LS RESEARCH, LLC
WIRELESS PRODUCT DEVELOPMENT
ACCREDITED
Testing Cert. 1255.01
W66 N220 Commerce Court ● Cedarburg, WI 53012 ● USA
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TEST REPORT # 312143 BLE
LSR Job #: C-1493

Compliance Testing of:
2.4 GHz Bluetooth Low Energy Radio

Test Date(s):
July 24-26, August 3, 6, October 2, 2012

Prepared For:
LS Research, LLC
W66N220 Commerce Ct.
Cedarburg, WI 53012

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

This Test Report is issued under the Authority of: Peter Feilen, EMC Engineer

Signature: Date: 11/6/12

Test Report Reviewed by:	**Tested by:** Peter Feilen, EMC Engineer
Khairul Aidi Zainal, Senior EMC Engineer	
Signature: Date: 11/6/12	Signature: Date: 11/6/12

TABLE OF CONTENTS *(page 1 of 2)*

Contents

EXHIBIT 1. INTRODUCTION

1.1 SCOPE

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

1.2 NORMATIVE REFERENCES

Publication	Title
47 CFR, Parts 0-15 (FCC)	Code of Federal Regulations - Telecommunications
RSS 210 Annex 8	Low-power License-exempt Radio-communication Devices (All Frequency Bands): Category I Equipment
ANSI C63.4	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
CISPR 16-1-1	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus.
CISPR 16-2-1	Specification for radio disturbance and immunity measuring apparatus and methods. Part 201: Conducted disturbance measurement.
FCC Public Notice DA 00-1407	Part 15 Unlicensed Modular Transmitter Approval
FCC Procedures	Measurement of Digital Transmission Systems operating under Section 15.247.
FCC KDB 558074 D01 DTS Meas Guidance V01	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under CFR Title 47 15.247

1.3 LS Research, LLC TEST FACILITY

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to conform to 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. A copy of the accreditation may be accessed on our web site: www.lsr.com. Accreditation status can be verified at A2LA’s web site: www.a2la2.net.

1.4 LOCATION OF TESTING

All testing was performed at LS Research, LLC, W66 N220 Commerce Court, Cedarburg, Wisconsin, 53012 USA, utilizing the facilities listed below, unless otherwise noted.

List of Facilities Located at LS Research, LLC:

- Compact Chamber
- Semi-Anechoic Chamber
- Open Area Test Site (OATS)

1.5 TEST EQUIPMENT UTILIZED

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated in accordance with A2LA standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	LS Research, LLC
Address:	W66N220 Commerce Ct
Contact Name:	Bill Steinike

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	2.4 GHz Bluetooth Radio with Chip Antenna
Model Number:	TiWi-uB2
Serial Number:	311201, 281301

2.3 - Associated Antenna Description

Ceramic chip antenna (maximum gain of +1.3 dBi) and a reverse-gendered, SMA connection articulating dipole antenna (maximum gain of +2.0 dBi) have been tested in conjunction with this module.

2.4 EUT'S TECHNICAL SPECIFICATIONS

Additional Information:

EUT Frequency Range (in MHz)	2402MHz – 2480MHz
RF Power in Watts (Conducted measurement)	
Minimum:	0.0098 W
Maximum:	0.0100 W
Max Conducted Output Power (in dBm)	10.0 dBm
Field Strength at 3 meters (Maximum)	Not Applicable
Occupied Bandwidth (99% BW)	1.04 MHz
Type of Modulation	FSK
Emission Designator	1M04F1D
Occupied Bandwidth (6 dB BW)	@ 2402 MHz: 688 kHz @ 2440 MHz: 684 kHz @ 2480 MHz: 686 kHz
Transmitter Spurious (worst case) at 3 meters	50.8 dBµV/m at 4960 MHz
Receiver Spurious (worst case) at 3 meters	47.2 dBuV/m @ 3m @ 19.515 GHz
Receiver Sensitivity	-92 dBm
Stepped (Y/N)	N
Step Value:	N/A
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Transceiver Model # (if applicable)	CC2564
Antenna Information	
Detachable/non-detachable	Detachable and non-detachable
Type	Articulating Dipole and Ceramic Chip
Gain, maximum (in dBi) From data sheet	+2.0 dBi (dipole), +1.3 dBi (chip)
EUT will be operated under FCC Rule Part(s)	Title 47 Part 15.247
EUT will be operated under RSS Rule Part(s)	RSS 210
Modular Filing	☒ Yes ☐ No
Portable or Mobile?	Portable

RF Technical Information:

Type of Evaluation (check one)	X	SAR Evaluation: Device Used in the Vicinity of the Human Head
		SAR Evaluation: Body-worn Device
		RF Evaluation

Between 2.2GHz and 3.0GHz the limit is 20 mW before SAR testing is required. This device has a maximum EIRP of 15.85 mW. As 15.85 mW is below the limit of 20 mW, no SAR testing is required.

2.5 PRODUCT DESCRIPTION

The TiWi-uB2 Module is a radio module that implements a dual mode Bluetooth (BT) and Bluetooth Low Energy (BLE) transceiver. A Texas Instruments CC2564 (System on Integrated Circuit) has one transceiver that can operate in either BT or BLE mode.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 CLIMATE TEST CONDITIONS

Temperature:	15-35 ºC
Humidity:	30-60%
Pressure:	645-795 mmHg

3.2 APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC and IC Paragraph	Test Requirements	Compliance (Yes/No)
FCC : 15.247(b) & 1.1310 IC : RSS 210 A8.4	Maximum Output Power	Yes
FCC : 15.247(i), 1.1307, 1.1310, 2.1091 & 2.1093 IC : RSS 102	RF Exposure Limit	Yes
FCC :15.247(d) IC : RSS 210 A8.5	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC:15.247 (a)(2) IC: RSS 210 A8.2 (a)	6 dB Bandwidth of a Digital Modulation System	Yes
FCC:15.247 (d) IC: RSS 210 A8.2 (b)	Power Spectral Density of a Digital Modulation System	Yes
IC : RSS GEN 4.6	99% Bandwidth	Yes
FCC : 15.247(c), 15.209 & 15.205 IC : RSS 210 A8.2(b), section 2.2, 2.6 and 2.7	Transmitter Radiated Emissions	Yes
The digital circuit portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class B Digital Devices (RSS GEN and RSS 210 of IC) and the associated Radio Receiver has also been tested and found to comply with Part 15, Subpart B – Radio Receivers (RSS GEN and RSS 210 of IC). The Receiver Test Report is available upon request.		

3.3 MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

☒ **None** ☐ **Yes (explain below)**

3.4 DEVIATIONS & EXCLUSIONS FROM TEST SPECIFICATIONS

☒ **None** ☐ **Yes (explain below)**

EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the requirements as described within the specification of FCC Title 47, CFR Part 15.247, and Industry Canada RSS-210, Issue 8 (2010), Annex 8 for a Digital Transmission System (DTS) transmitter.

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

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

EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 - Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15, RSS GEN and ANSI C63.4-2003. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber. The EUT was operated in continuous modulated transmit mode for final testing using power as provided by a bench DC supply.

The applicable limits apply at a 3 meter distance. Measurements above 4 GHz were performed at a 1.0 meter separation distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of three (3) standard channels: low (2402), middle (2440) and high (2480) to comply with FCC Part 15.31(m). The channels and operating modes were set via laptop computer using proprietary software.

5.2 - Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Bi-conical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 25 GHz. The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities.

The EUT was rotated along three orthogonal axes during the investigations to find the highest emission levels.

5.3 - Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at an IEC/ISO 17025 accredited calibration laboratory, traceable to the SI standard. In addition, the Connecting Cables were measured for losses using a calibrated Signal Generator and an EMI Receiver. The resulting correction factors and the cable loss factors from these calibrations were entered into the EMI Receiver database. As a result, the data taken from the EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading. The EMI Receiver was operated with resolution bandwidths as prescribed in ANSI C63.4.

5.4 - Test Results

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

5.5 CALCULATION OF RADIATED EMISSIONS LIMITS

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

The following table depicts the general radiated emission limits above 30 MHz. These limits are obtained from Title 47 CFR, Part 15.209, for radiated emissions measurements. These limits were applied to any signals found in the 15.205 restricted bands. The mentioned limits correspond to those limits listed in RSS 210 section 2.7.

Frequency (MHz)	3 m Limit μV/m	3 m Limit (dBμV/m)	1 m Limit (dBμV/m)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-24,000	500	54.0	63.5

Sample conversion from field strength μV/m to dBμV/m:
dBμV/m = 20 $\log_{10}$ (100)
= 40 dBμV/m (from 30-88 MHz)

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

> 960 MHz
500μV/m or 54.0 dB/μV/m at 3 meters
54.0 + 9.5 = 63.5 dB/μV/m at 1 meter

Sample Calculation using correction factors from the device

Raw Receiver Data + Antenna Factor + Cable Factor + = Reported Value

Generic example of reported data at 200 MHz:

Reported Measurement data = 18.2 (raw receiver measurement) + 15.8 (antenna factor) + 1.45 (cable factor) = 35.45 dBμV

5.6 RADIATED EMISSIONS TEST DATA CHART

3 Meter Measurements of Electromagnetic Radiated Emissions
Test Standard: 47CFR, Part 15.205 and 15.247(DTS)
RSS 210 A8, sections 2.2, 2.6 and 2.7
Frequency Range Inspected: 30 MHz to 25000 MHz

Manufacturer:	LS Research, LLC					
Date(s) of Test:	July 24-26, August 3, 2012					
Project Engineer:	Peter Feilen					
Test Engineer(s):	Peter Feilen, Adam Alger					
Voltage:	3.6VDC (nominal)					
Operation Mode:	Continuous modulated transmit mode					
Environmental Conditions in the Lab:	Temperature: 71° F Relative Humidity: 32 %					
EUT Power:		Single Phase ___VAC		3 Phase ___VAC		
		Battery	X	Other: Bench DC Supply		
EUT Placement:	X	80cm non-conductive table		10cm Spacers		
EUT Test Location:	X	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS		
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:	X	Peak	X	Quasi-Peak	X	Average

Duty cycle relaxation was used at certain times when measuring radiated spurious emissions.

The duty cycle justification can be found in Appendix D of this report.

A total amount of 14 dB is applied. This 14 dB is subtracted from the peak value of any measurement applied to, and this adjusted value is compared to the 15.209 limit, which compares to an average value for frequencies above 1 GHz.

A peak and average measurement are recorded for each frequency measured. If the average value exceeds the limit, the peak value with duty cycle relaxation is considered, to determine a pass or fail result for the measurement.

Example: An average value of 66.8 dBuV/m is recorded at a given frequency. This exceeds the limit of 63.5 dBuV/m by 4.8 db. Then, the peak value measured for the same frequency is considered. If the peak value is measured at 68.3 dBuV/m, then reduced by 14.0 dB to 54.3 dBuV/m and compared to the limit, a passing result is obtained using duty cycle relaxation. 54.3 dBV/m as compared to the limit of 63.5 dBuV/m is less yielding a passing result.

5.7 RADIATED EMISSIONS DATA CHARTS

DIPOLE ANTENNA

Duty cycle relaxation was utilized to adjust spurious emissions values. Please reference Appendix D for duty cycle explanation.

The following table depicts the level of significant radiated harmonic emissions seen on Channel Low, 1 MBPS:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty-Cycle Amount (dB)	Duty-Cycle Corrected Average Measurement (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4804	1.11	301	68.3	66.8	14.0	54.3	63.5	9.2	Horizontal	Side
12010	1	218	63.0	56.2	14.0	49.0	63.5	14.5	Vertical	Flat
19216	1	67	69.9	57.8	14.0	55.9	63.5	7.6	Horizontal	Side

The following table depicts the level of significant radiated harmonic emissions seen on Channel Middle, 1 MBPS:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty-Cycle Amount (dB)	Duty-Cycle Corrected Average Measurement (dBuV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4880	1.05	198	72.3	71.2	14.0	58.3	63.5	5.2	Horizontal	Vertical
7320	1.00	207	61.9	59.2	14.0	47.9	63.5	15.6	Horizontal	Side
12200	1.04	115	63.7	57.2	14.0	49.7	63.5	13.8	Horizontal	Side
19520	1.00	71	73.3	61.2	14.0	59.3	63.5	4.2	Horizontal	Side

The following table depicts the level of significant radiated harmonic emissions seen on Channel High, 1 MBPS:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty-Cycle Amount (dB)	Duty-Cycle Corrected Average Measurement	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4960	1.05	196	70.9	69.7	14.0	56.9	63.5	6.6	Horizontal	Vertical
7440	1.00	327	59.9	56.9	14.0	45.9	63.5	17.6	Horizontal	Side
12400	1.00	127	67.2	61.4	14.0	53.2	63.5	10.3	Horizontal	Side
19840	1.00	71	67.8	56.4	14.0	53.8	63.5	9.7	Horizontal	Side
22320	1.00	347	59.1	48.0	14.0	45.1	63.5	18.4	Horizontal	Vertical

Notes:

1. A Quasi-Peak Detector was used in measurements below 1 GHz. To ensure the peak emissions did not exceed 20 dB above the limits a peak detector was used. A peak detector with video averaging was used for measurements above 1 GHz.
2. Measurements above 4 GHz were made at 1 meters of separation from the EUT. Limits have been corrected to reflect the change in measurement distance.

CHIP ANTENNA

The following table depicts the level of significant radiated harmonic emissions seen on Channel Low:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty Cycle Correction Amount (dB)	Corrected Average Reading (dBuV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4804	1.10	260	73.3	72.2	14.0	58.2	63.5	5.3	Vertical	Vertical
12010	1.00	133	59.3	52.6	14.0	38.6	63.5	24.9	Horizontal	Flat

The following table depicts the level of significant radiated harmonic emissions seen on Channel Middle:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty Cycle Correction Amount (dB)	Corrected Average Reading (dBuV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4880	1.00	239	74.3	73.3	14.0	59.3	63.5	4.2	Vertical	Vertical
7320	1.21	115	60.0	56.0	14.0	42.0	63.5	21.5	Vertical	Side
12200	1.18	342	63.3	55.7	14.0	41.7	63.5	21.9	Horizontal	Vertical

The following table depicts the level of significant radiated harmonic emissions seen on Channel High:

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Duty Cycle Correction Amount (dB)	Corrected Average Reading (dBuV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
4960	1.02	236	75.2	74.3	14.0	60.3	63.5	3.2	Vertical	Vertical
7440	1.00	150	57.3	52.2	14.0	38.2	63.5	25.3	Horizontal	Flat
12400	1.07	13	61.0	51.9	14.0	37.9	63.5	25.6	Horizontal	Side

Notes:

1. A Quasi-Peak Detector was used in measurements below 1 GHz. A peak detector with video averaging was used for measurements above 1 GHz. To ensure the peak emissions did not exceed 20 dB above the limits a peak detector was used.
2. Measurements above 4 GHz were made at 1 meter separation from the EUT. Limits have been corrected to reflect the change in measurement distance.

The following table depicts the level of significant spurious radiated RF emissions found (other than the fundamentals and its harmonics):

Frequency (MHz)	Height (m)	Azimuth (degree)	Field Strength Reading (dBµV/m)	Field Strength Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
1862.4	1.00	0	39.6	54.0	14.4	H	F
3931.0	1.00	0	49.1	54.0	4.9	H	F
83.2	1.00	107	26.7	40.0	13.3	V	V
82.8	1.00	121	25.6	40.0	14.4	V	F
72.1	4.00	0	19.1	40.0	20.9	H	F
72.1	4.00	0	19.3	40.0	20.7	H	S
83.0	1.00	122	26.3	40.0	13.7	V	S

Note:

1. H: Horizontal, V: Vertical, F: Flat, S: Side

5.8 - RECEIVE MODE

Setup follows that specified in sections 5.1 - 5.3.

Measurement data from the receive tests are presented below:

Frequency (MHz)	Height (m)	Azimuth (degree)	Quasi Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
82.5	1.00	161	24.0	40.0	16.0	V	V

Frequency (GHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Avg Reading (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation
9.605	1.04	58	53.6	58.0	63.5	5.5	Horizontal	Flat
4.802	1.01	97	57.6	54.5	63.5	9.0	Vertical	Side
19.835	1.00	149	58.1	54.3	63.5	9.2	Horizontal	Side
19.515	1.04	146	59.8	56.4	63.5	7.1	Vertical	Side
19.211	1.07	147	58.1	53.3	63.5	10.3	Vertical	Side

Note: Emissions are a not function of the antenna and similar emissions were demonstrated regardless of the channel specified

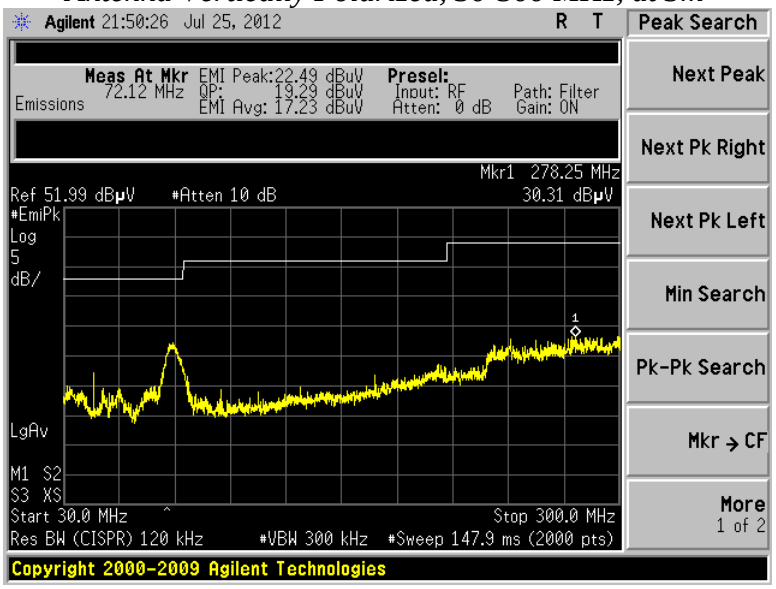
Screen Captures

TRANSMIT MODE

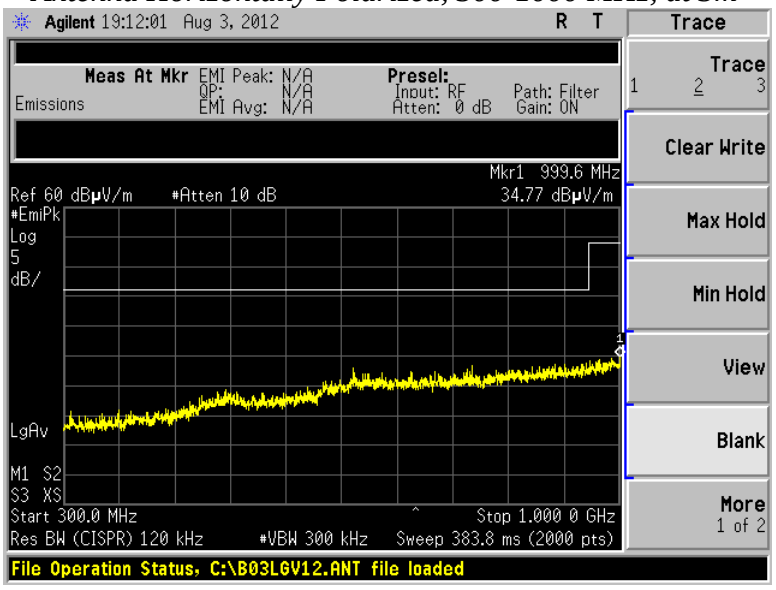
These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and a video averaged Peak detector function is utilized when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 2402 MHz, 2440 MHz, or 2480 MHz, 1 MBPS data rate, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

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

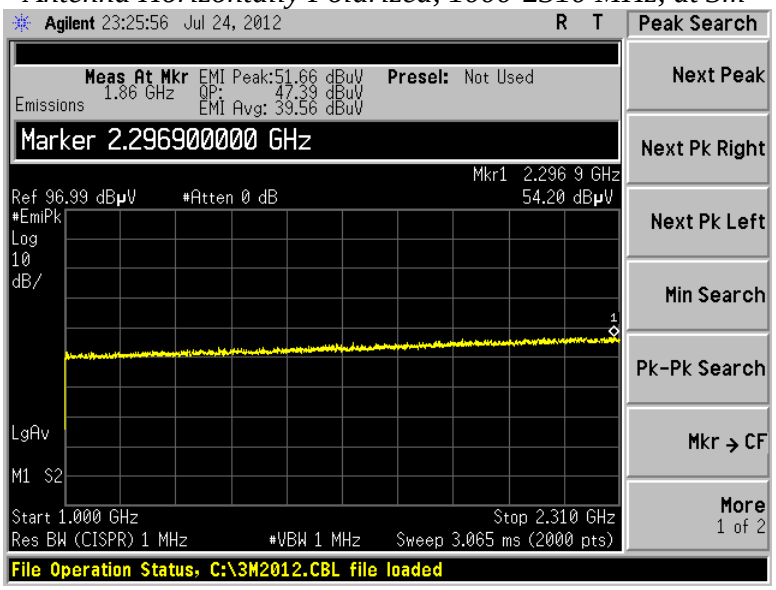


Antenna Horizontally Polarized, 300-1000 MHz, at 3m



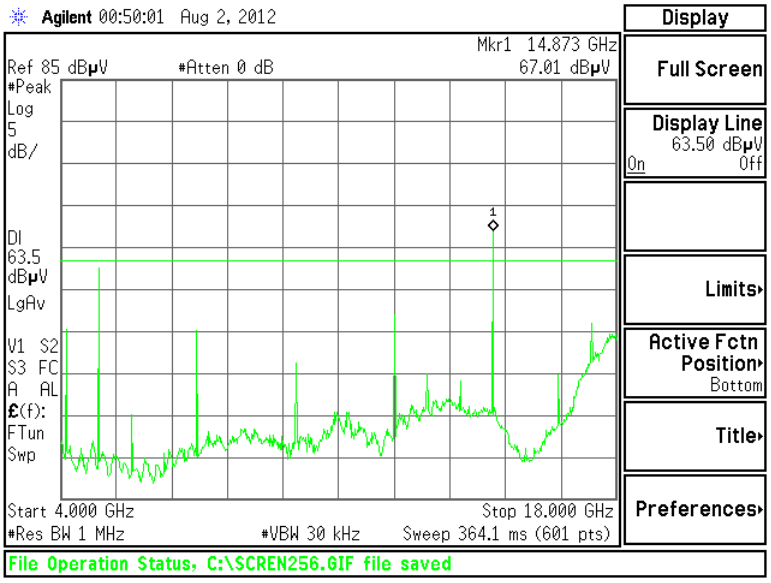
Screen Captures - Radiated Emissions Testing – Transmit Mode (continued)

Antenna Horizontally Polarized, 1000-2310 MHz, at 3m



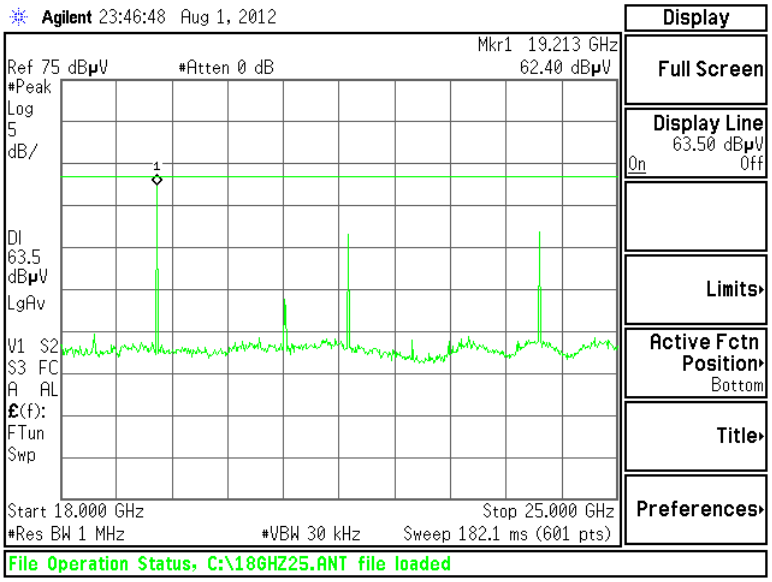
Note: The restricted band frequency ranges 2310-2390 MHz and 2483.5-2500 MHz is in the Band-edge section.

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



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

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



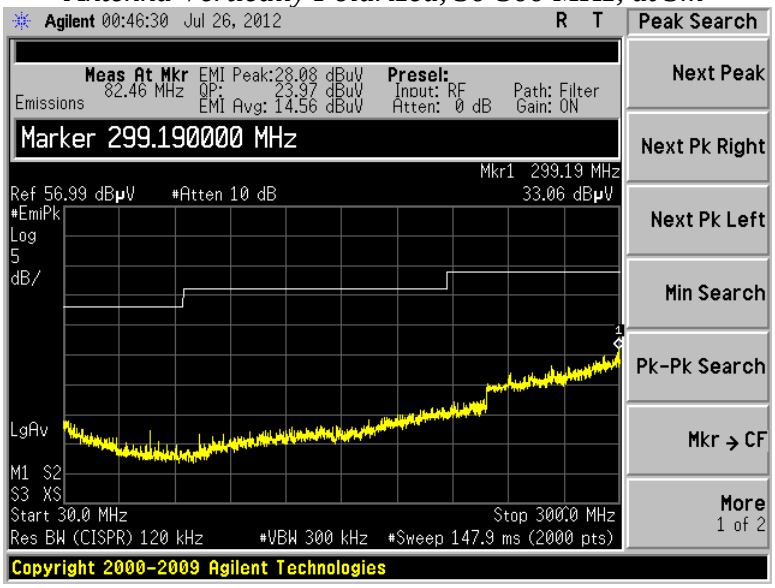
Screen Captures

RECEIVE MODE

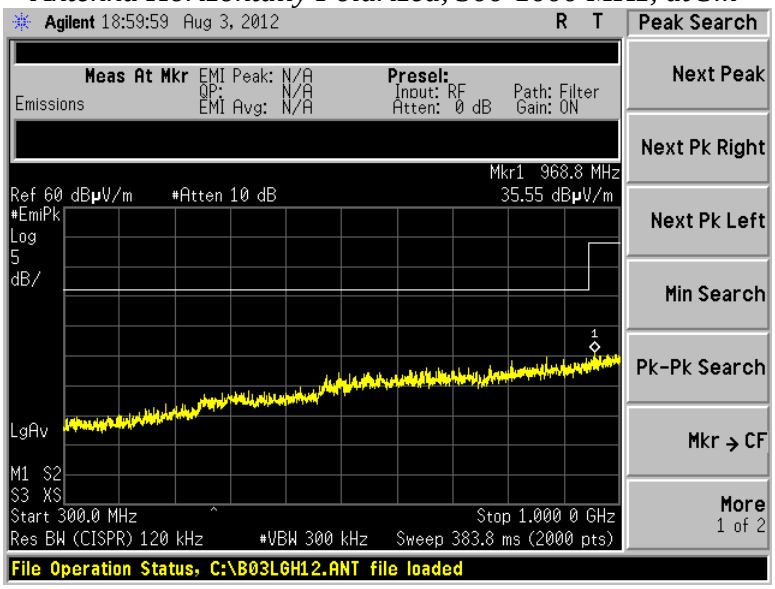
These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and a video averaged Peak detector function is utilized when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels 2402 MHz, 2440 MHz, or 2480 MHz, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

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

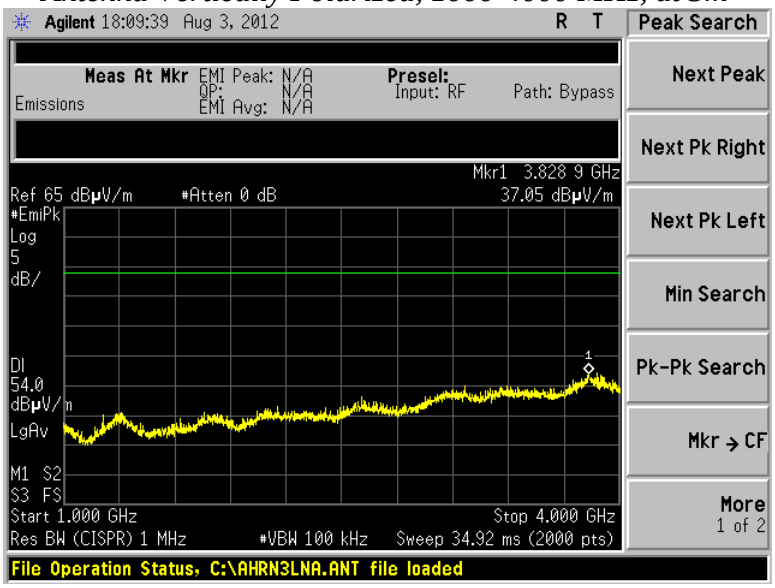


Antenna Horizontally Polarized, 300-1000 MHz, at 3m

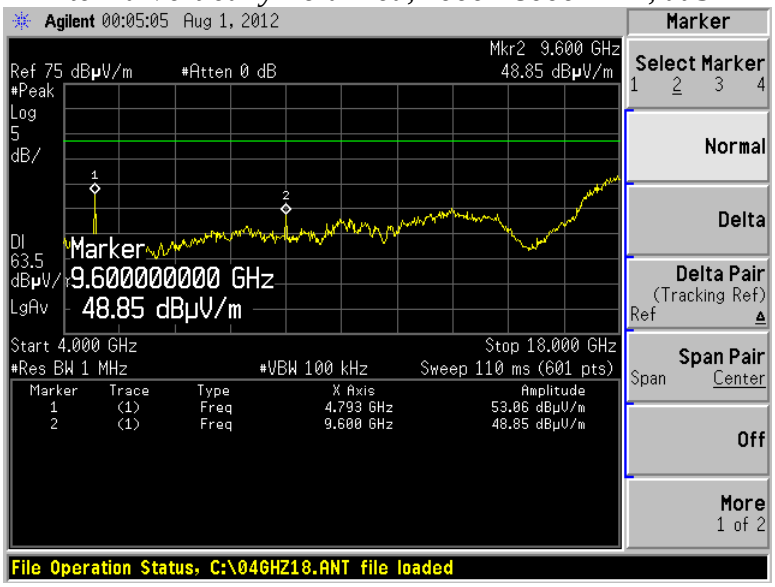


Screen Captures - Radiated Emissions Testing – Receive Mode (continued)

Antenna Vertically Polarized, 1000-4000 MHz, at 3m



Antenna Vertically Polarized, 4000-18000 MHz, at 3m



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

Antenna Vertically Polarized, 18000-25000 MHz, at 3m

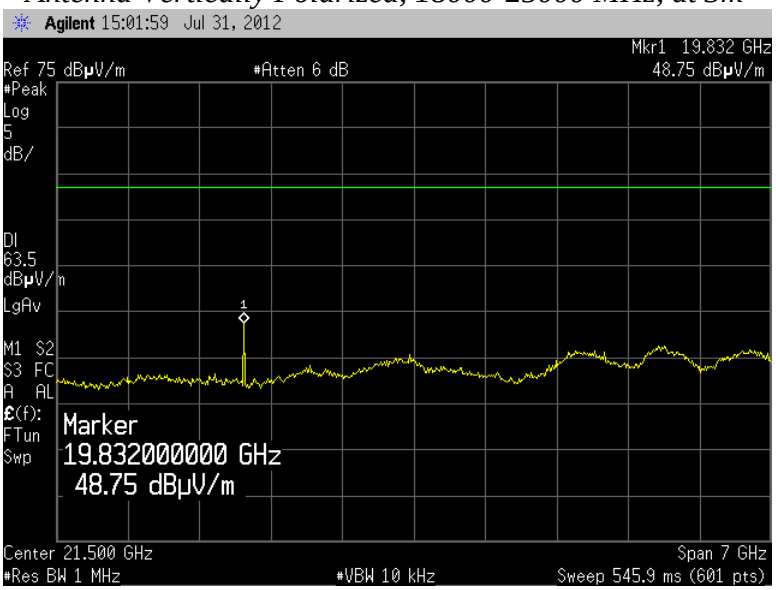


EXHIBIT 6. OCCUPIED BANDWIDTH:

6.1 - Limits

For a DTS system operating in the 2400 to 2483.5 MHz band, the 6dB emission bandwidth minimum is 500 kHz.

6.2 - Method of Measurements

Industry Canada (IC RSS GEN 4.6.1) also requires the measurement of the 99% bandwidth in addition to the 6 dB emission bandwidth. For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to 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. A bandwidth measurement function that is built into the spectrum analyzer was used to measure the 99 % bandwidth while the 6 dB bandwidth was measured using FCC OET KDB 558074.

6.3 Test Equipment List

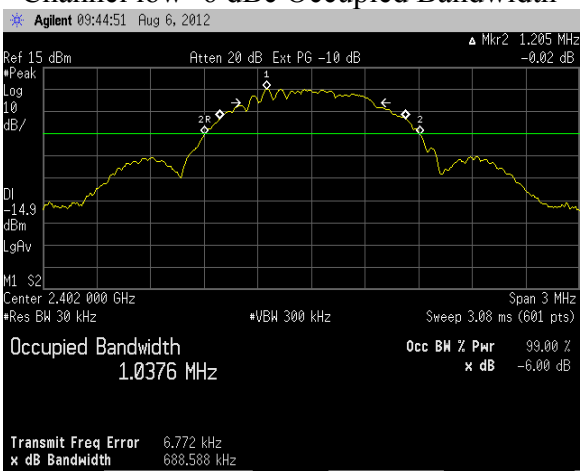
Please see Appendix A

6.4 Test Data

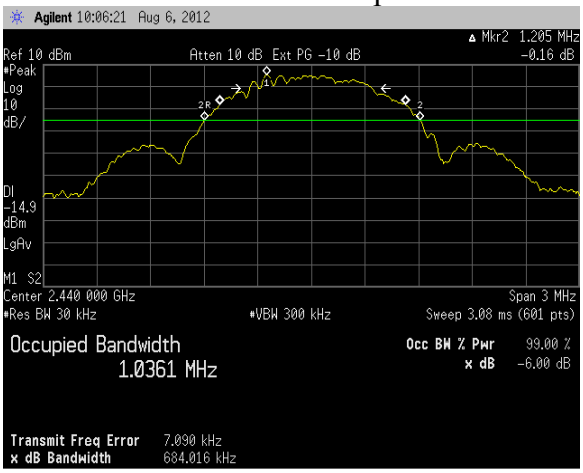
Channel	Frequency (MHz)	Minimum EBW 6 dB (kHz)	EBW 6 dB (kHz)	EBW 99 % (kHz)
0	2402	500	688	1038
19	2440	500	684	1036
39	2480	500	686	1038

6.5 Screen Captures - OCCUPIED BANDWIDTH

Channel low -6 dBc Occupied Bandwidth



Channel middle -6 dBc Occupied Bandwidth



Channel high -6 dBc Occupied Bandwidth

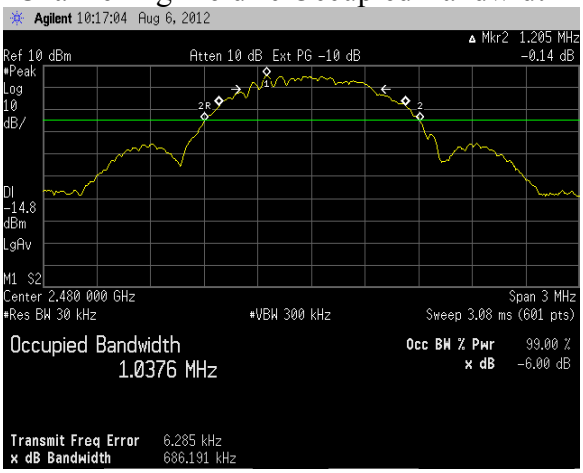


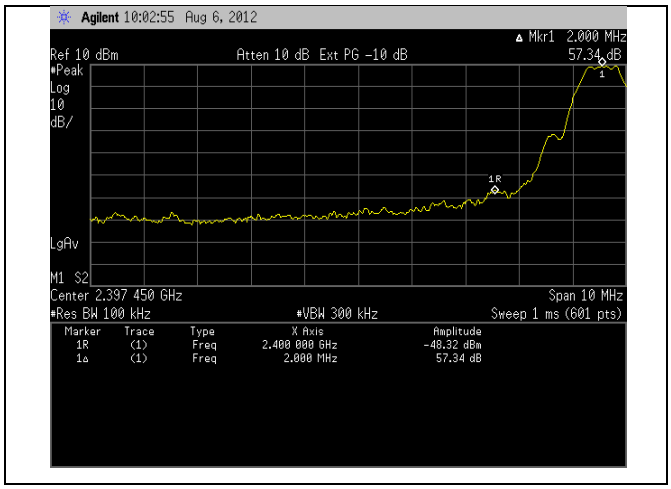
EXHIBIT 7. BAND-EDGE MEASUREMENTS

7.1 Method of Measurements

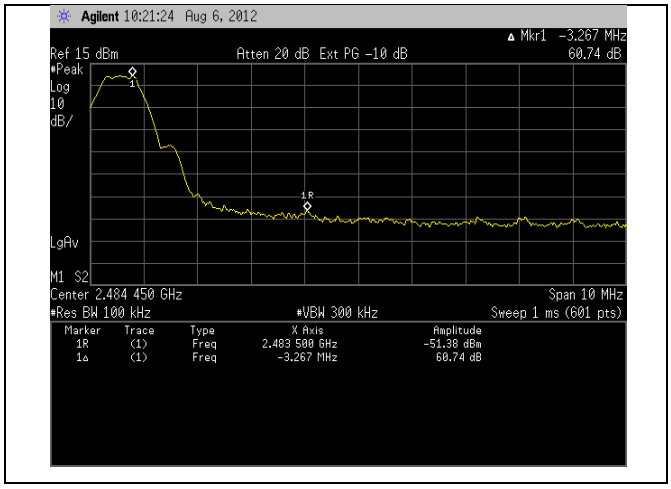
FCC 15.209(b) and 15.247(d) require a measurement of spurious emission levels to be at least 20 dB lower than the fundamental emission level, in particular at the Band-Edges where the intentional radiator operates. Also, RSS 210 Section 2.2 requires that unwanted emissions meet limits listed in tables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

CONDUCTED MEASUREMENTS:

Screen Capture Demonstrating Compliance at the Lower Band-Edge



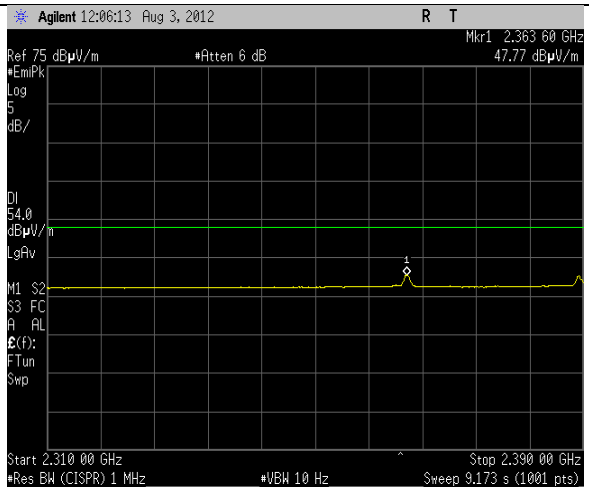
Screen Capture Demonstrating Compliance at the Higher Band-Edge



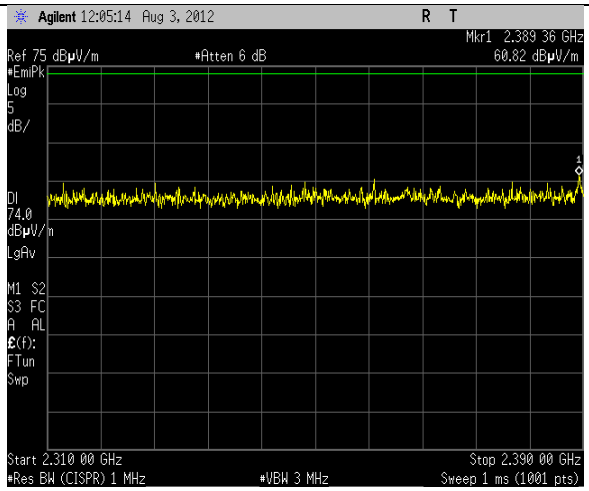
RADIATED MEASUREMENTS:

DIPOLE ANTENNA

Screen Capture Demonstrating Compliance at the Lower Band-Edge

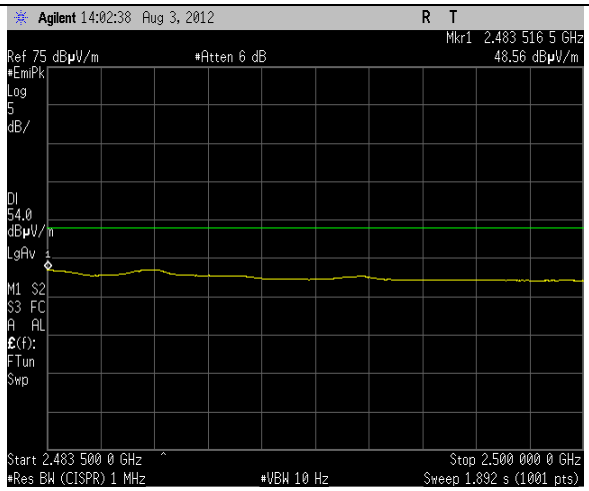


Average Measurement

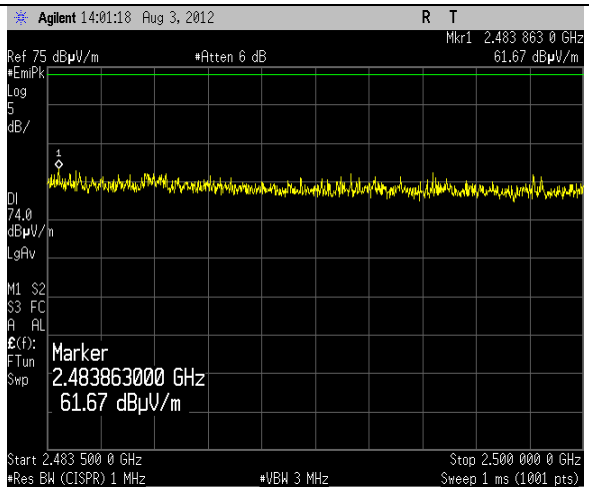


Peak Measurement

Screen Capture Demonstrating Compliance at the Higher Band-Edge



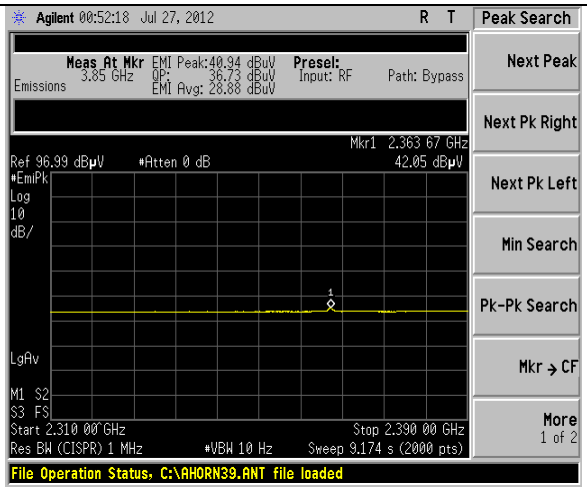
Average Measurement



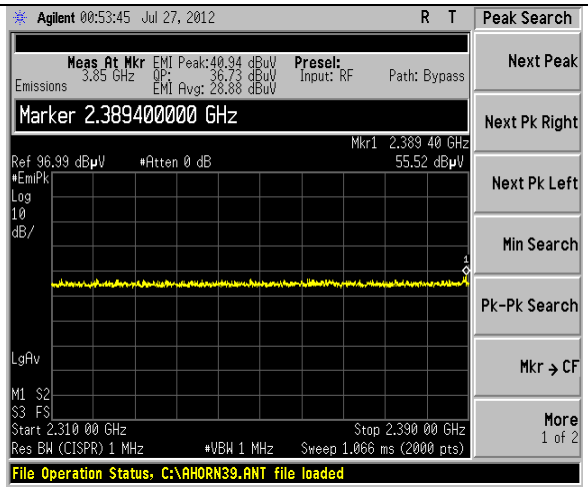
Peak Measurement

CHIP ANTENNA

Screen Capture Demonstrating Compliance at the Lower Band-Edge

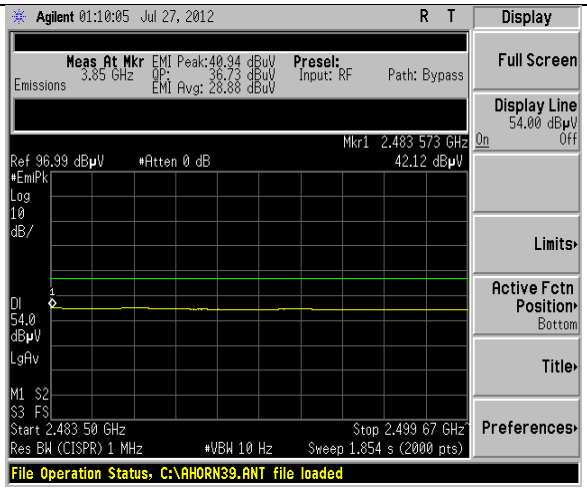


Average Measurement

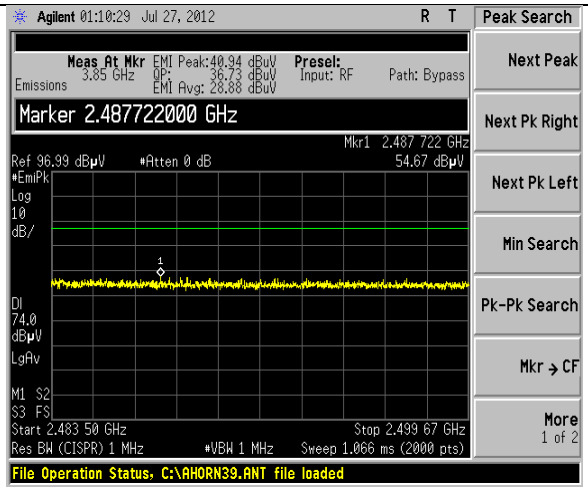


Peak Measurement

Screen Capture Demonstrating Compliance at the Higher Band-Edge



Average Measurement



Peak Measurement

EXHIBIT 8. POWER OUTPUT (CONDUCTED): 15.247(b)

8.1 Method of Measurements

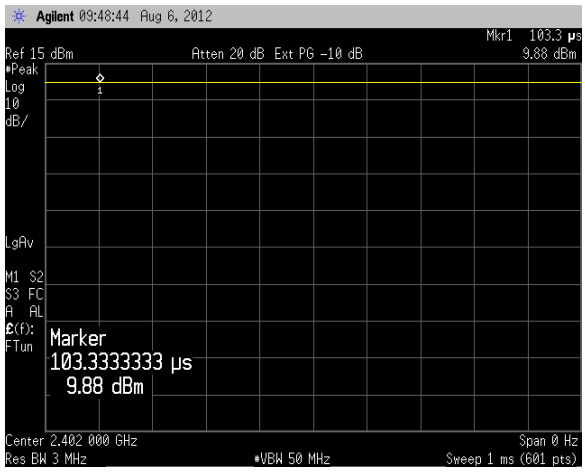
The conducted RF output power of the EUT was measured at the antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, allowing direct measurements without the need for any further corrections. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with RBW=3 MHz, VBW=50 MHz and a span of 0 Hz. Measurements from a peak detector are presented in the charts below.

8.2 Test Data

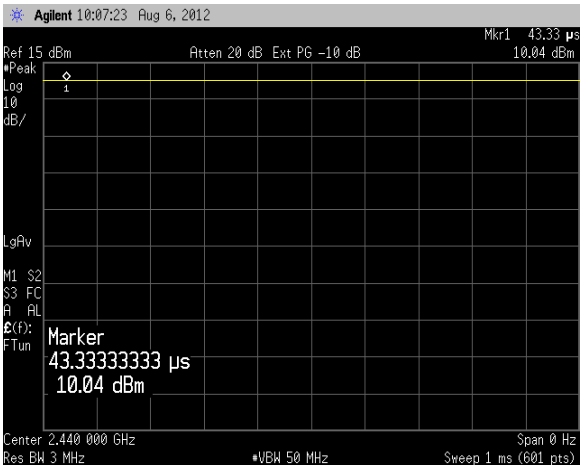
Channel	Frequency (MHz)	Power (dBm)
0	2402	9.9
19	2440	10.0
39	2480	10.0

8.3 Screen Captures – Power Output (Conducted)

Channel Low



Channel Middle



Channel High

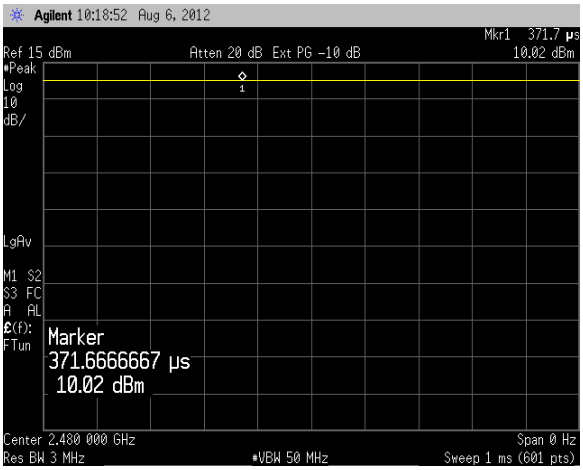


EXHIBIT 9 POWER SPECTRAL DENSITY: 15.247(e)

9.1 Limits

For digitally modulated systems, such as the BLE radio on this EUT, the power spectral density conducted from the intentional radiator
to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

In accordance with FCC Part 15.247(e) and RSS 210 A8.2(b), the peak power spectral density should not exceed +8 dBm in any 3 kHz band.

9.2 Test Result

This measurement was performed in accordance with KDB 558074 D01 DTS Measurement Guidance v01 (1-18-2012). The highest density was found to be no greater than -6.0 dBm, which is under the allowable limit by 14.0 dB.

9.3 Test Equipment List

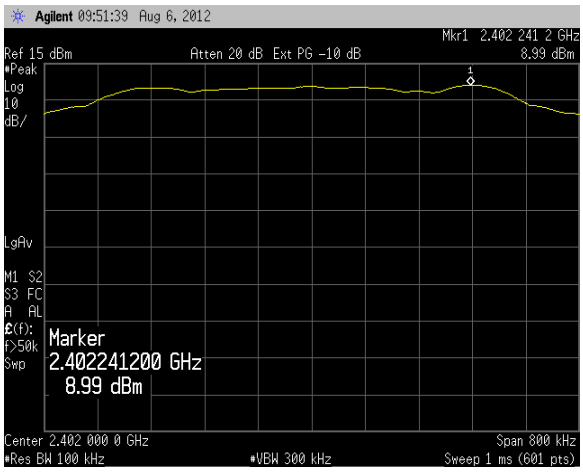
Please see Appendix A

9.4 Test Data

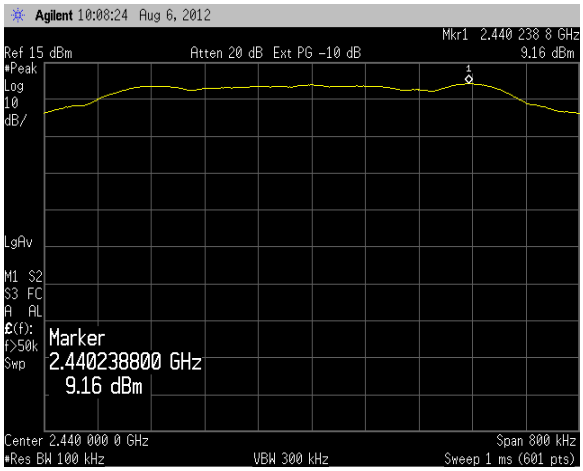
Channel	Frequency (MHz)	PKPSD (dBm in 100 kHz RBW)	BW Correction Value (dB)	PKPSD (dBm in 3 kHz RBW)	PSD Limit	PSD Margin
0	2402	9.0	-15.2	-6.2	8.0	14.2
19	2440	9.2	-15.2	-6.0	8.0	14.0
39	2480	9.1	-15.2	-6.1	8.0	14.1

9.5 Screen Captures – Power Spectral Density

Channel 0



Channel 19



Channel 39

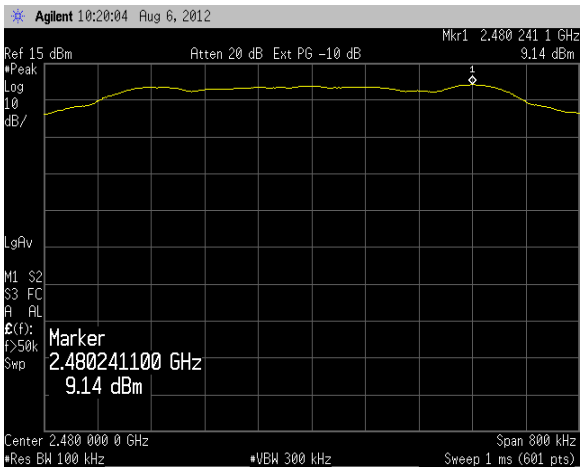


EXHIBIT 10. CONDUCTED SPURIOUS EMISSIONS: 15.247(d)

10.1 - Limits

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

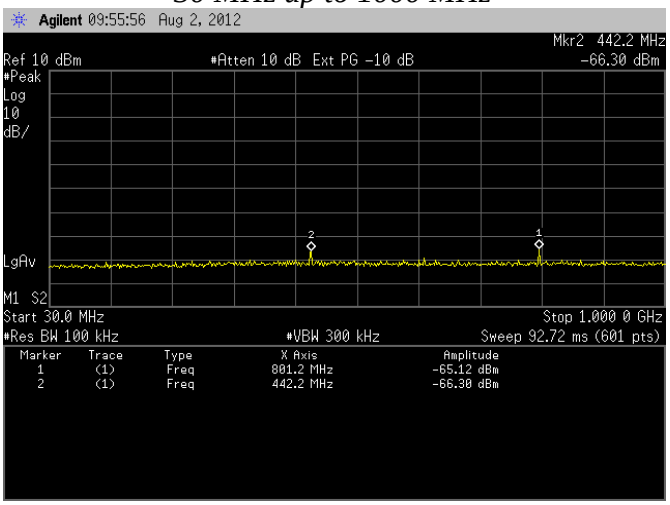
10.2 – Conducted Harmonic And Spurious RF Measurements

FCC Part 15.247(d) and IC RSS 210 A8.5 both require a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, thereby allowing direct readings of the measurements made without the need for any further corrections. A spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

10.3- Screen Captures – Spurious Radiated Emissions

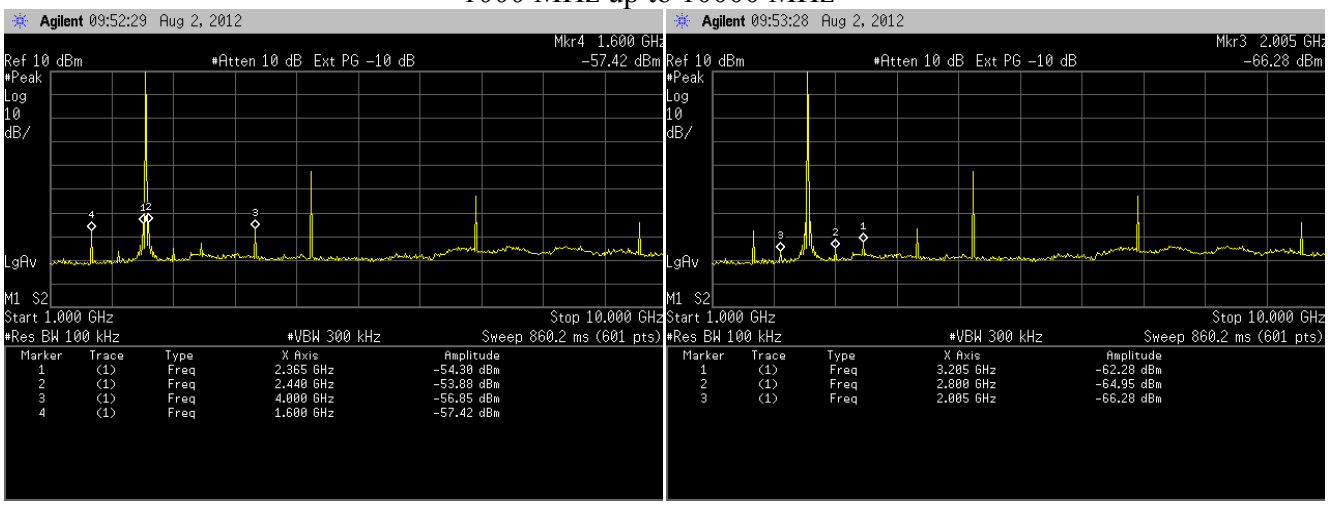
The following captures are representative of the product. Measurements were taken on three channels. Low channel emissions are shown below and are representative of the product.

30 MHz up to 1000 MHz



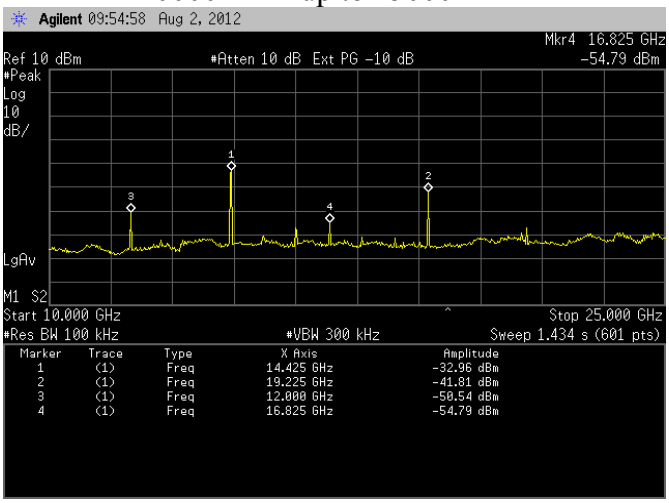
Conducted Spurious Emissions Screen Captures (cont.)

1000 MHz up to 10000 MHz



TWO CAPTURES OF THE 1000-10000MHZ RANGE ARE PRESENTED TO DEMONSTRATE MULTIPLE SPURIOUS EMISSIONS INCLUDING HARMONICS OF THE FUNDAMENTAL. SIMILAR RESULTS ARE OBSERVED REGARDLESS OF FUNDMENTAL FREQUENCY SELECTED.

10000 MHz up to 25000 MHz



APPENDIX A
List of Test Equipment

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 20-Jun-2012 Type Test : Radiated Band-Edge Job # : C-1493

Prepared By: Peter Customer : LSR Quote #: 312143

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960013	EMI Receiver	HP	8546A System	3617A00320;3448A	11/22/2011	11/22/2012	Active Calibration
2	EE 960014	EMI Receiver-filter section	HP	85460A	3448A00296	11/22/2011	11/22/2012	Active Calibration
3	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	5/16/2012	5/16/2013	Active Calibration

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 20-Jun-2012 Type Test : Rad spurious Emissions Job # : C-1493

Prepared By: Customer : LSR Quote #: 312143

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960156	100kHz-1GHz Analog Signal Generator	Agilent	N5181A	MY49060062	6/6/2011	6/6/2012	Calibration Due
2	EE 960157	3Hz-13.2GHz Spectrum Analyzer	Agilent	E4445A	MY48250225	6/6/2011	6/6/2012	Calibration Due
3	EE 960158	RF Preselecter	Agilent	N9039A	MY46520110	6/11/2011	6/11/2012	Calibration Due
4	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	6/10/2011	6/10/2012	Calibration Due
5	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	11/15/2011	11/15/2012	Active Calibration
6	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	5/16/2012	5/16/2013	Active Calibration
7	EE 960147	Pre-Amp	Adv. Micro	WLA612	123101	1/6/2012	1/6/2013	Active Calibration

LS RESEARCH LLC
Wireless Product Development
Equipment Calibration

Date : 20-Jun-2012 Type Test : Conducted Radio Measurements Job # : C-1493

Prepared By: Peter Customer : LSR Quote #: 312143

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	6/1/2011	6/1/2013	Active Calibration
2	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2012	5/9/2013	Active Calibration

APPENDIX B
TEST STANDARDS: CURRENT PUBLICATION DATES

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2009		
CISPR 11	2009-05	2009-12 P	
CISPR 16-1-1	2010-01		
CISPR 16-1-2	2003	2004-04	2006-07
FCC 47 CFR, Parts 0-15, 18, 90, 95	2009		
FCC Public Notice DA 00-705	2000		
RSS GEN	2007-06		
RSS 210	2010-08		
FCC Measurement Procedure 558074 D01 V01	2012-03		

APPENDIX C
Uncertainty Statement

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

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

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

APPENDIX D

Duty Cycle Justification

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 D1: Advertising channel PDU Header's PDU Type field encoding

ADV_IND = 37 octets (47)
ADV_DIRECT_IND= 12 octets (22)
DV_NONCONN_IND=37 octets (47)
ADV_SCAN_=37 octets (47)
SCAN_REQ=12 octets (22)
SCAN_RSP = 37 octets (47)
CONNECT_REQ=34 octets. (44)

(Plus 1 octet for preamble.
Plus 4 octets for adress.
Plus 2 octets for PDU header.
Plus 3 octets for CRC.)

47 octets is 376 bits, stated as worst case length packet.

Undirected Advertising Events

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 a*dvInterval* 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 D1 ,** the advertising events are perturbed in time using the advDelay.

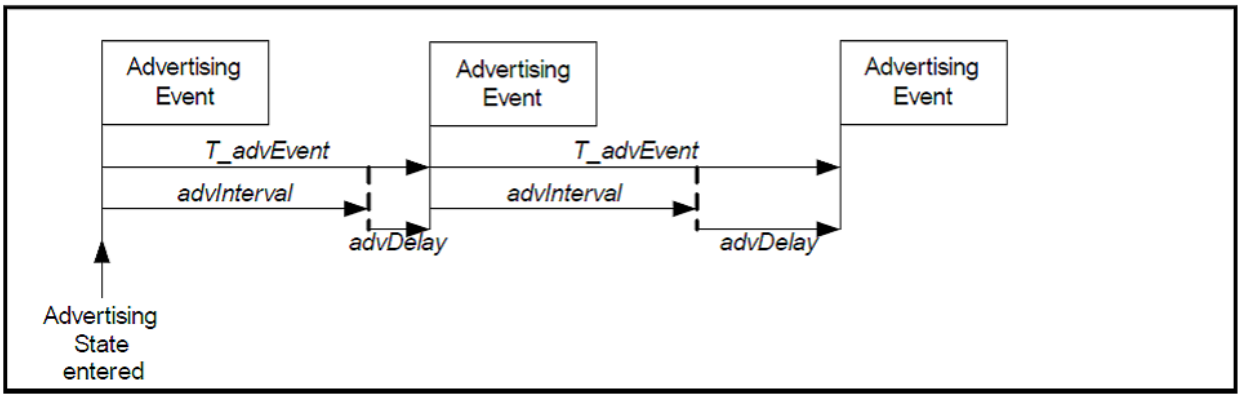


Figure D1: Advertising events perturbed in time using advDelay

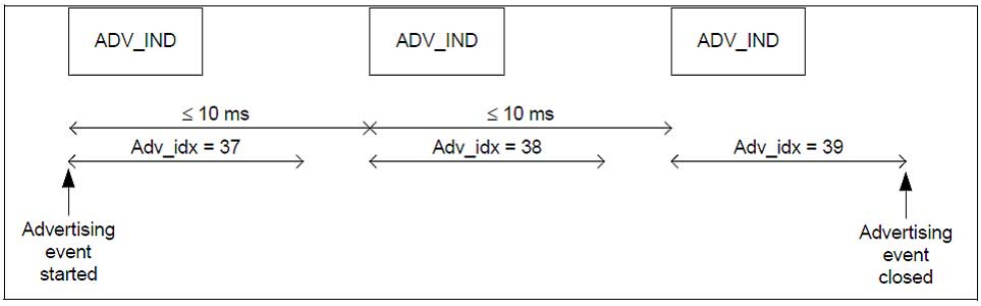


Figure D2: Connectable undirected advertising event with only advertising PDUs

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

ADV_IND = 376 uS duration. (ON channel 37)
IFS = 150 uS (OFF)
ADV_IND = 376 uS duration (OFF channel 38)
IFS =150 uS (OFF)
ADV_IND = 376 uS duration (OFF Channel 39).
Adv_Internal (min) = 20 mS.

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

Relaxation factor =-min(20*log10 (DF),-20 dB) =-min(-35.119 ,-20) = 20 dB

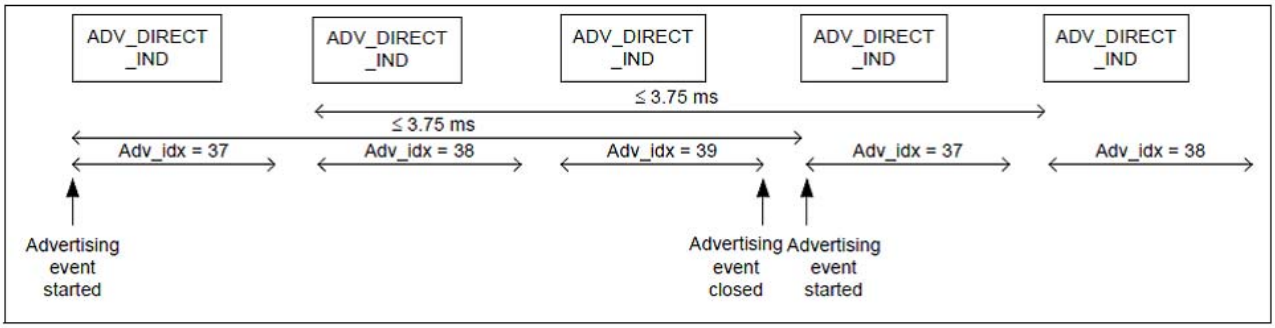


Figure D3: Connectable directed advertising event type with only advertising PDUs

Duty Factor for Connectable Directed Advertising Event, per advertising channel

ADV_DIRECT_IND = 176 uS duration. (22 octets) (ON channel 37)
IFS = 150 uS (OFF)
ADV_IND = 176 uS duration (OFF channel 38)
IFS =150 uS (OFF)
ADV_IND = 176 uS duration (OFF Channel 39).
IFS=150 uS (OFF)

Time from open to close of advertising event = 3*176 + 3*150 =978 uS

DF = 176/(978)= 0.179

Relaxation factor =-min(20*log10 (DF),-20 dB) =-min(-14.9 ,-20) = 14.9 dB