FCC PART 15, SUBPART C

TEST REPORT

For

Punch Through Design, LLC

665 Chestnut Street Floor 3
San Francisco, CA 94133, USA

FCC ID: 2AAV5-PTD1503001

Report Type:	Product Type:
Original Report	BLE Starter Kit

Prepared By:	Frank Wang Test Engineer
Report Number:	R1605161-247
Report Date:	2017-08-31
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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1605161-247	Original Report	2017-01-13
1	R1605161-247	Remove ISEDC	2017-08-24
2	R1605161-247	Updated Comments	2017-08-31

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of *Punch Through Design, LLC*, and their product model: LightBlue Bean+, *FCC ID: 2AAV5-PTD1503001* or the "EUT" as referred to in this report. It is a Bluetooth Low Energy Starter Kit.

1.2 Mechanical Description of EUT

The EUT measures approximately 68 mm (L) x 30 mm (W) x 15 mm (H) and weighs 29.5 g.

The test data gathered are from typical production sample, serial number: R1605161-1 assigned by BACL.

1.3 Objective

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

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:

A- ***An independent, 3rd-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2005 by A2LA (Test Laboratory Accreditation Certificate Number 3279.02),*** 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 3279.03)*** 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 3279.01)*** 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: (Industry Canada - IC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
  - BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
  - NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
  - EMC Directive 2014/30/EC US-EU EMC & Telecom MRA CAB
  - 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:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - 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 v03r03.

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

N/A

2.3 Duty Cycle Correction Factor

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

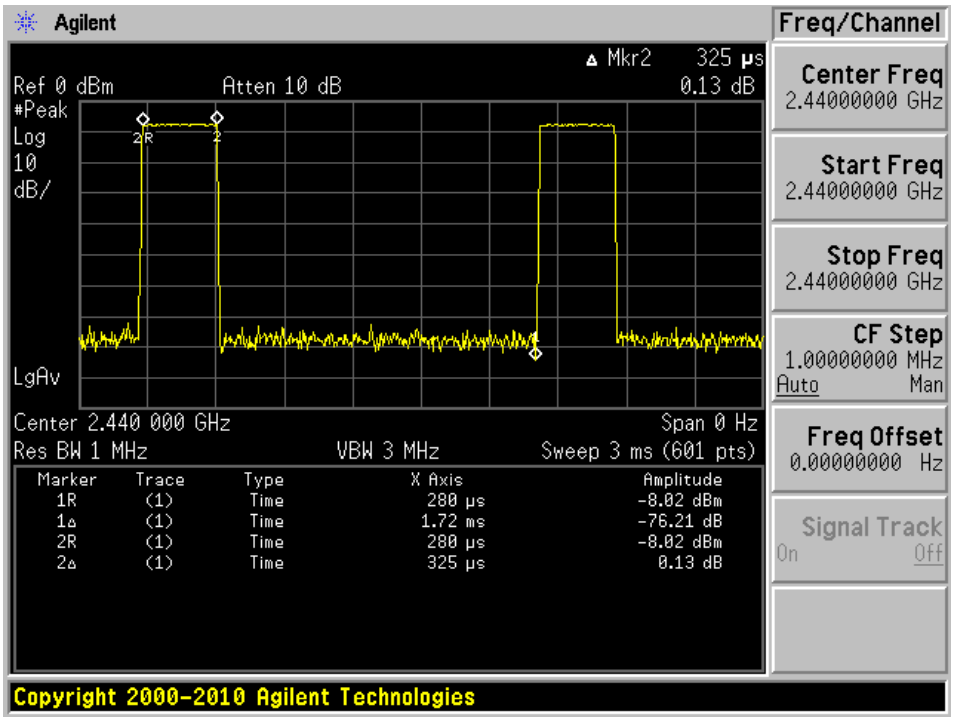
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized 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 (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
BLE	0.325	1.72	18.9	14.473

Duty Cycle = On Time (ms)/ Period (ms)
Duty Cycle Correction Factor (dB) = 20*log(1/Duty Cycle)

Please refer to the following plots.

BLE Middle Channel



2.4 Equipment Modifications

N/A

2.5 Local Support Equipment

N/A

2.6 EUT Internal Configuration Details

Manufacturer	Description	Model
Texas Instruments	-	CC2590
Texas Instruments	SoC	CC2541

2.7 Support Equipment

Manufacturer	Description	Model
Samsung	USB Power Adapter	RT1C305hS/A-E
-	Controller	Botton v1.1

2.8 Interface Ports and Cabling

Cable Description	Length (m)	To	From
USB Cable	< 1 m	AC adapter	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 §15.207	AC Line Conducted Emissions	Compliant
FCC §2.1091, §15.247(i)	RF Exposure	Compliant
FCC §15.247 (d)	Spurious Emissions at Antenna Port	Compliant
FCC §15.205	Restricted Bands	Compliant
FCC §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

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

Antenna Type	Antenna Gain (dBi) @ 2.4 GHz
Internal Antenna	3.3

5 FCC§2.1091, §15.247(i)– RF Exposure

5.1 Applicable Standards

According to FCC §2.1091, §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^2)	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	* ($180/f^2$)	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

BLE

Maximum peak output power at antenna input terminal (dBm):	4.8
Maximum peak output power at antenna input terminal (mW):	3.02
Prediction distance (cm):	20
Prediction frequency (MHz):	2402
Maximum Antenna Gain, typical (dBi):	3.3
Maximum Antenna Gain (numeric):	2.138
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.001285
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	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 0.001285 mW/cm^2. Limit is 1.0 mW/cm^2.

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 C63.4-2014 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 cord of the support equipment was connected to LISN-2.

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

All data was recorded in the peak detection mode, quasi-peak and average. 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:

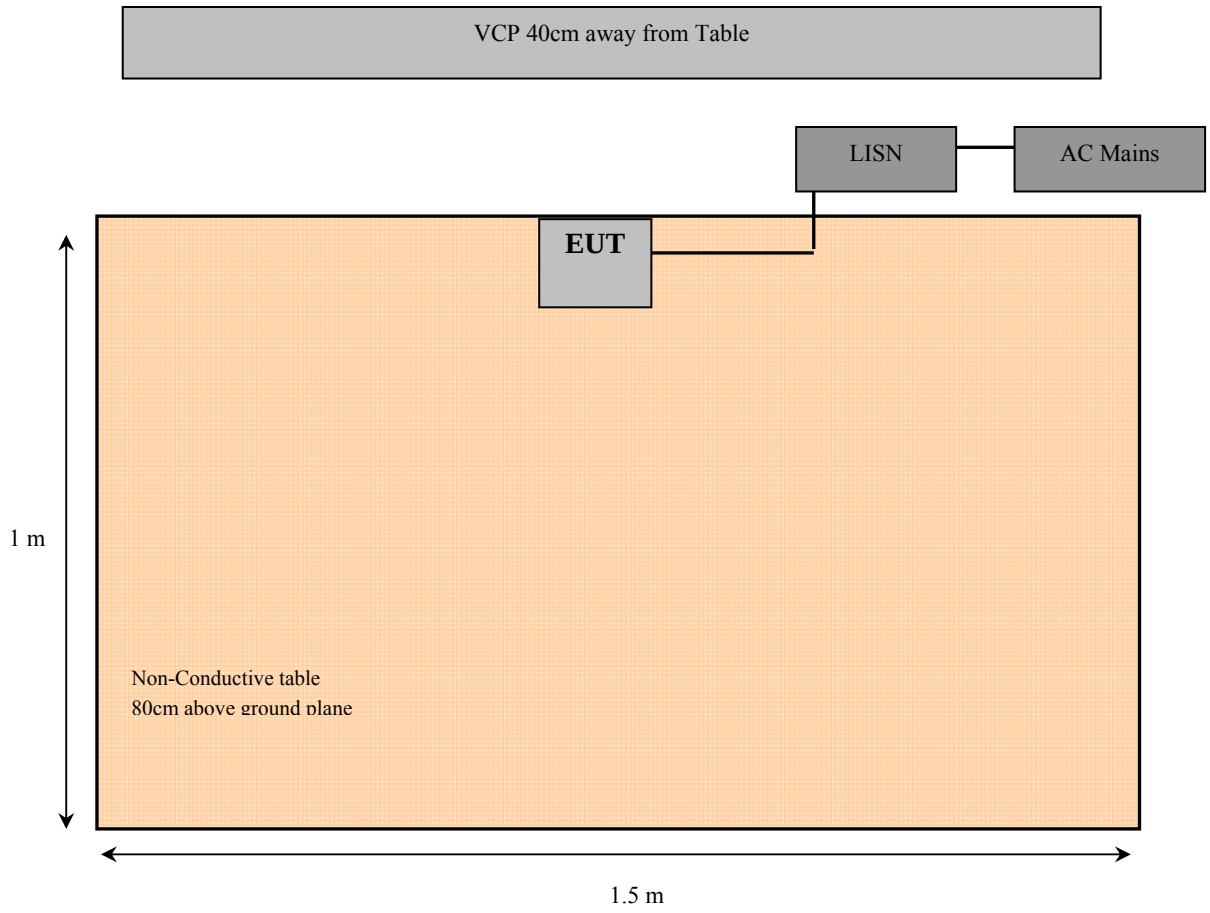
CA = Ai + CL + Atten

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	100337	2015-06-18	1 year
FCC	LISN	FCC-LISN-50-2-10-CISPR16 1PA ANSI 14	160130	2016-04-07	1 year
TTE INCORPORATED	High Pass Filter	H985-150k-50-720N	H 886	2016-01-09	1 year
Keysight Technologies	RF Limiter	11867A	MY42242931	2015-12-15	1year
Suirong	30 ft conductive emission cable	LMR 400	-	2016-03-05	1 year
Hewlett-Packard	5 ft N-type RF cable	-	1268	2016-04-15	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:	15º C
Relative Humidity:	42 %
ATM Pressure:	101.31 kPa

The testing was performed by Frank Wang on 2016-05-17 in 5 chamber3

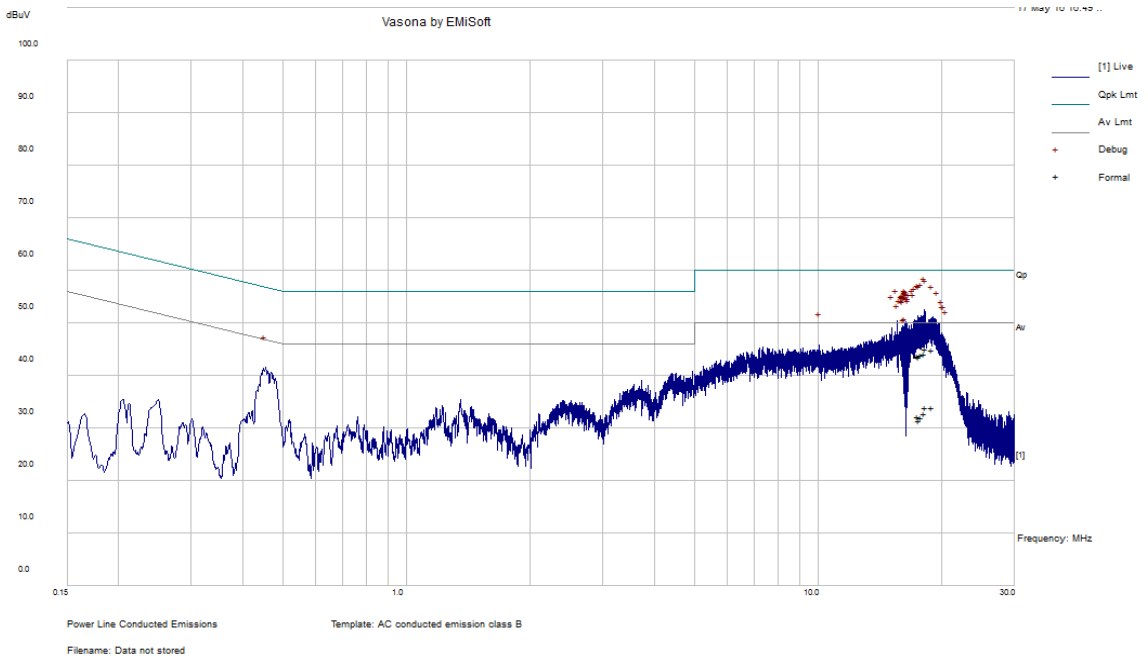
6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC 15C and ISED RSS-Gen 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)**
-14.96	18.2122	Line	0.15-30

6.9 Conducted Emissions Test Plots and Data

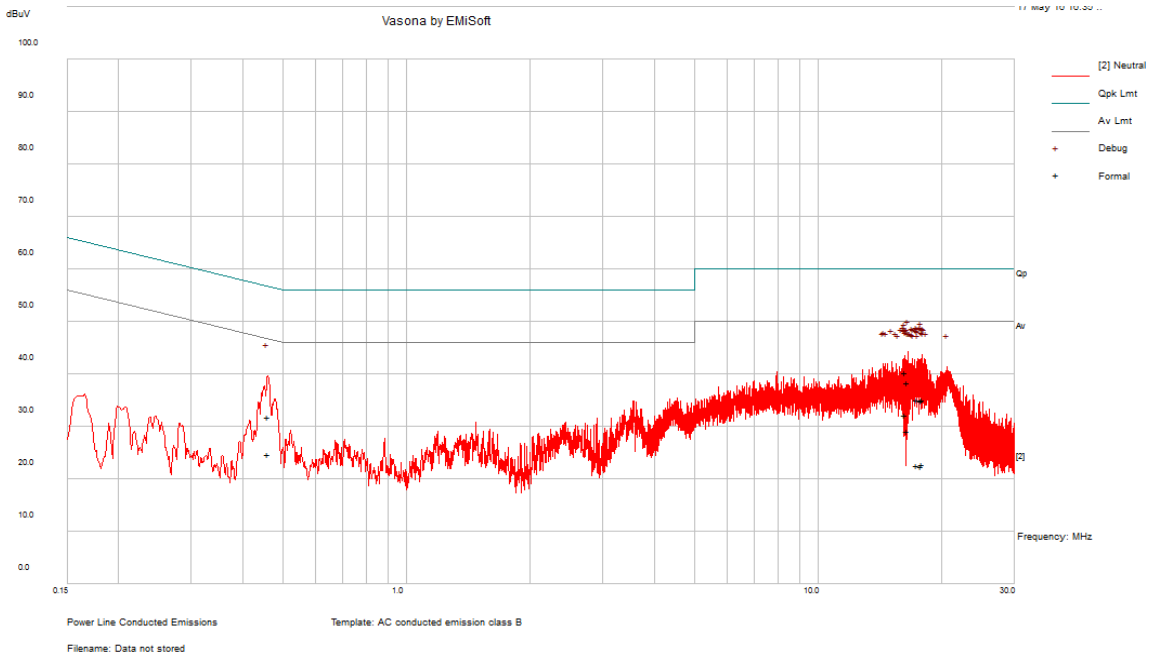
120 V, 60 Hz – Live



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave)
18.10583	44.17	Line	60	-15.83	QP
18.2122	45.04	Line	60	-14.96	QP
17.80452	43.9	Line	60	-16.1	QP
17.48986	43.79	Line	60	-16.21	QP
18.93367	44.84	Line	60	-15.16	QP
17.63077	43.55	Line	60	-16.45	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave)
18.10583	32.73	Line	50	-17.27	Ave
18.2122	33.99	Line	50	-16.01	Ave
17.80452	32.13	Line	50	-17.87	Ave
17.48986	32.21	Line	50	-17.79	Ave
18.93367	34	Line	50	-16	Ave
17.63077	31.54	Line	50	-18.46	Ave

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave)
16.51153	38.37	Neutral	60	-21.63	QP
17.87427	35.15	Neutral	60	-24.85	QP
16.26989	40.26	Neutral	60	-19.74	QP
17.82984	34.98	Neutral	60	-25.02	QP
0.462168	31.92	Neutral	56.65	-24.73	QP
17.42618	35.06	Neutral	60	-24.94	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave)
16.51153	29.16	Neutral	50	-20.84	Ave
17.87427	22.8	Neutral	50	-27.2	Ave
16.26989	32.32	Neutral	50	-17.68	Ave
17.82984	22.48	Neutral	50	-27.52	Ave
0.462168	24.71	Neutral	46.65	-21.94	Ave
17.42618	22.64	Neutral	50	-27.36	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 §15.209(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 §15.205(a) and RSS-Gen 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 §15.247 (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 was 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 is set 3 meter away from the testing antenna, which is varied from 1-4 meter, and the EUT is placed on a turntable, which is 0.8 meter above ground plane, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna should be changed the polarization both of horizontal and vertical.

The spectrum analyzer or receiver is 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: Peak Value – 20*log(1/Duty Cycle)

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	EMI Test Receiver	ESCI 1166.5950K03	100337	2015-06-18	1 year
Agilent	Spectrum Analyzer	E4440A	MY44303352	2015-06-22	1 year
Sunol Science Corp	System Controller	SC99V	011003-1	N/R	N/R
Sunol Science Corp	Combination Antenna	JB3	A020106-3	2015-07-11	1 year
EMCO	Horn Antenna	3115	9511-4627	2016-01-15	1 year
Agilent	Pre-amplifier	8447D	2944A10187	2016-03-20	1 year
Suirong	30 ft conductive emission cable	LMR 400	-	2016-03-05	1 year
-	SMA cable	-	C0002	Each time[1]	N/A
IW Microwave	High Frequency Cable	DC-1438	SPS-2303-3840-SPS	2015-09-23	1 year
Hewlett-Packard	5 ft N-type RF cable	-	1268	2016-04-15	1 year
Hewlett	Pre-Amplifier	8449B	3008A01978	2016-03-11	1year
Fluke Corp	Multimeter, Digital	233	23790031	2015-07-06	1 year

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:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 kPa

The testing was performed by Frank Wang on 2016-05-16 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:

30 MHz – 25 GHz

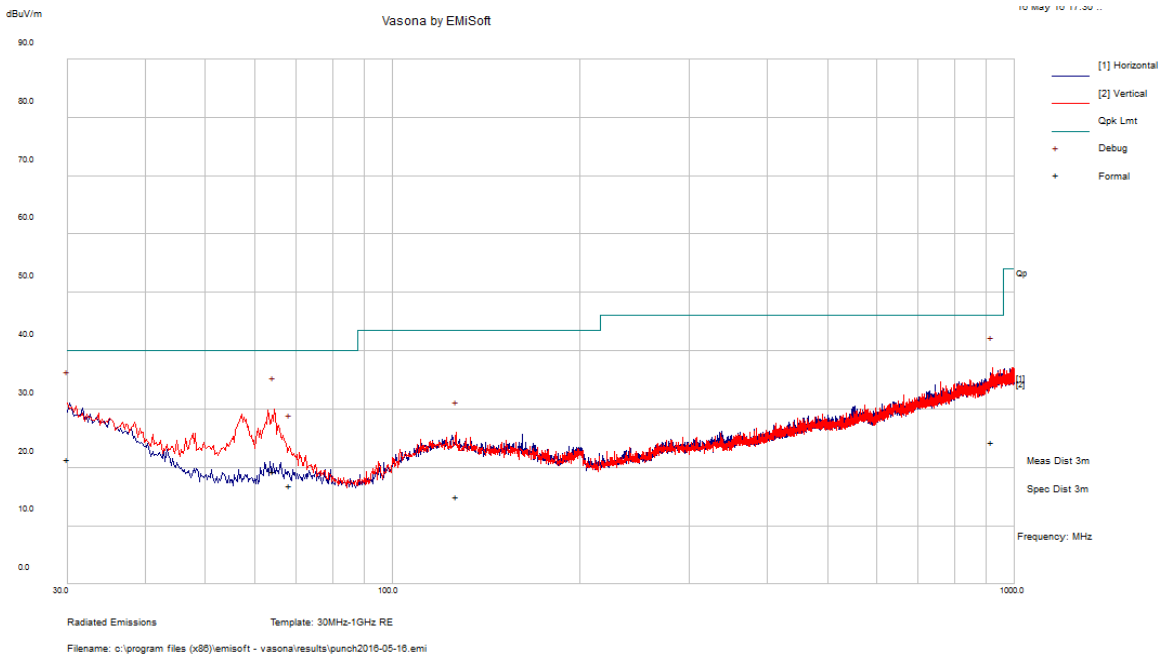
Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Channel**
-5.02	2483.5	Horizontal	High Channel

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

BLE



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (PK/QP/Ave)
30.00405	21.45	109	V	43	40	-18.55	QP
919.949	24.4	122	V	53	46	-21.6	QP
64.25	19.28	100	V	240	40	-20.72	QP
68.37025	16.84	98	V	70	40	-23.16	QP
126.6188	15.01	206	V	68	43.5	-28.49	QP

2) 1–25 GHz Measured at 3 meters

BLE

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC/IC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2402 MHz, measured at 3 meters											
2402	69.67	152	110	H	29.05	5.21	-	103.93	-	-	Peak
2402	55.20	152	110	H	29.05	5.21	-	89.46	-	-	Ave
2402	62.57	141	126	V	29.05	5.21	-	96.83	-	-	Peak
2402	48.10	141	126	V	29.05	5.21	-	82.36	-	-	Ave
2390	26.62	152	110	H	28.98	5.20	-	60.80	74	-13.20	Peak
2390	12.15	152	110	H	28.98	5.20	-	46.33	54	-7.67	Ave
4804	58.59	137	108	H	32.48	7.75	37.85	60.97	74	-13.03	Peak
4804	44.12	137	108	H	32.48	7.75	37.85	46.50	54	-7.50	Ave
7206	51.46	148	112	H	36.72	9.72	37.50	60.40	74	-13.60	Peak
7206	36.99	148	112	H	36.72	9.72	37.50	45.93	54	-8.07	Ave
9608	48.02	152	110	H	37.78	11.37	38.06	59.11	74	-14.89	Peak
9608	33.55	152	110	H	37.78	11.37	38.06	44.64	54	-9.36	Ave
Middle Channel 2440 MHz, measured at 3 meters											
2440	69.3	140	115	H	29.19	5.26	-	103.75	-	-	Peak
2440	54.83	140	115	H	29.19	5.26	-	89.28	-	-	Ave
2440	63.04	228	101	V	29.19	5.26	-	97.49	-	-	Peak
2440	48.57	228	101	V	29.19	5.26	-	83.02	-	-	Ave
4880	59.18	187	110	H	32.60	7.82	37.77	61.83	74	-12.17	Peak
4880	44.71	187	110	H	32.60	7.82	37.77	47.36	54	-6.64	Ave
7320	51.52	163	106	H	37.15	9.80	37.52	60.95	74	-13.05	Peak
7320	37.05	163	106	H	37.15	9.80	37.52	46.48	54	-7.52	Ave
9760	48.1	145	113	H	37.89	11.46	38.15	59.30	74	-14.70	Peak
9760	33.63	145	113	H	37.89	11.46	38.15	44.83	54	-9.17	Ave

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC/IC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
High Channel 2480 MHz, measured at 3 meters											
2480	66.28	168	104	H	29.34	5.31	-	100.93	-	-	Peak
2480	51.81	168	104	H	29.34	5.31	-	86.46	-	-	Ave
2480	61.15	224	150	V	29.34	5.31	-	95.80	-	-	Peak
2480	46.68	224	150	V	29.34	5.31	-	81.33	-	-	Ave
2483.5	28.78	168	104	H	29.35	5.32	-	63.45	74	-10.55	Peak
2483.5	14.31	168	104	H	29.35	5.32	-	48.98	54	-5.02	Ave
4960	55.14	180	112	H	32.85	7.90	37.70	58.19	74	-15.81	Peak
4960	40.67	180	112	H	32.85	7.90	37.70	43.72	54	-10.28	Ave
7440	50.21	152	110	H	37.04	9.88	37.55	59.58	74	-14.42	Peak
7440	35.74	152	110	H	37.04	9.88	37.55	45.11	54	-8.89	Ave
9920	48.85	160	108	H	38.00	11.54	38.18	60.21	74	-13.79	Peak
9920	34.38	160	108	H	38.00	11.54	38.18	45.74	54	-8.26	Ave

8 FCC§15.247(a)(2) – 6 dB & 99% 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 v03r03: 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	Spectrum Analyzer	E4440A	MY44303352	2015-06-22	1 year
-	SMA cable	-	C0002	Each time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: 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:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Frank Wang on 2016-05-18 in RF site.

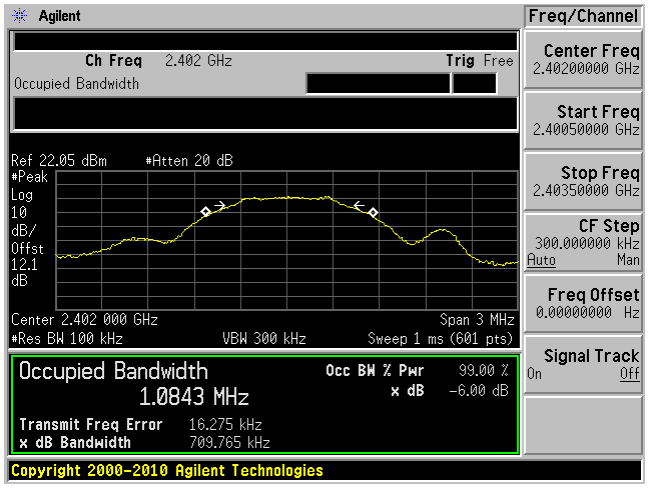
8.5 Test Results

Channel	Frequency (MHz)	99% OBW (MHz)	6 dB OBW (kHz)	6 dB OBW Limit (kHz)	Result
BLE					
Low	2402	1.0843	709.765	≥500	Pass
Middle	2440	1.0835	710.976	≥500	Pass
High	2480	1.0937	656.892	≥500	Pass

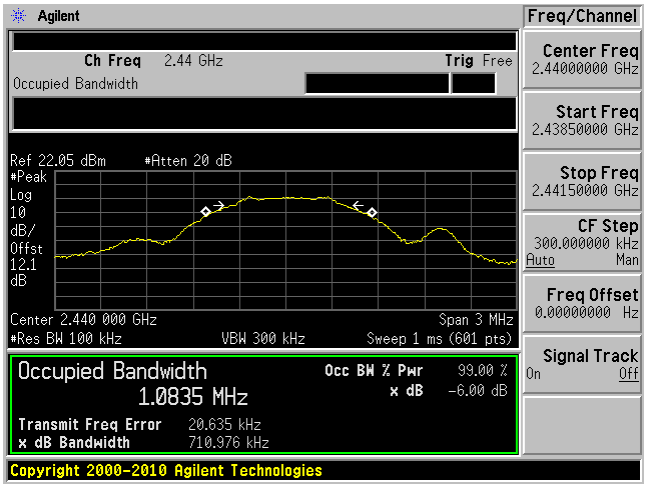
Please refer to the following plots for detailed test results

BLE

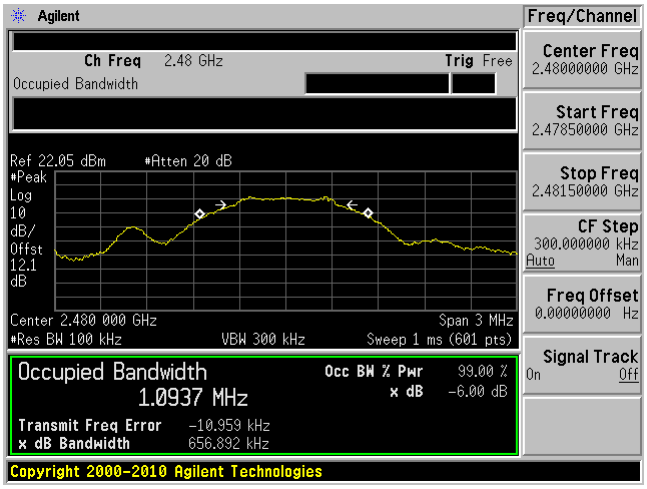
Low Channel 2402 MHz



Middle Channel 2440 MHz



High Channel 2480 MHz



9 FCC §15.247(b) – Output Power Measurement

9.1 Applicable Standards

According to FCC §15.247(b) 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 v03r03: 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	Spectrum Analyzer	E4440A	MY44303352	2015-06-22	1 year
-	SMA cable	-	C0002	Each time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: 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:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Frank Wang on 2016-05-18 at RF site.

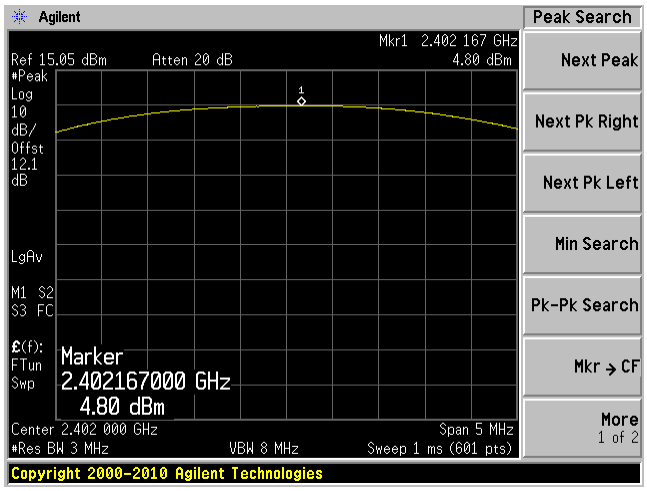
9.5 Test Results

Frequency (MHz)	Conducted Output Power (dBm)	Limit (dBm)	Margin (dB)	Result
BLE				
2402	4.8	30	-25.2	Pass
2440	4.66	30	-25.34	Pass
2480	4.68	30	-25.32	Pass

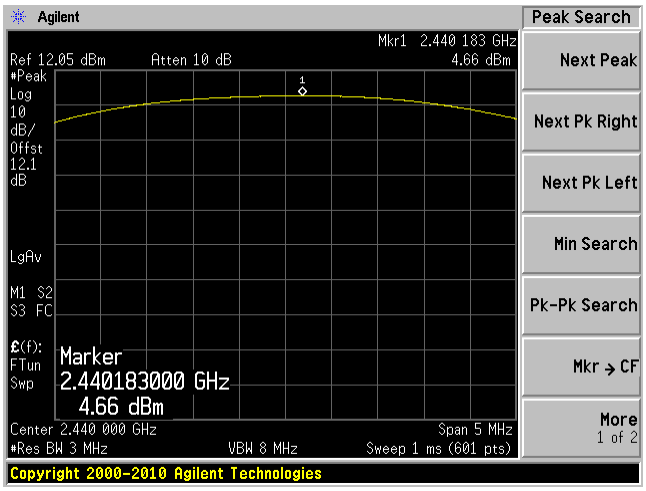
Please refer to the following plots for detailed test results

BLE

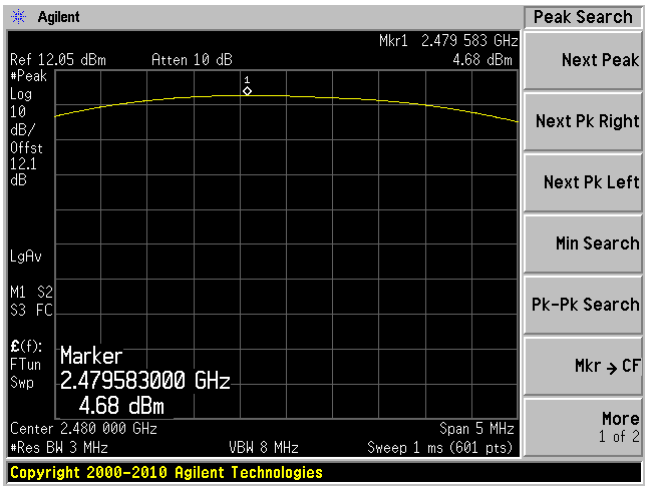
Low Channel 2402 MHz



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 v03r03: 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	Spectrum Analyzer	E4440A	MY44303352	2015-06-22	1 year
-	SMA cable	-	C0002	Each time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: 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:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

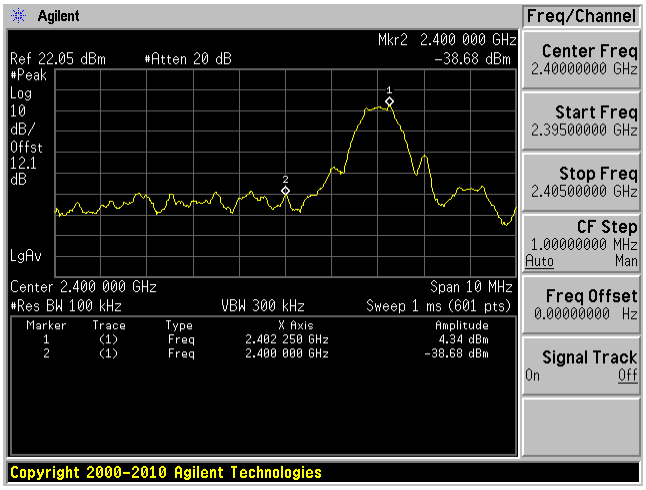
The testing was performed by Frank Wang on 2016-05-18 at RF site.

10.5 Test Results

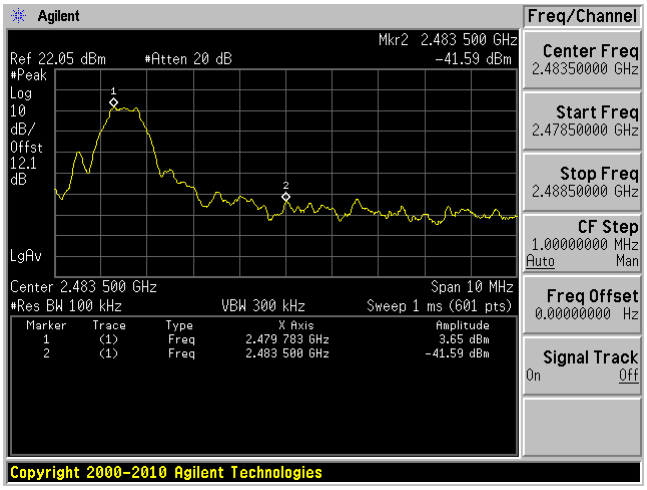
Please refer to the following plot for band edge.

BLE

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 v03r03: 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	Spectrum Analyzer	E4440A	MY44303352	2015-06-22	1 year
-	SMA cable	-	C0002	Each time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: 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:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Frank Wang on 2016-05-18 at RF site.

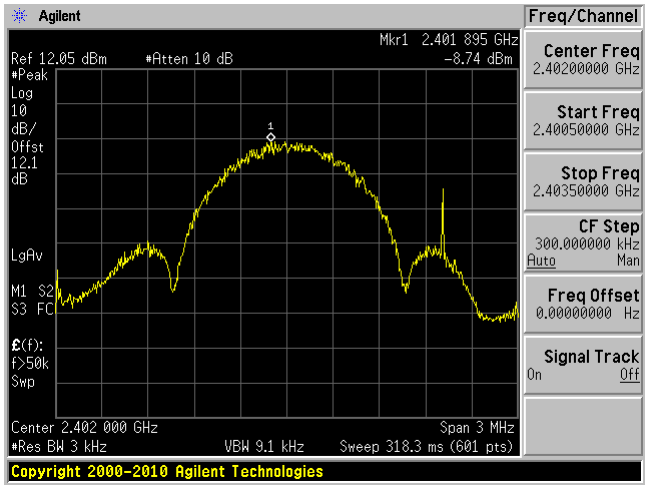
11.5 Test Results

Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Result
BLE			
2402	-8.74	8	Pass
2440	-8.84	8	Pass
2480	-8.12	8	Pass

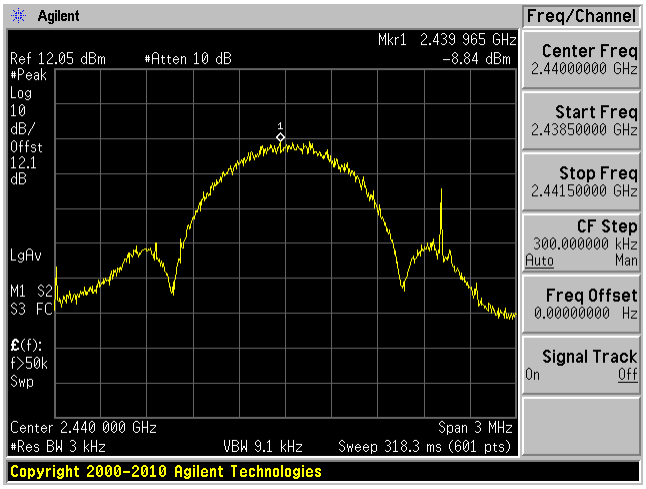
Please refer to the following plots for detailed test results

BLE

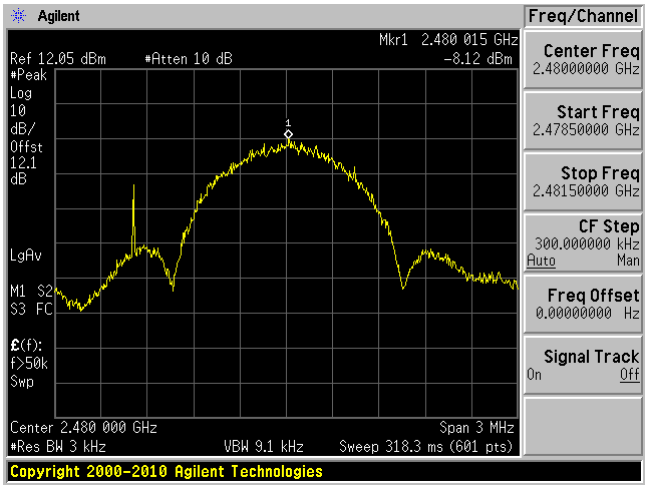
Low Channel 2402 MHz



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	Spectrum Analyzer	E4440A	MY44303352	2015-06-22	1 year
-	SMA cable	-	C0002	Each time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: 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:	22º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

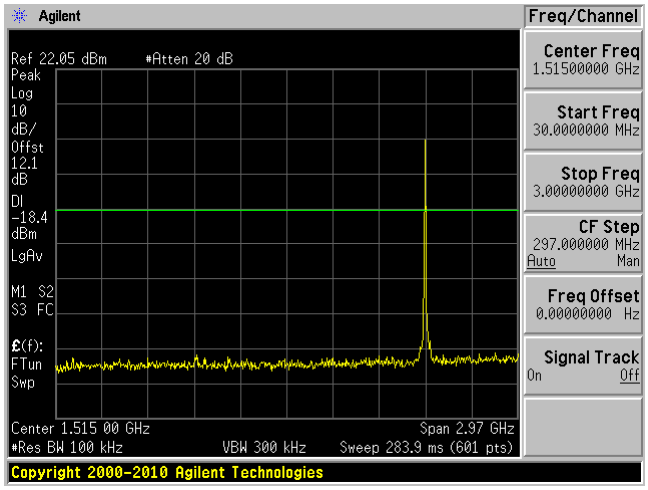
The testing was performed by Frank Wang on 2016-05-18 at RF site.

12.5 Test Results

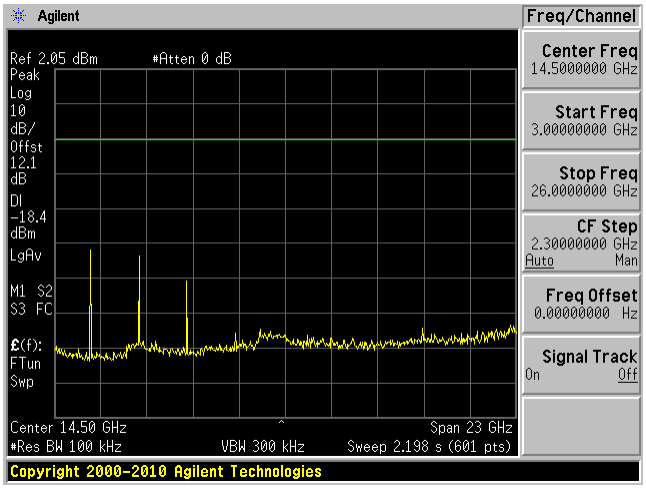
Please refer to following plots.

BLE

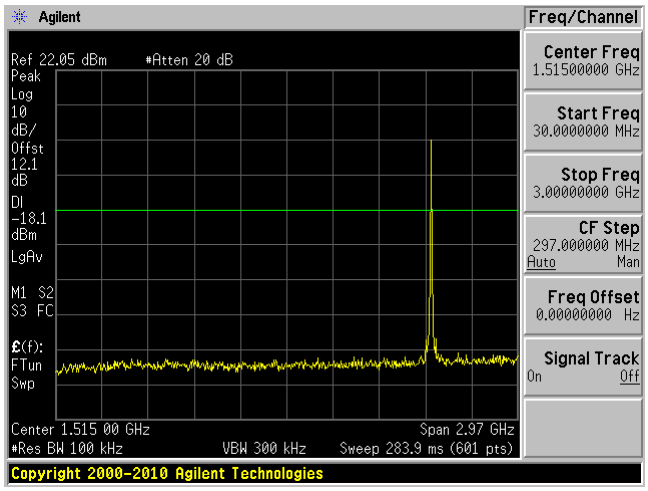
Low Channel 30 MHz – 3 GHz



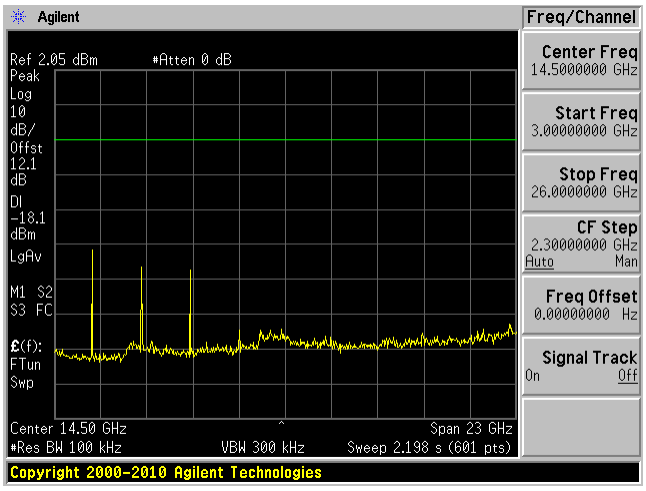
Low Channels 3 GHz – 26 GHz



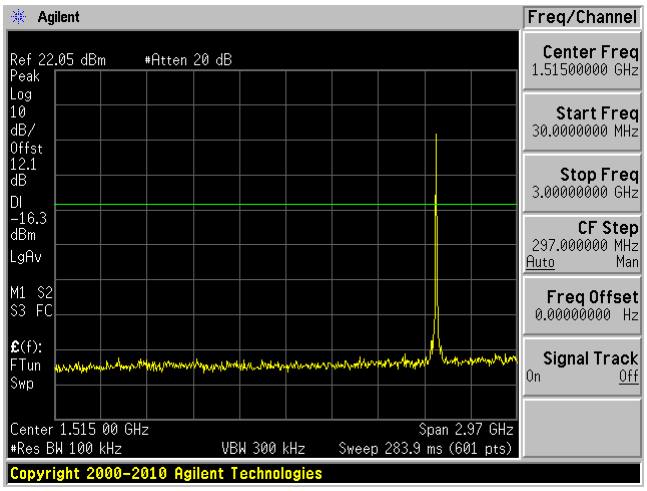
Middle Channel 30 MHz – 3 GHz



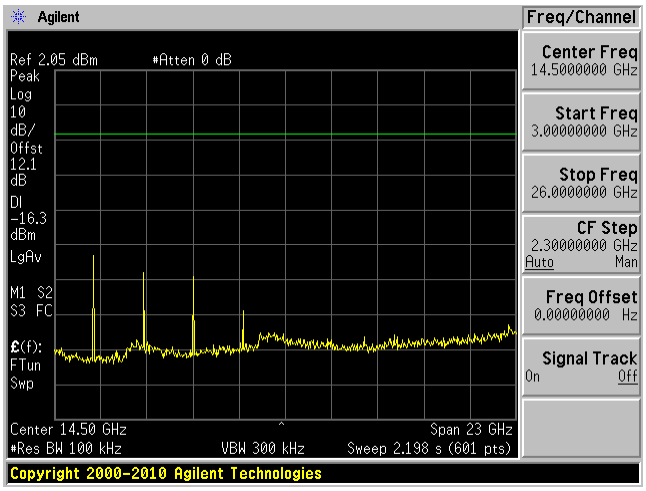
Middle Channels 3 GHz – 26 GHz



High Channel 30 MHz – 3 GHz



High Channels 3 GHz – 26 GHz



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