FCC PART 15.407

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:	R1808081-407
Report Date:	2018-09-17
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TABLE OF CONTENTS

DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1808081-407	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 FCC CFR47 §15.407.

The objective is to determine compliance with FCC Part 15.407 rules for Output Power, Antenna Requirements, AC Line Conducted Emissions, Emission Bandwidth, Power spectral density, and Radiated Spurious Emissions.

1.3 Related Submittal(s)/Grant(s)

FCC 15.247 Report: R1808081-247 DTS
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 for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz, and FCC KDB 789033 D02 General UNII Test Procedure New Rules v02r01.

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 EUT Test Configuration

2.1 Justification

The EUT was configured for testing according to ANSI C63.10-2013 and FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01.

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 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 *Roku Inc.*, the software is compliant with the standard requirements being tested against.

Modulation	Frequency (MHz)	Power Setting
802.11a	5180	53
	5200	53
	5240	53
	5745	63
	5785	63
	5825	63
802.11n20	5180	48
	5200	48
	5240	48
	5745	63
	5785	63
	5825	63
802.11ac20	5180	54
	5200	54
	5240	54
	5745	63
	5785	63
	5825	63

Data Rates Tested:

802.11a mode: 6Mbps
802.11n HT20 mode: MCS0
802.11ac VHT20 mode: MCS0

2.3 Duty Cycle Correction Factor

According to KDB 789033 D02 General UNII Test Procedures New Rules v02r01 section B:

All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximum-power transmission duration, T, are required for each tested mode of operation.

5.2 GHz Results

Radio Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11a	100	100	100	0.00
802.11n20	100	100	100	0.00
802.11ac20	100	100	100	0.00

5.8 GHz Results

Radio Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11a	100	100	100	0.00
802.11n20	100	100	100	0.00
802.11ac20	100	100	100	0.00

Note: Duty Cycle Correction Factor = 10*log(1/duty cycle)

Please refer to the following plots.

5.2 GHz

802.11a

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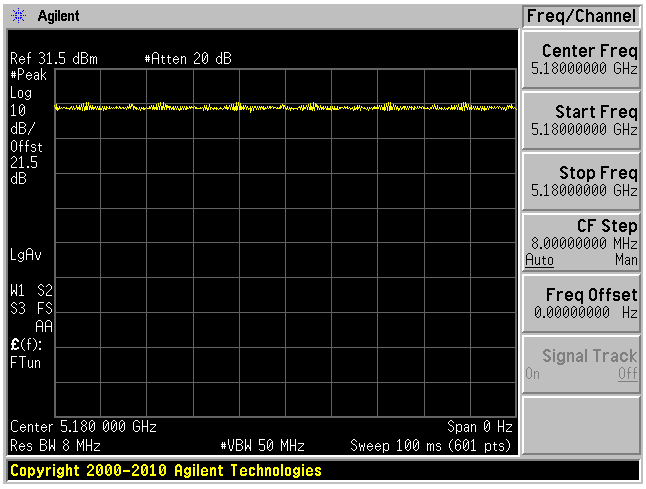

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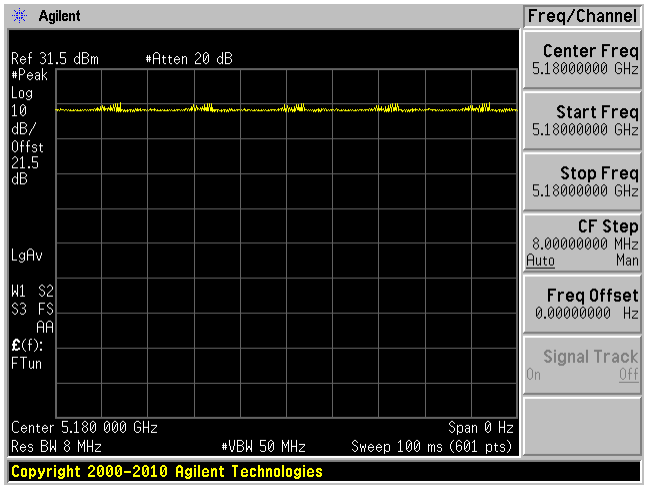

802.11n20

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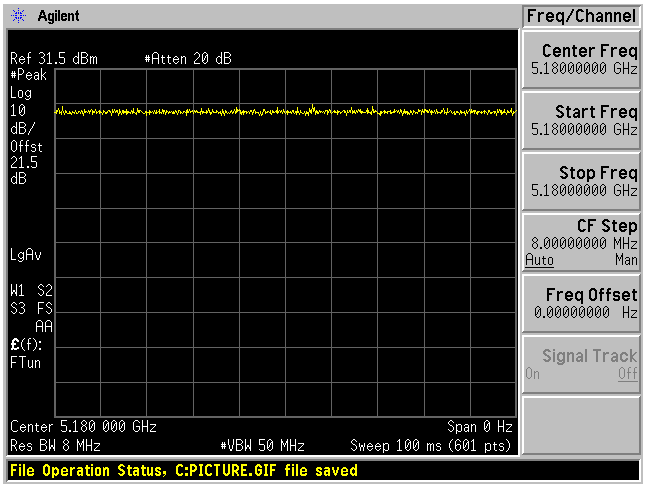

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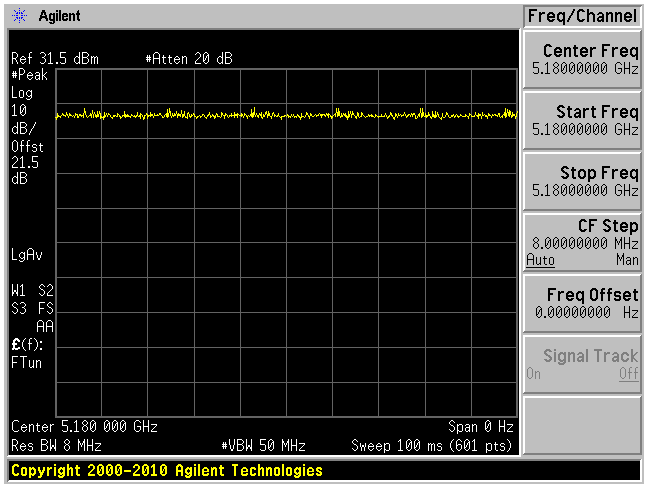

802.11ac20

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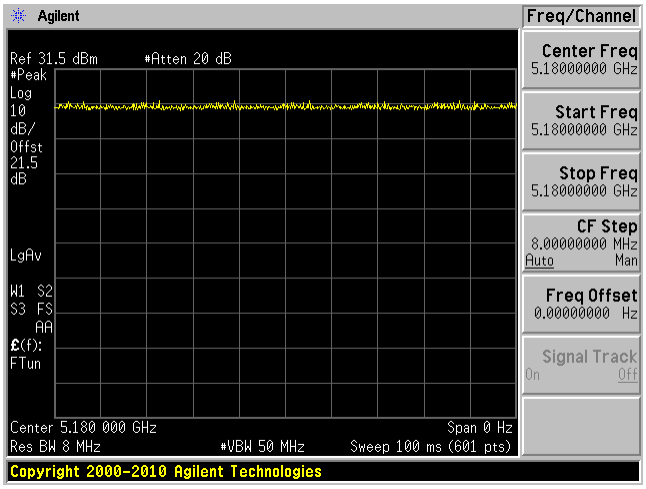

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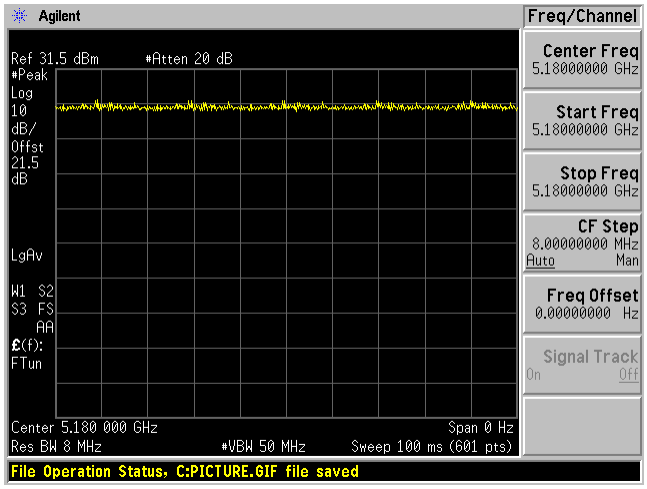

5.8 GHz

802.11a

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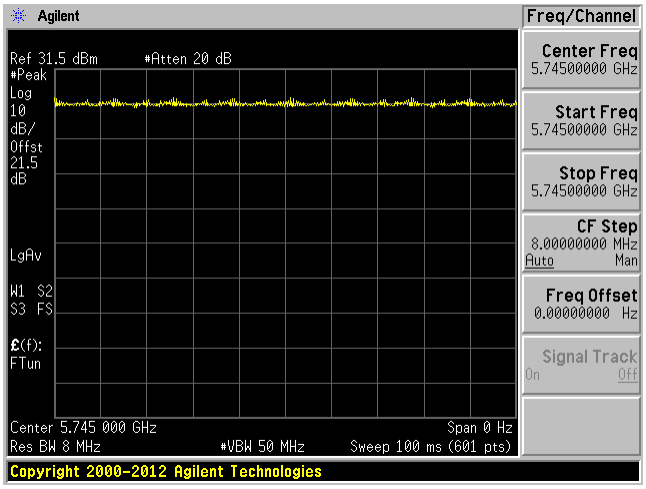

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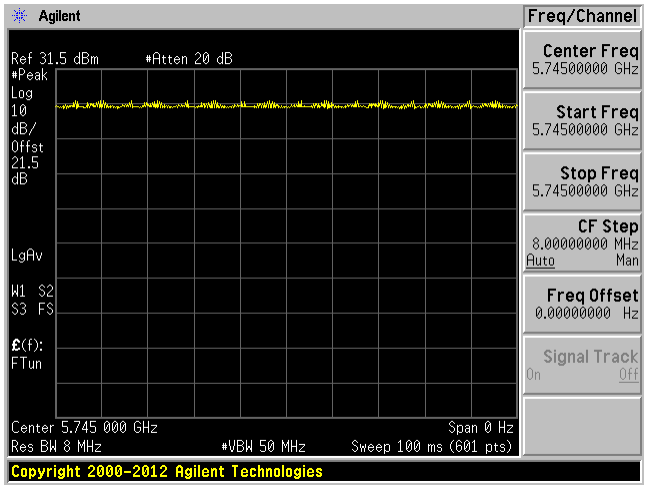
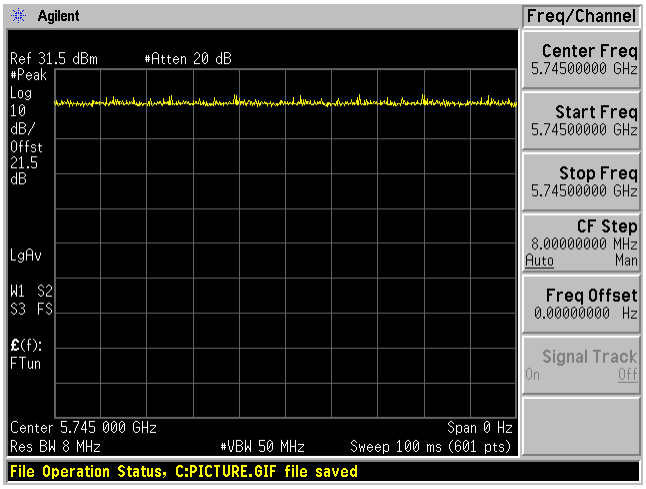


802.11n20

ANT1



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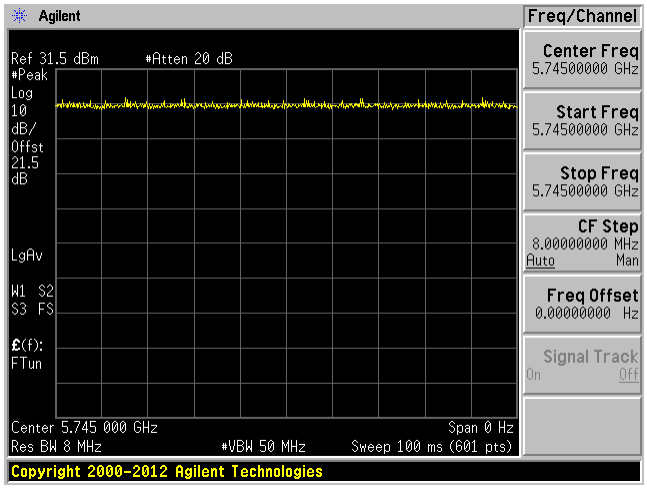

802.11ac20

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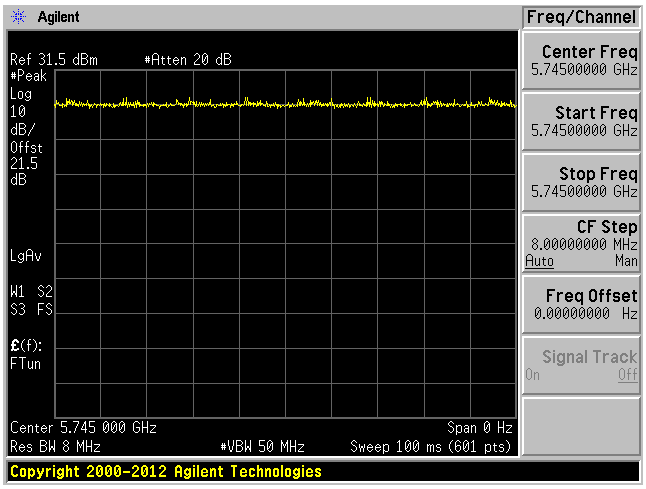

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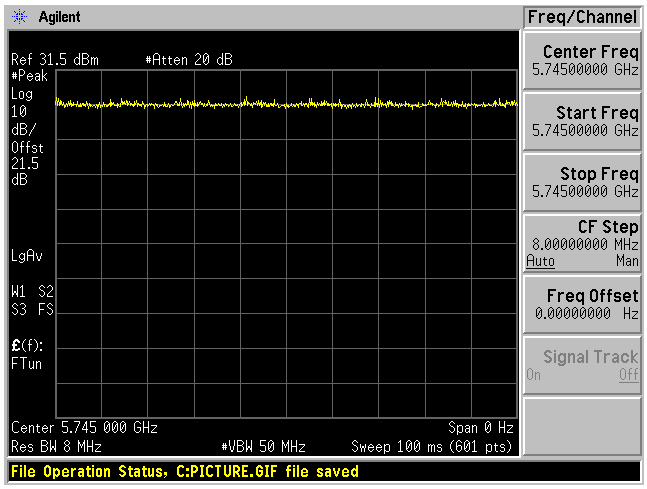


2.4 Equipment Modifications

N/A

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

FCC Rules	Description of Test	Result
§2.1091, §15.407(f),	RF Exposure	Compliant
§15.203	Antenna Requirement	Compliant
§15.207	AC Power Line Conducted Emissions	Compliant
§2.1053, §15.205, §15.209, 15.407(b)	Spurious Radiated Emissions	Compliant
§15.407(e)	Emission Bandwidth	Compliant
§407(a)	Output Power	Compliant
§2.1051, §15.407(b)	Band Edges	Compliant
§15.407(a)	Power Spectral Density	Compliant
§2.1051, §15.407(b)	Spurious Emissions at Antenna Terminals	Compliant

4 FCC §2.1091 & §15.407(f) - RF Exposure

4.1 Applicable Standards

According to FCC §15.407(f) 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

4.2 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

4.3 MPE Results

5 GHz Wi-Fi

Maximum output power at antenna input terminal (dBm):	19.04
Maximum output power at antenna input terminal (mW):	80.16781
Prediction distance (cm):	20
Prediction frequency (MHz):	5825
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):	0.0200785
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 0.0200785 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 5 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							
5 GHz WiFi	19.04	20	0.0200785	1.0	2.00785%	2.49285%	100%
2.4 GHz Classic Bluetooth	12.87	20	0.0048500	1.0	0.485%		

5 FCC §15.203 - Antenna Requirements

5.1 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 §15.407 (a) (ii), 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.

5.2 Antenna List

The antennas used by the EUT are permanent attached antennas.

Antenna usage	Band of Operation (GHz)	Maximum Antenna Gain (dBi)
Wi-Fi and Bluetooth	2400-2483.5	1.0
Wi-Fi	5000-6000	1.0

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:

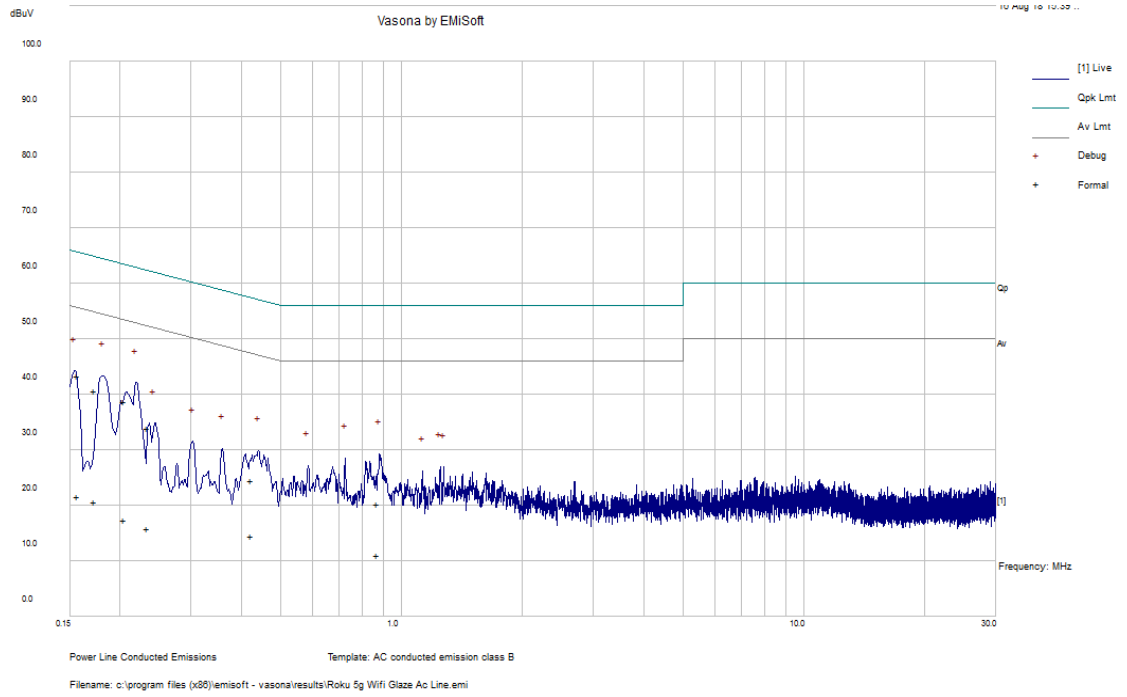
Colocation 5 GHz Wi-Fi and 2.4 GHz Classic Bluetooth

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-22.15	0.156647	Line	0.15-30

6.8 Conducted Emissions Test Plots and Data

Worst Case Colocation, 5 GHz Wi-Fi a mode (5745 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)

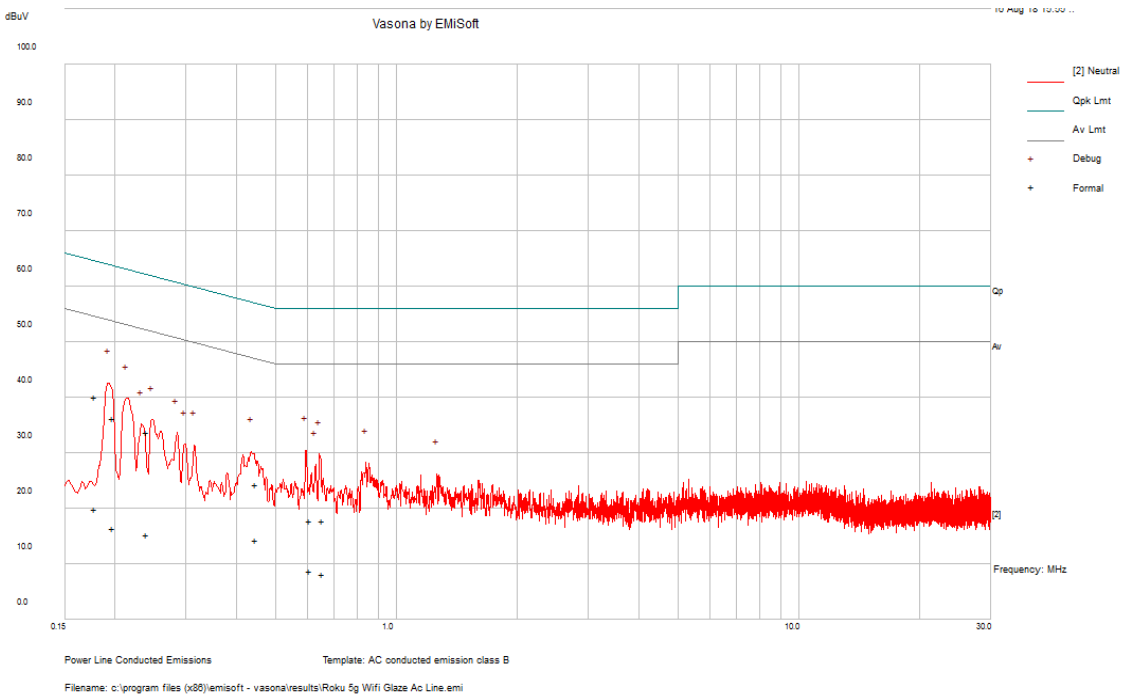
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.204156	38.77	Line	63.44	-24.67	QP
0.172498	40.61	Line	64.84	-24.23	QP
0.156647	**43.48**	**Line**	**65.64**	**-22.15**	**QP**
0.869306	20.38	Line	56	-35.62	QP
0.423306	24.47	Line	57.38	-32.91	QP
0.234527	34.03	Line	62.29	-28.26	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.204156	17.38	Line	53.44	-36.06	Ave.
0.172498	20.65	Line	54.84	-34.19	Ave.
0.156647	21.73	Line	55.64	-33.91	Ave.
0.869306	11.17	Line	46	-34.83	Ave.
0.423306	14.53	Line	47.38	-32.85	Ave.
0.234527	15.9	Line	52.29	-36.39	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.177751	40.11	Neutral	64.59	-24.48	QP
0.197731	36.26	Neutral	63.71	-27.45	QP
0.607633	17.81	Neutral	56	-38.19	QP
0.23968	33.72	Neutral	62.11	-28.39	QP
0.656226	17.83	Neutral	56	-38.17	QP
0.448328	24.28	Neutral	56.91	-32.63	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.177751	19.96	Neutral	54.59	-34.63	Ave.
0.197731	16.41	Neutral	53.71	-37.3	Ave.
0.607633	8.74	Neutral	46	-37.26	Ave.
0.23968	15.28	Neutral	52.11	-36.83	Ave.
0.656226	8.18	Neutral	46	-37.82	Ave.
0.448328	14.42	Neutral	46.91	-32.49	Ave.

7 FCC §15.209 & §15.407(b) - Spurious Radiated Emissions

7.1 Applicable Standard

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

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

As per FCC §15.209: 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 Note 1	3
88 - 216	150 Note 1	3
216 - 960	200 Note 1	3
Above 960	500	3

Note 1: 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 Part 15.407 (b)

(1) For transmitters operating in the 5.15-5.25 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(2) For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(3) For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(4) For transmitters operating in the 5.725-5.85 GHz band:

(i) All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

(ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease before March 2, 2020.

(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

(7) The provisions of §15.205 apply to intentional radiators operating under this section.

(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

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 15.407 limits.

The spacing between the peripherals was 10 centimeters.

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

7.3 Test Procedure

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

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

The EUT is set 3 meter away from the testing antenna, which is varied from 1-4 meter, and the EUT is placed on a turntable, which is 0.8 meter or 1.5 meter above ground plane, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna should be changed the polarization both of horizontal and vertical.

The spectrum analyzer or receiver is set as:

Below 1000 MHz:

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

Above 1000 MHz:

(1) Peak: RBW = 1MHz / VBW = 3MHz / Sweep = 100 ms
(2) Average: RBW = 1MHz / VBW = 1 / T or 10 Hz / 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 for Class A. 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
Wisewave	Antenna, Horn	ARH-4223-02	10555-01	2018-02-14	2 years
Agilent	Amplifier, Pre	8447D	2944A10187	2018-04-02	1 year
IW	AOBOR Hi frequency Co AX Cable	DC 1531	KPS-1501A3960K PS	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

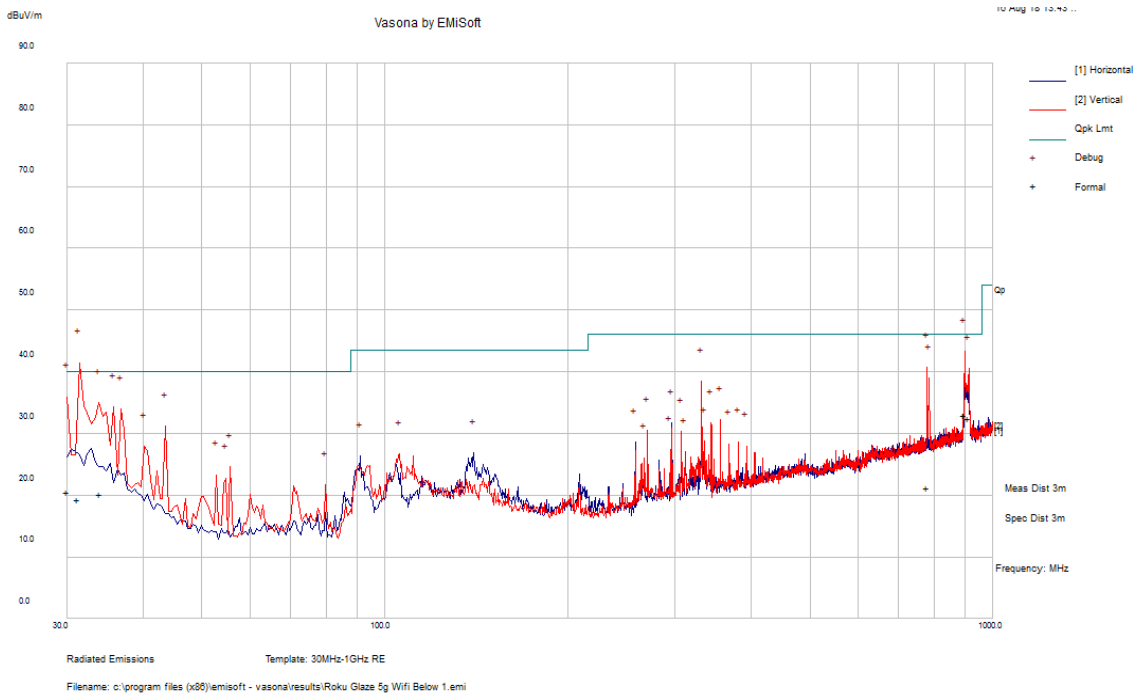
According to the data hereinafter, the EUT complied with the FCC Part 15.407 standards' radiated emissions limits, and had the worst margin of:

Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Mode, Channel**
-0.26	10400	Horizontal	n20 mode, 5200 MHz

7.8 Radiated Emissions Test Result Data

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

Worst Case Colocation, 5 GHz Wi-Fi a mode (5745 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
31.22575	19.32	162	V	173	40	-20.68	QP
898.5675	33.09	161	V	0	46	-12.91	QP
30	20.5	181	V	15	40	-19.5	QP
34.0435	20.28	127	V	127	40	-19.72	QP
779.4028	21.16	280	V	131	46	-24.84	QP
913.3198	32.56	105	V	45	46	-13.44	QP

2) 1–40 GHz

5150 - 5250 MHz

802.11a mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5180 MHz											
5180	64.95	263	295	H	33.59	8.53	0.00	107.07	-	-	PK
5180	57.77	263	295	H	33.59	8.53	0.00	99.89	-	-	AV
5180	61.47	70	181	V	33.59	8.53	0.00	103.59	-	-	PK
5180	54.18	70	181	V	33.59	8.53	0.00	96.30	-	-	AV
5150	50.07	263	295	H	33.53	9.71	33.15	60.15	74.00	-13.8	PK
5150	38.29	263	295	H	33.53	9.71	33.15	48.37	54.00	-5.63	AV
5150	46.58	70	181	V	33.53	9.71	33.15	56.66	74.00	-17.3	PK
5150	36.17	70	181	V	33.53	9.71	33.15	46.25	54.00	-7.75	AV
10360	45.76	23	295	H	38.15	14.55	32.88	65.58	74.00	-8.42	PK
10360	33.61	23	295	H	38.15	14.55	32.88	53.43	54.00	-0.57	AV
Middle Channel 5200 MHz											
5200	65.01	262	252	H	33.59	8.53	0.00	107.13	-	-	PK
5200	57.91	262	252	H	33.59	8.53	0.00	100.03	-	-	AV
5200	62.60	78	207	V	33.59	8.53	0.00	104.72	-	-	PK
5200	54.54	78	207	V	33.59	8.53	0.00	96.66	-	-	AV
10400	46.30	9	295	H	38.20	14.55	32.88	66.17	74.00	-7.83	PK
10400	33.83	9	295	H	38.20	14.55	32.88	53.70	54.00	-0.30	AV
High Channel 5240 MHz											
5240	64.20	265	291	H	33.62	8.53	0.00	106.35	-	-	PK
5240	56.54	265	291	H	33.62	8.53	0.00	98.69	-	-	AV
5240	61.94	74	257	V	33.62	8.53	0.00	104.09	-	-	PK
5240	54.04	74	257	V	33.62	8.53	0.00	96.19	-	-	AV
5350	45.57	265	291	H	33.76	9.81	33.22	55.91	74.00	-18.1	PK
5350	33.83	265	291	H	33.76	9.81	33.22	44.17	54.00	-9.83	AV
5350	45.33	74	257	V	33.76	9.81	33.22	55.67	74.00	-18.3	PK
5350	33.60	74	257	V	33.76	9.81	33.22	43.94	54.00	-10.0	AV
10480	45.54	5	292	H	38.26	14.59	32.88	65.51	74.00	-8.49	PK
10480	33.43	5	292	H	38.26	14.59	32.88	53.40	54.00	-0.60	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 (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5180 MHz											
5180	63.85	263	277	H	33.59	8.53	0.00	105.97	-	-	PK
5180	56.01	263	277	H	33.59	8.53	0.00	98.13	-	-	AV
5180	60.27	342	300	V	33.59	8.53	0.00	102.39	-	-	PK
5180	52.68	342	300	V	33.59	8.53	0.00	94.80	-	-	AV
5150	46.69	263	277	H	33.53	9.71	33.15	56.77	74.00	-17.2	PK
5150	34.40	263	277	H	33.53	9.71	33.15	44.48	54.00	-9.52	AV
5150	45.69	342	300	V	33.53	9.71	33.15	55.77	74.00	-18.2	PK
5150	34.12	342	300	V	33.53	9.71	33.15	44.20	54.00	-9.80	AV
10360	45.57	7	297	H	38.15	14.55	32.88	65.39	74.00	-8.61	PK
10360	33.74	7	297	H	38.15	14.55	32.88	53.56	54.00	-0.44	AV
Middle Channel 5200 MHz											
5200	63.98	261	300	H	33.59	8.53	0.00	106.10	-	-	PK
5200	56.43	261	300	H	33.59	8.53	0.00	98.55	-	-	AV
5200	60.56	343	267	V	33.59	8.53	0.00	102.68	-	-	PK
5200	53.03	343	267	V	33.59	8.53	0.00	95.15	-	-	AV
10400	45.94	6	296	H	38.20	14.55	32.88	65.81	74.00	-8.19	PK
10400	33.87	6	296	H	38.20	14.55	32.88	53.74	54.00	-0.26	AV
High Channel 5240 MHz											
5240	63.38	265	291	H	33.62	8.53	0.00	105.53	-	-	PK
5240	55.59	265	291	H	33.62	8.53	0.00	97.74	-	-	AV
5240	58.58	337	282	V	33.62	8.53	0.00	100.73	-	-	PK
5240	51.09	337	282	V	33.62	8.53	0.00	93.24	-	-	AV
5350	45.36	265	291	H	33.76	9.81	33.22	55.70	74.00	-18.3	PK
5350	33.69	265	291	H	33.76	9.81	33.22	44.03	54.00	-9.97	AV
5350	45.23	337	282	V	33.76	9.81	33.22	55.57	74.00	-18.4	PK
5350	33.61	337	282	V	33.76	9.81	33.22	43.95	54.00	-10.0	AV
10480	45.76	9	295	H	38.26	14.59	32.88	65.73	74.00	-8.27	PK
10480	33.71	9	295	H	38.26	14.59	32.88	53.68	54.00	-0.32	AV

802.11ac20 mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5180 MHz											
5180	64.87	20	217	H	33.59	8.53	0.00	106.99	-	-	PK
5180	56.89	20	217	H	33.59	8.53	0.00	99.01	-	-	AV
5180	60.10	69	279	V	33.59	8.53	0.00	102.22	-	-	PK
5180	51.73	69	279	V	33.59	8.53	0.00	93.85	-	-	AV
5150	48.81	20	217	H	33.53	9.71	33.15	58.89	74.00	-15.1	PK
5150	35.24	20	217	H	33.53	9.71	33.15	45.32	54.00	-8.68	AV
5150	44.95	69	279	V	33.53	9.71	33.15	55.03	74.00	-18.9	PK
5150	33.61	69	279	V	33.53	9.71	33.15	43.69	54.00	-10.3	AV
10360	45.78	4	297	H	38.15	14.55	32.88	65.60	74.00	-8.40	PK
10360	33.36	4	297	H	38.15	14.55	32.88	53.18	54.00	-0.82	AV
Middle Channel 5200 MHz											
5200	64.57	22	187	H	33.59	8.53	0.00	106.69	-	-	PK
5200	57.09	22	187	H	33.59	8.53	0.00	99.21	-	-	AV
5200	60.02	74	286	V	33.59	8.53	0.00	102.14	-	-	PK
5200	52.32	74	286	V	33.59	8.53	0.00	94.44	-	-	AV
10400	46.16	4	296	H	38.20	14.55	32.88	66.03	74.00	-7.97	PK
10400	33.44	4	296	H	38.20	14.55	32.88	53.31	54.00	-0.69	AV
High Channel 5240 MHz											
5240	64.46	24	300	H	33.62	8.53	0.00	106.61	-	-	PK
5240	56.89	24	300	H	33.62	8.53	0.00	99.04	-	-	AV
5240	59.79	75	282	V	33.62	8.53	0.00	101.94	-	-	PK
5240	52.10	75	282	V	33.62	8.53	0.00	94.25	-	-	AV
5350	45.33	24	300	H	33.76	9.81	33.22	55.67	74.00	-18.3	PK
5350	33.62	24	300	H	33.76	9.81	33.22	43.96	54.00	-10.0	AV
5350	45.25	75	282	V	33.76	9.81	33.22	55.59	74.00	-18.4	PK
5350	33.59	75	282	V	33.76	9.81	33.22	43.93	54.00	-10.1	AV
10480	45.48	4	297	H	38.26	14.59	32.88	65.45	74.00	-8.55	PK
10480	33.11	4	297	H	38.26	14.59	32.88	53.08	54.00	-0.92	AV

5725 - 5850 MHz

802.11a mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5745 MHz											
5745	65.80	122	279	H	34.07	9.00	0.00	108.87	-	-	PK
5745	58.12	122	279	H	34.07	9.00	0.00	101.19	-	-	AV
5745	62.49	89	120	V	34.07	9.00	0.00	105.56	-	-	PK
5745	54.97	89	120	V	34.07	9.00	0.00	98.04	-	-	AV
5725	62.96	122	279	H	34.02	10.22	33.22	73.99	122.00	-48.0	PK
5725	61.49	89	120	V	34.02	10.22	33.22	72.52	122.00	-49.4	PK
5720	53.52	122	279	H	34.02	10.22	33.22	64.55	110.90	-46.3	PK
5720	52.46	89	120	V	34.02	10.22	33.22	63.49	110.90	-47.4	PK
5700	45.17	122	279	H	34.02	10.22	33.22	56.20	68.26	-12.0	PK
5700	45.09	89	120	V	34.02	10.22	33.22	56.12	68.26	-12.1	PK
11490	43.55	0	100	H	38.45	15.68	32.75	64.93	74.00	-9.08	PK
11490	31.09	0	100	H	38.45	15.68	32.75	52.47	54.00	-1.54	AV
Middle Channel 5785 MHz											
5785	63.55	125	276	H	34.17	9.10	0.00	106.82	-	-	PK
5785	55.78	125	276	H	34.17	9.10	0.00	99.05	-	-	AV
5785	61.89	90	116	V	34.17	9.10	0.00	105.16	-	-	PK
5785	54.58	90	116	V	34.17	9.10	0.00	97.85	-	-	AV
11570	43.37	0	100	H	38.46	15.69	32.75	64.77	74.00	-9.23	PK
11570	30.98	0	100	H	38.46	15.69	32.75	52.38	54.00	-1.62	AV
High Channel 5825 MHz											
5825	61.77	102	208	H	34.24	9.10	0.00	105.11	-	-	PK
5825	54.42	102	208	H	34.24	9.10	0.00	97.76	-	-	AV
5825	59.43	97	174	V	34.24	9.10	0.00	102.77	-	-	PK
5825	52.10	97	174	V	34.24	9.10	0.00	95.44	-	-	AV
5850	50.60	102	208	H	34.24	10.36	33.22	61.98	68.26	-6.29	PK
5850	49.47	97	174	V	34.24	10.36	33.22	60.85	68.26	-7.42	PK
11650	42.95	0	100	H	38.60	15.69	32.75	64.49	74.00	-9.51	PK
11650	31.08	0	100	H	38.60	15.69	32.75	52.62	54.00	-1.38	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 (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5745 MHz											
5745	63.28	268	197	H	34.07	9.00	0.00	106.35	-	-	PK
5745	55.87	268	197	H	34.07	9.00	0.00	98.94	-	-	AV
5745	62.94	156	269	V	34.07	9.00	0.00	106.01	-	-	PK
5745	55.31	156	269	V	34.07	9.00	0.00	98.38	-	-	AV
5725	68.42	268	197	H	34.02	10.22	33.22	79.45	122.00	-42.5	PK
5725	67.44	156	269	V	34.02	10.22	33.22	78.47	122.00	-43.5	PK
5720	54.06	268	197	H	34.02	10.22	33.22	65.09	110.90	-45.8	PK
5720	53.26	156	269	V	34.02	10.22	33.22	64.29	110.90	-46.6	PK
5700	46.88	268	197	H	34.02	10.22	33.22	57.91	68.26	-10.3	PK
5700	46.05	156	269	V	34.02	10.22	33.22	57.08	68.26	-11.2	PK
11490	43.59	0	100	H	38.45	15.68	32.75	64.97	74.00	-9.04	PK
11490	31.12	0	100	H	38.45	15.68	32.75	52.50	54.00	-1.51	AV
Middle Channel 5785 MHz											
5785	62.29	267	182	H	34.17	9.10	0.00	105.56	-	-	PK
5785	54.33	267	182	H	34.17	9.10	0.00	97.60	-	-	AV
5785	61.53	155	266	V	34.17	9.10	0.00	104.80	-	-	PK
5785	53.97	155	266	V	34.17	9.10	0.00	97.24	-	-	AV
11570	43.31	0	100	H	38.46	15.69	32.75	64.71	74.00	-9.29	PK
11570	30.96	0	100	H	38.46	15.69	32.75	52.36	54.00	-1.64	AV
High Channel 5825 MHz											
5825	61.14	266	176	H	34.24	9.10	0.00	104.48	-	-	PK
5825	53.42	266	176	H	34.24	9.10	0.00	96.76	-	-	AV
5825	60.60	153	261	V	34.24	9.10	0.00	103.94	-	-	PK
5825	52.66	153	261	V	34.24	9.10	0.00	96.00	-	-	AV
5850	50.12	266	176	H	34.24	10.36	33.22	61.50	68.26	-6.77	PK
5850	49.33	153	261	V	34.24	10.36	33.22	60.71	68.26	-7.56	PK
11650	42.75	0	100	H	38.60	15.69	32.75	64.29	74.00	-9.71	PK
11650	31.05	0	100	H	38.60	15.69	32.75	52.59	54.00	-1.41	AV

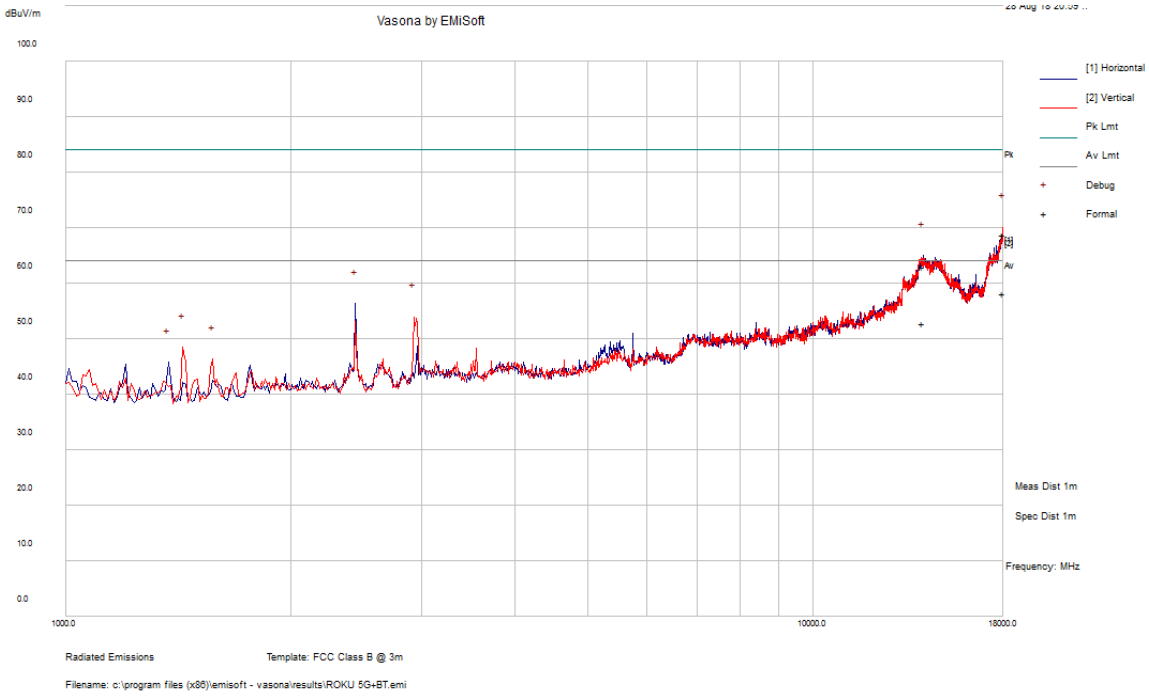
802.11ac20 mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5745 MHz											
5745	64.38	122	278	H	34.07	9.00	0.00	107.45	-	-	PK
5745	56.92	122	278	H	34.07	9.00	0.00	99.99	-	-	AV
5745	61.56	89	124	V	34.07	9.00	0.00	104.63	-	-	PK
5745	53.48	89	124	V	34.07	9.00	0.00	96.55	-	-	AV
5725	66.90	122	278	H	34.02	10.22	33.22	77.93	122.00	-44.1	PK
5725	65.12	89	124	V	34.02	10.22	33.22	76.15	122.00	-45.8	PK
5720	53.33	122	278	H	34.02	10.22	33.22	64.36	110.90	-46.5	PK
5720	52.56	89	124	V	34.02	10.22	33.22	63.59	110.90	-47.3	PK
5700	45.91	122	278	H	34.02	10.22	33.22	56.94	68.26	-11.3	PK
5700	45.69	89	124	V	34.02	10.22	33.22	56.72	68.26	-11.5	PK
11490	43.51	0	100	H	38.45	15.68	32.75	64.89	74.00	-9.12	PK
11490	31.43	0	100	H	38.45	15.68	32.75	52.81	54.00	-1.19	AV
Middle Channel 5785 MHz											
5785	62.35	262	209	H	34.17	9.10	0.00	105.62	-	-	PK
5785	54.68	262	209	H	34.17	9.10	0.00	97.95	-	-	AV
5785	62.07	153	266	V	34.17	9.10	0.00	105.34	-	-	PK
5785	54.30	153	266	V	34.17	9.10	0.00	97.57	-	-	AV
11570	43.35	0	100	H	38.46	15.69	32.75	64.75	74.00	-9.25	PK
11570	31.04	0	100	H	38.46	15.69	32.75	52.44	54.00	-1.56	AV
High Channel 5825 MHz											
5825	60.40	266	177	H	34.24	9.10	0.00	103.74	-	-	PK
5825	52.87	266	177	H	34.24	9.10	0.00	96.21	-	-	AV
5825	59.84	99	178	V	34.24	9.10	0.00	103.18	-	-	PK
5825	51.77	99	178	V	34.24	9.10	0.00	95.11	-	-	AV
5850	48.66	266	177	H	34.24	10.36	33.22	60.04	68.26	-8.23	PK
5850	47.73	99	178	V	34.24	10.36	33.22	59.11	68.26	-9.16	PK
11650	42.81	0	100	H	38.60	15.69	32.75	64.35	74.00	-9.65	PK
11650	31.14	0	100	H	38.60	15.69	32.75	52.68	54.00	-1.32	AV

Note 1: Any emissions above 12 GHz are emissions from the noise floor.
Note 2: The worst-case modulations were used to show compliance.

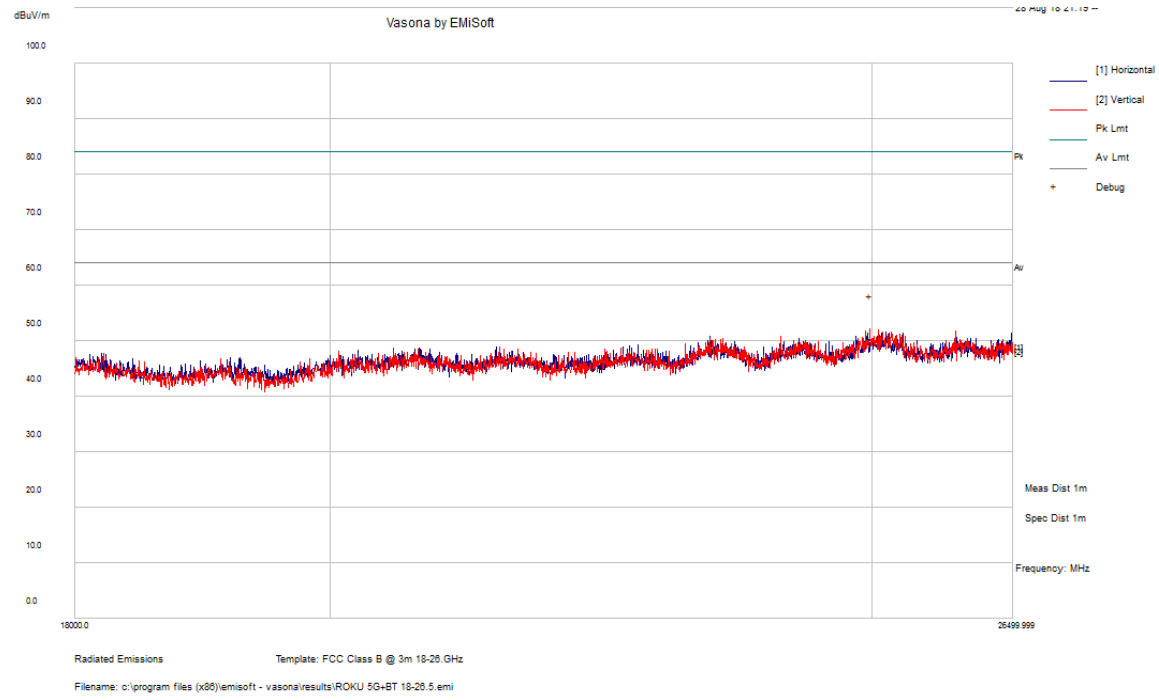
1-18 GHz

Worst Case Colocation, 5 GHz Wi-Fi a mode (5745 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)

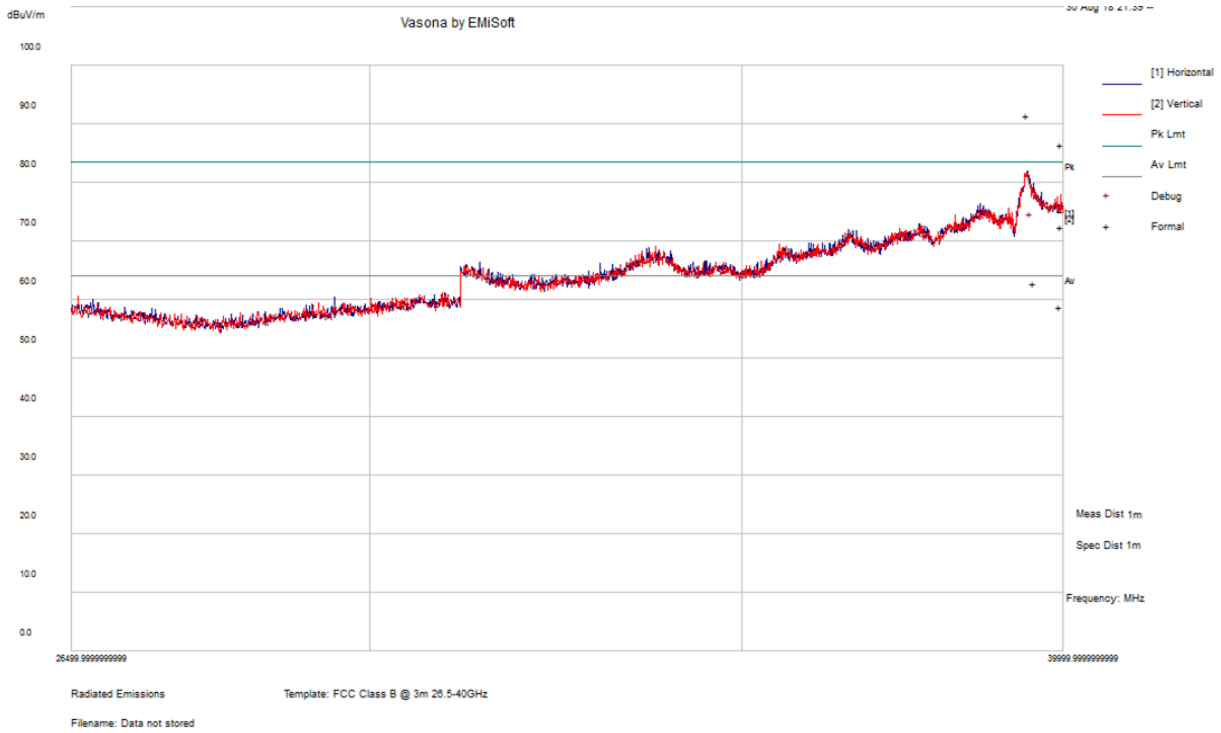


18-26.5 GHz

Worst Case Colocation, 5 GHz Wi-Fi a mode (5745 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)



Worst Case Colocation, 5 GHz Wi-Fi a mode (5745 MHz) and 2.4 GHz Classic Bluetooth 8DPSK (2441 MHz)



8 FCC §15.407(e) - 6 dB, 26 dB & 99% Occupied Bandwidth

8.1 Applicable Standards

As per FCC §15.407(e): for equipment operating in the band 5725 – 5850 MHz, the minimum 6 dB bandwidth of U-NII devices shall be 500 kHz.

8.2 Measurement Procedure

The measurements are based on FCC KDB 789033 D02 General U-NII Test Procedures New Rules v02r01: C. Bandwidth Measurement.

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
-	RF cable	-	-	Each time[1]	N/A
-	20dB attenuator	-	-	Each time[1]	N/A

Note1: cable and attenuator 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:	22-24 ºC
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Vincent Licata on 2018-08-14 in RF site.

8.5 Test Results

Please refer to the following table

5150 - 5250 MHz

Ant 1

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
36	5180	16.2235	23.801
40	5200	16.2119	25.874
48	5240	16.1089	21.086
802.11n20 mode			
36	5180	17.2334	21.627
40	5200	17.1841	21.223
48	5240	17.1487	20.220
802.11ac20 mode			
36	5180	17.4510	29.114
40	5200	17.4054	28.399
48	5240	17.2654	24.116

Ant 2

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
36	5180	16.1145	21.144
40	5200	16.1333	19.178
48	5240	16.1366	20.104
802.11n20 mode			
36	5180	17.1006	19.809
40	5200	17.1262	20.139
48	5240	17.1153	19.724
802.11ac20 mode			
36	5180	17.2253	21.272
40	5200	17.2322	21.222
48	5240	17.2269	20.801

5725 - 5850 MHz

Ant 1

Channel	Frequency (MHz)	99% OBW (MHz)	6 dB OBW (MHz)	6 dB OBW limit (kHz)
802.11a mode				
149	5745	16.3841	15.352	≥500
157	5785	16.3542	15.341	≥500
165	5825	16.3667	15.347	≥500
802.11n20 mode				
149	5745	17.4593	15.723	≥500
157	5785	17.4408	16.191	≥500
165	5825	17.4677	15.740	≥500
802.11ac20 mode				
149	5745	17.4840	15.631	≥500
157	5785	17.4602	16.062	≥500
165	5825	17.4744	15.676	≥500

Ant 2

Channel	Frequency (MHz)	99% OBW (MHz)	6 dB OBW (MHz)	6 dB OBW limit (kHz)
802.11a mode				
149	5745	16.4096	15.696	≥500
157	5785	16.4906	15.681	≥500
165	5825	16.5017	15.684	≥500
802.11n20 mode				
149	5745	17.5111	16.540	≥500
157	5785	17.5687	16.527	≥500
165	5825	17.5701	16.222	≥500
802.11ac20 mode				
149	5745	17.5226	16.527	≥500
157	5785	17.5974	16.526	≥500
165	5825	17.6052	16.565	≥500

Please refer to Annex E for plots.

9 FCC §15.407(a) - Output Power

9.1 Applicable Standards

According to FCC §15.407(a):

For client devices in the 5.15-5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

9.2 Measurement Procedure

The measurements are based on FCC KDB 789033 D02 General U-NII Test Procedures New Rules v02r01: E. Maximum Conducted Output Power.

9.3 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
-	20dB attenuator	-	-	Each time[1]	N/A

Note1: cable and attenuator 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 on 2018-08-14 in RF site.

9.5 Test Results

5150 - 5250 MHz

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total (dBm)	Limit (dBm)
		ANT 1	ANT 2		
802.11a mode					
Low	5180	14.53	13.71	17.15	24.00
Middle	5200	14.39	13.66	17.05	24.00
High	5240	14.06	13.71	16.90	24.00
802.11n20 mode					
Low	5180	12.69	11.47	15.13	24.00
Middle	5200	12.49	11.33	14.96	24.00
High	5240	12.2	11.32	14.79	24.00
802.11ac20 mode					
Low	5180	14.78	13.89	17.37	24.00
Middle	5200	14.54	13.79	17.19	24.00
High	5240	14.34	13.77	17.07	24.00

5745 - 5825 MHz

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total (dBm)	Limit (dBm)
		ANT 1	ANT 2		
802.11a mode					
Low	5745	15.83	15.47	18.66	30
Middle	5785	16.23	15.74	19.00	30
High	5825	16.47	15.53	19.04	30
802.11n20 mode					
Low	5745	15.33	15.38	18.37	30
Middle	5785	15.9	15.61	18.77	30
High	5825	16.36	15.33	18.89	30
802.11ac20 mode					
Low	5745	15.4	15.33	18.38	30
Middle	5785	15.87	15.61	18.75	30
High	5825	16.23	15.4	18.85	30

Please refer to Annex I for plots of results.

10 FCC §15.407(a) - Power Spectral Density

10.1 Applicable Standards

According to FCC §15.407(a):

For client devices in the 5.15-5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

10.2 Measurement Procedure

The measurements are based on FCC KDB 789033 D02 General U-NII Test Procedures New Rules v02r01: F. Maximum Power Spectral Density (PSD).

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
-	20dB attenuator	-	-	Each time[1]	N/A

Note1: cable and attenuator 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:	22-24 ºC
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Vincent Licata on 2018-08-14 in RF site.

10.5 Test Results

5150 - 5250 MHz

Channel	Frequency (MHz)	PSD (dBm/MHz)		Total (dBm/MHz)	Limit (dBm/MHz)
		ANT 1	ANT 2		
802.11a mode					
Low	5180	4.154	3.151	6.69	11.00
Middle	5200	4.122	3.376	6.78	11.00
High	5240	3.649	3.358	6.52	11.00
802.11n20 mode					
Low	5180	2.055	0.827	4.49	11.00
Middle	5200	2.036	0.798	4.47	11.00
High	5240	1.892	0.892	4.43	11.00
802.11ac20 mode					
Low	5180	4.359	3.21	6.83	11.00
Middle	5200	4.194	3.007	6.65	11.00
High	5240	3.947	3.103	6.56	11.00

5745 - 5825 MHz

Channel	Frequency (MHz)	PSD (dBm/100 kHz)		Total PSD (dBm/100 kHz)	Corrected PSD Total (dBm/500 kHz)	Limit (dBm/500 kHz)
		ANT 1	ANT 2			
802.11a mode						
Low	5745	-3.587	-4.303	-0.92	6.07	30
Middle	5785	-3.186	-3.866	-0.50	6.49	30
High	5825	-3.173	-4.214	-0.65	6.34	30
802.11n20 mode						
Low	5745	-4.252	-4.369	-1.30	5.69	30
Middle	5785	-3.774	-3.916	-0.83	6.16	30
High	5825	-3.386	-4.41	-0.86	6.13	30
802.11ac20 mode						
Low	5745	-4.211	-4.475	-1.33	5.66	30
Middle	5785	-3.632	-4.107	-0.85	6.14	30
High	5825	-3.362	-4.209	-0.75	6.24	30

Note: For the 5725-5850 MHz band, the Corrected PSD (dBm/500 kHz) is equal to:
Correct PSD (dBm/500 kHz) = PSD (dBm/100 kHz) + Duty Cycle Correction (dB) + 10*log(500 kHz/100 kHz)

Please refer to Annex G for plots.

11 FCC §15.407(b) - Out of Band Emissions

11.1 Applicable Standards

According to FCC §15.407(b):

For transmitters operating in the 5.15-5.25 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.725-5.85 GHz band: All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

The provisions of §15.205 apply to intentional radiators operating under this section.

11.2 Measurement Procedure

Add a correction factor (antenna gain+ Attenuator loss+cable loss) to the offset of the spectrum analyzer.
Integration Method

1. For peak emissions measurements, follow the procedures described in section H)5), “Procedures for Peak Unwanted Emissions Measurements above 1000 MHz”, except for the following changes:

- Set RBW = 100 kHz
- Set VBW = 3RBW
- Perform a band-power integration across the 1 MHz bandwidth in which the band-edge emission level is to be measured. CAUTION: You must ensure that the spectrum analyzer or EMI receiver is set for peak-detection and max-hold for this measurement.

2. For average emissions measurements, follow the procedures described in section H)6), “Procedures for Average Unwanted Emissions Measurements above 1000 MHz”, except for the following changes:

- Set RBW = 100 kHz
- Set VBW = 3RBW
- Perform a band-power integration across the 1 MHz bandwidth in which the band-edge emission level is to be measured.

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
-	20dB attenuator	-	-	Each time[1]	N/A

Note1: cable and attenuator 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".*

11.4 Test Environmental Conditions

Temperature:	22-24 ºC
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Vincent Licata on 2018-08-14 in RF site.

11.5 Test Results

Compliant

Please refer to Annex H and F for plots.

12 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

13 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.

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