

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

<u>Test Date(s)</u>: 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

Thomas T.Smith

Test Report Reviewed by:Tom Smith, VP of EMC Test ServicesSignature:Date: 9-19-13

Thomas T. Smith

Report by: Adam Alger, EMC Engineer

Signature: Alex OAlge

Date: 9-19-13

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

<u>A2LA – American Association for Laboratory Accreditation</u>

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope of Accreditation A2LA Certificate Number: 1255.01



Federal Communications Commission (FCC) – USA

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948 FCC Registration Number: 90756

Industrie Industry Canada Canada

Canada

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-212 – Issue 1 File Number: IC 3088-A On file, 3 and 10 Meter OATS based on RSS-212 – Issue 1 File Number: IC 3088



U. S. Conformity Assessment Body (CAB) Validation

Validated by the European Commission as a U. S. Competent Body operating under the U. S./EU, Mutual Recognition Agreement (MRA) operating under the European Union Electromagnetic Compatibility –Council Directive 2004/108/EC (formerly 89/336/EEC, Article 10.2).

Date of Validation: January 16, 2001

Validated by the European Commission as a U.S. Notified Body operating under the U.S. /EU, Mutual Recognition Agreement (MRA) operating under the European Union Telecommunication Equipment – Council Directive 99/5/EC, Annex V. Date of Validation: November 20, 2002 Notified Body Identification Number: 1243

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1.0 Summary of Test Report

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

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

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.

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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.

<i>v v v</i>	
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 dBµV/m @ 4804 MHz, AVG
Stepped (Y/N)	Ν
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 dBµV/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 dBµV/m @ 4874 MHz, AVG
Stepped (Y/N)	Ν
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 dBµV/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

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4.0 Conditions of Test

Environmental:

Temperature:20-25° CRelative 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

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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

Prepared B		igpe res	C: Radiated Emissi	ons		Job # :	0-1520	_	
No. Asset #	By: Adam	Customer :	LSR			Quote #	312182	_	
	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 Preselecter	Agilent	N9039A	MY46520110	6/29/2012	6/29/2013	Active Calibration		
3 AA 960150	Bicon Antenna Los Pariodia Antenna	ETS	3110B 92146	0003-3346	11/15/2011	11/15/2012	Active Calibration		
5 AA 960007	Double Bidge 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	WLA612	123101	1/6/2012	1/6/2013	Active Calibration		
B AA 960081	Double Ridge Horn Antenna	EMCO	3115 EKE01E010200	6907 5000070	1/6/2012	1/6/2013	Active Calibration		
0 EE 960161	26.5-40GHz LNA	Ducommun Tee	ch ALN-33144030	1103717-01	10/4/2011	10/4/2012	Active Calibration		
11 AA 960154	2.4GHz High Pass Filter	KWM	HPF-L-14186	7272-02	6/28/2012	6/28/2013	Active Calibration		
2 EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2012	5/9/2013	Active Calibration		
13 EE 360146	Std. Gain Horn Ant. wrpreamp	Adv. Micro	WLA622-4	123001	11/3/2011	11/3/2012	Active Calibration		
		Alex (Ahe			Alufid	4		
	Project Er	ngineer: ///////////////////////////////////		_	Quality Assuranc	e:			
	RESEARCH LLC								
Da	te : <u>5-Jun-2010</u>	Туре Те	est : Conducted Po	wer Output		Job	# : <u>C-884</u>		
Prepared	By: Peter	Customer	r: LSR			Quote	#: <u>310117</u>		
No. Asset#	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status		
						0/10/00/0	Active Calibration		
1 AA 960143	Phaseflex	Gore	EKD01D01048.0	5546519	9/16/2009	9/16/2010	Active calibration		
1 AA 960143 2 CC 000221C	Phaseflex Spectrum Analyzer	Gore HP	EKD01D01048.0 E4407B	5546519 US39160256	9/16/2009 3/9/2009	3/9/2010 3/9/2010	Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 AA 960144 Urrel Eg	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development upment Calibration	Gore HP Agilent Gore	EKD01D01048.0 E4407B E4446A EkD01D010720	5546519 US39160256 US45300564 5800373	9/16/2009 3/9/2009 9/17/2009 6/25/2009	9/16/2010 3/9/2010 9/17/2010 6/25/2010	Active Calibration Active Calibration Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 Virel Wirel Eq Da	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development uppment Calibration te : 28-Sep-2010	Gore HP Aglient Gore Type Te	EKD01D01048.0 E4407B E4446A EkD01D010720	5546519 US39160256 US45300564 5800373	9/16/2009 3/9/2009 9/17/2009 6/25/2009	9/16/2010 3/9/2010 9/17/2010 6/25/2010	Active Calibration Active Calibration Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 Wirel Eq Da Prepared	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development upment Calibration te : 28-Sep-2010 By: Peter	Gore HP Agilent Gore Type Te	EKD01D01048.0 E4407B E4446A EkD01D010720 est : <u>Conducted AC</u> r: <u>LSR</u>	5546519 US39160256 US45300564 5800373	9/16/2009 3/9/2009 9/17/2009 6/25/2009	9/16/2010 3/9/2010 9/17/2010 6/25/2010 	Active Calibration Active Calibration Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 Virel Eq Da Prepared I	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development spectrum Calibration te : 28-Sep-2010 By: Peter Description	Gore HP Agilent Gore Type Te Customer	EKD01D01048.0 E4407B E4446A EkD01D010720 est : <u>Conducted AC</u> r: <u>LSR</u> Model#	5546519 US39160256 US45300564 5800373 C Emissions	9/16/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009	9/16/2010 9/17/2010 9/25/2010 6/25/2010 	Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 Virel Eq Da Prepared 1 No. Asset # 1 AA 960008	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development quipment Calibration te : 28-Sep-2010 By: Peter Description LISN	Gore HP Agilent Gore Type Te Customer Manufacturer EMCO	EKD01D01048.0 E4407B E4446A EkD01D010720 est : <u>Conducted AC</u> r: <u>LSR</u> <u>Model #</u> 3816/2NM	5546519 US39160256 US45300564 5800373 C Emissions	9/16/2009 3/9/2009 9/17/2009 6/25/2009 Cal Date 12/15/2009	9/16/2010 9/17/2010 9/17/2010 6/25/2010 Job : Quote Cal Due Date 12/15/2010	Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 Virel Eq Da Prepared 1 No. Asset # 1 AA 960008 2 EE 960157	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development upipment Calibration te : 28-Sep-2010 By: Peter Description LISN 3Hz-13.2GHz Spectrum Analyzer	Gore HP Agilent Gore Type Te Customer Manufacturer EMCO Agilent	EKD01D01048.0 E4407B E4407B E446A EkD01D010720 est : <u>Conducted AC</u> r: <u>LSR</u> <u>Model #</u> 3816/2NM E445A	S546519 US39160256 US45300564 5800373 C Emissions Serial # 9701-1057 MY48250225	9/16/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009 2/17/2009 3/17/2009	9/16/2010 9/17/2010 9/17/2010 6/25/2010 	Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 LS R Wirel Eq Da Prepared 1 No. Asset # 1 AA 960008 2 EE 960157 3 EE 960156 4 AA 960072	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESECARCH LLC Less Product Development Julpment Calibration te : 28-Sep-2010 By: Peter Description LISN 3Hz-13.2GHz Spectrum Analyzer RF Preselecter Transient Linter	Gore HP Agilent Gore Uype Te Customer Manufacturer ENCO Agilent HP	EKD01D01048.0 E4407B E4446A EKD01D010720 r: LSR Model# 3816/2NM E4445A N9039A 11947A	S546519 US39160256 US45300564 5800373 C Emissions Serial # 9701-1057 MY46520215 MY46520110 31072-M1708	9/16/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009 2/17/2009 7/2/2009 7/2/2009 7/2/2009	9/16/2010 9/17/2010 6/25/2010 6/25/2010 Cal Due Date 12/15/2010 3/17/2010 7/2/2010	Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status Active Calibration Active Calibration Active Calibration Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 LSR Wireles Da Prepared 1 No. Asset # 1 AA 960008 2 EE 960158 4 AA 960072 LSRE Wireless	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development upipment Calibration te : 28-Sep-2010 By: Peter Description LISN 3Hz-13.2GHz Spectrum Analyzer RF Preselecter Transient Limiter SERACH LLC Product Development	Gore HP Aglient Gore Type Te Customer EMCO Aglient Aglient HP	EKD01D01048.0 E4407B E4446A EKD01D010720 r: LSR Model# 3816/2NM E4445A N9039A 11947A	S40519 US39160256 US45300564 5800373 C Emissions Serial # 9701-1057 MY48250225 MY48520110 3107A01708	9/16/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009 2/17/2009 3/17/2009 7/2/2009 9/15/2009	9/16/2010 9/17/2010 9/17/2010 6/25/2010 	Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status Active Calibration Active Calibration Active Calibration Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 AA 960144 Wireleg Da Prepared 1 1 AA 96008 2 EE 960157 3 EE 960158 4 AA 960072 Vireless Wireless Wireless Wireless Equip	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development uppment Calibration te: 28-Sep-2010 By: Peter Description LISN JH2-13.2GHz Spectrum Analyzer RF Preselecter Transient Limiter SEARCH LLinter SEARCH LIME product Development 18-Jan-2012	Gore HP Agilent Gore Type Te Customer Manufacturer EMCO Agilent Agilent HP	EKD01D01048.0 E4407B E4446A EkD01D010720 r: LSR Model# 3816/2NM E4445A N9039A 11947A	S546519 US39160256 US45300564 5800373 Cemissions Serial # 9701-1057 MY46250225 MY46520110 3107A01708	9/16/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009 12/15/2009 3/17/2009 7/2/2009 9/15/2009	9/16/2010 9/17/2010 9/17/2010 6/25/2010 Job # Quote 12/15/2010 10/15/2010 10/15/2010 Job #: C-1288	Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status Active Calibration Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 AA 960144 Wirel G Da Prepared 1 No. Asset # 1 AA 960008 2 EE 960157 3 EE 960158 4 AA 960072 Vireless Equip Prepared By: Prepared By:	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development uppment Calibration te : 28-Sep-2010 By: Peter Description LISN 3Hz-13.2GHZ Spectrum Analyzer RF Preselecter Transient Limiter SEARCH LLC s Product Development pment Calibration 18-Jan-2012 Shane Rismeyer	Gore HP Agilent Gore Ustomer ENCO Agilent HP Type Test : PO Customer : LS	EKD01D01048.0 E4407B E4446A EkD01D010720 r: LSR Model# 3816/2NM E4445A N9039A 11947A	S546519 US39160256 US45300564 5800373 CEmissions Serial # 9701-1057 MY48250225 MY48250225 MY48250110 3107A01708	9/16/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009 3/17/2009 3/17/2009 9/15/2009 9/15/2009	9/16/2010 9/17/2010 6/25/2010 6/25/2010 Guote 12/15/2010 3/17/2010 7/2/2010 10/15/2010 Job # : <u>C-1285</u> Quote #: <u>311258</u>	Active Calibration Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status Active Calibration Active Calibration Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 A 960144 E 960173 LS R Prepared 1 No. Asset # 1 AA 960008 2 EE 960157 3 EE 960158 4 AA 960072 E 960158 4 AA 960144 E 960158 4 AA 960072 E 960158 4 AA 960144 E 960158 4 AA 960158 4	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC less Product Development puipment Calibration te : 28-Sep-2010 By: Peter Description LISN 3Hz-13.2GHZ Spectrum Analyzer RF Preselecter Transient Limiter SEARCH LLC sproduct Development pment Calibration 18-Jan-2012 Shane Rismeyer Description	Gore HP Agilent Gore Uustomer ENCO Agilent Agilent HP Type Test : <u>PC</u> Customer : <u>LS</u>	EKD01D01048.0 E4407B E4446A EkD01D010720 est : <u>Conducted AC</u> r: <u>LSR</u> <u>Model#</u> 3816/2NM E4445A N9039A 11947A N9039A 11947A Second Spectral Dens	S546519 US39160256 US45300564 5800373 CEmissions Serial # 9701-1057 MY46250215 MY46250210 3107A01708	9/15/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009 2/17/2009 3/17/2009 3/17/2009 9/15/2009 9/15/2009	9/16/2010 9/17/2010 6/25/2010 6/25/2010 0 classing for the second	Active Calibration Active Calibration		
1 AA 960143 2 CC 000221C 3 EE 960073 4 AA 960144 A 860144	Phaseflex Spectrum Analyzer Spectrum Analyzer Phaseflex RESEARCH LLC Less Product Development uppment Calibration te : 28-Sep-2010 By: Peter Description LISN SHZ-13.2GHZ Spectrum Analyzer RF Preselecter Transient Limiter SEARCH LLC sproduct Development pment Calibration 18-Jan-2012 Shane Rismeyer Description Phaseflex	Gore HP Aglient Gore Ustomer ENCO Aglient HP Type Test : P0 Customer: LS Manufacturer Indiantianter Gore Ek	EKD01D01048.0 E4407B E4446A EkD01D010720 est : <u>Conducted AC</u> r: <u>LSR</u> <u>Model#</u> 3816/2NM E4445A N9039A 11947A <u>SR</u> <u>ower Spectral Dens</u> <u>SR</u> <u>odel#</u> <u>Se</u> <u>ColiD01048.0</u> 55-	S546519 US39160256 US45300564 5800373 C Emissions Serial # 9701-1057 MY48250225 MY48250210 3107A01708 3107A01708	9/15/2009 3/9/2009 9/17/2009 6/25/2009 6/25/2009 3/17/2009 3/17/2009 7/2/2009 9/15/2009 9/15/2009	9/16/2010 9/17/2010 9/17/2010 6/25/2010 6/25/2010 Quote Cal Due Date 12/15/2010 3/17/2010 7/2/2010 10/15/2010 10/15/2010 U/15/20	Active Calibration Active Calibration Active Calibration Active Calibration #: C-884 #: 310117 Equipment Status Active Calibration Active Calibration Active Calibration Active Calibration S ent Status Calibration		

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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.

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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

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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Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
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Channel 2 (2417 MHz)



Channel 6 (2437 MHz)



Channel 11 (2462 MHz)



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LSR: C-1808	Serial: Eng. Sample
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Prepared For: LS Research	Name: TiWi-BLECA
Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
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Channel 6 (2437 MHz)



Plots (MCS 7) Channel 1 (2412 MHz)

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Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA	
LSR: C-1808	Serial: Eng. Sample	
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High Channel (2480 MHz)



Mid Channel (2440 MHz)



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

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Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA
LSR: C-1808	Serial: Eng. Sample
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Plots (1 Mbps) Channel 1 (2412 MHz)



Channel 2 (2417 MHz) Agilent 12:00:03 Sep 19, 2013 Peak Search Aaile nt 11-29-R T R T 2.416 282 5 GH -5.08 dBm #Atten 20 dB Ext PG -10 dB f 20 dBm Atten 20 dB Ext PG -10 dB Next Peak Marker 2.416282500 GHz Dg Next Pk Right -5.08 dBm Next Pk Left Min Search Stop 2.432 00 GHz Sweep 3.64 ms (601 pts) .402 00 GHz Pk-Pk Search ∗VBW 100 kHz Res BW 100 kHz Channel Power **Power Spectral Density** Mkr→CF 17.84 dBm /20.0000 MHz -55.17 dBm/Hz More 1 of 2 2.416 033 3 GHz Span 500 kHz es BW 3 kHz Sweep 51.28 ms (601 pts) VBW 30 kHz 10 Agilent Technologie **Output Power Peak Power Spectral Density**

Channel 3 (2422 MHz) Agilent 11:55:44 Sep 19, 2013 Agilent 11:58:05 Sep 19, 2013 R T R T Peak Search 2.421 079 9 GH _4.84 dBm Atten 20 dB Ext PG -10 dB Atten 20 dB Ext PG -10 dB ef 20 ef 20 dBm Next Peak Pea οa Log 10 Next Pk Right łR Next Pk Left Min Search enter 2.422 00 GHz Res BW 100 kHz Span 30 MHz Sweep 3.64 ms (601 pts) Pk-Pk Search #VBW 100 kHz **Channel Power Power Spectral Density** Mkr→CF 19.39 dBm /20.0000 MHz -53.62 dBm/Hz 2.420 833 3 GHz Span 500 kHz es BW 3 kHz VBW 30 kHz Sweep 51.28 ms (601 pts

Output Power

Peak Power Spectral Density

More 1 of 2

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LSR: C-1808	Serial: Eng. Sample
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Prepared For: LS Research	Name: TiWi-BLECA
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LSR: C-1808	Serial: Eng. Sample
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Prepared For: LS Research	Name: TiWi-BLECA
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Mid Channel (2440 MHz)

LSR:





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C-1808	Serial: Eng. Sample		
t: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA		
red For: LS Research	Name: 11W1-BLECA		

B.1.3 – RF Conducted – Spurious

Dille III Coll	autitu Spanous
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		
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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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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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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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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 - F	CC Listed 3 meter Sem	i-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	Biconical: 30-300 MHzLog Periodic Dipole Array: 300-1000 MHz		Standard Gain Horn: 18-25GHz	
Measurement Detectors	30-1000MHz1 - 25 GHz:Peak DetectorPeak DetectorRBW: 120 kHzRBW : 1MHzVBW: 300 kHzVBW: 3MHz (Peak Measurement)				
Description of Measurement	 1) The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are preformed. The data is gathered and reported as the corrected values. 2) The EUT is placed on a non-conductive pedestal centered on a turn-table in the test location with the antenna at the test distance from the EUT 3) Maximum radiated RF emissions are determined by rotation of azimuth and scanning the sense antenna between 1 and 4 meters in height using both horizontal and vertical antenna polarities. Maximized levels are manually noted at degree values of azimuth and at sense antenna height. 				
Example Calculations	Reported Measuremer Cable factor (dB) - applicable)	nt data = Raw receiver amplification factor (v	measurement + Antenr vhen applicable) + Ad	a Correction Factor + ditional factor (when	

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

Frequency (MHz)	3 m Limit (µV/m)	3 m Limit (dBµV/m)	Туре	
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		
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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	 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. 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. See Appendix F for duty cycle calculation.

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

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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	Table. WEAN Transmit fratmomes in Nestricieu Danus								
	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
	4824	1.15	9	64.59	62.38	63.5	1.1	Horizontal	Flat
Low	12060	1	148	56.18	46.75	63.5	16.8	Horizontal	Flat
LOW	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
	4874	1.1	114	64.44	62.54	63.5	1.0	Vertical	Side
N 4: d	7311	1.05	288	54.63	43.01	63.5	20.5	Horizontal	Flat
IVIIU	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
	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
High	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

Table: WLAN Transmit Harmonics in Restricted bands

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
	4804	1.06	248	72.22	14.9	57.32	63.5	6.2	Vertical	Side
Low	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
	4880	1	66	68.21	14.9	53.31	63.5	10.2	Horizontal	Flat
NC 1	7320	1.18	201	56.79	14.9	41.89	63.5	21.6	Vertical	Side
Mid	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
	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
High	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

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Average

Peak

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



Average



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LSR: C-1808	Serial: Eng. Sample			
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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

🔆 🗮	gilent 18:2	20:30	Aug	22,20	12					Т	Display	🔆 🗮	jilent 18	3:21:56	Aug 2	2,2012	2					Т	Trace
Ref 70 #Peak) dBµV		#Atte	en 0 dE	3			Mkr	1 19.8 52.58	43 GHz 3 dBµV	Full Screen	Ref 75 #Peak	i dBµV		#Atter	n 0 dB				Mkr:	1 19.8 57.48	43 GHz dBµV	Trace 1 <u>2</u> 3
Log 5 dB/											Display Line 63.50 dBµV On Off	Log 5 dB/											Clear Write
DI			\$									DI			\$								Max Hold
63.5 dB µ V LgAv	mkunned	hrown	mar	an Mirthe	mennon	m	home	Jord Mulan	an a	and a	Limits≻	63.5 dB µ V LgAv	~	yurtherspo		n North	at An Aller	A MARINA	the for the second	Minister	N MARINA	yedraha	Min Hold
M1 S2 S3 FC A AL											Active Fctn Position Bottom	M1 S2 S3 FC A AL											View
€(f): FTun Swp											Title⊦	€(f): FTun Swp	Ref 75.0	Leve 00 dB	⊧l μV—								Blank
Start : #Res E	18.000 G 3W 1 MHz	iHz		#	 VBW 30	kHz	Swee	 Sto 0 182.1	p 25.0 ms (60	 00 GHz 1 pts)	Preferences	Start 1 #Res E	L 18.000 3W 1 MH	 GHz Iz		 #\	/BW 3 N	 1Hz	Sw	 Sto eep 35	p 25.0 ms (60	00 GHz 1 pts)	More 1 of 2
File 0	peration	ı Statı	ıs, C	:\STA	E262.	STA fil	e save	d				File 0	peratio	on Stat	us, A:	SCRE	N263.0	IF file	saved				
1												Г)aal	-									

Average

Peak

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Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA			
LSR: C-1808	Serial: Eng. Sample			
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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	 Tested in continuous transmit modulated mode in low and high channels with EUT Antenna in three orthogonal positions. Maximum levels recorded.

B2.2 - Radiated Band-edge into restricted bands

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 Lmit (dBµV/m)	Peak Margin (dB)	Average (dBμV/m)	Average Lmit (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 Lmit (dBµV/m)	Peak Margin (dB)	Average (dBµV/m)	Average Lmit (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 Lmit (dBµV/m)	Peak Margin (dB)	Average (dBµV/m)	Average Lmit (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

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LSR: C-1808	Serial: Eng. Sample				
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WLAN Channel 1 Lower Band-edge into restricted band

ዡ Agilent 18:21:03 Aug 21, 2012	Peak Search
Mkr1 2.385 60 GH Ref 76.99 dBµV/m #Atten 0 dB 59.17 dBµV/m #Peak	z Next Peak
Log 5 dB/	Next Pk Right
	Next Pk Left
74.0 dBpV/pJmglozalladulaymadaalaangiyhiintadhalaangiyhiintadhiintadhiintadhiintadhiintadhiinta LgAv	Min Search
M1 S2 S3 FC A	Pk-Pk Search
E(t): FTun Swp	Mkr → CF
Start 2.310 00 GHz Stop 2.390 00 GHz #Res BW 1 MHz Sweep 1 ms (601 pts)	More 1 of 2
Copyright 2000–2009 Agilent Technologies	

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



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

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Report: TR 313249 A FCCICTX (DTS)	Model: TiWi-BLECA			
LSR: C-1808	Serial: Eng. Sample			
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MCS7:

🗰 Agilent 20:17:39 Aug 2:	1,2012	R	T Peak Search			
Ref 76.99 dBµV/m #Atten #Peak	0 dB	Mkr1 2.389 73 60.99 dBµ	3 GHz W/m Next Peak			
Log 5 dB/			Next Pk Right			
DI			Next Pk Left			
74.0 dBµV/ <mark>www.hyp/www.weblawitan</mark> LgAv	Mulmall Multaniko Malarigh	ndraatseringtheddarsonal Awat Mareth	Min Search			
M1 S2 S3 FC A AL			Pk-Pk Search			
£(f): FTun Swp 2.389730000	GHz		Mkr → CF			
60.99 dBµV/ı Start 2.310 00 GHz #Res BW 1 MHz	n	Stop 2.390 00 Sweep 1 ms (601	GHz More pts) 1 of 2			
Copyright 2000–2009 Agilent Technologies						

Lower Band-edge restricted band, MCS7, Peak

🔆 Ag	jilent 20):16:32	Aug 2	1,2012	2				R	? T	Peak Search
Ref 66 #Peak	.99 dB	µV∕m	#Atter	n 0 dB				Mkr1 4	2.390 5.72 df	00 GHz 3 µ V/m	Next Peak
Log 5 dB/											Next Pk Right
DI 54 0										4	Next Pk Left
dBµV/ LgAv	n										Min Search
M1 S2 S3 FC A AL											Pk-Pk Search
FTun Swp											Mkr → CF
Start 2.310 00 GHz #Res BW 1 MHz #VBW 10 H							Swee	Stop p 6.23	2.390(8 s (60	00 GHz 1 pts)	More 1 of 2

Lower Band-edge restricted band, MCS7, Average

Prepared For: LS Research	Name: TiWi-BLECA				
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LSR: C-1808	Serial: Eng. Sample				
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Channel 2 Lower Band-edge into restricted band

🔆 Agilent 18:22:53	Aug 22, 2012		RT	Trace
Meas At Mkr Emissions	· EMI Peak: N/A OP: N/A EMI Ava: N/A	Presel: Input: RF	Path: Bypass	Trace <u>1</u> 2 3
Marker 2.3899	20000 GHz	Mkr1	2 389 92 GHz	Clear Write
Ref 76.99 dB µ V # #EmiPk Log	+Atten 0 dB		60.26 dBµV	Max Hold
10 dB/	(กระการสารสารสารสารสารสารสารสารสารสารสารสารสา	an air a faar a transford en an an an an transford t		Min Hold
DI 74.0				View
LgAv				Blank
S3 FS Start 2.310 00 GHz Res BW (CISPR) 1 MHz	#VBW 50 MH	Stop Hz Sweep 1.066 r	2.390 00 GHz ns (2000 pts)	More 1 of 2
File Operation Status	s, C:\AHORN39.ANT	file loaded		

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

🔆 Agile	nt 18:20:21	Aug 22	2,2012	2				R	Т	Peak Search
Emissions	Meas At Mi	kr EMI OP: Emi	Peak: Avg:	\/A \/A \/A	F	Presel: Input: RF Path:			ypass	Next Peak
							Mkr1	2.390 (00 GHz	Next Pk Right
Ref 76.9% #EmiPk Log	9 dBµV	#Atten	0 dB					52.09	dBµV	Next Pk Left
dB/										Min Search
DI 54.0 dBuV										Pk-Pk Search
LgAv M1 S2										Mkr → CF
S3 FS Start 2.3 Res BW (1	10 00 GHz CISPR) 1 MH	Iz	#V	BW 10	Hz	Sweep	^ Stop 9.174	2.390 0 s (2000	0 GHz) pts)	More 1 of 2
File Ope	ration Stat	us, C:\	AHORN	139.AN	T file	loaded				

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				
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Channel 3 Lower Band-edge into restricted band

Full Power



Lower Band-edge restricted band, 1 Mbps, Peak

Meas At Mkr EMI Peak: N/A Presel: Next Peak Emissions EMI Avg: N/A Input: RF Path: Bypass Next Peak Mkr1 2.384 84 GHz Next Pk Right Next Pk Right Mkr1 2.384 84 GHz Next Pk Right Mkr1 2.384 84 GHz Next Pk Ler Log Input: RF Input: RF Next Pk Right Min Searce Min Searce Min Searce DI Input Input Input LgAv Input Input Input	🔆 Ag	gilent 18	:47:07	Aug 2	2,201	2			R	t 1	_	Peak Search	
Mkr1 2.384 84 GHz Ref 76.99 dBµV •Atten 0 dB 47.04 dBµV *EmiPk Image: Constraint of the second se	Emissi	Mea: ons	kr EMI OP: Emi	F	Presel: Input: F	۲F	Path: E	Зура	3S	Next Peak			
Ref 76.99 dBµV #Atten 0 dB 47.04 dBµV #EmiPk Image: state									Mkr1	2.384	84 G	Hz	Next Pk Right
DI Min Search DI Pk-Pk Search dByV Min Search LgAv Min Search	Ref 76 #EmiPk Log	6.99 dB	VL ا	#Atter	10 dB					47.04	dBµ		Next Pk Left
DI 54.0 dBpV LgAv LgAv Mkr → C	dB/										- ¹	~	Min Search
LgAv Mkr→C	DI 54.0 dBµV												Pk-Pk Search
M1 \$2	LgAv M1 S2												Mkr → CF
S3 FS Mor Start 2.310 00 GHz \$\$\$\$ Stop 2.390 00 GHz 1 of Res BW (CISPR) 1 MHz #VBW 10 Hz \$weep 9.174 s (2000 pts)	S3 FS Start 2 Res Bk	2.310 00 1 (CISPF	0 GHz R) 1 MH	Hz	#	 JBW 10	Hz	Sweep	Stop 9.174	2.390 0 s (200	00 GH 0 pt:	lz s)	More 1 of 2

Lower Band-edge restricted band, 1 Mbps, Average

Prepared For: LS Research	Name: TiWi-BLECA					
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LSR: C-1808	Serial: Eng. Sample					
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Upper Band-edge into restricted band



Upper Band-edge restricted band, MCS7, Peak

🔆 Agilent 21:24:06 Aug	21,2012	RT	Peak Search				
Ref 66.99 dBµV/m #Atte	n 0 dB	Mkr1 2.483 555 0 GHz 44.24 dB µ V/m	Next Peak				
Log 5 dB/			Next Pk Right				
DI			Next Pk Left				
54.0 ≵ dBµV/n LgAv	<u> </u>		Min Search				
M1 S2 S3 FC A AL			Pk-Pk Search				
€(f): FTun Swp			Mkr → CF				
Start 2.483 500 0 GHz #Res BW 1 MHz	*VBW 10 Hz	Stop 2.500 000 0 GHz Sweep 1.287 s (601 pts)	More 1 of 2				
Copyright 2000–2009 Agilent Technologies							

Upper Band-edge restricted band, MCS7, Average

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LSR: C-1808	Serial: Eng. Sample				
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Bluetooth (BLE Mode)

Radiated Lower Band-edge into restricted bands

BLE



Radiated Upper Band-edge into restricted bands BLE

DL.																				
* 1	Agilent 14:	52:59 Au	g 21, 20	12				RT			₩ 4	gilent 14:	53:32 A	ug 21, 2012				RΤ		
Ref 75	5 dBµV/m		#A	tten 2 d	В			Mkr1	2.484 7 59.28	⁷ 92 5 GHz dB µ V/m	Ref 75	dBµV/m		#Atten :	2 dB			Mkr1	2.483 46.18	500 0 GHz 8 dB µ V/m
#Peak Log											#Peak Log									
5 dB/											5 dB/									
DI 74.0	Normali	11. Mar Mar	handhiriya	vhphallopp	vvvnuodudu	NUMAN	wW.ump.m	n dhainna	4.hhhhrub	www.	DI 54.0									
dBµV∕ LgAv	/ n										dBµV∕ LgAv	n								
M1 S2	2										M1 S2	1 •								
S3 FU A AL	-										S3 FL A AL									
FTun											£(1). FTun									
Ъ₩р											Ѕ₩р									
Start	2.483 500	0 GHz						Stop	2.500 0	00 0 GHz	Start	2.483 500	0 GHz					Stop	2.500 (100 0 GHz
₩Res E	3W 1 MHz				VBW 8 M	Hz		Swee	p 1 ms (601 pts)	#Res E	SW 1 MHz			#VBW 10) Hz		Sweep 1	.287 s	(601 pts)

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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	Н	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	Н	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	Н	V	2
966.0	1.00	0	28.5	54.0	25.5	Н	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	Н	FLAT	2

Note 1: NOT A FUNCTION OF EUT CHANNEL, OR POWER LEVEL; LIKELY RELATED TO THE POWER SUPPLY Note 2: Noise Floor

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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	Н	V	0
4803.0	1.00	298	51.88	39.88	63.5	23.6	Н	S	0
4803.0	1.00	348	51.68	40.14	63.5	23.4	н	F	0
19211.0	1.00	329	52.8	41.69	63.5	21.8	н	V	0
19211.0	1.00	309	52.01	41.82	63.5	21.7	Н	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	Н	F	0
		_	_	_	_		_	_	_
4879.0	1.06	243	49.28	39.96	63.5	23.5	н	V	19
4879.0	1.25	131	48.54	35.95	63.5	27.6	н	S	19
4879.0	1.00	204	48.18	37.38	63.5	26.1	н	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	Н	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	Н	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	Н	V	19
19515.0	1.00	46	52.78	42.27	63.5	21.2	V	V	19
		-		-			-	1	
4959.0	1.06	267	49.65	38.53	63.5	25.0	Н	V	39
4959.0	1.00	0	48.73	37.73	63.5	25.8	Н	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	Н	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	н	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	н	F	39
19835.0	1.00	119	52.5	41.31	63.5	22.2	V	F	39

Bluetooth Receive Mode 4-25 GHz

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		•1 • 1 1 2 • 4							
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	н	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	Н	S	1
9648.0	1.00	45	59.73	56.27	63.5	7.2	Н	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	Н	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	Н	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	н	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	Н	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	н	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	н	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	н	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	Н	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	Н	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	н	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	н	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	н	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	н	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	н	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	н	F	11
19696.0	1.00	45	51.91	42.14	63.5	21.4	v	F	11

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Plots: Tested in three orthogonal positions, receive channel 6 300-1000MHz



Horizontal

30-300MHz



🔆 Agilent 22:59:33 Aug 22, 2012 R T Trace Trace **Presel:** Input: RF Atten: 0 Meas At Mkr 72.12 MHz EMI Peak:33 QP: 32 EMI Avg: 32 Path: Filter Gain: ON Emissions dE **Clear Write** 72.14 MH: Ref 56.99 dB**µ**V #EmiPk 34.24 dBµV #Atten 10 dB Max Hold og ٩R . Min Hold View Å aA Blank 11 More Stop 300.0 MHz #VBW 300 kHz Sweep 147.9 ms (2000 pts) Start 30.0 MHz #Res BW (CISPR) 120 kHz 1 of 2

Horizontal

1000-4000MHz



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Vertical

File Operation Status, C:\A03BCV12.ANT file loaded

Vertical

WLAN Receive Mode 4-25 GHz 4-18 GHz



Average

18-25 GHz Horizontal, EUT Flat, Ch 1



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Bluetooth Receive Mode 4-25 GHz



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

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



Average

Peak

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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 50 Ω (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 50 Ω (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.

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FCC Limits of Conducted Emissions at the AC Mains Ports

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.				

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

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

Limit = -19.12 (Log₁₀ (F [MHz] / 0.15 [MHz])) + 66.0 dB μ V

For a frequency of 200 kHz for example:

Quasi-Peak Limit (F=200 kHz) = -19.12 (Log₁₀ (0.2[MHz] / 0.15 [MHz])) + 66.0 dBµV

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

Average Limit (F=200 kHz) = -19.12 (Log₁₀ (0.2[MHz]/0.15[MHz])) + 56.0 dBµV

Average Limit (F = 200 kHz) = 53.6 dB μ V

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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:	Sep	September 28, 2010				
Test Engineer:	Pete	er Feilen				
Voltage:	5VI	DC				
Operation Mode:	Cor	tinuous Transmit/R	eceiv	e		
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %					
Test Location:	Χ	Other Chamber			Chamber	
FUT Decod One	Χ	X 40cm from Vertical Ground Plane				10cm Spacers
EUT Flaced OII:	Χ	X80cm above Ground PlaneOther:			Other:	
Measurements:		Pre-Compliance		Preliminary	X	Final
Detector Used:	X	Peak	X	Quasi-Peak	Χ	Average

			QUASI-PEAK				AVERAGE	
Frequency (MHz)	Radio	Line	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.

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Screen Captures - Conducted Emissions Test



WLAN Transmit Mode:

LINE 1





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WLAN Receive mode:



LINE 1



LINE 2

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Bluetooth Transmit mode:

₩ Agilent 00:00:41 Sep 29, 2010 R T	Peak Search
Meas At Mkr EMI Peak:59.13 dBuV Presel: Discrete Discre Discrete Discrete </th <th>Next Peak</th>	Next Peak
Marker 157.000 kHz Mkr1 157 kH	Next Pk Right
Ref 81.99 dBµV *Atten 10 dB 33.27 dBµV *EmiPk Log	Next Pk Left
	Min Search
	Pk-Pk Search
	Mkr→CF
Start 150 kHz Stop 30.00 MHz Res BW (CISPR) 9 kHz VBW 91 kHz Sweep <u>1.065 s (8192 pts)</u>	More 1 of 2
Copyright 2000–2009 Agilent Technologies	

LINE 1





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Bluetooth Receive mode:

LINE 1





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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
	3-Meter Chamber, Log Periodic	
Radiated Emissions	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

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Appendix D - References

Publication	Year	Title	
FCC CFR Parts 0-15	2013	Code of Federal Regulations – Telecommunications	
		American National Standard for Methods of	
ANEL CC2 4	2002	Measurement of Radio-Noise Emissions from Low-	
ANSI C03.4	2003	Voltage Electrical and Electronic Equipment in the	
		Range of 9 kHz to 40 GHz.	
		Low-power License-exempt Radio	
RSS-210 Annex 8	2010	communication Devices (All Frequency Bands):	
		Category I Equipment	
DCC CENTLESS 2	2010	General Requirements and Information for the	
RSS-GEN Issue 3 2010	2010	Certification of Radio Apparatus	

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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:	19.42 (dBm)
Maximum peak output power at antenna input terminal:	87.498 (mW)
Antenna gain(typical):	1.3 (dBi)
Maximum antenna gain:	1.349 (numeric)
Prediction distance:	20 (cm)
Prediction frequency:	2437 (MHz)
MPE limit for uncontrolled exposure at prediction frequency:	<u>1 (mW/cm^2)</u>
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

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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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<u>1.1</u> 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.

LSB			MSB	
Preamble	Access Address	PDU	CRC	
(1 octet)	(4 octets)	(2 to 39 octets)	(3 octets)	

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 ₃ b ₂ b ₁ b 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

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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)Address (4)Header (2)PDU Type (37)CRC (3)	Preamble (1)	Access Address (4)	PDU Header (2)	Worst Case PDU Type (37)	CRC (3)
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Stated worst case length packet: 47 octets = 376 bits Worst Case Packet Duration: 376 bits * $1 \ \mu$ S / bit = 376 μ S

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 μ s.

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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

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<u>1.3.1.1 Straight Duty Factor</u>

 $\overline{DF} = 376 / (376*3+150*2+20000) =0.0175$ Relaxation factor =-min (20*log10 (DF),-20 dB) =-min (-35.119,-20) = 20 dB

<u>1.3.1.2 Duty Factor in 100mS window:</u>

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 (rel 100 mS) = (5*376) / (100000) = 0.0188Relaxation Factor Relative to 100 mS = - Max (20*log10 (DF (rel 100mS)),-20 dB) = -Max (-34.51 dB, -20) = 20 dB

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1.4 Defining Directed Advertising Event





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

<u>1.4.1</u> 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 = $3*176 + 3*150 = 978 \mu S$

1.4.1.1 Straight Duty Factor

DF = 176 / (978) = 0.179Relaxation factor =-min (20*log10 (DF),-20 dB) =-min (-14.9,-20) = 14.9 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 (rel 100 mS) = (176*103) / (100000) = 0.18128Relaxation Factor Relative to 100 mS = - Max (20*log10 (DF (rel 100mS)),-20 dB) = -Max (-14.83 dB, -20) = 14.83 dB

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END OF REPORT

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

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