# FCC PART 15, SUBPART C

# TEST AND MEASUREMENT REPORT

For

## Ologic, Inc.

1394 Borregas Ave.,

Sunnyvale, CA 94089, USA

**FCC ID: 2AH6T070613**

| **Report Type:** | **Product Type:** |
|---|---|
| Original Report | Educational Robotics Kit |

| | |
|---|---|
| **Prepared By:** | Todd Moy<br>Test Engineer |
| **Report Number:** | R1604061-247 |
| **Report Date:** | 2016-05-24 |
| **Reviewed By:** | Bo Li<br>RF Supervisor |

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# DOCUMENT REVISION HISTORY

| Revision Number | Report Number | Description of Revision | Date of Revision |
|---|---|---|---|
| 0 | R1604061-247 | Original Report | 2016-05-24 |

# 1 General Description

## 1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report has been compiled on behalf of *Ologic, Inc.*, and their product, *FCC ID: 2AH6T070613*, model number: Jackson, Rev D, which henceforth is referred to as the EUT (Equipment Under Test.) The EUT is an Educational Robotics Kit that is to teach about robotics and software engineering with Bluetooth Low Energy and Wi-Fi capabilities. Wi-Fi module was pre-certified under FCC ID: YCJGTIMW302, which granted in October 11th, 2015.

## 1.2 Mechanical Description of EUT

The EUT measures approximately 95 mm (L) x 55 mm (W) x 17mm (H) and weighs 0.028 kg.

*The data gathered are from a production sample provided by the manufacturer, serial number: R1604061-01, assigned by BACL.*

## 1.3 Objective

This report is prepared on behalf of *Ologic, Inc.*, in accordance with Part 2, Subpart J, and Part 15, Subparts B and C of the Federal Communication Commission's rules.

The objective is to determine compliance with FCC Part 15.247 rules for Output Power, Antenna Requirements, 6 dB Bandwidth, Power Spectral Density, 100 kHz Bandwidth of Band Edges Measurement, Conducted and Radiated Spurious Emissions.

## 1.4 Related Submittal(s)/Grant(s)

N/A

## 1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and FCC KDB 558074 D01 DTS Meas Guidance v03r03: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

## 1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on CISPR16-4-2:2011, The Treatment of Uncertainty in EMC Measurements, the values ranging from $\pm$2.0 dB for Conducted Emissions tests and $\pm$4.0 dB for Radiated Emissions tests are the most accurate estimates pertaining to uncertainty of EMC measurements at BACL Corp.

## 1.7 Test Facility

Bay area compliance Laboratories Corp. (BACL) is:
1- An independent Commercial Test Laboratory accredited to **ISO 17025: 2005** by **A2LA**, in the fields of: Electromagnetic Compatibility & Telecommunications covering Emissions, Immunity, Radio, RF Exposure, Safety and Telecom. This includes NEBS (Network Equipment Building System), Wireless RF, Telecommunications Terminal Equipment (TTE); Network Equipment; Information Technology Equipment (ITE); Medical Electrical Equipment; Industrial, Commercial, and Medical Test Equipment; Professional Audio and Video Equipment; Electronic (Digital) Products; Industrial and Scientific Instruments; Cabled Distribution Systems and Energy Efficiency Lighting.

2- An ENERGY STAR Recognized Laboratory, for the LM80 Testing, a wide variety of Luminares and Computers.

3- A NIST Designated Phase-I and Phase-II CAB including: ACMA (Australian Communication and Media Authority), BSMI (Bureau of Standards, Metrology and Inspection of Taiwan), IDA (Infocomm Development Authority of Singapore), IC(Industry Canada), Korea ( Ministry of Communications Radio Research Laboratory), NCC (Formerly DGT; Directorate General of Telecommunication of Chinese Taipei) OFTA (Office of the Telecommunications Authority of Hong Kong), Vietnam, VCCI - Voluntary Control Council for Interference of Japan and a designated EU CAB (Conformity Assessment Body) (Notified Body) for the EMC and R&TTE Directives.

4- A Product Certification Body accredited to **ISO 17065: 2012** by **A2LA** to certify:
2. Radio Standards Specifications (RSS) in the Category I Equipment Standards List and All Broadcasting Technical Standards (BETS) in Category I Equipment Standards List for Industry Canada.
3. Radio Communication Equipment for Singapore.
4. Radio Equipment Specifications, GMDSS Marine Radio Equipment Specifications, and Fixed Network Equipment Specifications for Hong Kong.
5. Japan MIC Telecommunication Business Law (A1, A2) and Radio Law (B1, B2 and B3).
6. Audio/Video, Battery Charging Systems, Computers, Displays, Enterprise Servers, Imaging Equipment, Set-Top Boxes, Telephony, Televisions, Ceiling Fans, CFLs (Including GU24s),Decorative Light Strings, Integral LED Lamps, Luminaires, Residential Ventilating Fans.

The test site used by BACL Corp. to collect radiated and conducted emissions measurement data is located at its facility in Sunnyvale, California, USA.

The test site at BACL Corp. has been fully described in reports submitted to the Federal Communication Commission (FCC) and Voluntary Control Council for Interference (VCCI). The details of these reports have been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on February 11 and December 10, 1997, and Article 8 of the VCCI regulations on December 25, 1997. The test site also complies with the test methods and procedures set forth in CISPR 22:2008 §10.4 for measurements below 1 GHz and §10.6 for measurements above 1 GHz as well as ANSI C63.10-2013, ANSI C63.4-2014, TIA/EIA-603 & CISPR 24:2010.

The Federal Communications Commission and Voluntary Control Council for Interference have the reports on file and they are listed under FCC registration number: 90464 and VCCI Registration No.: A-0027. The test site has been approved by the FCC and VCCI for public use and is listed in the FCC Public Access Link (PAL) database.

Additionally, BACL Corp. is an American Association for Laboratory Accreditation (A2LA) accredited laboratory (Lab Code 3297-02). The current scope of accreditations can be found at

http://www.a2la.org/scopepdf/3297-02.pdf?CFID=1132286&CFTOKEN=e42a3240dac3f6ba-6DE17DCB-1851-9E57-477422F667031258&jsessionid=8430d44f1f47cf2996124343c704b367816b

# 2 System Test Configuration

## 2.1 Justification

The EUT was configured for testing according to ANSI C63.10-2013 and FCC KDB 558074 D01 DTS Meas Guidance v03r04.

The EUT was tested in a testing mode to represent worst-case results during the final qualification test.

The worst-case data rates are determined to be as follows for each mode based upon investigation by measuring the average power, peak power and PPSD across all data rates bandwidths, and modulations.

## 2.2 EUT Exercise Software

The test utility used were Nordic Direct Test Mode to run the BLE module and Marvell 3.3.30 SDK for the Wi-Fi module*;* the software were verified by *Todd Moy* to comply with the standard requirements being tested against.

## 2.3 Duty Cycle Correction Factor

According to KDB 558074 D01 DTS Meas Guidance v03r04 section 6.0:

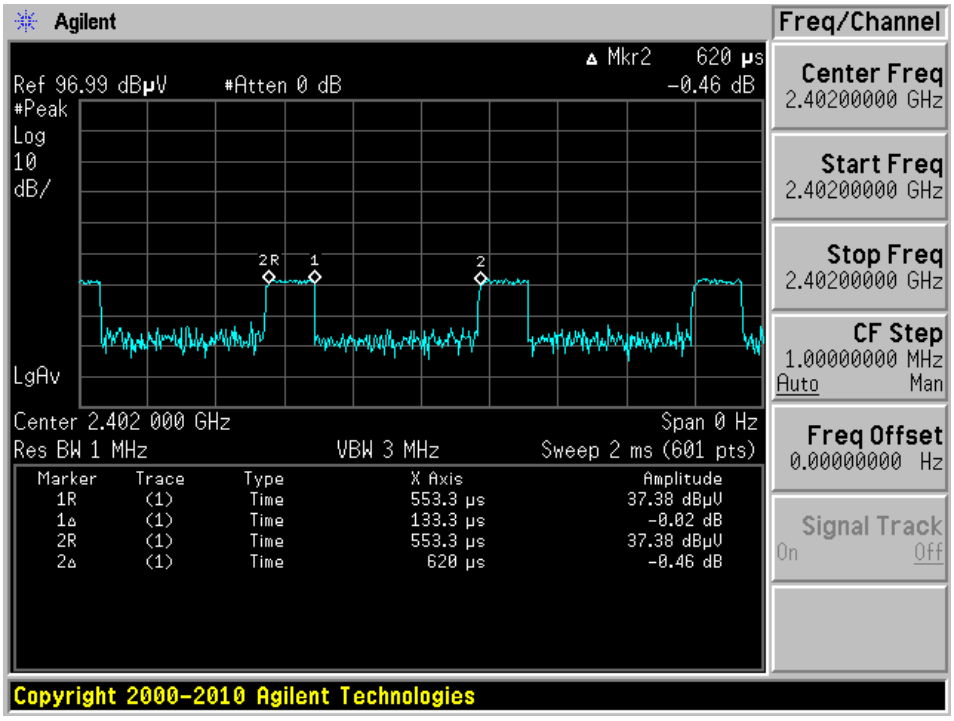
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data is being acquired (i.e., no transmitter off-time is to be considered).

| Radio Mode | On Time (µs) | Period (µs) | Duty Cycle (%) | Duty Cycle Correction Factor (dB) |
|---|---|---|---|---|
| BLE | 133.3 | 553.3 | 24 | 6.18 |

Duty Cycle = On Time (ms)/ Period (ms)
Duty Cycle Correction Factor (dB) = 10*log(1/Duty Cycle)

Please refer to the following plot.

BLE




## 2.4 Equipment Modifications

SMA cables were connected to the output trace of the Bluetooth and power leads were attached to the EUT.

## 2.5 Local Support Equipment

| Manufacturer | Description | Model |
|---|---|---|
| Dell | Laptop | Latitude D630 |

## 2.6 EUT Internal Configuration Details

| Manufacturers | Descriptions | Models | Serial Numbers |
|---|---|---|---|
| Nordic | - | NRF-1822QFAA-R7 | - |
| ST Micro | - | LSM6DS3 | - |
| GlobalScale | WiFi Module | RD-88Mw302-QFN88 | - |

## 2.7 Support Equipment

| Manufacturer | Description | Model |
|---|---|---|
| B&K Precision | DC Power Supply | 1670A |

## 2.8 Interface Ports and Cabling

| Cable Description | Length (m) | To | From |
|---|---|---|---|
| USB Cable | < 1 m | Laptop | EUT |
| Power Leads | < 1 m | Power Supply | EUT |
| SMA Pigtails | < 1 m | EUT | PSA |

# 3 Summary of Test Results

Results reported relate only to the product tested.

| FCC Rules | Description of Test | Results |
|---|---|---|
| §15.203 | Antenna Requirement | Compliant |
| §15.207 | AC Line Conducted Emissions | Compliant |
| §2.1091, §15.247(i) | RF Exposure | Compliant |
| §2.1051, §15.247(d) | Spurious Emissions at Antenna Port | Compliant |
| §15.209, §15.247(d) | Radiated Spurious Emissions | Compliant |
| §15.247(a)(2) | 6 dB & 99% Emission Bandwidth | Compliant |
| §15.247(b)(3) | Output Power | Compliant |
| §15.247(d) | Band Edge | Compliant |
| §15.247(e) | Power Spectral Density | Compliant |

# 4 FCC §15.203 - Antenna Requirements

## 4.1 Applicable Standards

According to FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

And according to FCC §15.247 (b) (4), if transmitting antennas of directional gain greater than 6 dBi are used the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

## 4.2 Antenna Description

The antennas used by the EUT are permanently attached antennas.

| Antenna Port | Maximum Antenna Gain (dBi) @ 2.4 GHz |
|---|---|
| Bluetooth | 0 |
| Wi-Fi | 0 |

# 5 FCC §2.1091 & §15.247(i) - RF Exposure Information

## 5.1 Applicable Standards

FCC §2.1091, (a) Requirements of this section are a consequence of Commission responsibilities under the National Environmental Policy Act to evaluate the environmental significance of its actions. See subpart I of part 1 of this chapter, in particular §1.1307(b).

Limits for Exposure

| Frequency Range (MHz) | Electric Field Strength (V/m) | Magnetic Field Strength (A/m) | Power Density ($mW/cm^2$) | Averaging Time (minutes) |
|---|---|---|---|---|
| **(A) Limits for Occupational/Controlled Exposures** | | | | |
| 0.3-3.0 | 614 | 1.63 | *(100) | 6 |
| 3.0-30 | 1842/f | 4.89/f | *($900/f^2$) | 6 |
| 30-300 | 61.4 | 0.163 | 1.0 | 6 |
| 300-1500 | / | / | f/300 | 6 |
| 1500-100,000 | / | / | 5 | 6 |
| **(B) Limits for General Population/Uncontrolled Exposure** | | | | |
| 0.3-1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34-30 | 842/f | 2.19/f | *($180/f^2$) | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | / | / | f/1500 | 30 |
| 1500-100,000 | / | / | 1 | 30 |

## 5.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

*Where: S = power density*
*P = power input to antenna*
*G = power gain of the antenna in the direction of interest relative to an isotropic radiator*
*R = distance to the center of radiation of the antenna*

BLE:

| | |
|---|---|
| Maximum peak output power at antenna input terminal (dBm): | -7.56 |
| Maximum peak output power at antenna input terminal (mW): | 0.1754 |
| Prediction distance (cm): | 20 |
| Prediction frequency (MHz): | 2442 |
| Maximum Antenna Gain, typical (dBi): | 0 |
| Maximum Antenna Gain (numeric): | 1 |
| Power density of prediction frequency at 20 cm ($mW/cm^2$): | 3.49E-05 |
| FCC MPE limit for uncontrolled exposure at prediction frequency ($mW/cm^2$): | 1.0 |

Wi-Fi (FCC ID: YCJGTIMW302):

| | |
|---|---|
| Maximum peak output power at antenna input terminal (dBm): | 23.24 |
| Maximum peak output power at antenna input terminal (mW): | 211 |
| Prediction distance (cm): | 20 |
| Prediction frequency (MHz): | 2437 |
| Maximum Antenna Gain, typical (dBi): | 0 |
| Maximum Antenna Gain (numeric): | 1 |
| Power density of prediction frequency at 20 cm ($mW/cm^2$): | 0.042 |
| FCC MPE limit for uncontrolled exposure at prediction frequency ($mW/cm^2$): | 1.0 |

## Conclusion

The total MPE is 0.042 $mW/cm^2$+3.49E-05 $mW/cm^2$, which is less than 1.0 $mW/cm^2$. The device complies with the MPE requirements by providing a safe separation distance of at least 20 cm between the antenna with maximum 0 dBi gain, including any radiating structure, and any persons when normally operated.

# 6 FCC §15.207 - AC Line Conducted Emissions

## 6.1 Applicable Standards

As per FCC §15.207 Conducted limits:

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

| Frequency of Emission (MHz) | Conducted Limit (dBuV) | |
|---|---|---|
| | Quasi-Peak | Average |
| 0.15-0.5 | 66 to 56 Note1 | 56 to 46 Note2 |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |

*Note1: Decreases with the logarithm of the frequency.*
*Note2: A linear average detector is required*

## 6.2 Test Setup

The measurement was performed at shield room, using the setup per ANSI C63.10-2013 measurement procedure. The specification used were FCC §15.207 limits.

External I/O cables were draped along the edge of the test table and bundle when necessary.

The AC/DC power adapter of the EUT was connected with LISN-1 which provided 120 V / 60 Hz AC power.

## 6.3 Test Procedure

During the conducted emissions test, the power cord of the EUT host system was connected to the mains outlet of the LISN-1 and the power cords of support equipment were connected to LISN-2.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All data were recorded in the peak, quasi-peak, and average detection mode. Quasi-Peak readings are distinguished with a “QP.” Average readings are distinguished with an “Ave”.

## 6.4 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Cable Loss (CL), the Attenuator Factor (Atten) to indicated Amplitude (Ai) reading. The basic equation is as follows:

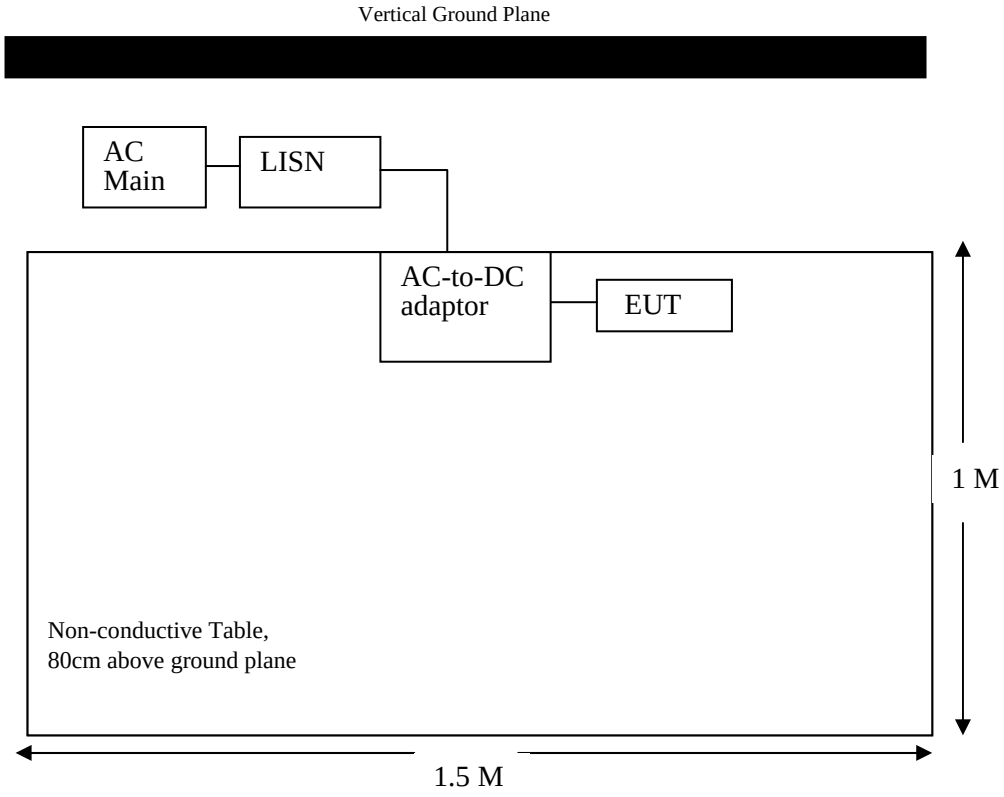
CA = Ai + CL + Atten

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Cable Loss (3.7 dB) + Attenuator (10 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

Margin = Corrected Amplitude – Limit

## 6.5 Test Setup Block Diagram



## 6.6 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Rohde & Schwarz | Receiver, EMI Test | ESCI 1166.5950K03 | 100044 | 2015-07-23 | 1 year |
| Rohde & Schwarz | Impulse Limiter | ESH3-Z2 | 101963 | 2015-07-15 | 1 year |
| Keysight Technologies | RF Limiter | 11867A | MY42242931 | 2015-12-15 | 1 year |
| Solar Electronics Company | High Pass Filter | Type 7930-100 | 7930150204 | 2016-03-09 | 1 year |
| Wireless Solutions | Conducted Emission Cable | LMR 400 | 691 | 2015-07-02 | 1 year |
| FCC | LISN | FCC-LISN-50-25-2-10-CISPR16 | 160129 | 2016-04-11 | 1 year |

***Statement of Traceability: BACL Corp.*** *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

## 6.7 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23º C |
| **Relative Humidity:** | 56 % |
| **ATM Pressure:** | 101.2 kPa |

*The testing was performed by Todd Moy on 2016-05-05 in 5m chamber3.*

## 6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC 15C standard's conducted emissions limits, with the margin reading of:

BLE

| Connection: AC/DC adapter connected to 120 V/60 Hz, AC | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Conductor Mode (Line/Neutral)** | **Range (MHz)** |
| -17.15 | 0.600581 | Line | 0.15-30 |

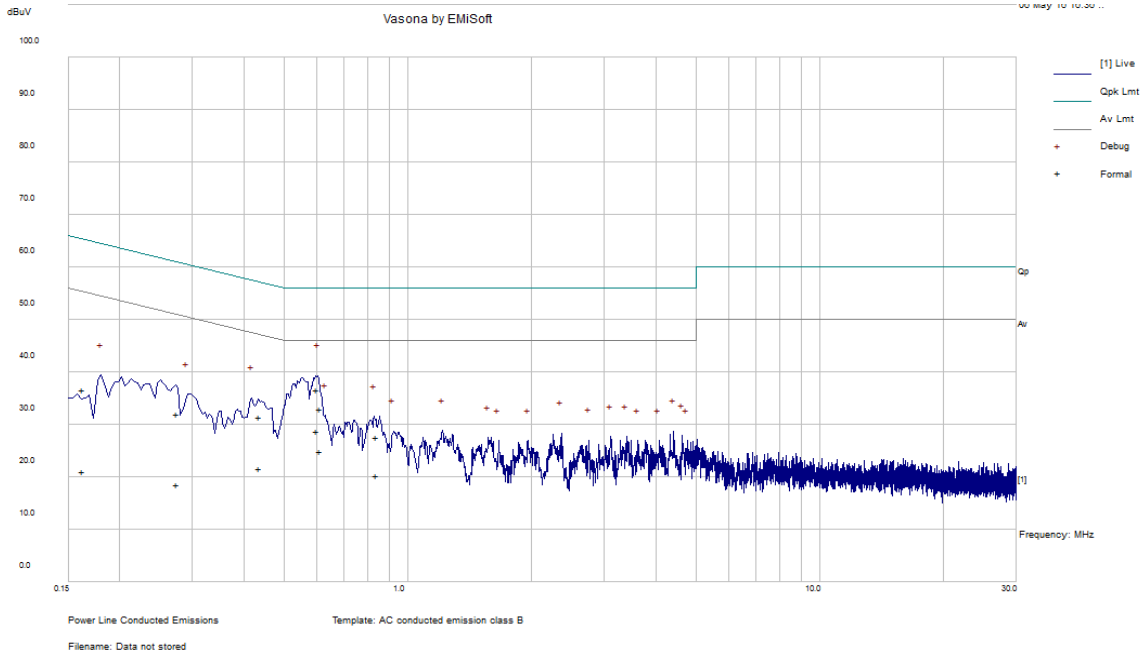
Collocation

| Connection: AC/DC adapter connected to 120 V/60 Hz, AC | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Conductor Mode (Line/Neutral)** | **Range (MHz)** |
| -11.5 | 0.588812 | Line | 0.15-30 |

## 6.9 Conducted Emissions Test Plots and Data

**BLE**

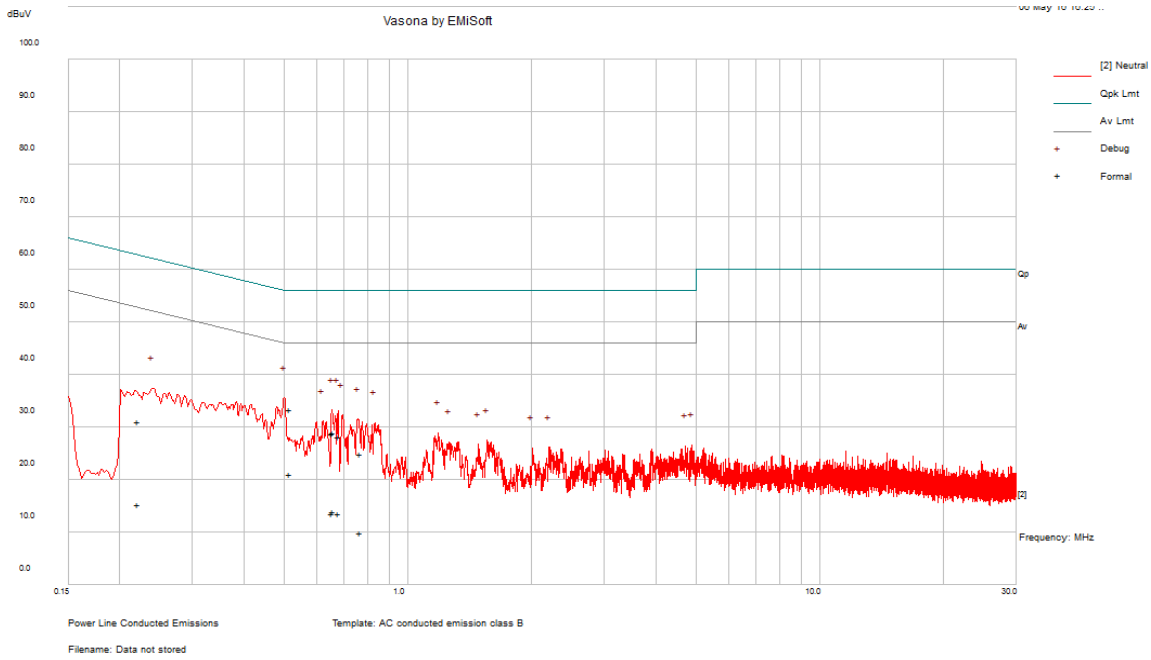
**120 V, 60 Hz – Line**




| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.600581 | 36.72 | Line | 56 | -19.28 | QP |
| 0.436164 | 31.56 | Line | 57.13 | -25.57 | QP |
| 0.613508 | 32.94 | Line | 56 | -23.06 | QP |
| 0.837935 | 27.72 | Line | 56 | -28.28 | QP |
| 0.275867 | 32.04 | Line | 60.94 | -28.9 | QP |
| 0.162626 | 36.67 | Line | 65.33 | -28.66 | QP |

| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.600581 | 28.85 | Line | 46 | -17.15 | Ave. |
| 0.436164 | 21.58 | Line | 47.13 | -25.55 | Ave. |
| 0.613508 | 25 | Line | 46 | -21 | Ave. |
| 0.837935 | 20.33 | Line | 46 | -25.67 | Ave. |
| 0.275867 | 18.56 | Line | 50.94 | -32.38 | Ave. |
| 0.162626 | 21.11 | Line | 55.33 | -34.21 | Ave. |

## 120 V, 60 Hz – Neutral



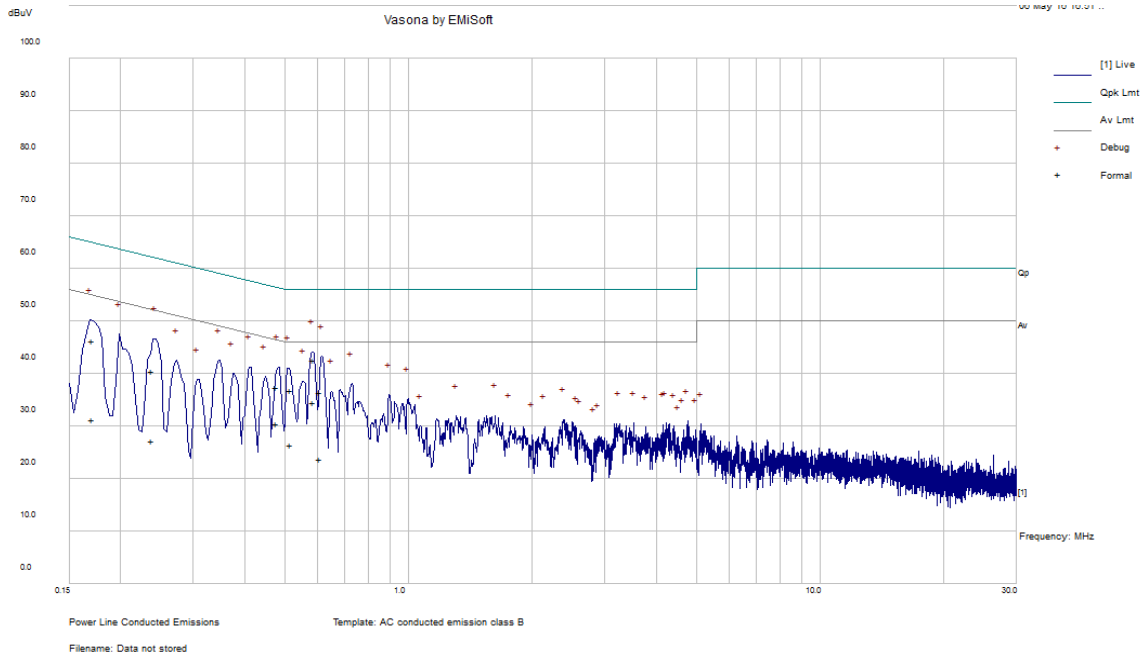

| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.517058 | 33.42 | Neutral | 56 | -22.58 | QP |
| 0.653445 | 28.88 | Neutral | 56 | -27.12 | QP |
| 0.658863 | 28.97 | Neutral | 56 | -27.03 | QP |
| 0.681107 | 28.2 | Neutral | 56 | -27.8 | QP |
| 0.768348 | 24.92 | Neutral | 56 | -31.08 | QP |
| 0.22167 | 31.12 | Neutral | 62.76 | -31.63 | QP |

| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.517058 | 21.17 | Neutral | 46 | -24.83 | Ave. |
| 0.653445 | 13.66 | Neutral | 46 | -32.34 | Ave. |
| 0.658863 | 13.89 | Neutral | 46 | -32.11 | Ave. |
| 0.681107 | 13.54 | Neutral | 46 | -32.46 | Ave. |
| 0.768348 | 10.04 | Neutral | 46 | -35.96 | Ave. |
| 0.22167 | 15.25 | Neutral | 52.76 | -37.5 | Ave. |

## Collocation

Worst Case Mode: BLE Low Channel and 802.11g mode Middle Channel

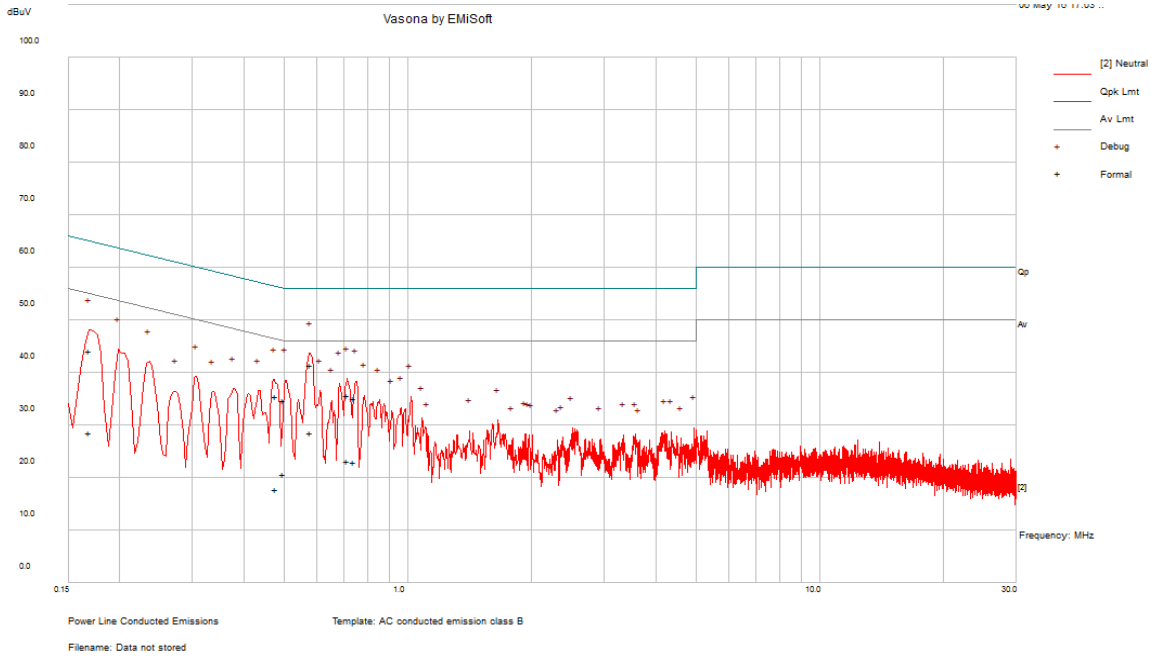
### 120 V, 60 Hz – Line




| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.588812 | 42.61 | Line | 56 | -13.39 | QP |
| 0.609922 | 36.5 | Line | 56 | -19.5 | QP |
| 0.170944 | 46.31 | Line | 64.91 | -18.6 | QP |
| 0.518598 | 36.9 | Line | 56 | -19.1 | QP |
| 0.47944 | 37.44 | Line | 56.35 | -18.91 | QP |
| 0.23877 | 40.55 | Line | 62.14 | -21.59 | QP |

| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.588812 | 34.5 | Line | 46 | -11.5 | Ave. |
| 0.609922 | 23.78 | Line | 46 | -22.22 | Ave. |
| 0.170944 | 31.29 | Line | 54.91 | -23.63 | Ave. |
| 0.518598 | 26.52 | Line | 46 | -19.48 | Ave. |
| 0.47944 | 30.52 | Line | 46.35 | -15.83 | Ave. |
| 0.23877 | 27.16 | Line | 52.14 | -24.98 | Ave. |

## 120 V, 60 Hz – Neutral




| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.580815 | 41.49 | Neutral | 56 | -14.51 | QP |
| 0.168874 | 44.25 | Neutral | 65.02 | -20.76 | QP |
| 0.711747 | 35.73 | Neutral | 56 | -20.27 | QP |
| 0.498265 | 34.73 | Neutral | 56.03 | -21.3 | QP |
| 0.741676 | 35.22 | Neutral | 56 | -20.78 | QP |
| 0.477431 | 35.58 | Neutral | 56.38 | -20.8 | QP |

| Frequency (MHz) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|
| 0.580815 | 28.61 | Neutral | 46 | -17.39 | Ave. |
| 0.168874 | 28.58 | Neutral | 55.02 | -26.44 | Ave. |
| 0.711747 | 23.21 | Neutral | 46 | -22.79 | Ave. |
| 0.498265 | 20.76 | Neutral | 46.03 | -25.26 | Ave. |
| 0.741676 | 22.98 | Neutral | 46 | -23.02 | Ave. |
| 0.477431 | 17.85 | Neutral | 46.38 | -28.53 | Ave. |

# 7 FCC §15.209 & §15.247(d) - Spurious Radiated Emissions

## 7.1 Applicable Standards

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

As Per FCC §15.205(a) except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090 – 0.110<br>0.495 – 0.505<br>2.1735 – 2.1905<br>4.125 – 4.128<br>4.17725 – 4.17775<br>4.20725 – 4.20775<br>6.215 – 6.218<br>6.26775 – 6.26825<br>6.31175 – 6.31225<br>8.291 – 8.294<br>8.362 – 8.366<br>8.37625 – 8.38675<br>8.41425 – 8.41475<br>12.29 – 12.293<br>12.51975 – 12.52025<br>12.57675 – 12.57725<br>13.36 – 13.41 | 16.42 – 16.423<br>16.69475 – 16.69525<br>25.5 – 25.67<br>37.5 – 38.25<br>73 – 74.6<br>74.8 – 75.2<br>108 – 121.94<br>123 – 138<br>149.9 – 150.05<br>156.52475 – 156.52525<br>156.7 – 156.9<br>162.0125 –167.17<br>167.72 – 173.2<br>240 – 285<br>322 – 335.4<br>399.9 – 410<br>608 – 614 | 960 – 1240<br>1300 – 1427<br>1435 – 1626.5<br>1645.5 – 1646.5<br>1660 – 1710<br>1718.8 – 1722.2<br>2200 – 2300<br>2310 – 2390<br>2483.5 – 2500<br>2690 – 2900<br>3260 – 3267<br>3.332 – 3.339<br>3 3458 – 3 358<br>3.600 – 4.400 | 4. 5 – 5. 15<br>5. 35 – 5. 46<br>7.25 – 7.75<br>8.025 – 8.5<br>9.0 – 9.2<br>9.3 – 9.5<br>10.6 – 12.7<br>13.25 – 13.4<br>14.47 – 14.5<br>15.35 – 16.2<br>17.7 – 21.4<br>22.01 – 23.12<br>23.6 – 24.0<br>31.2 – 31.8<br>36.43 – 36.5<br>Above 38.6 |

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

| Frequency (MHz) | Field Strength (micro volts/meter) | Measurement Distance (meters) |
|---|---|---|
| 0.009 - 0.490 | 2400/F(kHz) | 300 |
| 0.490 - 1.705 | 24000/F(kHz) | 30 |
| 1.705 - 30.0 | 30 | 30 |
| 30 - 88 | 100** | 3 |
| 88 - 216 | 150** | 3 |
| 216 - 960 | 200** | 3 |
| Above 960 | 500 | 3 |

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per FCC §15.247 (d), 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, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c).

## 7.2 Test Setup

The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the FCC 15 Subpart C limits.

The spacing between the peripherals was 10 centimeters.

External I/O cables were draped along the edge of the test table and bundle when necessary.

## 7.3 Test Procedure

For the radiated emissions test, the EUT host, and all support equipment power cords were connected to the AC floor outlet.

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

The EUT was set 3 meter away from the testing antenna, which was varied from 1-4 meter, and the EUT was placed on a turntable, which was 0.8 meter and 1.5 meter above the ground plane for below and above 1000 MHz measurements, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna's polarity should be changed between horizontal and vertical.

The spectrum analyzer or receiver was set as:

Below 1000 MHz:

RBW = 100 kHz / VBW = 300 kHz / Sweep = Auto

Above 1000 MHz:

(1) Peak: RBW = 1MHz / VBW = 1MHz / Sweep = Auto
(2) Average: RBW = 1MHz / VBW = 10Hz / Sweep = Auto

## 7.4 Corrected Amplitude & Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) to indicated Amplitude (Ai) reading. The basic equation is as follows:

CA = Ai + AF + CL + Atten – Ga

For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

Margin = Corrected Amplitude – Limit

## 7.5 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Rohde & Schwarz | Receiver, EMI Test | ESCI 1166.5950K03 | 100044 | 2015-07-23 | 1 year |
| Agilent | Analyzer, Spectrum | E4440A | MY44303352 | 2015-06-22 | 1 year |
| Sunol Science Corp | System Controller | SC99V | 011003-1 | N/R | N/R |
| Keysight Technologies | RF Limiter | 11867A | MY42242931 | 2015-12-17 | 1 year |
| Sunol Sciences | Antenna, Biconi-Log | JB3 | A020106-2 | 2015-07-11 | 2 years |
| Sunol Sciences | Antenna, Horn | DRH-118 | A052704 | 2015-03-09 | 2 years |
| Agilent | Amplifier, Pre | 8447D | 2944A10187 | 2016-03-23 | 1 year |
| Agilent | Pre-Amplifier | 8449B | 3008A01978 | 2015-09-02 | 1year |
| Wisewave | Amplifier, Low Noise | ALN-22093530-01 | 12263-01 | 2016-05-16 | 1 year |
| Wisewave | Antenna, Horn | ARH-4223-02 | 10555-02 | 2013-09-20 | 3 years |

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability: BACL*** *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

## 7.6 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 20-22º C |
| **Relative Humidity:** | 42-50 % |
| **ATM Pressure:** | 102.7 kPa |

*The testing was performed by Todd Moy from 2016-05-11 in 5m chamber 3.*

## 7.7 Summary of Test Results

According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C standard's radiated emissions limits, and had the worst margin of:

**BLE**

| Mode: Transmitting | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Polarization (Horizontal/Vertical)** | **Channel** |
| -3.88 | 2483.5 | Horizontal | High CH |

**Collocation**

| Mode: Transmitting | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Polarization (Horizontal/Vertical)** | **Mode, Channel** |
| -3.86 | 2390 | Horizontal | BLE, Low CH and 802.11g Mid CH |

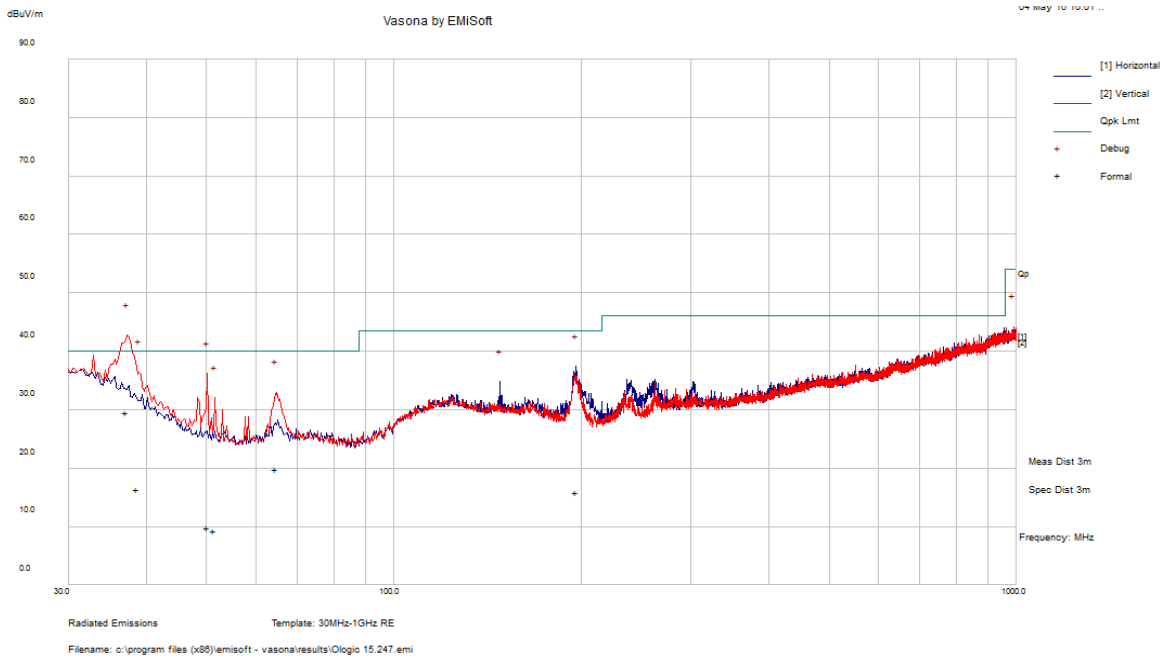
Note: Testing was performed to the EUT without enclosure, the enclosure is made of plastic with no metal parts.

Please refer to the following table and plots for specific test result details

## 7.8 Radiated Emissions Test Results

### 1) 30 MHz – 1 GHz Worst Case, Measured at 3 meters

**BLE**

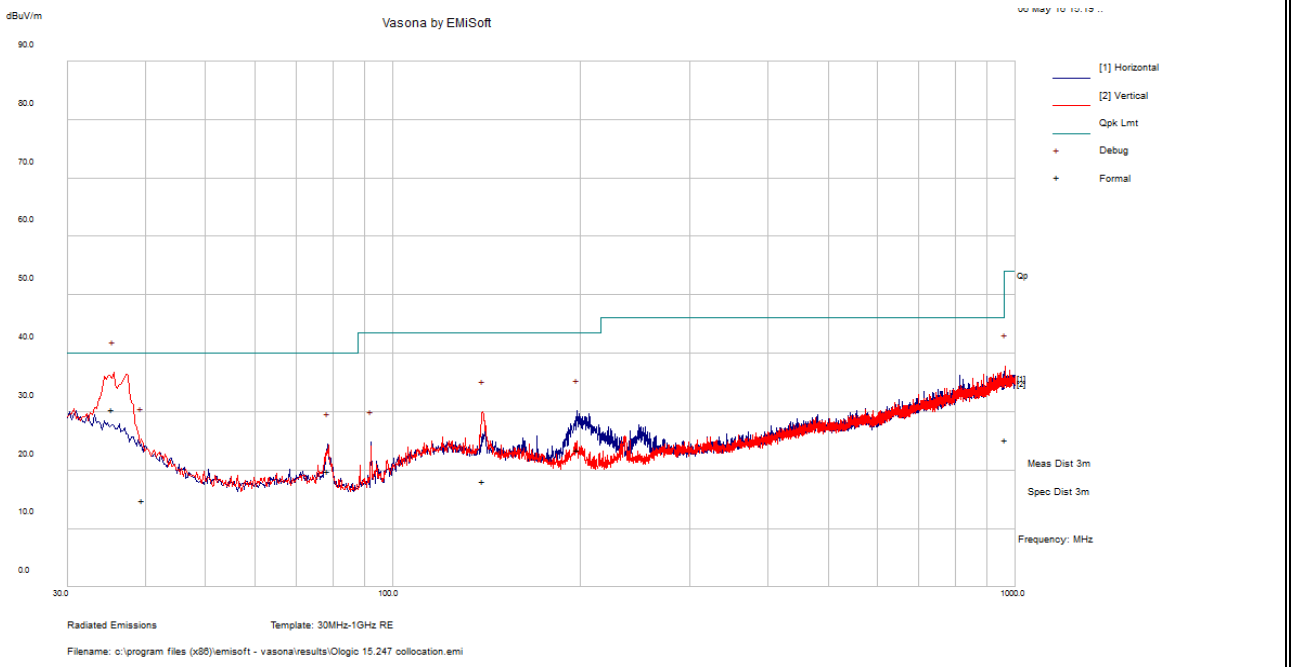



| Frequency (MHz) | Corrected Amplitude (dBµV/m) | Antenna Height (cm) | Antenna Polarity (H/V) | Turntable Azimuth (degrees) | Limit (dBµV/m) | Margin (dB) | Comment |
|---|---|---|---|---|---|---|---|
| 37.17275 | 29.49 | 114 | V | 101 | 40 | -10.51 | QP |
| 38.73775 | 16.47 | 300 | V | 1 | 40 | -23.53 | QP |
| 50.22325 | 9.83 | 260 | V | 1 | 40 | -30.17 | QP |
| 196.3383 | 15.91 | 100 | H | 1 | 43.5 | -27.59 | QP |
| 64.7285 | 19.86 | 158 | V | 291 | 40 | -20.14 | QP |
| 51.41675 | 9.24 | 235 | V | 294 | 40 | -30.76 | QP |

.

## Collocation

Worst Case Mode: BLE Low Channel and 802.11g mode Middle Channel




| Frequency (MHz) | Corrected Amplitude (dBµV/m) | Antenna Height (cm) | Antenna Polarity (H/V) | Turntable Azimuth (degrees) | Limit (dBµV/m) | Margin (dB) | Comment |
|---|---|---|---|---|---|---|---|
| 35.374 | 30.35 | 124 | V | 176 | 40 | -9.65 | QP |
| 197.8355 | 23.52 | 139 | H | 163 | 43.5 | -19.98 | QP |
| 139.6045 | 18.16 | 260 | V | 0 | 43.5 | -25.34 | QP |
| 39.5435 | 14.91 | 206 | V | 112 | 40 | -25.09 | QP |
| 78.572 | 19.8 | 218 | H | 166 | 40 | -20.2 | QP |
| 963.2873 | 25.15 | 184 | V | 145 | 54 | -28.85 | QP |

**2) 1–25 GHz Measured at 3 meters**

**BLE** (Max Power)

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| Low Channel 2402 MHz | | | | | | | | | | | |
| 2402 | 56.13 | 13 | 291 | V | 29.04 | 5.22 | 0.00 | 90.39 | - | - | Peak |
| 2402 | 60.35 | 346 | 233 | H | 29.04 | 5.22 | 0.00 | 94.61 | - | - | Peak |
| 2402 | 42.15 | 92 | 292 | V | 29.04 | 5.22 | 0.00 | 76.41 | - | - | Ave |
| 2402 | 46.37 | 342 | 293 | H | 29.04 | 5.22 | 0.00 | 80.63 | - | - | Ave |
| 2390 | 27.07 | 13 | 219 | V | 29.04 | 5.22 | 0.00 | 61.33 | 74.00 | -12.67 | Peak |
| 2390 | 28.57 | 346 | 233 | H | 29.04 | 5.22 | 0.00 | 62.83 | 74.00 | -11.17 | Peak |
| 2390 | 13.07 | 92 | 292 | V | 29.04 | 5.22 | 0.00 | 47.33 | 54.00 | -6.67 | Ave |
| 2390 | 13.10 | 342 | 293 | H | 29.04 | 5.22 | 0.00 | 47.36 | 54.00 | -6.64 | Ave |
| 4804 | 57.22 | 225 | 260 | V | 32.47 | 7.76 | 38.01 | 59.45 | 74.00 | -14.55 | Peak |
| 4804 | 58.51 | 253 | 258 | H | 32.47 | 7.76 | 38.01 | 60.74 | 74.00 | -13.26 | Peak |
| 4804 | 43.24 | 0 | 100 | V | 32.47 | 7.76 | 38.01 | 45.47 | 54.00 | -8.53 | Ave |
| 4804 | 44.53 | 252 | 129 | H | 32.47 | 7.76 | 38.01 | 46.76 | 54.00 | -7.24 | Ave |
| 7206 | 47.81 | 0 | 100 | V | 36.69 | 9.71 | 37.53 | 56.68 | 70.39 | -13.70 | Peak |
| 7206 | 48.94 | 0 | 100 | H | 36.69 | 9.71 | 37.53 | 57.81 | 74.61 | -16.79 | Peak |
| 7206 | 33.83 | 0 | 100 | V | 36.69 | 9.71 | 37.53 | 42.71 | 56.41 | -13.70 | Ave |
| 7206 | 34.96 | 0 | 100 | H | 36.69 | 9.71 | 37.53 | 43.84 | 60.63 | -16.79 | Ave |
| 9608 | 48.17 | 0 | 100 | V | 37.77 | 11.37 | 38.00 | 59.32 | 70.39 | -11.07 | Peak |
| 9608 | 48.85 | 0 | 100 | H | 37.77 | 11.37 | 38.00 | 60.00 | 74.61 | -14.61 | Peak |
| 9608 | 34.19 | 0 | 100 | V | 37.77 | 11.37 | 38.00 | 45.34 | 56.41 | -11.07 | Ave |
| 9608 | 34.87 | 0 | 100 | H | 37.77 | 11.37 | 38.00 | 46.02 | 60.63 | -14.61 | Ave |
| Middle Channel 2442 MHz | | | | | | | | | | | |
| 2442 | 54.77 | 301 | 281 | V | 29.04 | 5.22 | 0.00 | 89.03 | - | - | Peak |
| 2442 | 59.76 | 269 | 291 | H | 29.04 | 5.22 | 0.00 | 94.02 | - | - | Peak |
| 2442 | 40.79 | 296 | 282 | V | 29.04 | 5.22 | 0.00 | 75.05 | - | - | Ave |
| 2442 | 45.78 | 145 | 169 | H | 29.04 | 5.22 | 0.00 | 80.04 | - | - | Ave |
| 4884 | 57.27 | 128 | 253 | V | 32.64 | 7.93 | 37.92 | 59.92 | 74.00 | -14.08 | Peak |
| 4884 | 59.36 | 254 | 182 | H | 32.64 | 7.93 | 37.92 | 62.01 | 74.00 | -11.99 | Peak |
| 4884 | 43.29 | 129 | 251 | V | 32.64 | 7.93 | 37.92 | 45.95 | 54.00 | -8.05 | Ave |
| 4884 | 45.38 | 356 | 276 | H | 32.64 | 7.93 | 37.92 | 48.04 | 54.00 | -5.96 | Ave |
| 7326 | 48.26 | 0 | 100 | V | 37.15 | 9.86 | 37.53 | 57.74 | 74.00 | -16.26 | Peak |
| 7326 | 48.24 | 0 | 100 | H | 37.15 | 9.86 | 37.53 | 57.72 | 74.00 | -16.28 | Peak |
| 7326 | 34.28 | 0 | 100 | V | 37.15 | 9.86 | 37.53 | 43.76 | 54.00 | -10.24 | Ave |
| 7326 | 34.26 | 0 | 100 | H | 37.15 | 9.86 | 37.53 | 43.74 | 54.00 | -10.26 | Ave |
| 9768 | 49.30 | 0 | 100 | V | 37.92 | 11.48 | 38.27 | 60.43 | 69.03 | -8.60 | Peak |
| 9768 | 49.34 | 0 | 100 | H | 37.92 | 11.48 | 38.27 | 60.47 | 74.02 | -13.55 | Peak |
| 9768 | 35.32 | 0 | 100 | V | 37.92 | 11.48 | 38.27 | 46.45 | 55.05 | -8.60 | Ave |
| 9768 | 35.36 | 0 | 100 | H | 37.92 | 11.48 | 38.27 | 46.49 | 60.04 | -13.55 | Ave |

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| High Channel 2480 MHz | | | | | | | | | | | |
| 2480 | 51.87 | 77 | 246 | V | 29.41 | 5.47 | 0.00 | 86.76 | - | - | Peak |
| 2480 | 56.45 | 301 | 241 | H | 29.41 | 5.47 | 0.00 | 91.34 | - | - | Peak |
| 2480 | 37.89 | 214 | 100 | V | 29.41 | 5.47 | 0.00 | 72.78 | - | - | Ave |
| 2480 | 42.47 | 140 | 106 | H | 29.41 | 5.47 | 0.00 | 77.36 | - | - | Ave |
| 2483.5 | 28.45 | 0 | 100 | V | 29.41 | 5.47 | 0.00 | 63.34 | 74.00 | -10.66 | Peak |
| 2483.5 | 29.21 | 301 | 242 | H | 29.41 | 5.47 | 0.00 | 64.10 | 74.00 | -9.90 | Peak |
| 2483.5 | 14.47 | 0 | 100 | V | 29.41 | 5.47 | 0.00 | 49.36 | 54.00 | -4.64 | Ave |
| 2483.5 | 15.23 | 0 | 100 | H | 29.41 | 5.47 | 0.00 | 50.12 | 54.00 | -3.88 | Ave |
| 4960 | 57.09 | 153 | 230 | V | 32.99 | 7.93 | 37.85 | 60.16 | 74.00 | -13.84 | Peak |
| 4960 | 60.84 | 240 | 230 | H | 32.99 | 7.93 | 37.85 | 63.91 | 74.00 | -10.09 | Peak |
| 4960 | 43.11 | 151 | 294 | V | 32.99 | 7.93 | 37.85 | 46.18 | 54.00 | -7.82 | Ave |
| 4960 | 46.86 | 292 | 106 | H | 32.99 | 7.93 | 37.85 | 49.93 | 54.00 | -4.07 | Ave |
| 7440 | 49.05 | 0 | 100 | V | 37.14 | 9.86 | 37.62 | 58.42 | 74.00 | -15.58 | Peak |
| 7440 | 49.16 | 0 | 100 | H | 37.14 | 9.86 | 37.62 | 58.53 | 74.00 | -15.47 | Peak |
| 7440 | 35.07 | 0 | 100 | V | 37.14 | 9.86 | 37.62 | 44.44 | 54.00 | -9.56 | Ave |
| 7440 | 35.18 | 0 | 100 | H | 37.14 | 9.86 | 37.62 | 44.55 | 54.00 | -9.45 | Ave |
| 9920 | 49.10 | 0 | 100 | V | 37.99 | 11.59 | 38.38 | 60.29 | 66.76 | -6.46 | Peak |
| 9920 | 48.65 | 0 | 100 | H | 37.99 | 11.59 | 38.38 | 59.84 | 71.34 | -11.49 | Peak |
| 9920 | 35.12 | 0 | 100 | V | 37.99 | 11.59 | 38.38 | 46.31 | 52.78 | -6.46 | Ave |
| 9920 | 34.67 | 0 | 100 | H | 37.99 | 11.59 | 38.38 | 45.86 | 57.36 | -11.49 | Ave |

Note: Duty Cycle Correction Factor has been added to the measurements.

## Collocation

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| 2390 | 28.16 | 222 | 288 | V | 29.04 | 5.22 | 0.00 | 62.42 | 74.00 | -11.58 | Peak |
| 2390 | 29.23 | 127 | 300 | H | 29.04 | 5.22 | 0.00 | 63.49 | 74.00 | -10.51 | Peak |
| 2390 | 14.81 | 222 | 288 | V | 29.04 | 5.22 | 0.00 | 49.07 | 54.00 | -4.93 | Ave |
| 2390 | 15.88 | 127 | 300 | H | 29.04 | 5.22 | 0.00 | 50.14 | 54.00 | -3.86 | Ave |
| 4804 | 57.38 | 206 | 235 | V | 32.47 | 7.76 | 38.01 | 59.61 | 74.00 | -14.39 | Peak |
| 4804 | 57.92 | 34 | 252 | H | 32.47 | 7.76 | 38.01 | 60.15 | 74.00 | -13.85 | Peak |
| 4804 | 44.03 | 206 | 235 | V | 32.47 | 7.76 | 38.01 | 46.25 | 54.00 | -7.75 | Ave |
| 4804 | 44.57 | 34 | 252 | H | 32.47 | 7.76 | 38.01 | 46.79 | 54.00 | -7.21 | Ave |
| 7206 | 48.20 | 0 | 100 | V | 36.69 | 9.71 | 37.53 | 57.07 | 70.85 | -13.78 | Peak |
| 7206 | 48.16 | 0 | 100 | H | 36.69 | 9.71 | 37.53 | 57.03 | 73.30 | -16.27 | Peak |
| 7206 | 34.84 | 0 | 100 | V | 36.69 | 9.71 | 37.53 | 43.72 | 57.50 | -13.78 | Ave |
| 7206 | 34.80 | 0 | 100 | H | 36.69 | 9.71 | 37.53 | 43.68 | 59.95 | -16.27 | Ave |
| 9608 | 47.95 | 0 | 100 | V | 37.77 | 11.37 | 38.00 | 59.09 | 70.85 | -11.76 | Peak |
| 9608 | 48.23 | 0 | 100 | H | 37.77 | 11.37 | 38.00 | 59.37 | 73.30 | -13.93 | Peak |
| 9608 | 34.60 | 0 | 100 | V | 37.77 | 11.37 | 38.00 | 45.74 | 57.50 | -11.76 | Ave |
| 9608 | 34.88 | 0 | 100 | H | 37.77 | 11.37 | 38.00 | 46.02 | 59.95 | -13.93 | Ave |
| 4874 | 52.07 | 218 | 264 | V | 32.638 | 7.93 | 37.92 | 54.72 | 74.00 | -19.28 | Peak |
| 4874 | 52.53 | 30 | 300 | H | 32.638 | 7.93 | 37.92 | 55.18 | 74.00 | -18.82 | Peak |
| 4874 | 38.04 | 220 | 100 | V | 32.638 | 7.93 | 37.92 | 40.69 | 54.00 | -13.31 | Ave |
| 4874 | 36.96 | 33 | 274 | H | 32.638 | 7.93 | 37.92 | 39.61 | 54.00 | -14.39 | Ave |
| 7311 | 47.33 | 0 | 100 | V | 37.148 | 9.86 | 37.53 | 56.80 | 74.00 | -17.20 | Peak |
| 7311 | 47.27 | 0 | 100 | H | 37.148 | 9.86 | 37.53 | 56.74 | 74.00 | -17.26 | Peak |
| 7311 | 33.30 | 205 | 300 | V | 37.148 | 9.86 | 37.53 | 42.77 | 54.00 | -11.23 | Ave |
| 7311 | 33.42 | 195 | 107 | H | 37.148 | 9.86 | 37.53 | 42.89 | 54.00 | -11.11 | Ave |
| 9748 | 47.32 | 0 | 100 | V | 37.923 | 11.48 | 38.27 | 58.45 | 84.83 | -26.38 | Peak |
| 9748 | 47.56 | 0 | 100 | H | 37.923 | 11.48 | 38.27 | 58.69 | 86.72 | -28.03 | Peak |
| 9748 | 33.96 | 0 | 100 | V | 37.923 | 11.48 | 38.27 | 45.09 | 76.41 | -31.32 | Ave |
| 9748 | 33.94 | 0 | 100 | H | 37.923 | 11.48 | 38.27 | 45.07 | 77.01 | -31.94 | Ave |

# 8 FCC §15.247(a) (2) -Emission Bandwidth

## 8.1 Applicable Standards

According to FCC §15.247(a) (2), systems using digital modulation techniques may operate in the 902~928 MHz, 2400~2483.5 MHz, and 5725~5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz

## 8.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r04: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8: DTS bandwidth

## 8.3 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Agilent | Analyzer, Spectrum | E4440A | MY44303352 | 2015-06-22 | 1 year |

***Statement of Traceability: BACL Corp.*** *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

## 8.4 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 22º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

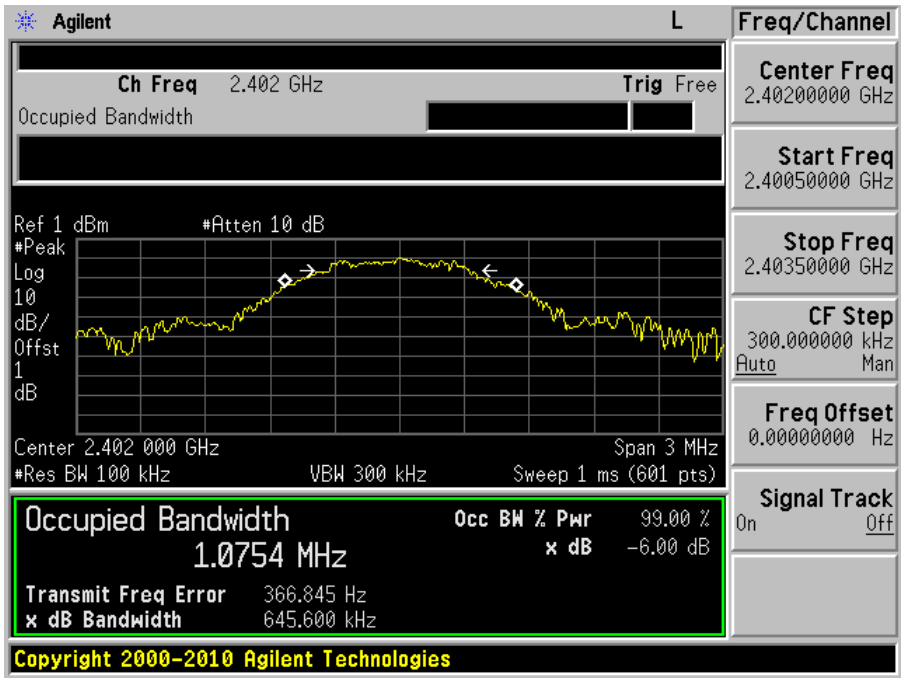
*The testing was performed by Todd Moy on 2016-04-08 in RF site.*

## 8.5 Test Results

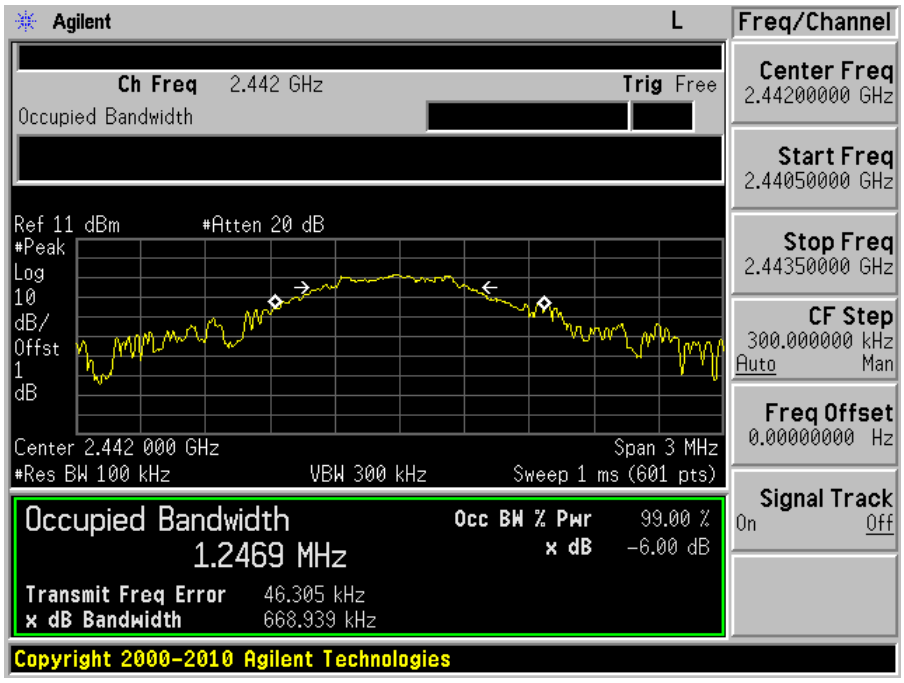
| Channel | Frequency (MHz) | 99% OBW (kHz) | 6 dB OBW (kHz) | 6 dB OBW limit (kHz) |
|---|---|---|---|---|
| BLE | | | | |
| Low | 2402 | 1075.4 | 645.600 | 500 |
| Middle | 2442 | 1246.9 | 668.939 | 500 |
| High | 2480 | 1114.1 | 650.349 | 500 |

Please refer to the following plots for detailed test results.

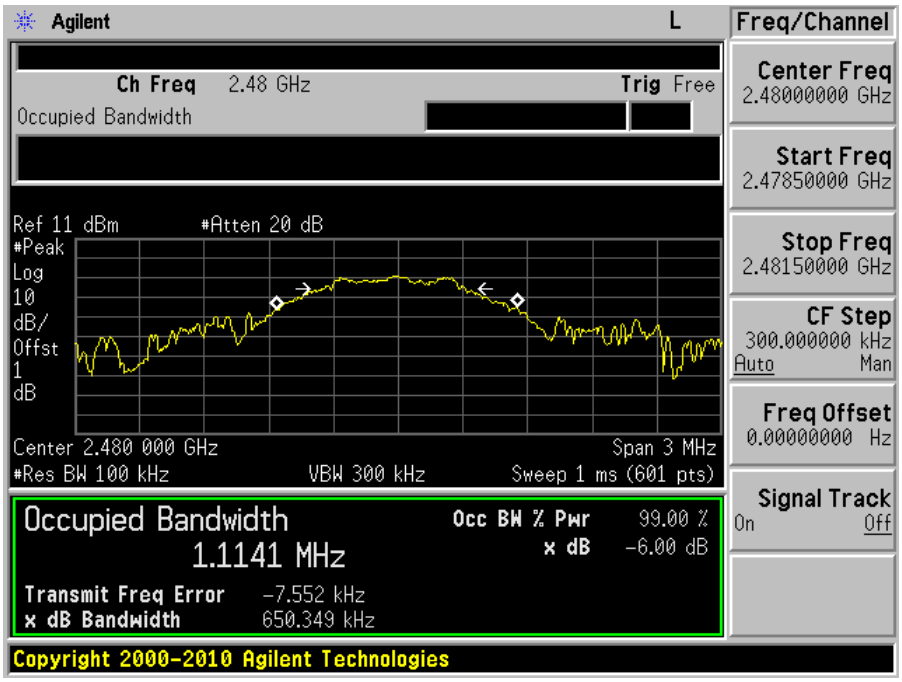
Low Channel 2402 MHz




Middle Channel 2442 MHz



High Channel 2480 MHz



# 9 FCC §15.247(b) (3) - Output Power Measurement

## 9.1 Applicable Standards

According to FCC §15.247(b) (3) for systems using digital modulation in the 902~928 MHz, 2400~2483.5 MHz, and 5725~5850 MHz bands: 1 Watt.

## 9.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r04: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 9: Fundamental emission output power

## 9.3 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Agilent | Analyzer, Spectrum | E4440A | MY44303352 | 2015-06-22 | 1 year |

***Statement of Traceability: BACL Corp.*** *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

## 9.4 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 22º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

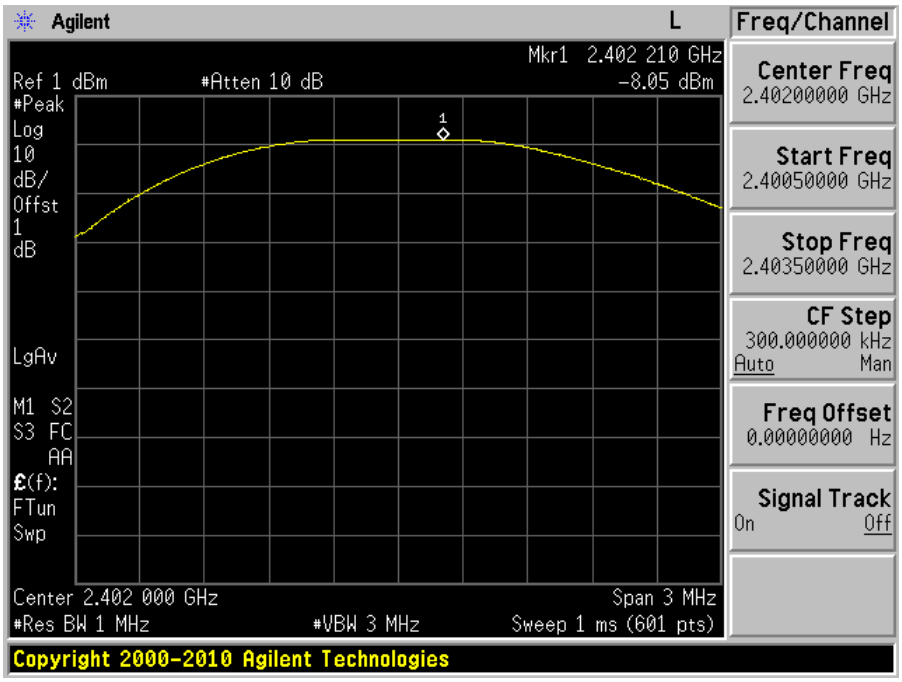
*The testing was performed by Todd Moy on 2016-04-08 in RF site.*

## 9.5 Test Results

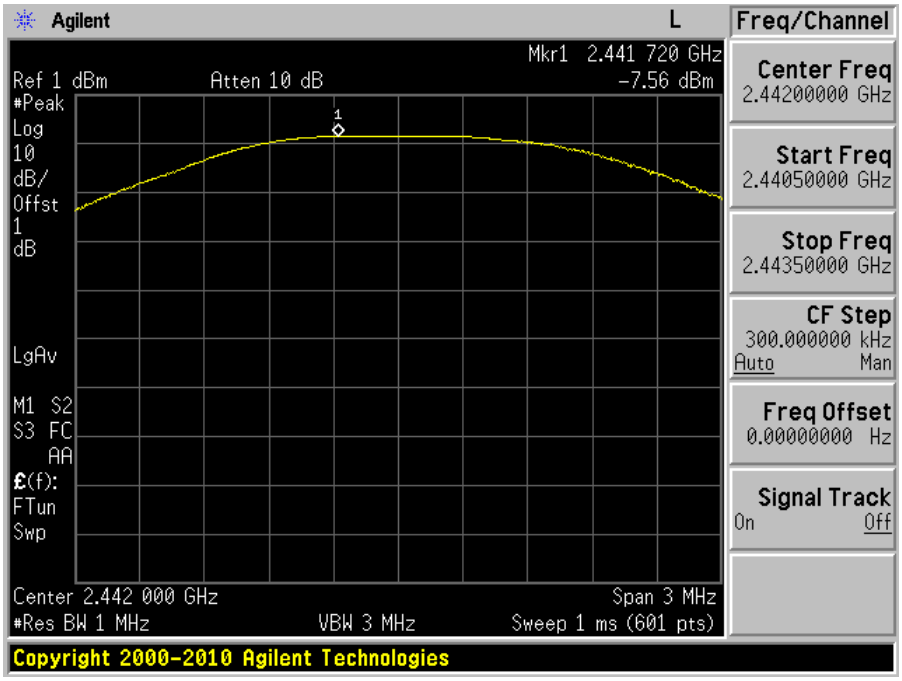
| Channel | Frequency (MHz) | Conducted Output Power (dBm) | Limit (dBm) |
|---|---|---|---|
| BLE | | | |
| Low | 2402 | -8.05 | 30 |
| Middle | 2442 | -7.56 | 30 |
| High | 2480 | -8.16 | 30 |

Please refer to the following plots for detailed test results.

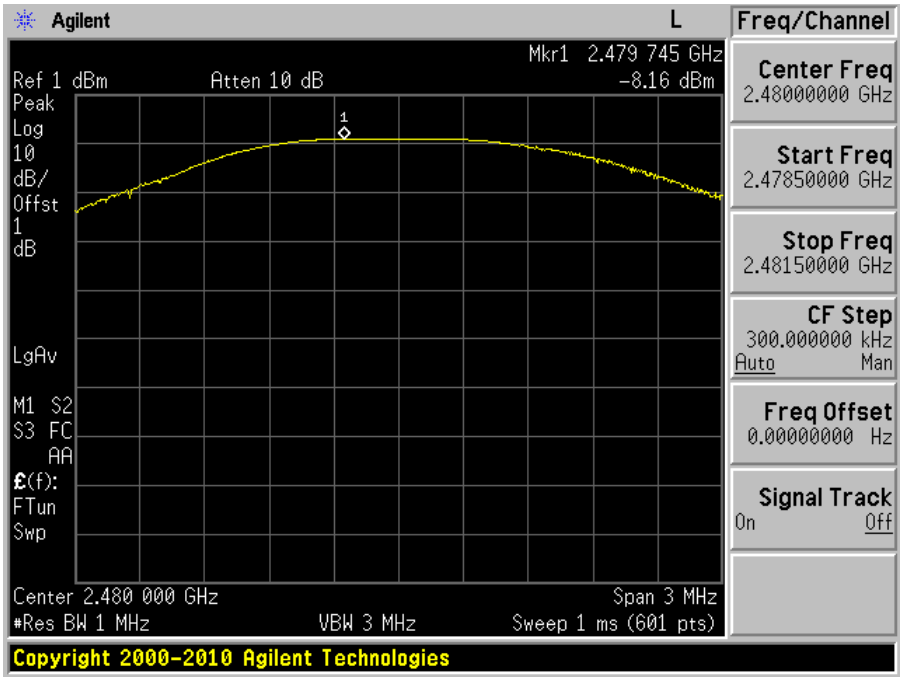
Low Channel 2402 MHz




Middle Channel 2440 MHz



High Channel 2480 MHz



# 10 FCC §15.247(d) – 100 kHz Bandwidth of Band Edges

## 10.1 Applicable Standards

According to FCC §15.247(d), in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum 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 §15.205(a), must also comply with the radiated emissions limits specified in §15.209(a) see §15.205(c).

## 10.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r04: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 13: Band-edge measurements

## 10.3 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Agilent | Analyzer, Spectrum | E4440A | MY44303352 | 2015-06-22 | 1 year |

***Statement of Traceability: BACL Corp.*** *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

## 10.4 Test Environmental Conditions

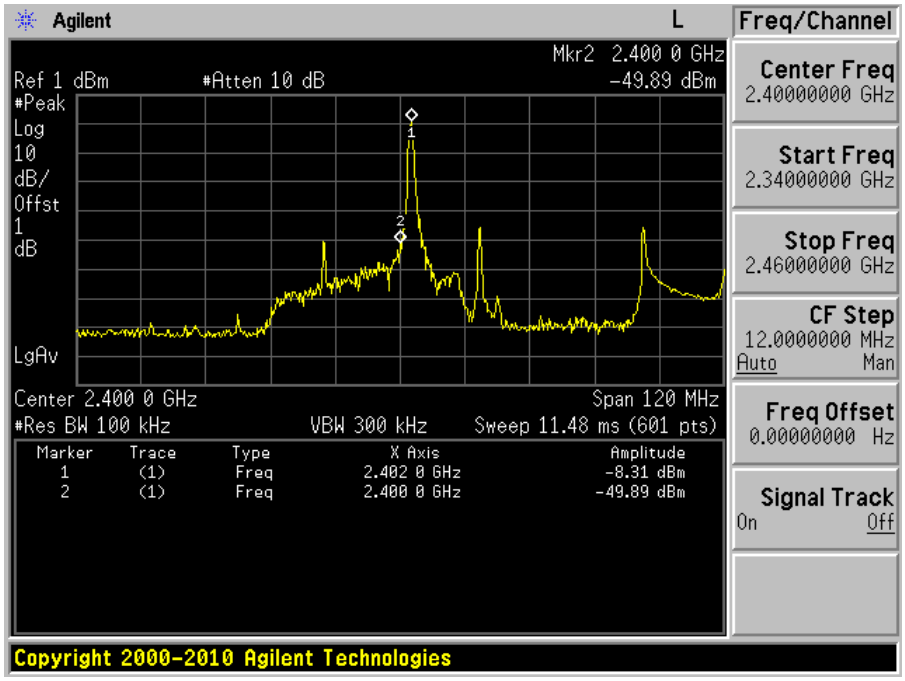
| | |
|---|---|
| **Temperature:** | 22º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

*The testing was performed by Todd Moy on 2016-04-08 in RF site.*

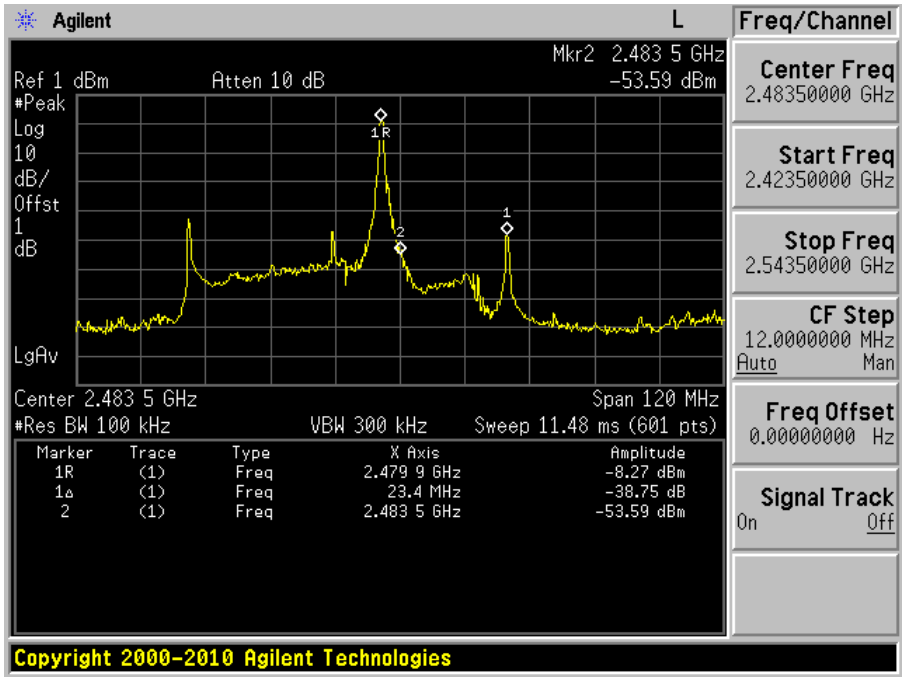
## 10.5 Test Results

Please refer to the following plots for detailed test results.

Low Channel 2402 MHz




High Channel 2480 MHz



# 11 FCC §15.247(e) – Power Spectral Density

## 11.1 Applicable Standards

According to FCC §15.247(e), for digitally modulated 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.

## 11.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v03r04: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 10: Maximum power spectral density level in the fundamental emission.

## 11.3 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Agilent | Analyzer, Spectrum | E4440A | MY44303352 | 2015-06-22 | 1 year |

***Statement of Traceability: BACL Corp.*** *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

## 11.4 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 22º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

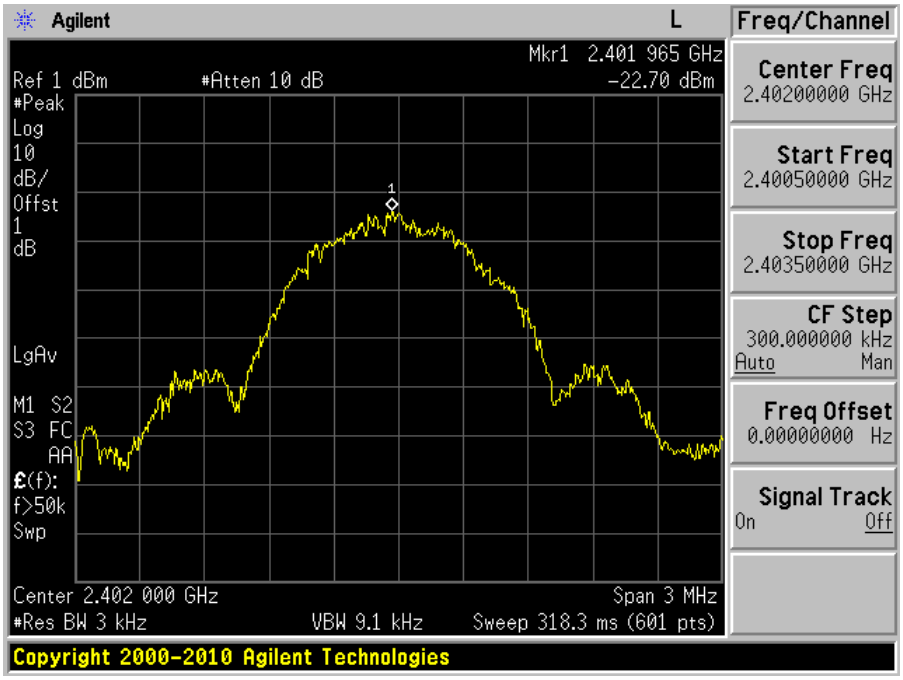
*The testing was performed by Todd Moy on 2016-04-08 in RF site.*

## 11.5 Test Results

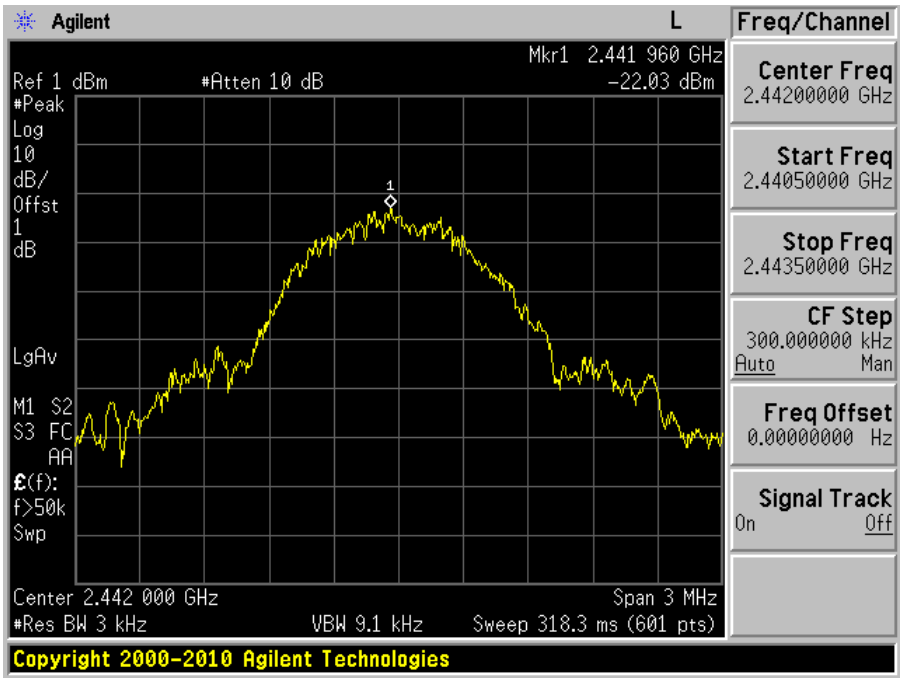
| Channel | Frequency (MHz) | PSD (dBm/3 kHz) | Limit (dBm/3 kHz) |
|---|---|---|---|
| Low | 2402 | -22.70 | 8 |
| Middle | 2442 | -22.03 | 8 |
| High | 2480 | -22.31 | 8 |

Please refer to the following plots for detailed test results

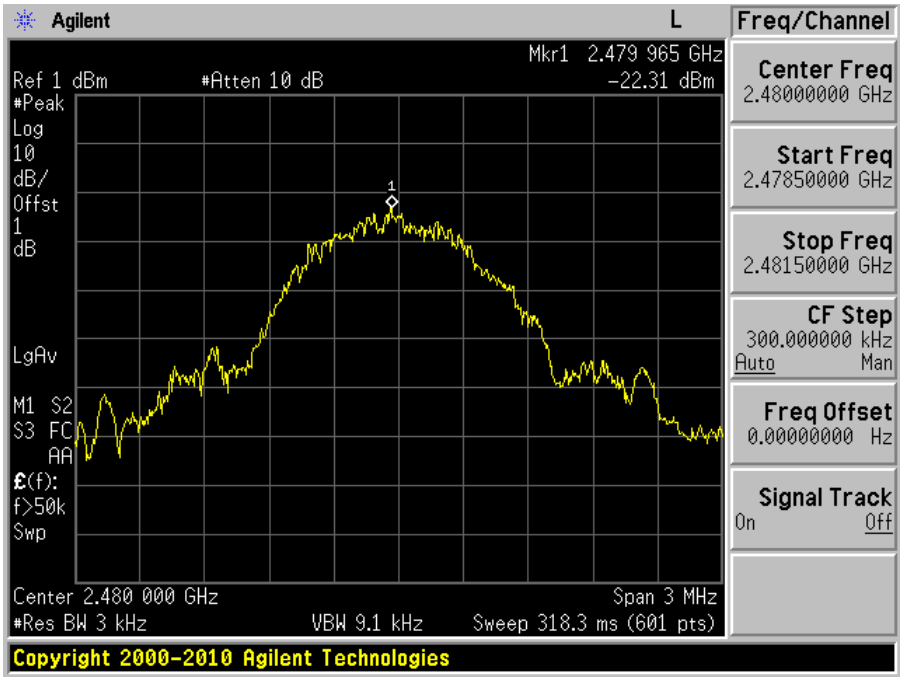
Low Channel 2402 MHz




Middle Channel 2442 MHz



High Channel 2480 MHz



# 12 FCC §15.247(d) – Spurious Emissions at Antenna Terminals

## 12.1 Applicable Standards

For FCC §15.247(d) 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, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

## 12.2 Test Procedure

The RF output of the EUT was connected to a spectrum analyzer through appropriate attenuation. The resolution bandwidth of the spectrum analyzer was set at 100 kHz. Sufficient scans were taken to show any out of band emissions up to 10th harmonic.

## 12.3 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Agilent | Analyzer, Spectrum | E4440A | MY44303352 | 2015-06-22 | 1 year |

***Statement of Traceability: BACL Corp.*** *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

## 12.4 Test Environmental Conditions

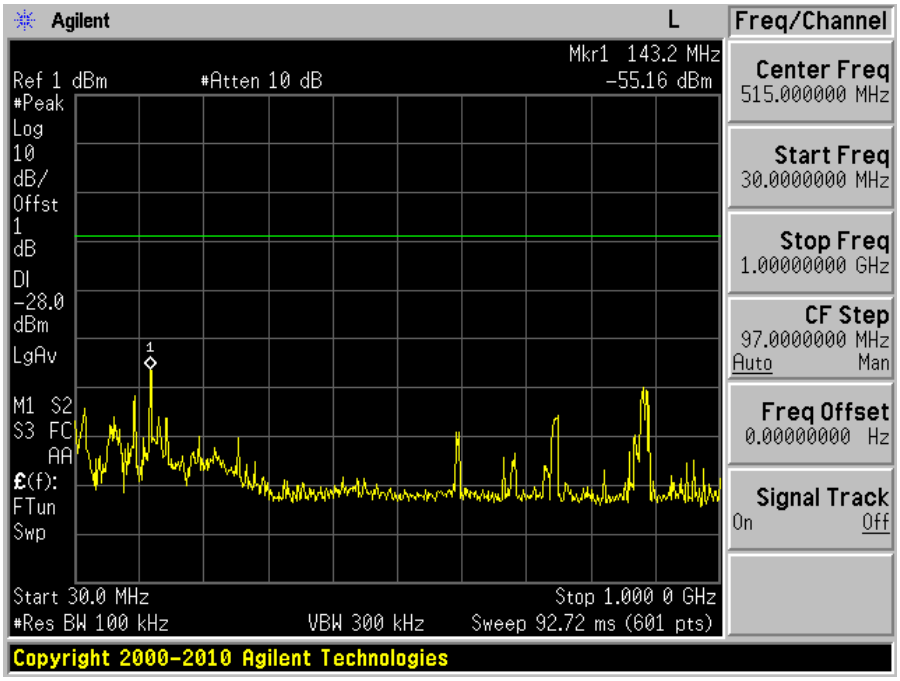
| | |
|---|---|
| **Temperature:** | 22º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

*The testing was performed by Todd Moy on 2016-04-08 in RF site.*

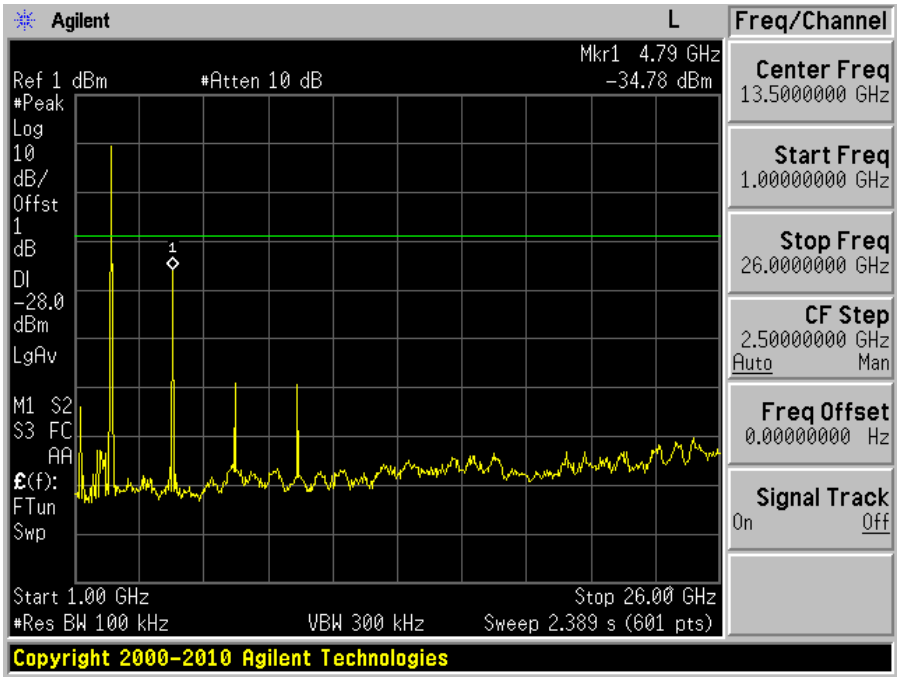
## 12.5 Test Results

Please refer to following plots.

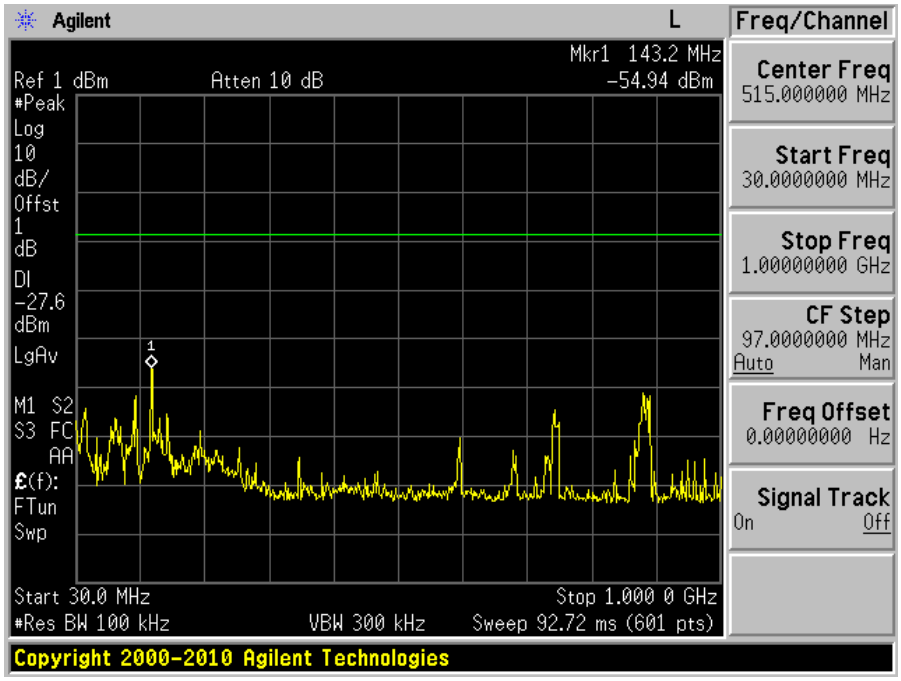
Low Channel 30 MHz – 3 GHz



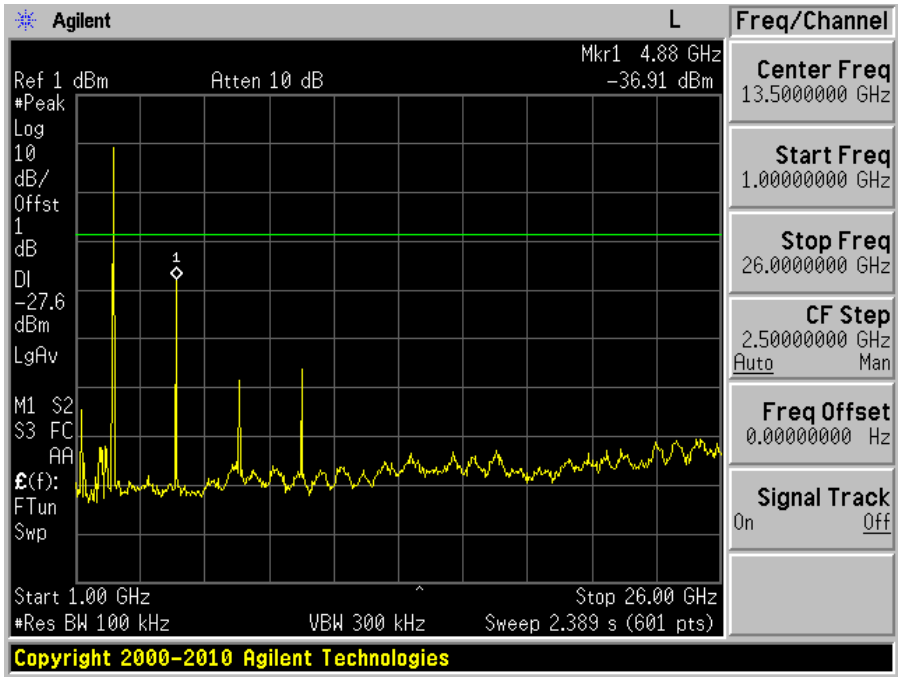

Low Channel 3 GHz – 26 GHz



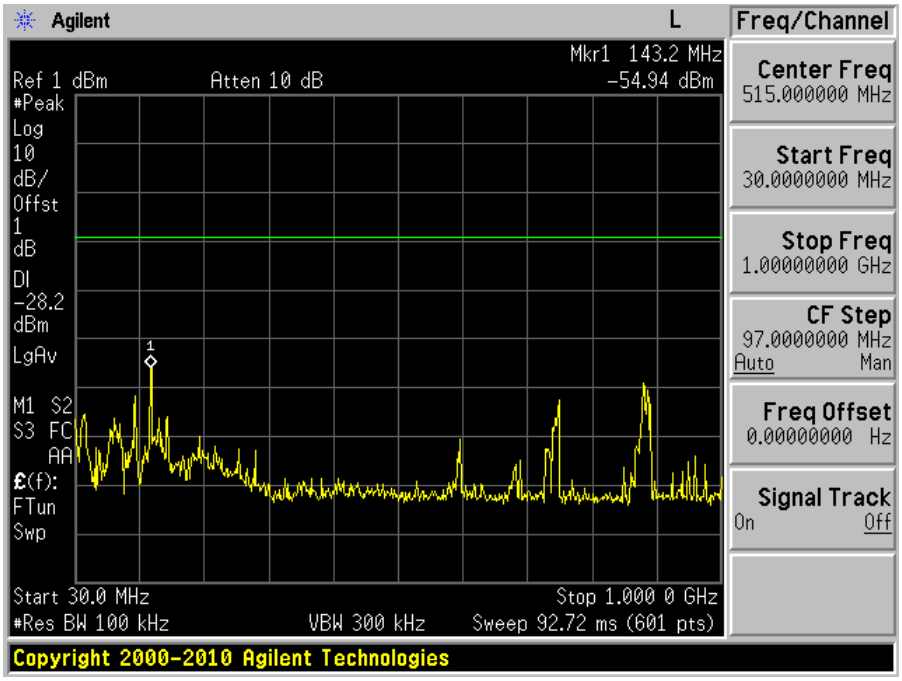
Middle Channel 30 MHz – 3 GHz




Middle Channel 3 GHz – 26 GHz



High Channel 30 MHz – 3 GHz




High Channel 3 GHz – 26 GHz