



# FCC PART 15, SUBPART C TEST AND MEASUREMENT REPORT

For

## Arch Systems Inc.

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Mountain View, CA 94043, USA

**FCC ID: 2AJS3-BTC1**

<b>Report Type:</b> Original Report	<b>Product Type:</b> Bluetooth Module for Industrial Sensors
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\* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "\*" Rev-03

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**DOCUMENT REVISION HISTORY**

<b>Revision Number</b>	<b>Report Number</b>	<b>Description of Revision</b>	<b>Date of Revision</b>
0	R16101322-247	Original Report	2016-11-04

## **1 General Description**

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

This test and measurement report was prepared on behalf of *Arch Systems Inc.*, and their product model: *con\_nrf52832*, FCC ID: 2AJS3-BTC1 or the “EUT” as referred to in this report. It is a Bluetooth Module for industrial sensors.

### **1.2 Objective**

This report is prepared on behalf of *Arch Systems 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.

### **1.3 Related Submittal(s)/Grant(s)**

N/A

### **1.4 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 v03r05: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

## 1.5 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.

Parameter	Measurement uncertainty
Occupied Channel Bandwidth	$\pm 5$ %
RF output power, conducted	$\pm 0.57$ dB
Power Spectral Density, conducted	$\pm 1.48$ dB
Unwanted Emissions, conducted	$\pm 1.57$ dB
All emissions, radiated	$\pm 4.0$ dB
AC power line Conducted Emission	$\pm 2.0$ dB
Temperature	$\pm 2$ ° C
Humidity	$\pm 5$ %
DC and low frequency voltages	$\pm 1.0$ %
Time	$\pm 2$ %
Duty Cycle	$\pm 3$ %

## 1.6 Test Facility Registrations

BACL's test facilities that are used to perform Radiated and Conducted Emissions tests are currently recognized by the Federal Communications Commission as Accredited with NIST Designation Number US1129.

BACL's test facilities that are used to perform Radiated and Conducted Emissions tests are currently registered with Industry Canada under Registration Numbers: 3062A-1, 3062A-2, and 3062A-3.

BACL is a Chinese Taipei Bureau of Standards Metrology and Inspection (BSMI) validated Conformity Assessment Body (CAB), under Appendix B, Phase I Procedures of the APEC Mutual Recognition Arrangement (MRA). BACL's BSMI Lab Code Number is: SL2-IN-E-1002R

BACL's test facilities that are used to perform AC Line Conducted Emissions, Telecommunications Line Conducted Emissions, Radiated Emissions from 30 MHz to 1 GHz, and Radiated Emissions from 1 GHz to 6 GHz are currently recognized as Accredited in accordance with the Voluntary Control Council for Interference [VCCI] Article 15 procedures under Registration Number A-0027.

## 1.7 Test Facility Accreditations

Bay Area Compliance Laboratories Corp. (BACL) is:

**A- An independent, 3<sup>rd</sup>-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2005 by A2LA (Test Laboratory Accreditation Certificate Number 3297.02),** in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (\*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2005 Scope of Accreditation includes all of the Test Method Standards and/or the Product Family Standards detailed in this Test Report..

BACL's ISO/IEC 17025:2005 Scope of Accreditation includes a comprehensive suite of EMC Emissions, EMC Immunity, Radio, RF Exposure, Safety and wireline Telecommunications test methods applicable to a wide range of product categories. These product categories include Central Office Telecommunications Equipment [including NEBS - Network Equipment Building Systems], Unlicensed and Licensed Wireless and RF devices, Information Technology Equipment (ITE); Telecommunications Terminal Equipment (TTE); Medical Electrical Equipment; Industrial, Scientific and Medical Test Equipment; Professional Audio and Video Equipment; Industrial and Scientific Instruments and Laboratory Apparatus; Cable Distribution Systems, and Energy Efficient Lighting.

**B- A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.03)** to certify

- For the USA (Federal Communications Commission):

- 1- All Unlicensed radio frequency devices within FCC Scopes A1, A2, A3, and A4;
- 2- All Licensed radio frequency devices within FCC Scopes B1, B2, B3, and B4;
- 3- All Telephone Terminal Equipment within FCC Scope C.

- For the Canada (Industry Canada):

- 1 All Scope 1-Licence-Exempt Radio Frequency Devices;
- 2 All Scope 2-Licensed Personal Mobile Radio Services;
- 3 All Scope 3-Licensed General Mobile & Fixed Radio Services;
- 4 All Scope 4-Licensed Maritime & Aviation Radio Services;
- 5 All Scope 5-Licensed Fixed Microwave Radio Services
- 6 All Broadcasting Technical Standards (BETS) in the Category I Equipment Standards List.

- For Singapore (Info-Communications Development Authority (IDA)):

- 1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2

- For the Hong Kong Special Administrative Region:

- 1 All Radio Equipment, per KHCA 10XX-series Specifications;
- 2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
- 3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.

- For Japan:

- 1 MIC Telecommunication Business Law (Terminal Equipment):
  - All Scope A1 - Terminal Equipment for the Purpose of Calls;
  - All Scope A2 - Other Terminal Equipment
- 2 Radio Law (Radio Equipment):
  - All Scope B1 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 1 of the Radio Law
  - All Scope B2 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 2 of the Radio Law
  - All Scope B3 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 3 of the Radio Law

**C- A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.01) to certify Products to USA's Environmental Protection Agency (EPA) ENERGY STAR Product Specifications for:**

- 1 Electronics and Office Equipment:
  - for Telephony (ver. 3.0)
  - for Audio/Video (ver. 3.0)
  - for Battery Charging Systems (ver. 1.1)
  - for Set-top Boxes & Cable Boxes (ver. 4.1)
  - for Televisions (ver. 6.1)
  - for Computers (ver. 6.0)
  - for Displays (ver. 6.0)
  - for Imaging Equipment (ver. 2.0)
  - for Computer Servers (ver. 2.0)
- 2 Commercial Food Service Equipment
  - for Commercial Dishwashers (ver. 2.0)
  - for Commercial Ice Machines (ver. 2.0)
  - for Commercial Ovens (ver. 2.1)
  - for Commercial Refrigerators and Freezers
- 3 Lighting Products
  - For Decorative Light Strings (ver. 1.5)
  - For Luminaires (including sub-components) and Lamps (ver. 1.2)
  - For Compact Fluorescent Lamps (CFLs) (ver. 4.3)
  - For Integral LED Lamps (ver. 1.4)
- 4 Heating, Ventilation, and AC Products
  - for Residential Ceiling Fans (ver. 3.0)
  - for Residential Ventilating Fans (ver. 3.2)
- 5 Other
  - For Water Coolers (ver. 3.0)

**D- A NIST Designated Phase-I and Phase-II Conformity Assessment Body (CAB) for the following economies and regulatory authorities under the terms of the stated MRAs/Treaties:**

- Australia: ACMA (Australian Communication and Media Authority) – APEC Tel MRA -Phase I;
- Canada: (Innovation, Science, and Economic Development Canada - ISED) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
  - o BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
  - o NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
  - o Radio & Teleterminal Equipment (R&TTE) Directive 1995/5/EC
  - US -EU EMC & Telecom MRA CAB
- Hong Kong Special Administrative Region: (Office of the Telecommunications Authority – OFTA) APEC Tel MRA -Phase I & Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Development Authority - IDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
  - o ENERGY STAR Recognized Test Laboratory – US EPA
  - o Telecommunications Certification Body (TCB) – US FCC;
- Vietnam: APEC Tel MRA -Phase I;



## 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 v03r05.

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 software used was nrf52832\_fcc version 1.1 provided by *Arch System, Inc.* the software complied with the standard requirements being tested against.

### 2.3 Duty Cycle Correction Factor

According to KDB 558074 D01 DTS Meas Guidance v03r05 section 6.0:

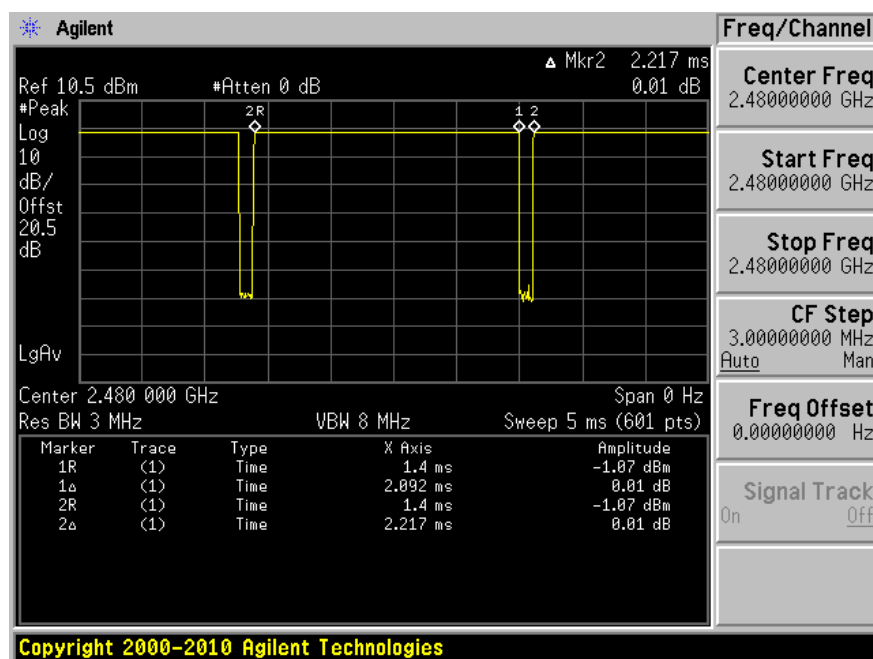
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized 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 (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
BLE	2.092	2.217	94.36	0.25

Duty Cycle = On Time (ms)/ Period (ms)

Duty Cycle Correction Factor (dB) =  $10 \cdot \log(1/\text{Duty Cycle})$

Please refer to the following plots.



## 2.4 Local Support Equipment

Manufacturer	Description	Model
Dell	Laptop	Latitude D630

## 2.5 Support Equipment

Debug board which is provide by client was used for testing, please refers to photo section for detail.

## 2.6 Interface Ports and Cabling

Cable Description	Length (m)	To	From
USB Cable	< 1 m	Laptop	EUT
RF Cable	< 1 m	EUT	PSA

### 3 Summary of Test Results

Results reported relate only to the product tested.

FCC Rules	Description of Test	Results
FCC §15.203	Antenna Requirement	Compliant
FCC §2.1091, §15.247(i)	RF Exposure	Compliant
FCC §15.207	AC Conducted Line Emissions	Compliant
FCC §2.1051, §15.247 (d)	Spurious Emissions at Antenna Port	Compliant
FCC §2.1053, §15.205, §15.209, §15.247 (d)	Radiated Spurious Emissions	Compliant
FCC §15.247(a)(2)	6 dB & 99% Emission Bandwidth	Compliant
FCC §15.247(b)(3)	Maximum Peak Output Power	Compliant
FCC §15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliant
FCC §15.247(e)	Power Spectral Density	Compliant

## 4 FCC §15.203 - Antenna Requirements

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### 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 permanent attached antennas.

Antenna type	Frequency Range (MHz)	Maximum Antenna Gain (dBi)
Trace Monopole antenna	2400-2483.5	5.2

## 5 FCC §15.247(i) - RF Exposure

### 5.1 Applicable Standards

According to FCC §15.247(i) and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

#### Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm <sup>2</sup> )	Averaging Time (minutes)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	* (100)	30
1.34-30	824/f	2.19/f	* (180/f <sup>2</sup> )	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz

\* = Plane-wave equivalent power density

### 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

### 5.3 MPE Results

Maximum peak output power at antenna input terminal (dBm): -0.73

Maximum peak output power at antenna input terminal (mW): 0.845

Prediction distance (cm): 20

Prediction frequency (MHz): 2402

Maximum Antenna Gain, typical (dBi): 5.2

Maximum Antenna Gain (numeric): 3.311

Power density of prediction frequency at 20.0 cm (mW/cm<sup>2</sup>): 0.0006

FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>): 1.0

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.0006 mW/cm<sup>2</sup>. Limit is 1.0 mW/cm<sup>2</sup>.

## 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  $\mu$ H/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 <sup>Note1</sup>	56 to 46 <sup>Note2</sup>
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 was 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:

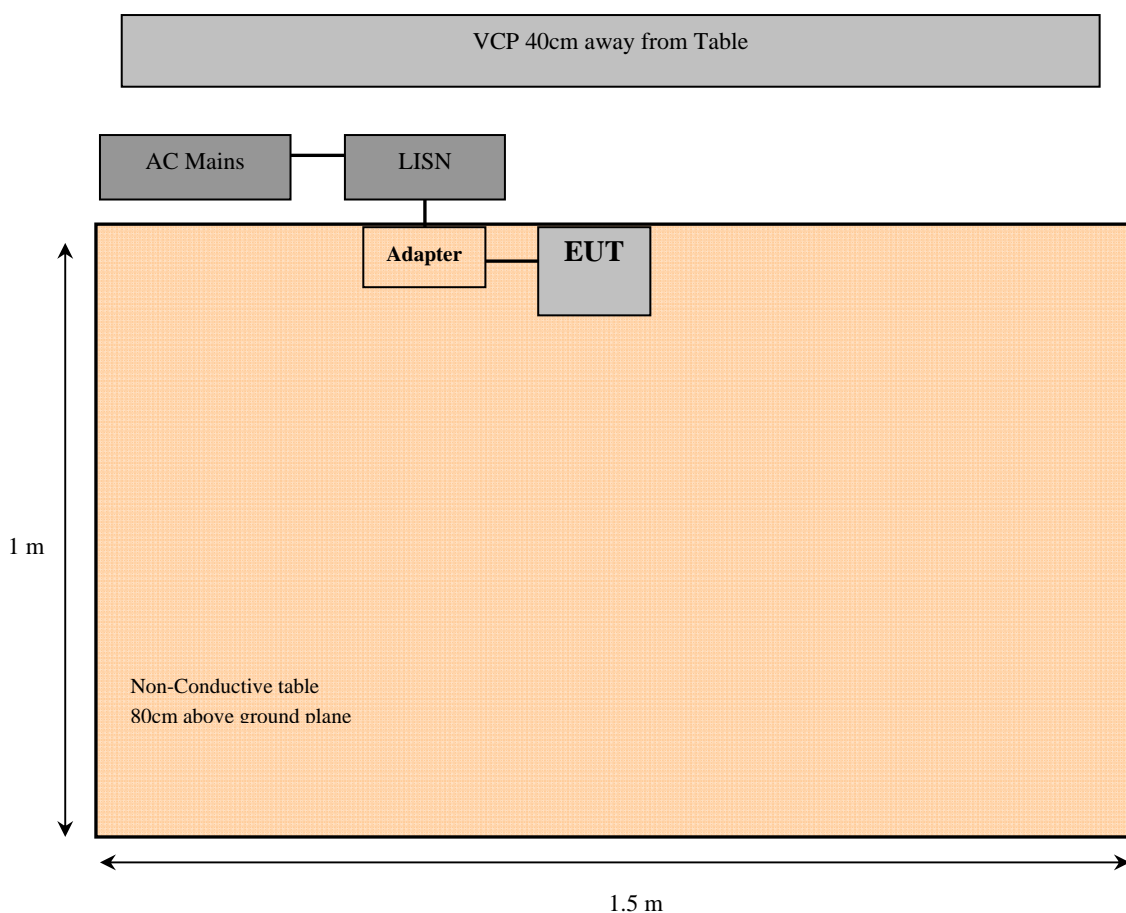
$$CA = Ai + CL + Atten$$

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:

$$\text{Margin} = \text{Corrected Amplitude} - \text{Limit}$$

## 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	100338	2016-02-04	2 years
Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101964	2016-07-22	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150204	2016-03-09	1 Year
Suirong	30 ft conductive emission cable	LMR 400	-	2016-03-05	1 year
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160131	2016-04-25	1year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

**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

<b>Temperature:</b>	20-22 °C
<b>Relative Humidity:</b>	42-45 %
<b>ATM Pressure:</b>	102 kPa

The testing was performed by Xiao Lin on 2016-11-04 in RF site.

## 6.8 Summary of Test Results

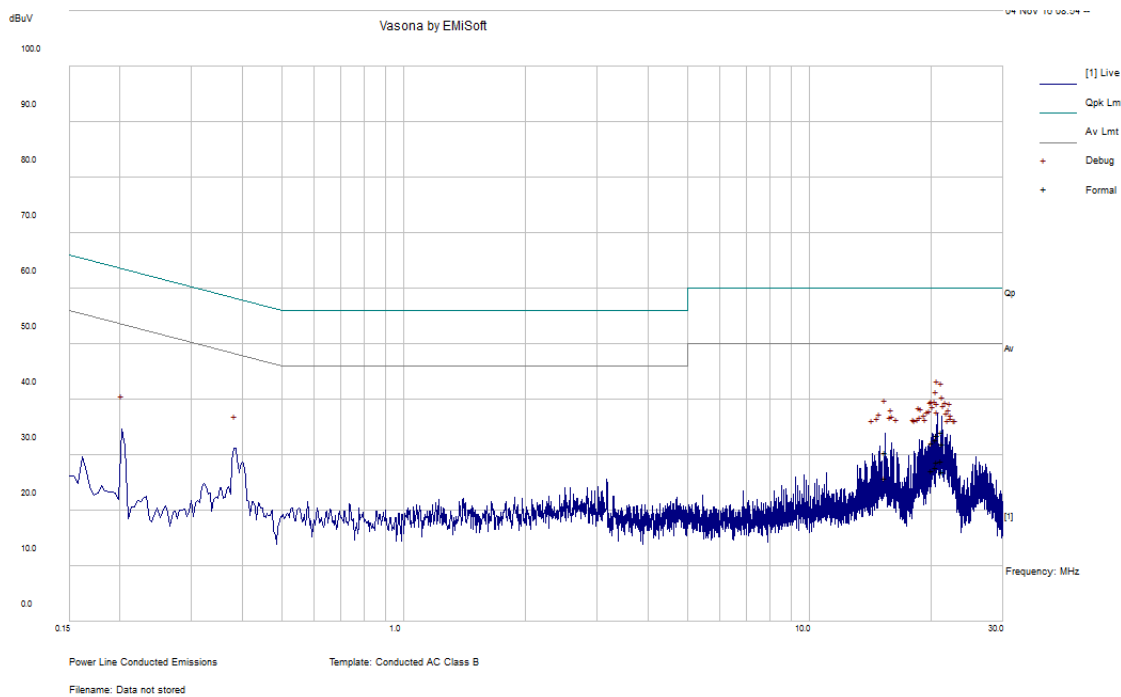
According to the recorded data in following table, the EUT complied with the FCC 15C standard's conducted emissions limits, with the margin reading of:

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	Frequency (MHz)	Conductor Mode (Line/Neutral)	Range (MHz)
-20.98	21.18225	Line	0.15-30



## 6.9 Conducted Emissions Test Plots and Data

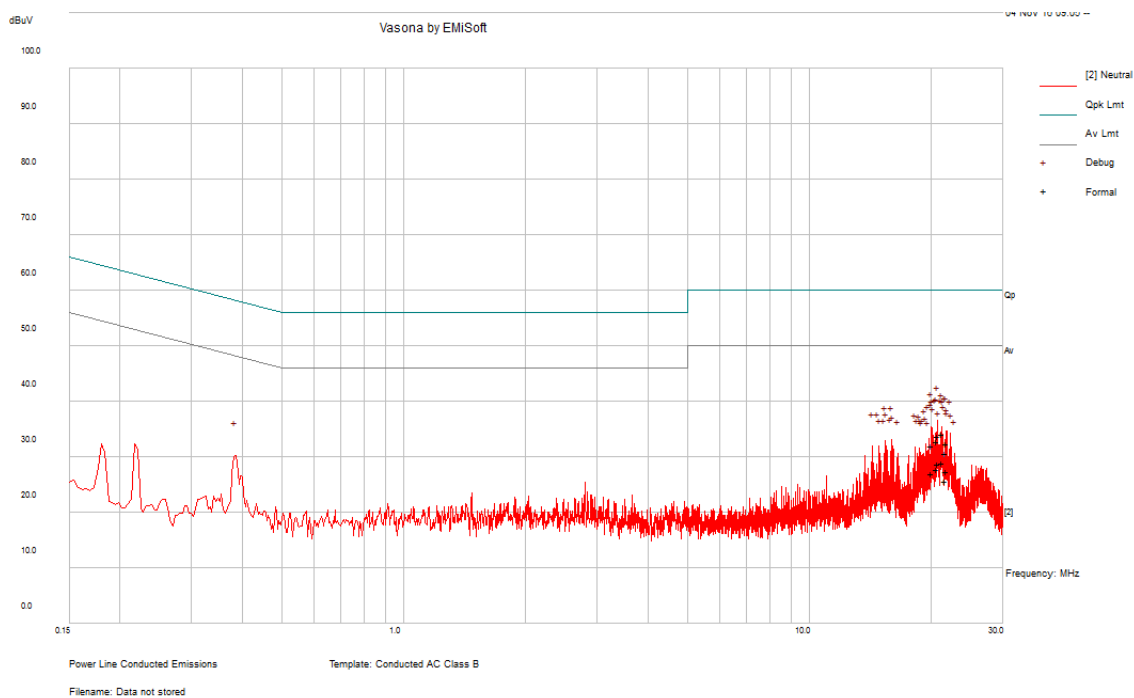
### 120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
20.70761	33.68	Line	60	-26.32	QP
21.18225	34.21	Line	60	-25.79	QP
20.59133	32.91	Line	60	-27.09	QP
21.30529	31.99	Line	60	-28.01	QP
15.38425	30.48	Line	60	-29.52	QP
20.11629	32.15	Line	60	-27.85	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
20.70761	28.72	Line	50	-21.28	Ave.
21.18225	29.02	Line	50	-20.98	Ave.
20.59133	27.88	Line	50	-22.12	Ave.
21.30529	27.01	Line	50	-22.99	Ave.
15.38425	25.89	Line	50	-24.11	Ave.
20.11629	27.22	Line	50	-22.78	Ave.

## 120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
20.70919	33.76	Neutral	60	-26.24	QP
20.00004	32.07	Neutral	60	-27.93	QP
21.18314	34.18	Neutral	60	-25.82	QP
21.66498	30.69	Neutral	60	-29.31	QP
21.7752	32.52	Neutral	60	-27.48	QP
20.59231	32.82	Neutral	60	-27.18	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
20.70919	28.75	Neutral	50	-21.25	Ave.
20.00004	27.09	Neutral	50	-22.91	Ave.
21.18314	29	Neutral	50	-21	Ave.
21.66498	25.81	Neutral	50	-24.19	Ave.
21.7752	27.44	Neutral	50	-22.56	Ave.
20.59231	27.79	Neutral	50	-22.21	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	16.42 – 16.423	960 – 1240	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	1300 – 1427	5. 35 – 5. 46
2.1735 – 2.1905	25.5 – 25.67	1435 – 1626.5	7.25 – 7.75
4.125 – 4.128	37.5 – 38.25	1645.5 – 1646.5	8.025 – 8.5
4.17725 – 4.17775	73 – 74.6	1660 – 1710	9.0 – 9.2
4.20725 – 4.20775	74.8 – 75.2	1718.8 – 1722.2	9.3 – 9.5
6.215 – 6.218	108 – 121.94	2200 – 2300	10.6 – 12.7
6.26775 – 6.26825	123 – 138	2310 – 2390	13.25 – 13.4
6.31175 – 6.31225	149.9 – 150.05	2483.5 – 2500	14.47 – 14.5
8.291 – 8.294	156.52475 – 156.52525	2690 – 2900	15.35 – 16.2
8.362 – 8.366	156.7 – 156.9	3260 – 3267	17.7 – 21.4
8.37625 – 8.38675	162.0125 – 167.17	3.332 – 3.339	22.01 – 23.12
8.41425 – 8.41475	167.72 – 173.2	3 3458 – 3 358	23.6 – 24.0
12.29 – 12.293	240 – 285	3.600 – 4.400	31.2 – 31.8
12.51975 – 12.52025	322 – 335.4		36.43 – 36.5
12.57675 – 12.57725	399.9 – 410		Above 38.6
13.36 – 13.41	608 – 614		

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:

$$\text{Margin} = \text{Corrected Amplitude} - \text{Limit}$$

## 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	100338	2016-02-04	2 year
Agilent	Analyzer, Spectrum	E4440A	US45303156	2016-01-19	1 year
Sunol Science Corp	System Controller	SC99V	011003-1	N/R	N/R
Sunol Sciences	Antenna, Biconi-Log	JB3	A020106-2	2015-07-11	2 Years
EMCO	Antenna, Horn	3115	9511-4627	2016-01-28	2 years
HP	Amplifier, Pre	8449B	3147A00400	2016-03-30	1 year
IW	Armored High Frequency Cable	DC 1531	KPS-1501A3960KPS	2016-08-05	1 Year
-	SMA cable	-	C0002	Each time <sup>1</sup>	N/A
-	N-Type Cable	-	C00013	2016-04-28	1 year
-	N-Type Cable	-	C00014	2016-05-28	1 year
HP	Pre-Amplifier	8447D	2443A04374	2016-06-28	1year
Wisewave	Antenna, Horn	ARH-4223-02	10555-01	2015-10-22	2 years
Wisewave	Amplifier, Low Noise	ALN-22093530-01	12263-01	2016-05-16	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Note<sup>1</sup>: 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

<b>Temperature:</b>	20-22 °C
<b>Relative Humidity:</b>	42-45 %
<b>ATM Pressure:</b>	102 kPa

*The testing was performed by Xiao Lin 2016-10-12 in 5m chamber 3.*

## 7.7 Summary of Test Results

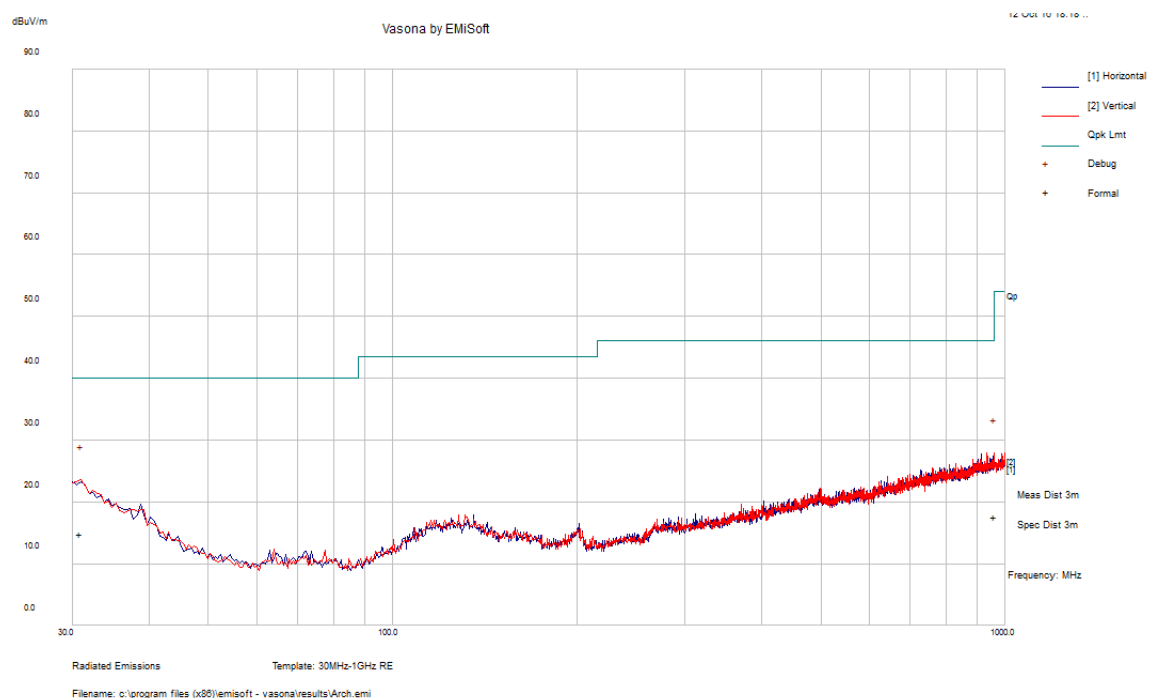
According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C standard's radiated emissions limits, and had the worst margin of:

<b>Mode: Transmitting</b>			
<b>Margin (dB)</b>	<b>Frequency (MHz)</b>	<b>Polarization (Horizontal/Vertical)</b>	<b>channel</b>
-4.06	2483.5	Vertical	High channel

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



Frequency (MHz)	Corrected Amplitude (dBμV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBμV/m)	Margin (dB)	Comment
30.90575	14.88	202	V	141	40	-25.12	QP
959.917	17.55	141	V	290	46	-28.45	QP

*Note: Only 2 emissions were present, others are under noise floor.*

## 2) 1–25 GHz Measured at 3 meters

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	58.97	179	119	H	29.04	5.19	0	93.20	-	-	PK
2402	56.88	179	119	H	29.04	5.19	0	91.12	-	-	AV
2402	61.03	344	166	V	29.04	5.19	0	95.26	-	-	PK
2402	58.92	344	166	V	29.04	5.19	0	93.16	-	-	AV
2390	28.68	179	119	H	29.04	5.19	0	62.91	74.00	-11.09	PK
2390	15.37	179	119	H	29.04	5.19	0	49.61	54.00	-4.39	AV
2390	28.57	344	166	V	29.04	5.19	0	62.80	74.00	-11.20	PK
2390	15.37	344	166	V	29.04	5.19	0	49.61	54.00	-4.39	AV
4804	52.65	0	140	V	32.47	8.93	38.56	55.49	74.00	-18.51	PK
4804	46.43	0	140	V	32.47	8.93	38.56	49.27	54.00	-4.73	AV
7206	47.76	0	265	V	36.69	11.48	37.9	58.03	75.26	-17.23	PK
7206	35.45	0	265	V	36.39	11.48	37.9	45.42	73.16	-27.73	AV
9608	48.44	0	100	V	37.77	13.82	38.29	61.74	75.26	-13.52	PK
9608	34.08	0	100	V	37.77	13.82	38.29	47.38	73.16	-25.77	AV
Middle Channel 2440 MHz											
2440	58.71	295	100	H	29.04	5.19	0.00	92.94	-	-	PK
2440	56.54	295	100	H	29.04	5.19	0.00	90.78	-	-	AV
2440	61.30	99	175	V	29.04	5.19	0.00	95.53	-	-	PK
2440	59.15	99	175	V	29.04	5.19	0.00	93.39	-	-	AV
4880	52.82	0	245	V	32.64	8.83	38.54	55.75	74.00	-18.25	PK
4880	45.70	0	245	V	32.64	8.83	38.54	48.63	54.00	-5.37	AV
7320	48.55	0	236	V	37.15	12.01	37.90	59.81	74.00	-14.19	PK
7320	37.92	0	236	V	37.15	12.01	37.90	49.18	54.00	-4.82	AV
9760	47.98	0	100	V	37.92	13.70	38.29	61.31	75.53	-14.22	PK
9760	34.59	0	100	V	37.92	13.70	38.29	47.92	73.39	-25.46	AV



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	59.00	55	102	H	29.41	5.19	0.00	93.60	-	-	PK
2480	56.41	55	102	H	29.41	5.19	0.00	90.98	-	-	AV
2480	59.95	58	192	V	29.41	5.19	0.00	94.55	-	-	PK
2480	57.55	58	192	V	29.41	5.19	0.00	92.12	-	-	AV
2483.5	28.72	55	102	H	29.41	5.19	0.00	63.32	74.00	-10.68	PK
2483.5	15.36	55	102	H	29.41	5.19	0.00	49.93	54.00	-4.07	AV
2483.5	29.12	58	192	V	29.41	5.19	0.00	63.72	74.00	-10.28	PK
2483.5	15.37	58	192	V	29.41	5.19	0.00	49.94	54.00	-4.06	AV
4960	51.48	0	275	V	32.64	8.70	38.54	54.28	74.00	-19.72	PK
4960	43.56	0	275	V	32.64	8.70	38.54	46.32	54.00	-7.68	AV
7440	49.56	0	248	V	37.14	11.96	37.89	60.77	74.00	-13.23	PK
7440	37.68	0	248	V	37.14	11.96	37.89	48.85	54.00	-5.15	AV
9920	47.69	0	100	V	37.99	14.31	38.33	61.66	74.55	-12.89	PK
9920	33.62	0	100	V	37.99	14.31	38.33	47.55	72.12	-24.56	AV

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

## 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 v03r05: 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	US45303156	2016-01-19	1 year
-	RF cable	-	-	Each time <sup>1</sup>	N/A
-	20dB attenuator	-	-	Each time <sup>1</sup>	N/A

Note<sup>1</sup>: cable and attenuator included in the test set-up will be checked each time before testing.

**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:	20-22° C
Relative Humidity:	42-45 %
ATM Pressure:	102 KPa

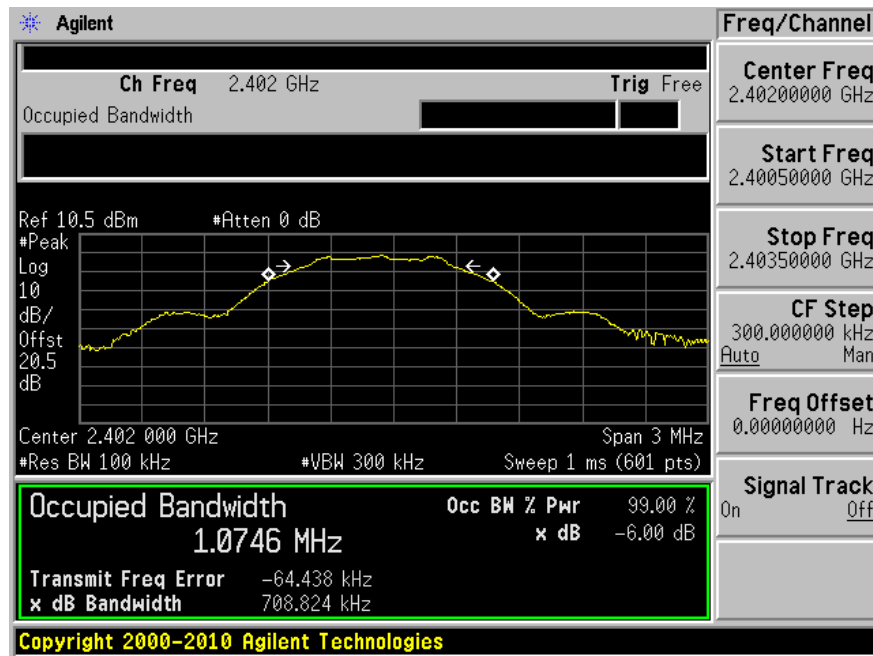
*The testing was performed by Xiao Lin on 2016-10-13 in RF site.*

### 8.5 Test Results

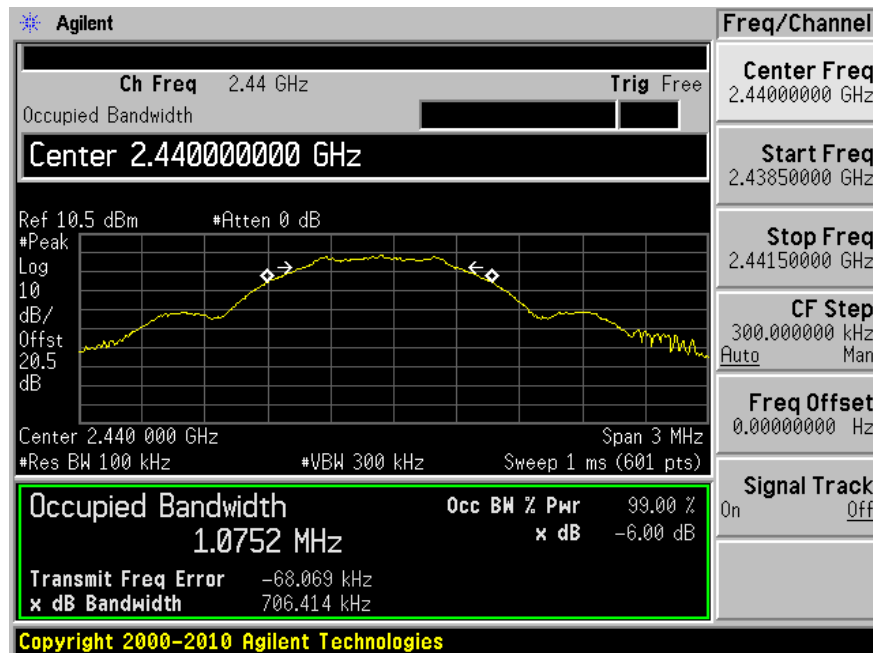
Channel	Frequency (MHz)	99% OBW (kHz)	6 dB OBW (kHz)	6 dB OBW limit (kHz)
Low	2402	1074.6	708.824	500
Middle	2440	1075.2	706.414	500
High	2480	1078.1	713.108	500

Please refer to the following plots for detailed test results.

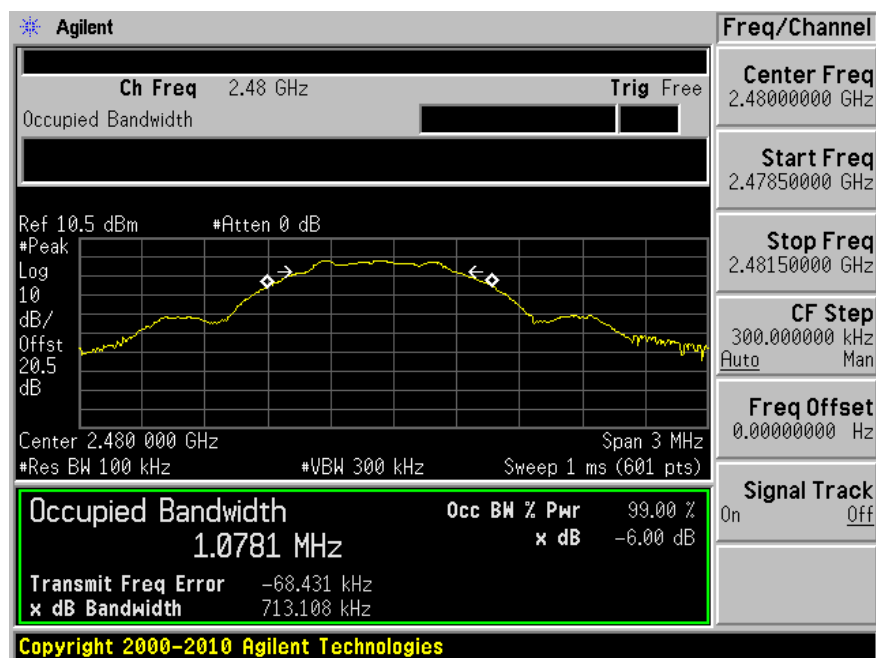
## Low Channel 2402 MHz



## Middle Channel 2440 MHz



## High Channel 2480 MHz



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

### 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 v03r05: 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	US45303156	2016-01-19	1 year
-	RF Cable	-	-	Each time <sup>1</sup>	N/A
-	20dB attenuator	-	-	Each time <sup>1</sup>	N/A

Note<sup>1</sup>: cable and attenuator included in the test set-up will be checked each time before testing.

**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:	20-22° C
Relative Humidity:	42-45 %
ATM Pressure:	102 KPa

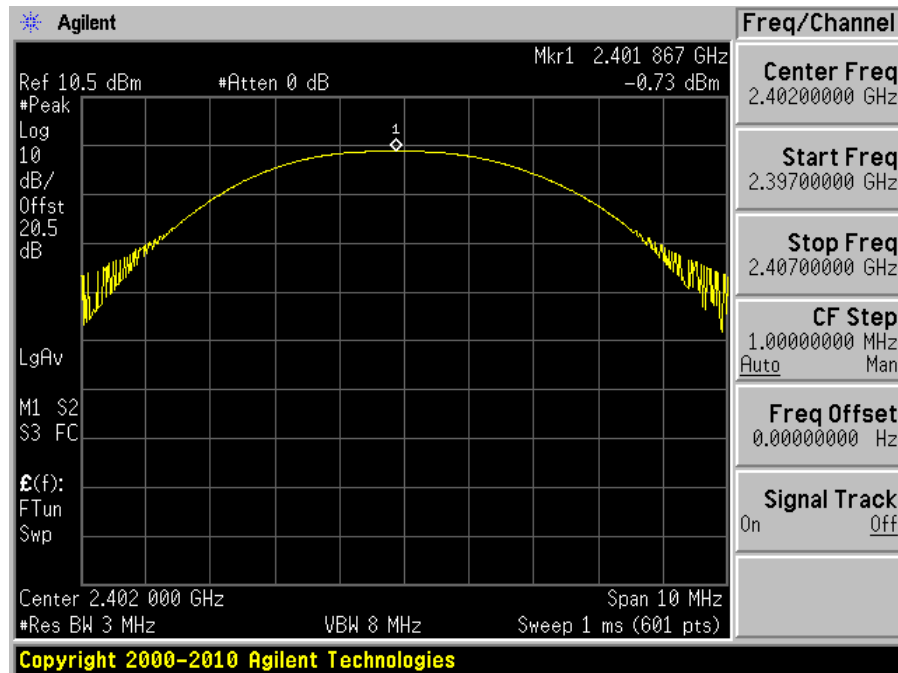
The testing was performed by Xiao Lin on 2016-10-13 in RF site.

### 9.5 Test Results

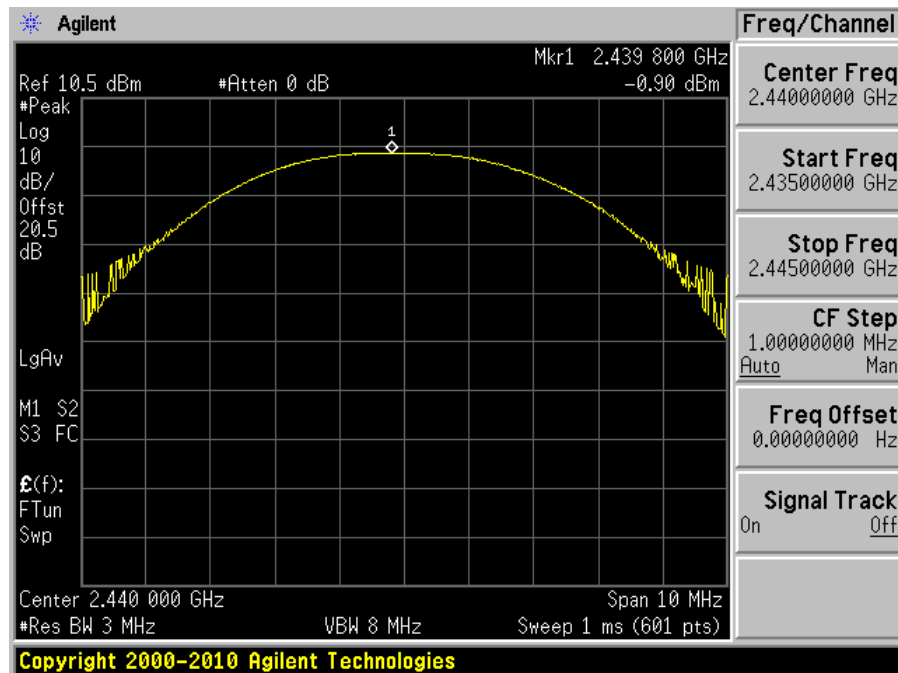
Channel	Frequency (MHz)	Conducted Output Power (dBm)	Limit (dBm)
Low	2402	-0.73	30
Middle	2440	-0.9	30
High	2480	-1.03	30

Please refer to the following plots for detailed test results.

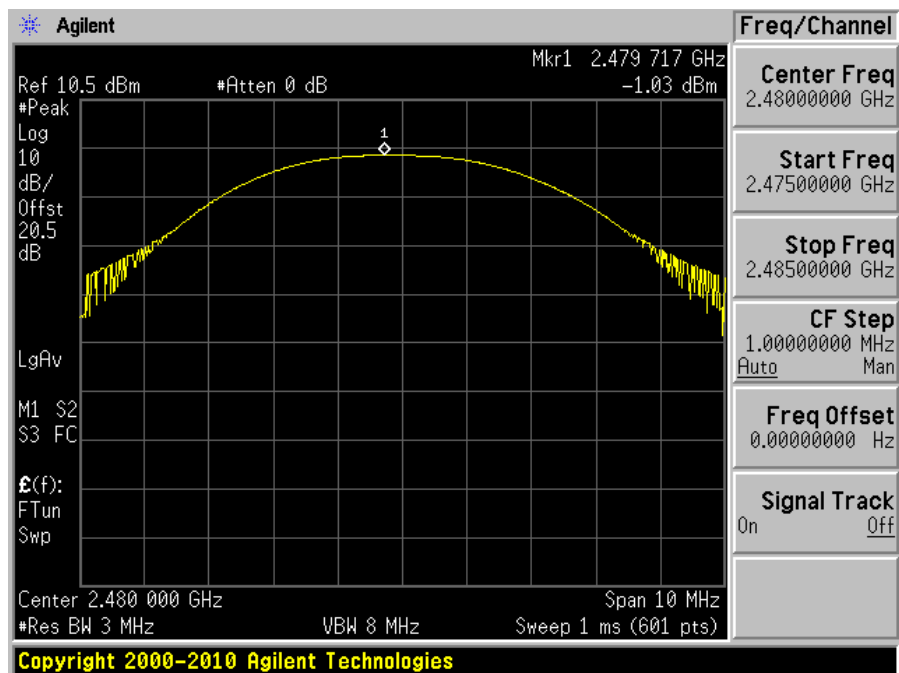
## Low Channel 2402 MHz



## 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 v03r05: 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	US45303156	2016-01-19	1 year
-	RF Cable	-	-	Each time <sup>1</sup>	N/A
-	20dB attenuator	-	-	Each time <sup>1</sup>	N/A

Note<sup>1</sup>: cable and attenuator included in the test set-up will be checked each time before testing.

**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

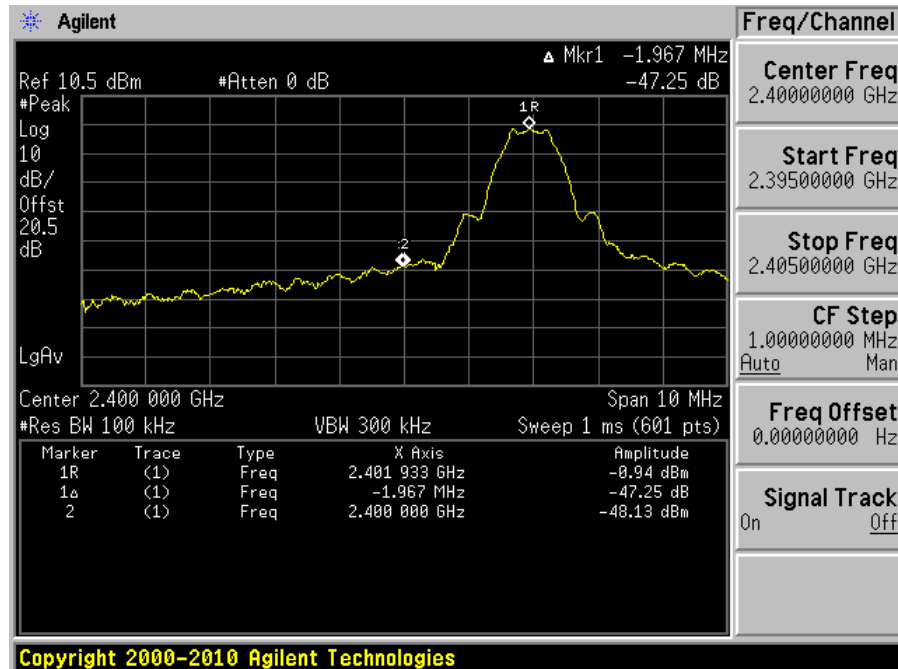
Temperature:	20-22° C
Relative Humidity:	42-45 %
ATM Pressure:	102 KPa

The testing was performed by Xiao Lin on 2016-10-13 in RF site.

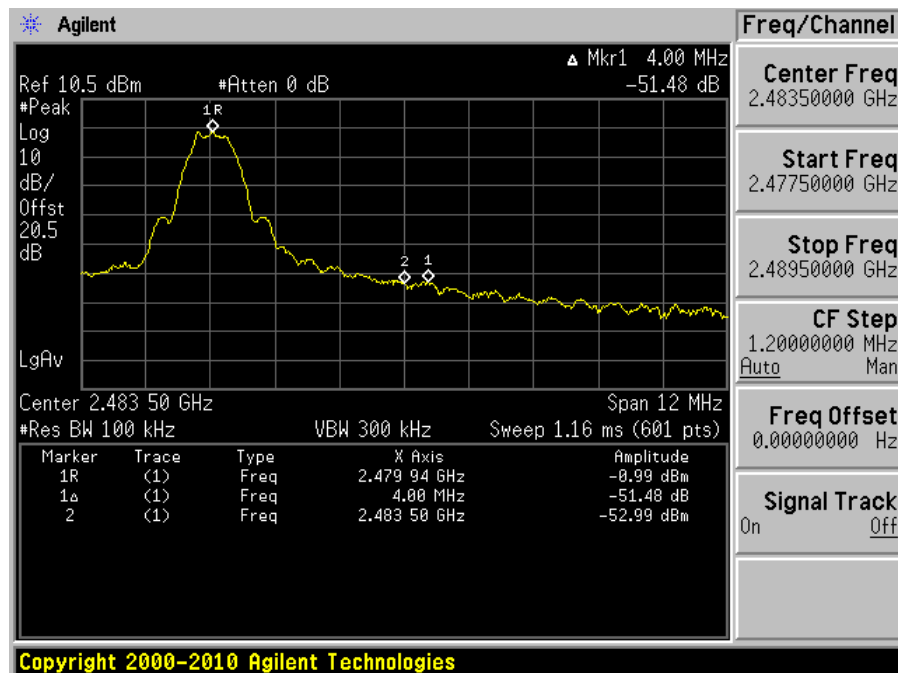


## 10.5 Test Results

Lowest Channel, 2402 MHz



Highest 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 v03r05: 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	US45303156	2016-01-19	1 year
-	RF Cable	-	-	Each time <sup>1</sup>	N/A
-	20dB attenuator	-	-	Each time <sup>1</sup>	N/A

Note<sup>1</sup>: cable and attenuator included in the test set-up will be checked each time before testing.

**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:	20-22° C
Relative Humidity:	42-45 %
ATM Pressure:	102 KPa

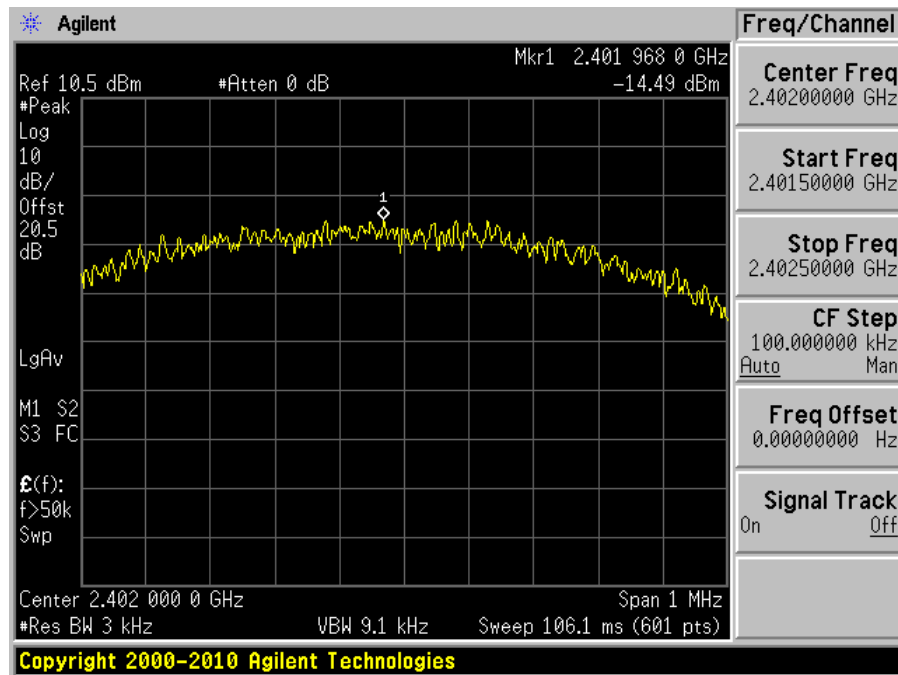
The testing was performed by Xiao Lin on 2016-10-13 in RF site.

### 11.5 Test Results

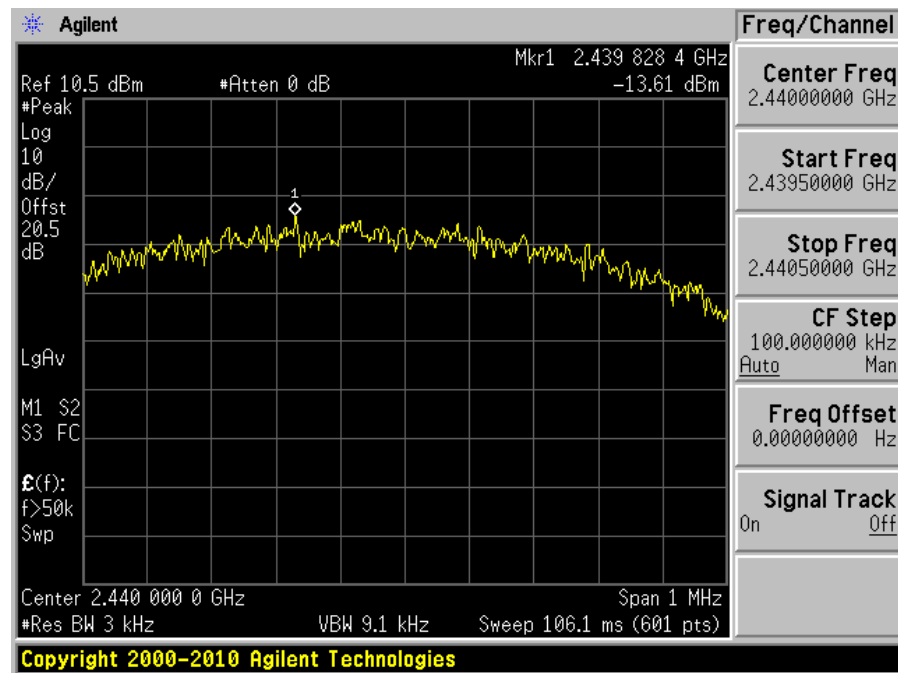
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)
Low	2402	-14.49	8
Middle	2440	-13.61	8
High	2480	-14.51	8

Please refer to the following plots for detailed test results

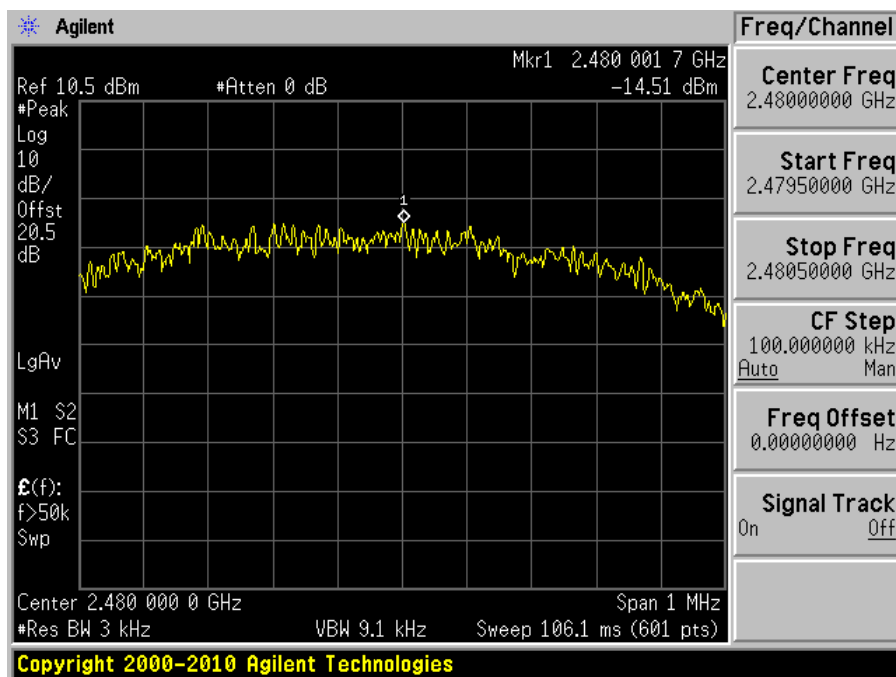
## Low Channel 2402 MHz



## Middle Channel 2440 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	US45303156	2016-01-19	1 year
-	RF Cable	-	-	Each time <sup>1</sup>	N/A
-	20dB attenuator	-	-	Each time <sup>1</sup>	N/A

Note<sup>1</sup>: cable and attenuator included in the test set-up will be checked each time before testing.

**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

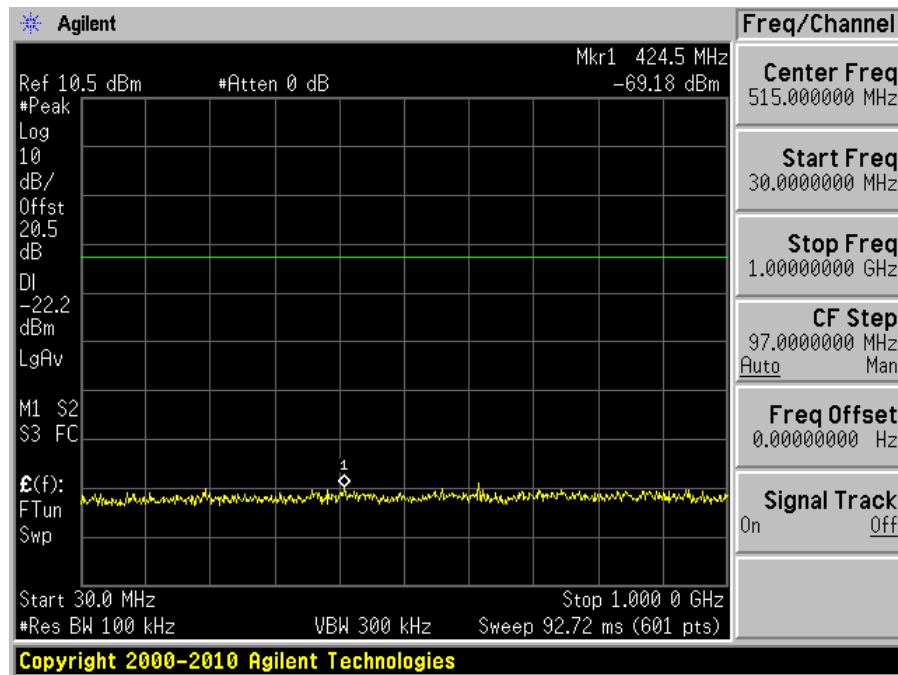
Temperature:	20-22° C
Relative Humidity:	42-45 %
ATM Pressure:	102 KPa

The testing was performed by Xiao Lin on 2016-10-13 in RF site.

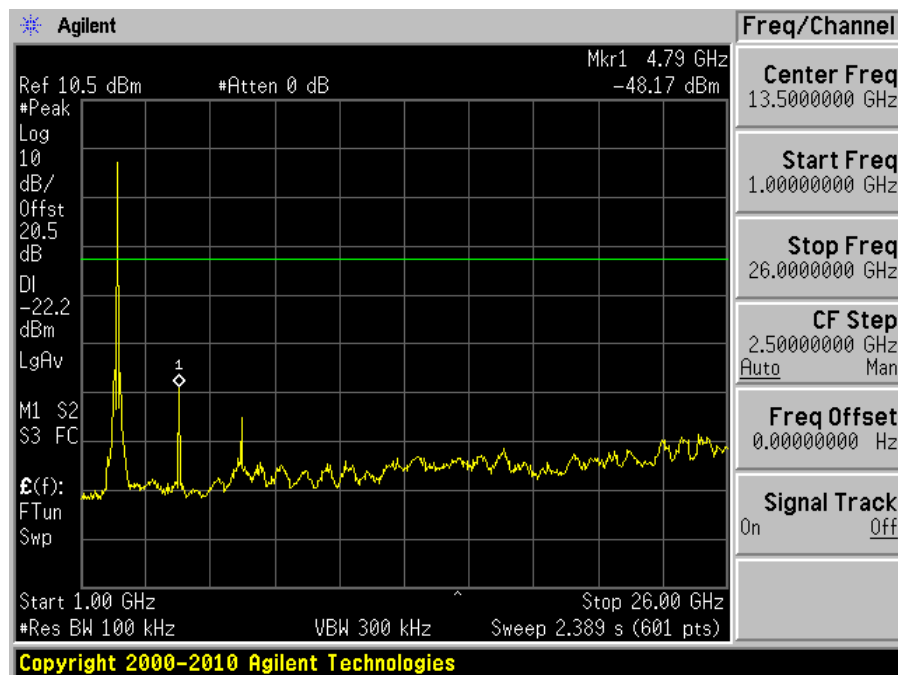
### 12.5 Test Results

Please refer to following plots.

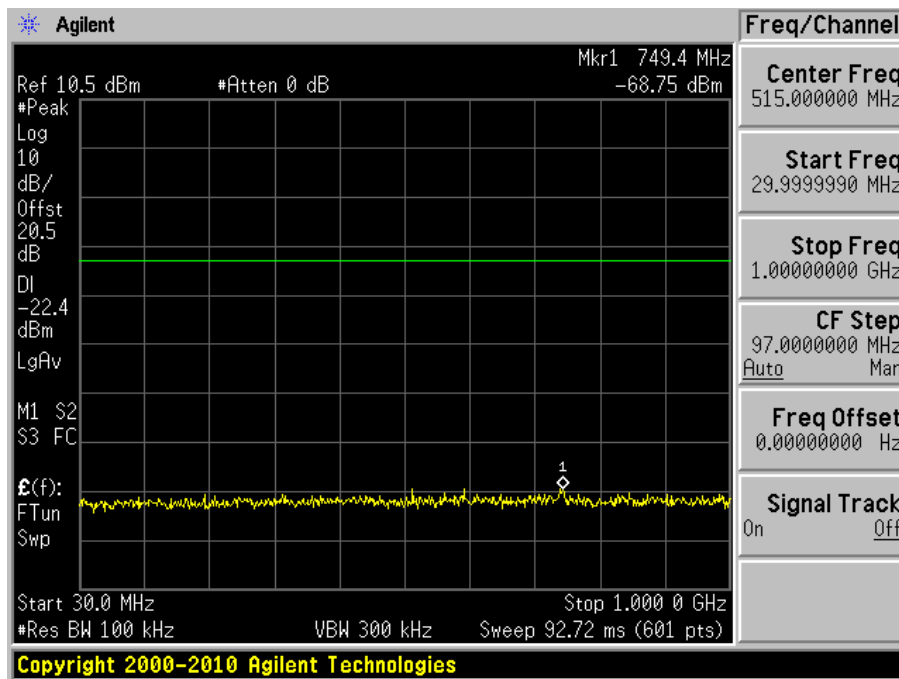
## Low Channel 30 MHz – 1 GHz



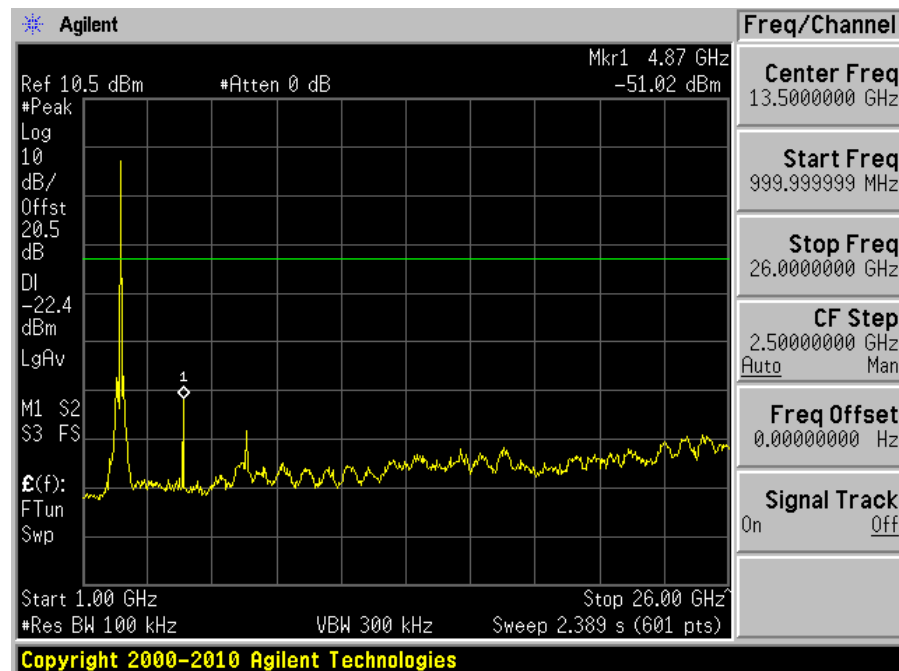
## Low Channel 1 GHz – 26 GHz



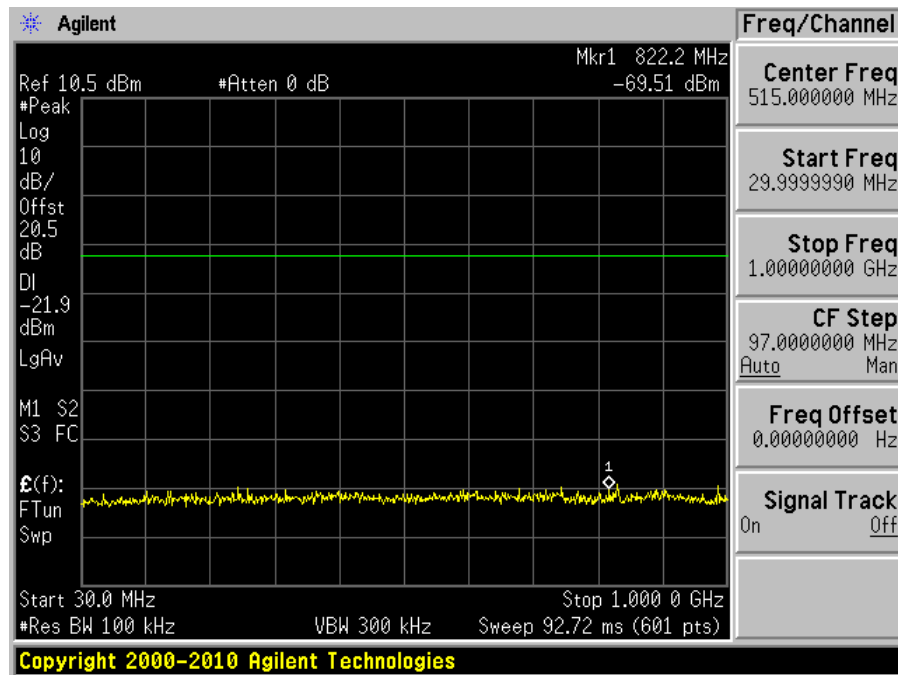
## Middle Channel 30 MHz – 1 GHz



## Middle Channel 1 GHz – 26 GHz



## High Channel 30 MHz – 1 GHz



## High Channel 1 GHz – 26 GHz

