FCC PART 15, SUBPART C

TEST REPORT

For

Roku Inc.

150 Winchester Circle,

Los Gatos, CA 95032, USA

FCC ID: TC2-R1023

Report Type:	Model:
Original Report	9030X

Prepared By:	Vincent Licata Test Engineer
Report Number:	R1808081-247 DTS
Report Date:	2018-09-17
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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1808081-247 DTS	Original Report	2018-09-17

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test and measurement report was prepared on behalf of *Roku Inc.,* and their product model: 9030X, FCC ID: TC2-R1023 or the "EUT" as referred to in this report.

1.2 Objective

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

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

1.3 Related Submittal(s)/Grant(s)

FCC 15.407 Report: R1808081-407
FCC 15.247 Report: R1808081-247 DSS

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 º C
Humidity	±5 %
DC and low frequency voltages	±1.0 %
Time	±2 %
Duty Cycle	±3 %

1.6 Test Facility Registrations

BACLs 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, 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: (Innovation, Science and Economic development Canada - ISEDC) 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/EU US-EU EMC & Telecom MRA CAB (NB)
  - Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
  - 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:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - Telecommunications Certification Body (TCB) – US FCC;
  - 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 and commands provided by *Roku Inc.*, the software is compliant with the standard requirements being tested against.

Modulation	Frequency (MHz)	Power Setting
802.11b	2412	63
	2437	63
	2462	63
802.11g	2412	57
	2437	63
	2462	63
802.11n20	2412	57
	2437	63
	2462	63
BLE	2402	23
	2440	23
	2480	23

Data Rates Tested:
802.11b mode: 1Mbps
802.11g mode: 6Mbps
802.11n HT20 mode: MCS0
BLE

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).

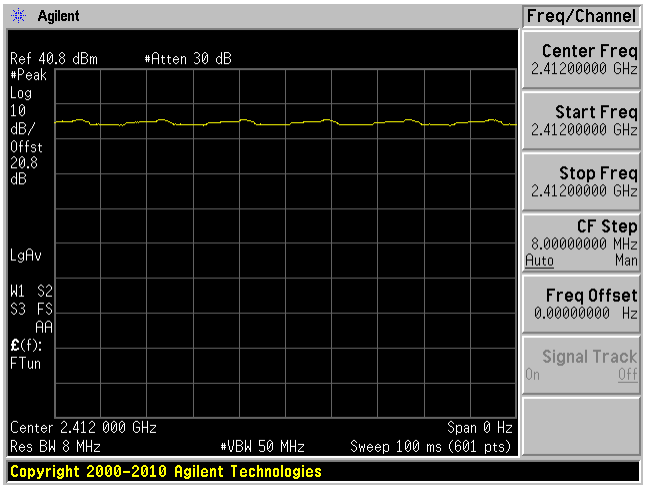
Radio Mode	Total On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11b	100	100	100	0.00
802.11g	100	100	100	0.00
802.11n20	100	100	100	0.00
BLE	100	100	100	0.00

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

Please refer to the following plot.

802.11b mode

ANT1



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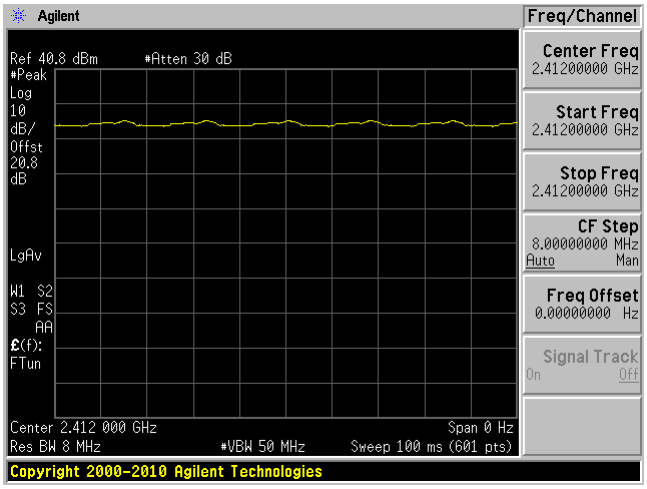
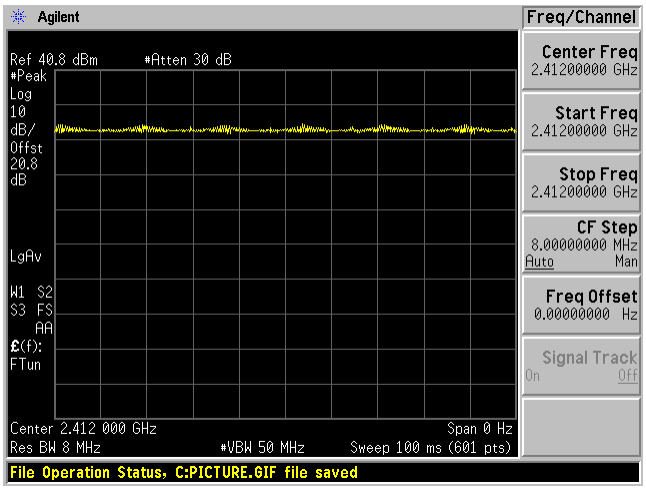


802.11g mode

ANT1



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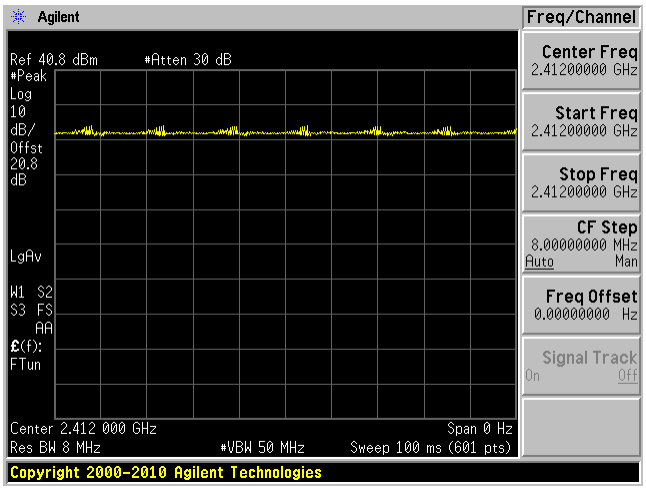
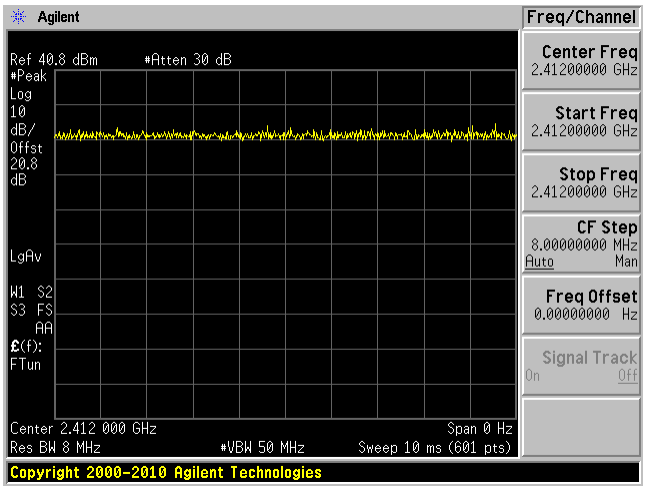


802.11n20 mode

ANT1



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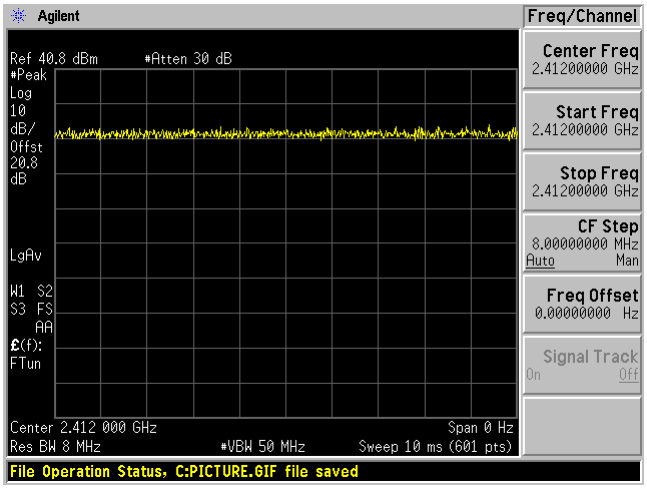
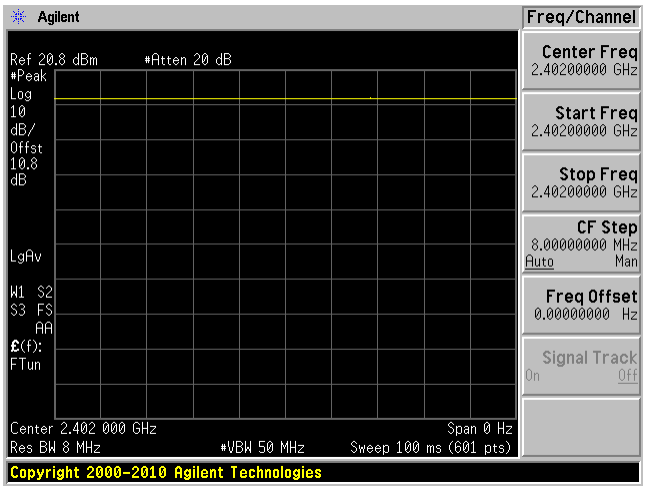


BLE mode



2.4 Equipment Modifications

No equipment modifications are made to the EUT

2.5 Local Support Equipment

Manufacturer	Description	Model	Serial Number
Dell	Laptop	Latitude E6410	3CKRAQ1

2.6 Support Equipment

Manufacturer	Description	Model
Roku	Debug Board	Unknown

2.7 Interface Ports and Cabling

Cable Description	Length (m)	To	From
USB 2.0 A-Male to B-Male	2 m	Laptop	EUT
RF Cable	< 1 m	EUT	PSA

3 Summary of Test Results

Results reported relate only to the product tested.

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

4 FCC §15.203- Antenna Requirements

4.1 Applicable Standards

According to FCC §15.203:

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

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

4.2 Antenna Description

The antennas used by the EUT are permanent attached antennas.

Antenna usage	Frequency Range (MHz)	Maximum Antenna Gain (dBi)
Wi-Fi and Bluetooth	2400-2483.5	1.0
Wi-Fi	5000-6000	1.0

5 FCC §2.1091, §15.247(i)– RF Exposure

5.1 Applicable Standards

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

Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^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

2.4 GHz Wi-Fi

Maximum output power at antenna input terminal (dBm):	23.06
Maximum output power at antenna input terminal (mW):	202.3019
Prediction distance (cm):	20
Prediction frequency (MHz):	2412
Maximum Antenna Gain, typical (dBi):	1.0
Maximum Antenna Gain (numeric):	1.258925
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.050668
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 0.050668 mW/cm^2. Limit is 1.0 mW/cm^2.

2.4 GHz BLE

Maximum peak output power at antenna input terminal (dBm):	12.77
Maximum peak output power at antenna input terminal (mW):	18.92344
Prediction distance (cm):	20
Prediction frequency (MHz):	2440
Maximum Antenna Gain, typical (dBi):	1.0
Maximum Antenna Gain (numeric):	1.258925
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.004739
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 0.004739 mW/cm^2. Limit is 1.0 mW/cm^2.

2.4 GHz Classic Bluetooth

Maximum peak output power at antenna input terminal (dBm):	12.87
Maximum peak output power at antenna input terminal (mW):	19.36422
Prediction distance (cm):	20
Prediction frequency (MHz):	2441
Maximum Antenna Gain, typical (dBi):	1.0
Maximum Antenna Gain (numeric):	1.258925
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.004850
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 0.004850 mW/cm^2. Limit is 1.0 mW/cm^2.

Worst case colocation 2.4 GHz Wi-Fi and 2.4 GHz Classic Bluetooth.

Frequency Band	Max Conducted Power(dBm)	Evaluated Distance (cm)	Worst-Case MPE (mW/cm^2)	MPE Limit (mW/cm^2)	Worst-Case MPE Ratios	Sum of MPE Ratios	Limit
Worst Case							
2.4 GHz WiFi	23.06	20	0.050668	1.0	5.0668%	5.5518%	100%
2.4 GHz Classic Bluetooth	12.87	20	0.004850	1.0	0.485%		

6 FCC §15.207 - AC Line Conducted Emissions

6.1 Applicable Standards

As per FCC §15.207 Conducted limits:

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

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

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

6.2 Test Setup

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

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

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

6.3 Test Procedure

During the conducted emissions test, the power cord of the EUT host system was connected to the mains outlet of the LISN-1.

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:

Margin = Corrected Amplitude – Limit

6.5 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2018-07-05	2 years
Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101964	2018-07-27	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150203	2018-02-28	1 year
Suirong	30 ft conductive emission cable	LMR 400	-	N/R	N/A
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2018-04-04	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2018-07-05	2 years

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 09 June 2016) "A2LA Policy on Metrological Traceability".*

6.6 Test Environmental Conditions

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

The testing was performed by Vincent Licata on 2018-08-16 in 5 meter chamber 3.

6.7 Summary of Test Results

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

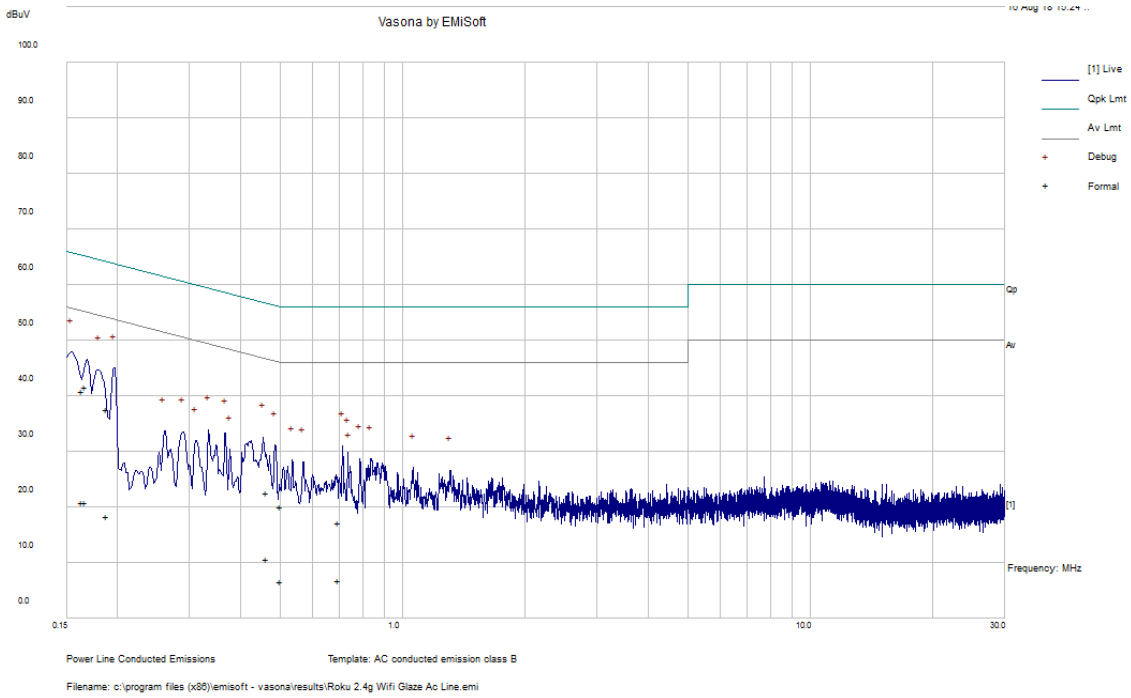
Colocation 2.4 GHz Wi-Fi and 2.4 GHz Classic Bluetooth

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-21.14	0.152987	Neutral	0.15-30

6.8 Conducted Emissions Test Plots and Data

Worst Case Colocation, 2.4 GHz Wi-Fi b mode (2412 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)

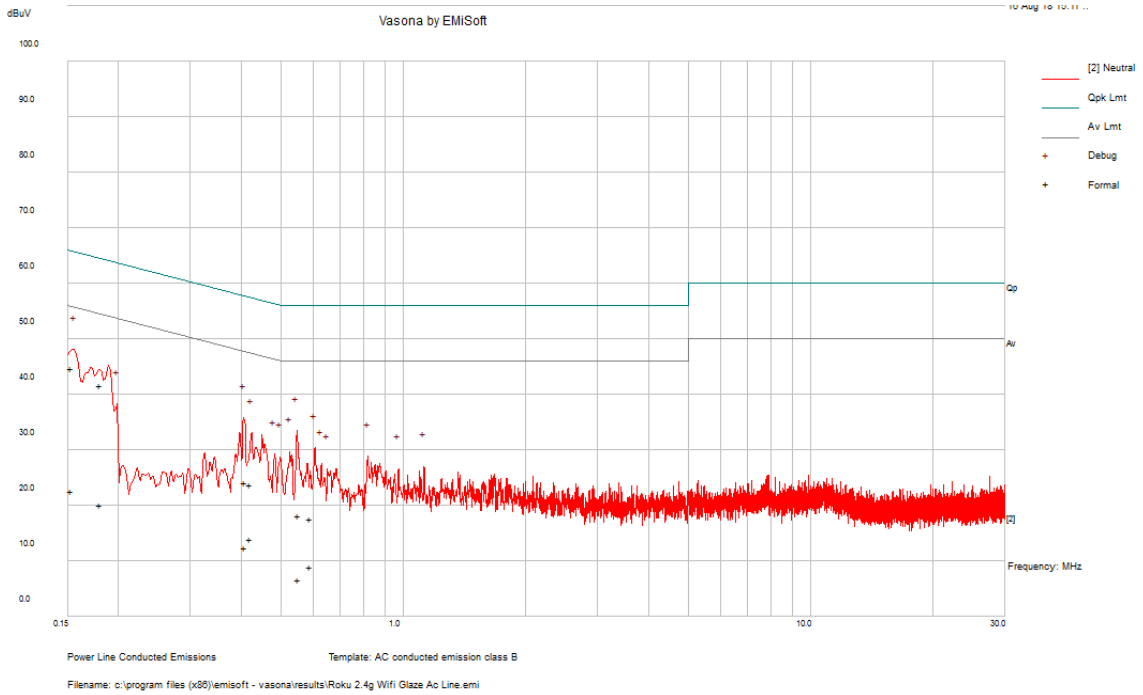
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.166529	41.71	Line	65.13	-23.42	QP
0.188664	37.54	Line	64.1	-26.55	QP
0.163648	40.91	Line	65.28	-24.37	QP
0.464924	22.67	Line	56.6	-33.93	QP
0.697332	17.29	Line	56	-38.71	QP
0.503376	20.11	Line	56	-35.89	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.166529	20.92	Line	55.13	-34.21	Ave.
0.188664	18.41	Line	54.1	-35.68	Ave.
0.163648	20.98	Line	55.28	-34.29	Ave.
0.464924	10.78	Line	46.6	-35.83	Ave.
0.697332	6.9	Line	46	-39.1	Ave.
0.503376	6.62	Line	46	-39.38	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.152987	**44.7**	**Neutral**	**65.84**	**-21.14**	**QP**
0.40795	24.2	Neutral	57.69	-33.49	QP
0.552014	18.2	Neutral	56	-37.8	QP
0.422087	23.77	Neutral	57.41	-33.64	QP
0.180593	41.64	Neutral	64.46	-22.82	QP
0.591532	17.65	Neutral	56	-38.35	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.152987	22.68	Neutral	55.84	-33.16	Ave.
0.40795	12.53	Neutral	47.69	-35.16	Ave.
0.552014	6.77	Neutral	46	-39.23	Ave.
0.422087	13.93	Neutral	47.41	-33.48	Ave.
0.180593	20.2	Neutral	54.46	-34.26	Ave.
0.591532	8.91	Neutral	46	-37.09	Ave.

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

7.1 Applicable Standards

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

As Per FCC §15.205(a) 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 0.495 – 0.505 2.1735 – 2.1905 4.125 – 4.128 4.17725 – 4.17775 4.20725 – 4.20775 6.215 – 6.218 6.26775 – 6.26825 6.31175 – 6.31225 8.291 – 8.294 8.362 – 8.366 8.37625 – 8.38675 8.41425 – 8.41475 12.29 – 12.293 12.51975 – 12.52025 12.57675 – 12.57725 13.36 – 13.41	16.42 – 16.423 16.69475 – 16.69525 25.5 – 25.67 37.5 – 38.25 73 – 74.6 74.8 – 75.2 108 – 121.94 123 – 138 149.9 – 150.05 156.52475 – 156.52525 156.7 – 156.9 162.0125 –167.17 167.72 – 173.2 240 – 285 322 – 335.4 399.9 – 410 608 – 614	960 – 1240 1300 – 1427 1435 – 1626.5 1645.5 – 1646.5 1660 – 1710 1718.8 – 1722.2 2200 – 2300 2310 – 2390 2483.5 – 2500 2690 – 2900 3260 – 3267 3.332 – 3.339 3 3458 – 3 358 3.600 – 4.400	4. 5 – 5. 15 5. 35 – 5. 46 7.25 – 7.75 8.025 – 8.5 9.0 – 9.2 9.3 – 9.5 10.6 – 12.7 13.25 – 13.4 14.47 – 14.5 15.35 – 16.2 17.7 – 21.4 22.01 – 23.12 23.6 – 24.0 31.2 – 31.8 36.43 – 36.5 Above 38.6

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

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

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

As per FCC §15.247 (d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c).

7.2 Test Setup

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

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

Above 1000 MHz:

(1) Peak: RBW = 1MHz / VBW = 3MHz / Sweep = 100 ms
(2) Average: RBW = 1MHz / VBW = 1 / T / Sweep = Auto

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:

$$CA = Ai + AF + CL + Atten - Ga$$

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 and Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100337	2017-07-15	2 years
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
Sunol Sciences	Antenna, Biconi-Log	JB1	A013105-3	2018-02-26	2 years
Wisewave	Antenna, Horn	ARH-4223-02	10555-02	2017-12-15	2 years
Agilent	Amplifier, Pre	8447D	2944A10187	2018-04-02	1 year
IW	AOBOR Hi frequency Co AX Cable	DC 1531	KPS-1501A3960KPS	2018-01-11	1 year
-	SMA cable	-	C00011	Each time[1]	N/A
-	N-Type Cable	-	C00012	Each time[1]	N/A
-	N-Type Cable	-	C00014	Each time[1]	N/A
HP	Pre-Amplifier	8449B	3147A00400	2018-02-02	1 year
Sunol Sciences	Antenna, Horn	DRH-118	A052704	2017-03-27	2 years
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Note[1]: 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 09 June 2016) "A2LA Policy on Metrological Traceability".*

7.6 Test Environmental Conditions

Temperature:	20-22 ºC
Relative Humidity:	42-50 %
ATM Pressure:	102.7 kPa

The testing was performed by Vincent Licata from 2018-08-13 to 2018-08-16 in 5m chamber 3.

7.7 Summary of Test Results

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

2.4 GHz Wi-Fi

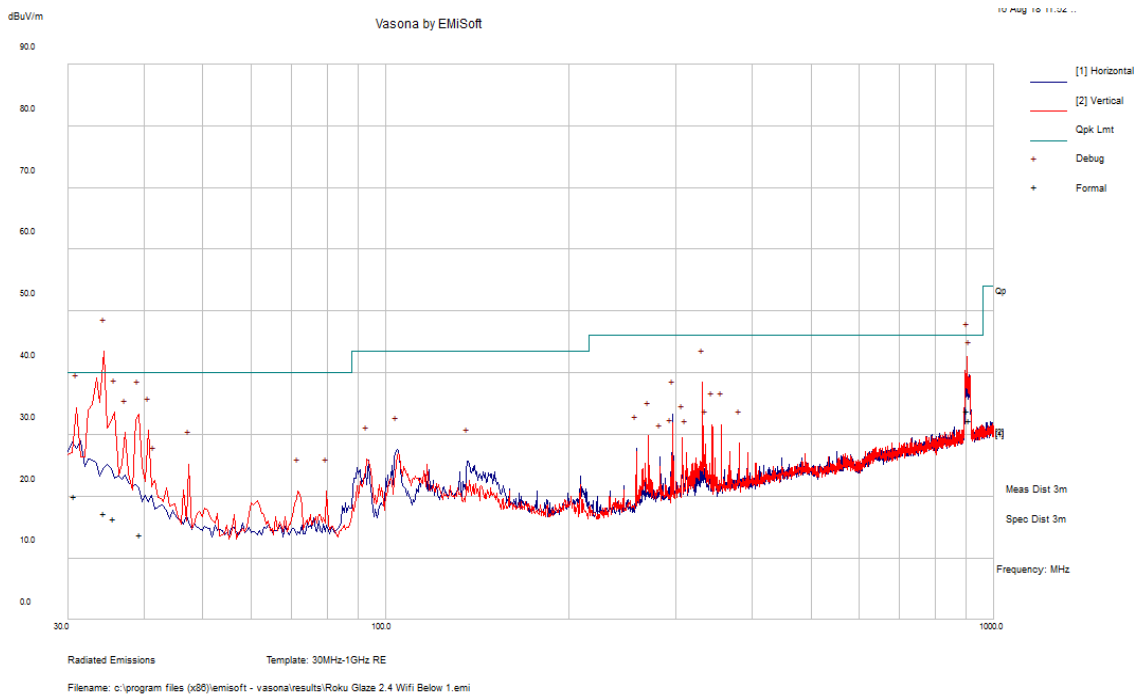
Mode: Transmitting		
Margin (dB)	**Frequency (MHz)**	**Mode, channel**
-1.81	7206	BLE mode, Low channel

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

7.8 Spurious Emissions Test Results

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

Colocation, 2.4 GHz Wi-Fi b mode (2412 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
34.4095	17.2	107	V	341	40	-22.8	QP
903.6605	33.81	99	V	351	46	-12.19	QP
30.75675	19.96	151	V	182	40	-20.04	QP
911.5313	32.25	110	H	324	46	-13.75	QP
35.71	16.4	300	V	360	40	-23.6	QP
39.3835	13.87	144	V	261	40	-26.13	QP

2) 1–26.5 GHz Measured at 3 meters

802.11b mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2412 MHz											
2412	68.90	276	291	H	28.93	5.76	0	103.59	-	-	PK
2412	65.79	276	291	H	28.93	5.76	0	100.48	-	-	AV
2412	60.90	49	100	V	28.93	5.76	0	95.59	-	-	PK
2412	57.19	49	100	V	28.93	5.76	0	91.88	-	-	AV
2390	49.61	276	291	H	28.93	6.489	32.207	52.83	74.00	-21.18	PK
2390	37.96	276	291	H	28.93	6.489	32.207	41.18	54.00	-12.83	AV
2390	47.73	49	100	V	28.93	6.489	32.207	50.95	74.00	-23.06	PK
2390	35.96	49	100	V	28.93	6.489	32.207	39.18	54.00	-14.83	AV
4824	49.08	62	283	H	32.56	9.36	32.993	58.01	74.00	-15.99	PK
4824	42.59	62	283	H	32.56	9.36	32.993	51.52	54.00	-2.48	AV
7236	46.22	0	100	H	36.88	12.01	33.248	61.86	74.00	-12.14	PK
7236	33.74	0	100	H	36.88	12.01	33.248	49.38	54.00	-4.62	AV
Middle Channel 2437 MHz											
2437	67.99	270	286	H	28.93	5.76	0	102.68	-	-	PK
2437	64.71	270	286	H	28.93	5.76	0	99.40	-	-	AV
2437	60.34	56	272	V	28.93	5.76	0	95.03	-	-	PK
2437	57.15	56	272	V	28.93	5.76	0	91.84	-	-	AV
4874	48.30	67	287	H	32.53	9.46	32.993	57.29	74.00	-16.71	PK
4874	40.73	67	287	H	32.53	9.46	32.993	49.72	54.00	-4.28	AV
7311	44.96	0	100	H	36.99	11.97	33.248	60.67	74.00	-13.33	PK
7311	33.21	0	100	H	36.99	11.97	33.248	48.92	54.00	-5.08	AV
High Channel 2462 MHz											
2462	66.46	57	100	H	29.19	5.86	0	101.51	-	-	PK
2462	63.21	57	100	H	29.19	5.86	0	98.26	-	-	AV
2462	64.55	94	297	V	29.19	5.86	0	99.60	-	-	PK
2462	61.44	94	297	V	29.19	5.86	0	96.49	-	-	AV
2483.5	48.48	57	100	H	29.18	6.61	32.207	52.06	74.00	-21.94	PK
2483.5	37.09	57	100	H	29.18	6.61	32.207	40.67	54.00	-13.33	AV
2483.5	50.72	94	297	V	29.18	6.61	32.207	54.30	74.00	-19.70	PK
2483.5	37.11	94	297	V	29.18	6.61	32.207	40.69	54.00	-13.31	AV
4924	45.23	0	100	H	32.70	9.42	32.993	54.35	74.00	-19.65	PK
4924	33.44	0	100	H	32.70	9.42	32.993	42.56	54.00	-11.44	AV
7386	45.29	0	100	H	37.10	12.01	33.248	61.15	74.00	-12.85	PK
7386	33.02	0	100	H	37.10	12.01	33.248	48.88	54.00	-5.12	AV

802.11g mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2412 MHz											
2412	67.91	68	247	H	28.93	5.76	0	102.60	-	-	PK
2412	60.11	68	247	H	28.93	5.76	0	94.80	-	-	AV
2412	64.12	55	300	V	28.93	5.76	0	98.81	-	-	PK
2412	56.75	55	300	V	28.93	5.76	0	91.44	-	-	AV
2390	57.91	60	246	H	28.93	6.489	32.207	61.13	74.00	-12.88	PK
2390	43.54	60	246	H	28.93	6.489	32.207	46.76	54.00	-7.25	AV
2390	50.46	45	100	V	28.93	6.489	32.207	53.68	74.00	-20.33	PK
2390	37.12	45	100	V	28.93	6.489	32.207	40.34	54.00	-13.67	AV
4824	46.62	64	249	H	32.56	9.36	32.993	55.55	74.00	-18.45	PK
4824	35.72	64	249	H	32.56	9.36	32.993	44.65	54.00	-9.35	AV
7236	45.63	0	100	H	36.88	12.01	33.248	61.27	74.00	-12.73	PK
7236	33.37	0	100	H	36.88	12.01	33.248	49.01	54.00	-4.99	AV
Middle Channel 2437 MHz											
2437	66.30	83	135	H	28.93	5.76	0	100.99	-	-	PK
2437	59.07	83	135	H	28.93	5.76	0	93.76	-	-	AV
2437	61.34	277	286	V	28.93	5.76	0	96.03	-	-	PK
2437	54.09	277	286	V	28.93	5.76	0	88.78	-	-	AV
4874	45.59	87	140	H	32.53	9.46	32.993	54.58	74.00	-19.42	PK
4874	34.96	87	140	H	32.53	9.46	32.993	43.95	54.00	-10.05	AV
7311	45.53	0	100	H	36.99	11.97	33.248	61.24	74.00	-12.76	PK
7311	33.35	0	100	H	36.99	11.97	33.248	49.06	54.00	-4.94	AV
High Channel 2462 MHz											
2462	69.18	59	237	H	29.19	5.86	0	104.23	-	-	PK
2462	61.26	59	237	H	29.19	5.86	0	96.31	-	-	AV
2462	62.35	265	140	V	29.19	5.86	0	97.40	-	-	PK
2462	54.86	265	140	V	29.19	5.86	0	89.91	-	-	AV
2483.5	55.10	59	237	H	29.18	6.61	32.207	58.68	74.00	-15.32	PK
2483.5	42.18	59	237	H	29.18	6.61	32.207	45.76	54.00	-8.24	AV
2483.5	49.80	265	140	V	29.18	6.61	32.207	53.38	74.00	-20.62	PK
2483.5	37.25	265	140	V	29.18	6.61	32.207	40.83	54.00	-13.17	AV
4924	47.51	43	241	H	32.70	9.42	32.993	56.63	74.00	-17.37	PK
4924	36.68	43	241	H	32.70	9.42	32.993	45.80	54.00	-8.20	AV
7386	44.41	0	100	H	37.10	12.01	33.248	60.27	74.00	-13.73	PK
7386	33.05	0	100	H	37.10	12.01	33.248	48.91	54.00	-5.09	AV

802.11n20 mode

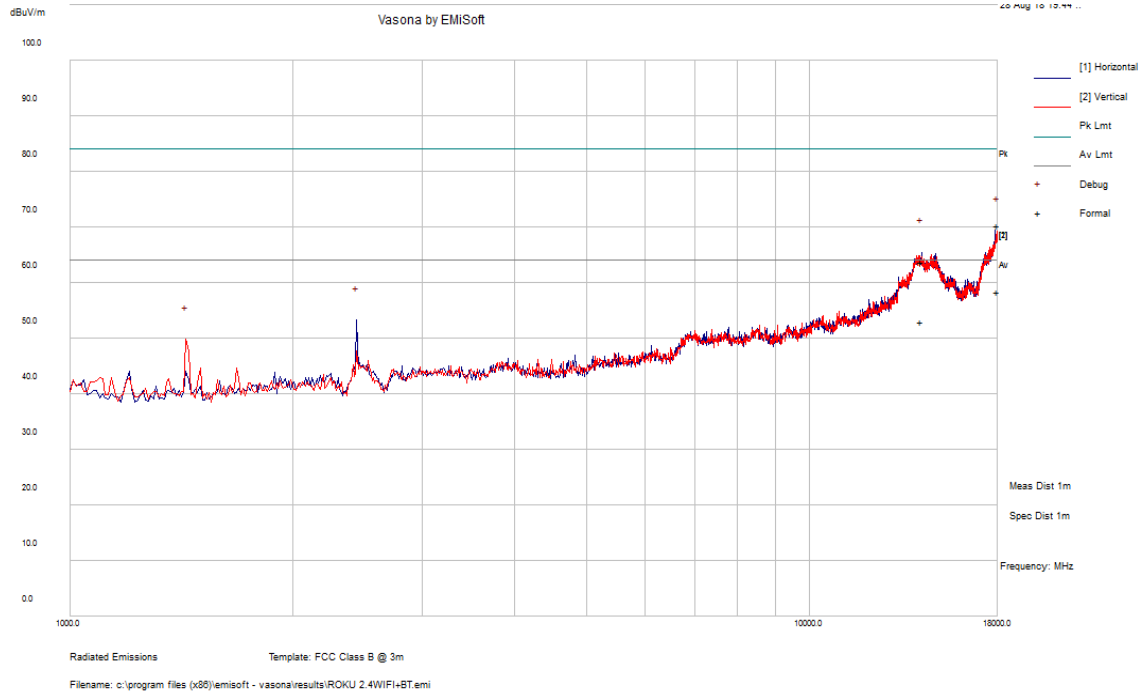
Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2412 MHz											
2412	66.81	275	294	H	28.93	5.76	0	101.50	-	-	PK
2412	59.10	275	294	H	28.93	5.76	0	93.79	-	-	AV
2412	57.30	54	253	V	28.93	5.76	0	91.99	-	-	PK
2412	49.57	54	253	V	28.93	5.76	0	84.26	-	-	AV
2390	63.81	275	294	H	28.93	6.489	32.207	67.03	74.00	-6.97	PK
2390	47.41	275	294	H	28.93	6.489	32.207	50.63	54.00	-3.38	AV
2390	54.80	54	253	V	28.93	6.489	32.207	58.02	74.00	-15.99	PK
2390	38.17	54	253	V	28.93	6.489	32.207	41.39	54.00	-12.62	AV
4824	46.62	276	290	H	32.56	9.36	32.993	55.55	74.00	-18.45	PK
4824	35.93	276	290	H	32.56	9.36	32.993	44.86	54.00	-9.14	AV
7236	45.34	0	100	H	36.88	12.01	33.248	60.98	74.00	-13.02	PK
7236	33.44	0	100	H	36.88	12.01	33.248	49.08	54.00	-4.92	AV
Middle Channel 2437 MHz											
2437	67.05	298	260	H	28.93	5.76	0	101.74	-	-	PK
2437	58.69	298	260	H	28.93	5.76	0	93.38	-	-	AV
2437	61.68	131	178	V	28.93	5.76	0	96.37	-	-	PK
2437	53.89	131	178	V	28.93	5.76	0	88.58	-	-	AV
4874	45.94	297	260	H	32.53	9.46	32.993	54.93	74.00	-19.07	PK
4874	34.48	297	260	H	32.53	9.46	32.993	43.47	54.00	-10.53	AV
7311	45.02	0	100	H	36.99	11.97	33.248	60.73	74.00	-13.27	PK
7311	33.36	0	100	H	36.99	11.97	33.248	49.07	54.00	-4.93	AV
High Channel 2462 MHz											
2462	71.29	59	233	H	29.19	5.86	0	106.34	-	-	PK
2462	63.03	59	233	H	29.19	5.86	0	98.08	-	-	AV
2462	62.18	277	139	V	29.19	5.86	0	97.23	-	-	PK
2462	54.51	277	139	V	29.19	5.86	0	89.56	-	-	AV
2483.5	65.06	59	233	H	29.18	6.61	32.207	68.64	74.00	-5.36	PK
2483.5	48.92	59	233	H	29.18	6.61	32.207	52.50	54.00	-1.50	AV
2483.5	57.53	277	139	V	29.18	6.61	32.207	61.11	74.00	-12.89	PK
2483.5	42.30	277	139	V	29.18	6.61	32.207	45.88	54.00	-8.12	AV
4924	47.25	55	215	H	32.70	9.42	32.993	56.37	74.00	-17.63	PK
4924	35.94	55	215	H	32.70	9.42	32.993	45.06	54.00	-8.94	AV
7386	44.77	0	100	H	37.10	12.01	33.248	60.63	74.00	-13.37	PK
7386	33.08	0	100	H	37.10	12.01	33.248	48.94	54.00	-5.06	AV

BLE mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2402 MHz											
2402	71.27	133	141	H	28.93	5.76	0	105.96	-	-	PK
2402	70.80	133	141	H	28.93	5.76	0	105.49	-	-	AV
2402	70.65	267	300	V	28.93	5.76	0	105.34	-	-	PK
2402	70.13	267	300	V	28.93	5.76	0	104.82	-	-	AV
2390	52.57	133	141	H	28.93	6.489	32.207	55.79	74.00	-18.22	PK
2390	38.09	133	141	H	28.93	6.489	32.207	41.31	54.00	-12.70	AV
2390	47.97	267	300	V	28.93	6.489	32.207	51.19	74.00	-22.82	PK
2390	36.86	267	300	V	28.93	6.489	32.207	40.08	54.00	-13.93	AV
4804	47.70	292	158	H	32.56	9.36	32.993	56.63	74.00	-17.37	PK
4804	38.36	292	158	H	32.56	9.36	32.993	47.29	54.00	-6.71	AV
7206	47.02	292	300	H	36.88	12.01	33.248	62.66	74.00	-11.34	PK
7206	**36.55**	**292**	**300**	**H**	**36.88**	**12.01**	**33.248**	**52.19**	**54.00**	**-1.81**	**AV**
Middle Channel 2440 MHz											
2440	70.94	7	171	H	28.93	5.76	0	105.63	-	-	PK
2440	70.41	7	171	H	28.93	5.76	0	105.10	-	-	AV
2440	70.48	288	300	V	28.93	5.76	0	105.17	-	-	PK
2440	69.87	288	300	V	28.93	5.76	0	104.56	-	-	AV
4880	48.77	279	300	H	32.53	9.46	32.993	57.76	74.00	-16.24	PK
4880	40.33	279	300	H	32.53	9.46	32.993	49.32	54.00	-4.68	AV
7320	46.41	278	293	H	36.99	11.97	33.248	62.12	74.00	-11.88	PK
7320	36.17	278	293	H	36.99	11.97	33.248	51.88	54.00	-2.12	AV
High Channel 2480 MHz											
2480	70.62	7	121	H	29.19	5.86	0	105.67	-	-	PK
2480	69.13	7	121	H	29.19	5.86	0	104.18	-	-	AV
2480	69.16	288	289	V	29.19	5.86	0	104.21	-	-	PK
2480	68.59	288	289	V	29.19	5.86	0	103.64	-	-	AV
2483.5	52.03	7	121	H	29.18	6.61	32.207	55.61	74.00	-18.39	PK
2483.5	42.05	7	121	H	29.18	6.61	32.207	45.63	54.00	-8.37	AV
2483.5	50.84	288	289	V	29.18	6.61	32.207	54.42	74.00	-19.58	PK
2483.5	41.50	288	289	V	29.18	6.61	32.207	45.08	54.00	-8.92	AV
4960	47.49	281	300	H	32.70	9.42	32.993	56.61	74.00	-17.39	PK
4960	38.86	281	300	H	32.70	9.42	32.993	47.98	54.00	-6.02	AV
7440	46.22	280	293	H	37.10	12.01	33.248	62.08	74.00	-11.92	PK
7440	35.46	280	293	H	37.10	12.01	33.248	51.32	54.00	-2.68	AV

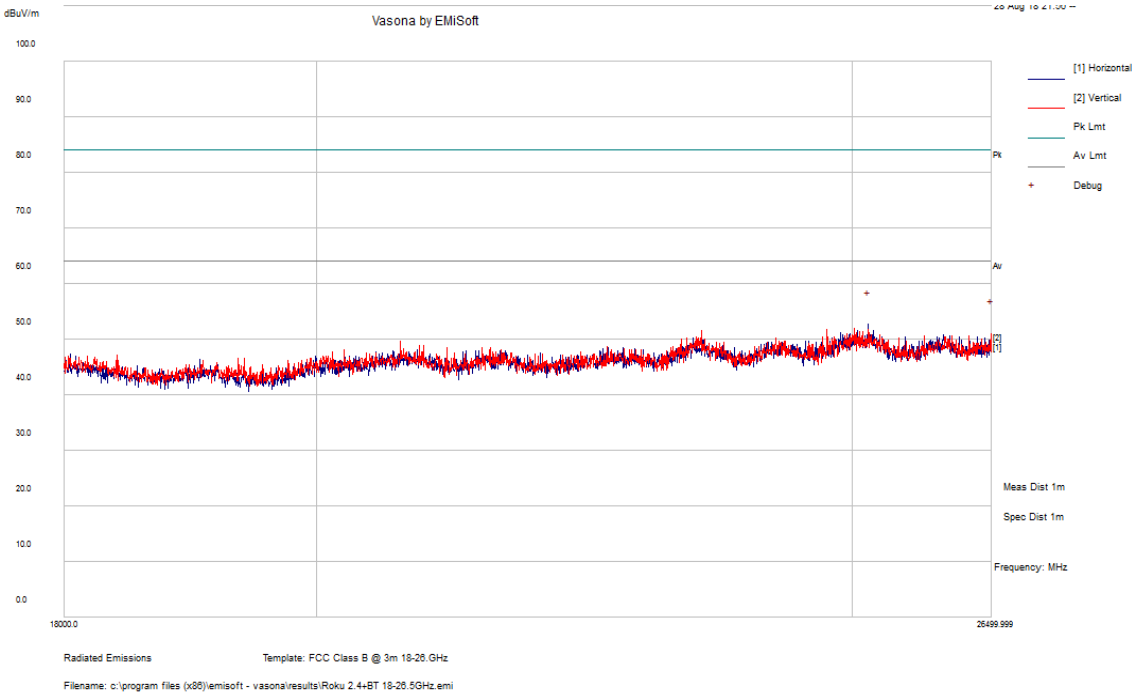
1-18 GHz

Colocation, 2.4 GHz Wi-Fi b mode (2412 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)



18-26.5 GHz

Colocation, 2.4 GHz Wi-Fi b mode (2412 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)



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

8.1 Applicable Standards

According to ECFR §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 v04: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8: DTS bandwidth

8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	20 dB Attenuator	-	-	Each time[1]	N/A
-	10 dB Attenuator	-	-	Each time[1]	N/A
-	RF cable	-	-	Each time[1]	N/A

Note[1]: cable and attenuators 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 09 June 2016) "A2LA Policy on Metrological Traceability".*

8.4 Test Environmental Conditions

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

The testing was performed by Vincent Licata from 2018-08-14 to 2018-08-15 in RF site.

8.5 Test Results

2.4 GHz Wi-Fi 99% and 6 dB Bandwidth ANT1

Channel	Frequency (MHz)	99% OBW (MHz)	6 dB BW (MHz)	6 dB OBW limit (MHz)
802.11b mode				
Low	2412	13.4400	9.084	≥0.5
Middle	2437	13.3204	9.080	≥0.5
High	2462	13.2785	9.076	≥0.5
802.11g mode				
Low	2412	16.0535	15.686	≥0.5
Middle	2437	16.1423	15.366	≥0.5
High	2462	16.0864	15.357	≥0.5
802.11n20 mode				
Low	2412	17.0937	15.090	≥0.5
Middle	2437	17.1918	15.671	≥0.5
High	2462	17.1686	15.671	≥0.5

2.4 GHz Wi-Fi 99% and 6 dB Bandwidth ANT2

Channel	Frequency (MHz)	99% OBW (MHz)	6 dB BW (MHz)	6 dB OBW limit (MHz)
802.11b mode				
Low	2412	13.2779	9.101	≥0.5
Middle	2437	13.2690	9.095	≥0.5
High	2462	13.3294	9.089	≥0.5
802.11g mode				
Low	2412	16.0668	15.838	≥0.5
Middle	2437	16.1658	15.819	≥0.5
High	2462	16.1771	15.826	≥0.5
802.11n20 mode				
Low	2412	16.060	15.696	≥0.5
Middle	2437	16.070	15.706	≥0.5
High	2462	17.2161	15.696	≥0.5

BLE 99% and 6 dB Bandwidth

Channel	Frequency (MHz)	99% OBW (kHz)	6 dB BW (kHz)	6 dB OBW limit (kHz)
BLE mode				
Low	2402	1062.8	772.509	≥500
Middle	2440	1065.0	767.086	≥500
High	2480	1062.6	768.526	≥500

Please refer to Annex E for plots.

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

9.1 Applicable Standards

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

9.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v04: 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
ETS- Lindgren	Power Sensor	7002-006	160097	2016-12-05	2 years
-	RF cable	-	-	Each time[1]	N/A
-	20 dB Attenuator	-	-	Each time[1]	N/A
-	10 dB Attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuators 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 09 June 2016) "A2LA Policy on Metrological Traceability".*

9.4 Test Environmental Conditions

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

The testing was performed by Vincent Licata from 2018-08-14 to 2018-08-15 in RF site.

9.5 Test Results

Output Power 2.4 GHz Wi-Fi

Channel	Frequency (MHz)	ANT 1 (dBm)	ANT 2 (dBm)	Total (dBm)	Limit (dBm)
802.11b mode					
Low	2412	20.13	19.97	23.06	30
Middle	2437	19.66	19.77	22.73	30
High	2462	19.61	19.87	22.75	30
802.11g mode					
Low	2412	14.52	14.03	17.29	30
Middle	2437	16.59	16.52	19.57	30
High	2462	16.38	16.44	19.42	30
802.11n20 mode					
Low	2412	14.24	13.85	17.06	30
Middle	2437	16.44	16.38	19.42	30
High	2462	16.18	16.23	19.22	30

Output Power BLE

Channel	Frequency (MHz)	Total (dBm)	Limit (dBm)
BLE mode			
Low	2402	12.56	30
Middle	2440	12.77	30
High	2480	12.38	30

Please refer to Annex I for plots of results.

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 v04: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 13: Band-edge measurements

10.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	RF cable	-	-	Each time[1]	N/A
-	20 dB Attenuator	-	-	Each time[1]	N/A
-	10 dB Attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuators 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 09 June 2016) "A2LA Policy on Metrological Traceability".*

10.4 Test Environmental Conditions

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

The testing was performed by Vincent Licata from 2018-08-14 to 2018-08-15 in RF site.

10.5 Test Results

Compliant

Please refer to Annex H for plots of results.

11 FCC §15.247(e) – Power Spectral Density

11.1 Applicable Standards

According to ECFR §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 v04: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 10: Maximum power spectral density level in the fundamental emission.

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	RF cable	-	-	Each time[1]	N/A
-	20 dB Attenuator	-	-	Each time[1]	N/A
-	10 dB Attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuators 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 09 June 2016) "A2LA Policy on Metrological Traceability".*

11.3 Test Environmental Conditions

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

The testing was performed by Vincent Licata from 2018-08-14 to 2018-08-15 in RF site.

11.4 Test Results

Output Power 2.4 GHz Wi-Fi

Channel	Frequency (MHz)	ANT 1 (dBm/3 kHz)	ANT 2 (dBm/3 kHz)	Total (dBm/3 kHz)	Limit (dBm/3 kHz)
802.11b mode					
Low	2412	-8.66	-8.99	-5.81	8
Middle	2437	-9.32	-9.14	-6.22	8
High	2462	-9.35	-9.23	-6.28	8
802.11g mode					
Low	2412	-13.00	-13.24	-10.11	8
Middle	2437	-10.46	-11.36	-7.88	8
High	2462	-10.70	-10.90	-7.79	8
802.11n20 mode					
Low	2412	-12.72	-13.21	-9.95	8
Middle	2437	-10.74	-11.05	-7.88	8
High	2462	-10.55	-11.09	-7.80	8

Output Power BLE

Channel	Frequency (MHz)	Total (dBm/3 kHz)	Limit (dBm/3 kHz)
BLE mode			
Low	2402	-4.67	8
Middle	2440	-4.20	8
High	2480	-4.73	8

Please refer to Annex G for plots.

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

12.1 Applicable Standards

For ECFR §15.247(d) in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

12.2 Test Procedure

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

12.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	RF cable	-	-	Each time[1]	N/A
-	20 dB Attenuator	-	-	Each time[1]	N/A
-	10 dB Attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuators 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 09 June 2016) "A2LA Policy on Metrological Traceability".*

12.4 Test Environmental Conditions

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

The testing was performed by Vincent Licata from 2018-08-14 to 2018-08-15 in RF site.

12.5 Test Results

Compliant

Please refer to Annex F for plots.

13 Appendix

Please see attachments:

Annex E – Occupied Bandwidth
Annex F – Spurious Emissions at Antenna Port
Annex G – Power Spectral Density
Annex H – Band Edge
Annex I – Output Power

14 Annex A (Informative) - 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 the requirements of any additional program requirements in the Electrical field. 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 8 January 2009*).

Presented this 30th day of August 2016.

President and CEO
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2018
Revised November 14, 2016

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

----- END OF REPORT -----