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TESTING CERT #1255.01
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TEST REPORT #: 316191-a
LSR Job #: C-2496

Compliance Testing of:
W1001

Test Date(s):
7/12/2016 – 7/15/2016, 7/18/2016 – 7/22/2016, 7/25/2016 – 7/29/2016, 8/02/2016 – 8/03/2016, 8/15/2016, and 8/23/2016

Prepared For:
ThermoFisher Scientific
Attn: David Perez
2 Radcliff Road
Tewksbury, MA 1876

This Test Report is issued under the Authority of:
John Johnston, EMC Engineer

Signature: Date: 9/21/2016

Quality Assurance by:
Khairul Aidi Zainal, Engineering Manager- Test Services

Signature: Date: 9/19/16

Project Engineer:
John Johnston, EMC Engineer

Signature: Date: 9/21/2016

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EXHIBIT 1. INTRODUCTION

1.1 - Scope

References:	FCC Part 15, Subpart C, Section 15.247 and 15.209 FCC Part 2, RSS-GEN, and RSS-247
Title:	FCC: Telecommunication – Code of Federal Regulations, CFR 47, Part 15. IC : License-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
Purpose of Test:	To gain FCC and IC Certification Authorization for Radio Apparatus
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.10 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Environmental Classification:	Commercial, Industrial or Business Residential

1.2 – Normative References

Publication	Year	Title
47 CFR, Parts 0-15 (FCC)	2016	Code of Federal Regulations - Telecommunications
RSS-247	2015-05 Issue 1	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices
RSS-GEN	2014-11 Issue 4	General Requirements for Compliance of Radio Apparatus
ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
CISPR 16-1-1	2015-09 Ed. 4	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Radio disturbance and measuring apparatus – Measuring apparatus
CISPR 16-2-1	2014-02 Ed. 3	Specification for radio disturbance and immunity measuring apparatus and methods. Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements

1.3 - LS Research, LLC in Review

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

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

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

Federal Communications Commission (FCC) – USA

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

Industrie Canada Industry Canada

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-2
On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-3

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	ThermoFisher Scientific
Address:	2 Radcliff Road, Tewksbury, MA 1876
Contact Name:	David Perez

2.2 - Equipment Under Test (EUT) Information

Product Name:	W1001
Model Number:	W1001
Serial Numbers:	3-016181, 3-016205, and 3-016245

2.3 - Associated Antenna Description

The LS Research 2.4 GHz FlexPIFA antenna is flexible planar inverted-f antenna (PIFA) exhibiting a peak gain of +2 dBi. The LS Research 2.4 GHz FlexPIFA antenna includes a 001-0014 Rev. 3 U.FL connector.

2.4 - EUT'S Technical Specifications

BLE:

EUT Frequency Range (in MHz)	2402-2480 MHz
EIRP (in W)	
Minimum:	0.00808
Maximum:	0.00846
Field Strength @ 3 m	N/A
Occupied Bandwidth (-6 dB BW)	0.6652 MHZ
Type of Modulation	GFSK
Emission Designator	1M05G1D
Transmitter Spurious Conducted (worst case)	-46.413 dBm (@ 1653.4 MHz)
Transmitter Spurious Radiated (worst case)	41.16 dBuV/m (@ 826.7 MHz)
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Antenna Information	
Detachable/non-detachable	Detachable
Type	2.4 GHz FlexPIFA
Peak Gain (in dBi)	FlexPIFA: 2 dBi
EUT will be operated under FCC Rule Part(s)	15.247
EUT will be operated under RSS Rule Part(s)	247
Modular Filing	☒ Yes ☐ No
Portable or Mobile?	Portable

WLAN:

EUT Frequency Range (in MHz)	2412-2462 MHz
Maximum Conducted Output Power (W)	802.11b: 1 Mbps data rate: 0.0813 11 Mbps data rate: 0.0759 802.11g: 6 Mbps data rate: 0.141 54 Mbps data rate: 0.129 802.11n: MCS0 data rate: 0.126 MCS7 data rate: 0.0692
Minimum Conducted Output Power (W)	802.11b: 1 Mbps data rate: 0.0741 11 Mbps data rate: 0.0741 802.11g: 6 Mbps data rate: 0.107 54 Mbps data rate: 0.123 802.11n: MCS0 data rate: 0.112 MCS7 data rate: 0.0550
Occupied Bandwidth (DTS (-6 dB) BW)	802.11b: 9.5 MHz at 1 Mbps data rate 10.1 MHz at 11 Mbps data rate 802.11g: 15.4 MHz at 6 Mbps data rate 16.4 MHz at 54 Mbps data rate 802.11n: 15.4 MHz at MCS0 data rate 16.9 MHz at MCS7 data rate
Occupied Bandwidth (99% BW)	802.11b: 13.9 MHz at 1 Mbps data rate 14.4 MHz at 11 Mbps data rate 802.11g: 16.5 MHz at 6 Mbps data rate 16.5 MHz at 54 Mbps data rate 802.11n: 17.7 MHz at MCS0 data rate 17.7 MHz at MCS0 data rate
Type of Modulation	DSSS and OFDM
Emission Designator	802.11b: 14M4G1W 802.11g: 16M5W1W 802.11n: 17M7W1W
EIRP (in W)	FlexPIFA and 1 Mbps: 0.129 W FlexPIFA and 11 Mbps: 0.120 W FlexPIFA and 6 Mbps: 0.224 W

	FlexPIFA and 54 Mbps: 0.204 W FlexPIFA and MCS0: 0.200 W FlexPIFA and MCS7: 0.105 W
Transmitter Spurious Conducted (worst case)	-30.221 dBm at 2399.7 MHz
Transmitter Spurious Radiated (worst case)	49.80 dBuV/m (@ 4924 MHz)
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Antenna Information	
Detachable/non-detachable	Detachable
Type	2.4 GHz FlexPIFA
Gain (in dBi)	FlexPIFA: 2 dBi
EUT will be operated under FCC Rule Part(s)	15.247
EUT will be operated under RSS Rule Part(s)	247
Modular Filing	☒ Yes ☐ No
Portable or Mobile?	Portable

2.5 - Product Description

The W1001 module is a multi-standard module with support for WLAN (802.11 b/g/n), Bluetooth, and BLE. Both WLAN and Bluetooth/ BLE share the same antenna port.

The W1001 module includes an LSR TiWi BLE module and an LSR FlexPifa antenna. The W1001 operates on the following firmware file for WLAN operation: 930-005-R1.2_T.ini.

The W1001 operates on the following patch file for BLE operation: 480-0026-R3.hci.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	15-35 ˚C
Humidity:	30-60%
Pressure:	725-745 mmHg

3.2 - Applicability & Summary of EMC Emission Test Results

FCC and IC Paragraph	Test Requirements	Compliance (Yes/No)
FCC : 15.247(a)(2) IC : RSS 247 Section 5.2(1)	6 dB Bandwidth of a Digital Modulation System	Yes
FCC : 15.247(b)(3) & 1.1310 IC : RSS 247 Section 5.4(4)	Maximum Peak Conducted 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 247 Section 5.5	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC : 15.247(d) IC : RSS 247 Section 5.2(2)	Transmitted Power Spectral Density of a Digital Modulation System	Yes
FCC : 15.247(d), 15.209 & 15.205	Transmitter Radiated Emissions	Yes
FCC: 15.207 IC: RSS-GEN	AC Line Conducted 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 247 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

When tested on the specified dates, it was determined that the EUT was compliant with the requirements of FCC Title 47, CFR Part 15.247, 15.209, 15.207 and Industry Canada RSS-247, and RSS-GEN for a Digital Transmission System (DTS) Transmitter using the methods of ANSI C63.10-2013.

Any modifications made to the EUT after the specified test dates will invalidate the data contained herein.

If some measurements are seen to be within the uncertainty value, as listed in Appendix C, there is a possibility that this unit may not meet the required limit specification if subsequently tested.

EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 - Test Setup

The test setup was assembled in accordance with ANSI C63.10. The EUT was placed on an 80 cm (when investigating below 1GHz) or 150 cm (when investigating above 1 GHz) high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a Semi-Anechoic, FCC listed Chamber. The EUT was operated at various modulations and data rates in continuous transmit mode. Final testing was performed with the EUT operating in continuous transmit mode and being provided 3.3 V DC from a variable power supply. The EUT, serial no. 3-016245, operates as a WLAN DTS device, configured to transmit at any of 11 channels and programmable via a programming application and beta board. Likewise, the EUT, serial no. 3-016205 and 3-016181, operates as a BLE DTS device, configured to transmit at any of 40 channels and programmable via different programming application and the beta board.

It should be noted that radiated emission testing below 1 GHz and between 18-25 GHz was performed on BLE unit 3-016205 while all other testing (radiated emission testing and conducted measurements) was performed on BLE unit 3-016181.

Applicable limits apply at a 3 meter distance. Measurements above 4 GHz were performed with measuring equipment situated inside of the Semi-Anechoic, FCC listed chamber. The calculations to determine these limits are provided in the following pages. Please refer to Appendix A for a complete list of test equipment. The EUT was configured to operate on one of three (3) standard channels: WLAN - low (2412 MHz), middle (2437 MHz) and high (2462 MHz), and BLE - low (2402 MHz), middle (2440 MHz) and high (2480 MHz), to comply with FCC/IC regulations. The channels and operating modes were changed using the programming applications on a personal computer. To program the BLE DTS device, the TiWi Bluetooth RF Evaluation Tool Version 8.0.1.0 was used. To program the WLAN DTS device, the TiWi WLAN Evaluation Tool Version 2.1 was used.

5.2 - Test Procedure

Radiated RF measurements were performed on the EUT in the 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 Semi-Anechoic Chamber, with the antenna mast situated such that the antenna was 3 meters from the EUT. A biconical antenna coupled to a 6 dB attenuator was used to measure emissions from 30 MHz to 200 MHz, and a log periodic dipole antenna was used to measure emissions from 200 MHz to 1000 MHz. A double-ridged waveguide horn antenna was used from 1 GHz to 18 GHz and a small horn antenna was used from 18 GHz to 25 GHz. The maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. The EUT was rotated along three orthogonal axes during the investigations to find the highest emission levels. The EUT was situated on the turntable in three orientations using a support (the three orientations and provided in the images below)

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.

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-247, Issue 1 (2015) for a DTS transmitter. The frequencies with significant RF signal strength were recorded and plotted as shown in the data charts and screen captures provided below.

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 for a DTS device in Title 47 CFR 15.247 (b)(3) and RSS 247 Section 5.4(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 Section 5.5, 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 the applicable Industry Canada standard.

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.

Frequency (MHz)	3 m Quasi-Peak Limit μV/m	3 m Quasi-Peak Limit (dBμV/m)	3 m Peak Limit (dBμV/m)	3 m Average Limit (dBμV/m)
30-88	100	40.0	-	-
88-216	150	43.5	-	-
216-960	200	46.0	-	-
960+	500	54.0	-	-
1000	-	-	74	54

Sample conversion of field strength (μV/m to dBμV/m):

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

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

Sample reported data for 200MHz:

Raw Data + Antenna Factor + Cable Factor = Reported Data

18.2 dBμV/m + 15.8 dB + 1.45 dB = 35.45 dBμV/m

5.6 - Radiated Emissions Test Data Chart

3 Meter Measurements of Electromagnetic Radiated Emissions
Test Standard: 47 CFR, Part 15.205 and 15.247(DTS)
RSS 247 (DTS)
Frequency Range Inspected: 30 MHz to 25000 MHz

Manufacturer:	LS Research					
Date(s) of Test:	7/18/2016, 7/20/2016, 7/21/2016, 7/22/2016, 7/25/2016 – 7/27/2016, and 8/15/2016					
Test Engineer(s):	John Johnston and Kim Bay					
Voltage:	3.3 VDC					
Operation Mode:	Continuous Transmit					
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %					
EUT Power:		Single Phase ___VAC		3 Phase ___VAC		
		Battery	**X**	Other: DC Bench Supply		
EUT Placement:	**X**	80 cm non-conductive table	**X**	150 cm non-conductive table		
EUT Test Location:	**X**	3 Meter Semi-Anechoic FCC Listed Chamber	**X**	5 Meter Semi-Anechoic FCC Listed Chamber		
Measurements:		Pre-Compliance		Preliminary	**X**	Final
Detectors Used:	**X**	Peak	**X**	Quasi-Peak	**X**	Average

WLAN DATA:

The following table depicts the level of significant spurious radiated RF emissions found below 1 GHz:

Frequency (MHz)	Height (m)	Azimuth (degrees)	Quasi-Peak Measurement (dBuV/m)	Quasi-Peak Limit (dBuV/m)	Margin (dB)	Antenna Polarity (H/V)	EUT Orientation
130.50	2.99	256.00	30.19	43.50	13.31	H	V
82.79	1.00	200.00	37.10	40.00	2.90	V	V
301.00	1.20	275.00	33.28	46.00	12.72	H	V
290.70	1.17	263.00	34.88	46.00	11.12	H	V
71.21	1.00	185.00	35.74	40.00	4.26	V	V
291.20	1.63	186.00	33.29	46.00	12.71	V	V
39.50	1.00	79.00	35.26	40.00	4.74	V	V
406.20	1.40	360.00	28.61	46.00	17.39	V	V
74.44	1.00	175	34.72	40.00	5.28	V	V
291.20	1.10	124.00	35.23	46.00	10.77	H	S
291.40	2.03	187.00	30.19	46.00	15.81	V	S

**Note: EUT Orientations include V – vertical; S – Side; F – Flat (see set-up pictures in attached document)*

The following table depicts the level of significant spurious radiated RF emissions found above 1 GHz:

Tx Spurious Emissions – Restricted Bands

Tx Channel	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBuV/m)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Antenna Polarity	EUT Orientation
Low	4824	1.91	102	51.26	47.30	54.00	6.70	V	V
Low	14472	2.80	318	52.70	41.80	54.00	12.20	H	F
Mid	4874	1.00	346	50.50	47.20	54.00	6.80	H	S
Mid	7311	1.00	35	49.10	40.40	54.00	13.60	H	V
High	4924	1.00	89	52.90	49.80	54.00	4.20	H	F
High	7386	1.00	0	49.00	38.00	54.00	16.00	H	F
High	19696	1.00	0	53.10	39.90	54.00	14.10	H	S

Note: The data provided above depicts the highest spurious emissions at the low (2412 MHz), middle (2437 MHz), and high (2462 MHz) channels.

Tx Radiated Emissions – Restricted Band Edges

Tx Channel	Data Rate	Frequency (MHz)	Orientation	Polarization	Peak Reading (dBuV/m)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)
1	1 MBPS	2386	F	H	63.05	51.16	54.00	2.84
1	11 MBPS	2386	F	H	63.72	52.31	54.00	1.69
1	6 MBPS	2390	F	H	67.46	46.56	54.00	7.44
1	54 MBPS	2389	F	H	60.41	48.30	54.00	5.70
1	MCS0	2389	F	H	67.22	47.36	54.00	6.64
1	MCS7	2390	F	H	59.10	47.24	54.00	6.76
11	1 MBPS	2488	S	V	62.71	50.17	54.00	3.83
11	11 MBPS	2488	S	V	64.49	51.51	54.00	2.49
11	6 MBPS	2484	S	V	64.36	47.41	54.00	6.59
11	54 MBPS	2484	S	V	63.43	50.69	54.00	3.31
11	MCS0	2484	S	V	69.54	48.42	54.00	5.58
11	MCS7	2484	S	V	61.92	50.43	54.00	3.57

5.7 - Screen Captures - Radiated Emissions Test

Note: These screen captures represent peak emissions. For radiated emission measurements, a quasi-peak detector is utilized when measuring frequencies below 1 GHz, and a peak detector is utilized when measuring frequencies above 1 GHz. The signature scans shown here are from worst-case emissions, as measured on channels 1, 6, or 11 of the WLAN radio, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Channel 1, Flat Orientation, Antenna Vertically Polarized, 30-200 MHz, at 3m[1]

Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, Vertical Orientation, Antenna Vertically Polarized, 30-200 MHz, at 3m

Channel 1, Vertical Orientation, Antenna Vertically Polarized, 200-1000 MHz, at 3m

Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, Side Orientation, Antenna Vertically Polarized, 200-1000 MHz, at 3m

Channel 1, Flat Orientation, Antenna Horizontally Polarized, 1000-2310 MHz, Reduced VBW at 3m

Screen Captures - Radiated Emissions Testing *(continued)*

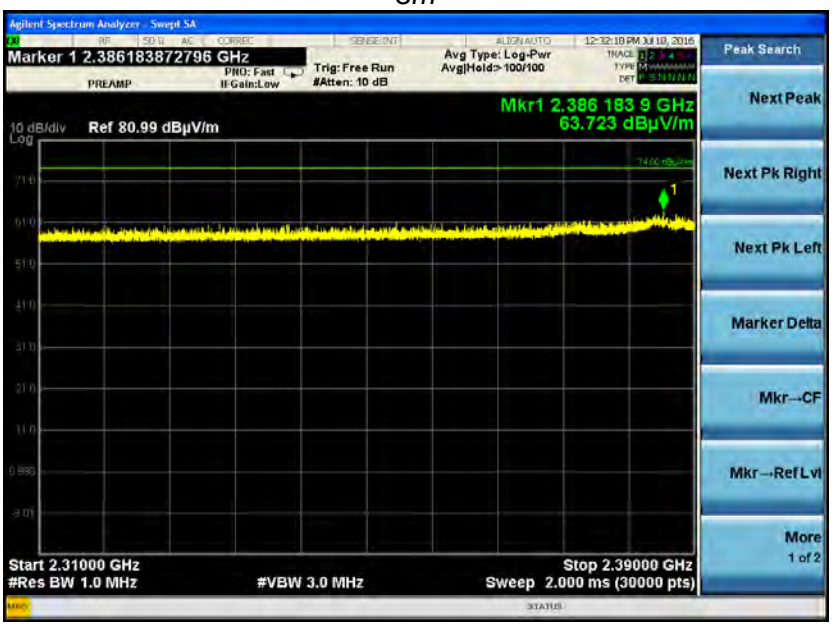
Channel 1, Flat Orientation, Antenna Vertically Polarized, 1000-2310 MHz, Reduced VBW at 3m

Channel 1, 1 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Peak at 3m

Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, 1 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Avg at 3m

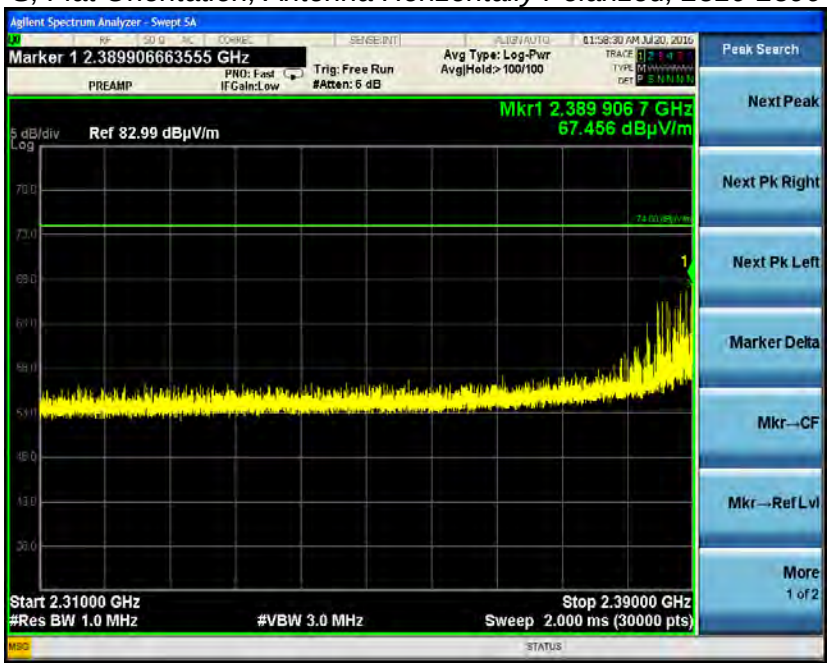
Channel 1, 11 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Peak at 3m



Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, 11 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Avg at 3m

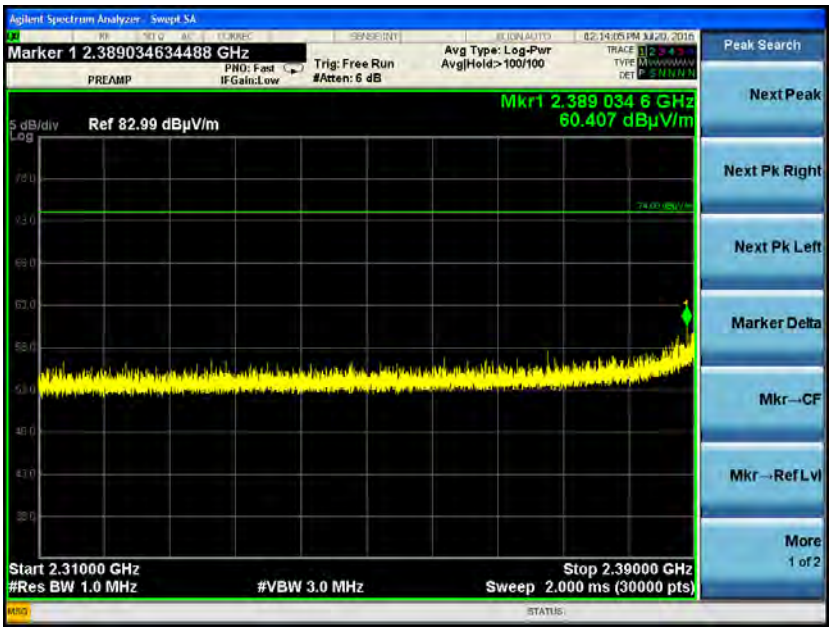
Channel 1, 6 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Peak at 3m



Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, 6 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Avg. at 3m

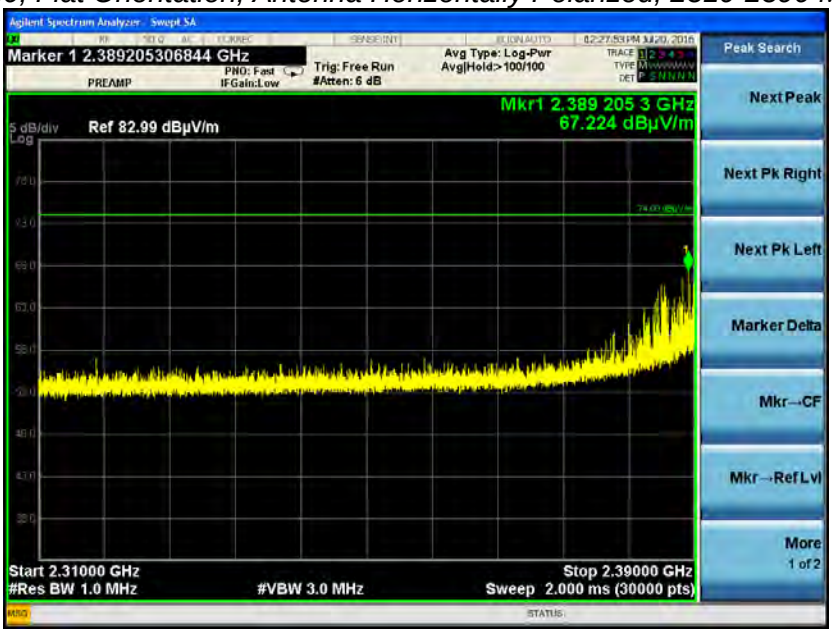
Channel 1, 54 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Peak at 3m



Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, 54 MBPS, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Avg. at 3m

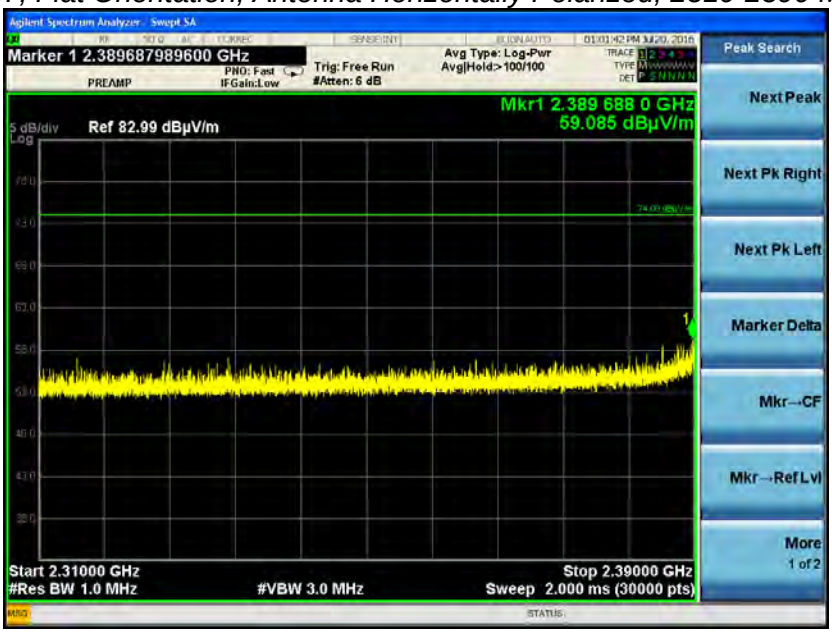
Channel 1, MCS0, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Peak at 3m



Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, MCS0, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Avg. at 3m

Channel 1, MCS7, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Peak at 3m



Screen Captures - Radiated Emissions Testing *(continued)*

Channel 1, MCS7, Flat Orientation, Antenna Horizontally Polarized, 2310-2390 MHz, Avg. at 3m

Channel 11, 1 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Peak at 3m

Screen Captures - Radiated Emissions Testing *(continued)*

Channel 11, 1 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Avg. at 3m

Channel 11, 11 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Peak at 3m

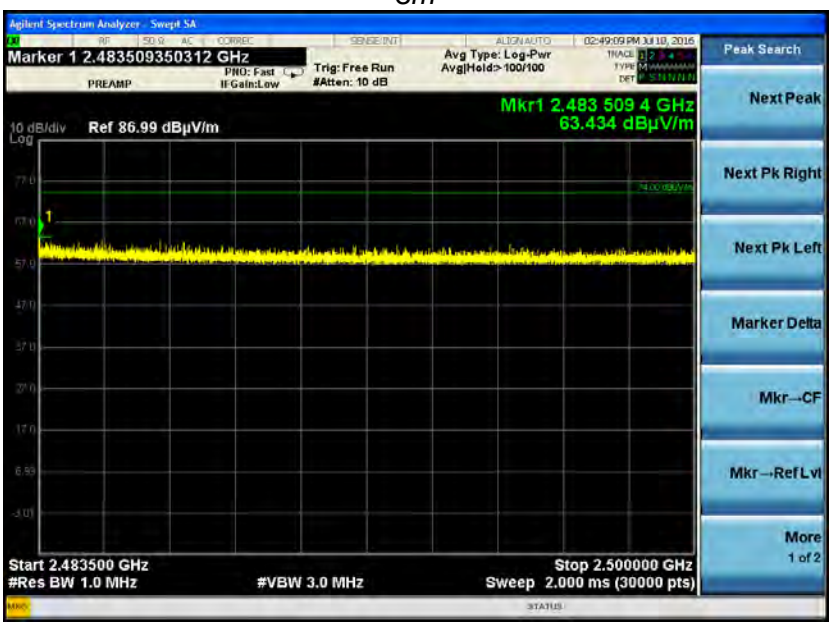
Screen Captures - Radiated Emissions Testing *(continued)*

Channel 11, 11 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Avg. at 3m

Channel 11, 6 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Peak at 3m

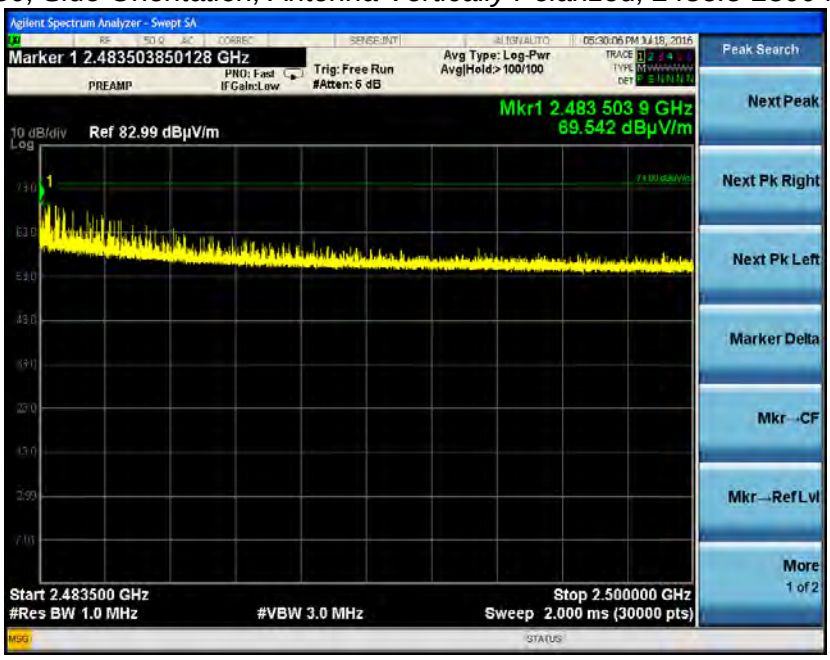
Channel 11, 6 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Avg. at 3m

Channel 11, 54 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Peak at 3m



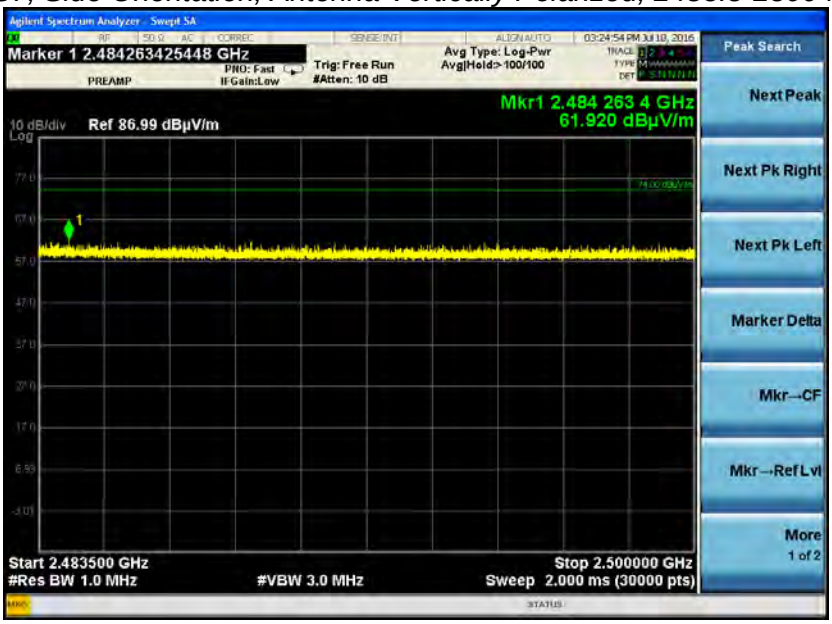
Channel 11, 54 MBPS, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Avg. at 3m

Channel 11, MCS0, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Peak at 3m



Channel 11, MCS0, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Avg. at 3m

Channel 11, MCS7, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Peak at 3m



Channel 11, MCS7, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Avg. at 3m

Channel 1, Side Orientation, Antenna Horizontally Polarized, 2500-4000 MHz, Peak at 3m, Reduced VBW

Channel 1, Side Orientation, Antenna Vertically Polarized, 2500-4000 MHz, Peak at 3m, Reduced VBW

Channel 1, Vertical Orientation, Vertically Polarized, 4-18 GHz, Reduced VBW at 3m

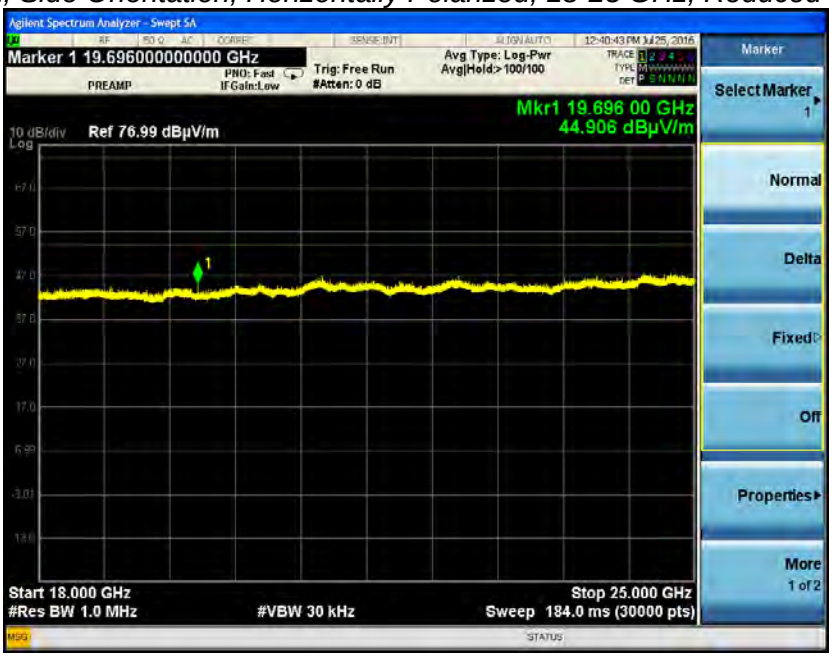
Channel 6, Side Orientation, Horizontally Polarized, 4-18 GHz, Reduced VBW at 3m

Channel 11, Flat Orientation, Horizontally Polarized, 4-18 GHz, Reduced VBW at 3m

Channel 1, Flat Orientation, Vertically Polarized, 18-25 GHz, Reduced VBW at 3m

Channel 6, Flat Orientation, Vertically Polarized, 18-25 GHz, Reduced VBW at 3m

Channel 11, Side Orientation, Horizontally Polarized, 18-25 GHz, Reduced VBW at 3m



BLE DATA:

Below 1 GHz:

Frequency (MHz)	Height (m)	Azimuth (degree)	Quasi Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation	Channel
185.0	1.66	244	35.20	43.50	8.30	H	V	0
35.5	1.00	54	36.50	40.00	3.50	V	F	39
185.1	3.17	254	28.85	43.50	14.70	V	V	0
36.8	1.00	156	34.84	40.00	5.16	V	F	39
184.8	1.67	283	35.48	43.50	8.00	H	S	0
75.3	1.00	235	35.49	40.00	4.50	V	V	39
191.2	1.71	255	34.80	43.50	8.70	H	F	0
38.5	1.00	43	28.88	40.00	11.12	V	F	19
194.8	1.60	101	31.87	43.50	11.60	H	V	19
79.9	1.00	238	36.10	40.00	3.90	V	F	39
185.1	1.76	275	36.48	43.50	7.00	H	S	19
185.5	1.69	264	35.82	43.50	7.70	H	F	19
74.6	1.00	262	35.89	40.00	4.10	V	S	39
185.2	1.65	260	34.61	43.50	8.90	H	V	39
40.1	1.00	121	37.20	40.00	2.80	V	F	0
185.3	1.69	272	36.46	43.50	7.00	H	S	39
75.2	1.00	203	32.51	40.00	7.49	V	V	19
185.4	1.72	252	35.95	43.50	7.60	H	F	39
826.7	1.10	174	33.42	46.00	12.60	V	F	39
826.7	1.08	215	41.16	46.00	4.80	H	S	39
826.7	1.00	254	37.30	46.00	8.70	H	V	39
813.4	1.00	130	38.47	46.00	7.50	H	V	19
813.4	1.00	210	40.20	46.00	5.80	H	S	19

Tx Spurious Emissions – Restricted Bands – Between 1-4 GHz

Tx Channel	Orientation	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBuV/m)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Antenna	Notes
0	V	1601	1.14	0	48.42	41.40	54	12.60	H	
0	V	1601	-	-	-	-	-	-	V	Noise Floor
0	S	1601	2.23	42	46.69	37.88	54	16.12	H	
0	S	1601	1.00	345	48.93	41.52	54	12.48	V	
0	F	1601	1.31	164	50.01	43.39	54	10.61	H	
0	F	1601	1.00	240	48.37	39.79	54	14.21	V	
19	V	1626	2.35	0	48.56	40.12	54	13.88	H	
19	V	1626	-	-	-	-	-	-	V	Noise Floor
19	S	1626	-	-	-	-	-	-	H	Noise Floor
19	S	1626	1.00	239	47.83	39.75	54	14.25	V	
19	F	1626	1.29	160	48.47	39.81	54	14.19	H	
19	F	1626	-	-	-	-	-	-	V	Noise Floor

**Note: Measurements denoted by "Noise floor" were not large enough in magnitude to be distinguished from noise floor and, thus, were not measured.*

Tx Spurious Emissions – Restricted Bands – Above 4 GHz

Tx Channel	Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBuV/m)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Antenna Polarity	EUT Orientation
Low	4804	1.00	122	48.40	41.30	54	12.70	V	S
Low	19216	3.30	165	54.60	44.00	54	10.00	H	S
Mid	4880	1.30	213	49.60	44.30	54	9.70	H	F
Mid	7320	1.00	117	48.10	38.90	54	15.10	H	F
Mid	19520	2.00	330	57.00	46.30	54	7.70	H	S
High	4960	1.00	208	52.20	48.10	54	5.90	H	F
High	7440	1.00	36	47.40	37.30	54	16.70	H	F
High	19840	1.45	330	56.30	46.10	54	7.90	H	S

Note: The data provided above depicts the highest spurious emissions at the low (2402 MHz), middle (2440 MHz), and high (2480 MHz) channels.

Tx Radiated Emissions – Restricted Band Edges

Tx Channel	Frequency (MHz)	Orientation	Polarization	Peak Reading (dBuV/m)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dB)	Peak Limit (dBuV/m)	Peak Margin (dB)
0	2389	S	V	62.94	45.97	54.00	8.03	74.00	11.06
39	2496	S	V	59.92	-	54.00	-	74.00	14.08
39	2483	S	V	-	46.41	54.00	7.59	74.00	-

BLE Screen Captures - Radiated Emissions Test

Note: These screen captures represent peak emissions. For radiated emission measurements, a quasi-peak detector is utilized when measuring frequencies below 1 GHz, and a peak detector is utilized when measuring frequencies above 1 GHz. In the 30-200 MHz and 200-1000 MHz range, screen shots provided are representative of the worst-case EUT orientation for each channel and antenna polarization.

Channel 0 (2402 MHz), Vertical Orientation, Antenna Vertically Polarized, 30-200 MHz, at 3m

Channel 39, Side Orientation Antenna Horizontally Polarized, 30-200 MHz, at 3m

Channel 19, Side Orientation, Antenna Vertically Polarized, 200 - 1000 MHz, at 3m

Channel 39, Flat Orientation, Antenna Vertically Polarized, 200 - 1000 MHz, at 3m

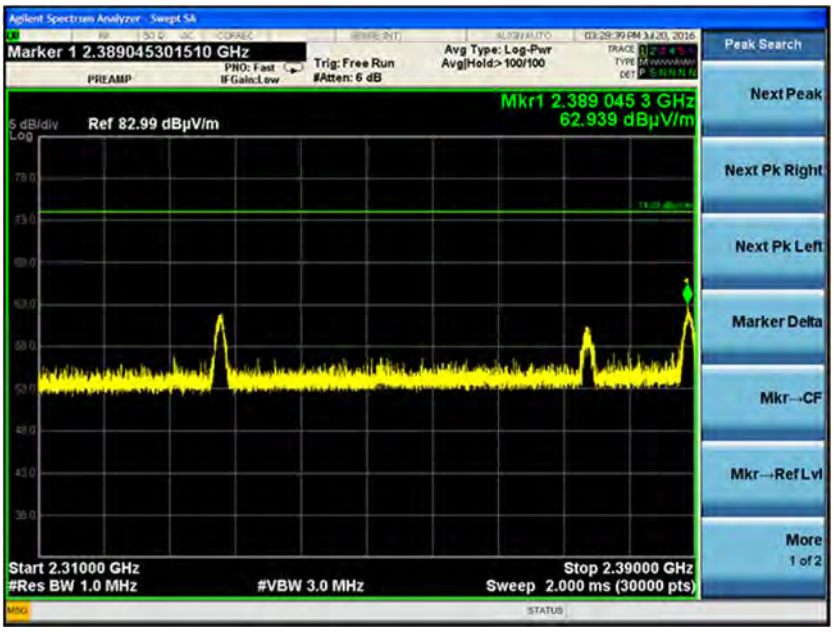
Channel 39, Side Orientation, Antenna Horizontally Polarized, 200 - 1000 MHz, at 3m

Channel 0, Vertical Orientation, Antenna Horizontally Polarized, 1000 MHz to 2310 MHz, Reduced VBW

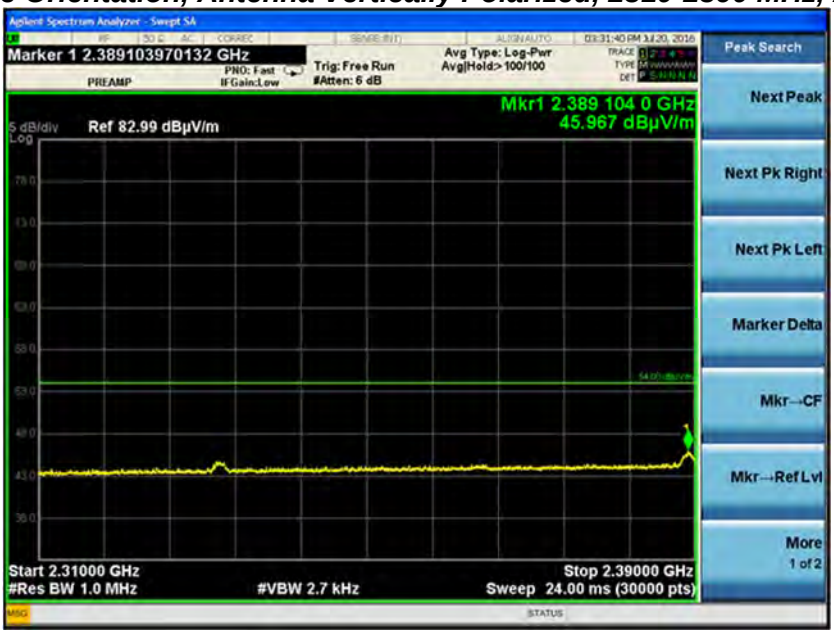
Channel 0, Side Orientation, Antenna Vertically Polarized, 1000 MHz to 2310 MHz, Reduced VBW

Channel 19, Vertical Orientation, Antenna Vertically Polarized, 1000 MHz to 2310 MHz, Reduced VBW

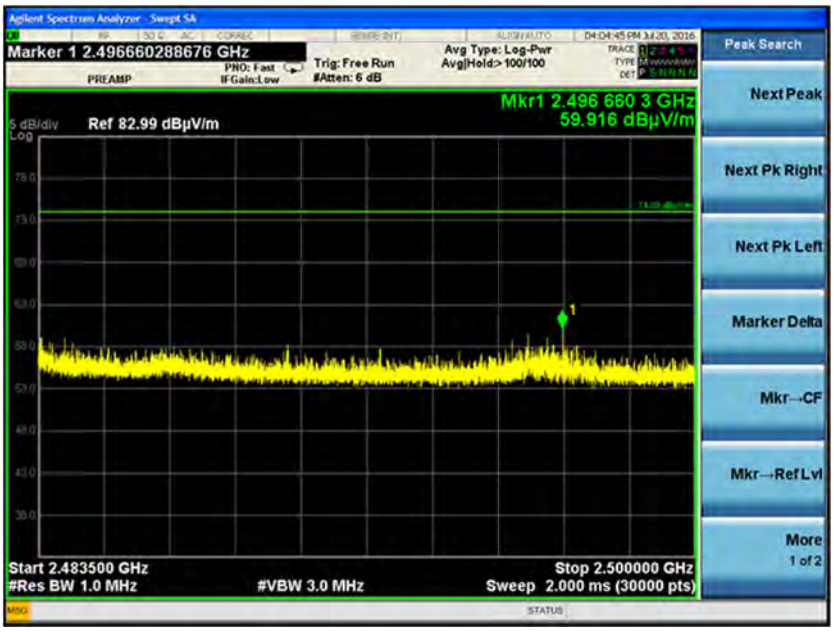
Channel 0, Side Orientation, Antenna Vertically Polarized, 2310-2390 MHz, Peak at 3m



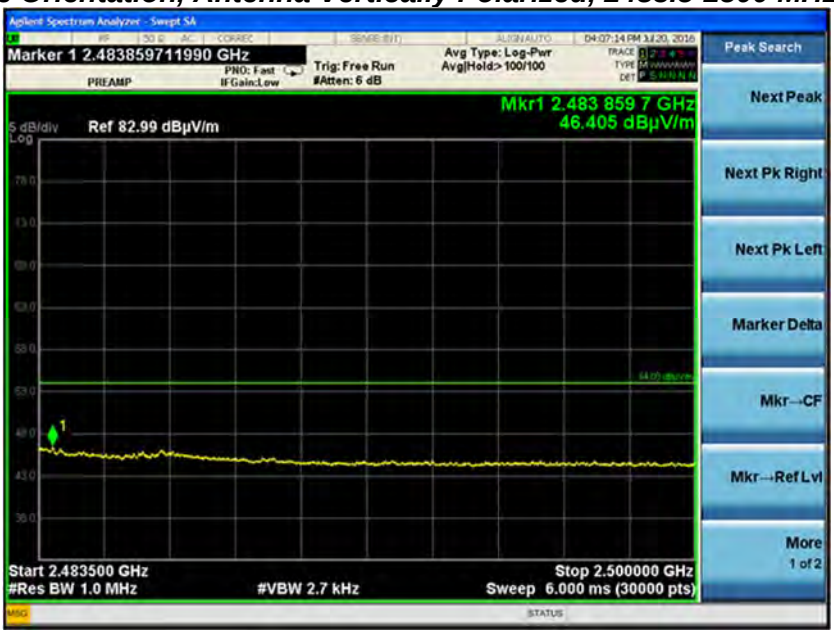
Channel 0, Side Orientation, Antenna Vertically Polarized, 2310-2390 MHz, Average at 3m



Channel 39, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Peak at 3m



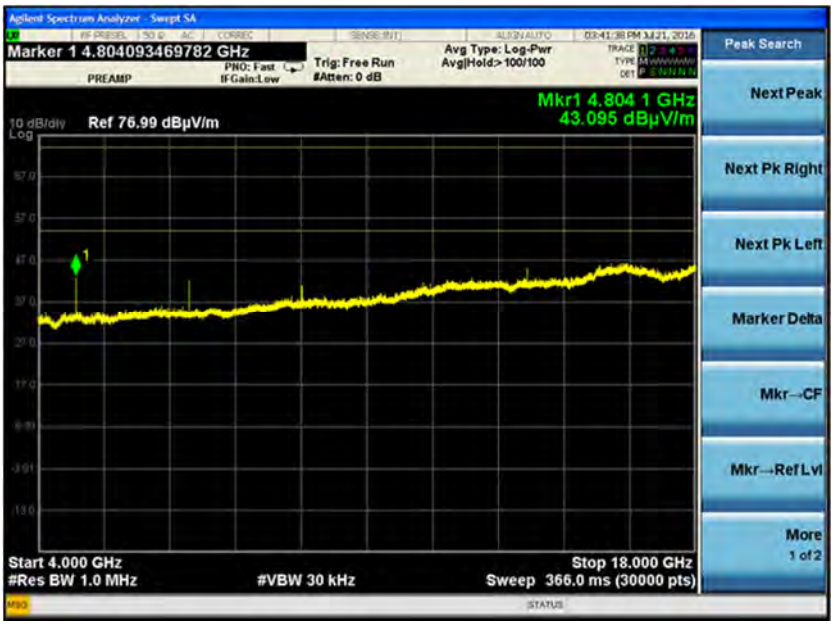
Channel 39, Side Orientation, Antenna Vertically Polarized, 2483.5-2500 MHz, Average at 3m



Channel 39, Vertical Orientation, Antenna Horizontally Polarized, 2500 MHz to 4000 MHz, Reduced VBW

Channel 39, Vertical Orientation, Antenna Vertically Polarized, 2500 MHz to 4000 MHz, Reduced VBW

Channel 0, Side Orientation, Antenna Vertically Polarized, 4-18 GHz, Reduced VBW at 3m



Channel 0, Side Orientation, Antenna Horizontally Polarized, 4-18 GHz, Reduced VBW at 3m

Channel 19, Flat Orientation, Antenna Horizontally Polarized, 4-18 GHz, Reduced VBW at 3m

Channel 39, Flat Orientation, Antenna Horizontally Polarized, 4-18 GHz, Reduced VBW at 3m

Channel 0, Side Orientation, Antenna Horizontally Polarized, 18-25 GHz, Reduced VBW at 3m

Channel 19, Side Orientation, Antenna Horizontally Polarized, 18-25 GHz, Reduced VBW at 3m

Channel 19, Vertical Orientation, Antenna Vertically Polarized, 18-25 GHz, Reduced VBW at 3m

EXHIBIT 6. OCCUPIED BANDWIDTH

6.1 - Limits

For a Digital Transmission System, the 6 dB bandwidth shall be at least 500 kHz per CFR 47 Part 15.247.

6.2 - Method of Measurements

Refer to ANSI C63.10 (2013) Section 11.8.

The transmitter output was connected to the Spectrum Analyzer via a 10 dB attenuator. The bandwidth requirement found in FCC Part 15.247(a)(2) and the applicable Canadian standard requires a minimum -6 dB occupied bandwidth of 500 kHz. The EUT was coupled to a low loss cable via a U.FL connector and provided to the spectrum analyzer via the 10 dB attenuator see images. The EUT was connected to a programming board that enabled modification of data rate, modulation type, and output power, thereby promoting quick and efficient collection of all applicable measurements. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, thereby allowing direct measurements, without the need for any further corrections. The EUT was configured to run in a continuous transmit mode.

6.3 - Test Equipment List

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

6.4 - Test Data

BLE:

Channel Frequency (MHz)	6 dB Bandwidth (MHz)	6 dB Bandwidth Minimum Limit (MHz)	99% Bandwidth (MHz)	Margin (MHz)
2402	0.665	0.500	1.041	0.165
2440	0.665	0.500	1.041	0.165
2480	0.665	0.500	1.045	0.165

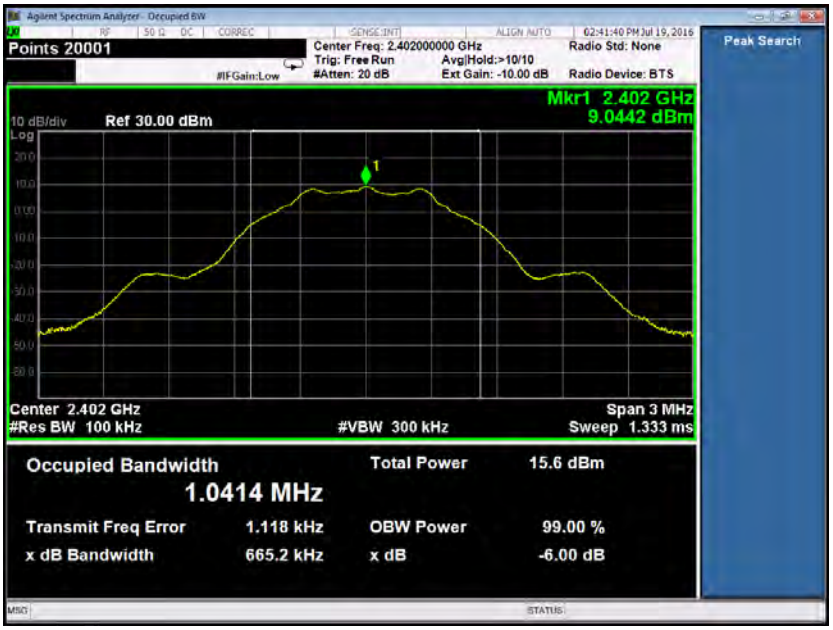
WLAN:

Data Rate (MBPS)	Channel	6dB Bandwidth (MHz)	6dB Bandwidth minimum limit (MHz)	99% Bandwidth (MHz)	Margin (MHz)
1 (DBPSK)	1	9.500	0.500	13.900	9.000
	6	9.100	0.500	13.900	8.600
	11	9.100	0.500	13.900	8.600
11 (8QPSK)	1	10.100	0.500	14.400	9.600
	6	10.100	0.500	14.400	9.600
	11	10.100	0.500	14.400	9.600
6 (BPSK)	1	15.400	0.500	16.500	14.900
	6	15.300	0.500	16.500	14.800
	11	15.300	0.500	16.500	14.800
54 (64QAM)	1	16.400	0.500	16.500	15.900
	6	16.400	0.500	16.500	15.900
	11	16.300	0.500	16.400	15.800
MCS0 (BPSK)	1	15.100	0.500	17.700	14.600
	6	15.400	0.500	17.700	14.900
	11	15.300	0.500	17.700	14.800
MCS7 (64QAM)	1	16.700	0.500	17.600	16.200
	6	16.900	0.500	17.700	16.400
	11	16.500	0.500	17.700	16.000

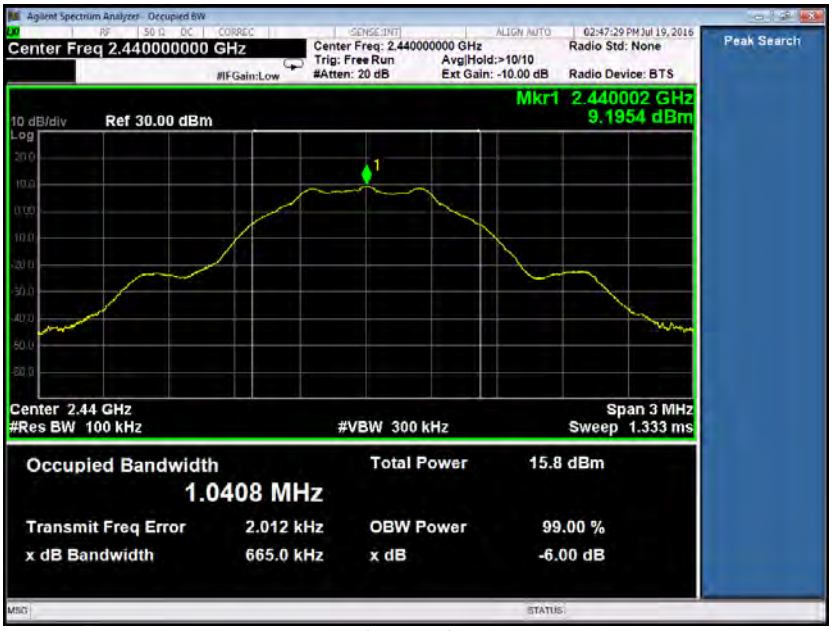
6.5 - Screen Captures – DTS Occupied Bandwidth (-6 dB BW)

BLE:

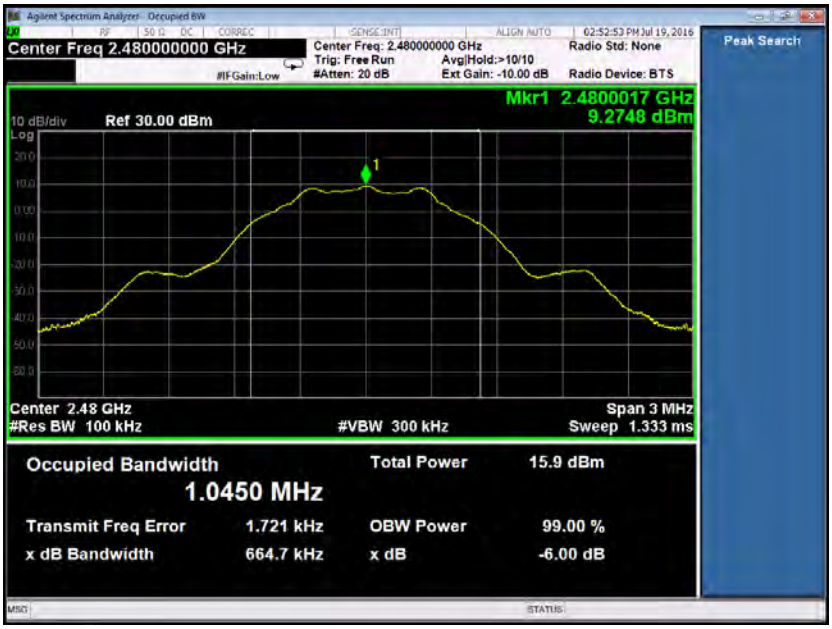
Channel 0



Channel 19



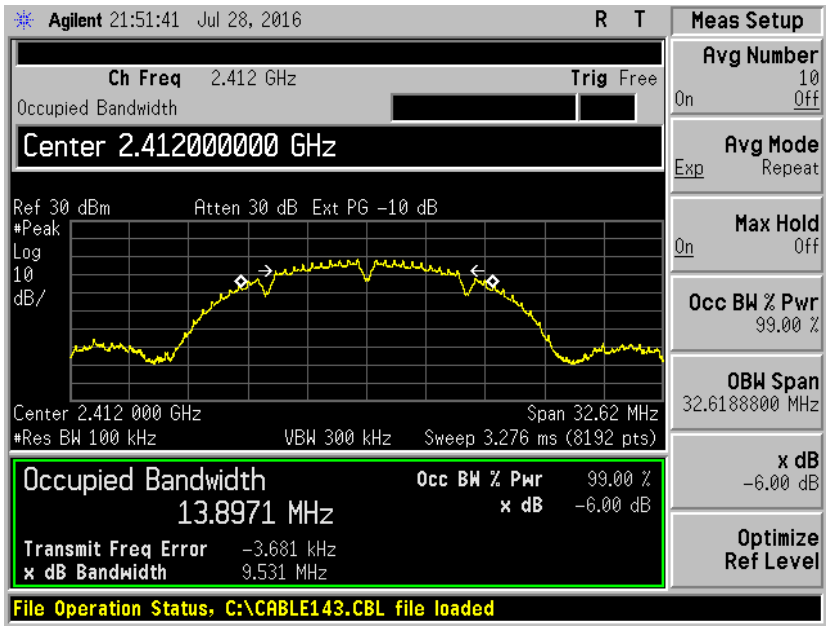
Channel 39



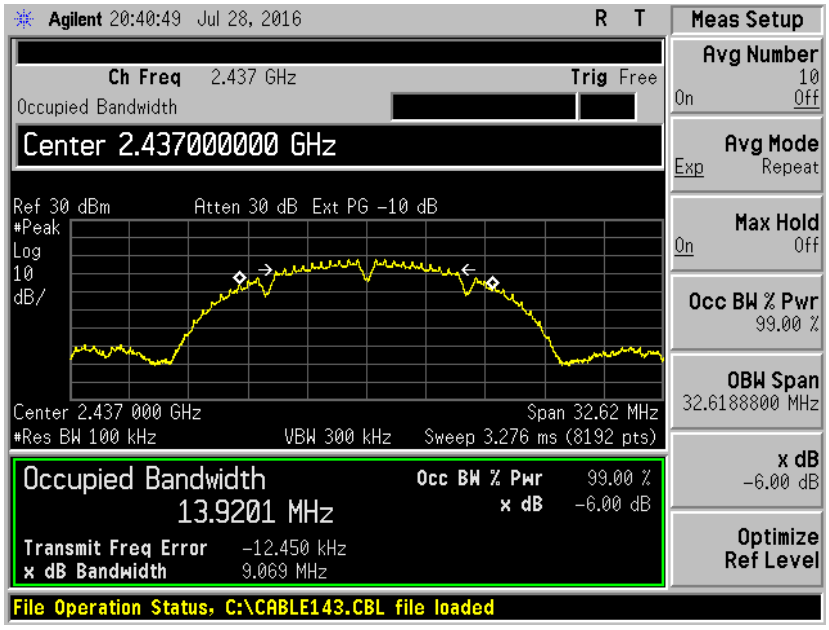
WLAN

1 Mbps Data Rate:

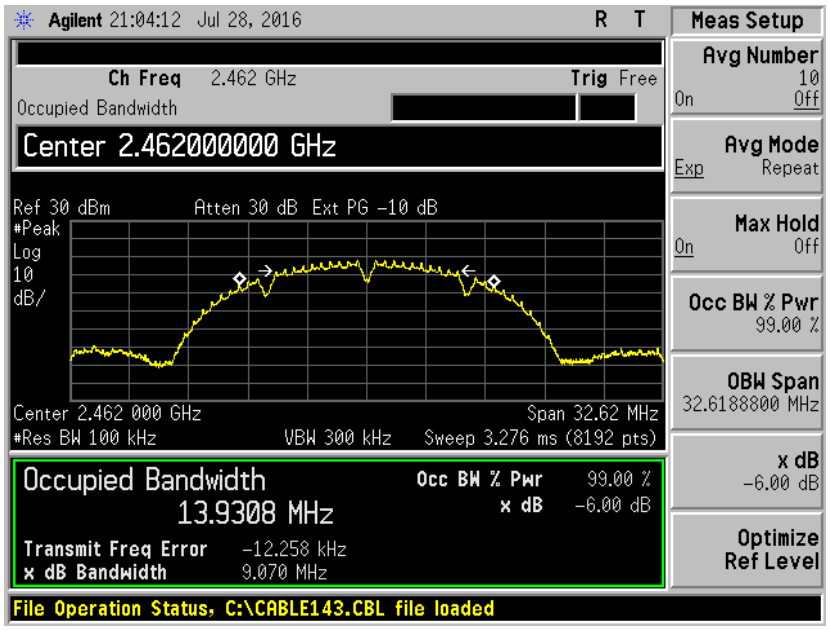
Channel 1



Channel 6

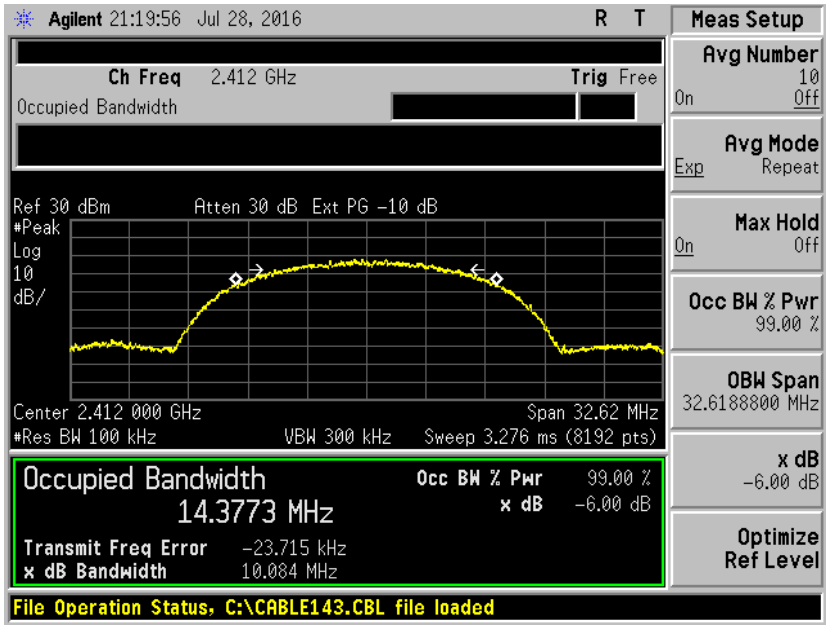


Channel 11

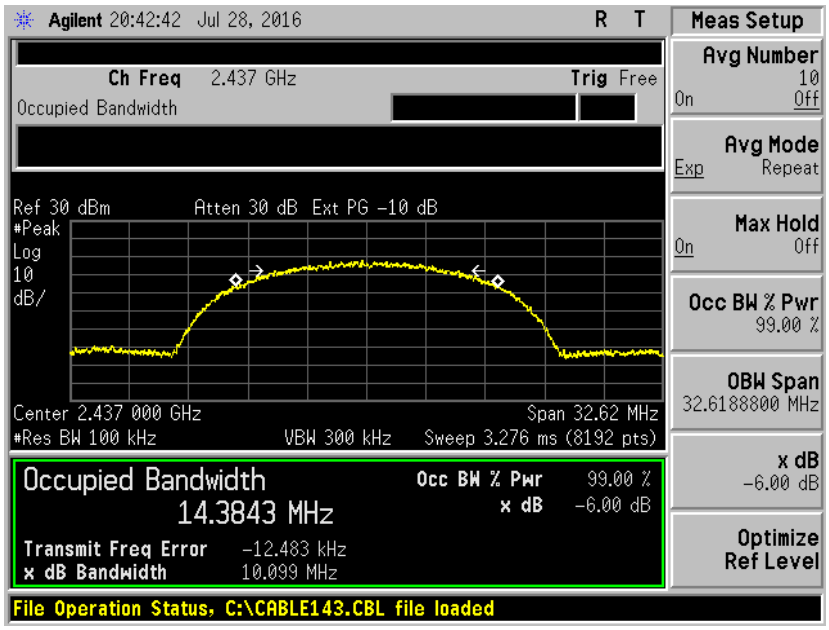


11 MBPS Data Rate:

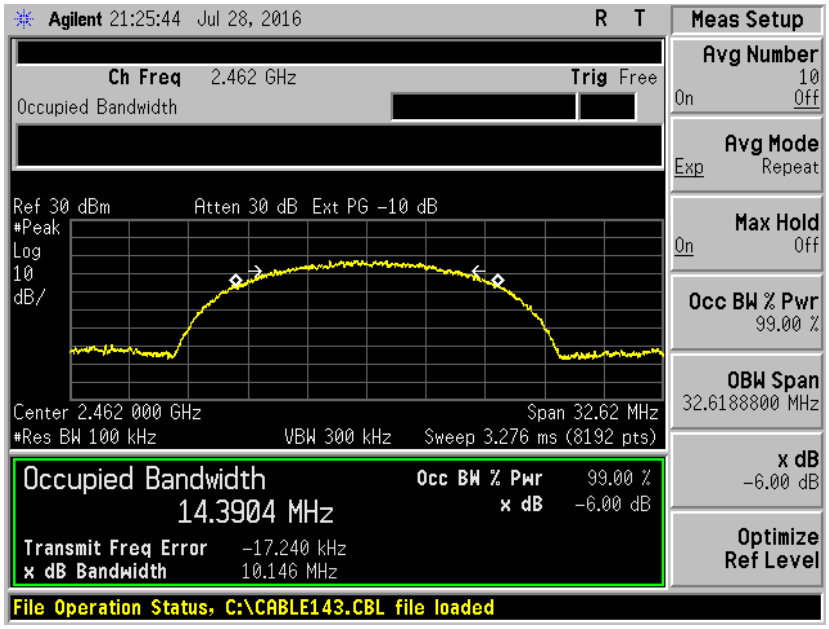
Channel 1



Channel 6

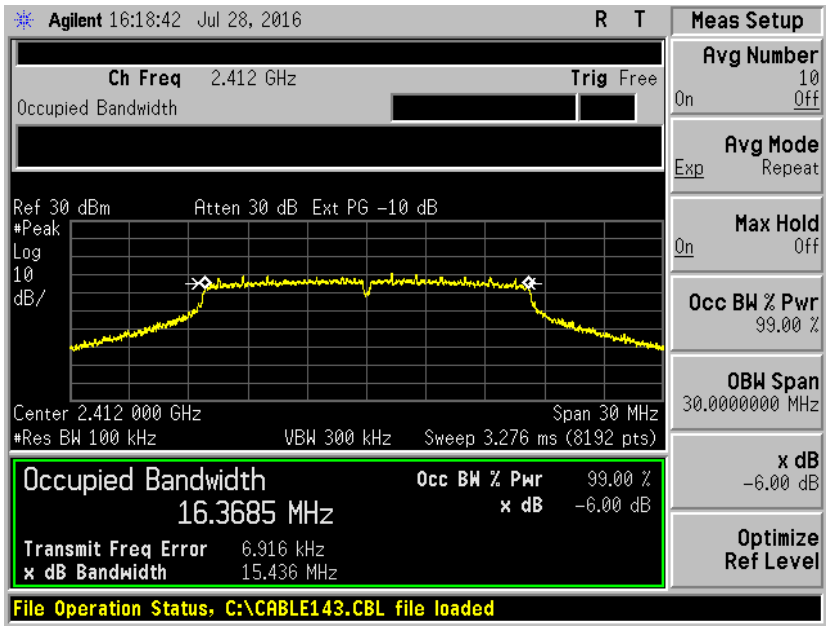


Channel 11

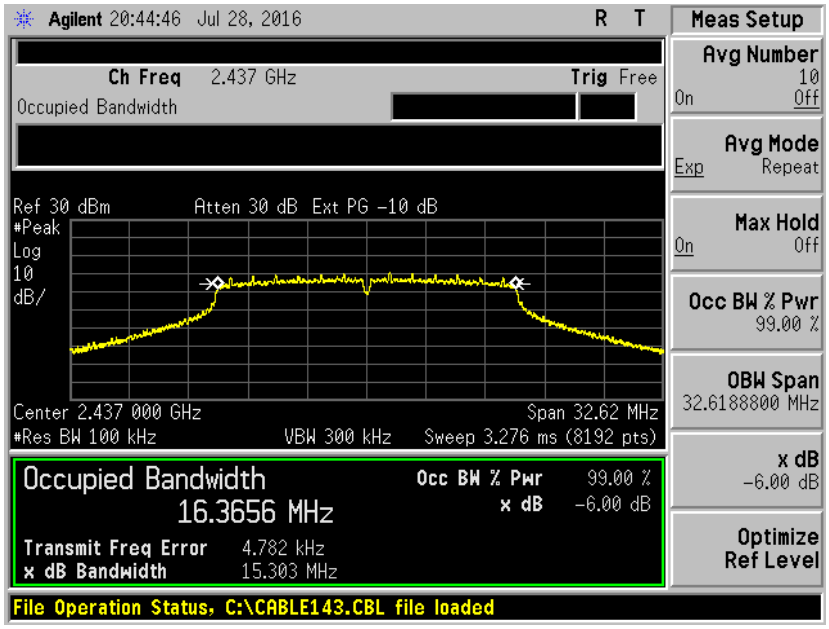


6 MBPS Data Rate:

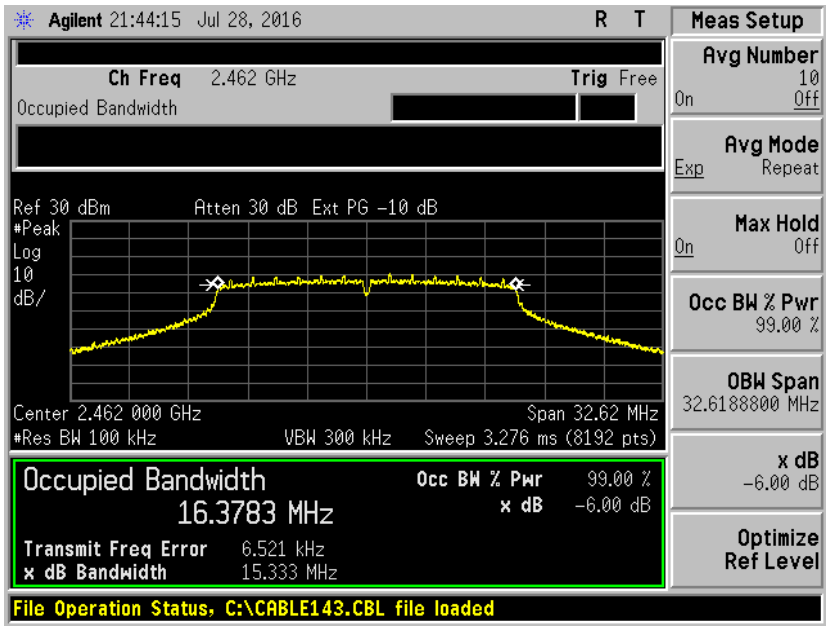
Channel 1



Channel 6

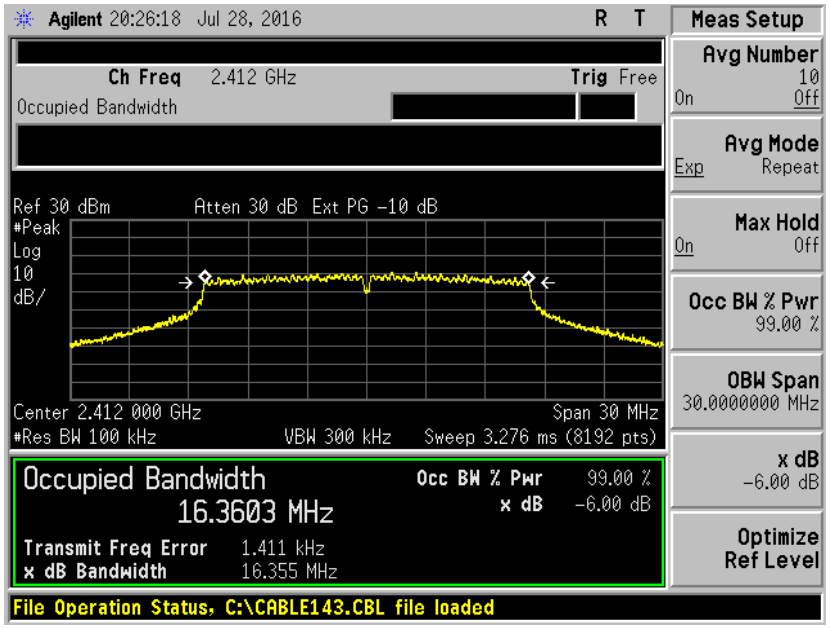


Channel 11

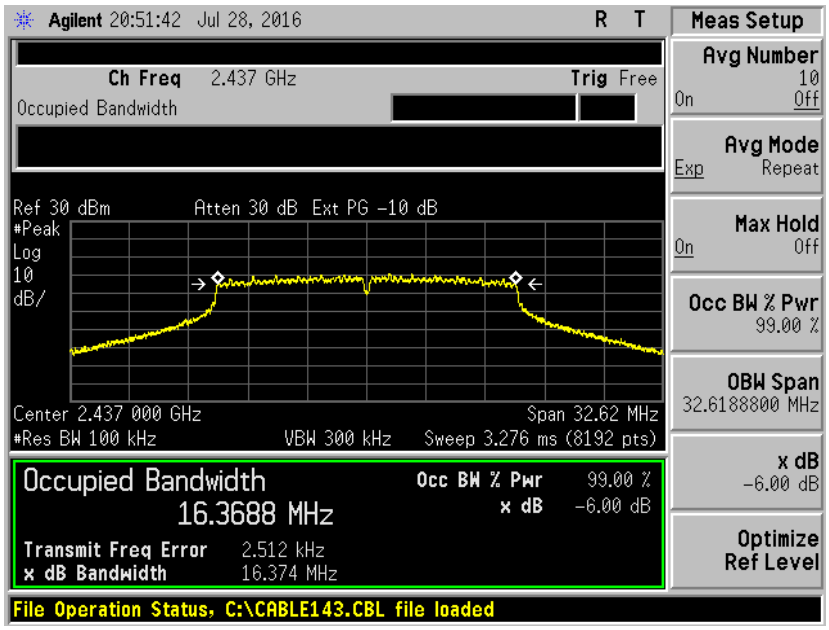


54 MBPS Data Rate:

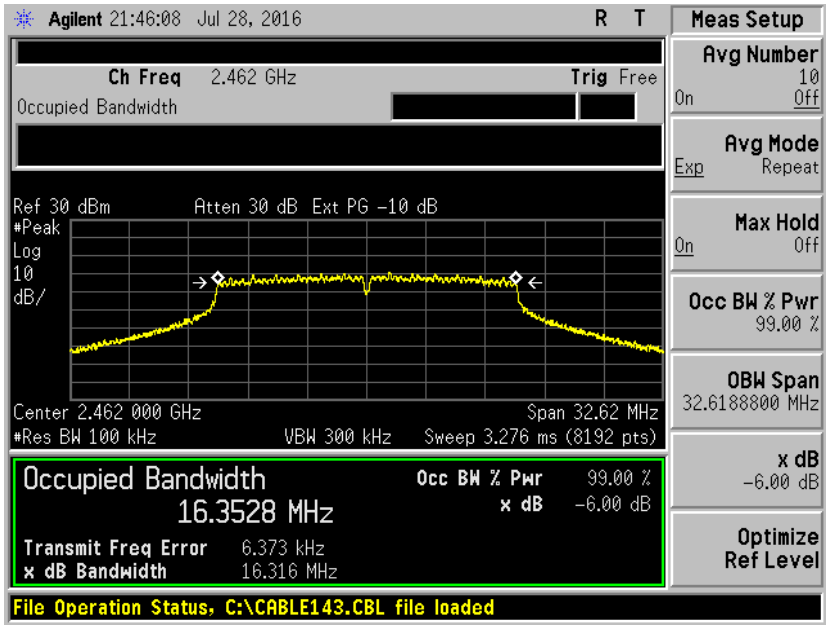
Channel 1



Channel 6

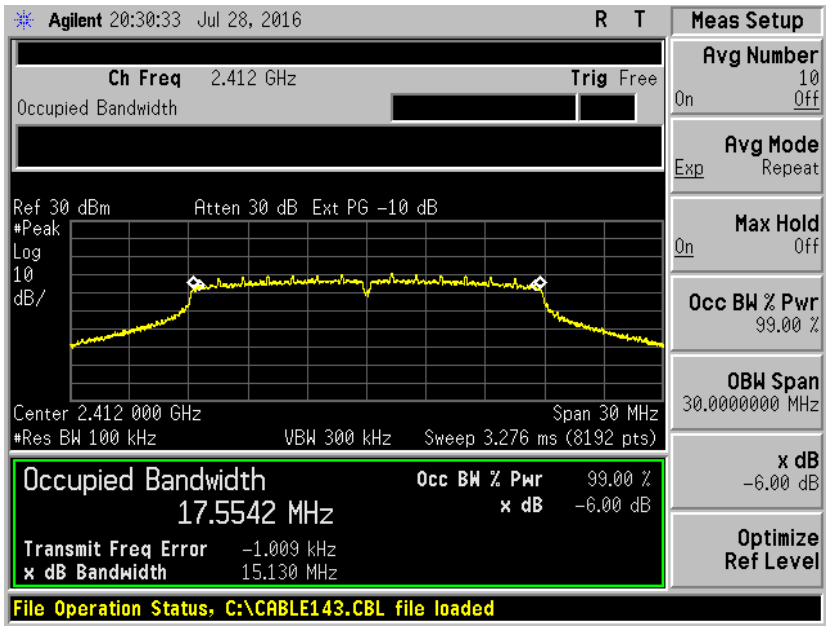


Channel 11

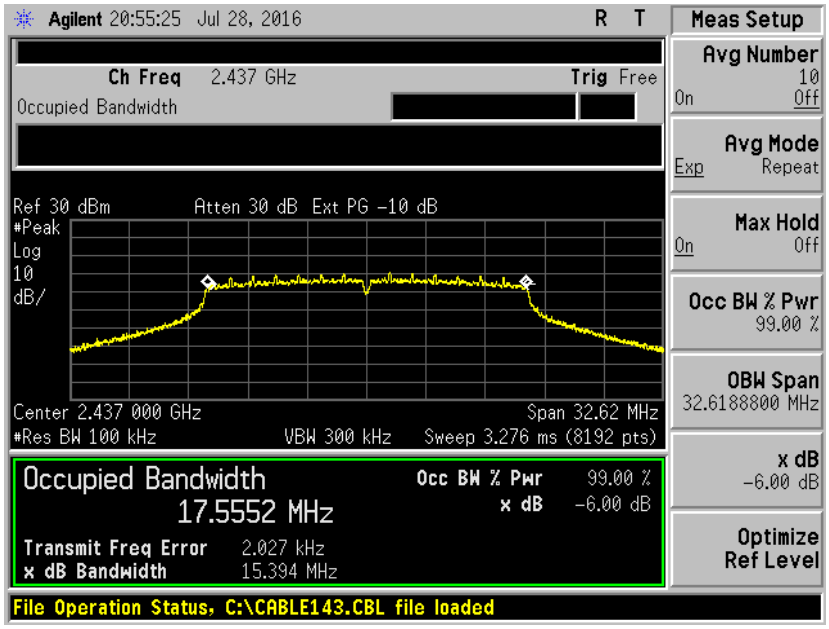


MCS0 Data Rate:

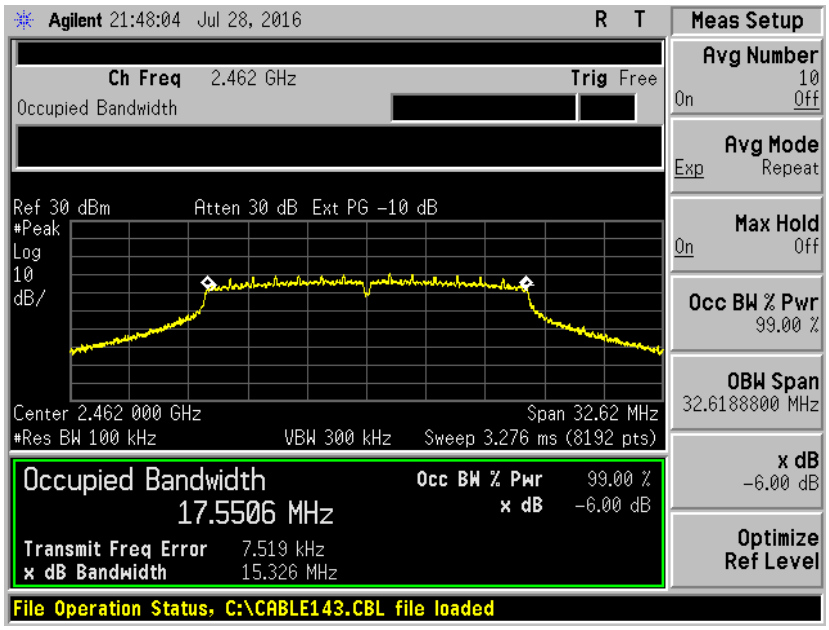
Channel 1



Channel 6

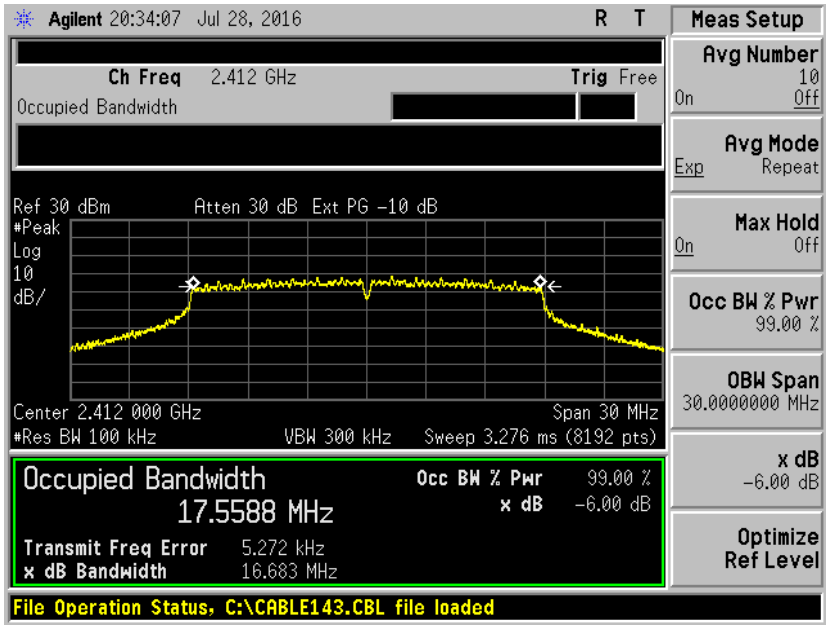


Channel 11

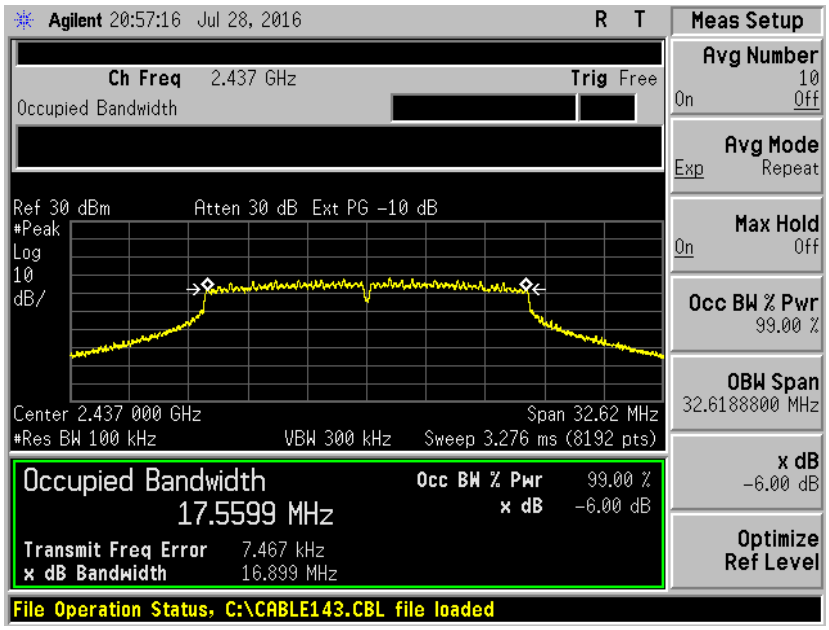


MCS7 Data Rate:

Channel 1



Channel 6



Channel 11

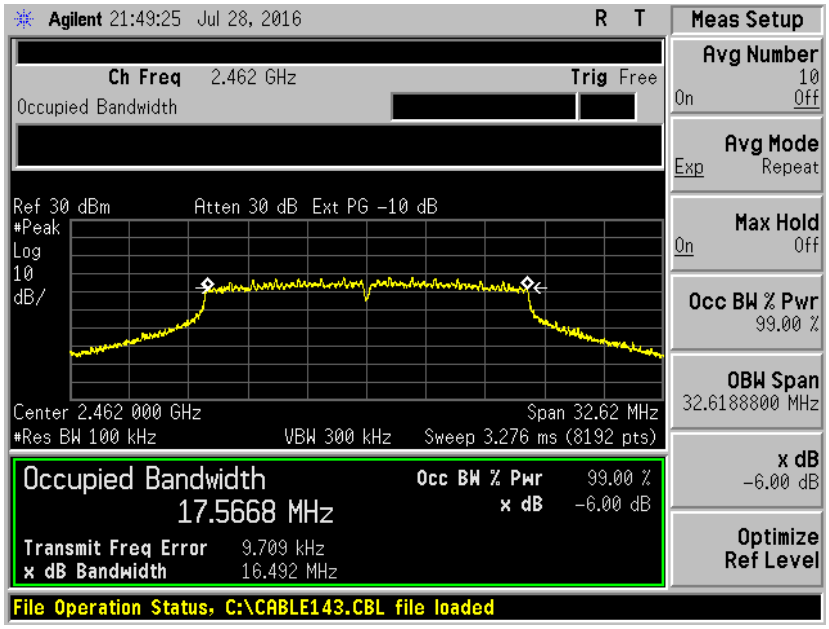


EXHIBIT 7. BAND EDGE MEASUREMENTS

7.1 - Method of Measurements

47 CFR Part 15.247(d) requires spurious emission levels to be at least 20 dB lower than the radio frequency power produced by the intentional radiator. 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 at each data rate and modulation type. The EUT operated at the low channel for investigation of the lower band-edge, and at the high channel for the investigation of the upper band-edge. The delta measurement represents the margin between the peak fundamental emission and the band edge or highest modulation product of the fundamental emission, whichever is higher.

7.2 - BLE

Screen Capture Demonstrating Compliance at the Lower Band-Edge

Screen Captures Demonstrating Compliance at the Upper Band-Edge

7.2 - WLAN

1 MBPS

Screen Capture Demonstrating Compliance at the Lower Band-Edge

Screen Capture Demonstrating Compliance at the Upper Band-Edge

11 MBPS

Screen Capture Demonstrating Compliance at the Lower Band-Edge

Screen Capture Demonstrating Compliance at the Upper Band-Edge

6 MBPS

Screen Capture Demonstrating Compliance at the Lower Band-Edge

Screen Capture Demonstrating Compliance at the Upper Band-Edge

54 MBPS

Screen Capture Demonstrating Compliance at the Lower Band-Edge

Screen Capture Demonstrating Compliance at the Upper Band-Edge

MCS0

Screen Capture Demonstrating Compliance at the Lower Band-Edge

Screen Capture Demonstrating Compliance at the Upper Band-Edge

MCS7

Screen Capture Demonstrating Compliance at the Lower Band-Edge

Screen Capture Demonstrating Compliance at the Upper Band-Edge

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. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. For BLE, a spectrum analyzer was used and configured to detect maximum peak conducted output power using a 1 MHz resolution bandwidth and 8 MHz video bandwidth. For WLAN, a power meter was used to measure the maximum peak conducted output power using the procedural guidance provided by ANSI C63.10 Section 11.9.1.3. The power meter captures are not shown.

8.2 - Test Equipment List

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

8.3 - Test Data

BLE:

Channel Frequency (MHz)	Max Peak Conducted Output Power (dBm)	Power Limit (dBm)	Margin (dB)
2402	9.076	30.000	20.924
2440	9.173	30.000	20.827
2480	9.272	30.000	20.728

WLAN:

Data Rate (MBPS)	Channel	PEAK Maximum Cond. Output Power (dBm)	Power Limit (dBm)	Margin (dB)
1 (DBPSK)	1	18.700	30.000	11.300
	6	19.100	30.000	10.900
	11	19.100	30.000	10.900
11 (8QPSK)	1	18.700	30.000	11.300
	6	18.800	30.000	11.200
	11	18.700	30.000	11.300
6 (BPSK)	1	21.100	30.000	8.900
	6	20.300	30.000	9.700
	11	21.500	30.000	8.500
54 (64QAM)	1	20.900	30.000	9.100
	6	21.100	30.000	8.900
	11	21.000	30.000	9.000
MCS0 (BPSK)	1	20.800	30.000	9.200
	6	21.000	30.000	9.000
	11	20.500	30.000	9.500
MCS7 (64QAM)	1	18.000	30.000	12.000
	6	17.400	30.000	12.600
	11	18.200	30.000	11.800

8.4 - Screen Captures – Power Output (Conducted)

BLE:

Channel 0

Channel 19

Channel 39


Agilent Spectrum Analyzer - Swept SA
Marker 1 2.479987582919 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
Atten: 20 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
Ext Gain: -10.00 dB
03:24:45 PM Jul 19, 2016
Mkr1 2.479 987 58 GHz
9.272 dBm
10 dB/div
Log
Ref 20.00 dBm
Center 2.480000 GHz
#Res BW 1.0 MHz
#VBW 8.0 MHz
Span 5.000 MHz
Sweep 2.000 ms (30000 pts)
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2

EXHIBIT 9. POWER SPECTRAL DENSITY: 15.247(e)

9.1 - Limits

For digital transmission systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission per 47 CFR Part 15 Section 247(e) and the applicable Canadian standard.

In accordance with FCC Part 15.247(e) and the applicable Canadian standard, the peak power spectral density should not exceed 8 dBm in any 3 kHz band. The peak output frequency for each representative frequency was scanned, with a narrow resolution bandwidth, and reduced sweep, and a power density measurement was performed. The resolution bandwidth was reduced to no less than 3 kHz to meet the 8 dBm limit for both BLE and WLAN operational modes.

9.2 - Test Equipment List

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

9.3 - Test Data

BLE:

Channel Frequency (MHz)	Peak PSD in 20 kHz RBW (dBm)	PSD Limit in 3kHz Band Limit (dBm)	PSD Margin (dBm)
2402	7.110	8.000	0.890
2440	7.240	8.000	0.760
2480	7.323	8.000	0.677

WLAN:

802.11 Standard	Data Rate (MBPS)	Channel	PSD in 100 kHz (dBm)	PSD in 3kHz limit(dBm)	PSD margin (dBm)
b	1 (DBPSK)	1	7.891[a]	8.000	0.109
		6	7.028[b]	8.000	0.972
		11	6.682[b]	8.000	1.318
b	11 (8QPSK)	1	7.258[a]	8.000	0.742
		6	6.946[a]	8.000	1.054
		11	7.937	8.000	0.063
g	6 (BPSK)	1	0.483	8.000	7.517
		6	0.496	8.000	7.504
		11	0.581	8.000	7.419
g	54 (64QAM)	1	1.089	8.000	6.911
		6	1.026	8.000	6.974
		11	1.186	8.000	6.814
n	MCS0 (BPSK)	1	0.550	8.000	7.450
		6	0.710	8.000	7.290
		11	0.672	8.000	7.328
n	MCS7 (64QAM)	1	-1.428	8.000	9.428
		6	-1.603	8.000	9.603
		11	-1.616	8.000	9.616

a – measured in 82 kHz RBW
b – measured in 51 kHz RBW

9.4 - Screen Captures – Power Spectral Density

BLE:

Channel 0

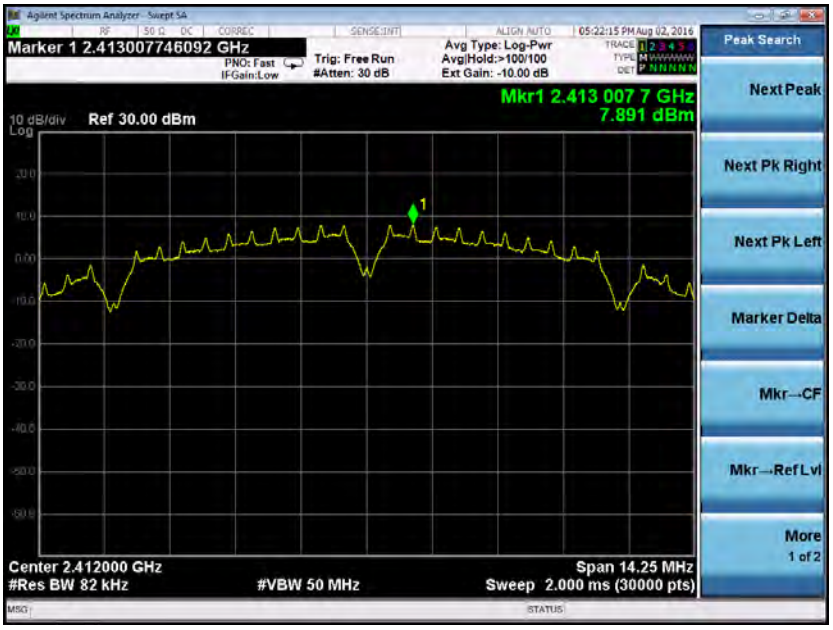
Channel 19

Channel 39

WLAN

1 Mbps:

Channel 1



Channel 6

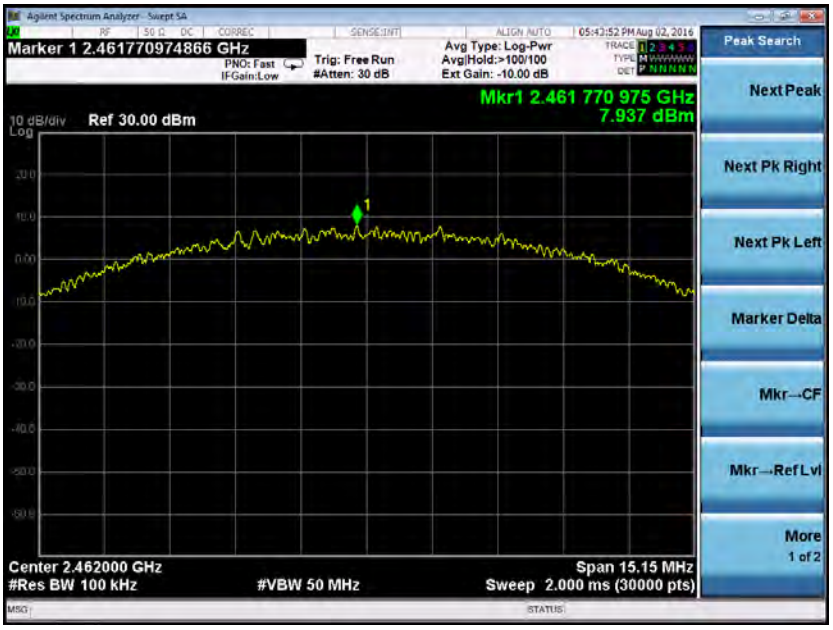
Channel 11

11 Mbps:

Channel 1

Channel 6

Channel 11



6 Mbps:

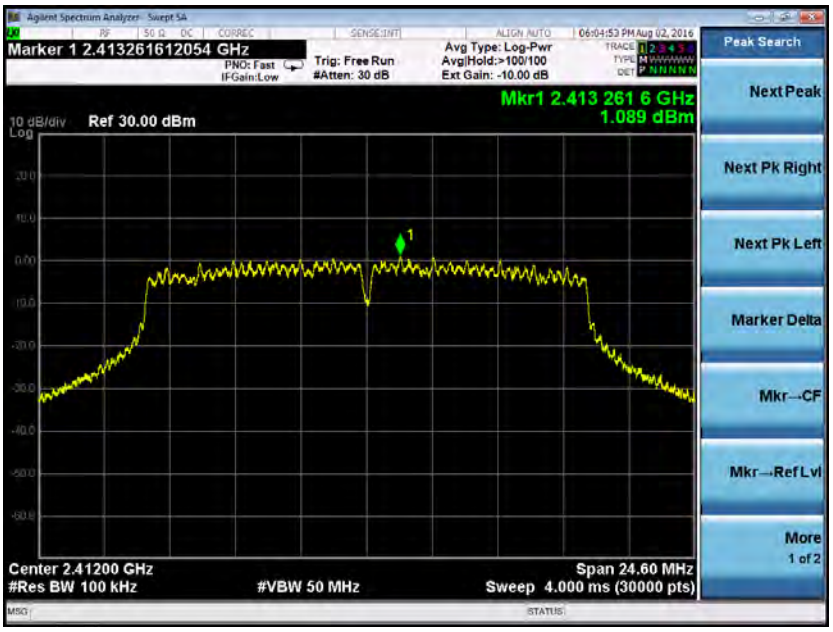
Channel 1

Channel 6

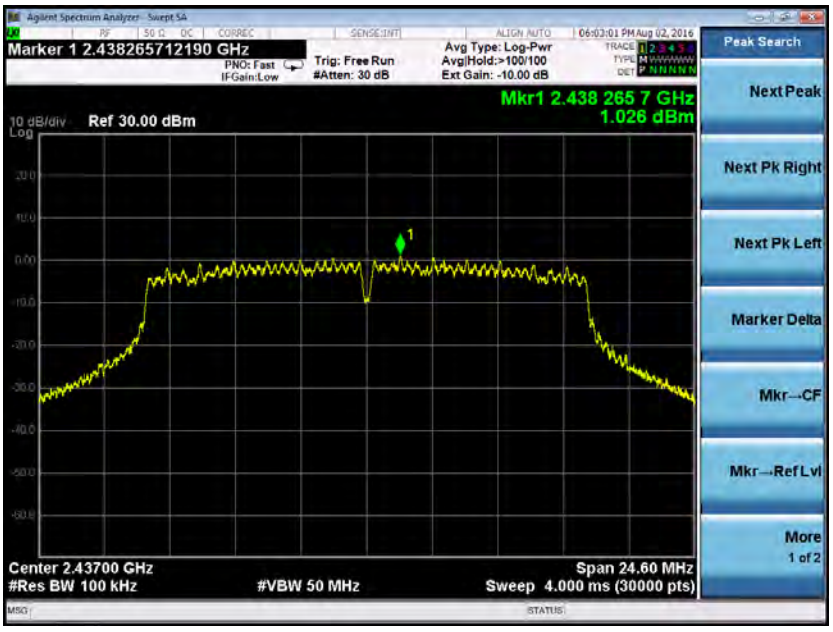
Channel 11

54 MBPS:

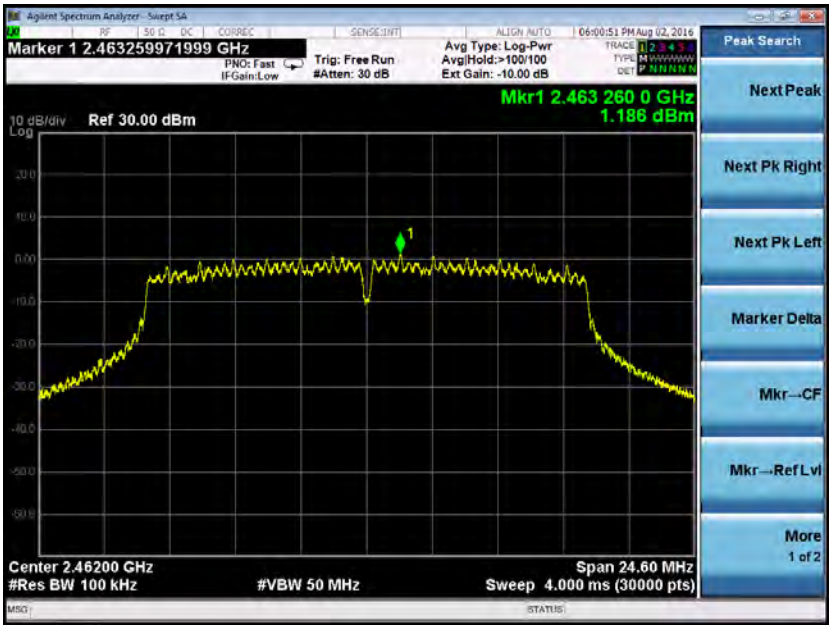
Channel 1



Channel 6



Channel 11



MCS0:

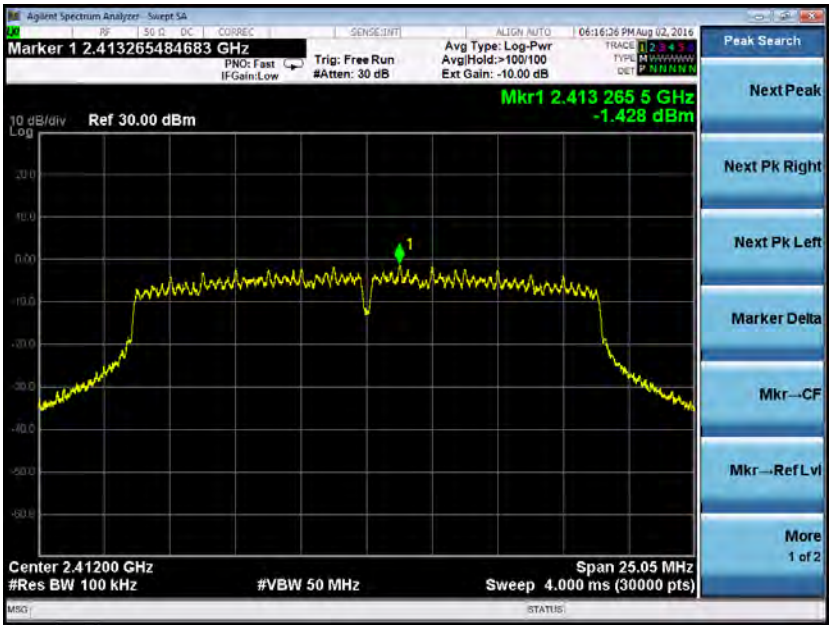
Channel 1

Channel 6

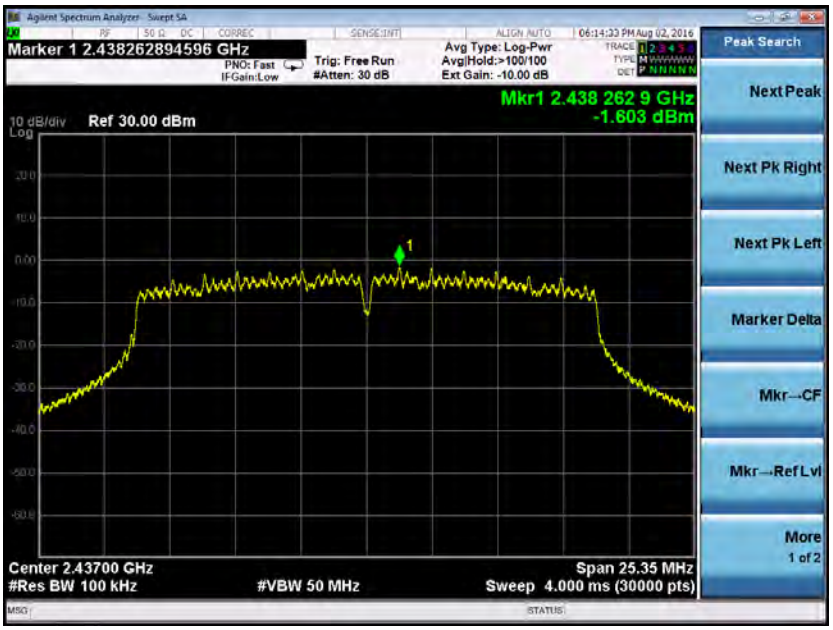
Channel 11

MCS7:

Channel 1



Channel 6



Channel 11


Agilent Spectrum Analyzer - Swept SA
Marker 1 2.463264354645 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
Ext Gain: -10.00 dB
06:12:23 PM Aug 02, 2016
Mkr1 2.463 264 4 GHz
-1.616 dBm
10 dB/div
Log
Ref 30.00 dBm
Center 2.46200 GHz
#Res BW 100 kHz
#VBW 50 MHz
Span 24.75 MHz
Sweep 4.000 ms (30000 pts)
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2

EXHIBIT 10. SPURIOUS CONDUCTED 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.

In addition, radiated emissions, which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(e)

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

10.2 – Conducted Harmonic and Spurious RF Measurements

FCC Part 15.247(d) require a measurement of conducted harmonic 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. A spectrum analyzer was used with a resolution bandwidth of 100 kHz for this portion of the test. A reference level was determined by measuring the peak conducted output power of the EUT in a 100 kHz bandwidth and subtracting 20 dB from that measurement. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer utilized a peak detector during the testing. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured. The three highest (worst case) spurious emissions are provided in the tables below for BLE and WLAN operability.

BLE:

Tx Channel	Frequency (MHz)	Peak Level (dBm)	Reference Level (dBm)	Margin (dB)
39	1653.400	-46.413	-10.730	35.683
39	826.700	-48.327	-10.730	37.597
19	23986.00	-48.940	-10.730	38.210

WLAN:

802.11 modulation	Data Rate	Tx Channel	Frequency (MHz)	Peak Emission Level (dBm)	Reference Level (dBm)	Margin (dB)
g	6 MBPS	Low	2399.700	-31.928	-19.419	12.509
n	MCS0	Low	2399.700	-30.221	-19.290	10.931
n	MCS7	Low	2399.700	-33.809	-21.616	12.193

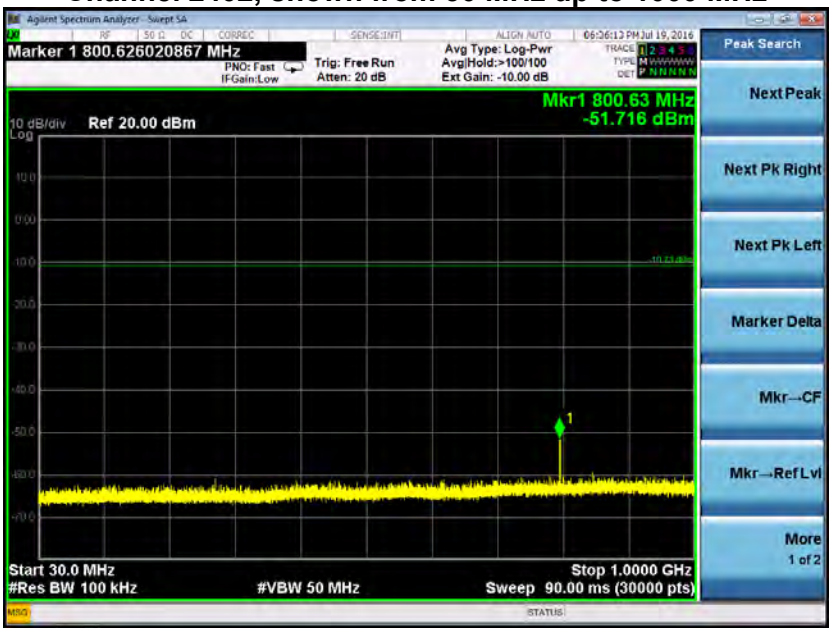
10.3 - Test Equipment List

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

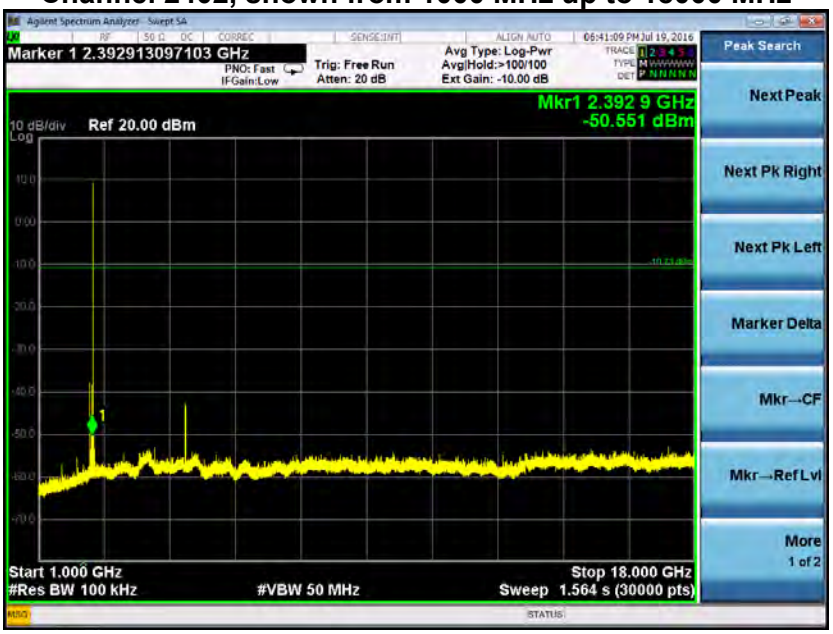
10.4 - Screen Captures – Spurious Conducted Measurements

BLE:

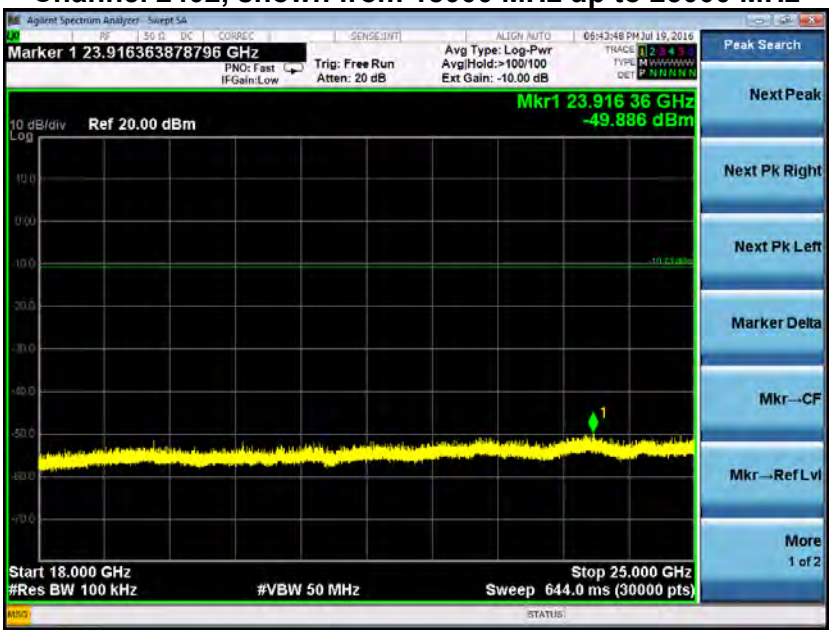
Channel 2402, shown from 30 MHz up to 1000 MHz



Channel 2402, shown from 1000 MHz up to 18000 MHz



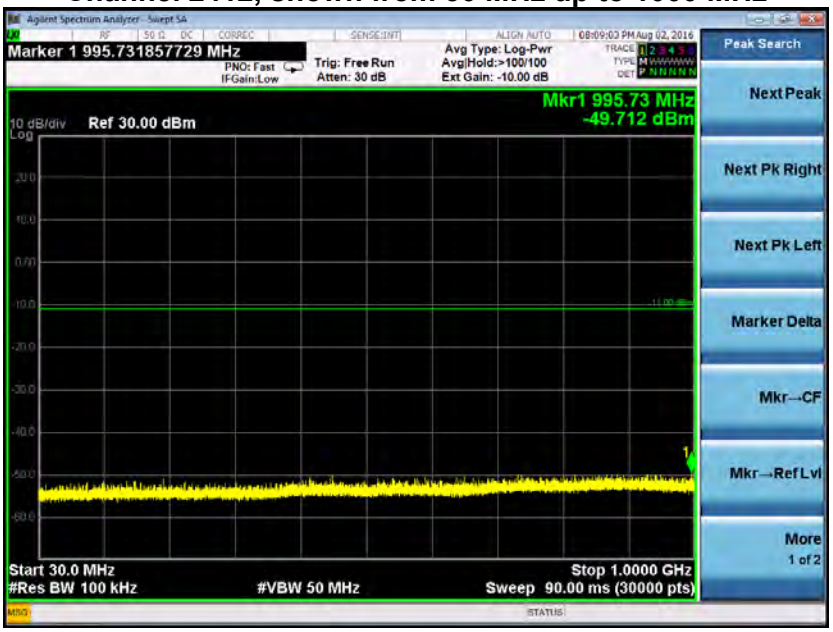
Channel 2402, shown from 18000 MHz up to 25000 MHz



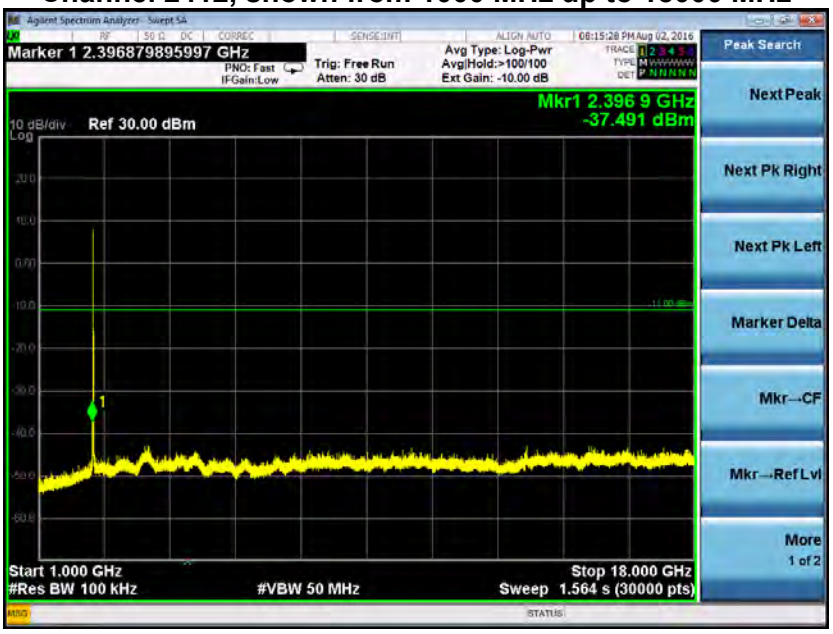
WLAN

1Mbps:

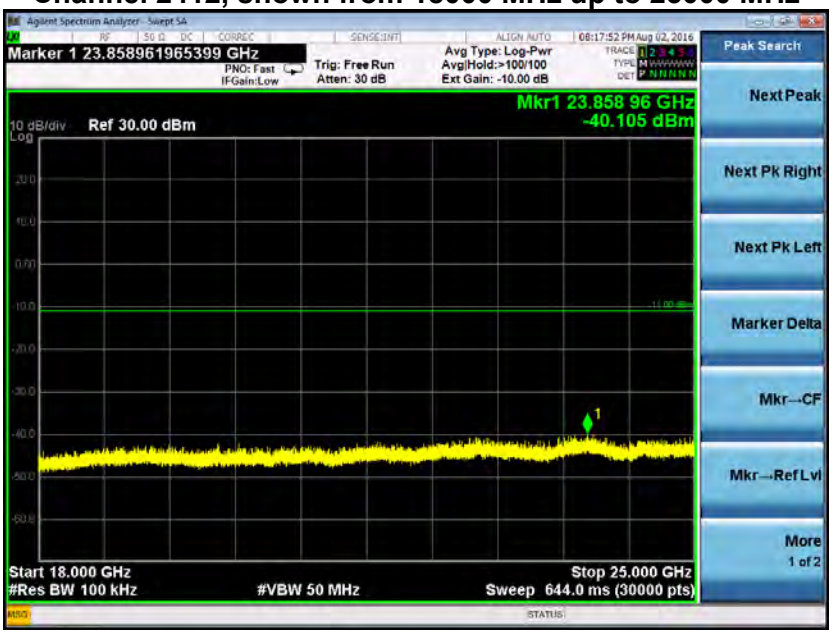
Channel 2412, shown from 30 MHz up to 1000 MHz



Channel 2412, shown from 1000 MHz up to 18000 MHz

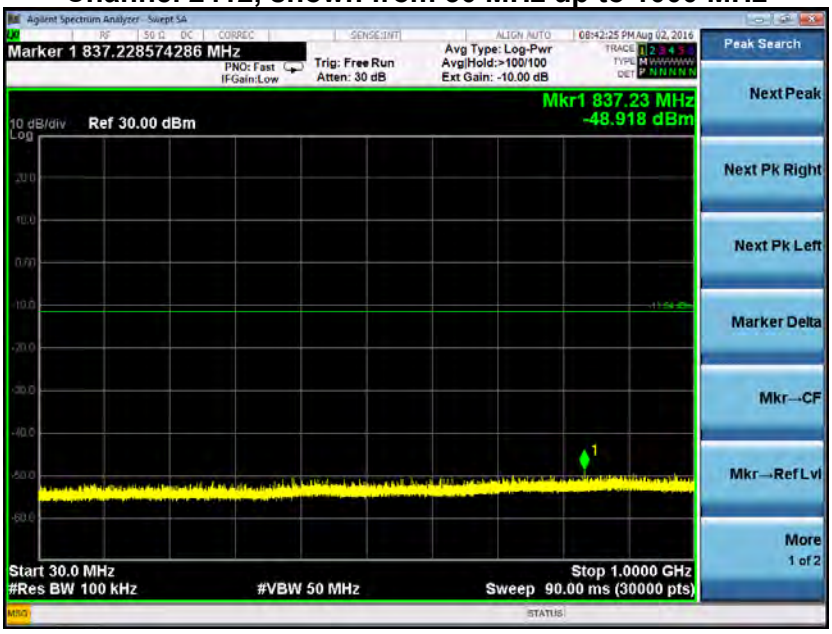


Channel 2412, shown from 18000 MHz up to 25000 MHz

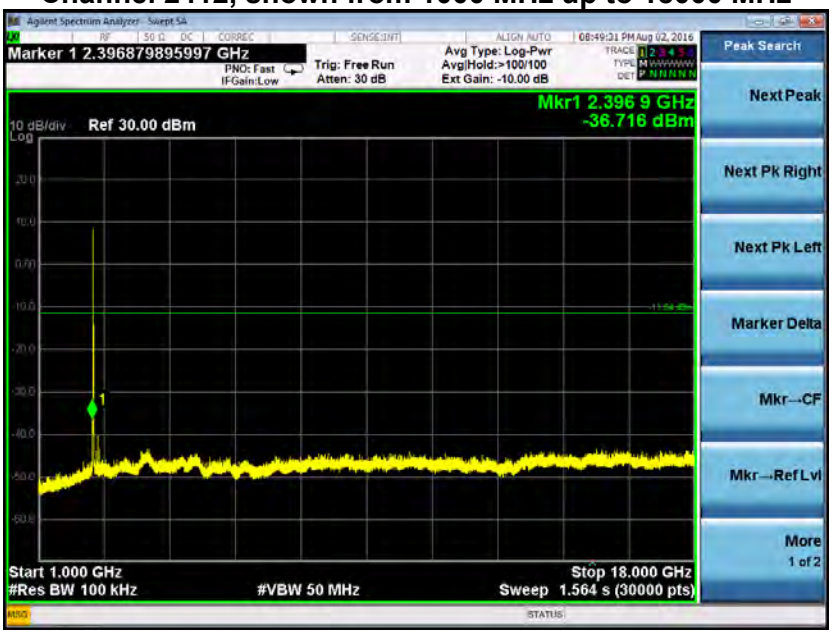


11 Mbps:

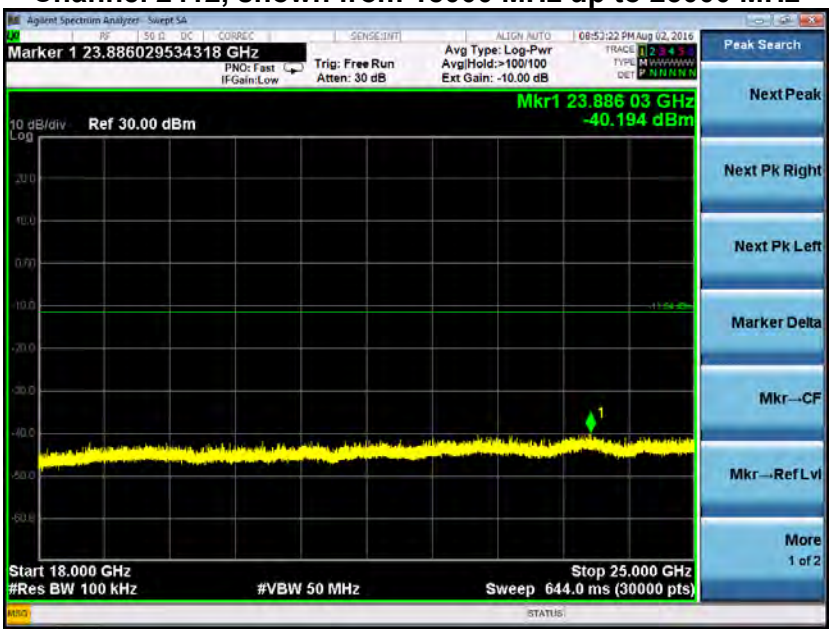
Channel 2412, shown from 30 MHz up to 1000 MHz



Channel 2412, shown from 1000 MHz up to 18000 MHz

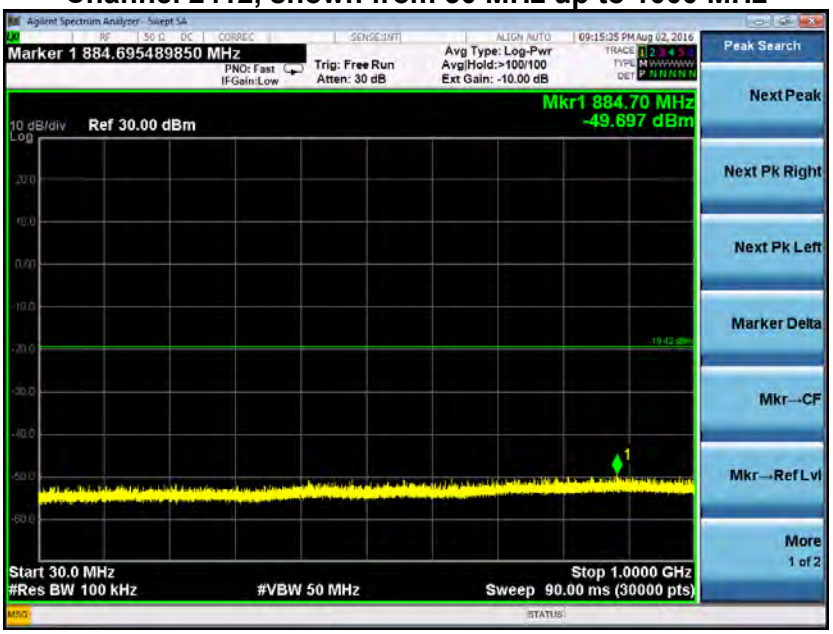


Channel 2412, shown from 18000 MHz up to 25000 MHz

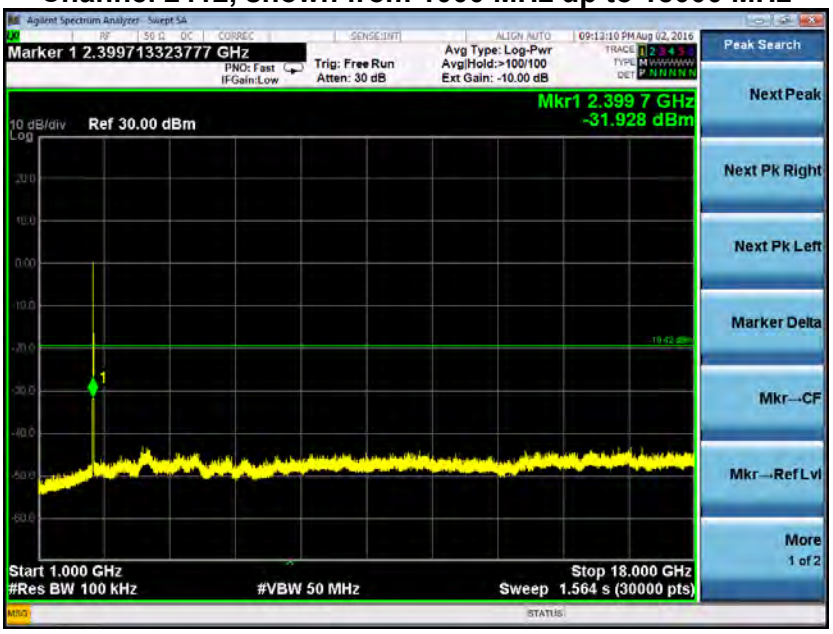


6 Mbps:

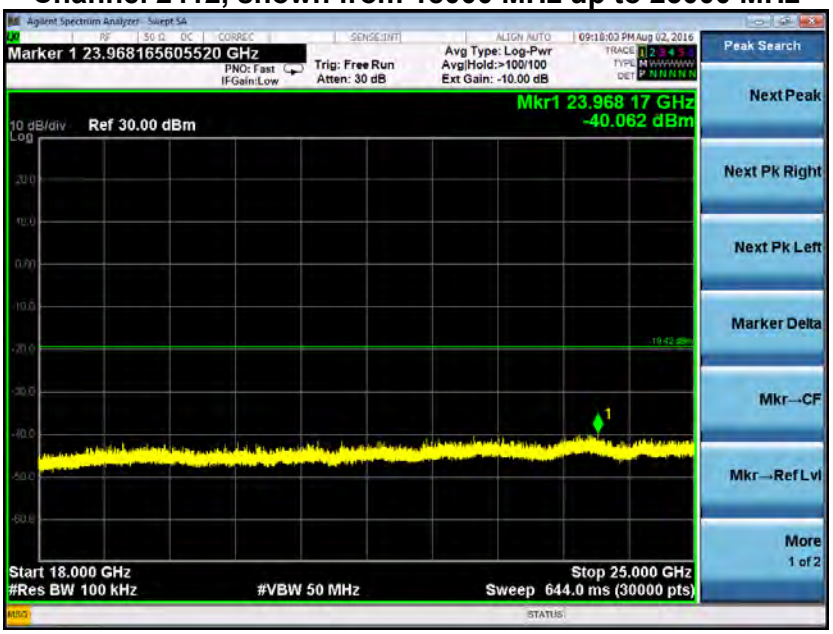
Channel 2412, shown from 30 MHz up to 1000 MHz



Channel 2412, shown from 1000 MHz up to 18000 MHz

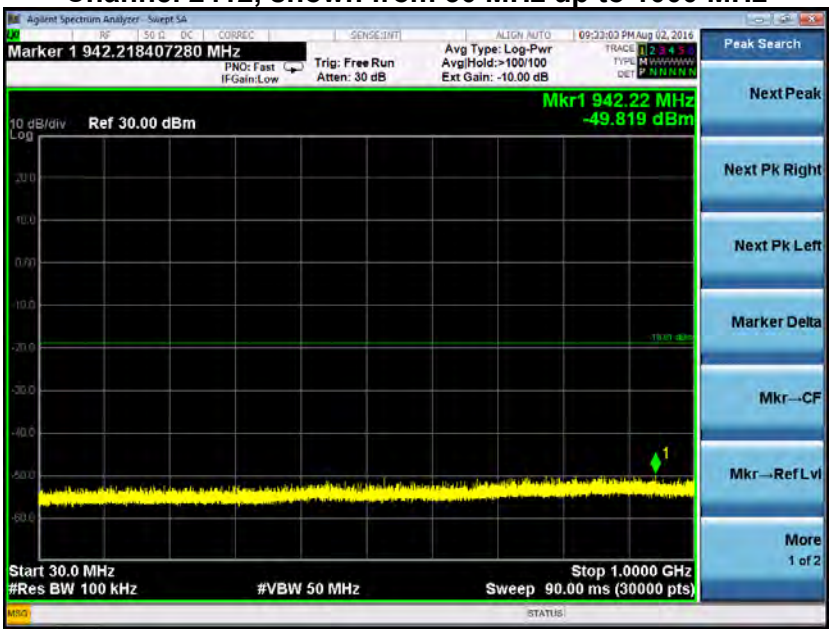


Channel 2412, shown from 18000 MHz up to 25000 MHz

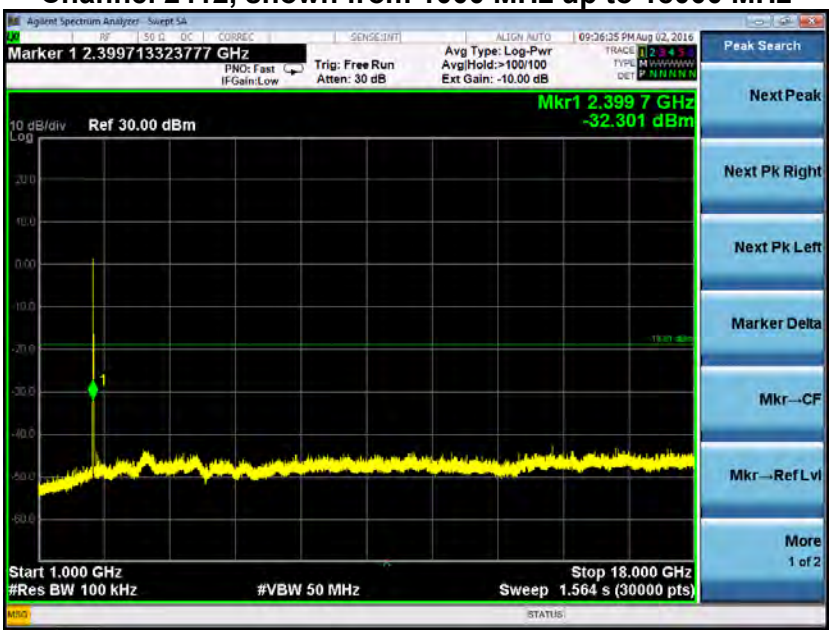


54 Mbps:

Channel 2412, shown from 30 MHz up to 1000 MHz



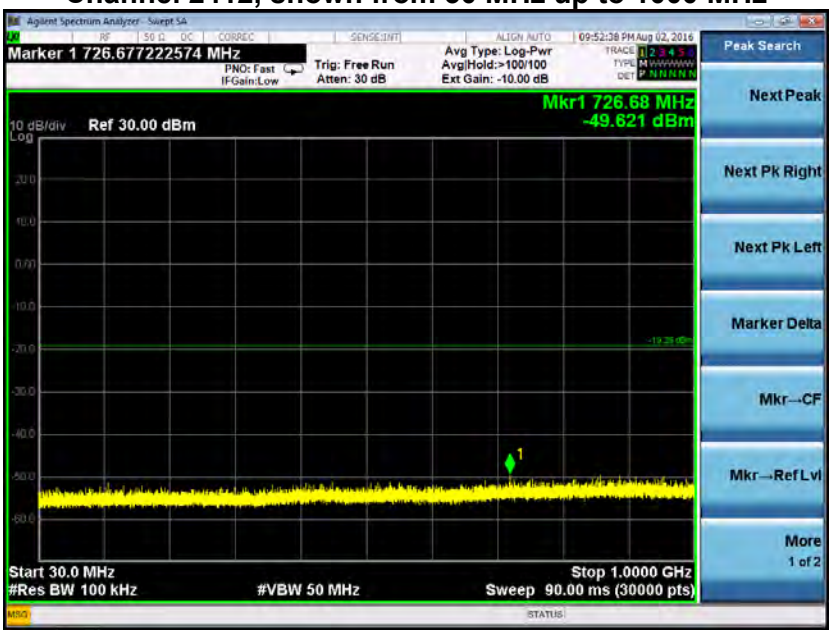
Channel 2412, shown from 1000 MHz up to 18000 MHz



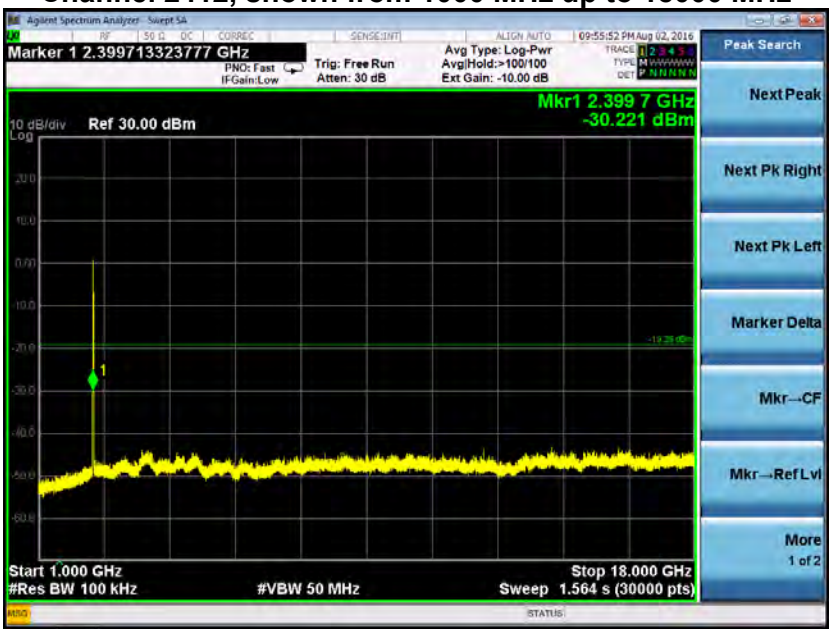
Channel 2412, shown from 18000 MHz up to 25000 MHz

MCS0:

Channel 2412, shown from 30 MHz up to 1000 MHz



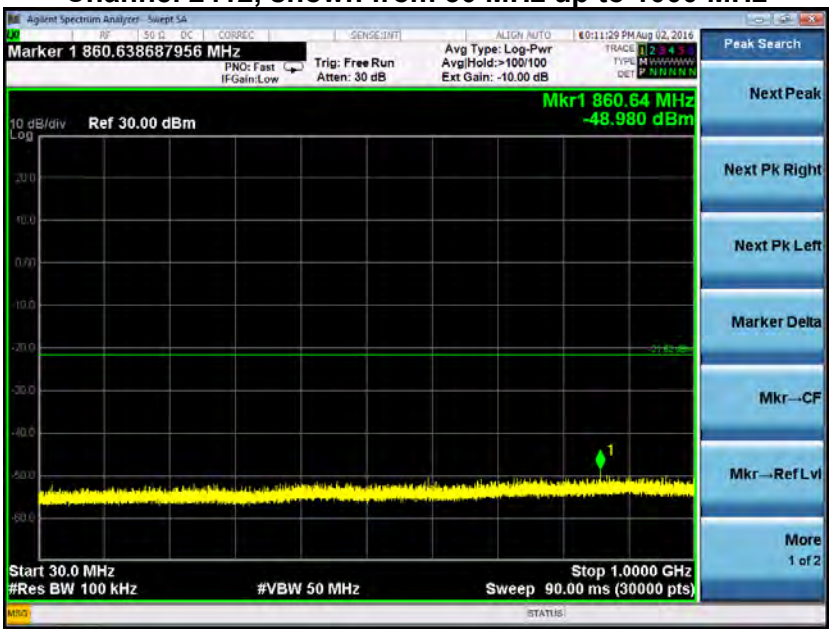
Channel 2412, shown from 1000 MHz up to 18000 MHz



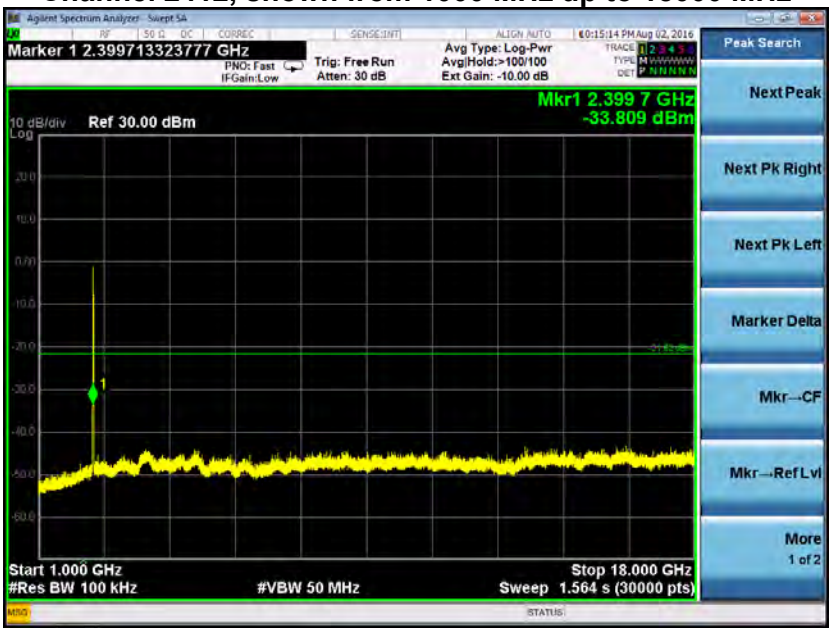
Channel 2412, shown from 18000 MHz up to 25000 MHz

MCS7:

Channel 2412, shown from 30 MHz up to 1000 MHz



Channel 2412, shown from 1000 MHz up to 18000 MHz



Channel 2412, shown from 18000 MHz up to 25000 MHz

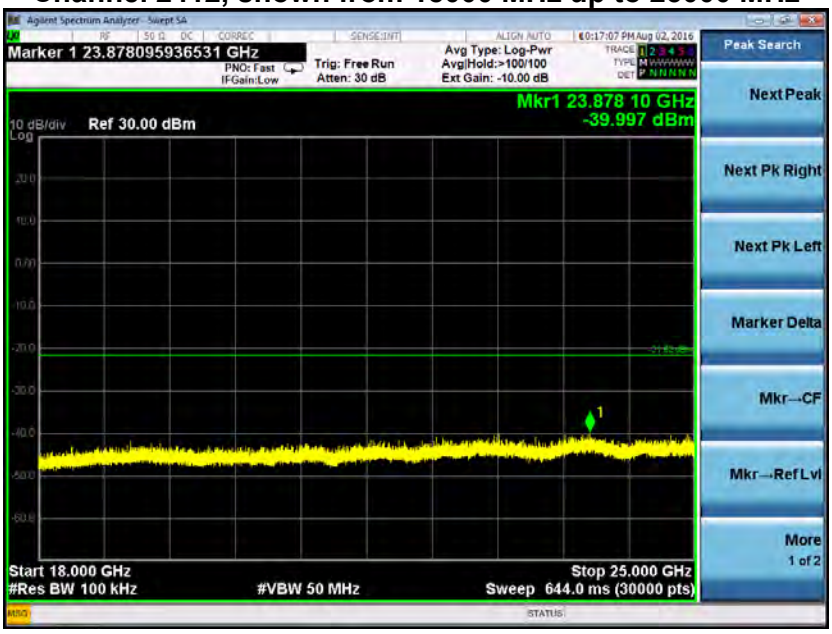


EXHIBIT 11. FREQUENCY STABILITY OVER VOLTAGE VARIATIONS

A spectrum analyzer was used to measure the frequency at the appropriate frequency markers. For this test, the EUT was placed in continuous transmit CW mode (i.e., transmitting unmodulated carrier signal). Power to the EUT was supplied by a variable power supply. The tables below meet the requirements of 47 CFR Part 15 Section 2.1055. The equations below illustrate how the margin was calculated.

Limit (Hz) = Channel Frequency (Hz)/10,000

Margin (Hz) = Limit (Hz) – | (Channel Frequency (Hz) – Measured Frequency (Hz)) |

11.1 - BLE

Low Channel

Frequency Stability f = 2402 MHz				
Supply Voltage (VDC)	Frequency (Hz)	Deviation		
		Measured Frequency (Hz)	Limit (Hz)	Margin (Hz)
2.8	2402000000	2402023632	240200	216568
3.3	2402000000	2402028914	240200	211286
3.8	2402000000	2402022226	240200	217974

Middle Channel

Frequency Stability f = 2441 MHz				
Supply Voltage (VDC)	Frequency (Hz)	Deviation		
		Measured Frequency (Hz)	Limit (Hz)	Margin (Hz)
2.8	2441000000	2441026971	244100	217129
3.3	2441000000	2441022800	244100	221300
3.8	2441000000	2441002774	244100	241326

High Channel

Frequency Stability f = 2480 MHz				
Supply Voltage (VDC)	Frequency (Hz)	Deviation		
		Measured Frequency (Hz)	Limit (Hz)	Margin (Hz)
2.8	2480000000	2479996838	248000	244838
3.3	2480000000	2480029720	248000	218280
3.8	2480000000	2480028396	248000	218280

11.2 - WLAN

Low Channel

Frequency Stability f = 2412 MHz				
Supply Voltage (VDC)	Frequency (Hz)	Deviation		
		Measured Frequency (Hz)	Limit (Hz)	Margin (Hz)
2.8	2412000000	2412000969	241200	240231
3.3	2412000000	2412000990	241200	240210
3.8	2412000000	2412000990	241200	240210

Mid Channel

Frequency Stability f = 2437 MHz				
Supply Voltage (VDC)	Frequency (Hz)	Deviation		
		Measured Frequency (Hz)	Limit (Hz)	Margin (Hz)
2.8	2437000000	2437000920	243700	242780
3.3	2437000000	2437000940	243700	242760
3.8	2437000000	2437000960	243700	242740

High Channel

Frequency Stability f = 2462 MHz				
Supply Voltage (VDC)	Frequency (Hz)	Deviation		
		Measured Frequency (Hz)	Limit (Hz)	Margin (Hz)
2.8	2462000000	2462000939	246200	245261
3.3	2462000000	2462000960	246200	245240
3.8	2462000000	2462000960	246200	245240

EXHIBIT 12. Compliance to KDB 594280 D01 and D02

In this exhibit, the data provided shows that WLAN channels 12 and 13 are compliant to the technical requirements for DTS operation in the 2400-2483.5 MHz band.

Conducted measurements were performed at the antenna port using the measurement methods provided in KDB 558074.

12.1 – Maximum Peak Conducted Output Power

The maximum peak conducted output power measurements were performed per ANSI C63.10 Section 11.9.1.3 using a power meter.

Data Rate (MBPS)	Channel	PEAK Maximum Cond. Output Power (dBm)	Power Limit (dBm)	2.4 GHz Flex Pifa Antenna Gain (dBi)	Calculated EIRP(dBm)[1]	EIRP Limit (dBm)	Margin (dB)
1 (DBPSK)	12	-13.2	30	2	-11.2	36	47.2
	13	-12.8	30	2	-10.8	36	46.8
11 (8QPSK)	12	-13.5	30	2	-11.5	36	47.5
	13	-13.5	30	2	-11.5	36	47.5
6 (BPSK)	12	-13.4	30	2	-11.4	36	47.4
	13	-13.7	30	2	-11.7	36	47.7
54 (64QAM)	12	-13.8	30	2	-11.8	36	47.8
	13	-13.6	30	2	-11.6	36	47.6
MCS0 (BPSK)	12	-13.2	30	2	-11.2	36	47.2
	13	-13.5	30	2	-11.5	36	47.5
MCS7 (64QAM)	12	-13.5	30	2	-11.5	36	47.5
	13	-13.7	30	2	-11.7	36	47.7

1 – EIRP Calculation – (Peak power at antenna terminal (in dBm)) + (EUT antenna gain (in dBi))

12.2 – Restricted Band Edge Testing - Conducted

Restricted band edge testing was performed via conducted means per ANSI C63.10 section 11.12. The screen captures provided illustrate worst case emission traces at channel 12 and channel 13, respectively.

Channel 12

802.11 Standard	Data Rate (MBPS)	Duty Cycle	Peak data Frequency (MHz)	Restricted Band - Band Edge - Peak (dBm)	Average data Frequency (MHz)	Restricted Band-edge: Avg (dBm)	Duty Cycle Correction Factor	Antenna Gain (dBi)	**Final peak Band-edge (dBm)**	**Peak Limit (dBm)**	**Peak Margin (dB)**	**Final Average Band-Edge (dBm)**	**Avg Limit (dBm)**	**Avg Margin (dB)**
b	1	0.99	2486.6	-50.07	2484.6	-55.924	0	2	-48.07	-21.23	26.84	-53.924	-41.23	12.694
b	11	0.95	2483.6	-42.497	2484	-50.605	0.223	2	-40.497	-21.23	19.267	-48.382	-41.23	7.152
a, g	6	0.97	2483.7	-38.371	2483.6	-50.093	0.132	2	-36.371	-21.23	15.141	-47.961	-41.23	6.731
a, g	54	0.78	2483.6	-40.327	2483.6	-51.113	1.079	2	-38.327	-21.23	17.097	-48.034	-41.23	6.804
n	MCS0	0.96	2483.8	-37.616	2483.6	-49.672	0.177	2	-35.616	-21.23	14.386	-47.495	-41.23	6.265
n	MCS7	0.75	2483.6	-40.14	2484.5	-50.665	1.249	2	-38.14	-21.23	16.91	-47.416	-41.23	6.186

Note:

a. Final Peak Band-edge = (Restricted Band-Band Edge – Peak) + (Antenna Gain)
b. Final Average Band-Edge = (Restricted Band – edge: Avg) + (Duty Cycle Correction Factor) + (Antenna Gain)
c. Peak data and average data include all applicable equipment factors (i.e., cable factor)
d. Peak and average limit was converted from field strength (dBuV/m) to dBm using equations provided in ANSI C63.10
e. The captures provided below exhibit the narrowest margins

MCS7 – Peak Measurement

MCS7 – Average Measurement

Channel 13

802.11 Standard	Data Rate (MBPS)	Duty Cycle	Peak data Frequency (MHz)	Restricted Band - Band Edge - Peak (dBm)	Average data Frequency (MHz)	Restricted Band-edge: Avg (dBm)	Duty Cycle Correction Factor	Antenna Gain (dBi)	**Final peak Band-edge (dBm)**	**Peak Limit (dBm)**	**Peak Margin (dB)**	**Final Average Band-Edge (dBm)**	**Avg Limit (dBm)**	**Avg Margin (dB)**
b	1	0.99	2483.5	-48.75	2489.6	-55.687	0	2	-46.75	-21.23	25.52	-53.687	-41.23	12.457
b	11	0.95	2487	-41.825	2486.4	-49.747	0.223	2	-39.825	-21.23	18.595	-47.524	-41.23	6.294
a, g	6	0.97	2485.2	-35.31	2483.7	-47.12	0.132	2	-33.31	-21.23	12.08	-44.988	-41.23	3.758
a, g	54	0.78	2484.2	-36.447	2483.6	-47.89	1.079	2	-34.447	-21.23	13.217	-44.811	-41.23	3.581
n	MCS0	0.96	2483.7	-34.2	2483.7	-46.907	0.177	2	-32.2	-21.23	10.97	-44.730	-41.23	3.500
n	MCS7	0.75	2484.3	-36.885	2483.8	-47.682	1.249	2	-34.885	-21.23	13.655	-44.433	-41.23	3.203

Note:

a. Final Peak Band-edge = (Restricted Band-Band Edge – Peak) + (Antenna Gain)
b. Final Average Band-Edge = (Restricted Band – edge: Avg) + (Duty Cycle Correction Factor) + (Antenna Gain)
c. Peak data and average data include all applicable equipment factors (i.e., cable factor)
d. Peak and average limit was converted from field strength (dBuV/m) to dBm using equations provided in ANSI C63.10
e. The captures provided below exhibit the narrowest margins

MCS7 - Peak Measurement

MCS7 - Average Measurement

The EUT does NOT have the ability to operate at different power levels. The power levels are set via firmware. This firmware is installed onto the radio module at the factory. The user has no access to any power level control.

In addition, the module EEPROM will be programmed at the factory to only operate and actively scan on these specific channels:

Channels 1 – 11, 2412-2462 MHz 802.11b mode
Channels 1 – 11, 2412-2462 MHz 802.11g mode
Channels 1 – 11, 2412-2462 MHz 802.11n mode (20 MHz channel)

The following channels will be programmed at the factory to passively scan and will only listen and cannot send a probe request to initiate communication on these specific channels. Ad-hoc mode is always disabled on these passive channels.

Channels 12 & 13, 2467 & 2472 MHz 802.11b mode
Channels 12 & 13, 2467 & 2472 MHz 802.11g mode
Channels 12 & 13, 2467 & 2472 MHz 802.11n mode (20MHz channel)

EXHIBIT 13. Conducted Emissions

13.1 - Test Setup

The test setup was assembled in accordance with ANSI C63.10. The EUT was placed on the rear of an 80 cm high non-conductive pedestal. The EUT was situated 40 cm from a vertical ground plane and appended to a generic, 3.3 V output AC/DC adapter. The generic adapter was coupled to a line impedance stabilization network, which, in turn, was connected to the input of the EMI Receiver. The EUT's power cable was plugged into a 50Ω (ohm), 50/250 μH Line Impedance Stabilization Network (LISN). The AC power supply of 120 V was supplied to the LISN input line and, in turn, the generic adapter via a broadband EMI filter. After the EUT was setup and connected to the LISN, the RF sampling port of the LISN was connected to a 10 dB attenuator-limiter, and then to the EMI receiver. The LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral).

13.2 - Test Procedure

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

13.3 - Test Equipment Utilized

A list of the test equipment for the conducted emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions.

13.4 - Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.207 and RSS 247 for a DTS transmitter. The frequencies with significant RF signal strength were recorded and plotted as shown in the data charts and screen captures provided below.

13.5 – Limits of Conducted Emissions

The following table represents the limits for conducted emissions for a transmitter per CFR 15.207.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency

13.6 – Conducted Emissions Test Data Chart

Frequency Range inspected: 150 KHz to 30 MHz

Manufacturer:	LS Research					
Date(s) of Test:	8/24/2016					
Test Engineer:	John Johnston					
Voltage:	3.3 VDC					
Operation Mode:	Continuous Transmit					
Environmental Conditions in the Lab:	Temperature: 20 – 25° C Relative Humidity: 30 – 60 %					
Test Location:	**X**	Other				Chamber
EUT Placed On:	**X**	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	**X**	Final
Detector Used:	**X**	Peak	**X**	Quasi-Peak	**X**	Average

WLAN

Test Results:

Line	Frequency (MHz)	Quasi-Peak Measurement (dBuV)	Quasi-Peak Limit (dBuV)	Margin (dB)	Average Measurement (dBuV)	Average Limit (dBuV)	Margin (dB)
1	0.15	42.7	66.00	23.30	33.8	56.00	22.20
1	0.661	37.7	56.00	18.30	27.7	46.00	18.30
1	2.58	31	56.00	25.00	19.5	46.00	26.50
2	0.179	37.7	64.53	26.83	25.5	54.53	29.03
2	0.598	39.3	56.00	16.70	30.9	46.00	15.10
2	0.257	35.7	61.53	25.83	26.1	51.53	25.43

BLE

Test Results:

Line	Frequency (MHz)	Quasi-Peak Measurement (dBuV)	Quasi-Peak Limit (dBuV)	Margin (dB)	Average Measurement (dBuV)	Average Limit (dBuV)	Margin (dB)
1	0.15	43.00	66.00	23.00	34.70	56.00	21.30
1	0.23	39.40	62.45	23.05	29.80	52.45	22.65
1	0.616	35.00	56.00	21.00	25.20	46.00	20.80
2	0.15	42.80	66.00	23.20	31.80	56.00	24.20
2	0.201	36.10	63.57	27.47	25.70	53.57	27.87
2	0.621	33.80	56.00	22.20	25.90	46.00	20.10

Screen Captures

WLAN

Line 1

Line 2

BLE

Line 1

Line 2

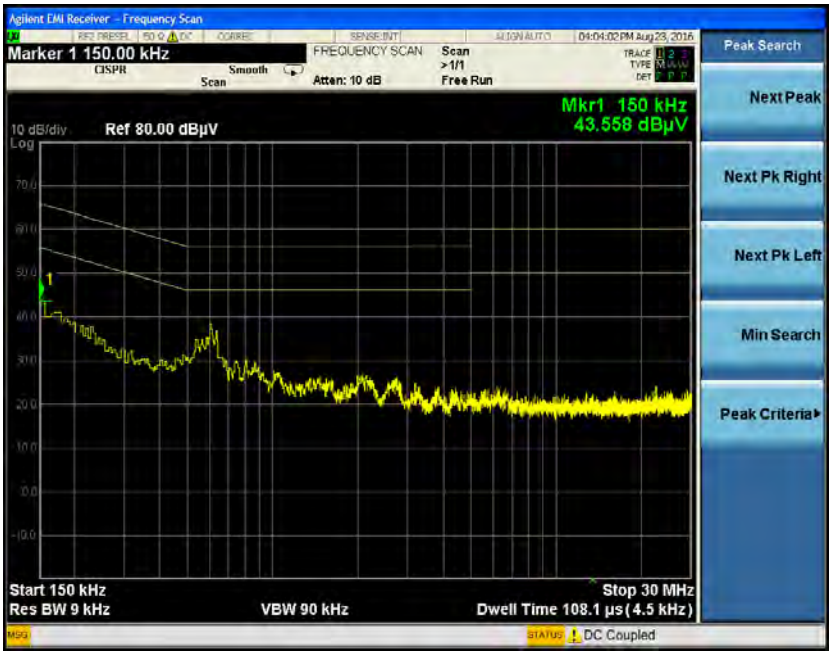


EXHIBIT 14. Appendix A – Test Equipment List

LSR
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Date: 25-Jul-2016 Type Test: WLAN Radiated Emissions - Below 1 GHz Job #: C-2496

Prepared By: John Johnston Customer: Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	3/31/2016	3/31/2017	Active Calibration
2	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	1/14/2016	1/14/2017	Active Calibration
3	EE 960088	8GHz MXE Spectrum Analyzer	Agilent	N9038A	MY51210138	2/24/2016	2/24/2017	Active Calibration

Project Engineer: Quality Assurance:

LSR
a Laird Business

Date: 27-Jul-2016 Type Test: BLE Radiated Emissions - Below 1 GHz Job #: C-2496

Prepared By: John Johnston Customer: Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	3/31/2016	3/31/2017	Active Calibration
2	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	1/14/2016	1/14/2017	Active Calibration
3	EE 960088	8GHz MXE Spectrum Analyzer	Agilent	N9038A	MY51210138	2/24/2016	2/24/2017	Active Calibration

Project Engineer: Quality Assurance:

LSR
a Laird Business

Date: 21-Jul-2016 Type Test: WLAN Tx Harmonics Job #: C-2496

Prepared By: John Johnston Customer: Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration
2	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	2/4/2016	2/4/2017	Active Calibration
3	EE 960159	0.8 - 21GHz LNA	Mini-Circuits	ZVA-213X-S+	40201429	2/4/2016	2/4/2017	Active Calibration
4	AA 960171	Cable - low loss 1m	A.H. Systems, Inc.	SAC-26G-6	395	3/31/2016	3/31/2017	Active Calibration
5	AA 960153	2.4GHz High Pass Filter	K.W.M	HPF-L-14186	7272-04	4/29/2016	4/29/2017	Active Calibration
6	AA 960174	Small Horn Antenna 18-40 GHz	ETS-Lindgren	3116C-PA	00206880	4/29/2016	4/29/2017	Active Calibration

Project Engineer: Quality Assurance:

LSR
a Laird Business

Date: 22-Jul-2016 Type Test: BLE Tx Harmonics Job #: C-2496

Prepared By: John Johnston Customer: Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration
2	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	2/4/2016	2/4/2017	Active Calibration
3	EE 960159	0.8 - 21GHz LNA	Mini-Circuits	ZVA-213X-S+	40201429	2/4/2016	2/4/2017	Active Calibration
4	AA 960171	Cable - low loss 1m	A.H. Systems, Inc.	SAC-26G-6	386	3/31/2016	3/31/2017	Active Calibration
5	AA 960153	2.4GHz High Pass Filter	K.W.M	HPF-L-14186	7272-04	4/29/2016	4/29/2017	Active Calibration
6	AA 960174	Small Horn Antenna 18-40 GHz	ETS-Lindgren	3116C-PA	00206880	4/23/2016	4/23/2017	Active Calibration

Project Engineer: Quality Assurance:

LSR
a Laird Business

Date: 12-Jul-2016 Type Test: WLAN Band-Edge Job #: C-2496

Prepared By: John Johnston Customer: Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration
2	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	2/4/2016	2/4/2017	Active Calibration
3	AA 960171	Cable - low loss 1m	A.H. Systems, Inc.	SAC-26G-6	386	3/31/2016	3/31/2017	Active Calibration
4	EE 960169	20V/5A DC Power Supply	Tenma	72-8350A	MG371512549	Verification	Verification	System

Project Engineer: Quality Assurance:

LSR
a Laird Business

Date: 20-Jul-2016 Type Test: BLE Band-Edge Job #: C-2496

Prepared By: John Johnston Customer: Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration
2	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	2/4/2016	2/4/2017	Active Calibration
3	AA 960171	Cable - low loss 1m	A.H. Systems, Inc.	SAC-26G-6	386	3/31/2016	3/31/2017	Active Calibration
4	EE 960169	20V/5A DC Power Supply	Tenma	72-8350A	MG371512549	Verification	Verification	System

Project Engineer: Quality Assurance:

LSR
a Laird Business

Date : 2-Aug-2016 Type Test : Conducted Measurements Job # : C-2496

Prepared By: John Johnston Customer : Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	44GHz EXA Spectrum Analyzer	Agilent	N9010A	MY53400296	12/8/2015	12/8/2016	Active Calibration
2	AA 960143	PhaseFlex	Gore	EKD01D01048.0	5546519	6/26/2015	6/26/2017	Active Calibration

Project Engineer: Quality Assurance:

LSR
a Laird Business

Date : 23-Aug-2016 Type Test : Conducted Emissions Job # : C-2496

Prepared By: John Customer : Thermo Fisher Scientific Quote #: 316191

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960088	8GHz MXE Spectrum Analyzer	Agilent	N9038A	MY51210138	2/24/2016	2/24/2017	Active Calibration
2	EE 960089	LISN - 15A	COM-POWER	LI-215A	191943	3/8/2016	3/8/2017	Active Calibration

Project Engineer: Quality Assurance:

EXHIBIT 15. Appendix B – Test Standards

Standard #	Date	Am. 1	Am. 2
ANSI C63.4	2014		
ANSI C63.10	2013		
FCC 47 CFR Parts 0-15, 18, 90, 95	2016		
RSS GEN	2014		
RSS 247	2015		

EXHIBIT 16. Appendix C – Uncertainty Statement

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

Measurement Type	Particular Configuration	Uncertainty Values
Radiated Emissions	Biconical Antenna	4.82 dB
Radiated Emissions	Log Periodic Antenna	4.88 dB
Radiated Emissions	Horn Antenna	4.85 dB
Absolute Conducted Emissions	PSA Series	1.38 dB
AC Line Conducted Emissions	LISN	3.20 dB
Radiated Immunity	3 Volts/Meter	2.05 Volts/Meter
Conducted Immunity	3 Volts rms	2.33 V
EFT Burst, Surge, VDI	230 VAC	54.4 V
ESD Immunity	Discharge at 15 kV	3200 V
Temperature/Humidity	Thermo-hygrometer	0.64 degrees/2.88% RH