



# FCC PART 15, SUBPART C ISEDC RSS-247, ISSUE 2, FEBRUARY 2017

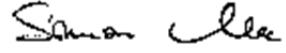
## TEST REPORT

For

### Culvert-IoT Corporation

1999 S Bascom Ave., Ste. 230, Campbell, CA 95008, USA

**FCC ID: 2AQ98-DOS  
IC: 26298-DOS**

<b>Report Type:</b> Original Report	<b>Product Type:</b> Asset Tracker
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<b>Report Number:</b> R2004023-247	
<b>Report Date:</b> 2020-08-22	
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**Note:** This test report is prepared for the customer shown above and for the device described herein. It may not be duplicated or used in part without prior written consent from Bay Area Compliance Laboratories Corp. This report **must not** be used by the customer to claim product certification, approval, or endorsement by A2LA\*, NIST, or any agency of the Federal Government.

\* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk “\*” (d)(1)(B)

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## DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2004023-247	Original Report	2020-07-28
1	R2004023-247	Updated reviewer's comments	2020-08-22

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## 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 *Culvert-IoT Corporation*, and their product model: *DOS, FCC ID: 2AQ98-DOS, IC: 26298-DOS* or the “EUT” as referred to in this report. The EUT is an Asset Tracker with BLE, LTE, Wi-Fi (Receiving only) and GPS (Receiving only) capabilities. LTE radio was incorporated by installing pre-certified radio module, FCC ID: XPY2AGQN4NNN, IC: 8595A-2AGQN4NNN. BLE and LTE do not transmit simultaneously.

### 1.2 Objective

This report was prepared on behalf of *Culvert-IoT Corporation*, in accordance with Part 2, Subpart J, and Part 15, Subpart and C of the Federal Communication Commission’s rules and ISED RSS-247 Issue 2, February 2017.

The objective was to determine compliance with FCC Part 15.247 and ISED RSS-247 rules for Output Power, Antenna Requirements, 6 dB Bandwidth, Power Spectral Density, 100 kHz Bandwidth of Band Edges Measurement, and Radiated Spurious Emissions.

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

None.

### 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 v04: 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	±5 %
RF output power, conducted	±0.57 dB
Power Spectral Density, conducted	±1.48dB
Unwanted Emissions, conducted	±1.57dB
All emissions, radiated	±4.0 dB
AC power line Conducted Emission	±2.0 dB
Temperature	±2 ° C
Humidity	±5 %
DC and low frequency voltages	±1.0 %
Time	±2 %
Duty Cycle	±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 3297.01),** 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 3297.02) 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 3297.03) 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 - ISEDC) 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 EMC Directive 2014/30/EU US-EU EMC & Telecom MRA CAB (NB)
  - o Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
  - o Low Voltage Directive (LVD) 2014/35/EU
- 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 Media Development Authority - IMDA) 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;
  - o Nationally Recognized Test Laboratory (NRTL) – US OSHA
- 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 v04.

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 firmware used was Tera Term, provided by *Culvert-IoT Corporation*, the software is compliant with the standard requirements being tested against.

Modulation	Frequency (MHz)	Power Setting
BLE	2402	-4
	2428	-4
	2480	-12

The data rate tested for the BLE radio was 1 Mbps.

### 2.3 Duty Cycle Correction Factor

According to KDB 558074 D01 DTS Meas Guidance v04 section 6.0:

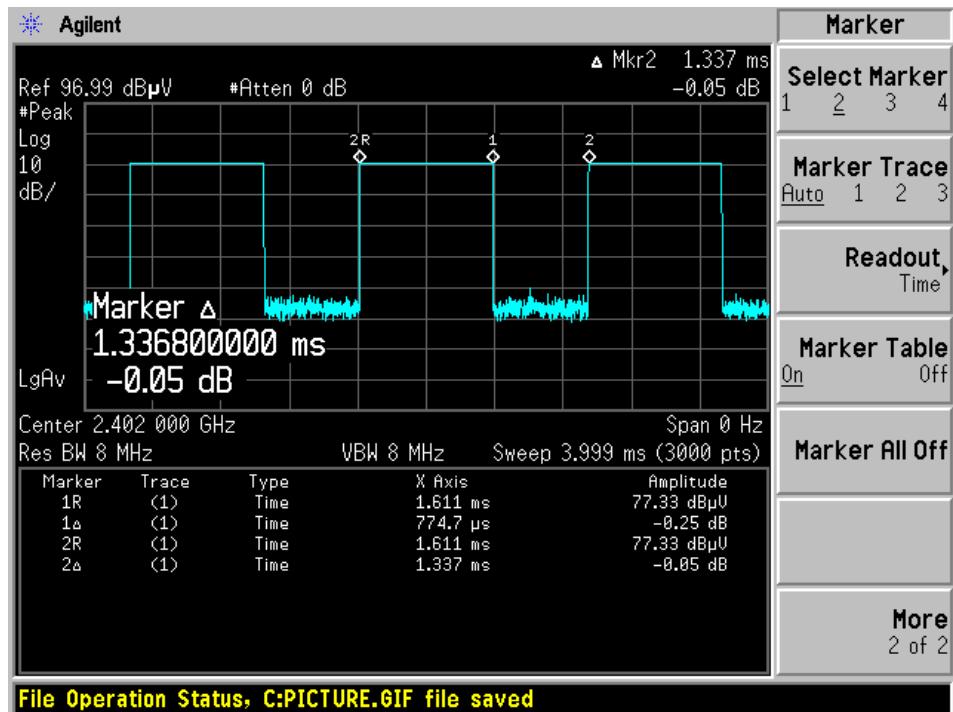
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized 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	Total On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
BLE	0.775	1.337	57.97	2.368

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

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

Please refer to the following plots.



## 2.4 Equipment Modifications

None

## 2.5 Local Support Equipment

Manufacturer	Description	Model	Serial Number
Dell	Laptop	Latitude E6410	3CKRAQ1

## 2.6 Support Equipment

Manufacturer	Description	Model
Culvert	Debug Board	Culvert Dongle

## 2.7 Power Supply/Adapter

None

## 2.8 Interface Ports and Cabling

Description	Length (m)	To	From
USB to Micro USB	< 1 m	Laptop	Debug Board
USB C to USB C	< 1 m	Debug Board	EUT

### 3 Summary of Test Results

Results reported relate only to the product tested.

FCC and ISEDC Rules	Description of Test	Results
FCC §15.203 ISEDC RSS-Gen §6.8	Antenna Requirement	Compliant
FCC §15.207 ISEDC RSS-Gen §8.8	AC Line Conducted Emissions	Compliant
FCC §2.1091, §15.247(i) ISEDC RSS-102	RF Exposure	Compliant
FCC §2.1053, §15.205, §15.209, §15.247 (d) ISEDC RSS-247 §5.5 ISEDC RSS-Gen §8.9 and §8.10	Radiated Spurious Emissions	Compliant
FCC §15.247(a)(2) ISEDC RSS-247 §5.2(a)	6 dB and 99% Emission Bandwidth	Compliant
FCC §15.247(b)(3) ISEDC RSS-247 §5.4(d)	Output Power	Compliant
FCC §15.247(d) ISEDC RSS-247 §5.5	100 kHz Bandwidth of Frequency Band Edge	Compliant
FCC §15.247(e) ISEDC RSS-247 §5.2(b)	Power Spectral Density	Compliant

## 4 FCC §15.203 & ISED RSS-Gen §6.8 - 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.

According to ISED RSS-Gen §6.8: Transmitter Antenna

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

### 4.2 Antenna Description

External/Internal/Integral	Maximum Antenna Gain (dBi)	Antenna Type
Integral	-1	PCB Antenna

## 5 FCC §2.1091, §15.247(i) & ISED RSS-102 - 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

According to ISED RSS-102 Issue 5:

### 2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz<sup>6</sup> and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than  $4.49/f^{0.5}$  W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than  $1.31 \times 10^{-2} f^{0.6834}$  W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

## 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

<u>Maximum rated output power at antenna input terminal (dBm):</u>	<u>26</u>
<u>Maximum rated output power at antenna input terminal (mW):</u>	<u>398</u>
<u>Prediction distance (cm):</u>	<u>20</u>
<u>Prediction frequency (MHz):</u>	<u>2428</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>-1</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>0.79</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm<sup>2</sup>):</u>	<u>0.06</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	<u>1.0</u>

### LTE (FCC ID: XPY2AGQN4NNN)

<u>Maximum conducted output power including tune-up tolerance (dBm):</u>	<u>25.00</u>
<u>Maximum conducted output power including tune-up tolerance (mW):</u>	<u>316.23</u>
<u>Prediction distance (cm):</u>	<u>20</u>
<u>Prediction frequency (MHz):</u>	<u>699</u>
<u>Maximum Antenna Gain, typical (dBi):</u>	<u>2</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1.58</u>
<u>Power density of prediction frequency at 20.0 cm (mW/cm<sup>2</sup>):</u>	<u>0.1</u>
<u>FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm<sup>2</sup>):</u>	<u>0.466</u>

The device is compliant with the required MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.06 mW/cm<sup>2</sup> and 0.1 mW/cm<sup>2</sup> for the BLE radio and LTE radio respectively. Limit is 1.0 mW/cm<sup>2</sup> and 0.466 mW/cm<sup>2</sup> at the predicted frequencies 2428 MHz and 699 MHz respectively.

## 5.4 RF exposure evaluation exemption for IC

$$\text{BLE: } 26 \text{ dBm} < 1.31 \times 10^{-2} f^{0.6834} = 2.696 \text{ W} = 34.3 \text{ dBm}$$

$$\text{LTE: } 27 \text{ dBm} < 1.31 \times 10^{-2} f^{0.6834} = 1.15 \text{ W} = 30.6 \text{ dBm}$$

Therefore the RF exposure is not required.

## 6 FCC §15.207 & ISEDC RSS-Gen §8.8 - AC Line Conducted Emissions

### 6.1 Applicable Standards

As per FCC §15.207 and ISEDC RSS-Gen §8.8 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 were FCC §15.207 and ISEDC RSS-Gen §8.8 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 and 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:

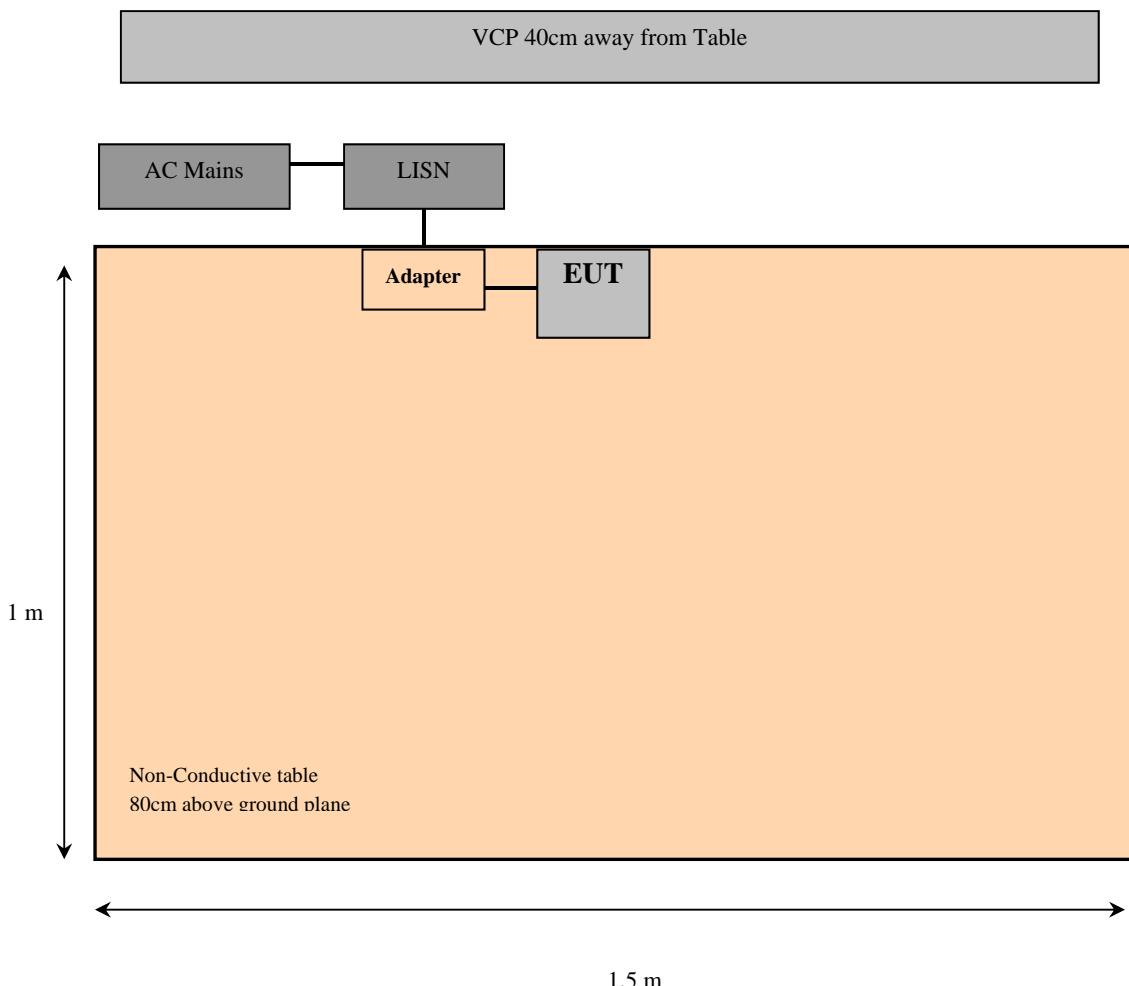
$$CA = Ai + CL + Atten$$

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
Rhode & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100044	2018-10-26	2 years
Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101964	2019-07-31	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150202	2020-02-26	1 year
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160131	2019-06-17	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R
Suirong	30 ft conductive emission cable	LMR 400	-	N/R	N/A

**Statement of Traceability:** *BACL Corp.* attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".

## 6.7 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	42 %
ATM Pressure:	101.31 kPa

The testing was performed by Christian McCaig on 2020-05-20 in Ground Plane test site

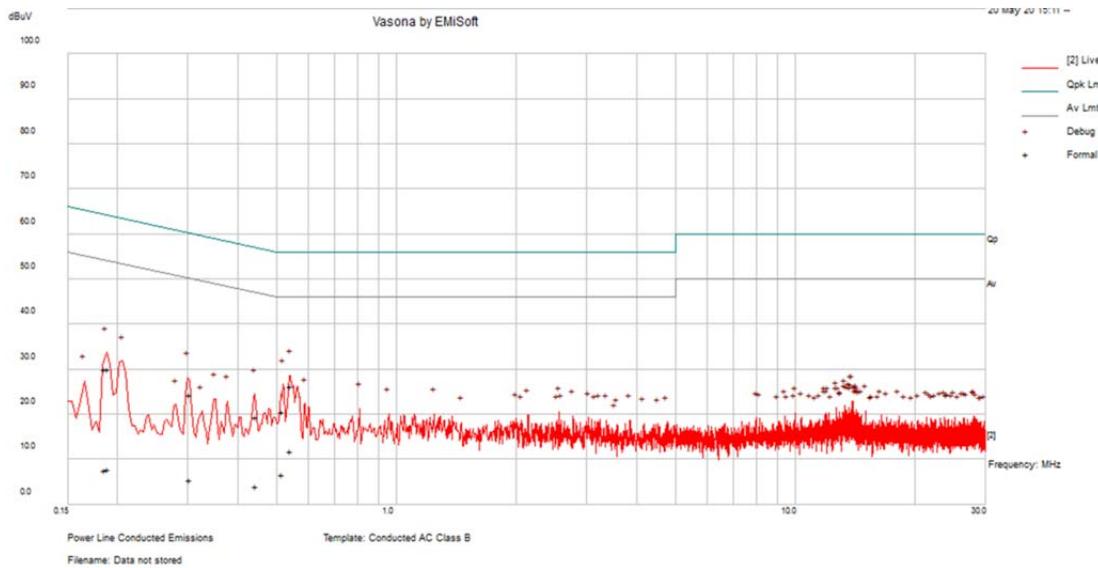
## 6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC 15C and ISEDC 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)
-29.86	0.54359	Line	0.15-30

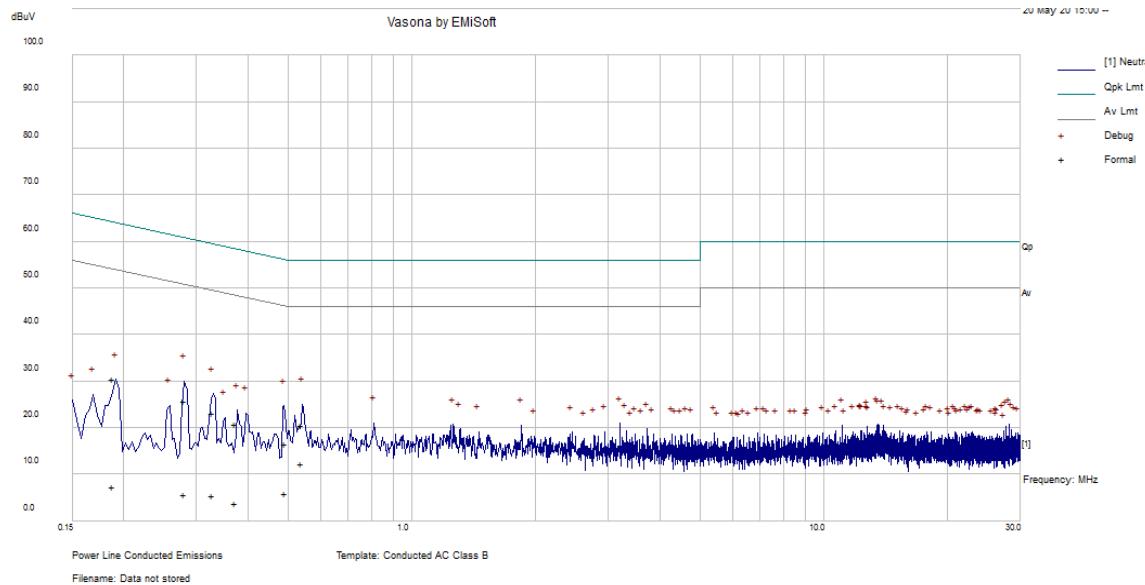
## 6.9 Conducted Emissions Test Plots and Data

### 120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.54359	26.14	Line	56	-29.86	QP
0.515999	20.56	Line	56	-35.44	QP
0.185695	29.93	Line	64.23	-34.3	QP
0.188711	30.11	Line	64.09	-33.98	QP
0.303652	24.29	Line	60.14	-35.85	QP
0.443379	19.44	Line	57	-37.56	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.54359	11.75	Line	46	-34.25	Ave.
0.515999	6.55	Line	46	-39.45	Ave.
0.185695	7.63	Line	54.23	-46.6	Ave.
0.188711	7.84	Line	54.09	-46.26	Ave.
0.303652	5.57	Line	50.14	-44.57	Ave.
0.443379	4.12	Line	47	-42.88	Ave.

**120 V, 60 Hz – Neutral**

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.188275	30.46	Neutral	64.11	-33.65	QP
0.280711	25.81	Neutral	60.79	-34.99	QP
0.327474	23.23	Neutral	59.52	-36.28	QP
0.373464	20.85	Neutral	58.42	-37.58	QP
0.494427	16.57	Neutral	56.09	-39.53	QP
0.541142	20.61	Neutral	56	-35.39	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.188275	7.29	Neutral	54.11	-46.82	Ave.
0.280711	5.62	Neutral	50.79	-45.18	Ave.
0.327474	5.47	Neutral	49.52	-44.04	Ave.
0.373464	3.79	Neutral	48.42	-44.64	Ave.
0.494427	5.97	Neutral	46.09	-40.13	Ave.
0.541142	12.32	Neutral	46	-33.68	Ave.

## 7 FCC §15.209, §15.247(d) & ISED/C RSS-247 §5.5, RSS-Gen §8.9, §8.10 - Spurious Radiated Emissions

### 7.1 Applicable Standards

As per FCC §15.35(b): 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) 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	3332 – 3339	22.01 – 23.12
8.41425 – 8.41475	167.72 – 173.2	3345.8 – 3358	23.6 – 24.0
12.29 – 12.293	240 – 285	3600 – 4400	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)).

As per ISEDC RSS-Gen §8.9, except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in the table below. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

General Field Strength Limits at Frequencies above 30 MHz

Frequency (MHz)	Field Strength (μv/m at 3 meters)
30-88	100
88-216	150
216-960	200
Above 960	500

As per ISEDC RSS-247 §5.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

## 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 and ISEDC RSS-247 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

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.

For radiated testing 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:

$$\text{RBW} = 100 \text{ kHz} / \text{VBW} = 300 \text{ kHz} / \text{Sweep} = \text{Auto}$$

Above 1000 MHz:

- (1) Peak:  $\text{RBW} = 1\text{MHz} / \text{VBW} = 3\text{MHz} / \text{Sweep} = 100 \text{ ms}$
- (2) Average: Peak – DC Correction

### 7.4 Corrected Amplitude and 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:

$$\text{CA} = \text{Ai} + \text{AF} + \text{CL} + \text{Atten} - \text{Ga}$$

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
Rhode & Schwarz	EMI Test Receiver	ESCI 1166.5950.03	100338	2018-07-05	2 years
Agilent	Spectrum Analyzer	E4446A	MY48250238	2019-06-26	1 year
Sunol Science Corp	System Controller	SC99V	011003-1	N/R	N/R
Sunol Sciences	Biconilog Antenna	JB3	A020106-2	2019-11-20	2 years
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2 years
IW Microwave	150 Series 2.92mm Cable	KPS-1501AN-3780-KPS	DC 1925	2019-09-11	1 year
MDP Digital	Times Microwave LMR 400 UltraFlex Coaxial Cable 35\'	LMR400UF	BACL190416 1	2019-05-18	13 months
IW Microwave	157 Series 2.92mm Cable	KPS-1571AN-2400-KPS	DC 1922	2019-06-07	1 year
-	SMA cable	-	-	Each time <sup>1</sup>	N/A
	Notch Filter			Each time <sup>1</sup>	N/A
HP/ Agilent	Pre Amplifier	8449B OPT HO2	3008A0113	2019-09-30	1 year
Agilent	Amplifier, Pre	8447D	2944A10187	2019-08-13	1 year
Wisewave	Antenna, Horn	ARH-4223-02	10555-02	2020-02-05	2 years
AH Systems	Preamplifier	PAM 1840 VH	170	2019-09-24	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

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

**Statement of Traceability:** **BACL Corp.** attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".

## 7.6 Test Environmental Conditions

<b>Temperature:</b>	20-22 °C
<b>Relative Humidity:</b>	42-50 %
<b>ATM Pressure:</b>	102.7 kPa

The testing was performed by Christian McCaig from 2020-05-19 to 2020-05-20 in 5m chamber 3.

## 7.7 Summary of Test Results

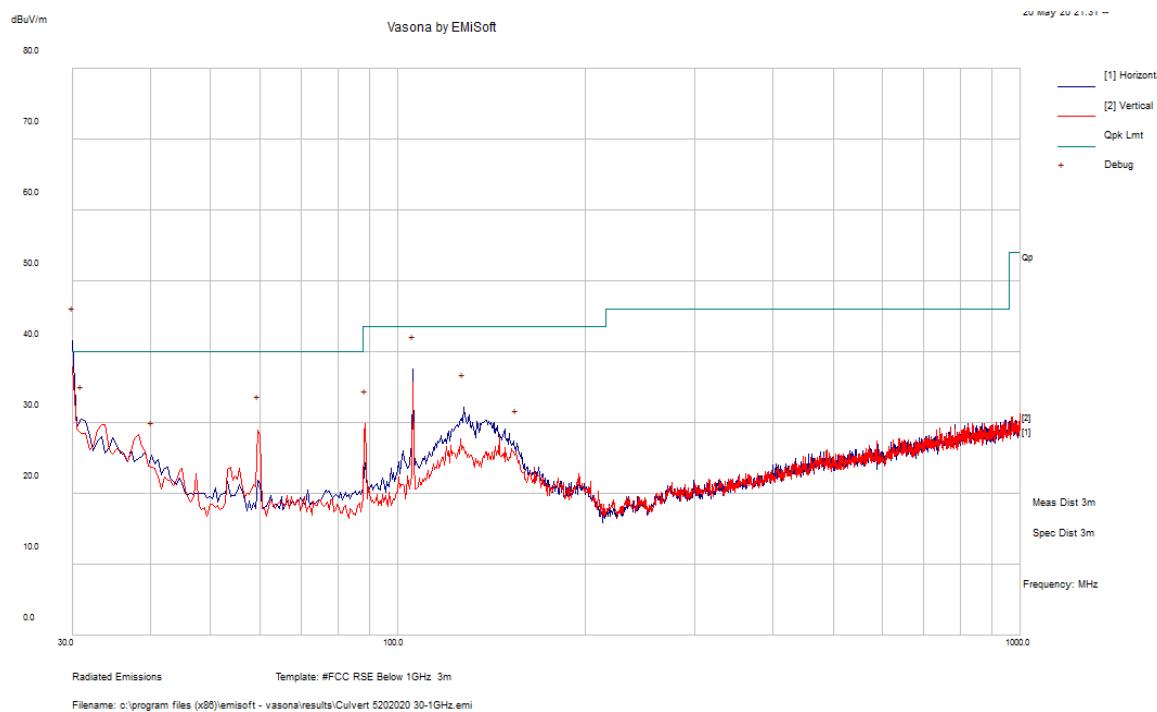
According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C and ISEDC RSS-247 standard's radiated emissions limits, and had the worst margin of:

Mode: Transmitting		
Margin (dB)	Frequency (MHz)	Mode, channel
-0.07	30.006464	BLE mode, Middle channel

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

## 7.8 Spurious Emissions Test Results

### 1) 30 MHz – 1 GHz



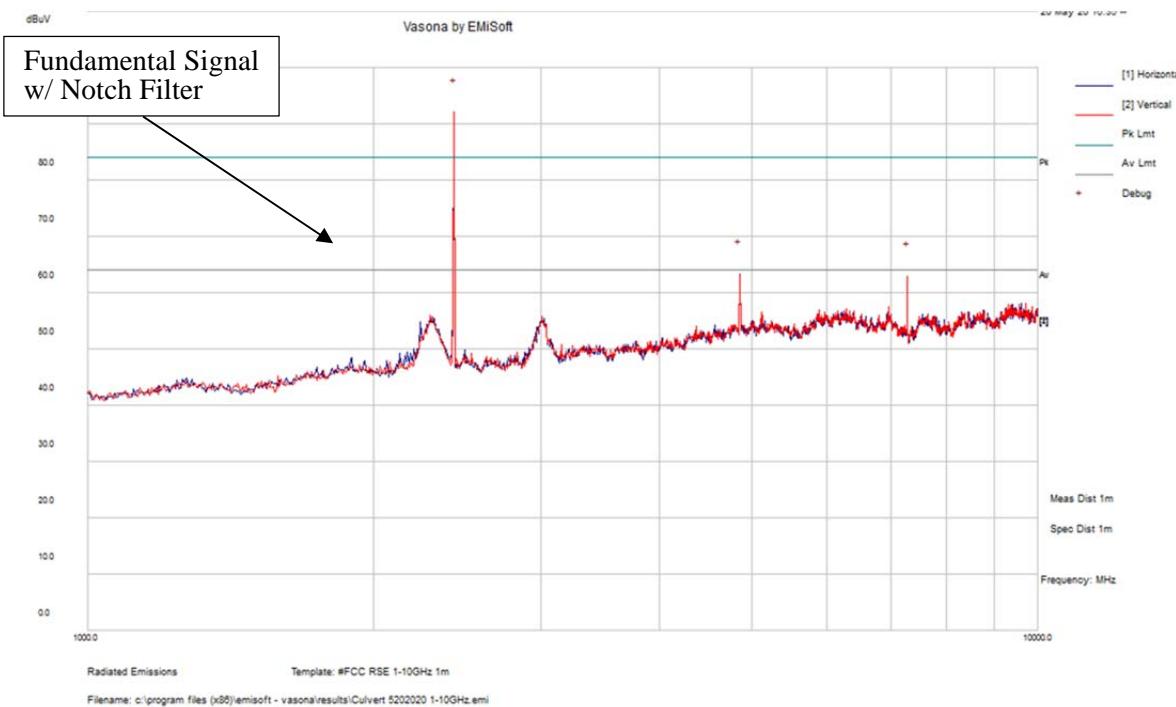
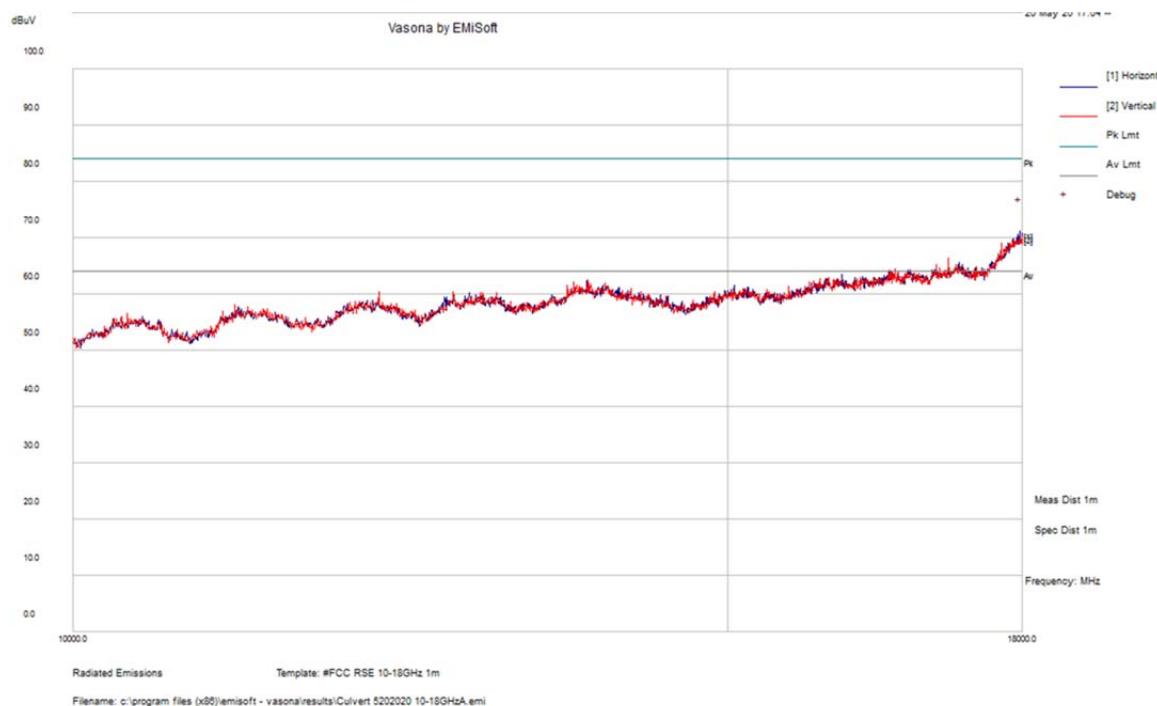
Frequency (MHz)	Corrected Amplitude (dB $\mu$ V/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dB $\mu$ V/m)	Margin (dB)	Comment
30.006464	39.93	101	H	310	40	-0.07	QP
105.70725	34.88	139	H	49	43.5	-8.62	QP
30.82825	23.5	260	H	173	40	-16.5	QP
59.406	13.3	150	V	96	40	-26.7	QP
127.05825	24.69	105	H	352	43.5	-18.81	QP
88.5055	25.47	126	V	344	43.5	-18.03	QP

## 2) 1–26.5 GHz Measured at 3 meters

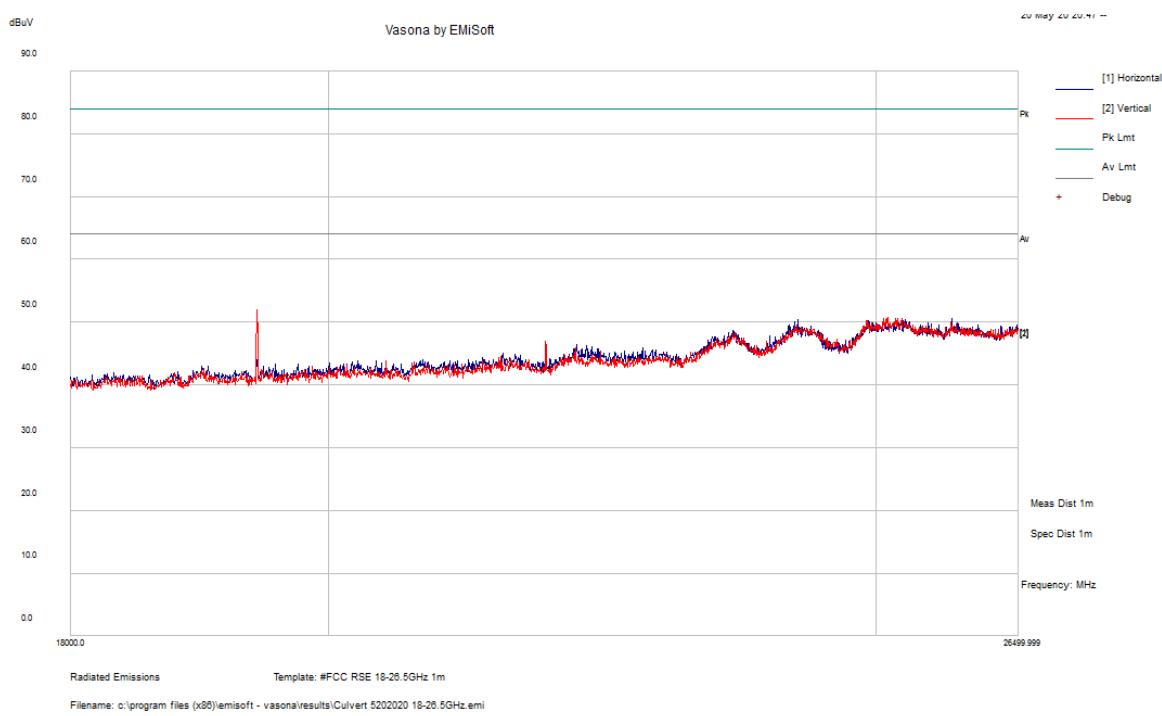
Frequency (MHz)	S.A. Reading (dB $\mu$ V)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dB $\mu$ V/m)	FCC/ISEDC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dB $\mu$ V/m)	Margin (dB)	
Low Channel 2402 MHz											
2402	77.5	10	285	V	32.6	5.594	-	115.694	-	-	Peak
2402	81.16	325	297	H	32.6	5.594	-	119.354	-	-	Peak
2390	58.34	160	300	V	32.6	6.33	36.42	60.85	74	-13.15	Peak
2390	62.55	190	140	H	32.6	6.33	36.42	65.06	74	-8.94	Peak
2390	43.437	160	300	V	32.6	6.33	36.42	45.947	54	-8.053	Ave
2390	45.75	190	140	H	32.6	6.33	36.42	48.26	54	-5.74	Ave
4804	48.65	15	280	V	35	9.753	35.43	57.973	74	-16.027	Peak
4804	49.58	270	280	H	35	9.753	35.43	58.903	74	-15.097	Peak
4804	41.547	15	280	V	35	9.753	35.43	50.87	54	-3.13	Ave
4804	43.883	270	280	H	35	9.753	35.43	53.206	54	-0.794	Ave
7206	48.64	340	260	V	36.1	9.83	35.82	58.75	85.694 <sup>1</sup>	-26.944	Peak
7206	48.33	200	170	H	36.1	9.83	35.82	58.44	89.354 <sup>1</sup>	-30.914	Peak
Middle Channel 2428 MHz											
2428	77.11	345	280	V	32.8	6.09	-	116	-	-	Peak
2428	81.87	325	285	H	32.8	6.09	-	120.76	-	-	Peak
4856	48.65	50	250	V	35.2	9.89	35.43	58.31	74	-15.69	Peak
4856	49.77	265	260	H	35.2	9.89	35.43	59.43	74	-14.57	Peak
4856	41.924	50	250	V	35.2	9.89	35.43	51.584	54	-2.416	Ave
4856	42.193	200	285	H	35.2	9.89	35.43	51.853	54	-2.147	Ave
7284	48.51	345	275	V	36.1	10.95	35.82	59.74	74	-14.26	Peak
7284	47.39	160	200	H	36.1	10.95	35.82	58.62	74	-15.38	Peak
7284	41.384	345	275	V	36.1	10.95	35.82	52.614	54	-1.386	Ave
7284	39.96	160	200	H	36.1	10.95	35.82	51.19	54	-2.81	Ave

Frequency (MHz)	S.A. Reading (dB $\mu$ V)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dB $\mu$ V/m)	FCC/ISEDC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dB $\mu$ V/m)	Margin (dB)	
High Channel 2480 MHz											
2480	66.74	15	300	V	33	5.44	-	105.18	-	-	Peak
2480	69.84	325	275	H	33	5.44	-	108.28	-	-	Peak
2483.5	58.13	15	300	V	33	5.65	36.34	60.44	74	-13.56	Peak
2483.5	61.56	320	120	H	33	5.65	36.34	63.87	74	-10.13	Peak
2483.5	45.662	15	300	V	33	5.65	36.34	47.972	54	-6.028	Ave
2483.5	49.165	330	100	H	33	5.65	36.34	51.475	54	-2.525	Ave
4960	45.39	350	150	V	35.4	11.07	35.43	56.43	74	-17.57	Peak
4960	47.6	270	270	H	35.4	11.07	35.43	58.64	74	-15.36	Peak
4960	37.997	360	150	V	35.4	11.07	35.43	49.037	54	-4.963	Ave
4960	38.726	270	270	H	35.4	11.07	35.43	49.766	54	-4.234	Ave
7440	45.86	350	150	V	36.1	12.73	35.9	58.79	74	-15.21	Peak
7440	46.33	270	270	H	36.1	12.73	35.9	59.26	74	-14.74	Peak
7440	37.269	360	150	V	36.1	12.73	35.9	50.199	54	-3.801	Ave
7440	37.532	270	270	H	36.1	12.73	35.9	50.462	54	-3.538	Ave

Note<sup>1</sup>: Outside of Restricted Bands. Limit is 30dB down from peak Fundamental Field Strength.

**Above 1 GHz Pre-scan Plots****1-10 GHz****10-18 GHz**

## 18-26.5 GHz



Note: test was done with Notch filter.

## 8 FCC §15.247(a) (2) & ISEDC RSS-247 §5.2 -Emission Bandwidth

### 8.1 Applicable Standards

According to ECFR §15.247(a) (2) and ISEDC RSS-247 §5.2(a), 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 6 dB bandwidth, i.e., DTS bandwidth, measurements were based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8.2: DTS bandwidth.

The 99% occupied bandwidth was measured in accordance with IC RSS-Gen Issue 5, Section 6.7.

### 8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4446A	US44300386	2019-08-24	1 year
Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
IW Microwave	157 Series 2.92mm Cable	KPS-1571AN-2400-KPS	DC 1922	2019-06-07	1 year
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2 years

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

**Statement of Traceability:** **BACL Corp.** attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".

### 8.4 Test Environmental Conditions

<b>Temperature:</b>	23° C
<b>Relative Humidity:</b>	42 %
<b>ATM Pressure:</b>	102.7 KPa

The testing was performed by Christian McCaig on 2020-05-20 in 5m chamber 3.

## 8.5 Test Results

### 99% and 6 dB Bandwidth

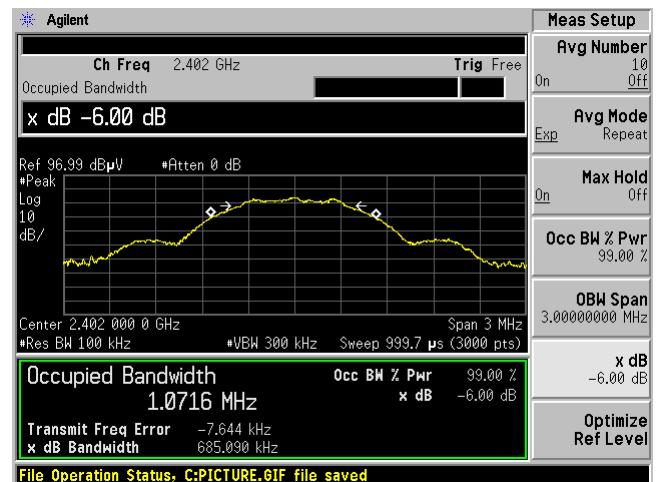
Channel	Frequency (MHz)	99% OBW (MHz)	6 dB OBW (kHz)	6 dB BW limit (kHz)
Low	2402	1.0561	685.090	>500
Middle	2428	1.0561	680.594	>500
High	2480	1.0586	691.677	>500

Please refer to the following plots.

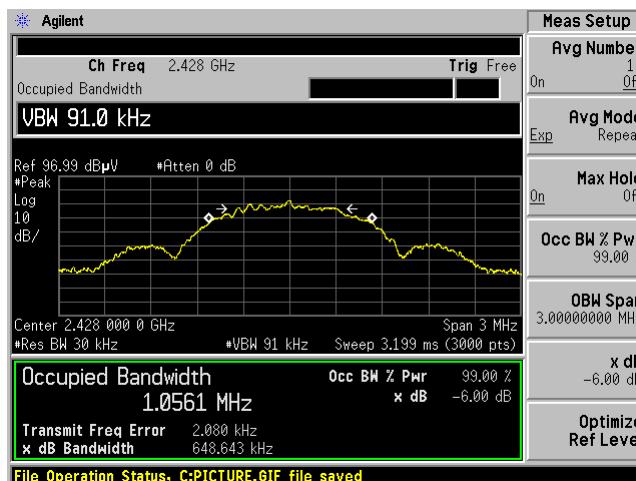
## BLE mode 2402 MHz 99% OBW



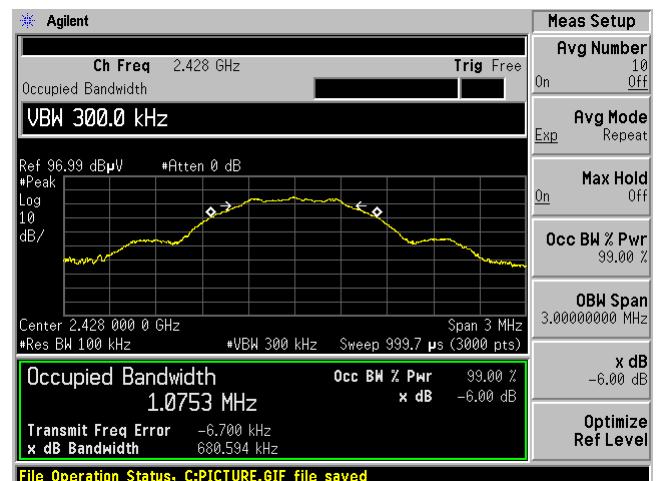
## BLE mode 2402 MHz 6 dB OBW



## BLE mode 2428 MHz 99% OBW



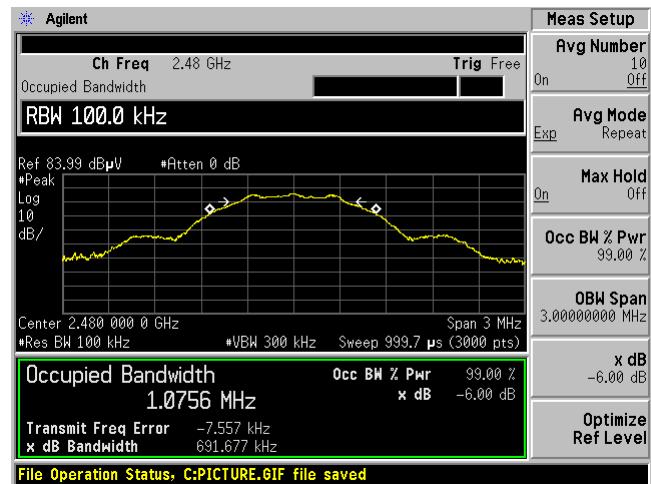
## BLE mode 2428 MHz 6 dB OBW



## BLE mode 2480 MHz 99% OBW



## BLE mode 2480 MHz 6 dB OBW



## 9 FCC §15.247(b) (3) & ISEDC RSS-247 §5.4 (4) - 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. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

According to RSS-247 §5.4(d): For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

### 9.2 Measurement Procedure

The measurements were based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8.3: DTS fundamental emission output power, 8.3.2.2 Measurement using a spectrum analyzer, and ANSI C63.10 Subclause 11.9.2.2.4 Method AVGSA-2.

Corrected Average Field Strength (dB $\mu$ V/m) = Measured Average Field Strength (dB $\mu$ V) + Cable Loss (dB) + Antenna Factor (dB/m)

EIRP (dBm) = Field Strength (dB $\mu$ V/m) + 20log(D(m)) - 104.77

Conducted Output Power = EIRP – Antenna Gain

### 9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4446A	US44300386	2019-08-24	1 year
Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
IW Microwave	157 Series 2.92mm Cable	KPS-1571AN-2400-KPS	DC 1922	2019-06-07	1 year
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2 years

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

**Statement of Traceability:** **BACL Corp.** attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".

## 9.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Christian McCaig on 2020-05-20 in 5m chamber 3.

## 9.5 Test Results

### Output Power

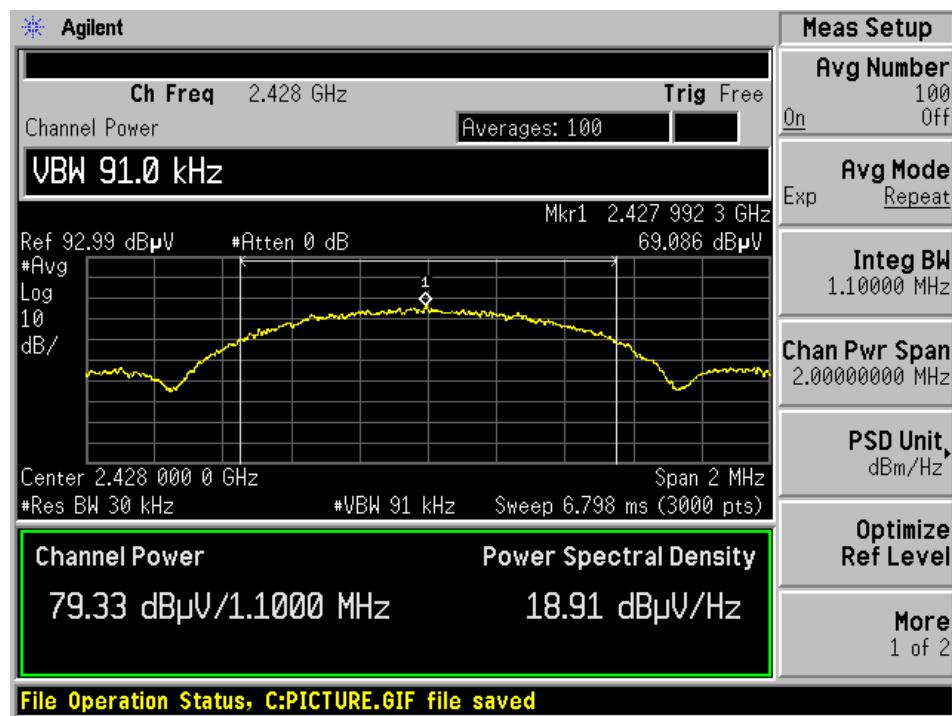
Channel	Frequency (MHz)	Measured Average Field Strength (dB $\mu$ V)	Antenna Factor (dB)	Cable Loss (dB)	Corrected Average Field Strength (dB $\mu$ V/m @ 3m)	Correction Factor (dB)	E.I.R.P (dBm)	Antenna Gain (dBi)	Duty Cycle Factor (dB)	Average Conducted Output Power (dBm)	Limit (dBm)
Low	2402	78.70	32.6	5.594	116.89	-95.23	21.66	-1	2.368	24.66	30
Middle	2428	79.33	32.8	6.09	118.22	-95.23	22.99	-1	2.368	25.99	30
High	2480	67.31	33	5.44	105.75	-95.23	10.52	-1	2.368	13.52	30

Note: Measurements made at 3 meters

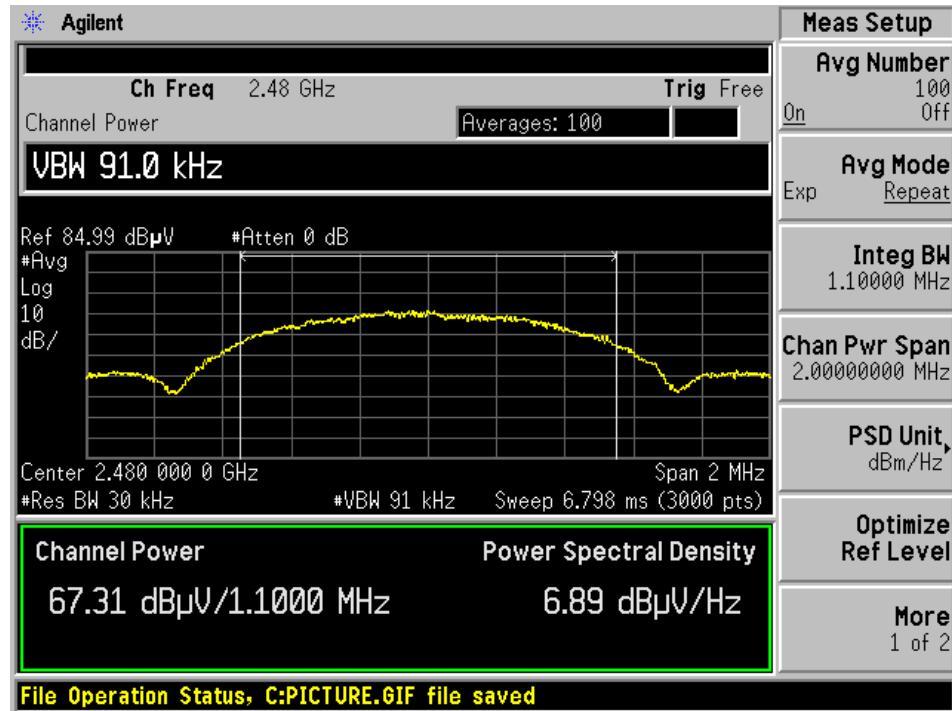
Please refer to the following plots.



## BLE mode 2428 MHz OP



## BLE mode 2480 MHz OP



## 10 FCC §15.247(d) & ISEDC RSS-247 §5.5 - 100 kHz Bandwidth of Band Edges

### 10.1 Applicable Standards

According to 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)).

According to ISEDC RSS-247 §5.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

### 10.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8.7: DTS band-edge emission measurements.

### 10.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4446A	US44300386	2019-08-24	1 year
Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
IW Microwave	157 Series 2.92mm Cable	KPS-1571AN-2400-KPS	DC 1922	2019-06-07	1 year
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2 years

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

**Statement of Traceability:** **BACL Corp.** attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".

## 10.4 Test Environmental Conditions

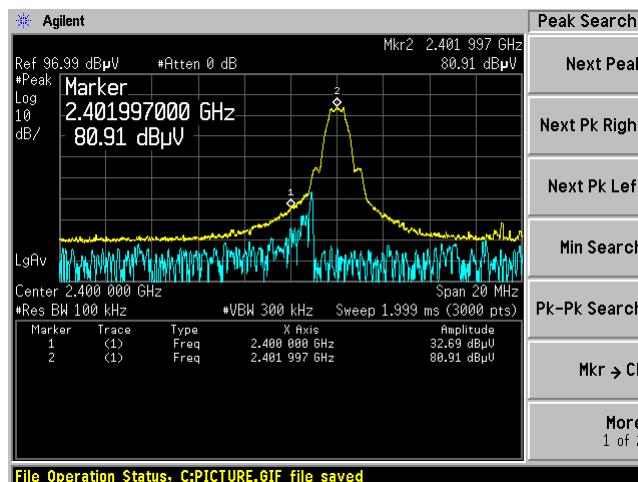
<b>Temperature:</b>	23° C
<b>Relative Humidity:</b>	42 %
<b>ATM Pressure:</b>	102.7 KPa

The testing was performed by Christian McCaig on 2020-05-20 in 5m chamber 3.

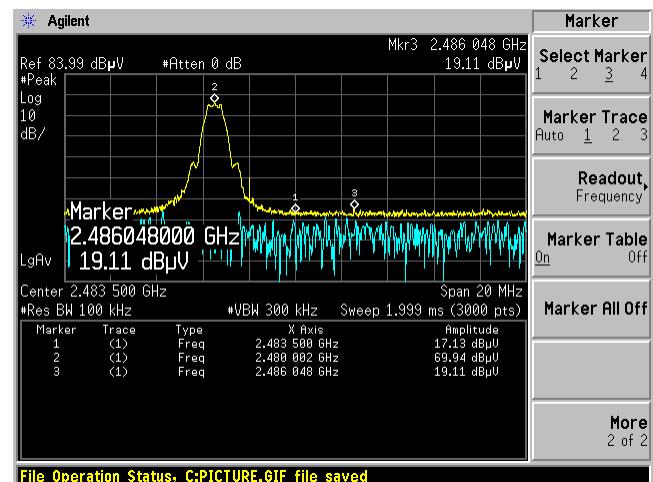
## 10.5 Test Results

### Band-Edge

BLE 2402 MHz



BLE 2480 MHz



## 11 FCC §15.247(e) & ISEDC RSS-247 §5.2(2) - Power Spectral Density

### 11.1 Applicable Standards

According to FCC §15.247(e) and RSS-247 §5.2(b), 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 were based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8.4: DTS maximum power spectral density level in the fundamental emission, and ANSI C63.10 Subclause 11.10.5 Method AVGPSD-2.

Corrected Average Field Strength (dB $\mu$ V/m) = Measured Average Field Strength (dB $\mu$ V) + Cable Loss (dB) + Antenna Factor (dB/m)

EIRP (dBm) = Field Strength (dB $\mu$ V/m) + 20log(D(m)) - 104.77

Conducted Output Power = EIRP – Antenna Gain

### 11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4446A	US44300386	2019-08-24	1 year
Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
IW Microwave	157 Series 2.92mm Cable	KPS-1571AN-2400-KPS	DC 1922	2019-06-07	1 year
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2 years

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

**Statement of Traceability:** *BACL Corp.* attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".

### 11.4 Test Environmental Conditions

Temperature:	23° C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Christian McCaig on 2020-05-20 in 5m chamber 3.

## 11.5 Test Results

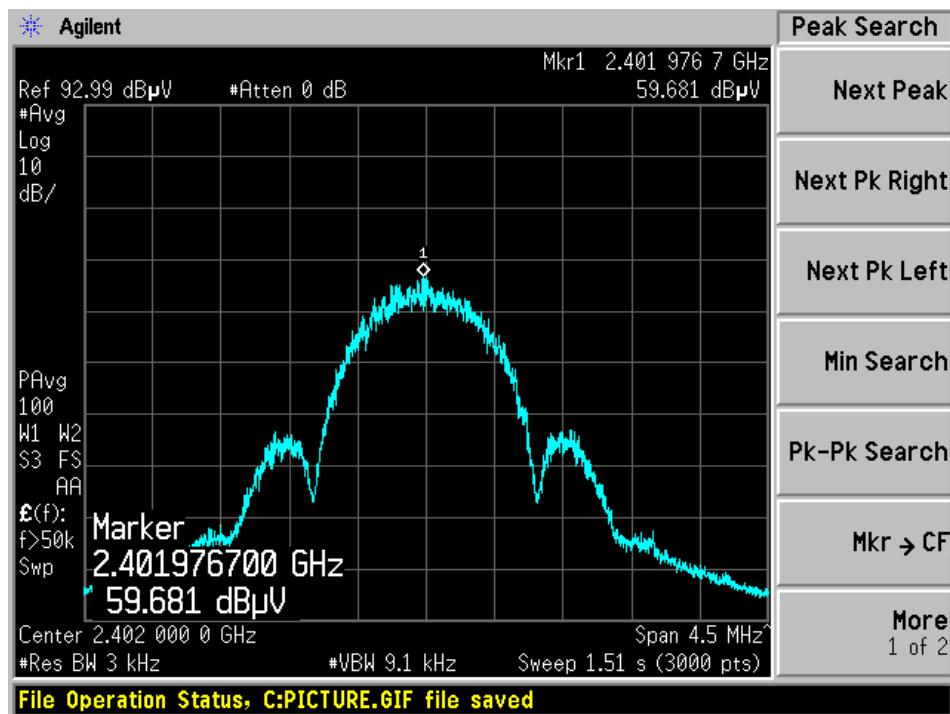
### PSD

Channel	Frequency (MHz)	Measured Average Field Strength (dB $\mu$ V)	Antenna Factor (dB)	Cable Loss (dB)	Corrected Average Field Strength (dB $\mu$ V/m @ 3m)	Correction Factor (dB)	E.I.R.P (dBm/3 kHz)	Antenna Gain (dBi)	Duty Cycle Cort. Factor (dB)	Average PSD (dBm/3 kHz)	Limit (dBm/3 kHz)
Low	2402	59.681	32.6	5.594	100.24	-95.23	5.01	-1	2.368	6.378	8
Middle	2428	60.075	32.8	6.09	101.33	-95.23	6.1	-1	2.368	7.468	8
High	2480	48.129	33	5.44	88.937	-95.23	-6.29	-1	2.368	-4.922	8

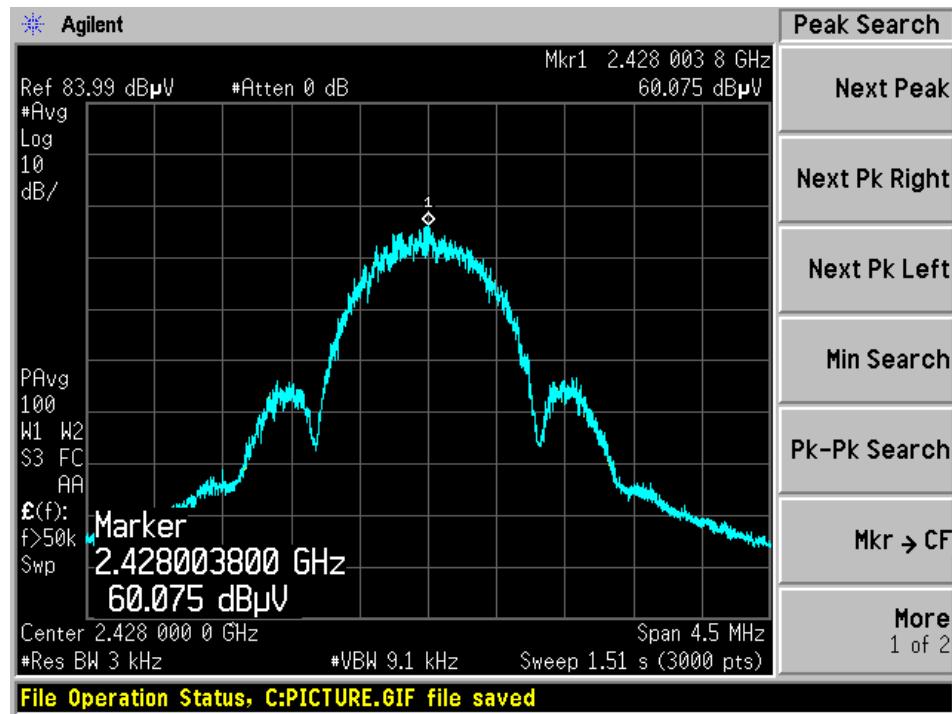
Note: Measurements made at 3 meters

Please refer to the following plots.

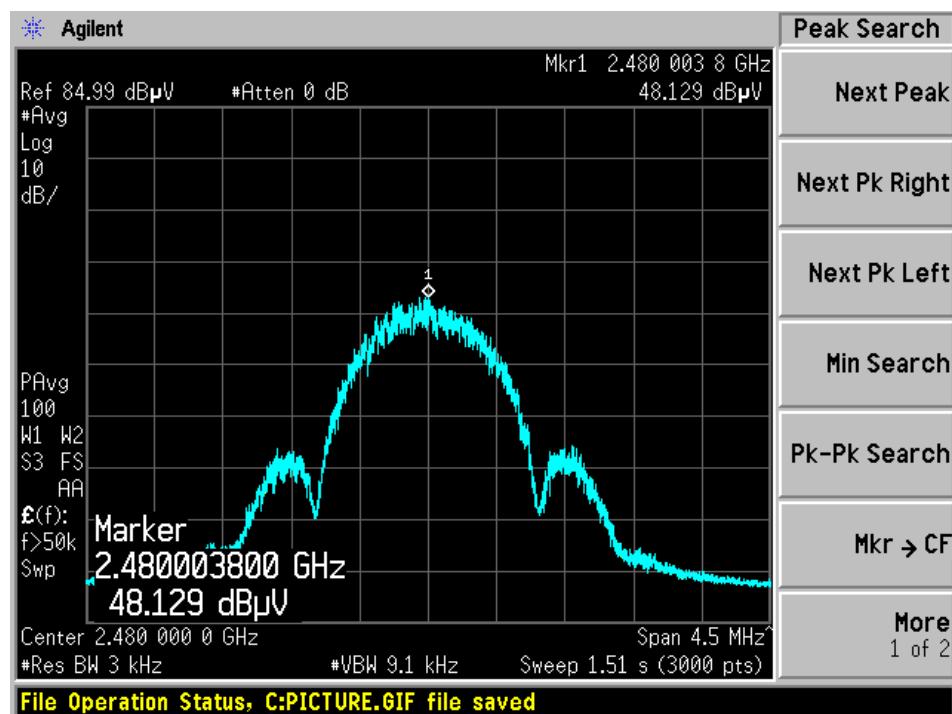
### BLE mode 2402 MHz PSD



## BLE mode 2428 MHz PSD



## BLE mode 2480 MHz PSD



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## **12 Annex A- EUT Setup Photographs**

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Please refer to the attachment

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## **13 Annex B- EUT External Photographs**

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Please refer to the attachment

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## **14 Annex C- EUT Internal Photographs**

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Please refer to the attachment

## 15 Annex D (Normative) - A2LA Electrical Testing Certificate



### Accredited Laboratory

A2LA has accredited

### BAY AREA COMPLIANCE LABORATORIES CORP. Sunnyvale, CA

for technical competence in the field of  
Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005  
General requirements for the competence of testing and calibration laboratories. This laboratory also meets A2LA R222  
- Specific Requirements EPA ENERGY STAR Accreditation Program. This accreditation demonstrates technical  
competence for a defined scope and the operation of a laboratory quality management system  
(refer to joint ISO-ILAC-IAF Communiqué dated April 2017).



Presented this 2nd day of October 2018.

A blue ink signature of a person's name, likely the Vice President of Accreditation Services.

Vice President, Accreditation Services  
For the Accreditation Council  
Certificate Number 3297.02  
Valid to September 30, 2020  
Revised June 5, 2019

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

Please follow the web link below for a full ISO 17025 scope

<https://www.a2la.org/scopepdf/3297-02.pdf>

--- END OF REPORT ---