



LS RESEARCH, LLC

Wireless Product Development

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

ENGINEERING TEST REPORT # 313249 A

LSR Job #: C-1808

Compliance Testing of:

TiWi-BLECA

Test Date(s):

8-7-2010, 01-20-12, August 15, 16, 20, 21, 22, 23 2012, 12-20-12,
and September 16, 17, 19 2013

Prepared For:

LS Research
Attn: Brian Petted
W66 N220 Commerce Court
Cedarburg, WI 53012

This Test Report is issued under the Authority of:

Tom Smith, VP of EMC Test Services

Signature: _____ Date: 9-19-13

Test Report Reviewed by:

Tom Smith, VP of EMC Test Services

Signature: _____ Date: 9-19-13

Report by:

Adam Alger, EMC Engineer

Signature: _____ Date: 9-19-13

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Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

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LS Research, LLC in Review

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



TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

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

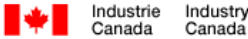
A2LA Certificate Number: 1255.01



Federal Communications Commission (FCC) – USA

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

FCC Registration Number: 90756



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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Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
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1.0 Summary of Test Report

The TiWi-BLECA was tested and MEETS the following DTS requirements:

Rule	Description	Procedure	Compliant	Note
FCC: 15.247(a)(2) IC: RSS-210 A8.2(a)	Emission Bandwidth 6 dB, 20dB, 99%	ANSI C63.4-2003	Yes	2
FCC: 15.247(b) IC: RSS-210 A8.4	Maximum Output Power	ANSI C63.4-2003	Yes	2
FCC: 15.247 (e) IC: RSS-210 A8.2	Peak Power Spectral Density	ANSI C63.4-2003	Yes	2
FCC: 15.247 (d) IC: RSS-210 A8.5	Spurious Emissions at Antenna Terminals	ANSI C63.4-2003	Yes	2
FCC: 15.247(d) IC: RSS-210 A8.5	Radiated Emissions at Band-edge	ANSI C63.4-2003	Yes	1
FCC: 15.247(d) IC: RSS-210 A8.5	Radiated Harmonics	ANSI C63.4-2003	Yes	1
FCC: 15.247(d) IC: RSS-210 A8.5	Radiated Emissions	ANSI C63.4-2003	Yes	1
FCC: 15.109 IC: RSS-GEN	Receiver radiated Emissions	ANSI C63.4-2003	Yes	1
FCC: 15.207 IC: RSS-GEN	AC Mains Emissions	ANSI C63.4-2003	Yes	No

Note 1: Tested in radiated stand-alone in three orthogonal positions.

Note 2: RF Conducted measurement at antenna terminal.

2.0 Test Facilities

All testing was performed at:

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

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to the requirements of ISO/IEC 17025, 2005 “General Requirements for the Competence of Calibration and Testing Laboratories”.

LS Research, LLC’s scope of accreditation includes all test methods listed herein, unless otherwise noted.

Prepared For: LS Research	Name: TiWi-BLECA
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3.0 Client Information

Manufacturer Name:	LS Research
Address:	W66 N220 Commerce Court Cedarburg, WI 53012
Contact Person:	Brian Petted

3.1 Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	TiWi-BLECA
Model Number:	TiWi-BLECA
Serial Number:	Eng. Sample
FCC ID	TFB-BLECA
IC Number	5969A-BLECA

3.2 Product Description

The TiWi-BLECA module is a multi-standard module with support for WLAN (802.11 b/g/n), Bluetooth V2.1 and Bluetooth 4.0.

BLE

Frequency Range (MHz)	2402-2480MHz
RF Power In Watts (conducted)	Max: 8.4 mW; Min: 7.8 mW
Max Conducted Output Power (dBm)	9.24
Occupied Bandwidth 99%	1.20 MHz
Type of Modulation	GFSK
Emission Designator	1M20F1D
Transmitter Spurious (worst case) at 3 meters	57.32 dB μ V/m @ 4804 MHz, AVG
Stepped (Y/N)	N
Step Value	N/A
Frequency Tolerance %,Hz, ppm	Better than 100 ppm
Antenna: Detachable / Non-detachable	Non-detachable
Antenna: Type	Chip
Antenna Gain (Peak)	1.3 dBi
FCC Rule Part	Title 47 Part 15.247
Industry Canada Rule Part	RSS-210 Issue 8 2010
Modular Filing	Yes
RF Exposure Type	Mobile
Receiver Spurious (worst case) at 3 meters	33.2 dB μ V/m @ 72.1MHz, QP

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WLAN

Frequency Range (MHz)	2412-2462MHz
RF Power In Watts (conducted)	WL1: Max 87.5 mW; Min 48.1 mW WL2: Max 19.8 mW; Min 16.6 mW
Max Conducted Output Power (dBm)	WL1: 19.42 WL2: 12.97
Occupied Bandwidth 99%	WL1: 15.7 MHz WL2: 19.8 MHz
Type of Modulation	WL1: DBPSK WL2: 64-QAM
Emission Designator	WL1: 15M7G1W WL2: 19M8W1W
Transmitter Spurious (worst case) at 3 meters	62.54 dB μ V/m @ 4874 MHz, AVG
Stepped (Y/N)	N
Step Value	N/A
Frequency Tolerance %,Hz, ppm	Better than 100 ppm
Antenna: Detachable / Non-detachable	Non-detachable
Antenna: Type	Chip
Antenna Gain (Peak)	1.3 dBi
FCC Rule Part	Title 47 Part 15.247
Industry Canada Rule Part	RSS-210 Issue 8 2010
Modular Filing	Yes
RF Exposure Type	Mobile
Receiver Spurious (worst case) at 3 meters	33.2 dB μ V/m @ 72.1MHz, QP

3.3 Modifications Incorporated In the EUT for Compliance Purposes

None noted at time of test

3.4 Deviations & Exclusions from Test Specifications

None noted at time of test

Prepared For: LS Research	Name: TiWi-BLECA
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4.0 Conditions of Test

Environmental:

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

Mains Voltage:

3.3VDC from bench supply

5.0 Additional Information

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

6.0 Test Equipment

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

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

7.0 Conformance Summary

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

If some emissions are seen to be within 3 dB of their respective limits:

As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

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

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Appendix A – Test Equipment



Date: 13-Aug-2012 Type Test: Radiated Emissions Job #: C-1520
 Prepared By: Adam Customer: LSR Quote #: 312182

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/29/2012	6/29/2013	Active Calibration
2	EE 960158	RF Preselector	Agilent	N9039A	MY46520110	6/29/2012	6/29/2013	Active Calibration
3	AA 960150	Bicon Antenna	ETS	310B	0003-3346	11/15/2011	11/15/2012	Active Calibration
4	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	11/15/2011	11/15/2012	Active Calibration
5	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	5/16/2012	5/16/2013	Active Calibration
6	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	6/30/2012	6/30/2013	Active Calibration
7	EE 960147	Pre-Amp	Adv. Micro	\VLA612	123101	1/6/2012	1/6/2013	Active Calibration
8	AA 960081	Double Ridge Horn Antenna	EMCO	3115	6907	1/6/2012	1/6/2013	Active Calibration
9	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/1/2011	6/1/2013	Active Calibration
10	EE 960161	26.5-40GHz LNA	Ducommun Tech	ALN-33144030	1103717-01	10/4/2011	10/4/2012	Active Calibration
11	AA 960154	2.4GHz High Pass Filter	KVM	HPF-L-14186	7272-02	6/28/2012	6/28/2013	Active Calibration
12	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2012	5/9/2013	Active Calibration
13	EE 960146	Std. Gain Horn Ant. w/preamp	Adv. Micro	\VLA622-4	123001	11/3/2011	11/3/2012	Active Calibration

Project Engineer: *Adam Adams* Quality Assurance: *Hybrid*



Date: 5-Jun-2010 Type Test: Conducted Power Output Job #: C-884
 Prepared By: Peter Customer: LSR Quote #: 310117

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960143	Phaseflex	Gore	EKD01D01048.0	5546519	9/16/2009	9/16/2010	Active Calibration
2	CC 000221C	Spectrum Analyzer	HP	E4407B	US39160256	3/9/2009	3/9/2010	Active Calibration
3	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	9/17/2009	9/17/2010	Active Calibration
4	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/25/2009	6/25/2010	Active Calibration



Date: 28-Sep-2010 Type Test: Conducted AC Emissions Job #: C-884
 Prepared By: Peter Customer: LSR Quote #: 310117

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960008	LIN	EMCO	3816/2NM	9701-1057	12/15/2009	12/15/2010	Active Calibration
2	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	3/17/2009	3/17/2010	Active Calibration
3	EE 960158	RF Preselector	Agilent	N9039A	MY46520110	7/2/2009	7/2/2010	Active Calibration
4	AA 960072	Transient Limiter	HP	11947A	3107A01708	9/15/2009	10/15/2010	Active Calibration



Date: 18-Jan-2012 Type Test: Power Spectral Density Job #: C-1285
 Prepared By: Shane Rismeyer Customer: LSR Quote #: 31258

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
3	CC 000221C	Spectrum Analyzer	HP	E4407B	US39160256	5/4/2011	5/4/2012	Active Calibration

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

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Appendix B – Test Data

B.1 – RF Conducted Emissions

Manufacturer	LS Research, LLC
Test Location	LS Research, LLC
Rule Part	FCC Part 15.247 / RSS-210 Annex 8
General Measurement Procedure	ANSI C63.4-2003
General Description of Measurement	A direct measurement of the transmitted signal was performed at the antenna port of the EUT via a cable connection to a spectrum analyzer. An attenuator was placed in series with the cable to protect the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings there by allowing direct measurements, without the need for any further corrections. The EUT was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source.

Prepared For: LS Research

Name: TiWi-BLECA

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B.1.1 – RF Conducted – Fundamental Bandwidth

Manufacturer	LS Research, LLC
Date	9-16-13 and 9-17-13
Operator	Aidi
Temp. / R.H.	20 - 25° C / 30-60% R.H.
Rule Part	FCC Part 15.247 / RSS-210 A8
Specific Measurement Procedure	ANSI C63.4-2003 RSS-GEN Section 4.6
Additional Description of Measurement	Peak detector used
Additional Notes	Continuous transmit modulated used for this test.

Table (WLAN 1 Mbps)

Frequency (MHz)	6 dB DTS BW (MHz)	99 % BW (MHz)	20 dB BW (MHz)
2412	9.2	13.6	15.3
2417	9.1	13.6	15.7
2422	9.1	13.6	15.7
2437	9.1	13.6	15.7
2462	9.1	13.7	15.7

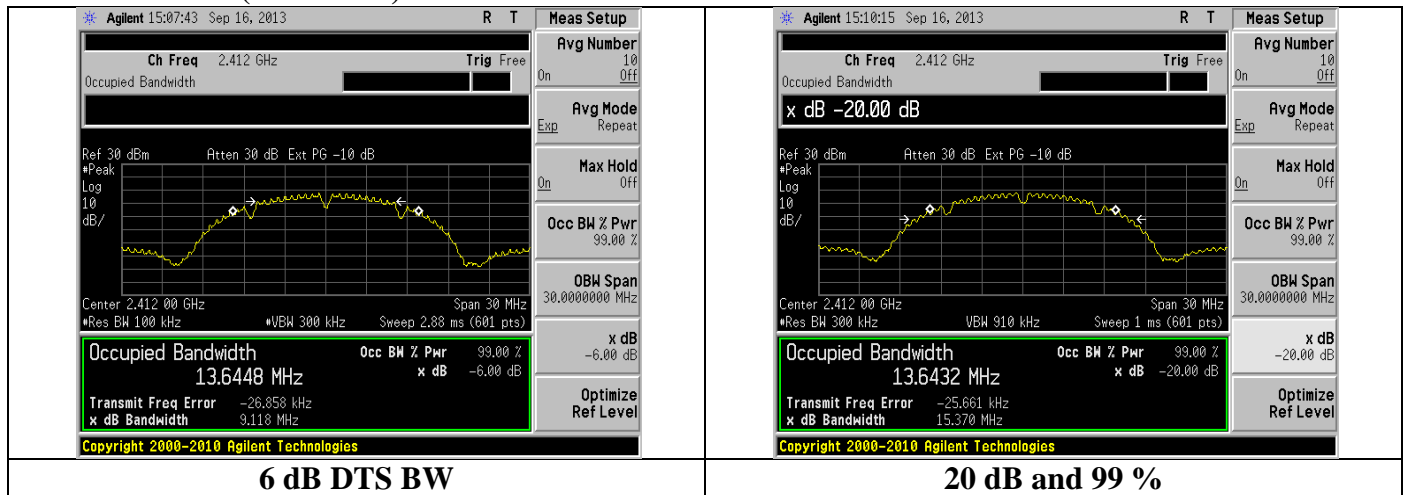
Table (WLAN MCS 7)

Frequency (MHz)	6 dB DTS BW (MHz)	99 % BW (MHz)	20 dB BW (MHz)
2412	16.9	17.7	19.5
2437	17.0	17.7	19.8
2462	16.9	17.7	19.7

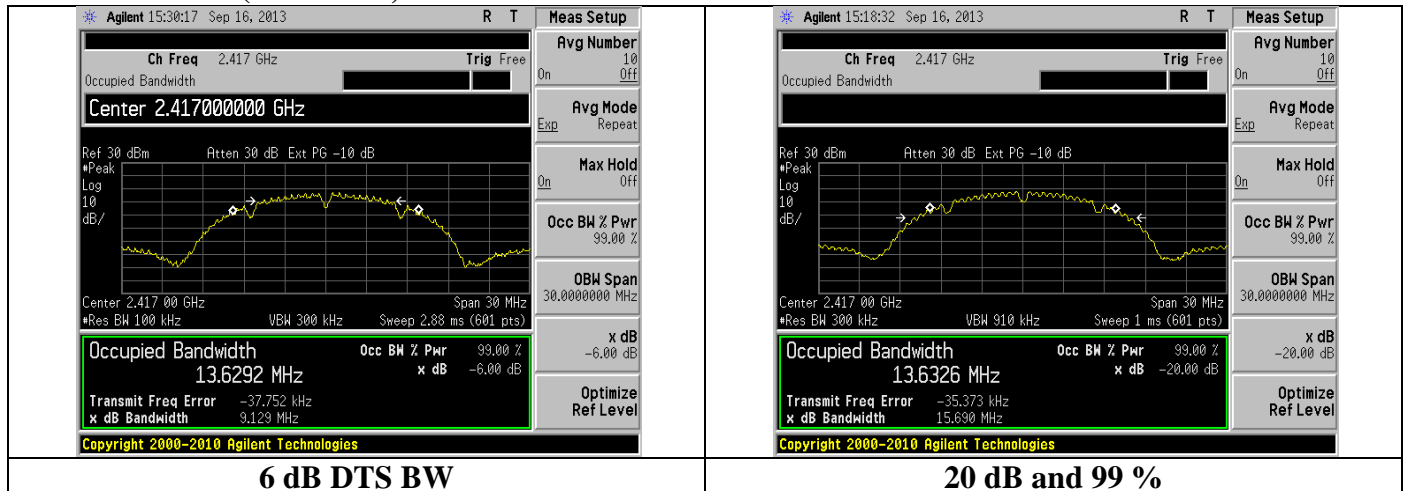
Table (BLE)

Frequency (MHz)	6 dB DTS BW (kHz)	99 % BW (MHz)	20 dB BW (MHz)
2412	750	1.0	1.2
2437	733	1.0	1.2
2462	733	1.0	1.2

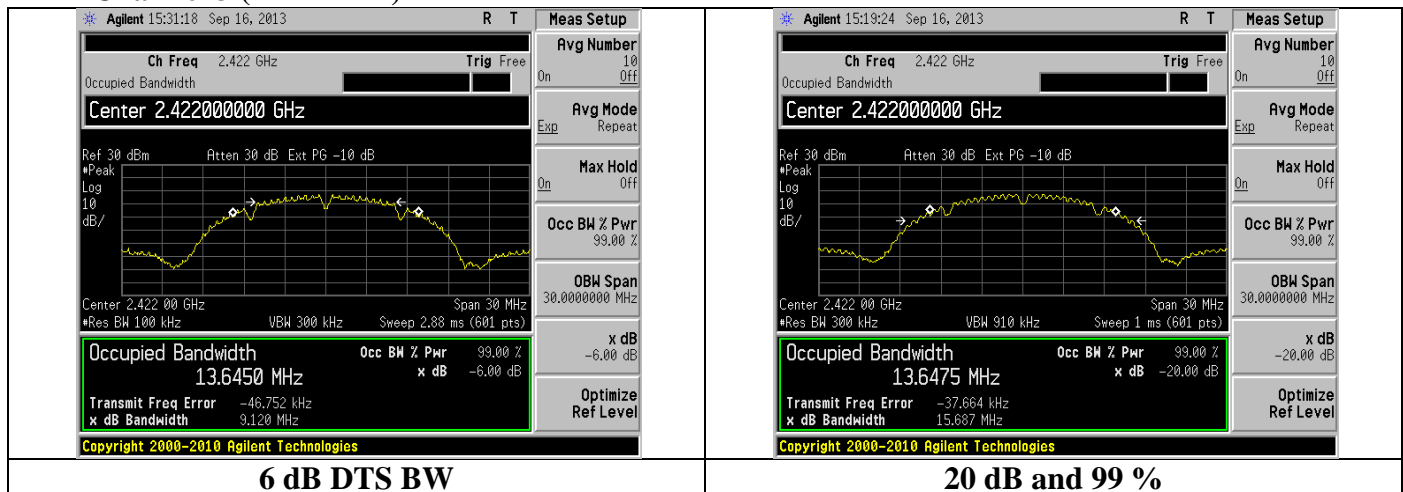
Plots (1 Mbps) Channel 1 (2412 MHz)



Channel 2 (2417 MHz)



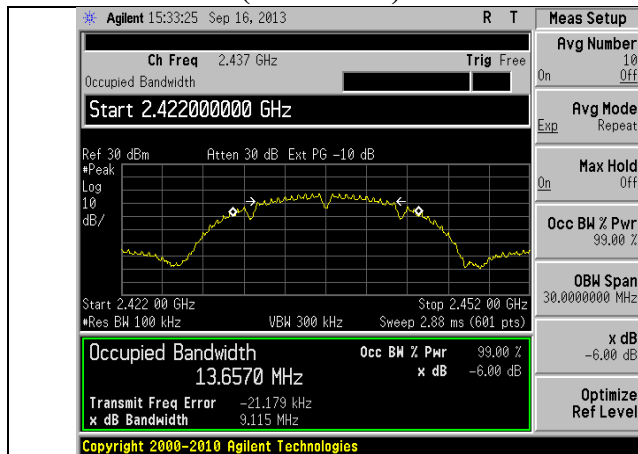
Channel 3 (2422 MHz)



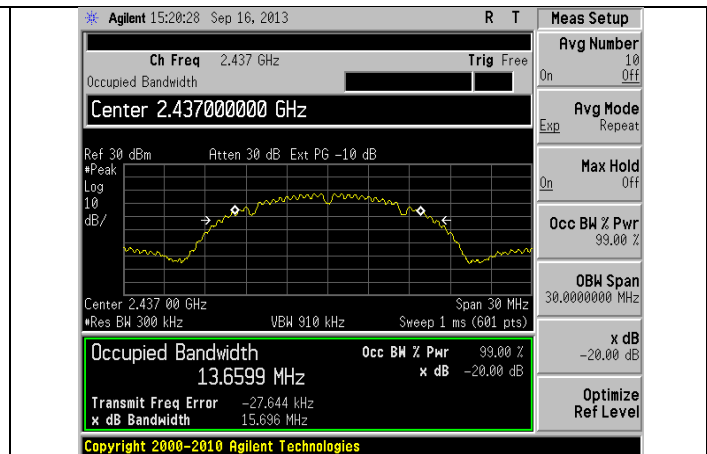
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Channel 6 (2437 MHz)

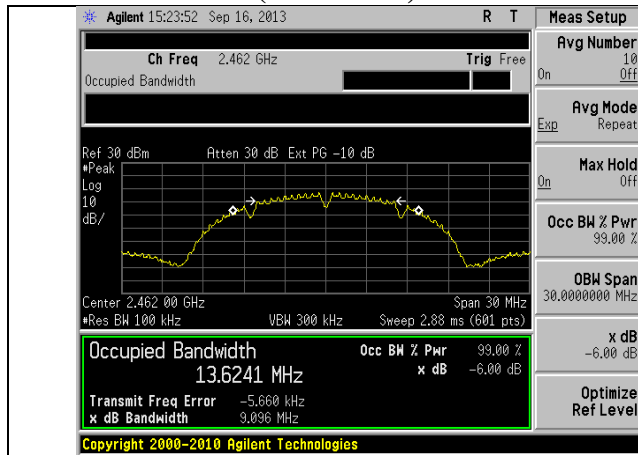


6 dB DTS BW

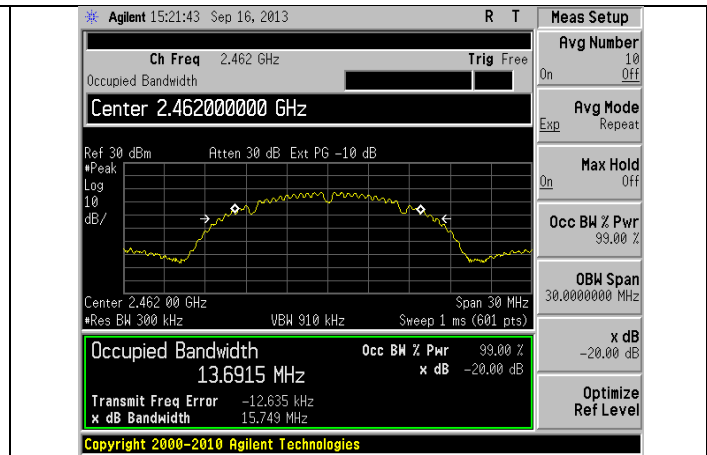


20 dB and 99 %

Channel 11 (2462 MHz)



6 dB DTS BW

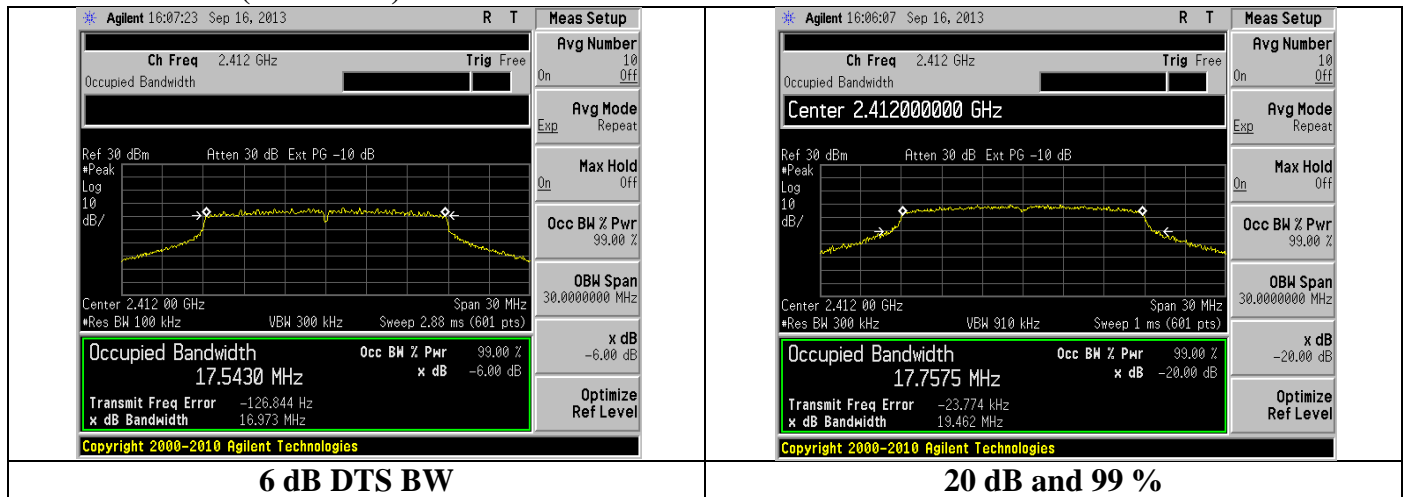


20 dB and 99 %

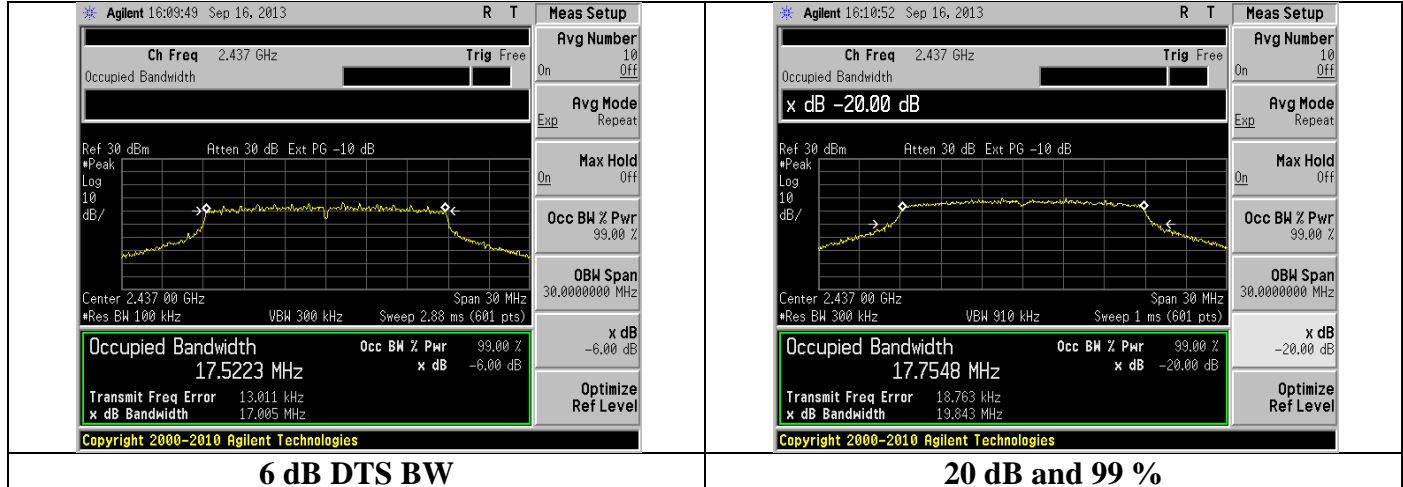
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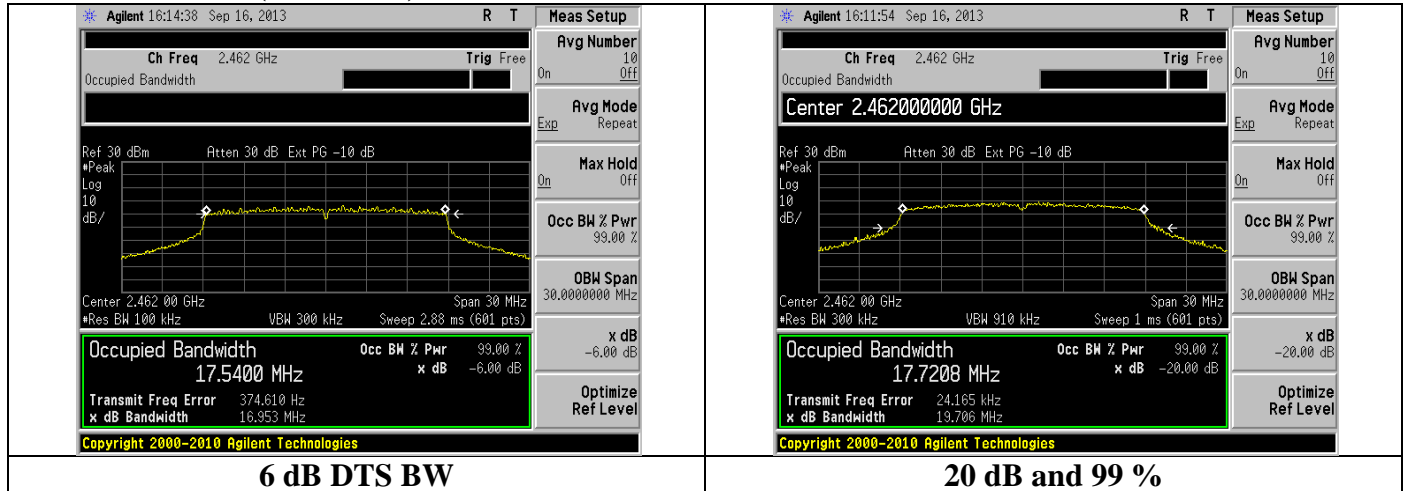
Plots (MCS 7) Channel 1 (2412 MHz)



Channel 6 (2437 MHz)



Channel 11 (2462 MHz)

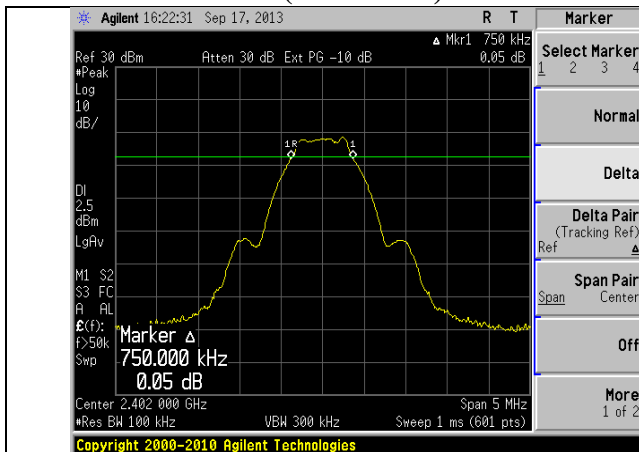


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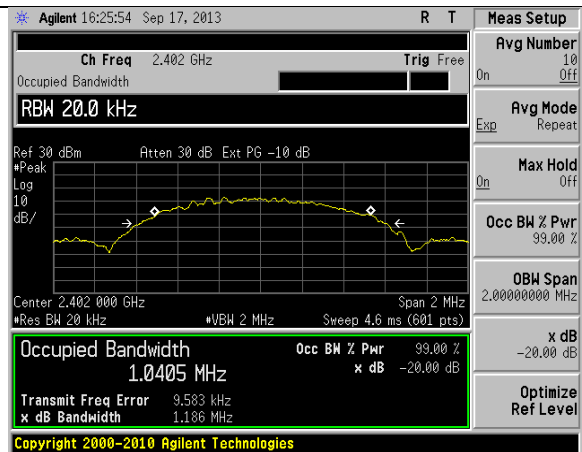
Name: TiWi-BLECA
Model: TiWi-BLECA
Serial: Eng. Sample

Plots (BLE)

Low Channel (2402 MHz)

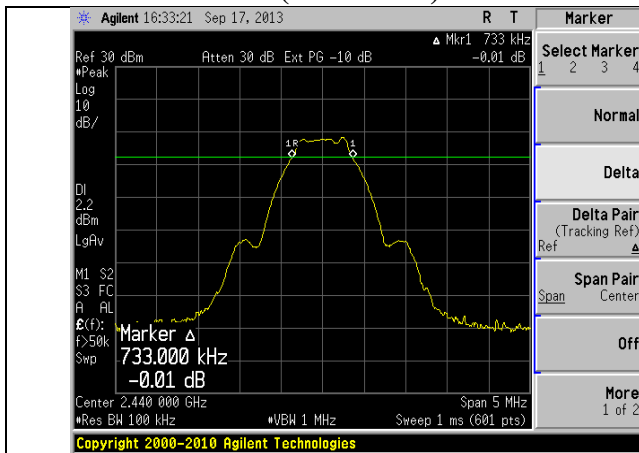


6 dB DTS BW

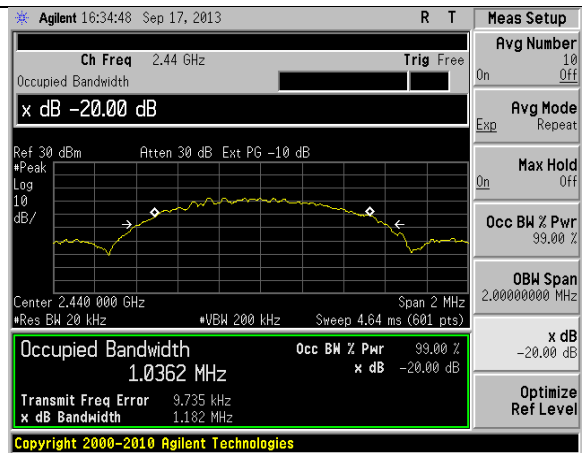


20 dB and 99 %

Mid Channel (2440 MHz)

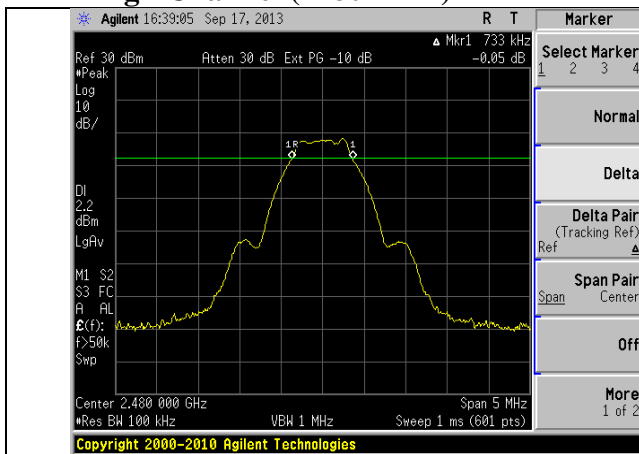


6 dB DTS BW

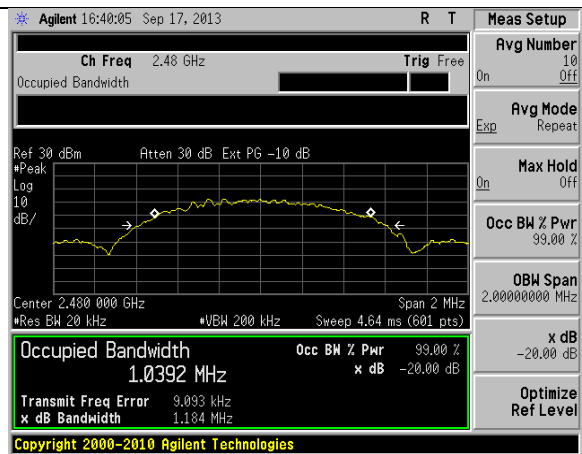


20 dB and 99 %

High Channel (2480 MHz)



6 dB DTS BW



20 dB and 99 %

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Name: TiWi-BLECA
 Model: TiWi-BLECA
 Serial: Eng. Sample

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

Manufacturer	LS Research, LLC
Date	8-7-10, 1-20-12, 8-23-12, 12-20-12, 9-17-13, 9-19-13
Operator	Peter F, Shane R, Aidi Z, Adam A
Temp. / R.H.	20 - 25° C / 30-60% R.H.
Rule Part	15.247 / RSS-210 A8
Specific Measurement Procedure	ANSI C63.4-2003
Additional Description of Measurement	3 kHz resolution bandwidth used for Peak Power Spectral Density measurement
Additional Notes	Sample Calculation: Margin (dB) = Limit – Measured level Continuous transmit modulated used for this test.

Table (WLAN 1 Mbps)

Frequency (MHz)	Power (dBm)	PKPSD (dBm)	Limit (dBm)	Margin (dB)
2412	16.82	-6.88	8	14.88
2417	17.84	-5.08	8	13.08
2422	19.39	-4.84	8	12.84
2437	19.42	-3.30	8	11.30
2462	18.76	-4.11	8	12.11

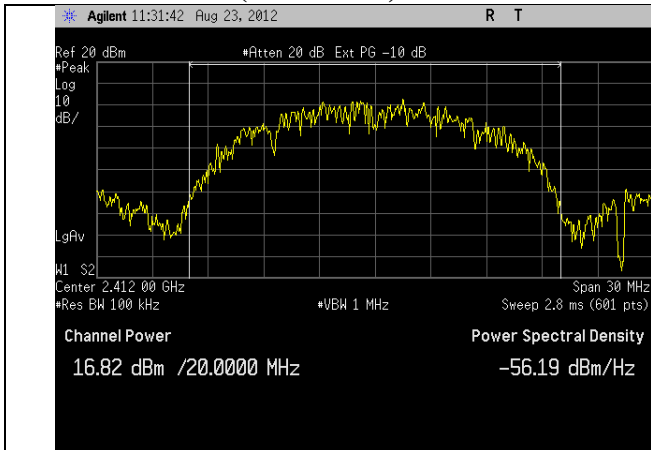
Table (WLAN MCS 7)

Frequency (MHz)	Power (dBm)	PKPSD (dBm)	Limit (dBm)	Margin (dB)
2412	12.97	-15.96	8	23.96
2437	12.45	-16.01	8	24.01
2462	12.21	-15.79	8	23.79

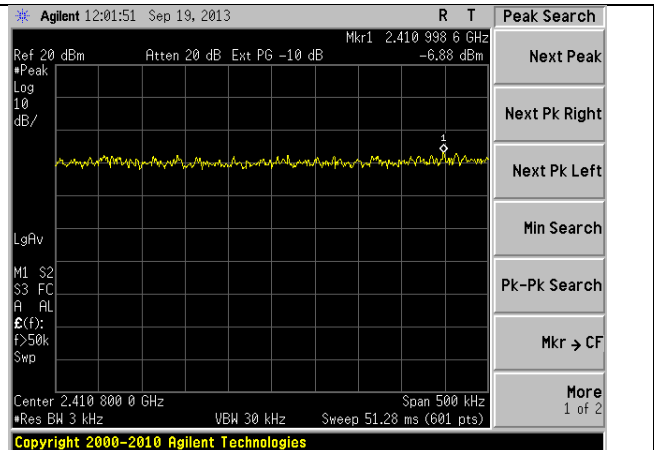
Table (BLE)

Frequency (MHz)	Power (dBm)	PKPSD (dBm)	Limit (dBm)	Margin (dB)
2402	9.24	-4.90	8	12.90
2440	8.99	-4.89	8	12.89
2480	8.94	-4.81	8	12.81

**Plots (1 Mbps)
Channel 1 (2412 MHz)**

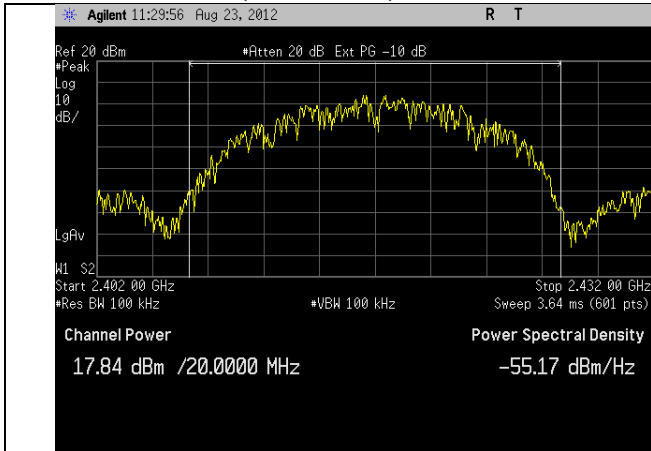


Output Power

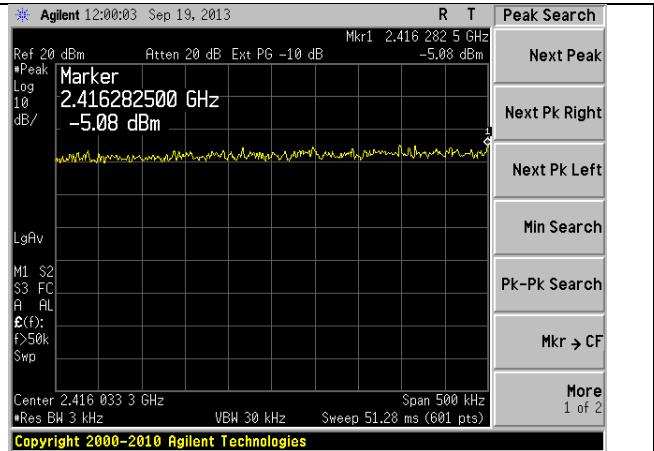


Peak Power Spectral Density

Channel 2 (2417 MHz)

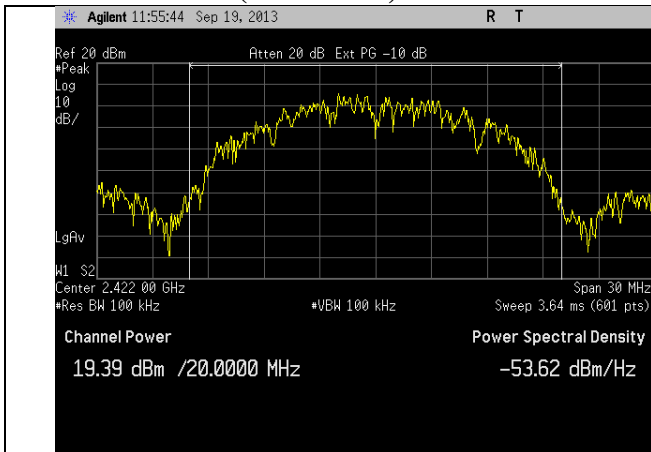


Output Power

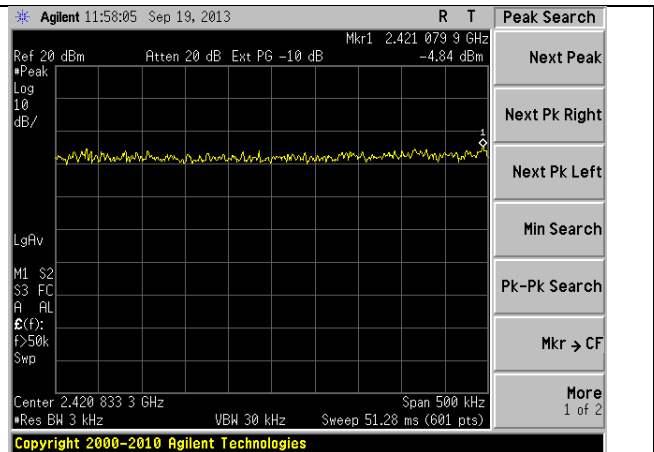


Peak Power Spectral Density

Channel 3 (2422 MHz)



Output Power

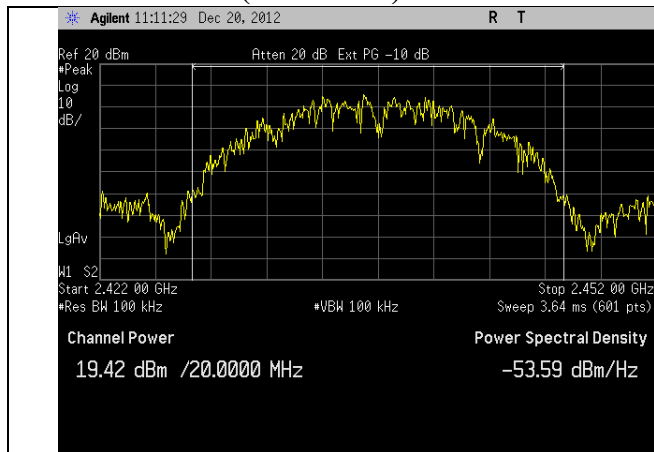


Peak Power Spectral Density

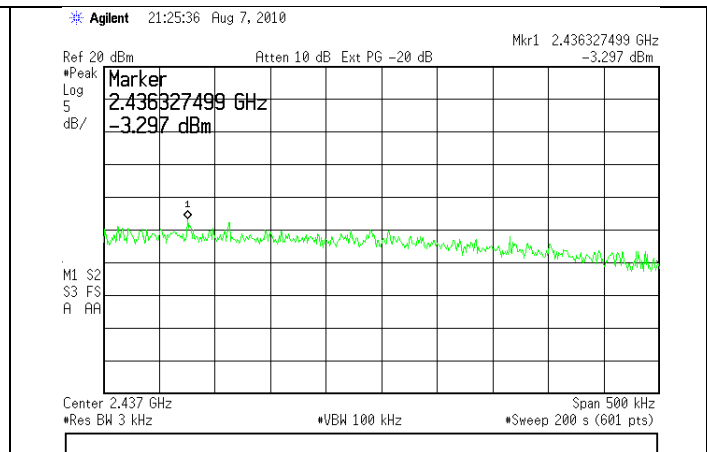
Prepared For: LS Research
Report: TR 313249 A FCCICTX (DTS)
LSR: C-1808

Name: TiWi-BLECA
Model: TiWi-BLECA
Serial: Eng. Sample

Channel 6 (2437 MHz)

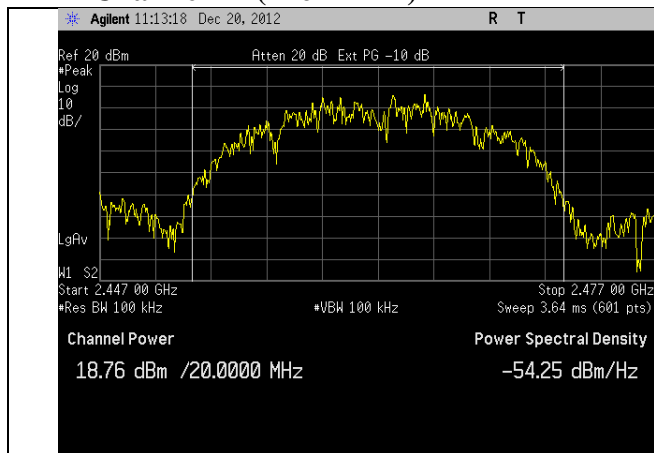


Output Power

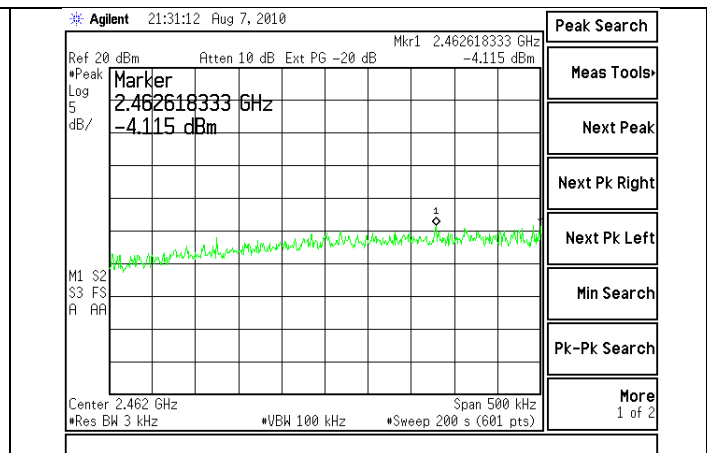


Peak Power Spectral Density

Channel 11 (2462 MHz)



Output Power

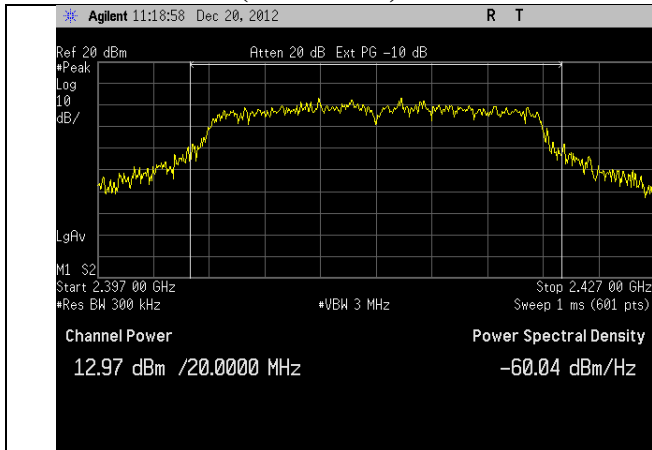


Peak Power Spectral Density

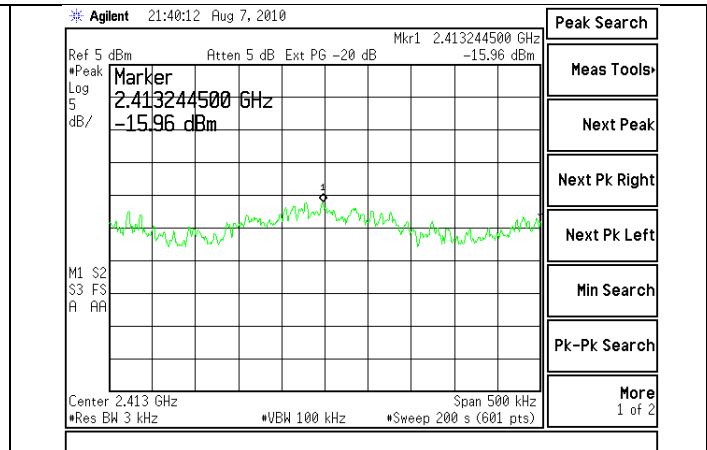
Prepared For: LS Research
 Report: TR 313249 A FCCICTX (DTS)
 LSR: C-1808

Name: TiWi-BLECA
 Model: TiWi-BLECA
 Serial: Eng. Sample

Plots (MCS 7)
Channel 1 (2412 MHz)

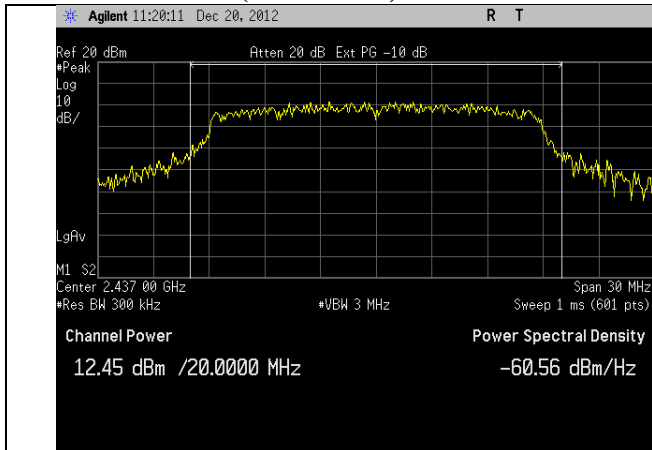


Output Power

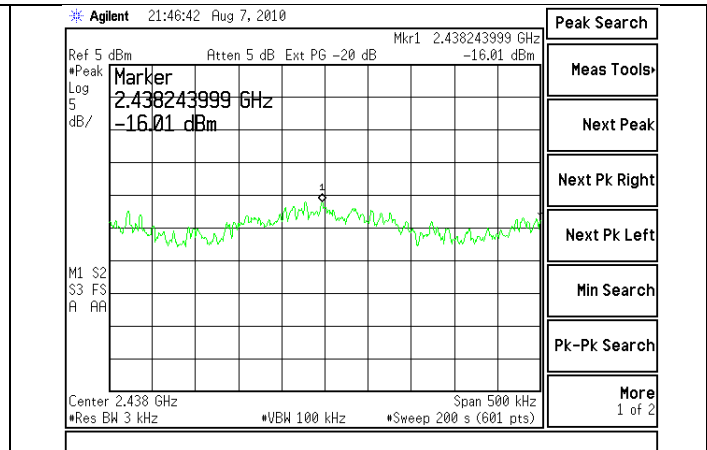


Peak Power Spectral Density

Channel 6 (2437 MHz)

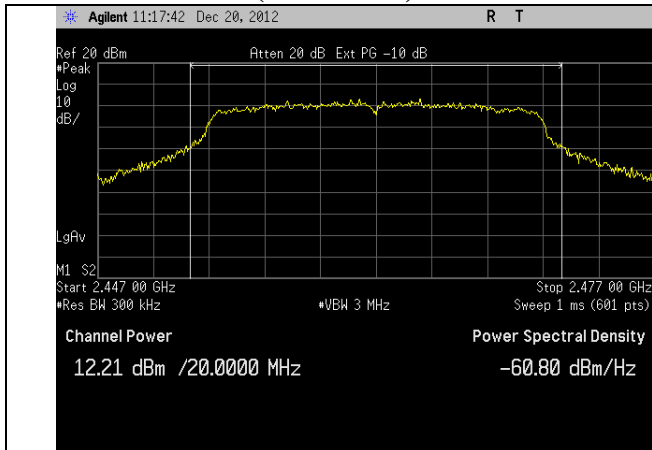


Output Power

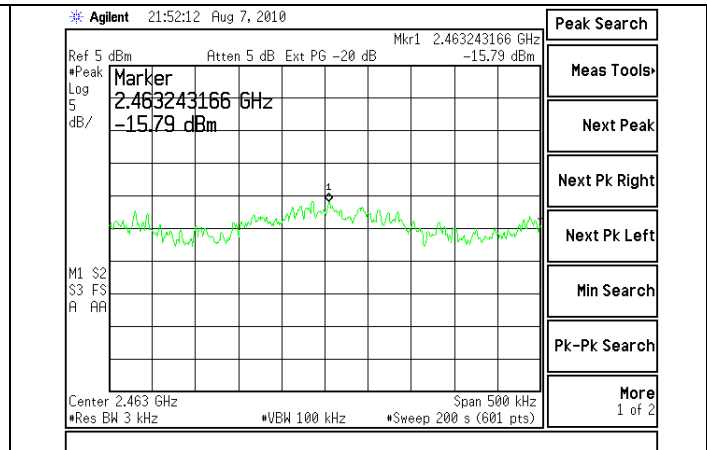


Peak Power Spectral Density

Channel 11 (2462 MHz)



Output Power

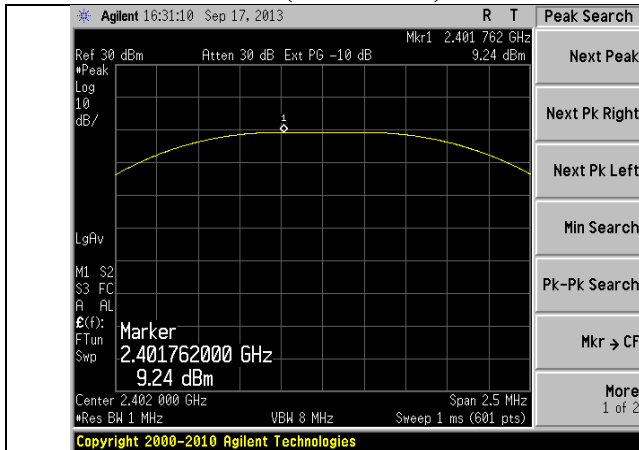


Peak Power Spectral Density

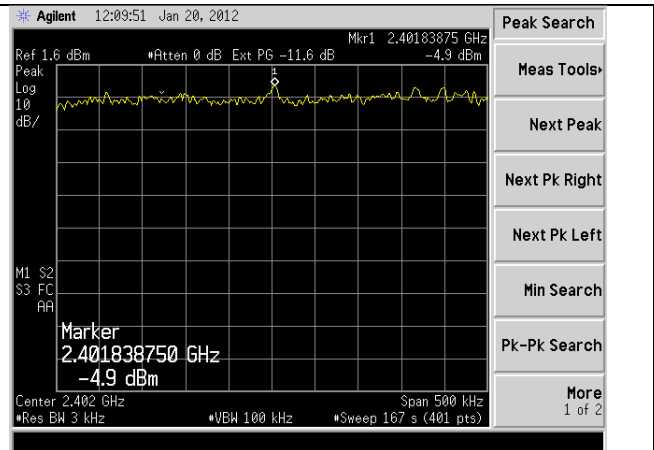
Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Plots (BLE)

Low Channel (2402 MHz)

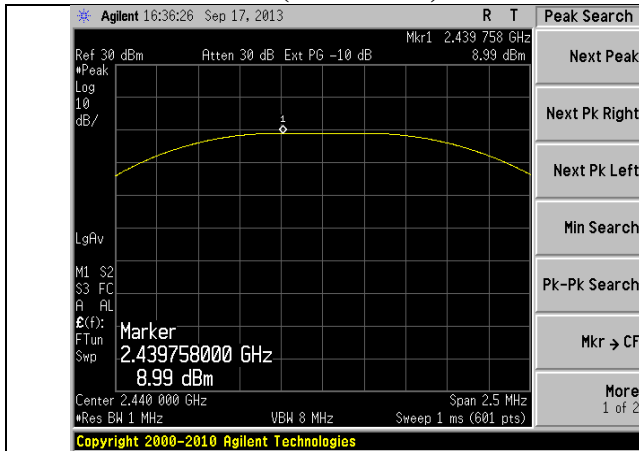


Output Power

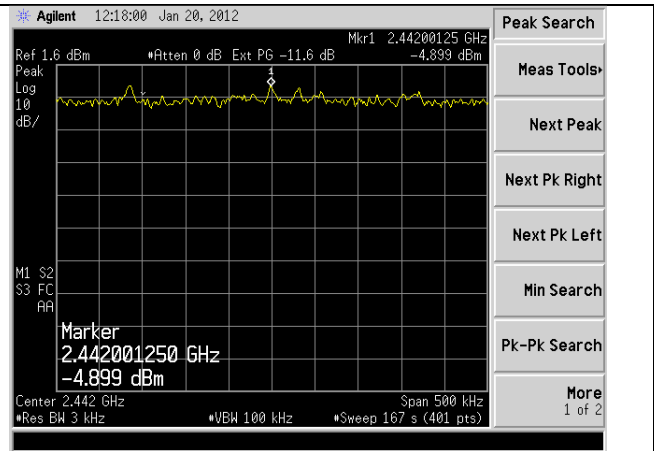


Peak Power Spectral Density

Mid Channel (2440 MHz)

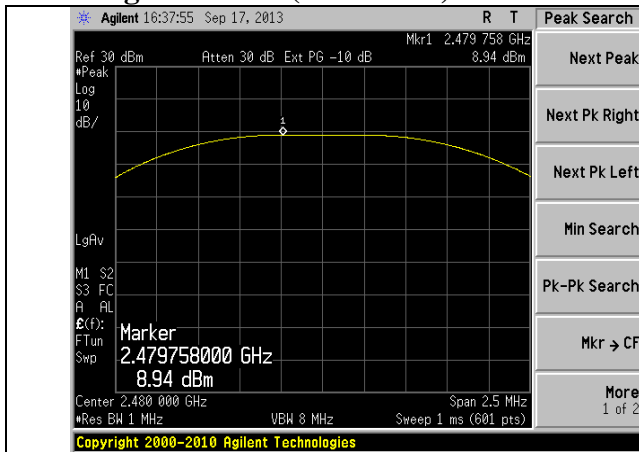


Output Power

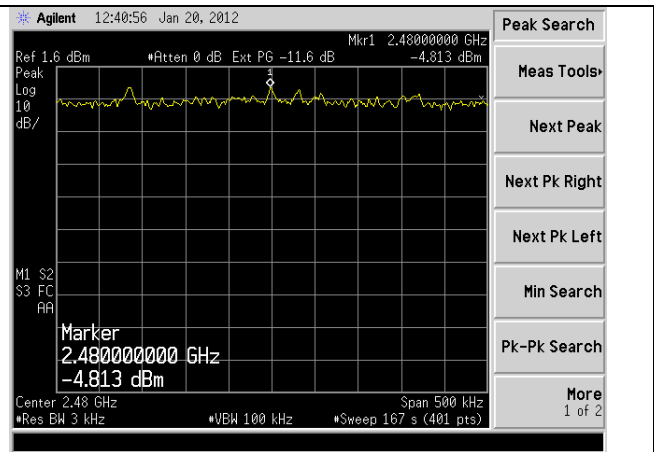


Peak Power Spectral Density

High Channel (2480 MHz)



Output Power



Peak Power Spectral Density

Prepared For: LS Research
 Report: TR 313249 A FCCICTX (DTS)
 LSR: C-1808

Name: TiWi-BLECA
 Model: TiWi-BLECA
 Serial: Eng. Sample

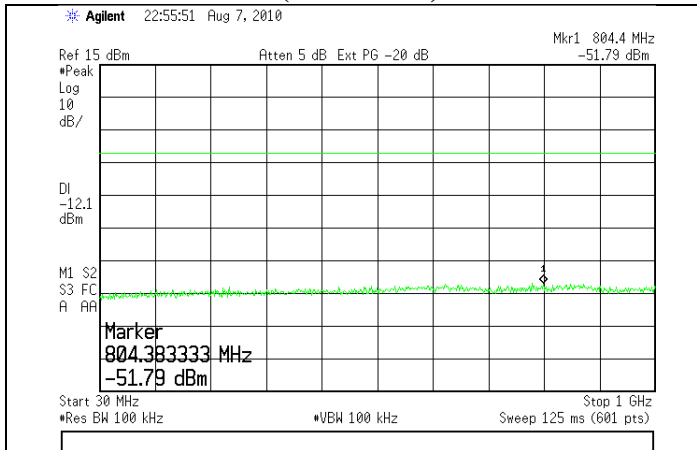
B.1.3 – RF Conducted – Spurious

Manufacturer	LS Research, LLC
Date	8-7-10 and 1-20-12
Operator	Peter F, Shane R
Temp. / R.H.	20 - 25° C / 30-60% R.H.
Rule Part	15.247 / RSS-210 A8
Specific Measurement Procedure	ANSI C63.4-2003
Additional Description of Measurement	RF Conducted Measurement
Additional Notes	No Emissions found to be within 30 dB of limit Continuous transmit modulated used for this test.

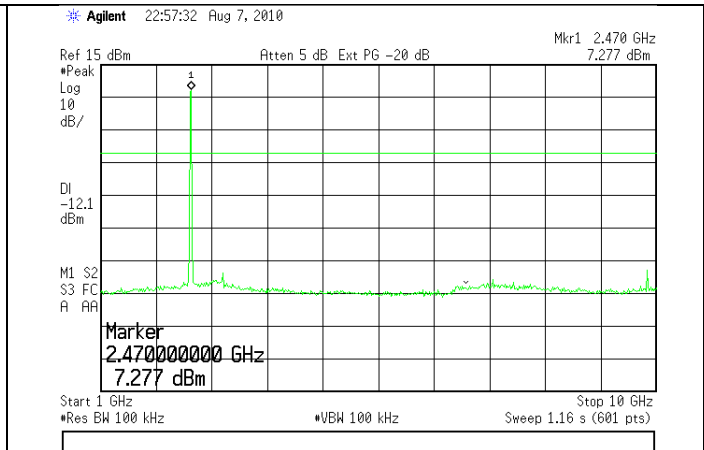
Plots start next page

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

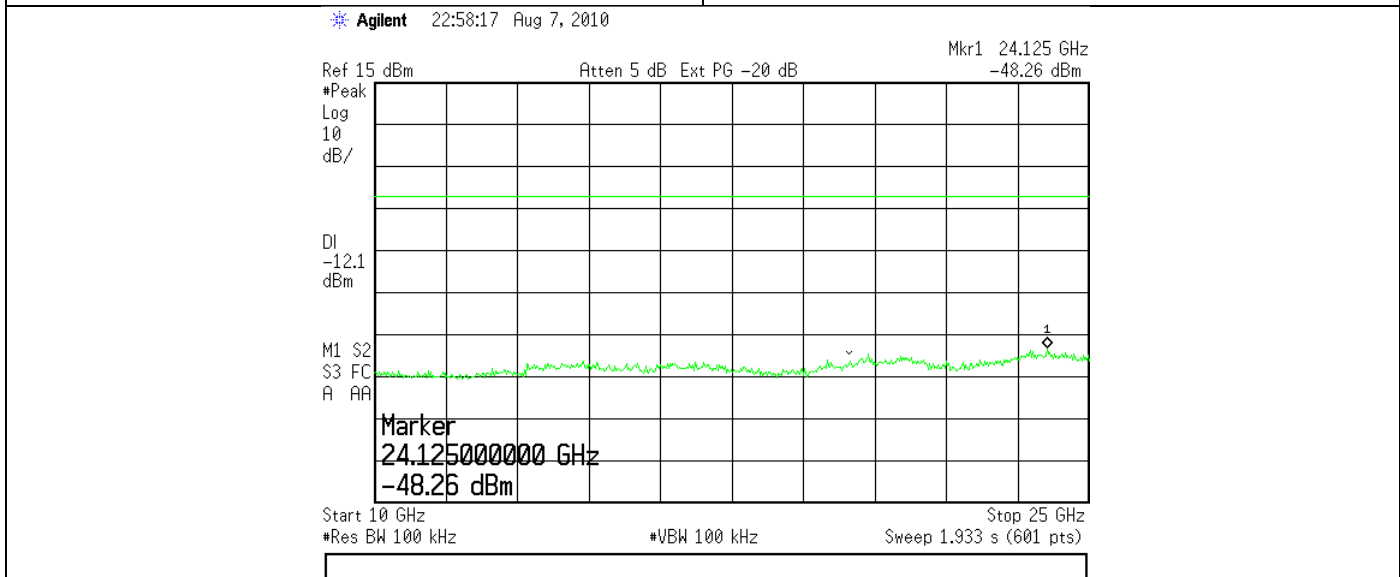
Plots (1 Mbps) Mid Channel (2480 MHz)



30-1000 MHz



1-10 GHz

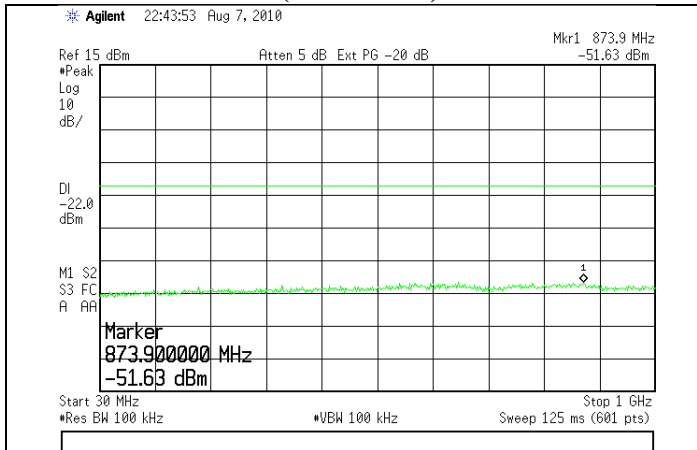


10-25 GHz

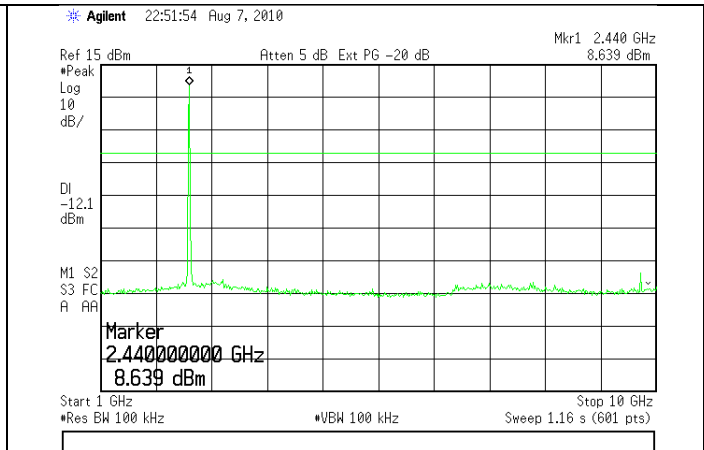
Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Plots (MCS 7)

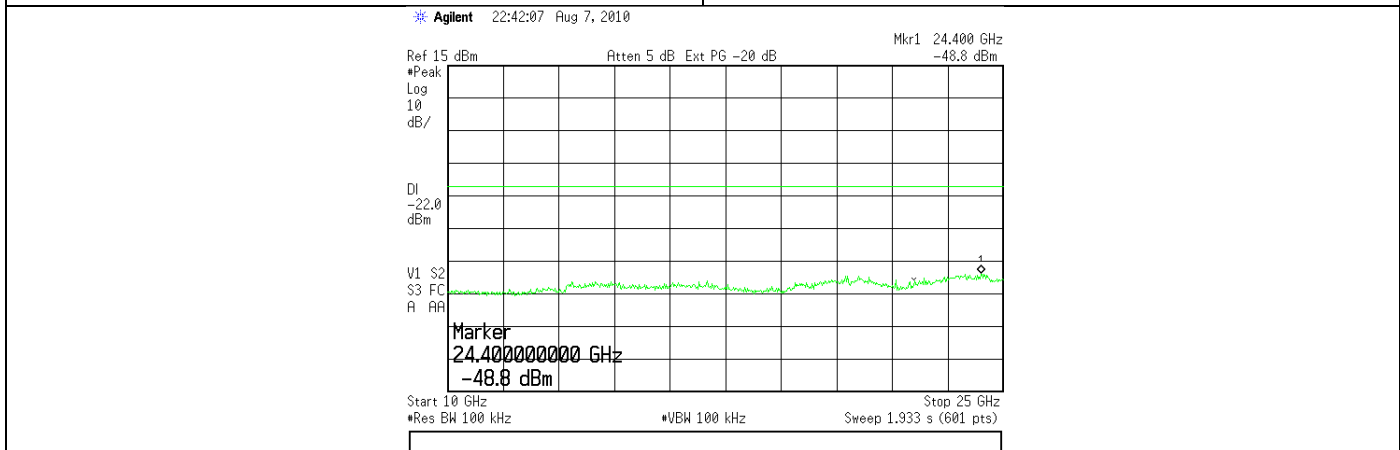
Mid Channel (2437 MHz)



30-1000 MHz



1-10 GHz



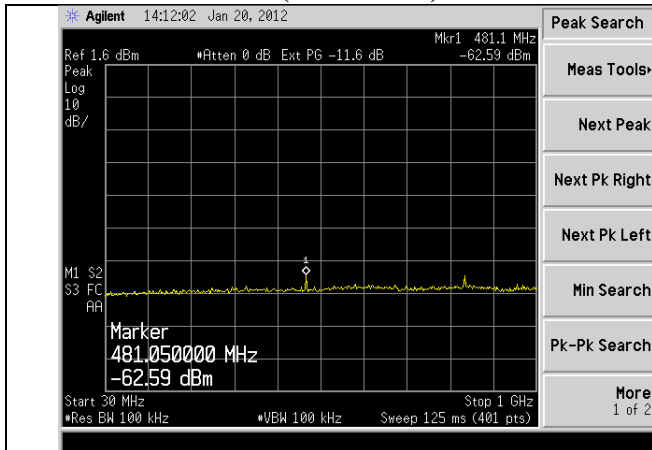
10-25 GHz

Prepared For: LS Research
Report: TR 313249 A FCCICTX (DTS)
LSR: C-1808

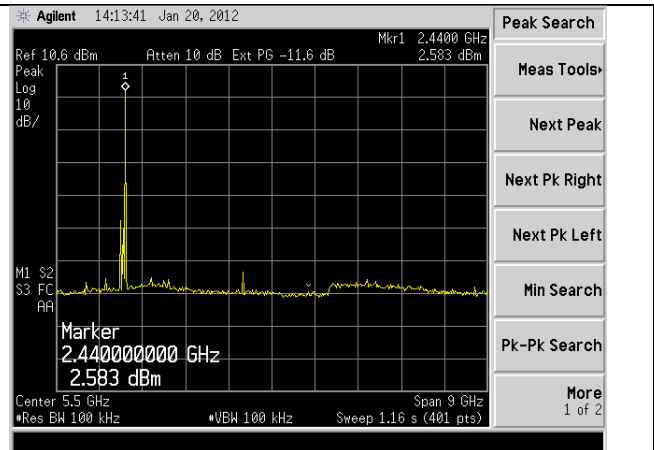
Name: TiWi-BLECA
Model: TiWi-BLECA
Serial: Eng. Sample

Plots (BLE)

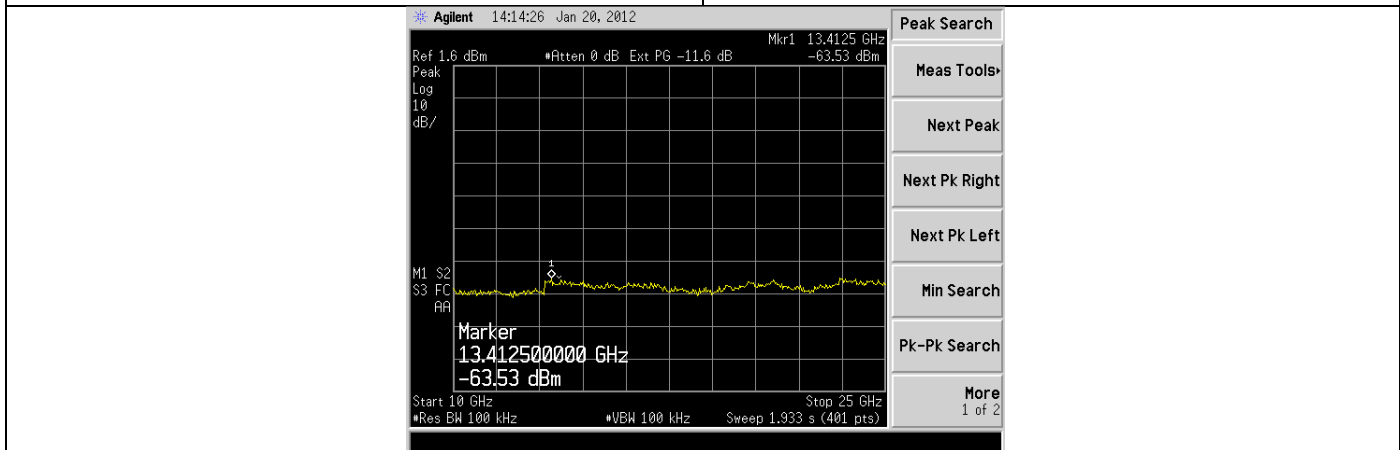
Mid Channel (2440 MHz)



30-1000 MHz



1-10 GHz



10-25 GHz

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

B.2 – Radiated Emissions

Rule Part(s)	FCC: 15.247(d) / 15.205 / 15.209 / IC: RSS-210 A8.2 (b) / RSS-210 Section 2.2, 2.6, 2.7			
Measurement Procedure	ANSI C63.4 - 2003			
Test Location	LS Research, LLC - FCC Listed 3 meter Semi-Anechoic Chamber			
Test Distance	3 meters : 30 - 4000 MHz 1 meter: 4 - 25 GHz			
EUT Placement	80 cm height non-conductive table above reference ground plane			
Frequency Range of Measurement	Biconical: 30-300 MHz	Log Periodic Dipole Array: 300-1000 MHz	Double-Ridged Waveguide Horn: 1-18 GHz	Standard Gain Horn: 18-25GHz
Measurement Detectors	30-1000MHz Peak Detector RBW: 120 kHz VBW: 300 kHz		1 - 25 GHz: Peak Detector RBW : 1MHz VBW: 3MHz (Peak Measurement) VBW: 10Hz (Average Measurement)	
Description of Measurement	<p>1) The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are performed. The data is gathered and reported as the corrected values.</p> <p>2) The EUT is placed on a non-conductive pedestal centered on a turn-table in the test location with the antenna at the test distance from the EUT</p> <p>3) Maximum radiated RF emissions are determined by rotation of azimuth and scanning the sense antenna between 1 and 4 meters in height using both horizontal and vertical antenna polarities. Maximized levels are manually noted at degree values of azimuth and at sense antenna height.</p>			
Example Calculations	Reported Measurement data = Raw receiver measurement + Antenna Correction Factor + Cable factor (dB) - amplification factor (when applicable) + Additional factor (when applicable)			

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

Frequency (MHz)	3 m Limit ($\mu\text{V/m}$)	3 m Limit (dB $\mu\text{V/m}$)	Type
30-88	100	40.0	Quasi-Peak
88-216	150	43.5	Quasi-Peak
216-960	200	46.0	Quasi-Peak
Above 960	500	54.0	Average (>1 GHz)

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

B.2.1 – Radiated Harmonics in Restricted Bands above 1 GHz

Manufacturer	LS Research
Date	8-15, 8-16, 8-22, 8-23
Operator	Adam A / Mike H
Temp. / R.H.	20 - 25° C / 30-60% R.H.
Test Voltage	3.3 VDC
Test Location	LS Research, LLC - FCC Listed 3 meter Semi-Anechoic Chamber
Rule Part	15.247 / 15.205 / 15.209
Measurement Procedure	ANSI C63.4 - 2003
Test Distance	3 meter (1-4 GHz) 1 meter (4-10 GHz)
EUT Placement	80 cm height non-conductive table centered on turn-table
Detectors	RBW 1MHz; Peak (VBW 3MHz); Average (VBW 10Hz)
Additional Notes	<ol style="list-style-type: none">1) Tested in the worst case of continuous transmit GFSK (BLE) and 1 Mbps (WLAN) modulated mode for radiated harmonics in restricted bands in low, mid, and high channels with EUT Antenna in three orthogonal positions with all channels at maximum power.2) BLE Mode: Peak measurements are made and then the duty cycle correction is applied to get the calculated average. Peak measurements are compared to the peak limit and the calculated average is compared to the average limit.3) See Appendix F for duty cycle calculation.

Prepared For: LS Research

Name: TiWi-BLECA

Report: TR 313249 A FCCICTX (DTS)

Model: TiWi-BLECA

LSR: C-1808

Serial: Eng. Sample

Table: WLAN Transmit Harmonics in Restricted bands

	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
Low	4824	1.15	9	64.59	62.38	63.5	1.1	Horizontal	Flat
	12060	1	148	56.18	46.75	63.5	16.8	Horizontal	Flat
	14472	1.02	33	61.9	56.31	63.5	7.2	Horizontal	Side
	19296	1	333	56.89	51.73	63.5	11.8	Vertical	Vertical
	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
Mid	4874	1.1	114	64.44	62.54	63.5	1.0	Vertical	Side
	7311	1.05	288	54.63	43.01	63.5	20.5	Horizontal	Flat
	12185	1	162	54.4	44.45	63.5	19.1	Vertical	Flat
	19496	1	197	55.97	50.51	63.5	13.0	Horizontal	Flat
	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
High	4924	1.01	116	61.43	59	63.5	4.5	Vertical	Side
	7386	1	234	53.96	43.48	63.5	20.0	Vertical	Flat
	12310	1.03	181	60.04	56.92	63.5	6.6	Horizontal	Side
	19696	1	338	56.47	51.82	63.5	11.7	Vertical	Vertical
	22158	NF	NF	NF	0	63.5	63.5	Vertical	Flat

Bluetooth (BLE Mode) Radiated Harmonics in restricted bands

	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Duty Cycle Correction (dB)	Avg Calculated (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
Low	4804	1.06	248	72.22	14.9	57.32	63.5	6.2	Vertical	Side
	12010	1.09	350	55.95	14.9	41.05	63.5	22.5	Horizontal	Side
	19216	1	207	58.59	14.9	43.69	63.5	19.8	Vertical	Side
Mid	4880	1	66	68.21	14.9	53.31	63.5	10.2	Horizontal	Flat
	7320	1.18	201	56.79	14.9	41.89	63.5	21.6	Vertical	Side
	12200	1.05	352	57.12	14.9	42.22	63.5	21.3	Horizontal	Side
	19520	1	0	60.49	14.9	45.59	63.5	17.9	Vertical	Side
High	4960	1	171	61.57	14.9	46.67	63.5	16.8	Horizontal	Vertical
	7440	1.04	237	55.81	14.9	40.91	63.5	22.6	Horizontal	Vertical
	12400	1.02	163	54.59	14.9	39.69	63.5	23.8	Horizontal	Side
	19840	1	9	63.05	14.9	48.15	63.5	15.4	Vertical	Side
	22320	1	1.08	59.47	14.9	44.57	63.5	18.9	Vertical	Flat

Prepared For: LS Research

Name: TiWi-BLECA

Report: TR 313249 A FCCICTX (DTS)

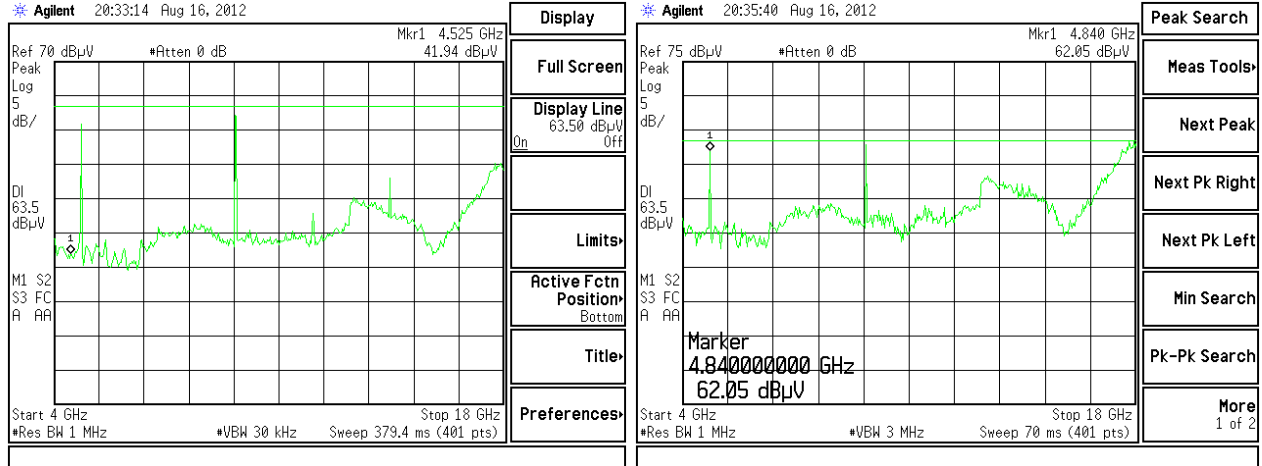
Model: TiWi-BLECA

LSR: C-1808

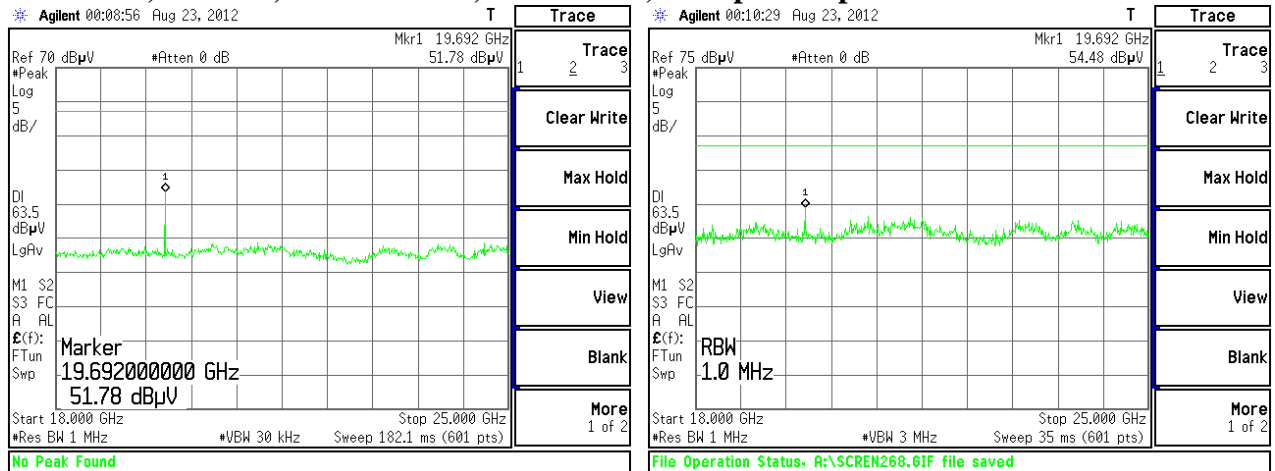
Serial: Eng. Sample

Plots:

**WLAN Transmit Harmonics in Restricted bands
4-18 GHz, Horizontal, Flat EUT, Channel 1, 1Mbps max power**



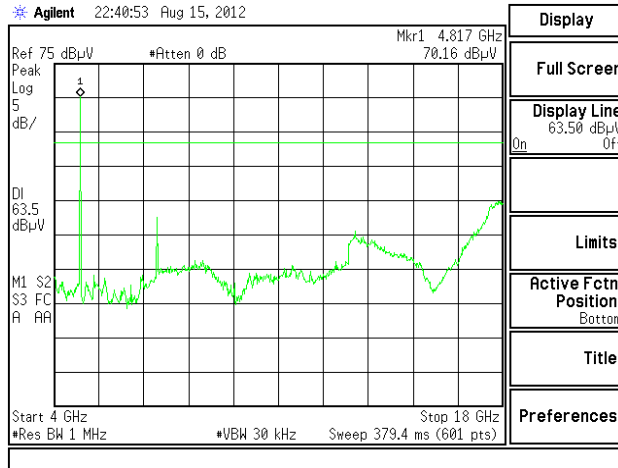
18-25 GHz, Vertical, Vertical EUT, Channel 11, 1 Mbps max power



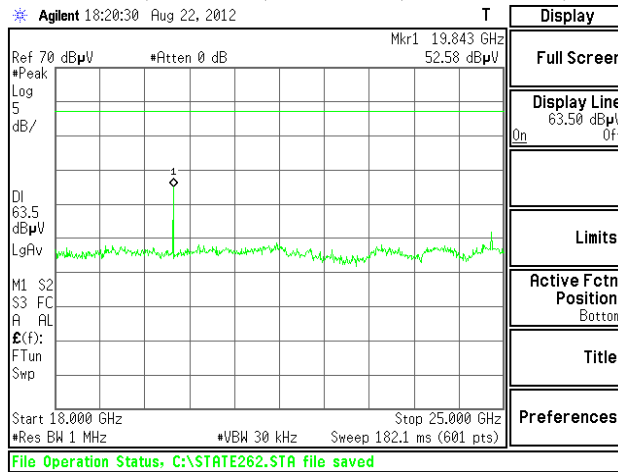
Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Bluetooth Radiated Harmonics in restricted bands

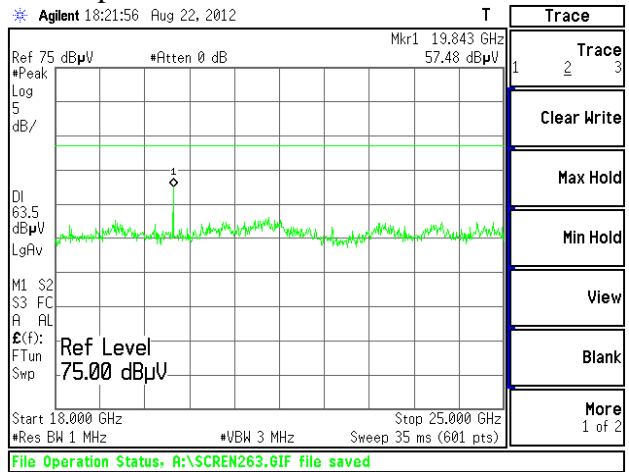
4-18 GHz Average, Vertical, EUT Side, Channel 0, GFSK max power



18-25 GHz, Vertical, EUT Flat, Channel 39, GFSK max power



Average



Peak

B2.2 - Radiated Band-edge into restricted bands

Manufacturer	LS Research
Date	8-21, 8-22
Operator	Adam A
Temp. / R.H.	20 - 25° C / 30-60% R.H.
Test Voltage	3.3 VDC
Test Location	LS Research, LLC - FCC Listed 3 meter Semi-Anechoic Chamber
Rule Part	15.247 / 15.205 / 15.209
Measurement Procedure	ANSI C63.4 - 2003
Test Distance	3 meter
EUT Placement	80 cm height non-conductive table
Detectors	RBW 1MHz; Peak (VBW 3MHz); Average (VBW 10Hz)
Additional Notes	1) Tested in continuous transmit modulated mode in low and high channels with EUT Antenna in three orthogonal positions. 2) Maximum levels recorded.

Example Calculation:

Peak Limit – Peak Reading = Peak Margin; Average Limit – Average Reading = Average Margin

WLAN Lower Band-Edge 2310 – 2390 MHz

EUT Channel	EUT Mode	EUT Power	Peak (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Average (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)
1	1 Mbps	16	59.17	74	14.8	49.32	54	4.7
1	MCS7	Max	60.99	74	13.0	45.72	54	8.3
2	1 Mbps	17	60.26	74	13.7	52.09	54	1.9
3	1 Mbps	Max	58.48	74	15.5	47.04	54	7.0

WLAN Upper Band-Edge 2483.5 – 2500 MHz

EUT Channel	EUT Mode	EUT Power	Peak (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Average (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)
11	1 Mbps	Max	61.32	74	12.7	50.39	54	3.6
11	MCS7	Max	57.58	74	16.4	44.24	54	9.8

BLE Upper and Lower Band-edge 2310 – 2390 MHz and 2483.5 – 2500 MHz

EUT Channel	EUT Mode	EUT Power	Peak (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Average (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)
0	BLE	Max	58.65	74	15.4	44.58	54	9.4
39	BLE	Max	59.28	74	14.7	46.18	54	7.8

Prepared For: LS Research

Name: TiWi-BLECA

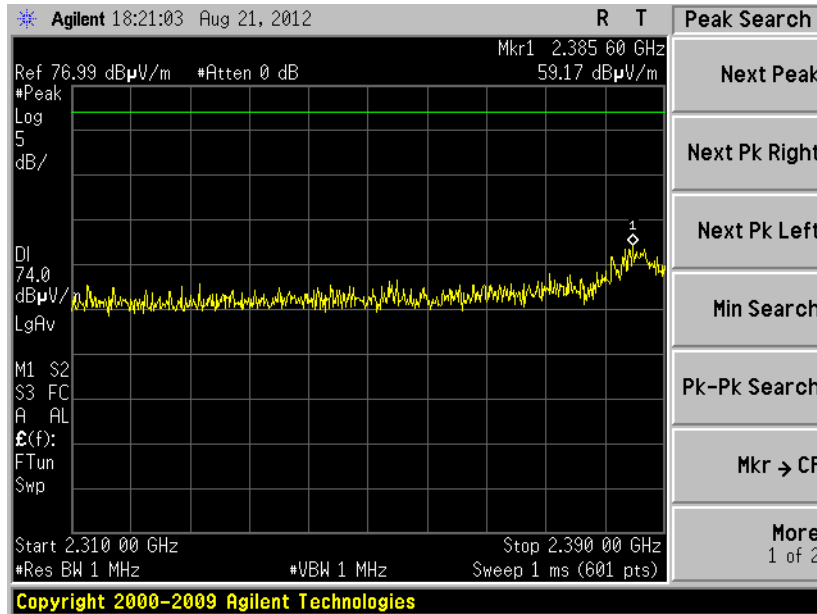
Report: TR 313249 A FCCICTX (DTS)

Model: TiWi-BLECA

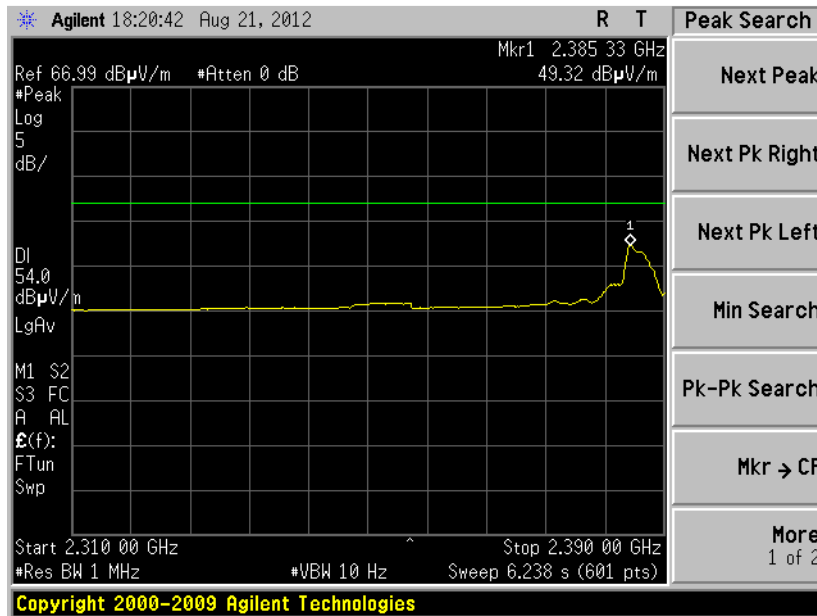
LSR: C-1808

Serial: Eng. Sample

WLAN
Channel 1 Lower Band-edge into restricted band



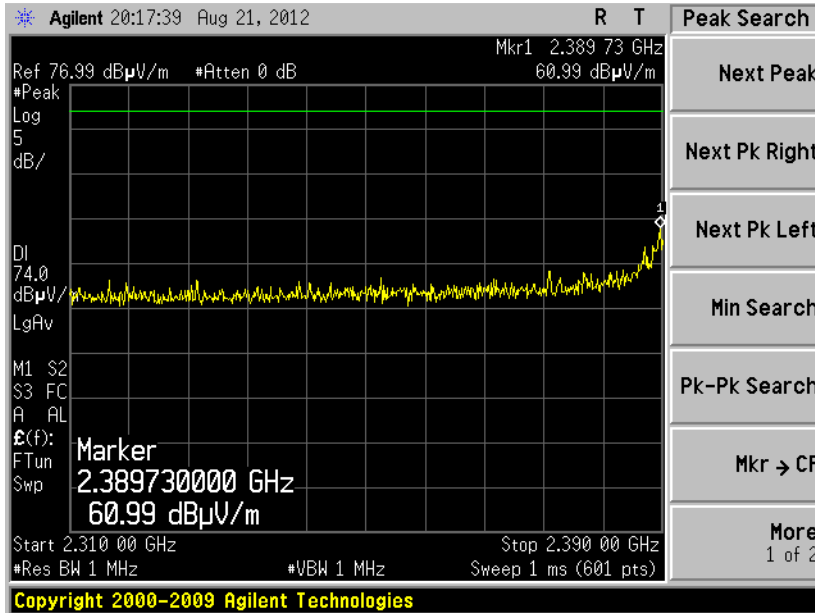
Lower Band-edge restricted band, 1 Mbps, Power Level 16, Peak



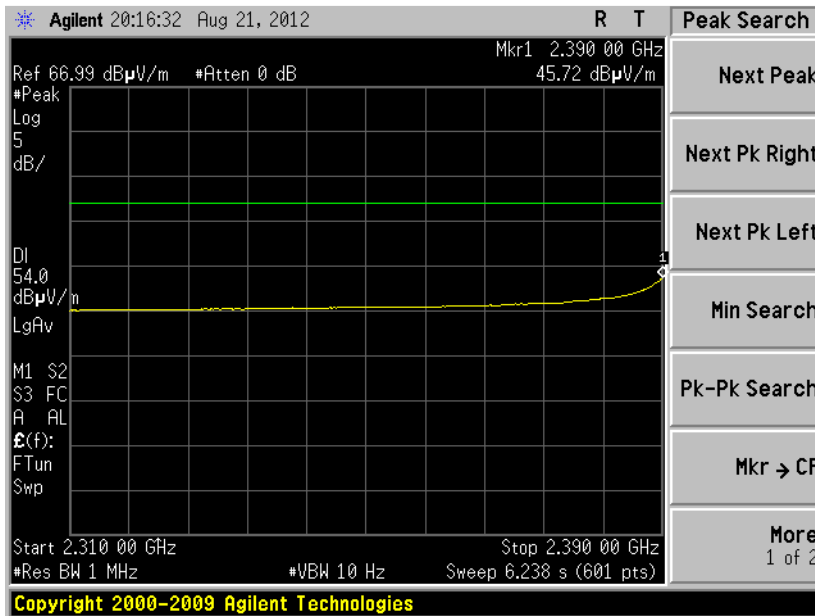
Lower Band-edge restricted band, 1 Mbps, Power Level 16, Average

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

MCS7:



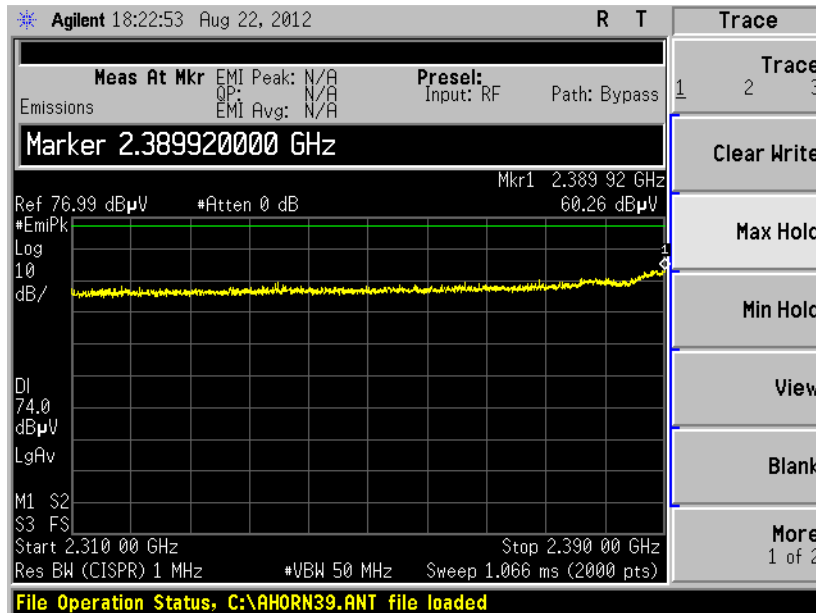
Lower Band-edge restricted band, MCS7, Peak



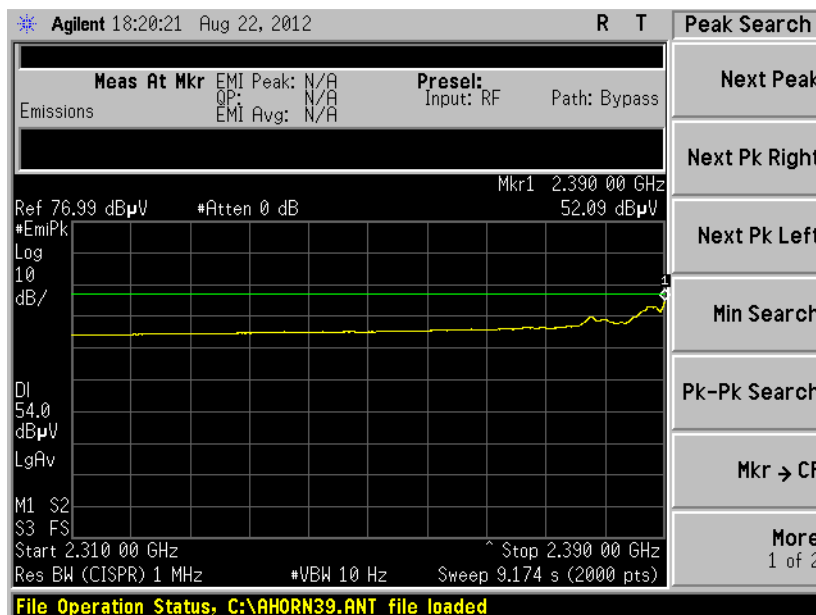
Lower Band-edge restricted band, MCS7, Average

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Channel 2 Lower Band-edge into restricted band



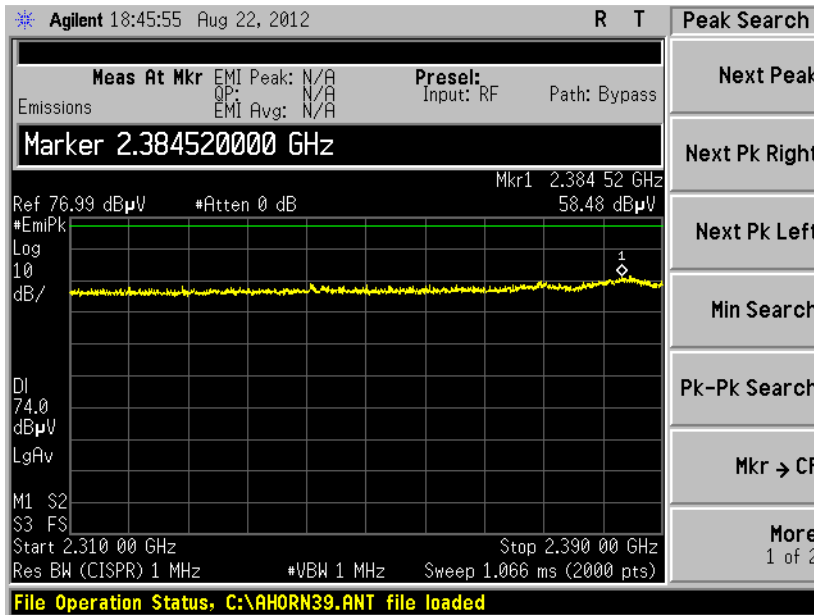
Lower Band-edge restricted band, 1 Mbps, Power Level 17, Peak



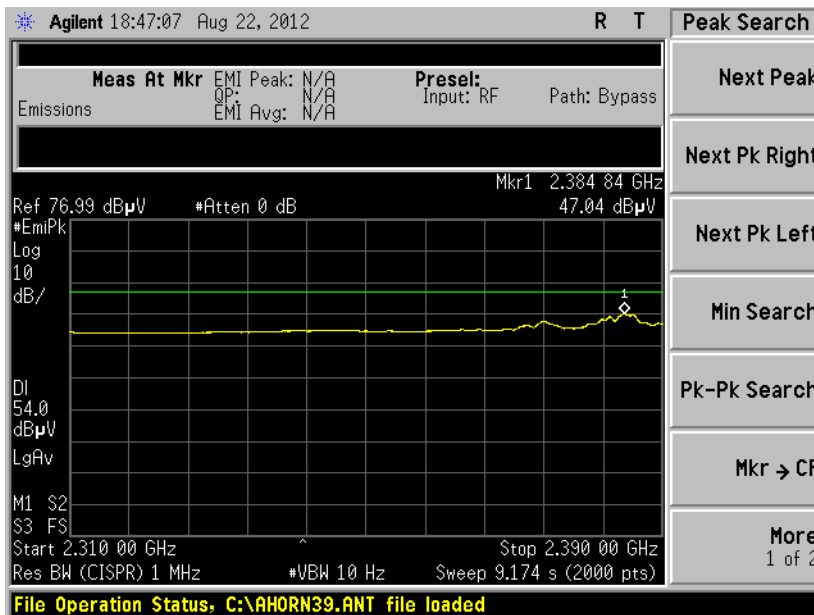
Lower Band-edge restricted band, 1 Mbps, Power Level 17, Average

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Channel 3 Lower Band-edge into restricted band Full Power



Lower Band-edge restricted band, 1 Mbps, Peak

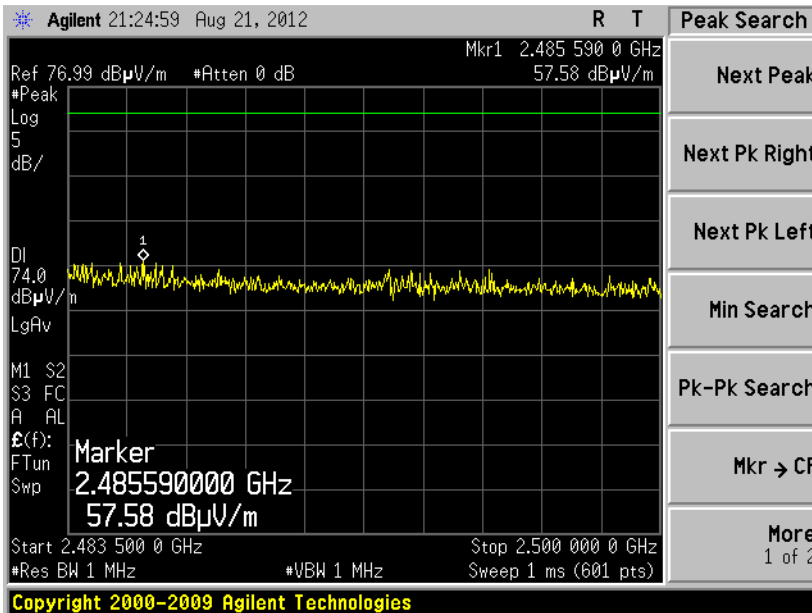


Lower Band-edge restricted band, 1 Mbps, Average

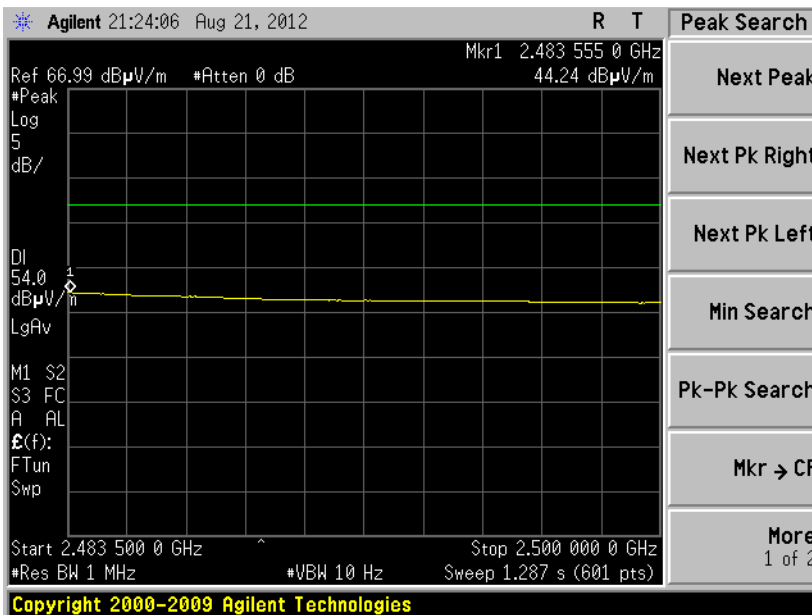
Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Upper Band-edge into restricted band

Full power – MCS7 – Channel 11



Upper Band-edge restricted band, MCS7, Peak



Upper Band-edge restricted band, MCS7, Average

Prepared For: LS Research

Report: TR 313249 A FCCICTX (DTS)

LSR: C-1808

Name: TiWi-BLECA

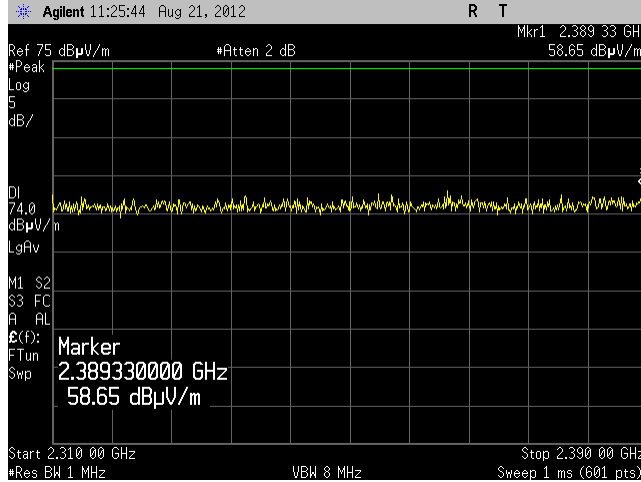
Model: TiWi-BLECA

Serial: Eng. Sample

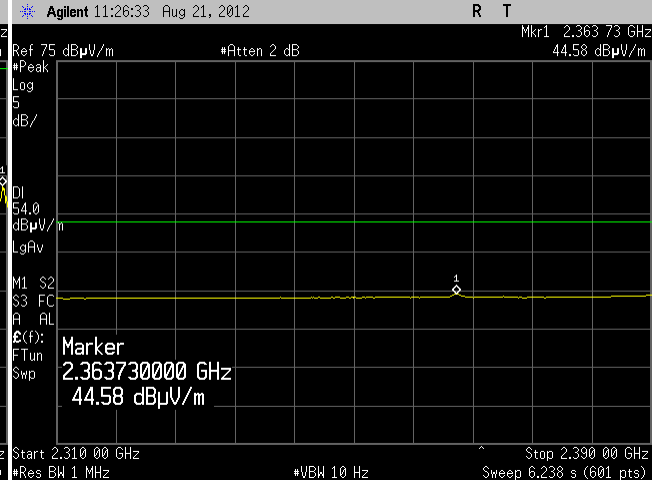
Bluetooth (BLE Mode)

Radiated Lower Band-edge into restricted bands

BLE



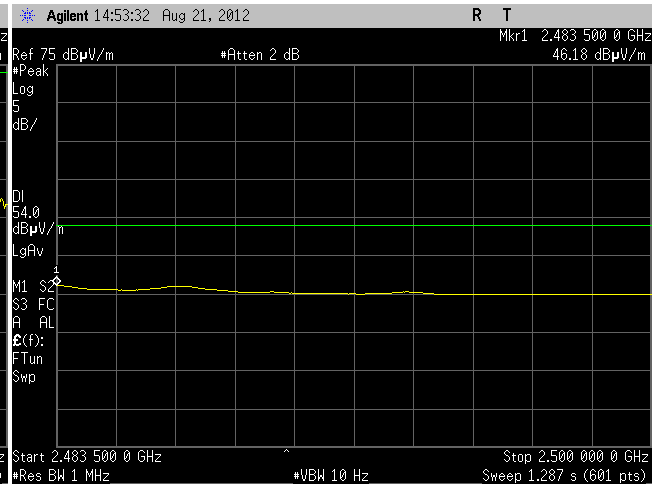
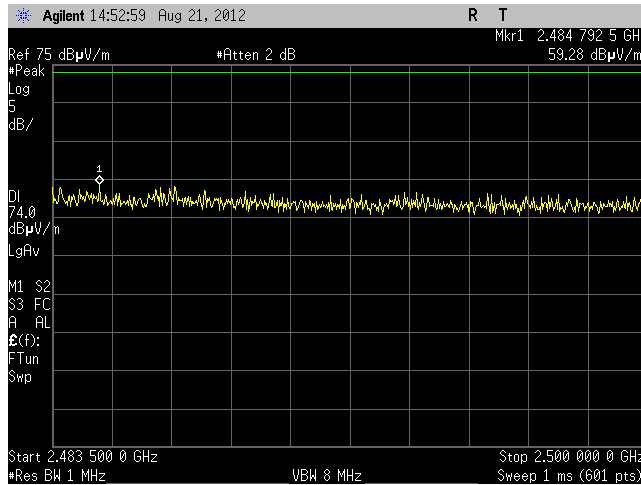
Peak



Average

Radiated Upper Band-edge into restricted bands

BLE



Prepared For: LS Research

Report: TR 313249 A FCCICTX (DTS)

LSR: C-1808

Name: TiWi-BLECA

Model: TiWi-BLECA

Serial: Eng. Sample

B.2.3 – Receive Mode Radiated Emissions

Manufacturer	LS Research
Date	8-21 to 8-23 0212
Operator	Peter F / Mike H
Temperature	20 - 25° C
Humidity	30 – 60%
Test Voltage	3.3 VDC
Test Location	LS Research, LLC - FCC Listed 3 meter Semi-Anechoic Chamber
Test Distance	3 meter (30 MHz to 4 GHz) 1 meter (4 GHz to 25 GHz)
EUT Placement	80 cm height non-conductive table
Measurements	Final
Detectors	Peak, Quasi-Peak, Average
Additional Notes	1) Emissions 30-4000MHz tested in receive mode on low, mid, high channels in three orientations. No significant difference noted in emissions from mode or channel selection. Worst case reported. 2) Emissions 4-25 GHz tested in Bluetooth BLE receive and WLAN receive on low, mid, high channels in three orientations and reported in separate tables/plots.

30-4000MHz

Frequency (MHz)	Height (m)	Azimuth (degree)	Quasi Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation	NOTES
72.1	3.93	352	33.2	40.0	6.9	H	FLAT	1
72.1	1.04	72	34.2	40.0	5.8	V	FLAT	1
72.1	3.81	0	31.0	40.0	9.0	H	V	1
72.1	1.00	0	33.1	40.0	6.9	V	V	1
984.9	1.00	0	28.0	54.0	26.0	V	V	2
998.9	1.00	0	29.1	54.0	24.9	H	V	2
966.0	1.00	0	28.5	54.0	25.5	H	SIDE	2
993.0	1.00	0	28.4	54.0	25.6	V	SIDE	2
975.5	1.00	0	27.79	54.0	26.2	V	FLAT	2
999.3	1.00	0	29.05	54.0	25.0	H	FLAT	2

Note 1: NOT A FUNCTION OF EUT CHANNEL, OR POWER LEVEL; LIKELY RELATED TO THE POWER SUPPLY

Note 2: Noise Floor

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Bluetooth Receive Mode 4-25 GHz

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBμV/m)	Average Reading (dBμV/m)	Average Limit (dBμV/m)	Margin (dB)	Antenna Polarity	EUT orientation	EUT Channel
4803.0	1.12	186	51.45	40.1	63.5	23.4	H	V	0
4803.0	1.00	298	51.88	39.88	63.5	23.6	H	S	0
4803.0	1.00	348	51.68	40.14	63.5	23.4	H	F	0
19211.0	1.00	329	52.8	41.69	63.5	21.8	H	V	0
19211.0	1.00	309	52.01	41.82	63.5	21.7	H	S	0
19211.0	1.00	207	52.63	42.65	63.5	20.9	V	S	0
19211.0	1.00	46	53.5	43.41	63.5	20.1	V	F	0
19211.0	1.00	325	53.96	42.62	63.5	20.9	H	F	0
 									
4879.0	1.06	243	49.28	39.96	63.5	23.5	H	V	19
4879.0	1.25	131	48.54	35.95	63.5	27.6	H	S	19
4879.0	1.00	204	48.18	37.38	63.5	26.1	H	F	19
4879.0	1.00	341	48.92	39.41	63.5	24.1	V	F	19
19515.0	1.00	180	52.82	41.97	63.5	21.5	H	F	19
19515.0	1.00	325	53.53	42.92	63.5	20.6	V	F	19
19515.0	1.00	291	52.98	41.66	63.5	21.8	H	S	19
19515.0	1.02	227	52.92	43.44	63.5	20.1	V	S	19
19515.0	1.00	326	52.7	42.99	63.5	20.5	H	V	19
19515.0	1.00	46	52.78	42.27	63.5	21.2	V	V	19
 									
4959.0	1.06	267	49.65	38.53	63.5	25.0	H	V	39
4959.0	1.00	0	48.73	37.73	63.5	25.8	H	F	39
4959.0	1.09	166	49.31	38.66	63.5	24.8	V	F	39
19835.0	1.05	346	52.42	41.9	63.5	21.6	H	V	39
19835.0	1.00	323	52.06	41.09	63.5	22.4	V	V	39
19535.0	1.00	38	52.1	40.77	63.5	22.7	H	S	39
19835.0	1.00	11	53.28	42.65	63.5	20.9	V	S	39
19835.0	1.00	330	53.09	44.15	63.5	19.4	H	F	39
19835.0	1.00	119	52.5	41.31	63.5	22.2	V	F	39

WLAN 15.109 Receive Mode Emissions 4-25 GHz

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Average Reading (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation	EUT Channel
9648.0	1.00	163	57.28	51.17	63.5	12.3	H	V	1
9648.0	1.27	355	55.14	48.23	63.5	15.3	V	V	1
9648.0	1.05	85	58.22	54.01	63.5	9.5	V	S	1
9648.0	1.00	217	56.23	51.42	63.5	12.1	H	S	1
9648.0	1.00	45	59.73	56.27	63.5	7.2	H	F	1
9648.0	1.00	205	58.25	54.14	63.5	9.4	V	F	1
19296.0	1.02	34	56.29	50.61	63.5	12.9	H	V	1
19296.0	1.00	291	55.99	50.81	63.5	12.7	V	V	1
19296.0	1.01	355	55.7	48.7	63.5	14.8	H	S	1
19296.0	1.00	303	57.63	52.84	63.5	10.7	V	S	1
19296.0	1.00	266	57.59	53.42	63.5	10.1	H	F	1
19296.0	1.00	39	54.19	46.4	63.5	17.1	V	F	1
 									
9748.0	1.15	174	56.98	51.52	63.5	12.0	H	V	6
9748.0	1.22	10	55.08	47.68	63.5	15.8	V	V	6
9748.0	1.11	232	56.82	51.48	63.5	12.0	H	S	6
9748.0	1.04	8	57.01	51.5	63.5	12.0	V	S	6
9748.0	1.01	48	60.12	56.85	63.5	6.7	H	F	6
9748.0	1.09	211	59.5	55.86	63.5	7.6	V	F	6
19496.0	1.00	33	55.65	49.97	63.5	13.5	H	V	6
19496.0	1.00	286	55.19	49.58	63.5	13.9	V	V	6
19496.0	1.00	347	54.31	46.79	63.5	16.7	H	S	6
19496.0	1.00	290	55.89	51.02	63.5	12.5	V	S	6
19496.0	1.00	272	56.92	52.19	63.5	11.3	H	F	6
19496.0	1.00	40	54.05	46.59	63.5	16.9	V	F	6
 									
9848.0	1.00	48	59.92	57.15	63.5	6.4	H	F	11
9848.0	1.07	213	57.29	53.78	63.5	9.7	V	F	11
9848.0	1.00	0	57.68	53.08	63.5	10.4	H	V	11
9848.0	1.29	6	55.81	48.89	63.5	14.6	V	V	11
9848.0	1.11	233	57.03	52.04	63.5	11.5	H	S	11
9848.0	1.16	191	57.65	53.05	63.5	10.5	V	S	11
19696.0	1.03	32	54.43	47.76	63.5	15.7	H	V	11
19695.0	1.00	295	54.36	47.24	63.5	16.3	V	V	11
19696.0	1.03	351	53.19	44.57	63.5	18.9	H	S	11
19696.0	1.04	57	54.47	45.65	63.5	17.9	V	S	11
19696.0	1.00	271	56.08	50.36	63.5	13.1	H	F	11
19696.0	1.00	45	51.91	42.14	63.5	21.4	V	F	11

Prepared For: LS Research

Name: TiWi-BLECA

Report: TR 313249 A FCCICTX (DTS)

Model: TiWi-BLECA

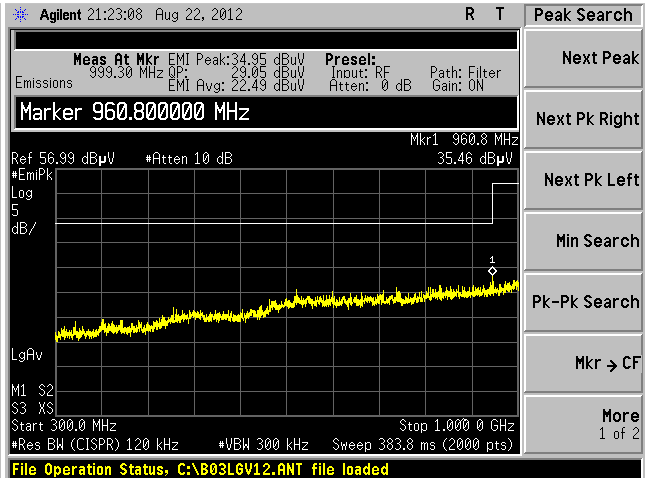
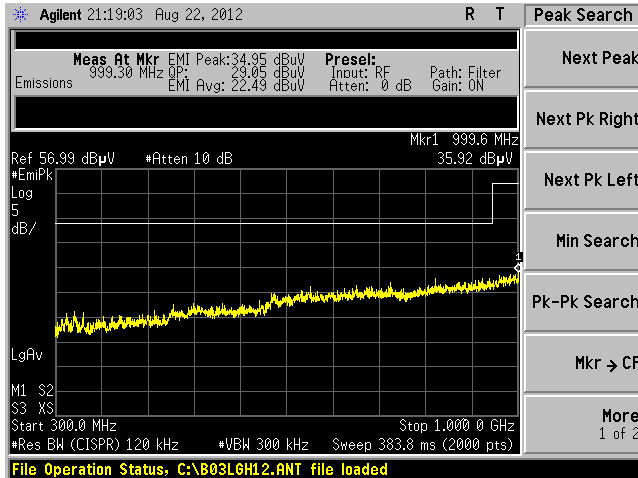
LSR: C-1808

Serial: Eng. Sample

Plots:

Tested in three orthogonal positions, receive channel 6

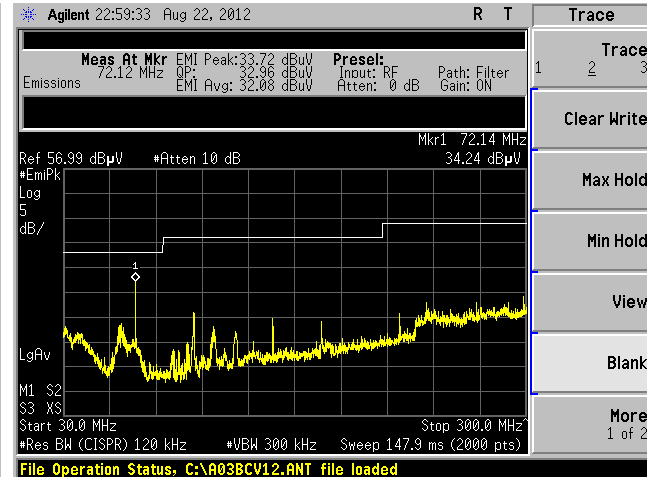
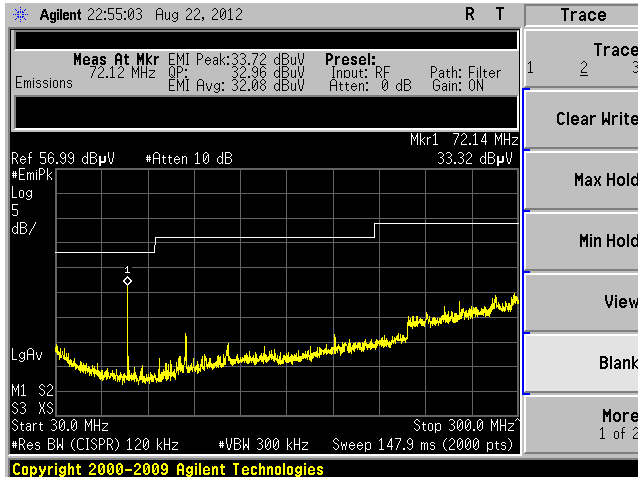
300-1000MHz



Horizontal

Vertical

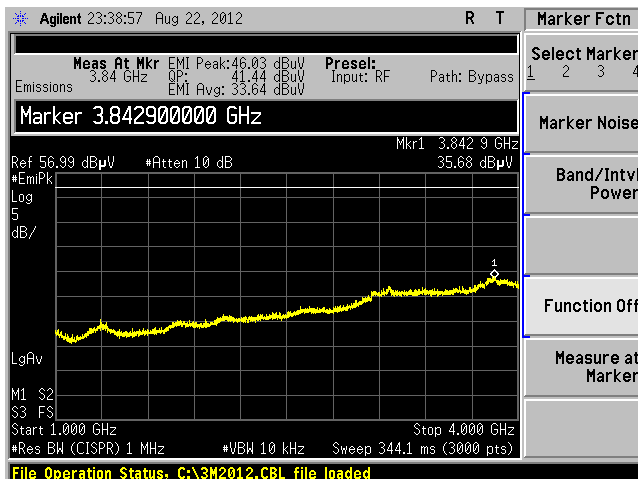
30-300MHz



Horizontal

Vertical

1000-4000MHz

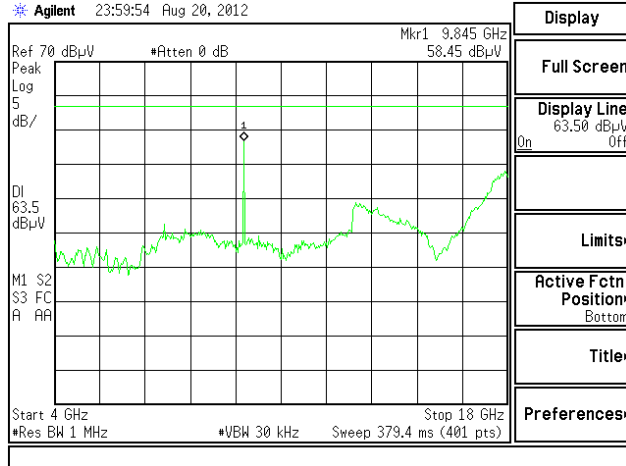


Horizontal – Reduced VBW

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

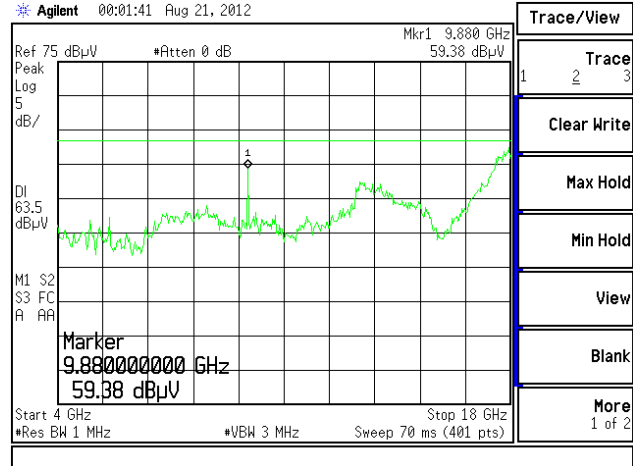
WLAN Receive Mode 4-25 GHz 4-18 GHz Horizontal, EUT Flat, Ch 11

* Agilent 23:59:54 Aug 20, 2012



Average

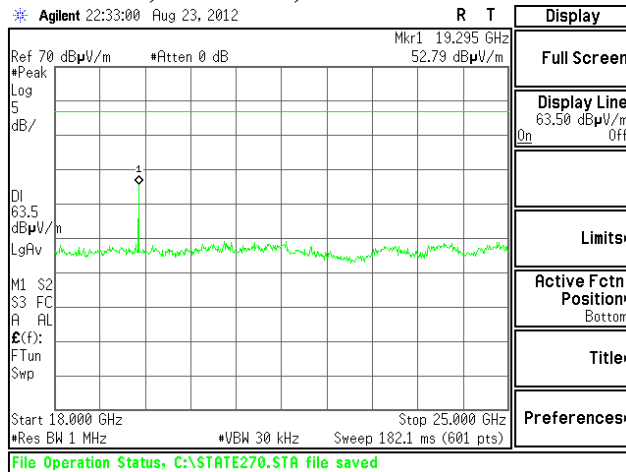
* Agilent 00:01:41 Aug 21, 2012



Peak

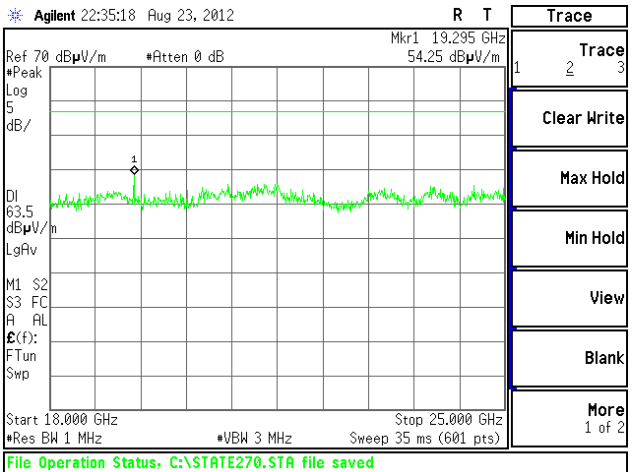
18-25 GHz Horizontal, EUT Flat, Ch 1

* Agilent 22:33:00 Aug 23, 2012



Average

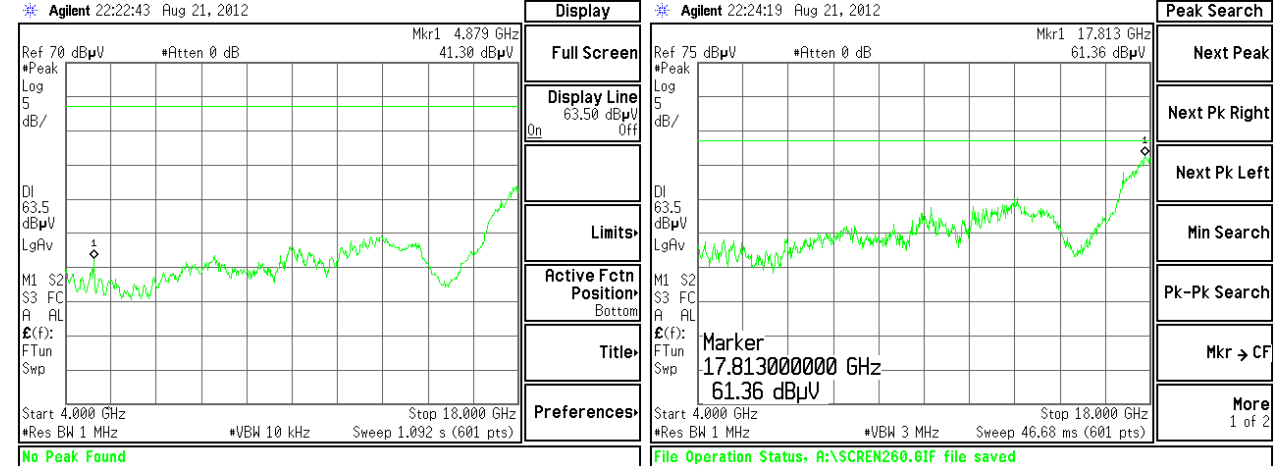
* Agilent 22:35:18 Aug 23, 2012



Peak

Bluetooth Receive Mode 4-25 GHz

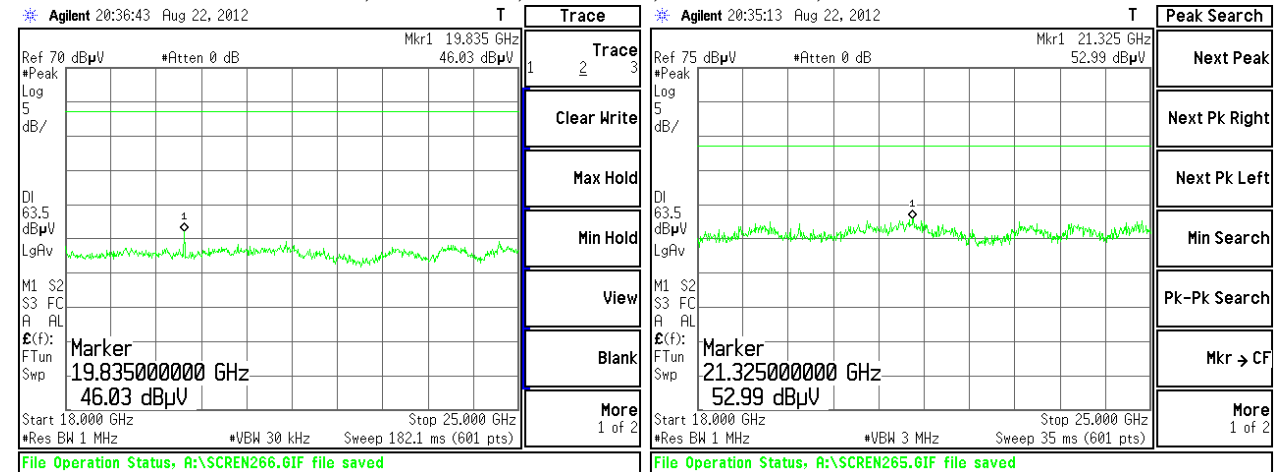
4-18 GHz Receive Mode, Vertical, EUT Flat, Channel 19,



Average

Peak

18 - 25 GHz Receive Mode, Horizontal, EUT Flat, Channel 39,



Average

Peak

B.3 – AC Mains Emissions

Test Setup

The test area and setup are in accordance with ANSI C63.4-2003 and with Title 47 CFR, FCC Part 15, Industry Canada RSS-210 and RSS GEN. The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The EUT's power cable was plugged into a 50Ω (ohm), 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 EMI Receiver. The LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral).

Test Procedure

The EUT was investigated in continuous modulated transmit mode for this portion of the testing. The appropriate frequency range and bandwidths were selected on the EMI Receiver, and measurements were made. The bandwidth used for these measurements 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.

Test Equipment Utilized

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

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	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

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:

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

For a frequency of 200 kHz for example:

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

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

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

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

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:	LS Research				
Date(s) of Test:	September 28, 2010				
Test Engineer:	Peter Feilen				
Voltage:	5VDC				
Operation Mode:	Continuous Transmit/Receive				
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:	<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 (dBµ V)	Margin (dB)	Reading (dBµV)	Limit (dBµ V)	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

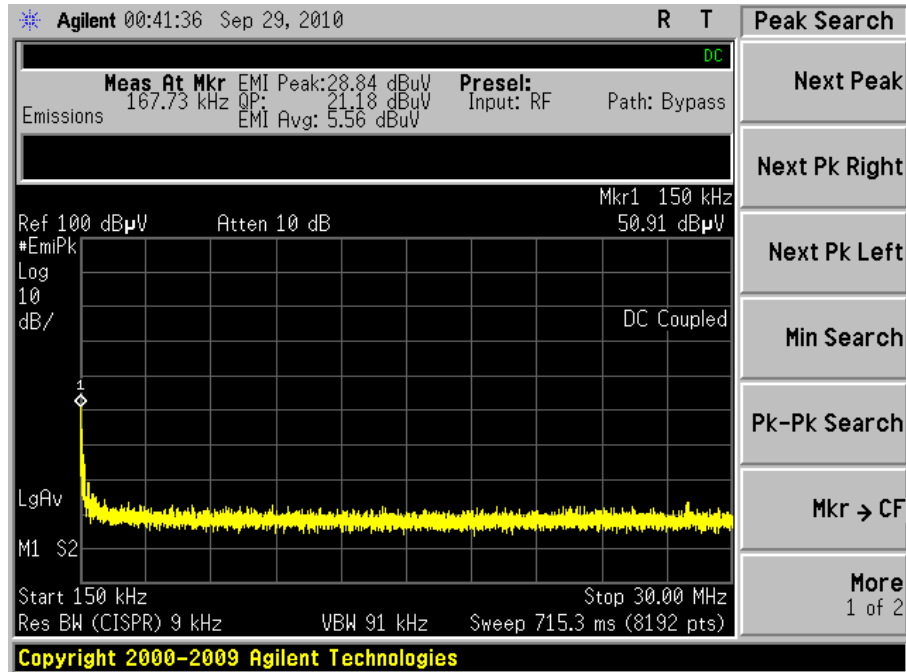
Notes:

- 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.

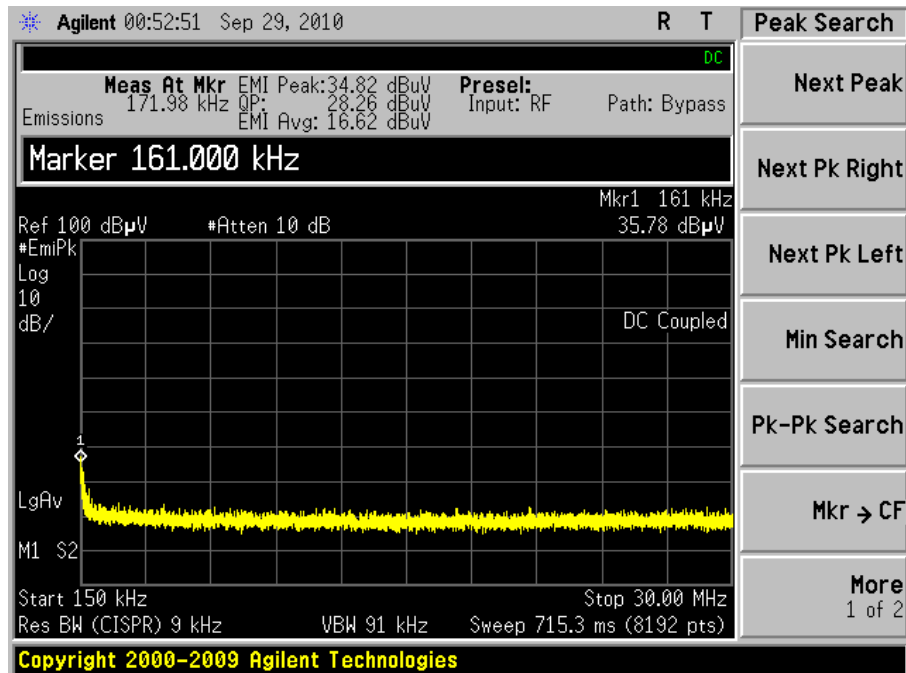
Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Screen Captures – Conducted Emissions Test

WLAN Transmit Mode:



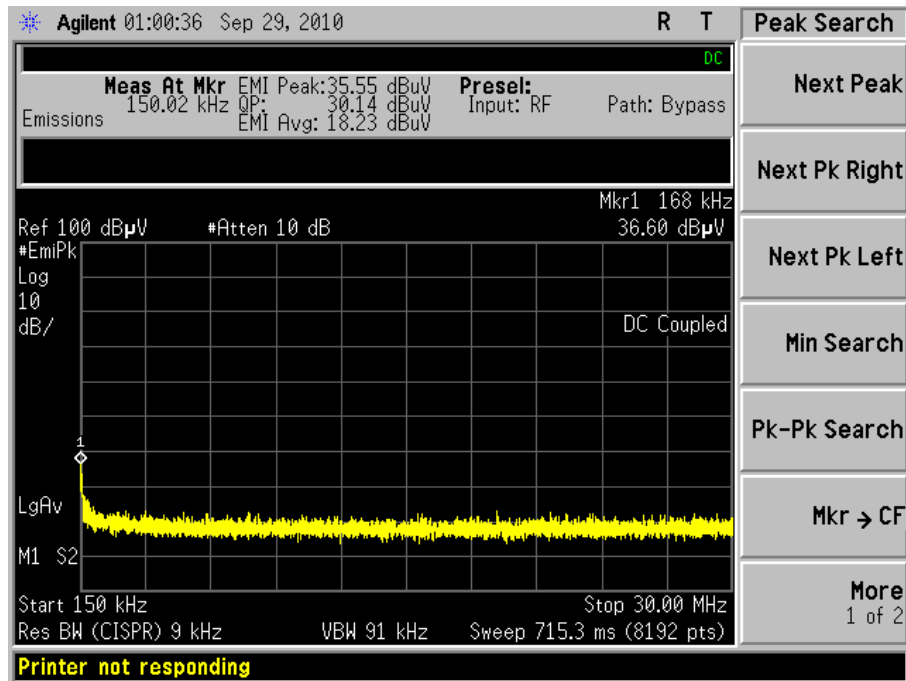
LINE 1



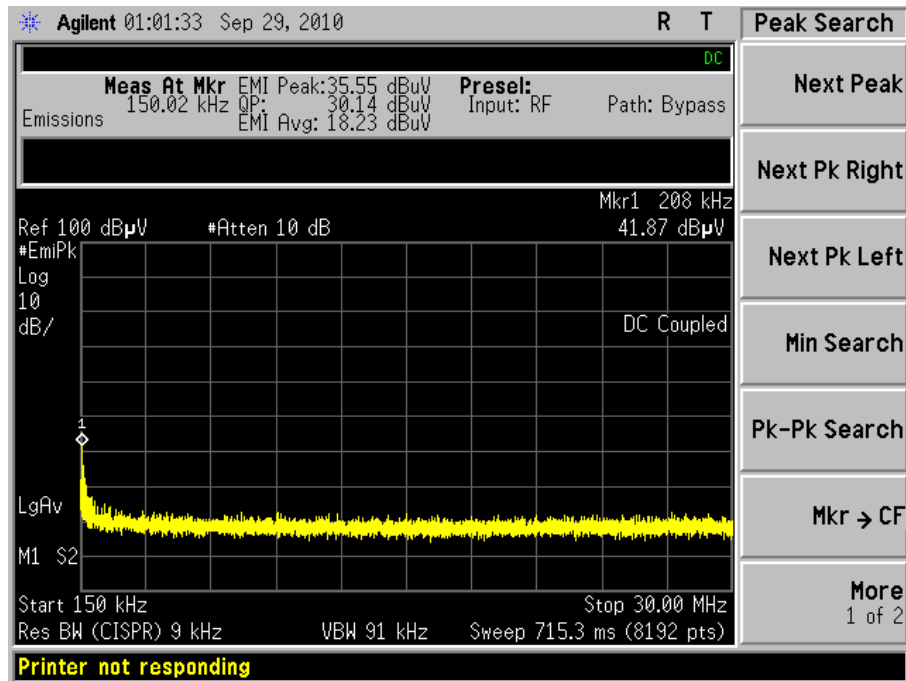
LINE 2

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

WLAN Receive mode:



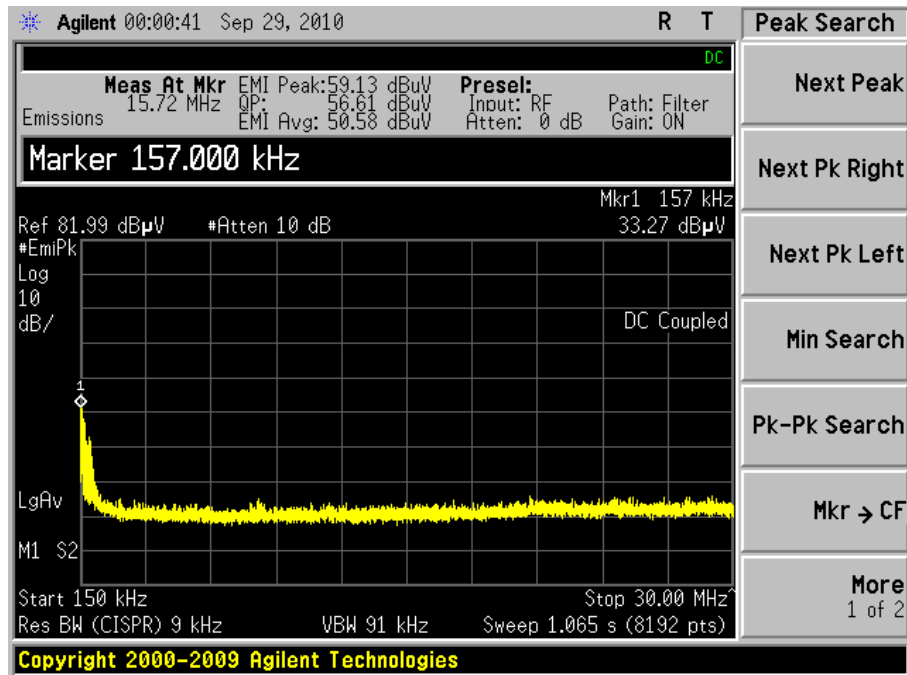
LINE 1



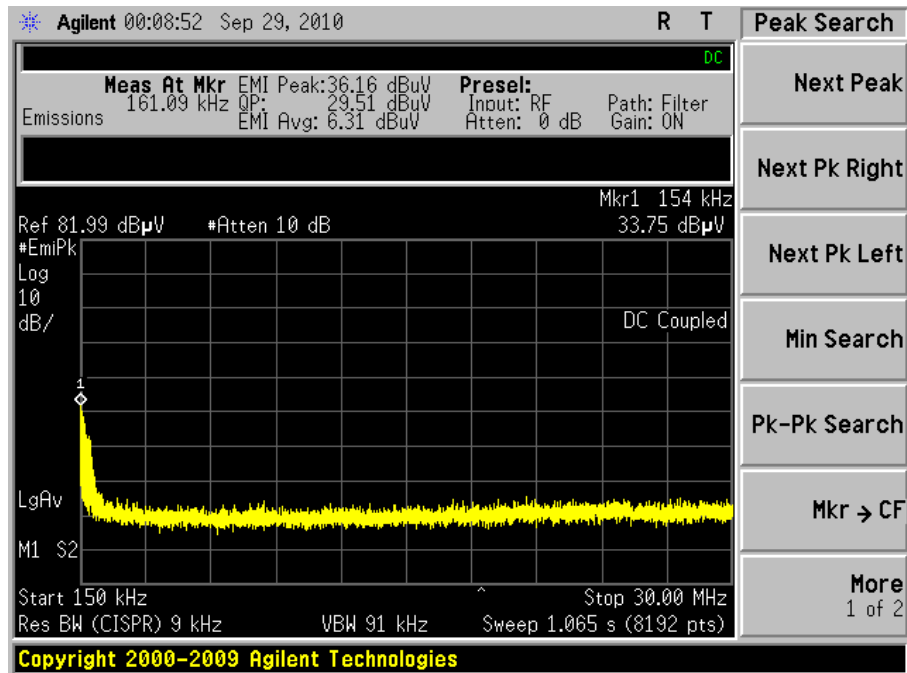
LINE 2

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Bluetooth Transmit mode:



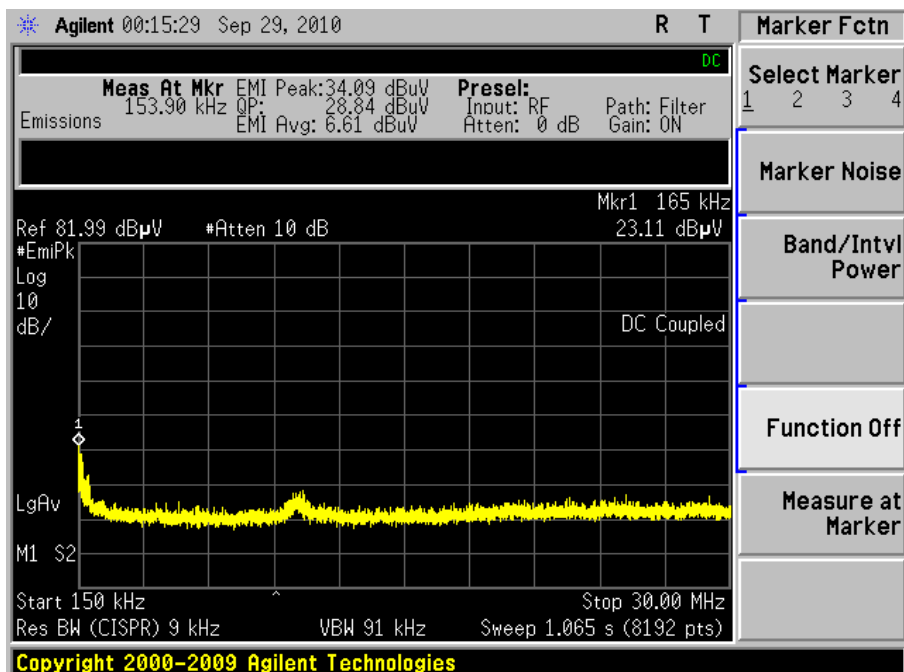
LINE 1



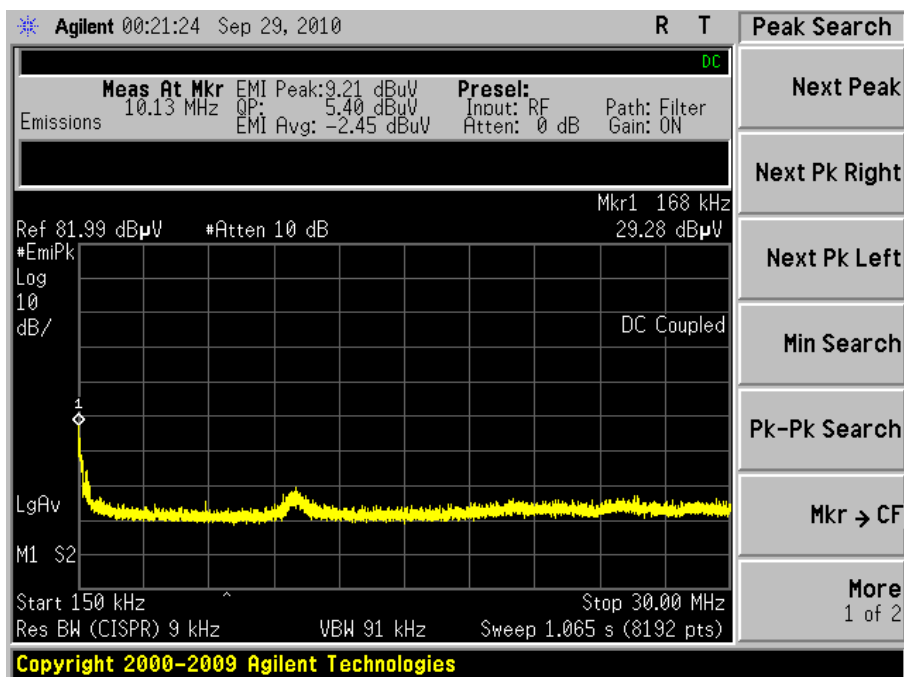
LINE 2

Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample

Bluetooth Receive mode:



LINE 1



LINE 2

Appendix C - Uncertainty Summary

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

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

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

Appendix D - References

Publication	Year	Title
FCC CFR Parts 0-15	2013	Code of Federal Regulations – Telecommunications
ANSI C63.4	2003	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
RSS-210 Annex 8	2010	Low-power License-exempt Radio communication Devices (All Frequency Bands): Category I Equipment
RSS-GEN Issue 3	2010	General Requirements and Information for the Certification of Radio Apparatus

Prepared For: LS Research

Report: TR 313249 A FCCICTX (DTS)

LSR: C-1808

Name: TiWi-BLECA

Model: TiWi-BLECA

Serial: Eng. Sample

Appendix E – MPE Calculations

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density

P = power input to the antenna

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal:	<u>19.42</u> (dBm)
Maximum peak output power at antenna input terminal:	<u>87.498</u> (mW)
Antenna gain(typical):	<u>1.3</u> (dBi)
Maximum antenna gain:	<u>1.349</u> (numeric)
Prediction distance:	<u>20</u> (cm)
Prediction frequency:	<u>2437</u> (MHz)
MPE limit for uncontrolled exposure at prediction frequency:	<u>1</u> (mW/cm ²)
Power density at prediction frequency:	0.023482 (mW/cm ²)
Maximum allowable antenna gain:	17.6 (dBi)
Margin of Compliance at 20 cm =	16.3 dB

Appendix F – BLE Duty Cycle Calculation

1.0 Summary

The fact that BLE is certified as a DTS (non-hopping), here is a worst-case indication for the BLE relaxation factor. The information contained in this appendix is from the Bluetooth Specification 4.0 dated June 30, 2010.

Channel dwell time cannot be incorporated into the relaxation factor as it can in Bluetooth 2.1+EDR. Shown below are the specifications for the link layer PDU (Physical Layer Protocol Data Unit) and the Inter frame spacing.

The worst case duty factor would be the interleaved concatenation of the maximum length packets and inter frame spaces. However, in the study of various sequence diagrams of the BLE protocol (particularly in the Advertising modes), this state does not really exist, there is typically 3 packets concatenated in the longest channel dwell. Also between channel dwells, there is more time allowed.

There are directed and undirected advertising events.

The worst case relaxation factor for a directed advertising event is 14.9 dB.

The worst case relaxation factor for an undirected advertising event is 20 dB.

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1.1 Defining Packet Length

2.1 PACKET FORMAT

The Link Layer has only one packet format used for both advertising channel packets and data channel packets.

The packet format is shown in [Figure 2.1](#). Each packet consists of four fields: the preamble, the Access Address, the PDU, and the CRC.

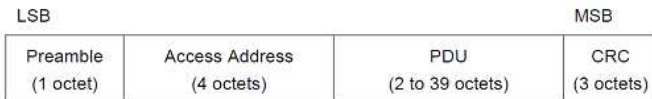


Figure 2.1: Link Layer packet format

The preamble is 1 octet and the Access Address is 4 octets. The PDU range is from 2 to a maximum of 39 octets. The CRC is 3 octets.

The Preamble is transmitted first, followed by the Access Address, followed by the PDU followed by the CRC.

The shortest packet is 80 bits in length. The longest packet is 376 bits in length.

PDU Type $b_3b_2b_1b_0$	Packet Name
0000	ADV_IND
0001	ADV_DIRECT_IND
0010	ADV_NONCONN_IND
0011	SCAN_REQ
0100	SCAN_RSP
0101	CONNECT_REQ
0110	ADV_SCAN_IND
0111-1111	Reserved

Table 2.1: Advertising channel PDU Header's PDU Type field encoding

Octets per Packet

ADV_IND = 37 octets

ADV_DIRECT_IND = 12 octets

ADV_NONCONN_IND = 37 octets

SCAN_REQ = 12 octets

SCAN_RSP = 37 octets

CONNECT_REQ = 34 octets

ADV_SCAN_IND = 37 octets

Preamble (1)	Access Address (4)	PDU Header (2)	Worst Case PDU Type (37)	CRC (3)
-----------------	--------------------------	----------------------	--------------------------------	------------

Stated worst case length packet: 47 octets = 376 bits

Worst Case Packet Duration: 376 bits * 1 μS / bit = 376 μS

1.2 Defining Inter Frame Space

4.1 INTER FRAME SPACE

The time interval between two consecutive packets on the same channel index is called the Inter Frame Space. It is defined as the time from the end of the last bit of the previous packet to the start of the first bit of the subsequent packet.

The Inter Frame Space is designated "T_IFS" and shall be 150 μs.

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1.3 Defining Undirected Advertising Event

For all undirected advertising events, the time between the start of two consecutive advertising events ($T_{advEvent}$) is computed as follows for each advertising event:

$$T_{advEvent} = advInterval + advDelay$$

The *advInterval* shall be an integer multiple of 0.625 ms in the range of 20 ms to 10.24 s. If the advertising event type is either a scannable undirected event type or a non-connectable undirected event type, the *advInterval* shall not be less than 100 ms. If the advertising event type is a connectable undirected event type, the *advInterval* can be 20 ms or greater.

The *advDelay* is a pseudo-random value with a range of 0 ms to 10 ms generated by the Link Layer for each advertising event.

As illustrated in Figure 4.1, the advertising events are perturbed in time using the *advDelay*.

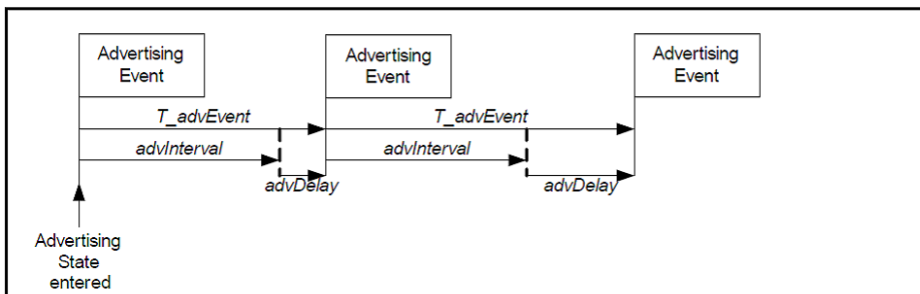


Figure 4.1: Advertising events perturbed in time using *advDelay*

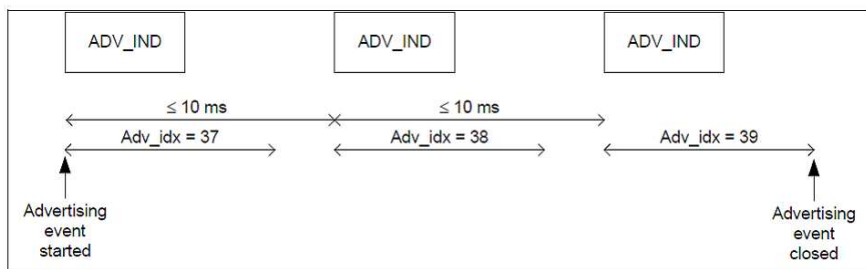


Figure F2: Connectable undirected advertising event with only advertising PDUs

1.3.1 Duty Factor for Connectable Undirected Advertising Event, per advertising channel:

ADV_IND = 376 μ S duration (ON channel 37)

IFS = 150 μ S (OFF)

ADV_IND = 376 μ S duration (OFF channel 38)

IFS = 150 μ S (OFF)

ADV_IND = 376 μ S duration (OFF Channel 39).

advInterval (min) = 20 mS

1.3.1.1 Straight Duty Factor

$$DF = 376 / (376*3+150*2+20000) = 0.0175$$

$$\text{Relaxation factor} = -\min(20*\log_{10}(DF), -20 \text{ dB}) = -\min(-35.119, -20) = 20 \text{ dB}$$

1.3.1.2 Duty Factor in 100mS window:

Packet Repetition Interval is $(376*3) + (2*150) + 20000$ microseconds = 21428 microseconds

Number of Packet Repetitions per 100 mS window = $21428/100000 = 4.667$ Packet Intervals

This will result in 5 packets being transmitted in a 100 mS window.

$$DF(\text{rel } 100 \text{ mS}) = (5*376) / (100000) = 0.0188$$

$$\text{Relaxation Factor Relative to 100 mS} = -\text{Max}(20*\log_{10}(DF(\text{rel } 100\text{mS})), -20 \text{ dB}) = -\text{Max}(-34.51 \text{ dB}, -20) = 20 \text{ dB}$$

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1.4 Defining Directed Advertising Event

Duty Factor for Connectable Directed Advertising Event, per advertising channel

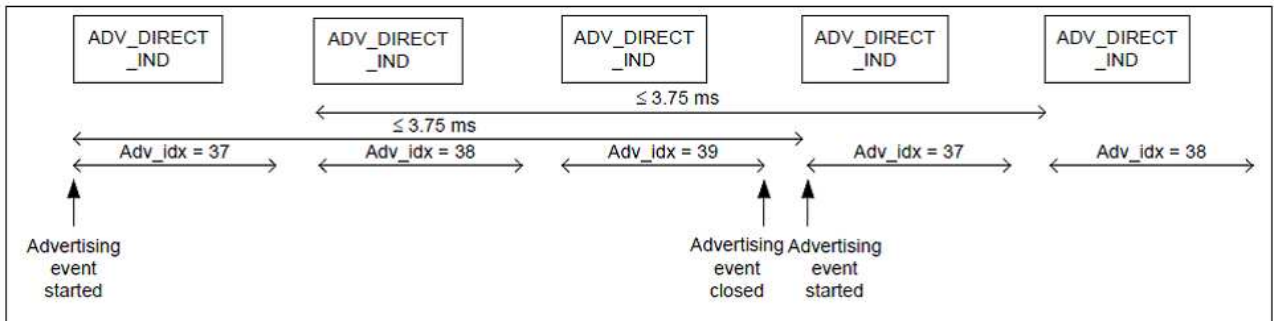


Figure F3: Connectable directed advertising event type with only advertising PDUs

1.4.1 Duty Factor for Connectable Directed Advertising Event, per advertising channel:

ADV_DIRECT_IND = 176 μ S duration. (22 octets) (ON channel 37)

IFS = 150 μ S (OFF)

ADV_IND = 176 μ S duration (OFF channel 38)

IFS = 150 μ S (OFF)

ADV_IND = 176 μ S duration (OFF Channel 39).

IFS = 150 μ S (OFF)

Time from open to close of advertising event = $3 \times 176 + 3 \times 150 = 978 \mu\text{S}$

1.4.1.1 Straight Duty Factor

$DF = 176 / (978) = 0.179$

Relaxation factor = $-\min(20 \times \log_{10}(DF), -20 \text{ dB}) = -\min(-14.9, -20) = 14.9 \text{ dB}$

1.4.1.2 Duty Factor in 100mS window:

Number of Connectable Directed Advertising Packets, per advertising channel, per 100 mS window:

$100000 / 978 = 102.78$ packets.

Therefore, there can be 103 transmissions of packets 176 microseconds in length on one channel within a 100 mS window.

Duty Factor relative to 100 mS window: $DF(\text{rel } 100 \text{ mS}) = (176 \times 103) / (100000) = 0.18128$

Relaxation Factor Relative to 100 mS = $-\text{Max}(20 \times \log_{10}(DF(\text{rel } 100 \text{ mS})), -20 \text{ dB}) = -\text{Max}(-14.83 \text{ dB}, -20) = 14.83 \text{ dB}$

END OF REPORT

Date	Version	Comments	Person
9-19-13	V0	Initial Draft	Adam A

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