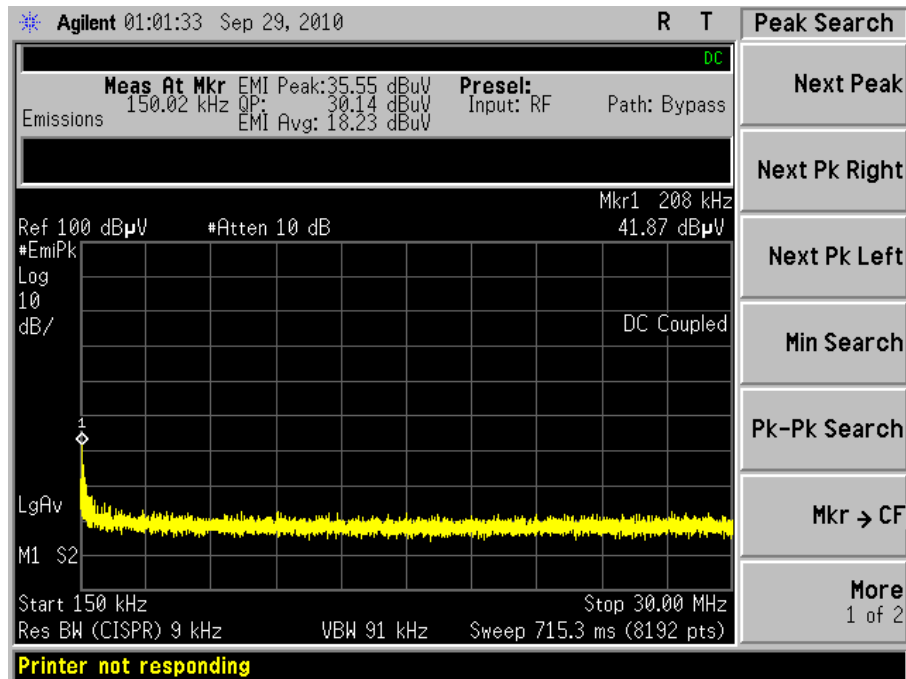
LINE 2

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

### WLAN Receive mode:



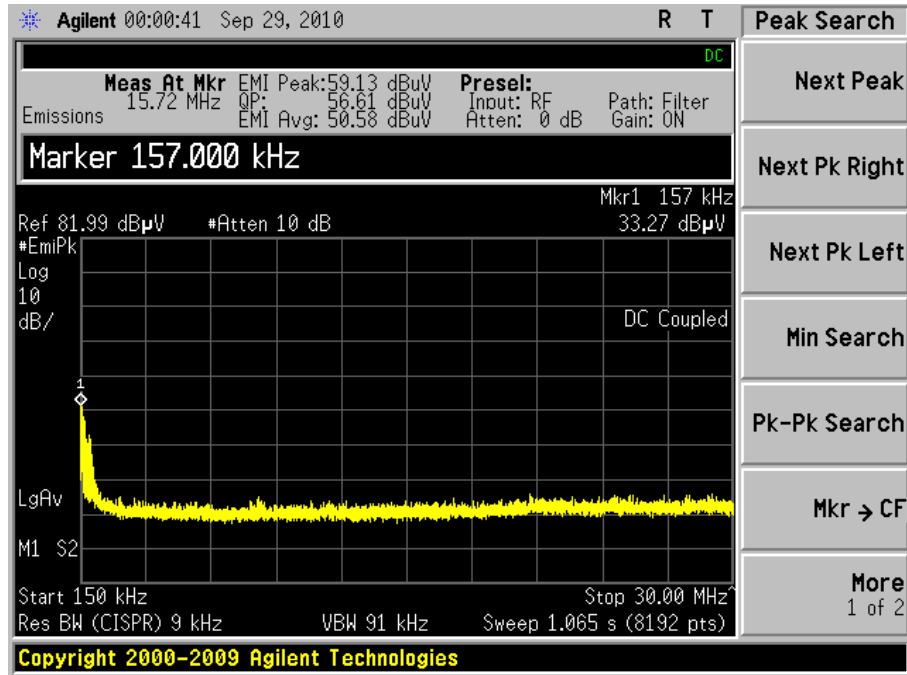
LINE 1



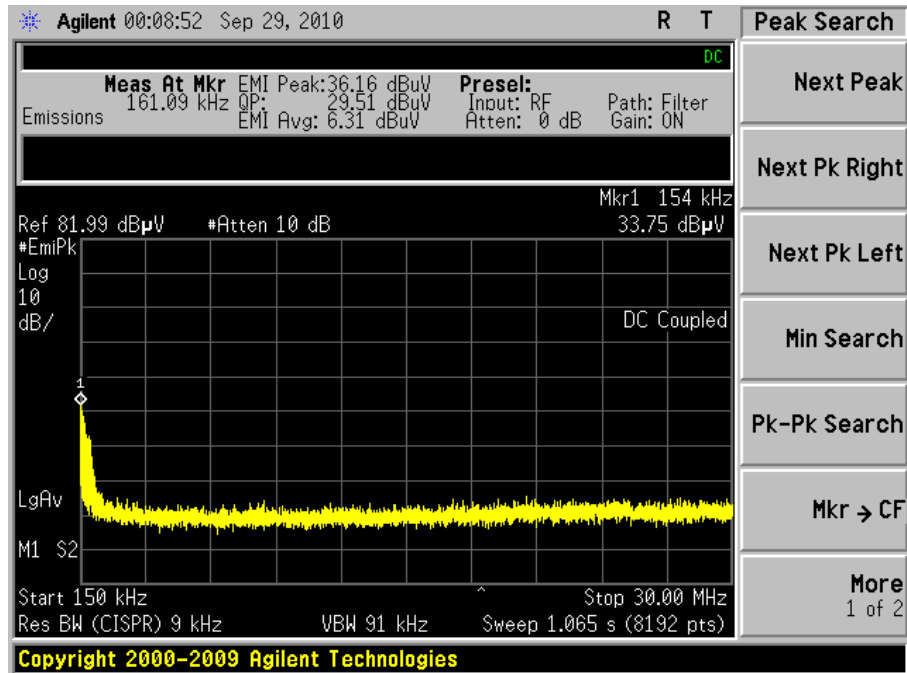
LINE 2

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: TiWi-BLE	Serial Number: 031202	LSR Job #: C-1285

### Bluetooth Transmit mode:



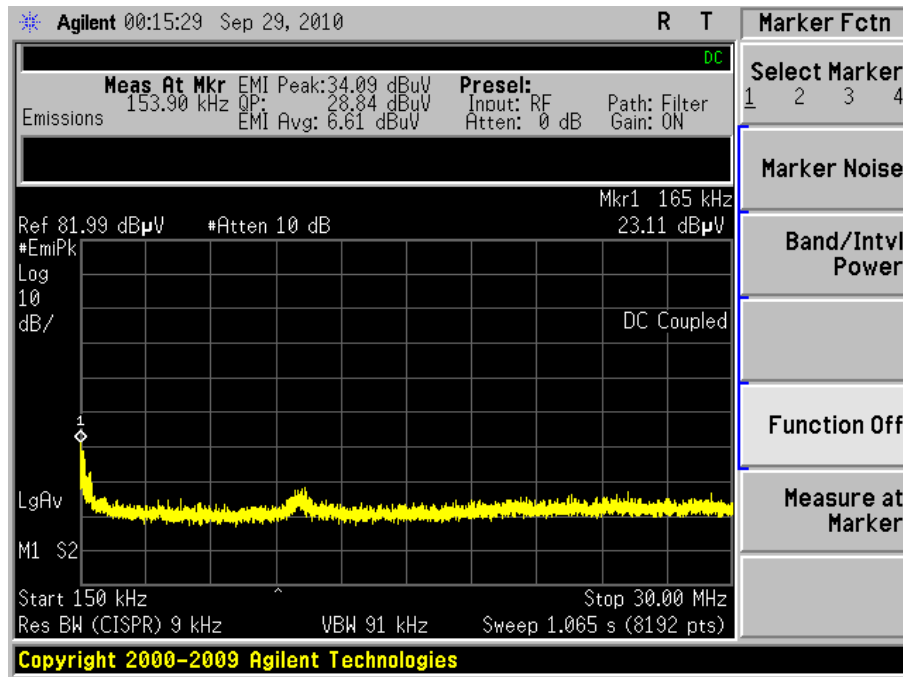
LINE 1



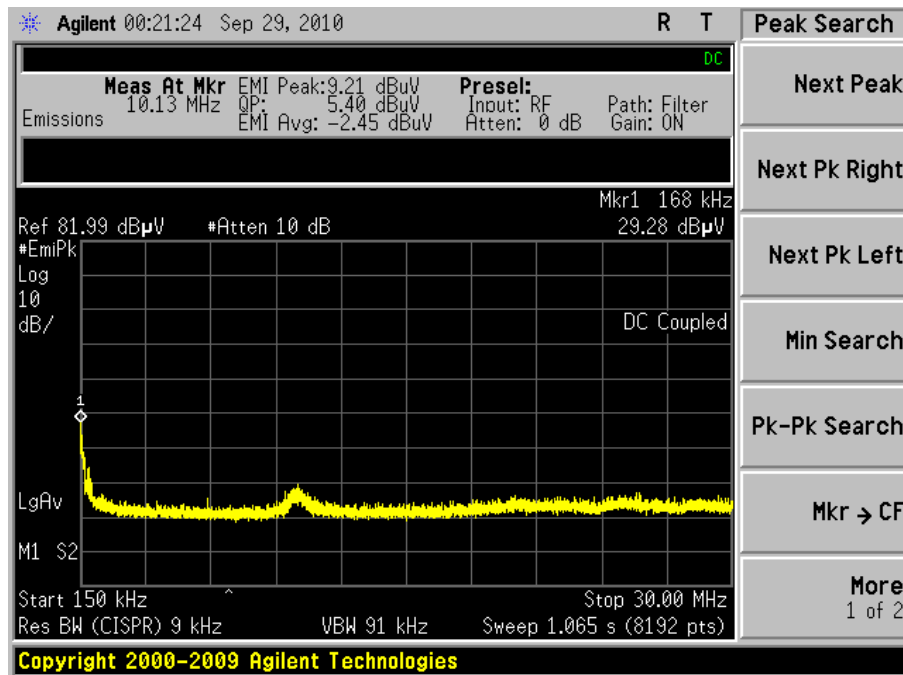
LINE 2

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Bluetooth Receive mode:**



LINE 1



LINE 2

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

# 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 (2003) and FCC Procedures (2007) for Digital Transmission Systems operating under 15.247.

The transmitter output was connected to the Spectrum Analyzer. 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.

From this data, the closest measurement (6 dB bandwidth) when compared to the specified limit, is 925 kHz, which is above the minimum of 500 kHz.

## **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**

### **Bluetooth**

Channel	Center Freq (MHz)	-20 dBc OBW (kHz)
1	2402	866.66
40	2441	858.33
79	2480	875.00

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: TiWi-BLE	Serial Number: 031202	LSR Job #: C-1285

**Bluetooth BLE:**

Channel	Center Freq (MHz)	-6 dBc OBW (kHz)	-26 dBc OBW (kHz)
0	2402	935	1340
20	2442	925	1325
39	2480	945	1345

**WLAN 1 Mbps Data Rate:**

Channel	Center Freq (MHz)	-6 dBc OBW (MHz)	-20 dBc OBW (MHz)
1	2412	9.625	14.068
6	2437	9.225	14.058
11	2462	9.220	14.017

**WLAN at MCS7 Data Rate:**

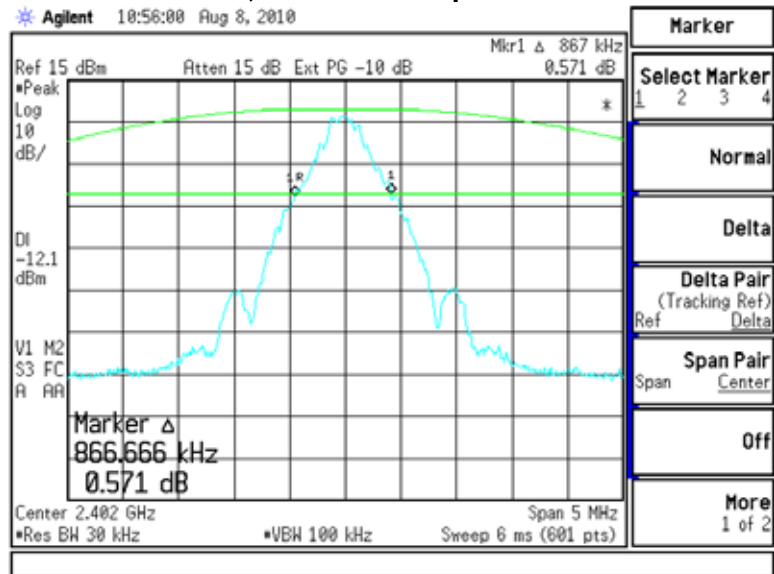
Channel	Center Freq (MHz)	-6 dBc OBW (MHz)	-20 dBc OBW (MHz)
1	2412	17.319	17.76
6	2437	17.465	17.76
11	2462	17.564	17.74

Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: TiWi-BLE	Serial Number: 031202	LSR Job #: C-1285

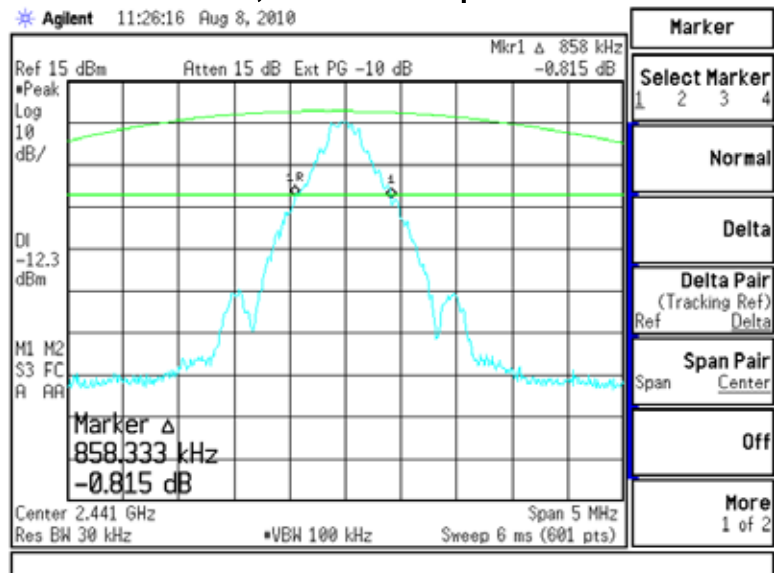
## 7.5 - Screen Captures - Occupied Bandwidth

### Bluetooth

Channel 1, -20 dBc Occupied Bandwidth

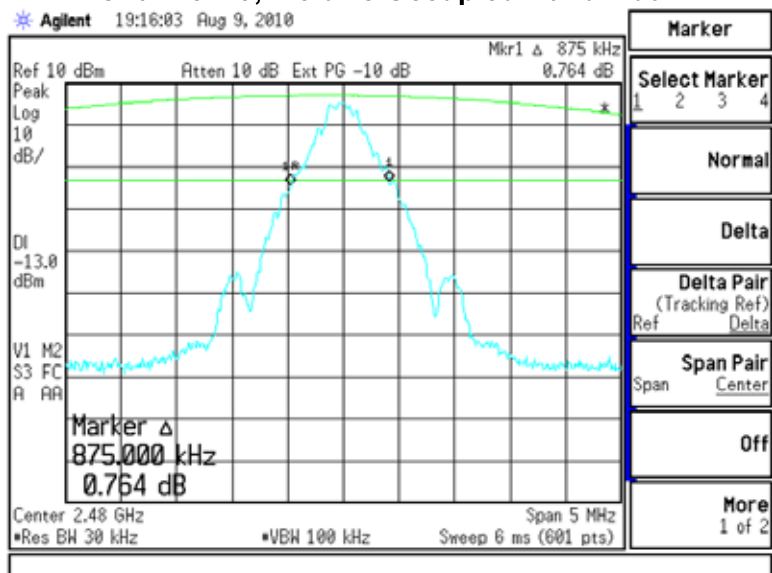


Channel 40, -20 dBc Occupied Bandwidth



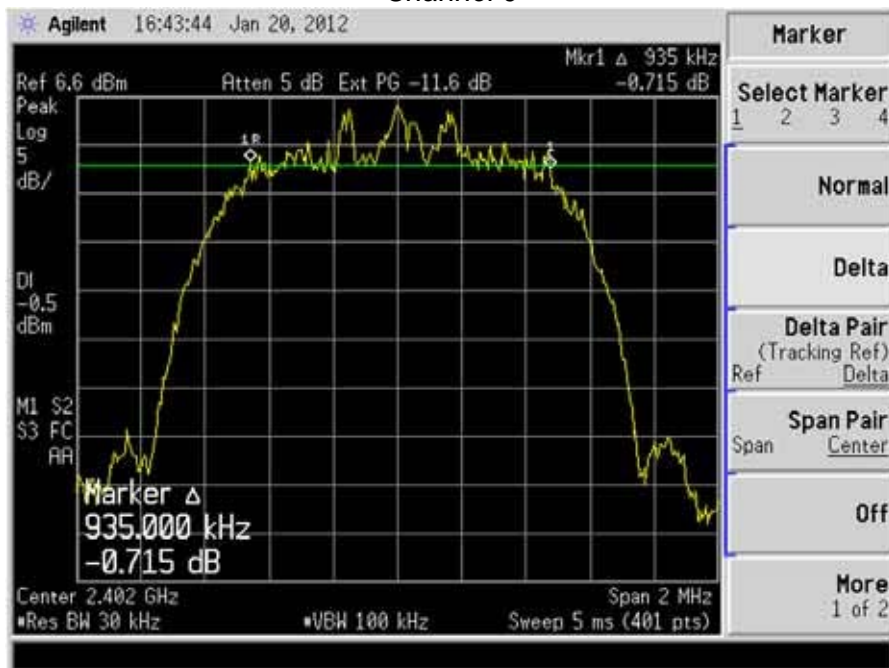
Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

### Channel 79, -20 dBc Occupied Bandwidth



Bluetooth BLE:

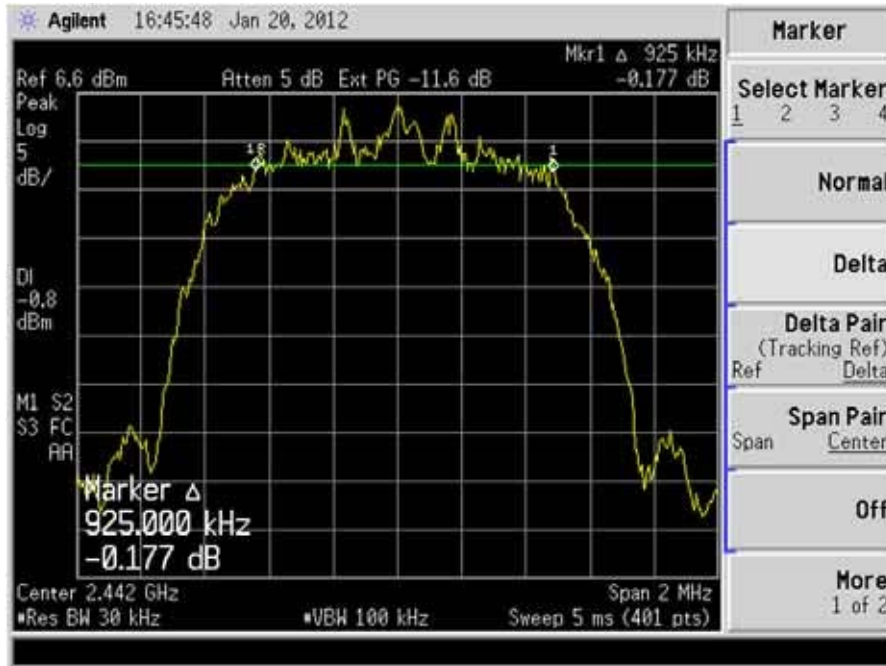
### Channel 0



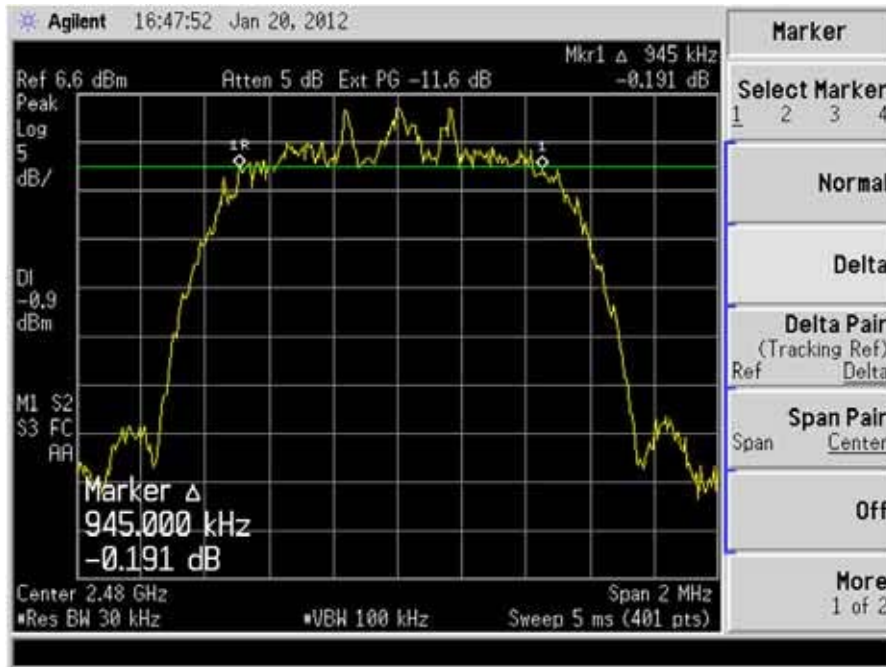
Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285



Channel 20

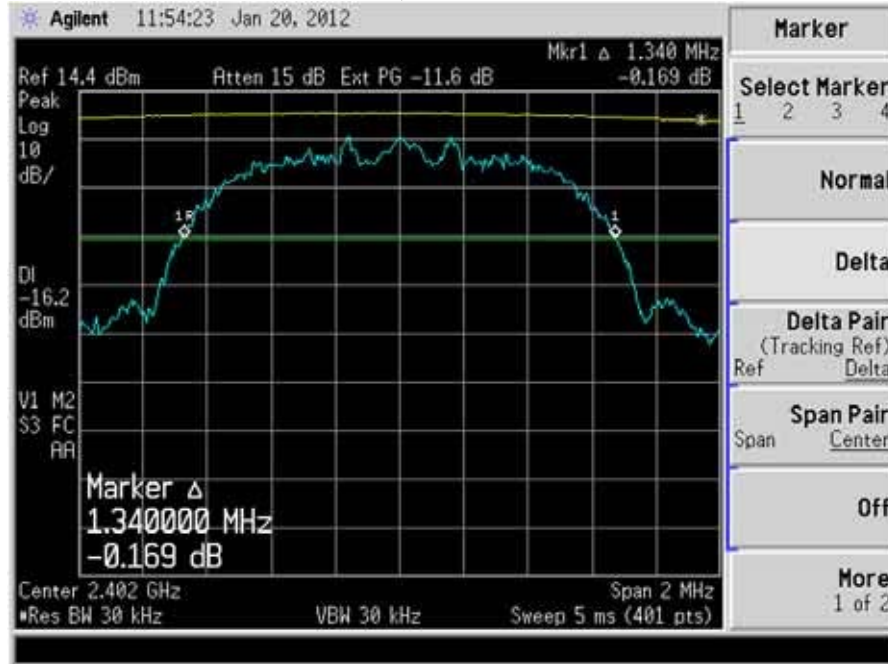


Channel 39

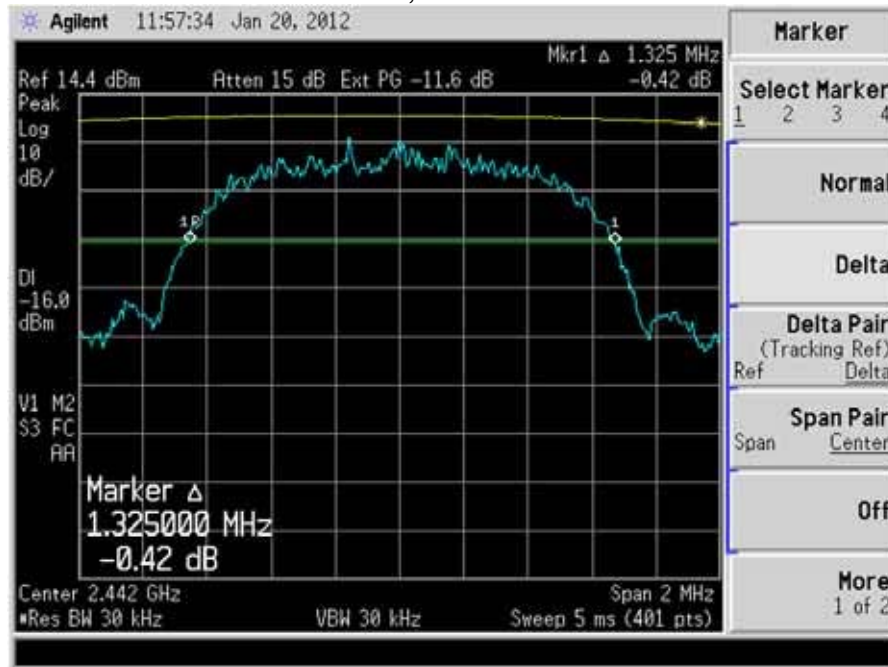


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

Channel 0, -26dB Bandwidth

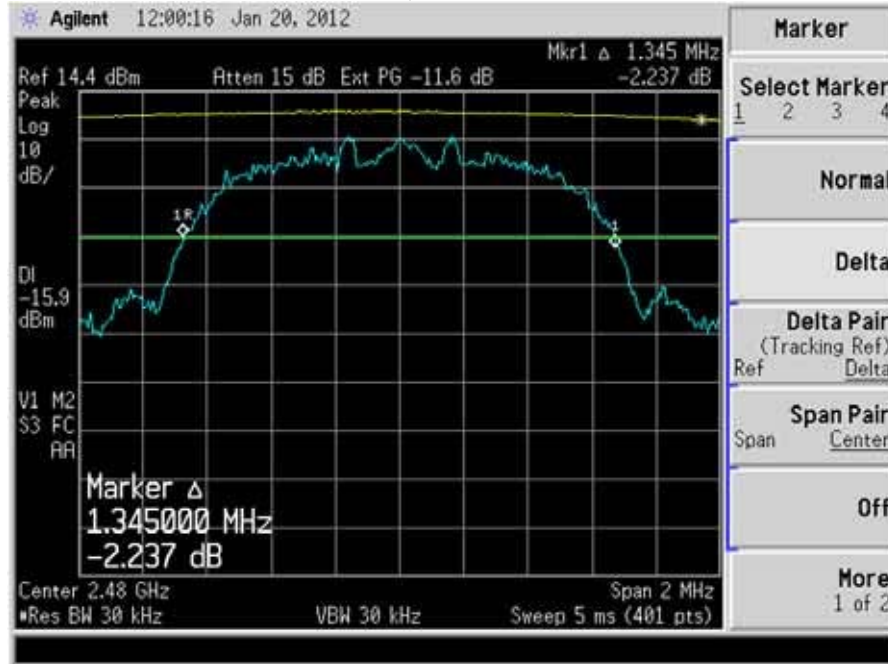


Channel 20, -26dB Bandwidth



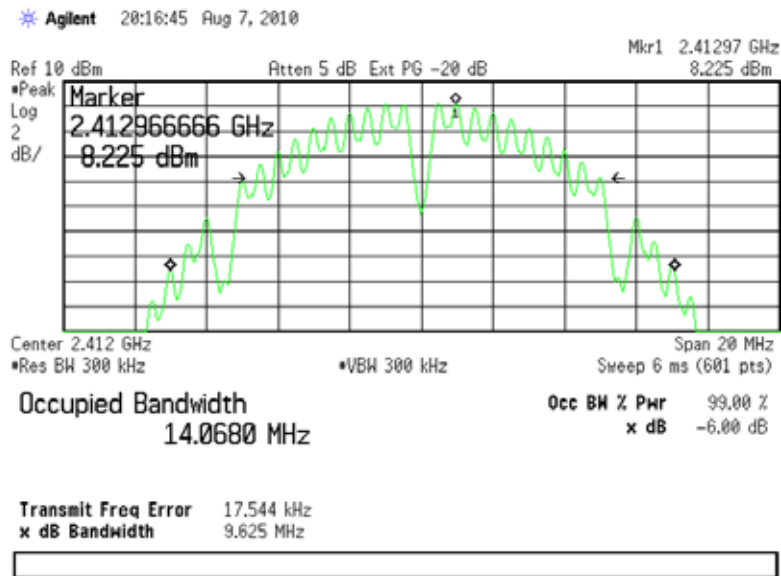
Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

Channel 39, -26dB Bandwidth



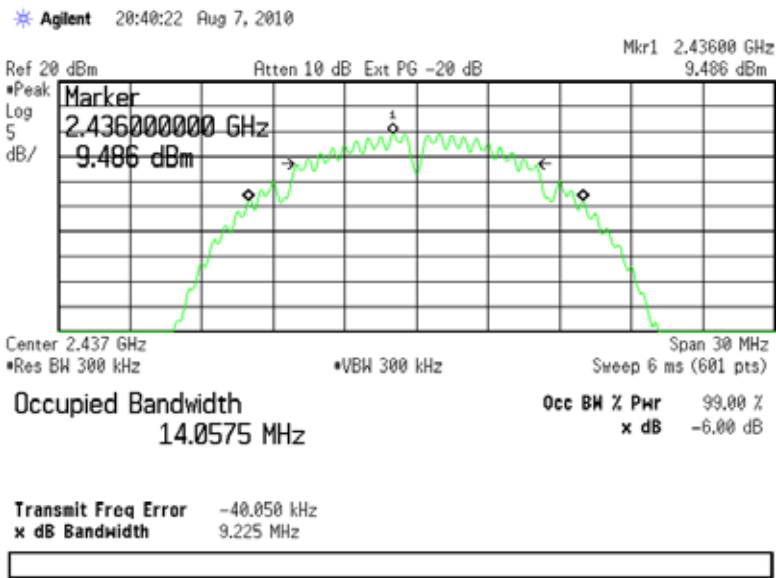
WLAN1 Mbps Data Rate:

Channel 1

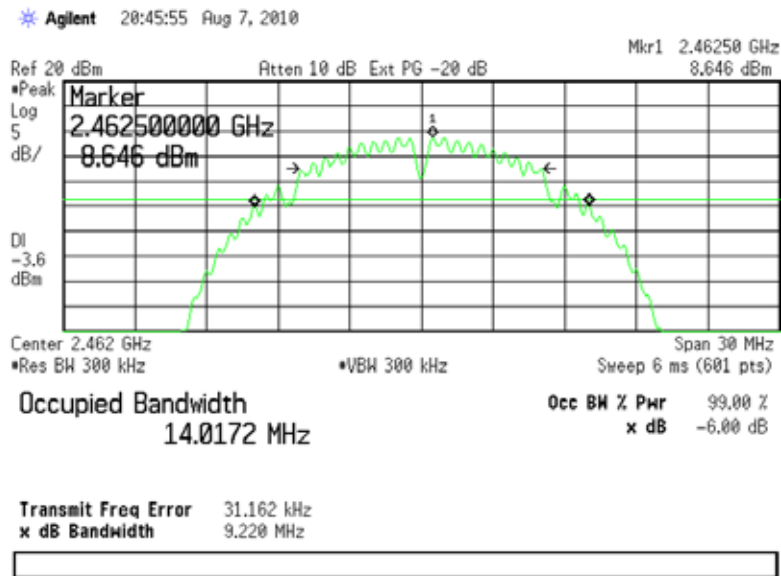


Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285

### Channel 6



### Channel 11



Prepared For: LS Research	Model Number: TiWi-BLE	Report #: 311258
EUT: Tiwi-BLE	Serial Number: 031202	LSR Job #: C-1285