



FCC PART 15.407
ISEDC RSS-247, ISSUE 2, FEBRUARY 2017

TEST REPORT

For

Roku, Inc.

1155 Coleman Avenue, San Jose, CA 95110, USA

FCC ID: TC2-R1043
IC: 5959A-R1040

Table with report details: Report Type (Original Report), Product Type (9104X), Prepared By (Arturo Reyes), Report Number (R2304281-407), Report Date (2023-08-28), Reviewed By (Shawn Mcmillen), and company contact information for Bay Area Compliance Laboratories Corp.



Note: This test report is prepared for the customer shown above and for the device described herein. It may not be duplicated or used in part without prior written consent from Bay Area Compliance Laboratories Corp. This report must not be used by the customer to claim product certification, approval, or endorsement by A2LA*, NIST, or any agency of the Federal Government.

* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "*" (see 2.1)

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2304281-407	Original Report	2023-08-28

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test report was prepared on behalf of *Roku, Inc.*, and their product model: 9104X, FCC ID: TC2-R1043, IC: 5959A-R1040, the “EUT” as referred to in this report. The EUT has 2.4 GHz/5 GHz Wi-Fi, Bluetooth Classic and Bluetooth Low Energy capabilities.

1.2 Objective

This report was prepared on behalf of *Roku, Inc.* in accordance with FCC CFR47 §15.407 and ISEDC RSS-247 Issue 2, February 2017.

The objective is to determine compliance with FCC Part 15.407 and ISEDC RSS-247 for RF Exposure, AC Line Conducted Emissions, Emission Bandwidth, Radiated & Conducted Spurious Emissions, 100 kHz Band Edges, Maximum Output Power, Power Spectral Density, DFS, Frequency Stability.

1.3 Related Submittal(s)/Grant(s)

Equipment Class: DSS, FCC ID: TC2-R1043, IC: 5959A-R1040
Equipment Class: DTS, FCC ID: TC2-R1043, IC: 5959A-R1040

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 ° 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 17025:2017 by A2LA (Test Laboratory Accreditation Certificate Number 3297.02), in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2017 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 17025:2017 Scope of Accreditation includes a comprehensive suite of EMC Emissions, EMC Immunity, Radio, RF Exposure, Safety and wireline Telecommunications test methods applicable to a wide range of product categories. These product categories include Central Office Telecommunications Equipment [including NEBS - Network Equipment Building Systems], Unlicensed and Licensed Wireless and RF devices, Information Technology Equipment (ITE); Telecommunications Terminal Equipment (TTE); Medical Electrical Equipment; Industrial, Scientific and Medical Test Equipment; Professional Audio and Video Equipment; Industrial and Scientific Instruments and Laboratory Apparatus; Cable Distribution Systems, and Energy Efficient Lighting.

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

- For the USA (Federal Communications Commission):

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

- For the Canada (Industry Canada):

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

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

- 1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
 2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2
- For the Hong Kong Special Administrative Region:
- 1 All Radio Equipment, per KHCA 10XX-series Specifications;
 - 2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
 - 3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.
- For Japan:
- 1 MIC Telecommunication Business Law (Terminal Equipment):
 - All Scope A1 - Terminal Equipment for the Purpose of Calls;
 - All Scope A2 - Other Terminal Equipment
 - 2 Radio Law (Radio Equipment):
 - All Scope B1 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 1 of the Radio Law
 - All Scope B2 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 2 of the Radio Law
 - All Scope B3 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 3 of the Radio Law

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

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

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

- Australia: ACMA (Australian Communication and Media Authority) – APEC Tel MRA -Phase I;

- Canada: (Innovation, Science and Economic development Canada - ISEDC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
 - o BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
 - o NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
 - o EMC Directive 2014/30/EU US-EU EMC & Telecom MRA CAB (NB)
 - o Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
 - o Low Voltage Directive (LVD) 2014/35/EU
- Hong Kong Special Administrative Region: (Office of the Telecommunications Authority – OFTA) APEC Tel MRA -Phase I & Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Media Development Authority - IMDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
 - o ENERGY STAR Recognized Test Laboratory – US EPA
 - o Telecommunications Certification Body (TCB) – US FCC;
 - o Nationally Recognized Test Laboratory (NRTL) – US OSHA

Vietnam: APEC Tel MRA -Phase I;

2 System Test Configuration

2.1 Justification

The EUT was configured for testing according to ANSI C63.10-2013 and FCC KDB 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.

2.2 EUT Exercise Software

The test utility used was the PuTTY, in conjunction with firmware provided by *Roku, Inc.* The software is compliant with the standard requirements being tested against.

UNII-1

Modulation	Frequency (MHz)	Power Setting	
		Ant. A	Ant. B
802.11a	5180	85	85
	5200	85	85
	5240	85	85
802.11n20	5180	63	63
	5200	63	63
	5240	63	63
802.11n40	5190	63	63
	5230	63	63
802.11ac80	5210	65	65

UNII-2A

Modulation	Frequency (MHz)	Power Setting	
		Ant. A	Ant. B
802.11a	5260	80	80
	5300	80	80
	5320	80	80
802.11n20	5260	78	78
	5300	78	78
	5320	78	78
802.11n40	5270	65	65
	5310	65	65
802.11ac80	5290	60	60

UNII-2C

Modulation	Frequency (MHz)	Power Setting	
		Ant. A	Ant. B
802.11a	5500	86	80
	5600	86	80
	5720	86	80
802.11n20	5500	78	70
	5600	78	70
	5720	78	70
802.11n40	5510	60	60
	5590	60	60
	5710	60	60
802.11ac80	5530	63	63
	5610	63	63
	5690	65	63

Note: 5600-5650 MHz range is not applicable for ISED.

UNII-3

Modulation	Frequency (MHz)	Power Setting	
		Ant. A	Ant. B
802.11a	5745	120	120
	5785	120	120
	5825	120	120
802.11n20	5745	120	120
	5785	120	120
	5825	120	120
802.11n40	5755	120	120
	5795	120	120
802.11ac80	5775	120	120

Data Rates Tested:

802.11a mode: 54Mbps

802.11n20 mode: HT-MCS0

802.11n40 mode: HT-MCS0

802.11ac80 mode: VT-MCS0

2.3 Duty Cycle Correction Factor

According to KDB 789033 D02 General U-NII Test Procedures New Rules v02r01 section B:

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).

Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11a	-	-	100	0
802.11n/ac20	-	-	100	0
802.11n/ac40	0.9083	1.117	81	0.90
802.11ac80	0.4333	0.7167	60	2.19

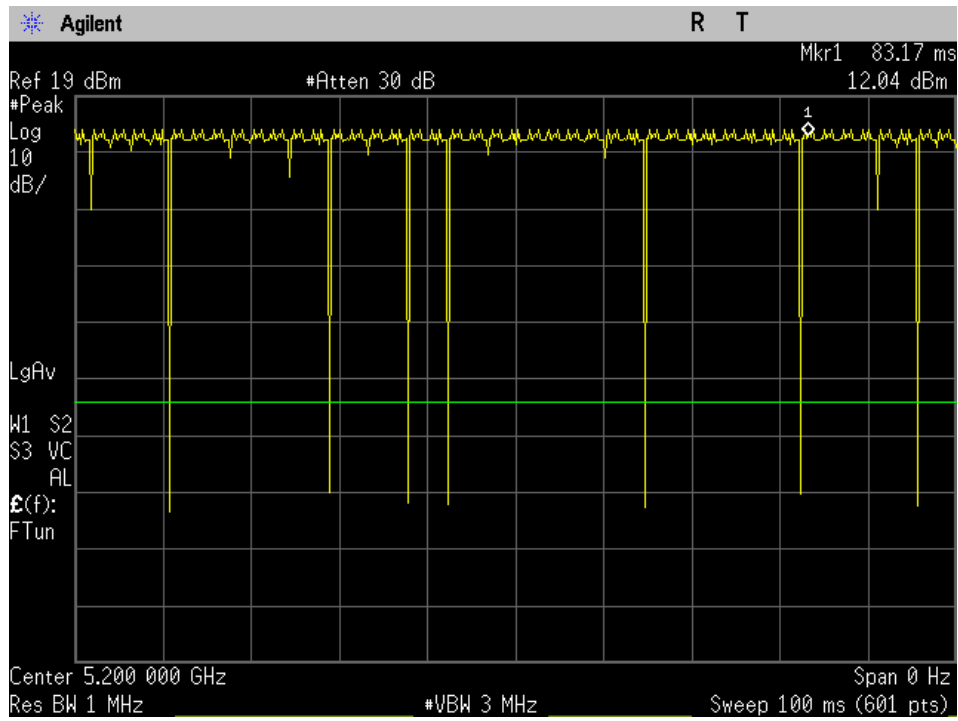
Duty Cycle = On Time (ms)/ Period (ms)

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

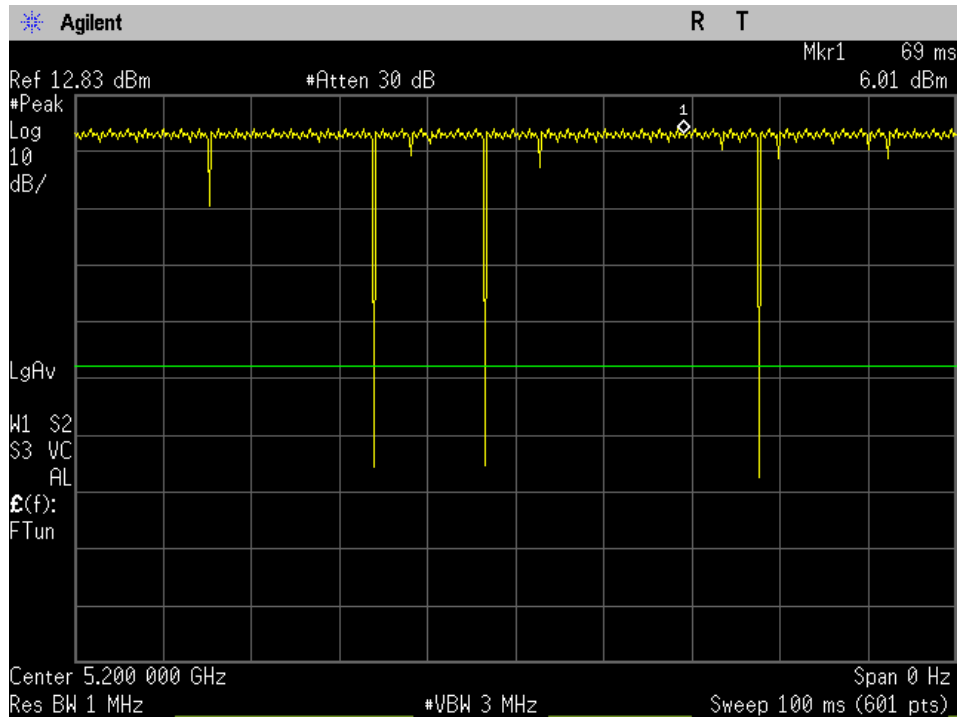
Note: Duty Cycle are identical in all UNII bands.

Please refer to the following plots.

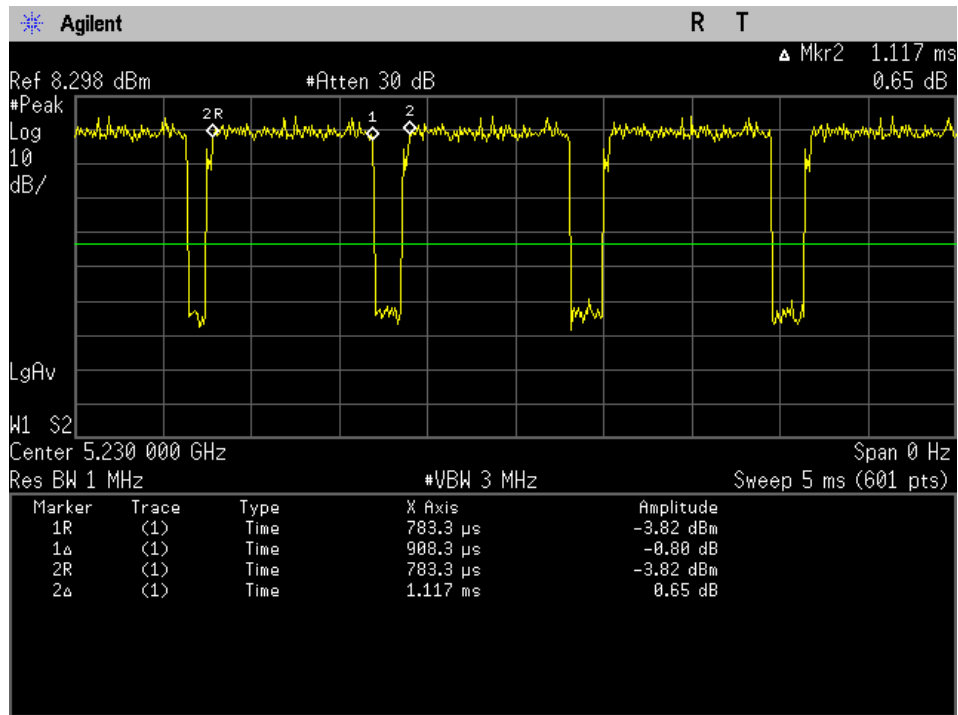
802.11a



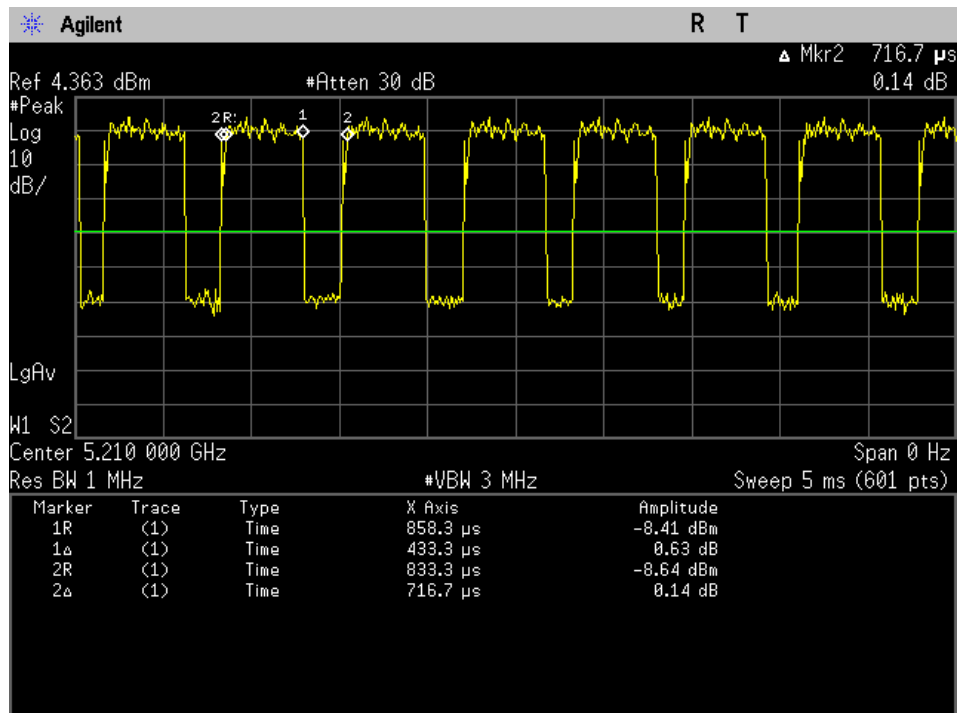
802.11n/ac20



802.11n/ac40



802.11ac80



2.4 EUT Exercise Software

The test utility used was the PuTTY, in conjunction with firmware provided by *Roku, Inc.* The software is compliant with the standard requirements being tested against.

2.5 Equipment Modification

None.

2.6 Local Support Equipment

Manufacturer	Description	Model
Dell	Laptop	Latitude E6410

2.7 Remote Support Equipment

Manufacturer	Description	Model
Roku, Inc.	Debug Board	-
Roku	AC/DC Power Adaptor	ADS-26FSG-12

2.8 Interface Ports and Cabling

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

3 Summary of Test Results

Results reported relate only to the product tested.

FCC & ISEDC Rules	Description of Test	Results
FCC §2.1091, §15.407(f) ISED RSS-102 §2.5	RF Exposure	Compliant
FCC §15.203 ISED RSS-GEN §6.8	Antenna Requirement	Compliant
FCC §15.207 ISED RSS-GEN §8.8	AC Power Line Conducted Emissions	Compliant
FCC §2.1053, §15.205, §15.209, 15.407(b) ISED RSS-247 §6.2	Spurious Radiated Emissions	Compliant
FCC §15.407(e) ISED RSS-247 §6.2	Emission Bandwidth	Compliant
FCC §407(a) ISED RSS-247 §6.2	Output Power	Compliant
FCC §2.1051, §15.407(b) ISED RSS-247 §6.2	Undesireable Spurious Emissions and Band Edges	Compliant
FCC §15.407(a) ISED RSS-247 §6.2	Power Spectral Density	Compliant
FCC §2.1051, §15.407(b) ISED RSS-247 §6.2	Spurious Radiated Emissions (Conducted)	Compliant
FCC §15.407(h) ISED RSS-247 §6.3	Dynamic Frequency Selection	Compliant
FCC §15.407(g)	Frequency Stability	Compliant ²

Note¹: Antenna gain was obtained from antenna specification provided by Roku, Inc.

Note²: Customer confirmed an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

BACL is responsible for all the information provided in this report, except when information is provided by the customer as identified in this report. Information provided by the customer, e.g., antenna gain, can affect the validity of results.

4 FCC §15.203 & ISEDC RSS-Gen §6.8 - Antenna Requirements

4.1 Applicable Standards

According to FCC §15.203:

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

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

According to ISEDC RSS-Gen §6.8: Transmitter Antenna

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

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

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

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

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

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

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

4.2 Antenna Description

External/Internal/Integral	Antenna Usage	Antenna Type	Frequency Range (MHz)	Maximum Antenna Gain (dBi)
Internal	5GHz Wi-Fi Ant. A	PCB	5150-5250	0.79
			5250-5350	1.80
			5470-5725	3.94
			5725-5850	4.43
Internal	5GHz Wi-Fi Ant. B	PCB	5150-5250	2.08
			5250-5350	2.38
			5470-5725	4.68
			5725-5850	4.46

Note: The antennas used by the EUT are permanent attached antennas.

Note: Antenna info is information provided by customer.

Note: Ant A and Ant B are Wi-Fi only antennas.

5 FCC §15.407(f) §2.1091 & ISED RSS-102 - RF Exposure

5.1 Applicable Standards

According to FCC KDB 447498 D04 Interim General RF Exposure Guidance v01, Section 2.1 RF Exposure Test Exemptions for Single Source,

2.1.1 General RF Exposure Test Exemption Considerations

RF exposure test exemptions provide means to obtain certification without the need of showing data (measurements, or analytical/numerical modeling) to demonstrate compliance. Hereafter, in this context, an RF source is referred to as “exempt RF device” in the sense that it is not required to show data demonstrating compliance to RF exposure limits.

Test exemptions apply for devices used in general population/uncontrolled exposure environments, according to the SAR-based, or MPE-based exemption thresholds. However, it is always possible, especially when the potential for exposure cannot be easily determined, that an RF exposure evaluation may become required according §§ 1.1307(c) and (d).

As detailed in Section 2.1.2, the 1 mW and SAR-based test exemption conditions are in terms of source-based available maximum time-averaged (matched conducted) output power for all operating configurations, adjusted for tune-up tolerance, and at the minimum test separation distance required for the particular RF exposure scenario under consideration. This minimum test separation distance is determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander.

To qualify for SAR test exemption, the test separation distances applied must be fully explained and justified (typically in the SAR measurement, or SAR analysis report, according to KDB Pub. 865664) by showing the actual operating configurations and exposure conditions of the transmitter, and applicable host platform requirements (e.g., KDB Pubs. 648474, 616217, 941225).

When no other RF exposure testing or reporting is required, a statement of justification and compliance must be included in the equipment approval, in lieu of the SAR report, to qualify for SAR test exemption.

If RF exposure testing requirements for a specific device are covered in a KDB Publication, those requirements must be satisfied before applying any SAR test exemption provisions. For example, this is the case for handheld PTT two-way radios, handsets, laptops, and tablets, etc.

Finally, when 10-g extremity SAR applies, SAR test exemption may be considered by applying a factor of 2.5 to the SAR-based exemption thresholds.

2.1.2 1-mW Test Exemption

Per §1.1307(b)(3)(i)(A), a single RF source is exempt RF device (from the requirement to show data demonstrating compliance to RF exposure limits, as previously mentioned) if the available maximum time-averaged power is no more than 1 mW, regardless of separation distance.

This exemption applies to all operating configurations and exposure conditions, for the frequency range 100 kHz to 100 GHz, regardless of fixed, mobile, or portable device exposure conditions. This is a standalone exemption, and it cannot be applied in conjunction with any other test exemption.

2.1.3 SAR-Based Exemption

A more comprehensive exemption, considering a variable power threshold that depends on both the separation distance and power, is provided in §1.1307(b)(3)(ii)(B). This exemption is applicable to the frequency range between 300 MHz and 6 GHz, with test separation distances between 0.5 cm and 40 cm, and for all RF sources in fixed, mobile, and portable device exposure conditions.

Accordingly, a RF source is considered an RF exempt device if it's available maximum time-averaged (matched conducted) power or its effective radiated power (ERP), whichever is greater, are below a specified threshold. This exemption threshold was derived based on general population 1-g SAR requirements and is detailed in Appendix C.

2.1.4 MPE-Based Exemption

An alternative to the SAR-based exemption is provided in §1.1307(b)(3)(ii)(C), for a much wider frequency range, from 300 kHz to 100 GHz, applicable for separation distances greater or equal to $\lambda/2\pi$, where λ is the free-space operating wavelength in meters. The MPE-based test exemption condition is in terms of ERP, defined as the

⁸ Specific test exemption thresholds for operations under occupational/controlled limits are not established.

⁹ When SAR evaluation is required by the hotspot mode or UMPC mini-tablet procedures, that is, where an antenna is ≤ 2.5 cm from a surface or edge, the *test separation distance* from the phantom to the antenna or device enclosure, as appropriate, should be applied to determine SAR test exemption for such configurations, according to the criteria in this document. For that case, the *test separation distance* cannot be determined from the distance of the antenna to the device surface or edge.

According to ISED RSS-102 Issue 5 Section 2.5.1 Exemption Limits for Routine Evaluation-SAR Evaluation:

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in table below,

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤ 5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤ 300	71	101	132	162	193
450	52	70	88	106	123
835	17	30	42	55	67
1900	7	10	18	34	60
2450	4	7	15	30	52
3500	2	6	16	32	55
5800	1	6	15	27	41

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥ 50 mm
≤ 300	223	254	284	315	345
450	141	159	177	195	213
835	80	92	105	117	130
1900	99	153	225	316	431
2450	83	123	173	235	309
3500	86	124	170	225	290
5800	56	71	85	97	106

2.3 FCC RF Exposure Exemption Evaluation Procedures

According to FCC KDB 447498 D04 Interim General RF Exposure Guidance v01, Annex B Exemptions for Single Source,

B.1 General

This appendix provides the exemption criteria and summarizes relevant parameters and usage considerations based on descriptions in FCC 19-126.

B.2 Blanket 1 mW Blanket Exemption

The 1 mW Blanket Exemption of § 1.1307(b)(3)(i)(A) applies for single fixed, mobile, and portable RF sources with available maximum time-averaged power of no more than 1 mW, regardless of separation distance. The 1 mW blanket exemption applies at separation distances less than 0.5 cm, including where there is no separation. This exemption shall not be used in conjunction with other exemption criteria other than those for multiple RF sources in paragraph § 1.1307(b)(3)(ii)(A). The 1 mW exemption is independent of service type and covers the full range of 100 kHz to 100 GHz, but it shall not be used in conjunction with other exemption criteria or in devices with higher-power transmitters operating in the same time-averaging period. Exposure from such higher-power transmitters would invalidate the underlying assumption that exposure from the lower-power transmitter is the only contributor to SAR in the relevant volume of tissue.

B.3 MPE-based Exemption

General frequency and separation-distance dependent MPE-based effective radiated power (ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] to support an exemption from further evaluation from 300 kHz through 100 GHz.

Table B.1 – THRESHOLD FOR SINGLE RF SOURCE SUBJECT TO ROUTINE ENVIRONMENTAL EVALUATION

RF Source			Minimum Distance			Threshold ERP
f_L MHz		f_H MHz	$\lambda_L/2\pi$		$\lambda_H/2\pi$	W
0.3	-	1.34	159 m	-	35.6 m	1,920 R ²
1.34	-	30	35.6 m	-	1.6 m	3,450 R ² /f ²
30	-	300	1.6 m	-	159 mm	3.83 R ²
300	-	1,500	159 mm	-	31.8 mm	0.0128 R ² f
1,500	-	100,000	31.8 mm	-	0.5 mm	19.2 R ²

Subscripts L and H are low and high; λ is wavelength.
From § 1.1307(b)(3)(i)(C), modified by adding Minimum Distance columns.

The table applies to any RF source (i.e., single fixed, mobile, and portable transmitters) and specifies power and distance criteria for each of the five frequency ranges used for the MPE limits. These criteria apply at separation distances from any part of the radiating structure of at least $\lambda/2\pi$. The thresholds are based on the general population MPE limits with a single perfect reflection, outside of the reactive near-field, and in the main beam of the radiator.

For mobile devices that are not exempt per Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] at distances from 20 cm to 40 cm and in 0.3 GHz to 6 GHz, evaluation of compliance with the exposure limits in § 1.1310 is necessary if the ERP of the device is greater than ERP_{20cm} in Formula (B.1) [repeated from § 2.1091(c)(1) and § 1.1307(b)(1)(i)(B)].

$$P_{th} \text{ (mW)} = ERP_{20 \text{ cm}} \text{ (mW)} = 2040f \quad 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz}$$

$$P_{th} \text{ (mW)} = ERP_{20 \text{ cm}} \text{ (mW)} = 3060 \quad 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz}$$
(B.1)

If the ERP is not easily obtained, then the available maximum time-averaged power may be used (i.e., without consideration of ERP only if the physical dimensions of the radiating structure(s) do not exceed the electrical length of $\lambda/4$ or if the antenna gain is less than that of a half-wave dipole.

SAR-based exemptions are constant at separation distances between 20 cm and 40 cm to avoid discontinuities in the threshold when transitioning between SAR-based and MPE-based exemption criteria at 40 cm, considering the importance of reflections.

B.4 SAR-based Exemption

SAR-based thresholds are derived based on frequency, power, and separation distance of the RF source. The formula defines the thresholds in general for either available maximum time-averaged power or maximum time-averaged ERP, whichever is greater.

If the ERP of a device is not easily determined, such as for a portable device with a small form factor, the applicant may use the available maximum time-averaged power exclusively if the device antenna or radiating structure does not exceed an electrical length of $\lambda/4$.

As for devices with antennas of length greater than $\lambda/4$ where the gain is not well defined, but always less than that of a half-wave dipole (length $\lambda/2$), the available maximum time-averaged power generated by the device may be used in place of the maximum time-averaged ERP, where that value is not known.

The separation distance is the smallest distance from any part of the antenna or radiating structure for all persons, during operation at the applicable ERP. In the case of mobile or portable devices, the separation distance is from the outer housing of the device where it is closest to the antenna.

The SAR-based exemption formula of § 1.1307(b)(3)(i)(B), repeated here as Formula (B.2), applies for single fixed, mobile, and portable RF sources with available maximum time-averaged power or effective radiated power (ERP), whichever is greater, of less than or equal to the threshold P_{th} (mW).

This method shall only be used at separation distances from 0.5 cm to 40 cm and at frequencies from 0.3 GHz to 6 GHz (inclusive). P_{th} is given by Formula (B.2).

$$P_{th} \text{ (mW)} = ERP_{20 \text{ cm}} (d/20 \text{ cm})^x \quad d \leq 20 \text{ cm}$$

$$P_{th} \text{ (mW)} = ERP_{20 \text{ cm}} \quad 20 \text{ cm} < d \leq 40 \text{ cm}$$
(B.2)

Where

$$x = -\log_{10} (60/(ERP_{20 \text{ cm}} \sqrt{f}))$$

and f is in GHz, d is the separation distance (cm), and $EPR_{20 \text{ cm}}$ is per Formula (B.1).

The example values shown in Table B.2 are for illustration only.

Table B.2 – Example Power Thresholds (mW)

Frequency (MHz)	Distance (mm)										
	5	10	15	20	25	30	35	40	45	50	
300	39	65	88	110	129	148	166	184	201	217	
450	22	44	67	89	112	135	158	180	203	226	
835	9	25	44	66	90	116	145	175	207	240	
1900	3	12	26	44	66	92	122	157	195	236	
2450	3	10	22	38	59	83	111	143	179	219	
3600	2	8	18	32	49	71	96	125	158	195	
5800	1	6	14	25	40	58	80	106	136	169	

According to ISED RSS-102 Issue 5:

2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

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

- below 20 MHz⁶ and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

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

5.2 RF Exposure Evaluation Exemption for FCC

WLAN 5 GHz Radio

Prediction frequency[f] (MHz)		5785	
Maximum output power (dBm)		25.97	
Maximum output power (W)		0.395	
Prediction distance[R] (m)		0.20	
Maximum allowed antenna gain (dBi)		7.46	
Max ERP (W)		1.34	
Option B	<i>ERP</i> _{20 cm} (mW)	<i>x</i>	SAR-based Exemption Threshold
	3060	2.6704	<i>P</i> _{th} (mW)
			d < 20 cm

As shown in the table above, the EUT's Max ERP is lower than the SAR-based Exemption Threshold. SAR testing for this device is exempted.

FCC Worst Case Colocation:

$$\text{BTC Contribution} + 2.4\text{Wifi Contribution} = 16.56/3060 + 104.95/3060 = 0.04 < 1$$

$$\text{BTC Contribution} + 5\text{Wifi Contribution} = 16.56/3060 + 1340/3060 = 0.44 < 1$$

Note: device can only operate BT/BLE + 2.4/5GHz Wifi simultaneously. Multiple BT configs can't transmit simultaneously with each other. Multiple Wifi configs can't transmit simultaneously with each other.

5.3 RF Exposure Evaluation Exemption for IC

$$25.97 \text{ dBm} + 7.46 \text{ dBi} = 33.43 \text{ dBm} < 1.31 \times 10^{-2} f^{0.6834} = 4.857 \text{ W} = 36.864 \text{ dBm}$$

Therefore, RF exposure is not required.

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

6.1 Applicable Standards

As per FCC §15.207 and ISEDC RSS GEN §8.8 Conducted limits:

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

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 ^{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 and ISEDC RSS GEN §8.8.

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

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

6.3 Test Procedure

During the conducted emissions test, the power cord of the EUT host system was connected to the mains outlet of the LISN-1 and the power cords of support equipment were connected to LISN-2.

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

All data were recorded in the peak, quasi-peak, and average detection mode. Quasi-Peak readings are distinguished with a "QP." Average readings are distinguished with an "Ave".

6.4 Corrected Amplitude and Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Cable Loss (CL), the Attenuator Factor (Atten) to indicated Amplitude (Ai) reading. The basic equation is as follows:

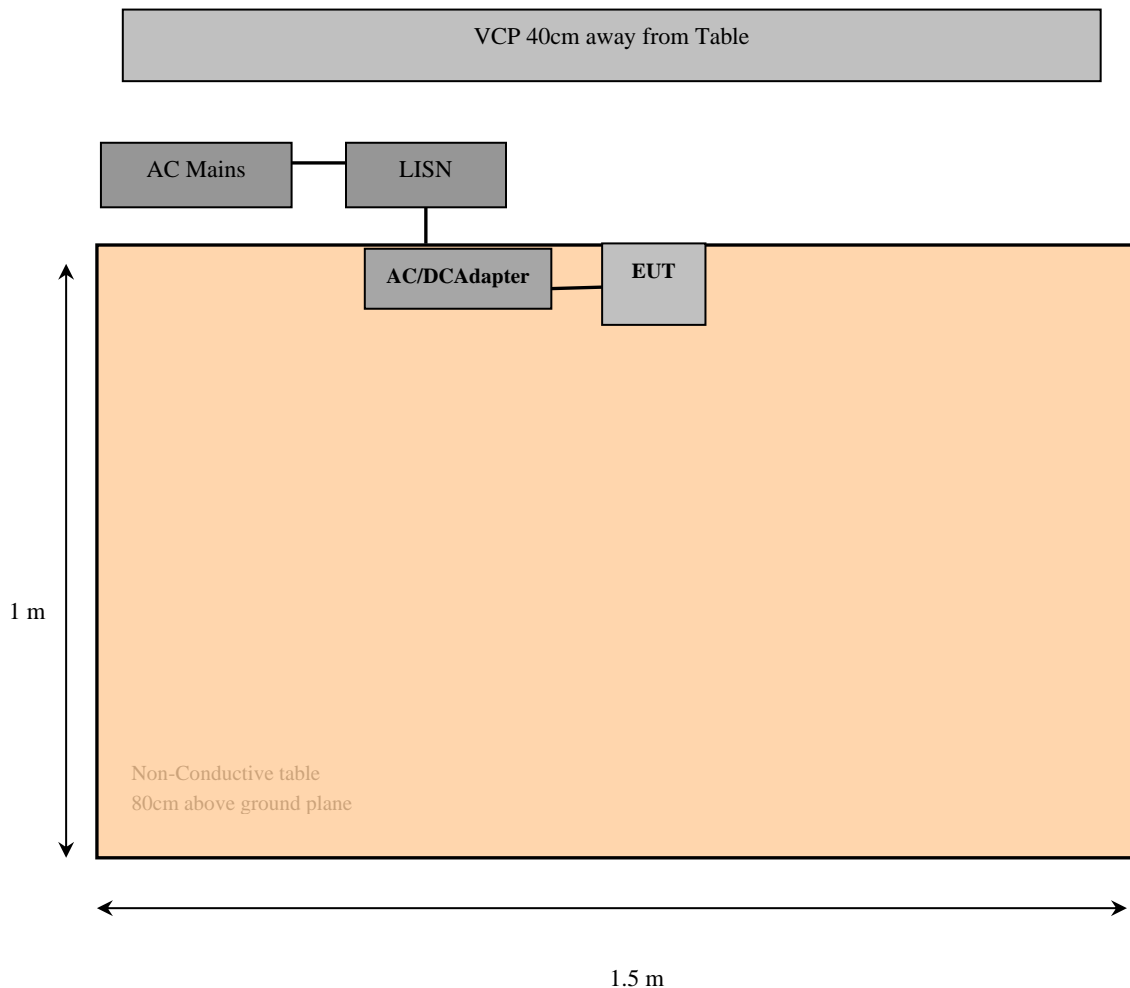
$$CA = Ai + CL + Atten$$

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Cable Loss (3.7 dB) + Attenuator (10 dB)

The “**Margin**” column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

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

6.5 Test Setup Block Diagram



6.6 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
310	Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950 K03	100044	2023-05-11	1 year
680	Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101964	2022-06-20	1 year
724	Solar Electronics Company	High Pass Filter	Type 7930-100	7930150203	2022-09-09	1 year
732	FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2022-09-01	1 year
1226	N/A	Ground Plane Coaxial Cable	N/A	2109241	2022-06-21	1 year
-	Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".

6.7 Test Environmental Conditions

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

The testing was performed by Steven Lianto on 2023-06-12 in the Ground Plane test site.

6.8 Summary of Test Results

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

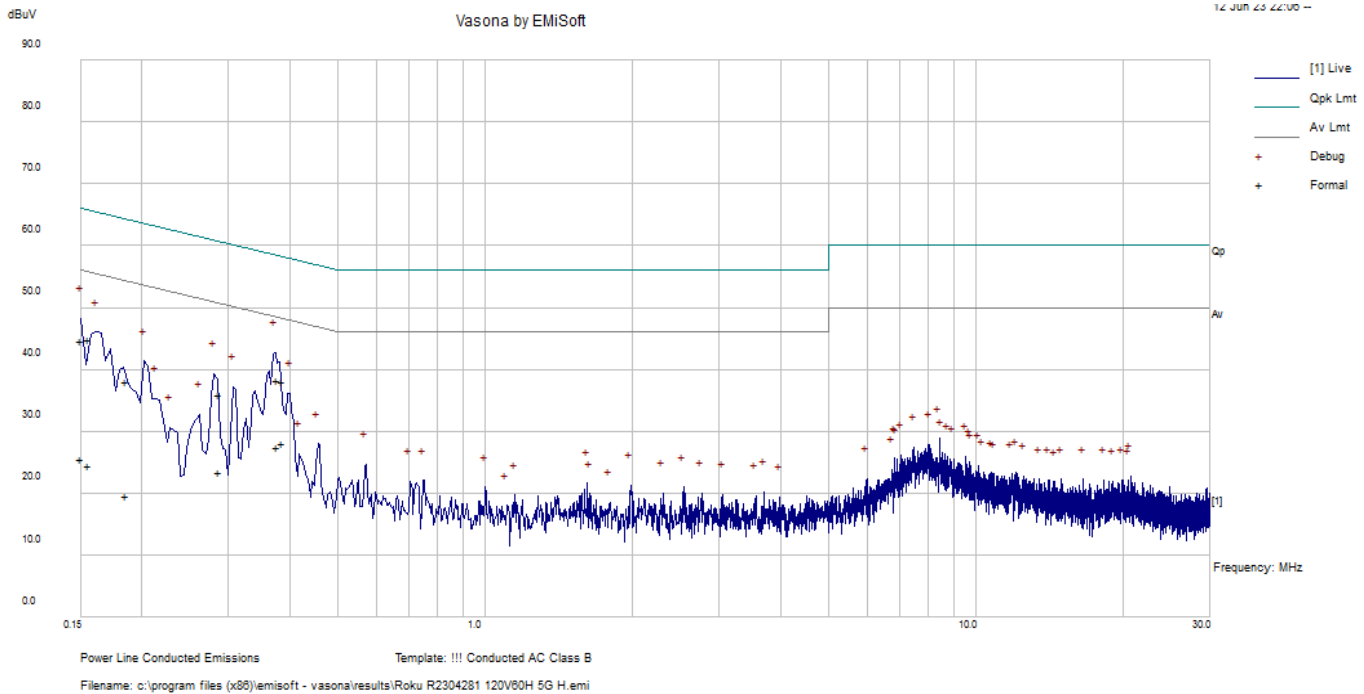
5 GHz Wi-Fi

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	Frequency (MHz)	Conductor Mode (Live/Neutral)	Range (MHz)
-20.04	0.378066	Live	0.15-30

6.9 Conducted Emissions Test Plots and Data

5 GHz Wi-Fi

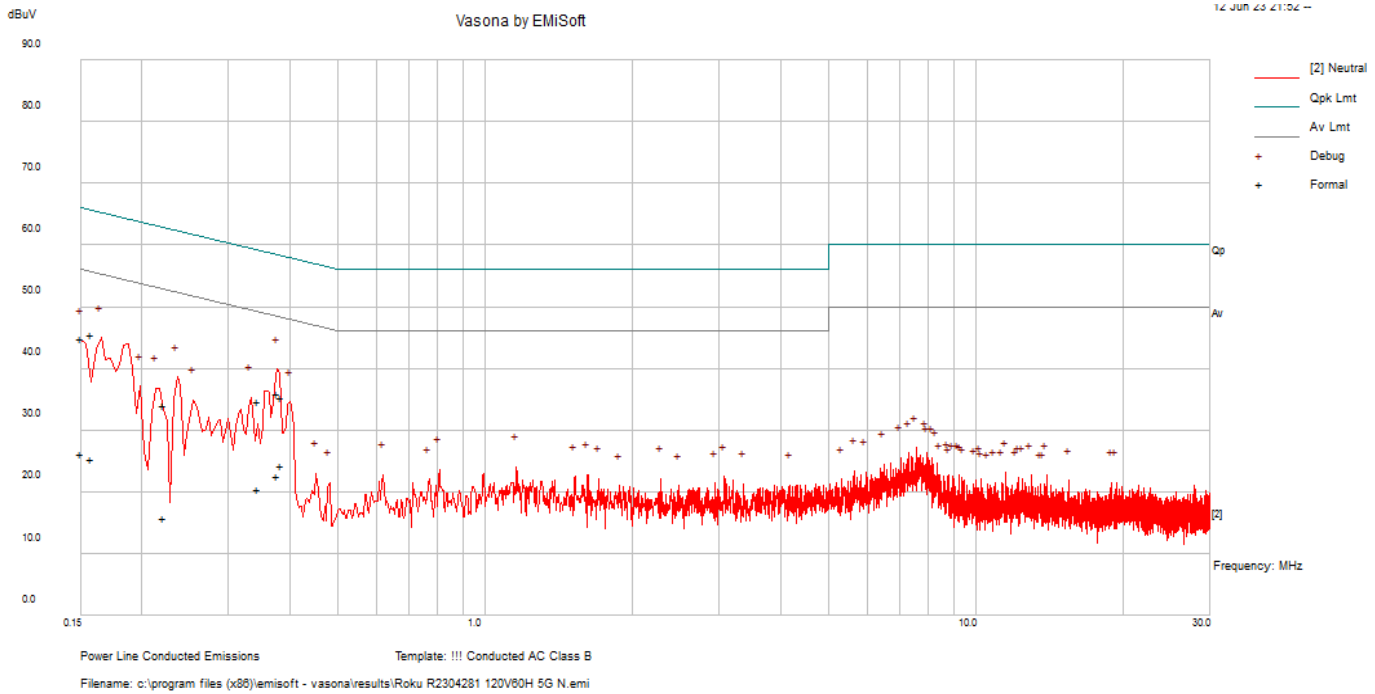
120 V, 60 Hz – Live



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.378066	38.28	Live	58.32	-20.04	QP
0.150032	44.63	Live	66	-21.37	QP
0.155975	44.85	Live	65.68	-20.83	QP
0.286705	36	Live	60.62	-24.62	QP
0.385791	37.97	Live	58.15	-20.19	QP
0.186311	38.13	Live	64.2	-26.07	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.378066	27.38	Live	48.32	-20.94	Ave.
0.150032	25.5	Live	56	-30.5	Ave.
0.155975	24.55	Live	55.68	-31.13	Ave.
0.286705	23.42	Live	50.62	-27.2	Ave.
0.385791	28	Live	48.15	-20.16	Ave.
0.186311	19.63	Live	54.2	-34.57	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.37764	35.87	Neutral	58.33	-22.46	QP
0.157402	45.48	Neutral	65.6	-20.12	QP
0.15001	44.77	Neutral	66	-21.23	QP
0.384495	35.27	Neutral	58.18	-22.92	QP
0.221335	34.09	Neutral	62.77	-28.68	QP
0.344976	34.67	Neutral	59.08	-24.41	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.37764	22.55	Neutral	48.33	-25.79	Ave.
0.157402	25.34	Neutral	55.6	-30.26	Ave.
0.15001	26.19	Neutral	56	-29.8	Ave.
0.384495	24.36	Neutral	48.18	-23.83	Ave.
0.221335	15.68	Neutral	52.77	-37.09	Ave.
0.344976	20.51	Neutral	49.08	-28.57	Ave.

7 FCC §15.209, §15.407(b) & ISEDC RSS-247 §6.2 - 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: All emissions within the frequency range from the band edge to 10 MHz above or below the band edge shall not exceed an e.i.r.p. of -17 dBm/MHz; for frequencies 10 MHz or greater above or below the band edge, emissions shall not exceed an e.i.r.p. of -27 dBm/MHz.

(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.

As per ISERC RSS-247 §6.2

For transmitters operating in the band 5150-5250 MHz, all emissions outside the band 5150-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p. However, any unwanted emissions that fall into the band 5250- 5350 MHz must be 26 dBc, when measured using a resolution bandwidth between 1 and 5% of the occupied bandwidth, above 5.25 GHz. Otherwise, the transmission is considered as intentional and the devices shall implement dynamic frequency selection (DFS) and transmitter power control (TPC) as per the requirements for the band 5250-5350 MHz.

For devices with both operating frequencies and channel bandwidths contained within the band 5250-5350 MHz, the device shall comply with the following:

1. All emissions outside the band 5250-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p. if the equipment is intended for outdoor use; or
2. All emissions outside the band 5150-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p. and any emissions within the band 5150-5250 MHz shall meet the power spectral density limits of Section 6.2.1. The device shall be labelled “for indoor use only.”

For devices with operating frequencies in the band 5250-5350 MHz but having a channel bandwidth that overlaps the band 5150-5250 MHz, the devices’ unwanted emission shall not exceed -27 dBm/MHz e.i.r.p. outside the band 5150-5350 MHz and its power shall comply with the spectral power density for operation within the band 5150-5250 MHz. The device shall be labelled “for indoor use only.”

For transmitters operating in the band 5470-5725 MHz, emissions outside the band shall not exceed -27 dBm/MHz e.i.r.p.

For the band 5725-5850 MHz, emissions at frequencies from the band edges to 10 MHz above or below the band edges shall not exceed -17 dBm/MHz e.i.r.p. For emissions at frequencies more than 10 MHz above or below the band edges, the emissions power shall not exceed -27 dBm/MHz.

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 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

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:

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

Above 1000 MHz:

- (1) Peak: RBW = 1MHz / VBW = 3MHz / Sweep = 100ms
- (2) Average: RBW = 1MHz / VBW = 10Hz or 1/T / Sweep = Auto

7.4 Corrected Amplitude and Margin Calculation

For emissions below 1 GHz,

The Corrected Amplitude (CA) is calculated by adding the Correction Factor to the S.A. Reading. The basic equation is as follows:

$$\text{CA} = \text{S.A. Reading} + \text{Correction Factor}$$

For example, a corrected amplitude of 40.3 dBuV/m = S.A. Reading (32.5 dBuV) + Correction Factor (7.8 dB/m)

The Correction Factor is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) together. This calculation is done in the measurement software, and reported in the test result section. The basic equation is as follows:

$$\text{Correction Factor} = \text{AF} + \text{CL} + \text{Atten} - \text{Ga}$$

The “**Margin**” column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

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

For emission above 1 GHz,

The Corrected Amplitude (CA) is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) to indicated Amplitude (Ai) reading. The basic equation is as follows:

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

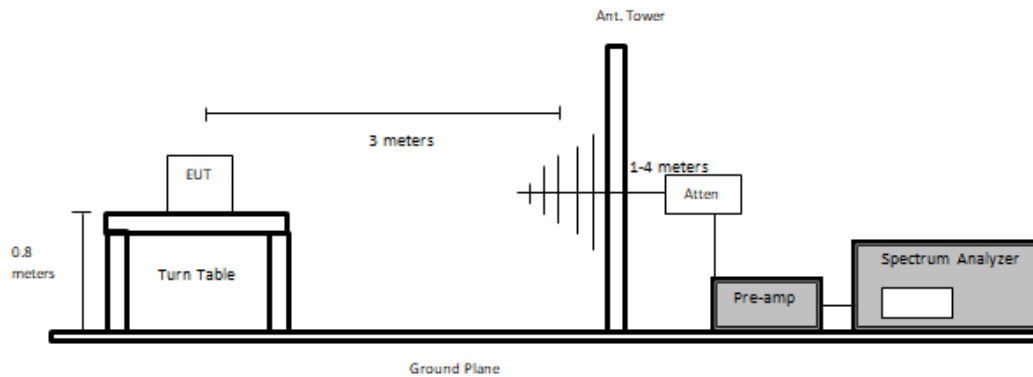
For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

The “**Margin**” column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

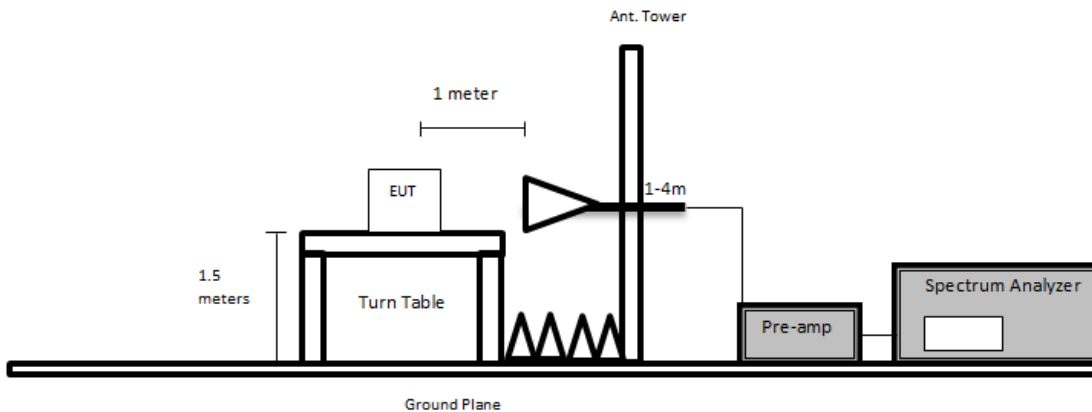
$$\text{Margin} = \text{Corrected Amplitude} - \text{Limit}$$

Test Setup Block Diagram

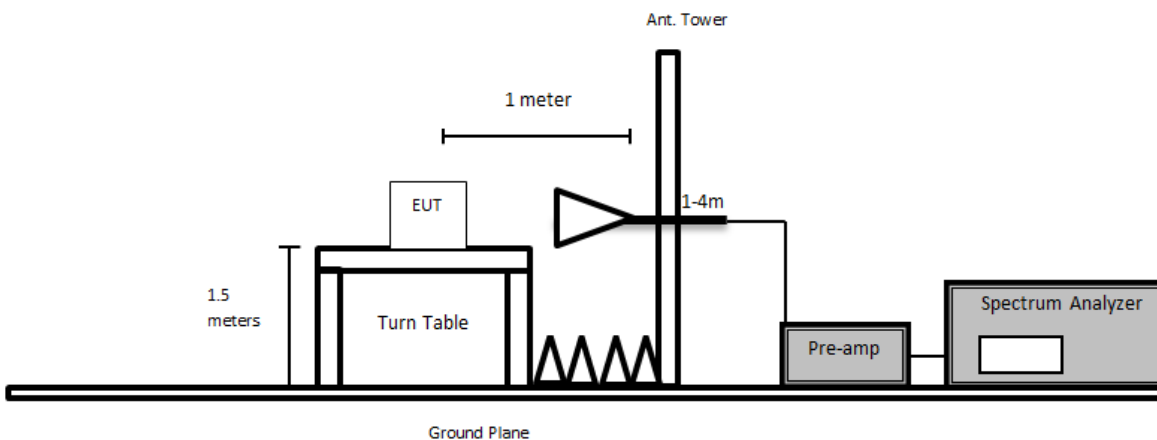
Below 1GHz:



Above 1GHz:
Using Asset #1192



Using Asset #91, #92



7.5 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
310	Rhode & Schwarz	EMI Test Receiver	ESCI 1166.5950.03	100338	2023-05-11	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
91	Wisewave	Horn Antenna	ARH-4223-02	10555-02	2022-03-08	2 years
230	Wisewave	Horn Antenna	ARH-2823-02	10555-02	2022-03-08	2 years
321	Sunol Sciences	Biconilog Antenna	JB3	A020106-2	2021-11-22	2 years
1192	ETS Lindgren	Horn Antenna	3117	00218973	2022-09-29	2 years
316	Sonoma Instruments	Pre Amplifier	317	260406	2023-04-12	6 months
658	HP/ Agilent	Pre Amplifier	8449B OPT HO2	3008A01103	2022-07-22	1 year
827	AH Systems	Pre Amplifier	PAM 1840 VH	170	2023-05-17	1 year
1186	Pasternack	Coaxial Cable, RG214	PE3062- 1050CM	N/A	2023-04-14	6 months
1248	Pasternack	RG214 COAX Cable	PE3062	N/A	2023-04-14	6 months
1249	Time Microwave	LMR-400 Cable DC-3GHz	AE13684	2k80612-5 6fts	2023-04-14	6 months
1295	Carlisle	10m Ultra Low Loss Coaxial Cable	UFB142A-1- 3937-200200	64639890912- 001	2023-05-04	6 months
1329	Pasternack	2.92mm short coaxial cable	PE360-12	N/A	2022-12-14	6 months
1346	RFMW	2.92mm 10ft RF cable	KMSE- 160SAW- 240.0-KSME	N/A	2023-02-03	6 months
1245	-	6dB Attenuator	PE7390-6	01182018A	2021-11-22	2 years
1246	HEWLET PACKARD	RF Limiter	11867A	01734	2023-04-13	1 year
1331	Micro-Tronics	Notch Filter	BRM50716	G262	2022-12-20	1 year

Note¹: cable and notch filters 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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".

7.6 Test Environmental Conditions

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

The testing was performed by Deepak Mishra and Steven Lianto from 2023-06-08 to 2023-06-09 in 5m chamber 3.

7.7 Summary of Test Results

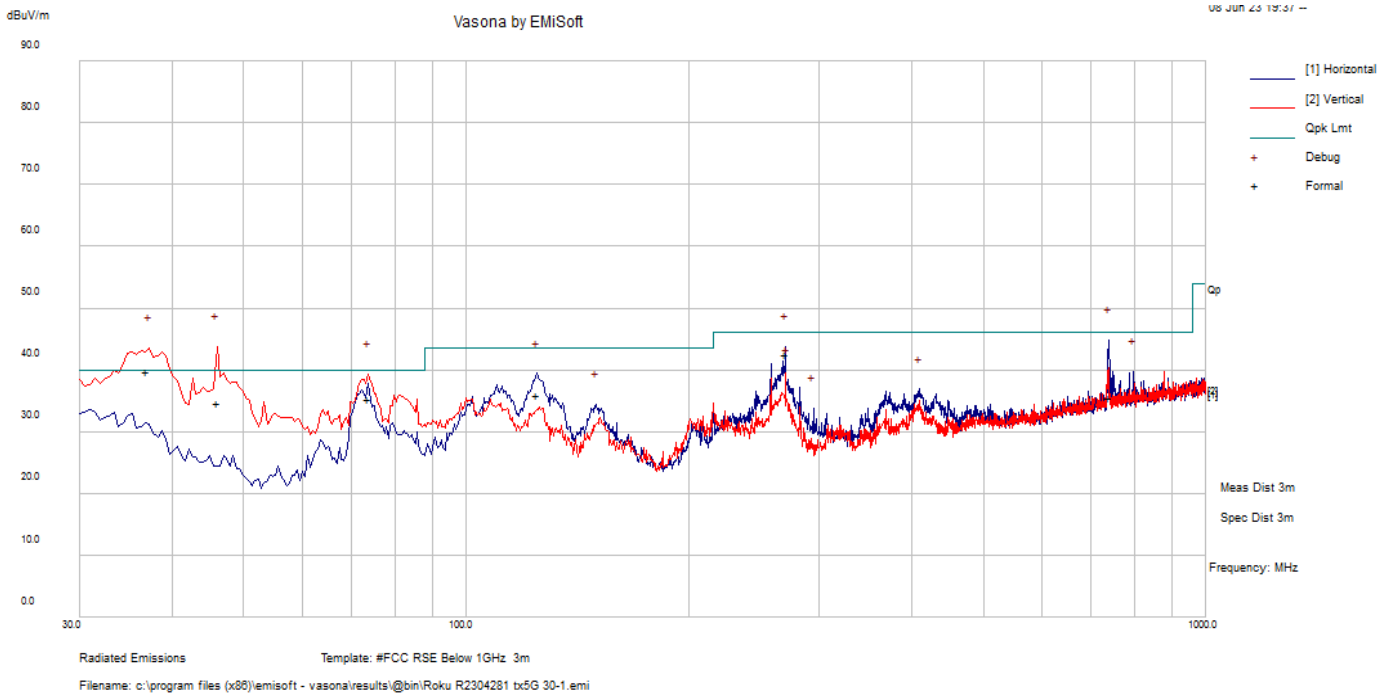
According to the data hereinafter, the EUT complied with the FCC Part 15.407 and ISEDC RSS-247 standards' radiated emissions limits, and had the worst margin of:

Mode: Transmitting			
Margin (dB)	Frequency (MHz)	Polarization (Horizontal/Vertical)	Mode, Channel
-0.17	37.0535	V	802.11a mode, 5745 MHz

7.8 Radiated Emissions Test Result Data

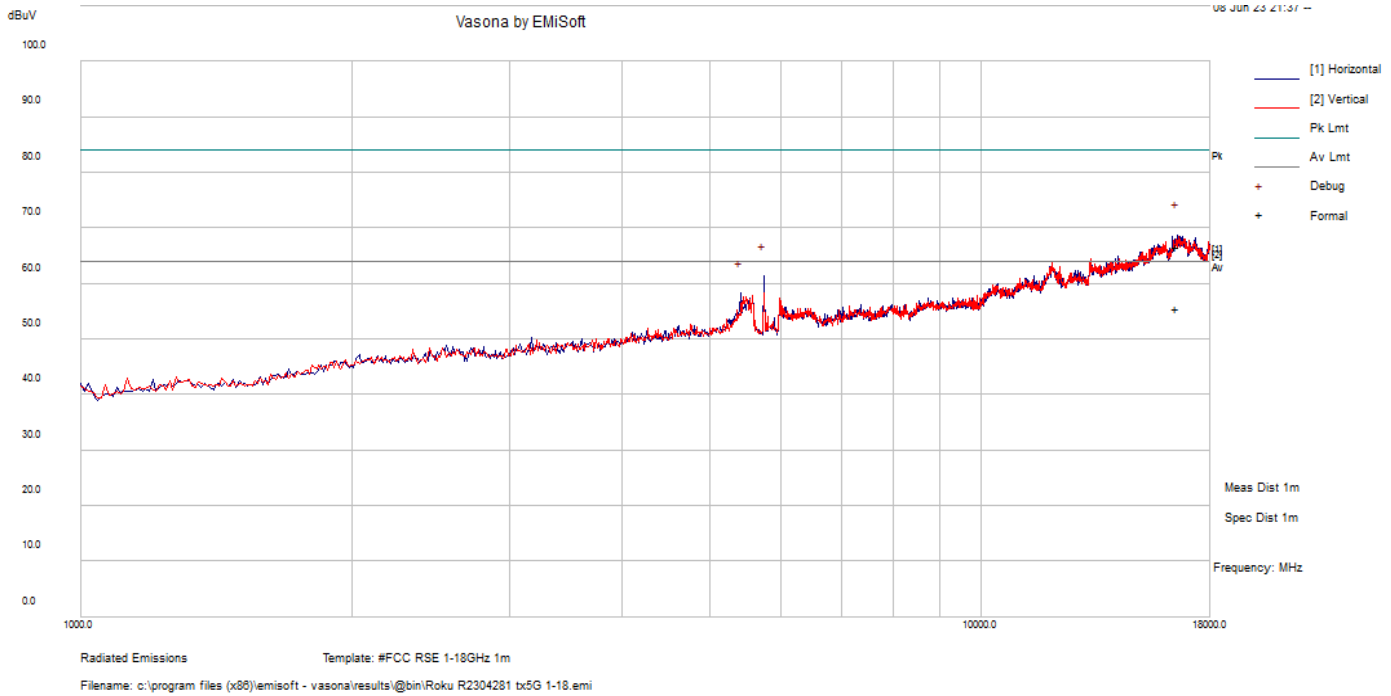
Note: Lowest Frequency emitted by the EUT is greater than 30MHz, thus spurious emission below 30MHz are not needed.

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



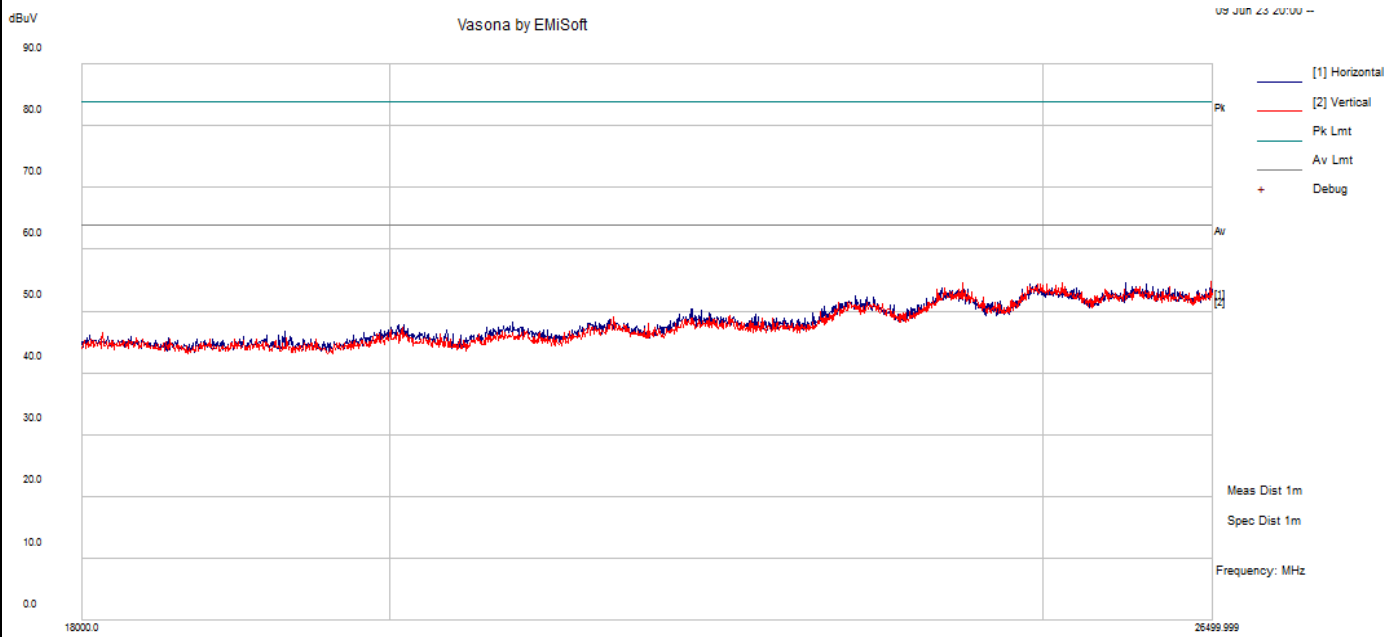
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comments (PK/QP/Ave.)
46.142	45.99	-11.32	34.67	106	V	299	40	-5.34	QP
37.0535	45.58	-5.74	39.84	106	V	216	40	-0.17	QP
73.69425	48.55	-13.24	35.31	232	V	154	40	-4.69	QP
740.11575	33.72	1.74	35.46	145	H	313	46	-10.54	QP
270.012	50.25	-7.73	42.52	106	H	232	46	-3.48	QP
124.57625	42.68	-6.83	35.85	194	H	268	43.5	-7.65	QP

2) 1–18 GHz Worst Case Emissions, Measured at 1 meter



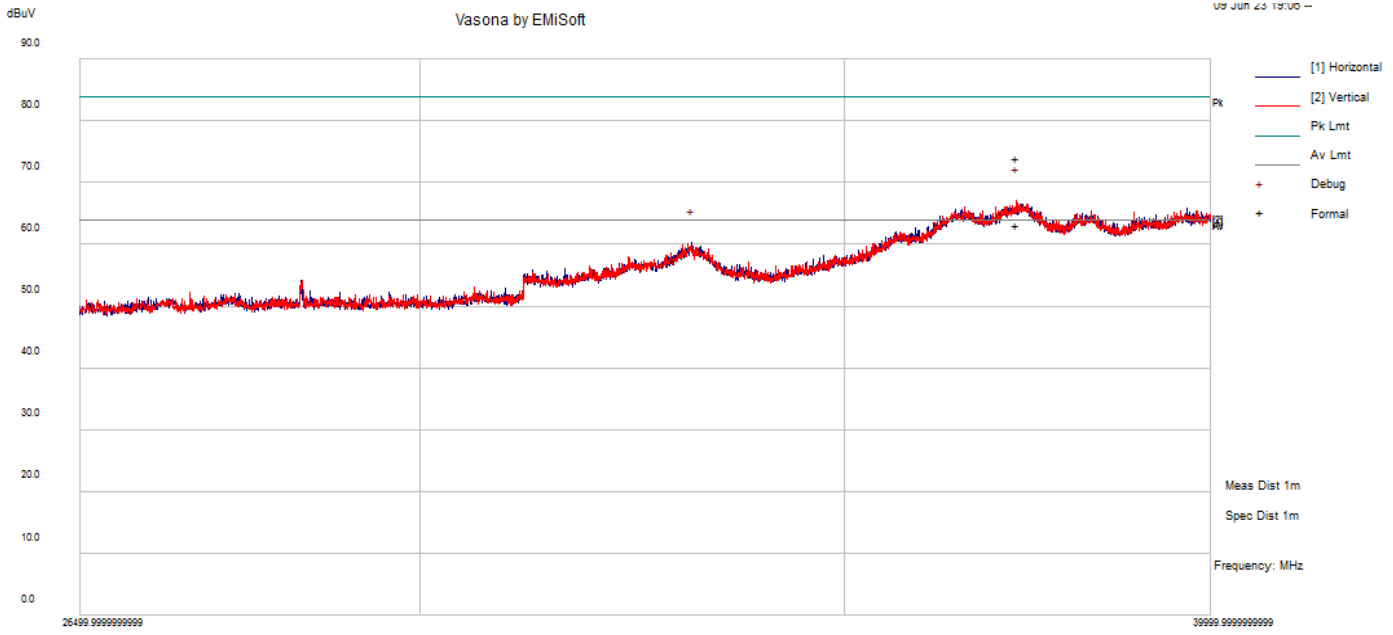
Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBμV/m)	Ant. Polarity (H/V)	Ant. Height (cm)	Turntable Azimuth (degrees)	Limit (dBμV/m)	Margin (dB)	Detector (Peak/Ave.)
16522.345	45.73	20.9	66.63	117	H	60	84	-17.37	Peak
16522.345	34.62	20.9	55.52	117	H	60	64	-8.48	Ave

3) 18-26.5 GHz Worst Case Emissions, Measured at 1 meter



Radiated Emissions Template: #FCC RSE 18-26.5GHz 1m
Filename: c:\program files (x86)\emisoft - vasona\results\@bin\Roku R2304281 tx5G 18-26.5.emi

4) 26.5-40 GHz Worst Case Emissions, Measured at 1 meter



Radiated Emissions Template: #FCC RSE 26.5-40Ghz 1m
 Filename: c:\program files (x86)\emisoft - vasona\results\@bin\Roku R2304281 tx5G 26.5-40.emi

Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Ant. Polarity (H/V)	Ant. Height (cm)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Detector (Peak/Ave.)
37268.927	55.54	18.47	74.01	137	V	209	84	-9.99	Peak
37268.927	44.77	18.47	63.24	137	V	209	64	-0.76	Ave

8 FCC §15.407(e) & ISEDC RSS-247 §6.2 - 6 dB, 26 dB, & 99% - Occupied Bandwidth

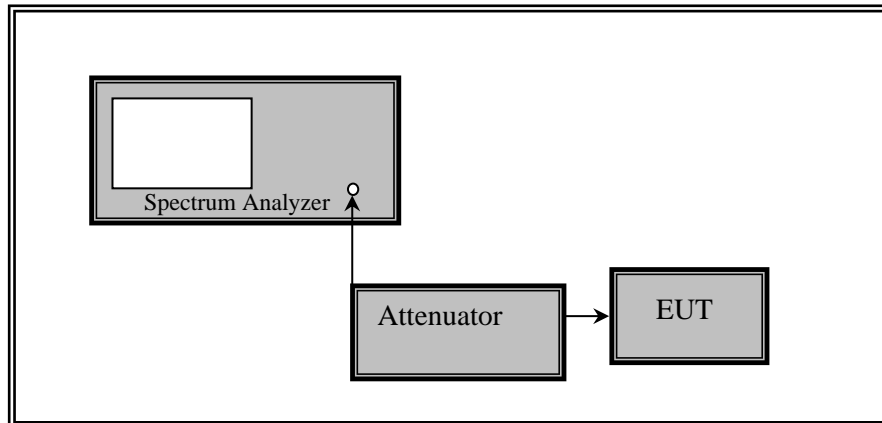
8.1 Applicable Standards

As per FCC §15.407(e) and ISEDC RSS-247 6.2.4(1): 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

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 6 or 26 dB from the reference level. Record the frequency difference as the minimum emission or emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

8.3 Test Setup Block Diagram



8.4 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303 156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250 238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time ¹	N/A
-	-	RF cables	-	-	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 the latest version of A2LA policy P102 “A2LA Policy on Metrological Traceability”.

8.5 Test Environmental Conditions

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

The testing was performed by Christian Schwarz from 2023-05-24 to 2023-06-06 in RF site.

8.6 Test Results

Please refer to the following tables.

Please refer to Annex A – UNII-1, UNII-2A, UNII-2C, and UNII-3 for the Emission Bandwidth plots for detailed test results.

U-NII-1

Ant A

Channel	Frequency (MHz)	99% OBW (MHz)	-26 dB BW (MHz)
802.11a			
36	5180	26.371	17.002
40	5200	31.025	16.963
48	5240	25.002	16.831
802.11n20			
36	5180	19.994	17.789
40	5200	20.119	17.779
48	5240	20.100	17.831
802.11n40			
38	5190	41.724	36.494
46	5230	41.874	36.373
802.11ac80			
42	5210	82.145	74.917

Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	-26 dB BW (MHz)
802.11a			
36	5180	18.948	16.719
40	5200	19.075	16.635
48	5240	20.440	16.741
802.11n20			
36	5180	20.082	17.834
40	5200	20.022	17.816
48	5240	19.986	17.737
802.11n40			
38	5190	41.507	36.229
46	5230	41.920	36.411
802.11ac80			
42	5210	82.982	74.900

U-NII-2A

Ant A

Channel	Frequency (MHz)	99% OBW (MHz)	-26 dB BW (MHz)
802.11a			
52	5260	19.759	16.714
60	5300	21.207	16.651
64	5320	21.351	16.648
802.11n20			
52	5260	23.176	17.776
60	5300	20.246	17.761
64	5320	24.048	17.855
802.11n40			
54	5270	46.943	36.601
62	5310	41.692	36.305
802.11ac80			
58	5290	82.442	74.789

Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	-26 dB BW (MHz)
802.11a			
52	5260	19.048	16.657
60	5300	19.246	16.626
64	5320	19.069	16.669
802.11n20			
52	5260	20.116	17.750
60	5300	20.003	17.708
64	5320	20.115	17.821
802.11n40			
54	5270	41.951	36.461
62	5310	41.774	36.341
802.11ac80			
58	5290	81.796	74.473

U-NII-2C

Ant A

Channel	Frequency (MHz)	99% OBW (MHz)	-26 dB BW (MHz)
802.11a			
100	5500	21.83	16.89
120	5600	21.79	17.02
144	5720	21.62	16.71
802.11n20			
100	5500	22.24	17.81
120	5600	22.19	17.97
144	5720	22.23	17.81
802.11n40			
102	5510	45.27	36.55
118	5590	45.34	36.52
142	5710	44.80	36.51
802.11ac80			
106	5530	89.64	75.14
122	5610	89.55	75.43
138	5690	89.80	74.99

Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	-26 dB BW (MHz)
802.11a			
100	5500	21.71	16.84
120	5600	22.68	16.90
144	5720	22.22	17.85
802.11n20			
100	5500	22.04	17.80
120	5600	22.54	17.96
144	5720	24.10	16.69
802.11n40			
102	5510	45.22	36.58
118	5590	45.26	36.67
142	5710	44.91	36.66
802.11ac80			
106	5530	89.66	75.47
122	5610	89.80	75.53
138	5690	89.27	74.98

U-NII-3

Ant A

Channel	Frequency (MHz)	99% OBW (MHz)	-6 dB BW (MHz)
802.11a			
149	5745	16.36	28.10
157	5785	16.38	28.33
165	5825	16.45	28.20
802.11n20			
149	5745	17.03	28.73
157	5785	17.67	29.38
165	5825	16.72	29.38
802.11n40			
151	5755	32.99	57.64
159	5795	32.60	57.26
802.11ac80			
155	5775	74.24	81.12

Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	-6 dB BW (MHz)
802.11a			
149	5745	16.50	27.80
157	5785	16.00	27.65
165	5825	16.41	27.25
802.11n20			
149	5745	17.66	29.12
157	5785	17.36	28.5
165	5825	17.61	27.90
802.11n40			
151	5755	34.515	58.27
159	5795	33.793	56.12
802.11ac80			
155	5775	73.213	82.07

9 FCC §15.407(a) & ISEDC RSS-247 §6.2 - 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 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 $11 \text{ dBm} + 10 \log B$, 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.

According to ISEDC RSS-247 §6.2.1 for frequency band 5150-5250 MHz:

The maximum e.i.r.p. shall not exceed 200 mW or $10 + 10 \log_{10} B$, dBm, whichever power is less. B is the 99% emission bandwidth in megahertz. The e.i.r.p. spectral density shall not exceed 10 dBm in any 1.0 MHz band.

According to ISEDC RSS-247 §6.2.2 for frequency band 5250-5350 MHz:

The maximum conducted output power shall not exceed 250 mW or $11 + 10 \log_{10} B$, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1.0 MHz band.

The maximum e.i.r.p. shall not exceed 1.0 W or $17 + 10 \log_{10} B$, dBm, whichever is less. B is the 99% emission bandwidth in megahertz. Note that devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.

According to ISEDC RSS-247 §6.2.3 for frequency band 5470-5600 MHz and 5650-5725 MHz:

The maximum conducted output power shall not exceed 250 mW or $11 + 10 \log_{10} B$, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1.0 MHz band.

The maximum e.i.r.p. shall not exceed 1.0 W or $17 + 10 \log_{10} B$, dBm, whichever is less. B is the 99% emission bandwidth in megahertz. Note that devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.

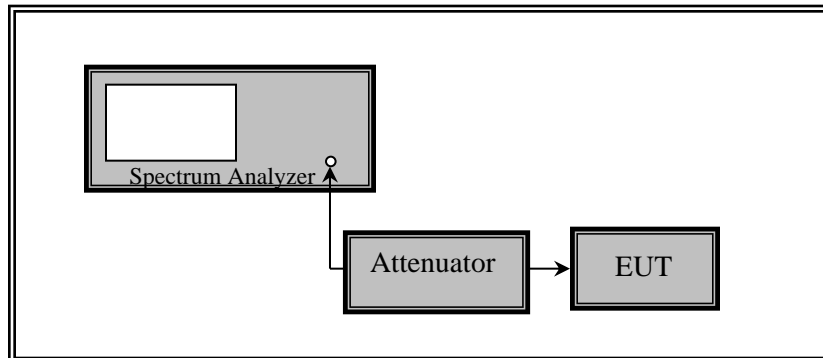
According to ISEDC RSS-247 §6.2.4 for frequency band 5725-5850 MHz:

The maximum conducted output power shall not exceed 1 W. The 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 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 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.

9.2 Measurement Procedure

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to a power meter.

9.3 Test Setup Block Diagram



9.4 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US453031 56	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY482502 38	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time ¹	N/A
-	-	RF cable	-	-	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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

9.5 Test Environmental Conditions

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

The testing was performed by Christian Schwarz from 2023-05-24 to 2023-06-06 in RF site.

9.6 Test Results

Please refer to Annex B – UNII-1, UNII-2A, UNII-2C, and UNII-3 for the Output Power plots for detailed test results.

UNII-1

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total Power (dBm) ^{1,2}	Output Power Limit (dBm)	EIRP (dBm) ³	EIRP Limit (dBm)
		ANT A	ANT B				
802.11a							
36	5180	17.75	16.18	-	24	18.54	23
40	5200	16.77	16.08	-	24	18.16	23
48	5240	17.48	16.60	-	24	18.68	23
802.11n20							
36	5180	11.59	10.68	14.17	24	18.64	23
40	5200	11.11	10.89	14.01	24	18.48	23
48	5240	12.31	10.89	14.67	24	19.14	23
802.11n40							
38	5190	11.62	11.34	14.49	24	18.96	23
46	5230	11.65	10.41	14.08	24	18.55	23
802.11ac80							
42	5210	11.30	11.41	14.37	24	18.84	23

Note 1: Conversion of dBm to mW is $[mW] = 10^{(dBm/10)}$

Note 2: Total Power [dBm] = $10 * \log(\text{Output Power @ Ant.A}[mW] + \text{Output Power @ Ant.B}[mW])$

Note 3: EIRP [dBm] = Total Power [dBm] + Antenna Gain [dBi]

Note 4: For 802.11a, only higher power port is shown for EIRP.

Note 5: Antenna gain

MHz	(dBi)
Ant A : 5150-5250	0.79
Ant B: 5150-5250	2.08

Directional Gain is 4.49dBi

UNII-2A

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total Power (dBm) ^{1,2}	Output Power Limit (dBm)	EIRP (dBm) ³	EIRP Limit (dBm)
		ANT A	ANT B				
802.11a							
52	5260	16.50	14.43	-	24	18.3	30
60	5300	16.24	14.88	-	24	18.04	30
64	5320	16.07	15.41	-	24	17.87	30
802.11n20							
52	5260	15.66	14.49	18.12	24	23.23	30
60	5300	15.85	14.62	18.29	24	23.40	30
64	5320	14.96	14.67	17.83	24	22.94	30
802.11n40							
54	5270	11.86	10.69	14.32	24	19.43	30
62	5310	10.88	10.77	13.84	24	18.95	30
802.11ac80							
58	5290	8.76	8.74	11.76	24	16.87	30

Note 1: Conversion of dBm to mW is $[mW] = 10^{(dBm)/10}$

Note 2: Total Power [dBm] = $10 \cdot \log(\text{Output Power @ Ant.A}[mW] + \text{Output Power @ Ant.B}[mW])$

Note 3: EIRP [dBm] = Total Power [dBm] + Antenna Gain [dBi]

Note 3: For 802.11a, only higher power port is shown for EIRP.

Note 4: Antenna gain

MHz	(dBi)
Ant A : 5250-5350	1.80
Ant B: 5250-5350	2.38

Directional Gain is 5.11dBi

UNII-2C

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total Power (dBm) ^{1,2}	Output Power Limit (dBm)	EIRP (dBm) ³	EIRP Limit (dBm)
		ANT A	ANT B				
802.11a							
100	5500	17.58	17.99	-	24	22.67	30
120	5600	17.89	18.16	-	24	22.84	30
144	5720	16.47	17.00	-	24	21.68	30
802.11n20							
100	5500	15.69	15.61	18.66	24	25.99	30
120	5600	16.27	15.96	19.13	24	26.46	30
144	5720	15.61	14.53	18.11	24	25.44	30
802.11n40							
102	5510	11.14	12.55	14.91	24	22.24	30
118	5590	10.79	13.45	15.33	24	22.66	30
142	5710	10.83	11.89	14.40	24	21.73	30
802.11ac80							
106	5530	11.08	13.06	15.19	24	22.52	30
122	5610	11.43	11.52	14.48	24	21.81	30
138	5690	11.17	11.72	14.46	24	21.79	30

Note 1: Conversion of dBm to mW is $[mW] = 10^{(dBm)/10}$

Note 2: Total Power [dBm] = $10 * \log(\text{Output Power @ Ant.A}[mW] + \text{Output Power @ Ant.B}[mW])$

Note 3: EIRP [dBm] = Total Power [dBm] + Antenna Gain [dBi]

Note 3: For 802.11a, only higher power port is shown for EIRP.

Note 4: Antenna gain

MHz	(dBi)
Ant A: 5470-5725	3.94
Ant B: 5470-5725	4.68

Directional Gain is 7.34dBi

UNII-3

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total Power (dBm) ^{1,2}	Output Power Limit (dBm)
		ANT A	ANT B		
802.11a					
149	5745	23.17	23.36	-	30
157	5785	22.74	22.60	-	30
165	5825	23.10	22.89	-	30
802.11n20					
149	5745	23.06	22.32	25.72	30
157	5785	22.90	23.03	25.97	30
165	5825	22.54	22.74	25.65	30
802.11n40					
151	5755	22.69	23.14	25.93	30
159	5795	22.62	22.12	25.39	30
802.11ac80					
155	5775	19.34	22.32	24.09	30

Note 1: Conversion of dBm to mW is $[mW] = 10^{(dBm)/10}$

Note 2: Total Power [dBm] = $10 * \log(\text{Output Power @ Ant.A}[mW] + \text{Output Power @ Ant.B}[mW])$

Note 3: EIRP [dBm] = Total Power [dBm] + Antenna Gain [dBi]

Note 3: For 802.11a, only higher power port is shown for EIRP.

Note 4: Antenna gain

MHz	(dBi)
Ant A: 5725-5850	4.43
Ant B: 5725-5850	4.46

Directional Gain is 7.46dBi

10 FCC §15.407(a) & ISEDC RSS-247 §6.2 - 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 $11 \text{ dBm} + 10 \log B$, 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.

According to ISEDC RSS-247 §6.2.1 for frequency band 5150-5250 MHz:

The maximum e.i.r.p. shall not exceed 200 mW or $10 + 10 \log_{10} B$, dBm, whichever power is less. B is the 99% emission bandwidth in megahertz. The e.i.r.p. spectral density shall not exceed 10 dBm in any 1.0 MHz band.

According to ISEDC RSS-247 §6.2.2 for frequency band 5250-5350 MHz:

The maximum conducted output power shall not exceed 250 mW or $11 + 10 \log_{10} B$, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1.0 MHz band.

The maximum e.i.r.p. shall not exceed 1.0 W or $17 + 10 \log_{10} B$, dBm, whichever is less. B is the 99% emission bandwidth in megahertz. Note that devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.

According to ISEDC RSS-247 §6.2.3 for frequency band 5470-5600 MHz and 5650-5725 MHz:

The maximum conducted output power shall not exceed 250 mW or $11 + 10 \log_{10} B$, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1.0 MHz band.

The maximum e.i.r.p. shall not exceed 1.0 W or $17 + 10 \log_{10} B$, dBm, whichever is less. B is the 99% emission bandwidth in megahertz. Note that devices with a maximum e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W.

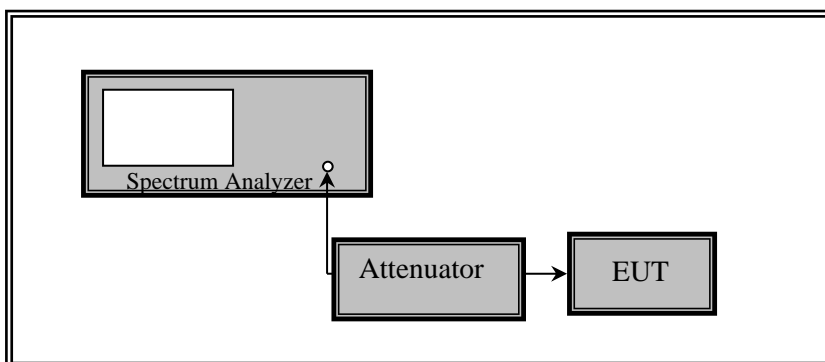
According to ISEDC RSS-247 §6.2.4 for frequency band 5725-5850 MHz:

The maximum conducted output power shall not exceed 1 W. The 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 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 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.

10.2 Measurement Procedure

- (i) Set span to encompass the entire emission bandwidth (EBW) of the signal.
- (ii) Set RBW = 1 MHz.
- (iii) Set VBW \geq 3 MHz.
- (iv) Number of points in sweep \geq 2 Span / RBW. (This ensures that bin-to-bin spacing is \leq RBW/2, so that narrowband signals are not lost between frequency bins.)
- (v) Sweep time = auto.
- (vi) Detector = RMS (i.e., power averaging), if available. Otherwise, use sample detector mode.
- (vii) If transmit duty cycle < 98 percent, use a video trigger with the trigger level set to enable triggering only on full power pulses. Transmitter must operate at maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no off intervals) or at duty cycle \geq 98 percent, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to “free run”.
- (viii) Trace average at least 100 traces in power averaging (i.e., RMS) mode.
- (ix) Compute power by integrating the spectrum across the 26 dB EBW of the signal using the spectrum analyzer’s band power measurement function with band limits set equal to the EBW band edges. If the spectrum analyzer does not have a band power function, sum the spectrum levels (in power units) at 1 MHz intervals extending across the 26 dB EBW of the spectrum.

10.3 Test Setup Block Diagram



10.4 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303 156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250 238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time ¹	N/A
-	-	RF cable	-	-	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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

10.5 Test Environmental Conditions

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

The testing was performed by Christian Schwarz from 2023-05-24 to 2023-06-06 in RF site.

10.6 Test Results

Please refer to Annex C – UNII-1, UNII-2A, UNII-2C, and UNII-3 for the Spectral Density plots for detailed test results.

UNII-1

Channel	Frequency (MHz)	PSD (dBm/MHz)		Limit (dBm/MHz)
		ANT A	ANT B	
802.11a				
36	5180	6.37	4.91	11
40	5200	5.66	5.05	
48	5240	6.14	5.21	
802.11n20				
36	5180	0.18	-0.89	11
40	5200	0.30	-0.61	
48	5240	0.74	-0.25	
802.11n40				
38	5190	-2.75	-1.48	11
46	5230	-2.85	-3.24	
802.11ac80				
42	5210	-5.86	-6.76	11

Channel	Frequency (MHz)	EIRP PSD (dBm/MHz)		Limit (dBm/MHz)
		ANT A	ANT B	
802.11a				
36	5180	7.16	6.99	10
40	5200	6.45	7.13	
48	5240	6.93	7.29	
802.11n20				
36	5180	7.16		10
40	5200	7.35		
48	5240	7.75		
802.11n40				
38	5190	5.41		10
46	5230	4.44		
802.11ac80				
42	5210	1.19		10

Note : Antenna gain

MHz	(dBi)
Ant A : 5150-5250	0.79
Ant B: 5150-5250	2.08

Directional Gain is 4.49dBi

UNII-2A

Channel	Frequency (MHz)	PSD (dBm/MHz)		Limit (dBm/MHz)
		ANT A	ANT B	
802.11a				
52	5260	4.85	3.75	11
60	5300	4.98	3.84	
64	5320	4.92	4.06	
802.11n20				
52	5260	3.44	3.14	11
60	5300	4.50	3.07	
64	5320	3.59	3.21	
802.11n40				
54	5270	-0.52	-3.23	11
62	5310	-3.36	-3.13	
802.11ac80				
58	5290	-8.18	-8.16	11

UNII-2C

Channel	Frequency (MHz)	PSD (dBm/MHz)		Limit (dBm/MHz)
		ANT A	ANT B	
802.11a				
100	5500	6.42	6.58	9.66
120	5600	6.71	6.93	
144	5720	5.35	5.62	
802.11n20				
100	5500	4.26	4.30	9.66
120	5600	4.92	4.29	
144	5720	3.80	3.18	
802.11n40				
102	5510	-3.04	-1.69	9.66
118	5590	-3.49	-0.47	
142	5710	-3.29	-2.26	
802.11ac80				
106	5530	-6.13	-3.83	9.66
122	5610	-6.33	-4.22	
138	5690	-6.40	-5.03	

Note: Limit is decreased by 1.34 dB since combined antenna gain is 7.34 dBi which is higher than 6 dBi.

UNII-3

Channel	Frequency (MHz)	PSD (dBm/MHz)		Limit (dBm/MHz)
		ANT A	ANT B	
802.11a				
149	5745	9.17	9.65	28.54
157	5785	8.98	9.32	
165	5825	9.14	8.82	
802.11n20				
149	5745	8.91	8.29	28.54
157	5785	9.18	8.80	
165	5825	8.66	8.54	
802.11n40				
151	5755	6.27	6.42	28.54
159	5795	5.86	5.47	
802.11ac80				
155	5775	-0.09	2.25	28.54

Note 3: Limit is decreased by 1.46 dB since combined antenna gain is 7.46 dBi which is higher than 6 dBi.

11 FCC §15.407(b) & ISEDC RSS-247 §6.2: Undesirable Spurious Emissions and Band Edges

11.1 Applicable Standards

According to FCC §15.407(b), undesirable emission limits. Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

- (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 solely in the 5.725–5.850 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.

According to ISEDC RSS-247 §6.2.1.2, for transmitters with operating frequencies in the band 5150-5250 MHz, all emissions outside the band 5150-5350MHz shall not exceed -27 dBm/MHz e.i.r.p. Any unwanted emissions that fall into the band 5250-5350 MHz shall be attenuated below the channel power by at least 26 dB, when measured using a resolution bandwidth between 1 and 5% of the occupied bandwidth (i.e. 99% bandwidth), above 5250 MHz. The 26 dB bandwidth may fall into the 5250-5350 MHz band; however, if the occupied bandwidth also falls within the 5250-5350 MHz band, the transmission is considered as intentional and the devices shall comply with all requirements in the band 5250-5350 MHz including implementing dynamic frequency selection (DFS) and TPC, on the portion of the emission that resides in the 5250-5350 MHz band.

According to ISEDC RSS-247 §6.2.2.2, devices shall comply with the following:

- a. All emissions outside the band 5250-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p.; or
- b. All emissions outside the band 5150-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p. and its power shall comply with the spectral power density for operation within the band 5150-5250 MHz. The device, except devices installed in vehicles, shall be labelled or include in the user manual the following text “for indoor use only.”

According to ISEDC RSS-247 §6.2.3.2, Emissions outside the band 5470-5725 MHz shall not exceed -27 dBm/MHz e.i.r.p. However, devices with bandwidth overlapping the band edge of 5725 MHz can meet the emission limit of -27 dBm/MHz e.i.r.p. at 5850 MHz instead of 5725 MHz.

According to ISEDC RSS-247 §6.2.4.2, devices operating in the band 5725-5850 MHz with antenna gain greater than 10 dBi can have unwanted emissions that comply with either the limits in this section or in section 5.5 until six (6) months after the publication date of this standard for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale or sold after April 1, 2018.

Devices operating in the band 5725-5850 MHz with antenna gain of 10 dBi or less can have unwanted emissions that comply with either the limits in this section or in section 5.5 until April 1, 2018 for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale or sold after April 1, 2020.

Devices operating in the band 5725-5850 MHz shall have e.i.r.p. of unwanted emissions comply with the following:

27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 Bm/MHz at 5 MHz above or below the band edges;

15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;

10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to -27 dBm/MHz at 75 MHz above or below the band edges; and

-27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

11.2 Measurement Procedure

Span = wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation

RBW = 1 MHz

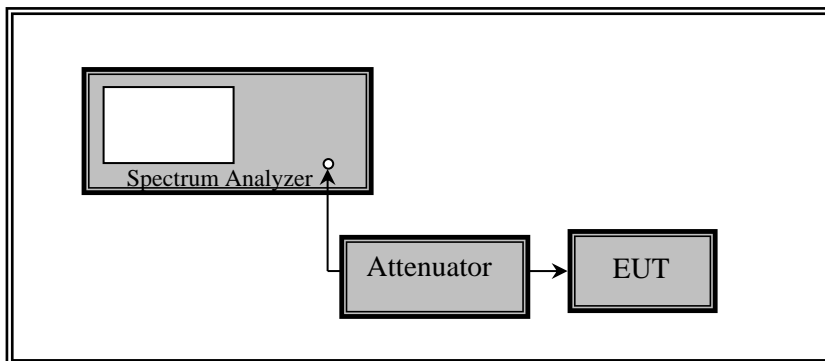
VBW = 3 MHz

Sweep = coupled

Detector function = peak

Trace = max hold

11.3 Test Setup Block Diagram



11.4 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time ¹	N/A
-	-	RF cable	-	-	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 the latest version of A2LA policy P102 “A2LA Policy on Metrological Traceability”.

11.5 Test Environmental Conditions

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

The testing was performed by Christian Schwartz from 2023-05-24 to 2023-06-06 in RF site.

11.6 Test Results

Please refer to Annex D – UNII-1, UNII-2A, UNII-2C, and UNII-3 for the Band Edges plots for detailed test results.

12 FCC §15.209, §15.407(b) & ISEDC RSS-247 §6.2 - Spurious Radiated Emissions

12.1 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.

(4) For transmitters operating in the 5.725-5.85 GHz band: All emissions within the frequency range from the band edge to 10 MHz above or below the band edge shall not exceed an e.i.r.p. of -17 dBm/MHz; for frequencies 10 MHz or greater above or below the band edge, emissions shall not exceed an e.i.r.p. of -27 dBm/MHz.

(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.

As per ISEDC RSS-247 §6.2

For transmitters operating in the band 5150-5250 MHz, all emissions outside the band 5150-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p. However, any unwanted emissions that fall into the band 5250- 5350 MHz must be 26 dBc, when measured using a resolution bandwidth between 1 and 5% of the occupied bandwidth, above 5.25 GHz. Otherwise, the transmission is considered as intentional and the devices shall implement dynamic frequency selection (DFS) and transmitter power control (TPC) as per the requirements for the band 5250-5350 MHz.

For devices with both operating frequencies and channel bandwidths contained within the band 5250-5350 MHz, the device shall comply with the following:

3. All emissions outside the band 5250-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p. if the equipment is intended for outdoor use; or
4. All emissions outside the band 5150-5350 MHz shall not exceed -27 dBm/MHz e.i.r.p. and any emissions within the band 5150-5250 MHz shall meet the power spectral density limits of Section 6.2.1. The device shall be labelled "for indoor use only."

For devices with operating frequencies in the band 5250-5350 MHz but having a channel bandwidth that overlaps the band 5150-5250 MHz, the devices' unwanted emission shall not exceed -27 dBm/MHz e.i.r.p. outside the band 5150-5350 MHz and its power shall comply with the spectral power density for operation within the band 5150-5250 MHz. The device shall be labelled "for indoor use only."

For transmitters operating in the band 5470-5725 MHz, emissions outside the band shall not exceed -27 dBm/MHz e.i.r.p.

For the band 5725-5850 MHz, emissions at frequencies from the band edges to 10 MHz above or below the band edges shall not exceed -17 dBm/MHz e.i.r.p. For emissions at frequencies more than 10 MHz above or below the band edges, the emissions power shall not exceed -27 dBm/MHz.

12.2 Test Procedure

The antenna-port methodology from ANSI C63.10: 2013 Section 12.1.2 was utilized as an alternative to radiated emissions in the restricted bands.

All in-band measurements in 12.2 through 12.6 are based on antenna-port conducted measurements. However, if antenna-port conducted tests cannot be performed on an EUT, then radiated tests are acceptable for determining compliance with the various conducted emission requirements. The guidance provided herein is applicable to either antenna-port conducted or radiated compliance measurements.

If a radiated test configuration is used, then the measured power or field strength levels shall be converted to equivalent conducted power levels for comparison with the applicable output power limit. This may be accomplished by first measuring the radiated field strength or power levels using an applicable methodology from 12.3 for maximum conducted power and from 12.5 for power spectral density. The radiated field strength or power level is converted to EIRP (see Annex G for guidance). The equivalent conducted output power or power spectral density is then determined by subtracting the EUT transmit antenna gain (guidance applicable to devices using MIMO or beamforming technologies is provided in Clause 13 or Clause 14, respectively) from the EIRP (assuming logarithmic representation). All calculations and parameter assumptions shall be provided in the test report.

For Peak Measurement:

12.7.6 Procedure for peak unwanted emissions measurements above 1000 MHz

The procedure for peak unwanted emissions measurements above 1000 MHz is as follows:

- a) Follow the requirements in 12.7.4.
- b) Peak emission levels are measured by setting the instrument as follows:
 - 1) RBW = 1 MHz.
 - 2) VBW $\geq [3 \times \text{RBW}]^{100}$
 - 3) Detector = peak.
 - 4) Sweep time = auto.
 - 5) Trace mode = max hold.
 - 6) Allow sweeps to continue until the trace stabilizes. Note that if the transmission is not continuous, then the time required for the trace to stabilize will increase by a factor of approximately $1 / D$, where D is the duty cycle. For example, at 50% duty cycle, the measurement time will increase by a factor of two, relative to measurement time for continuous transmission.

For Average Measurement:

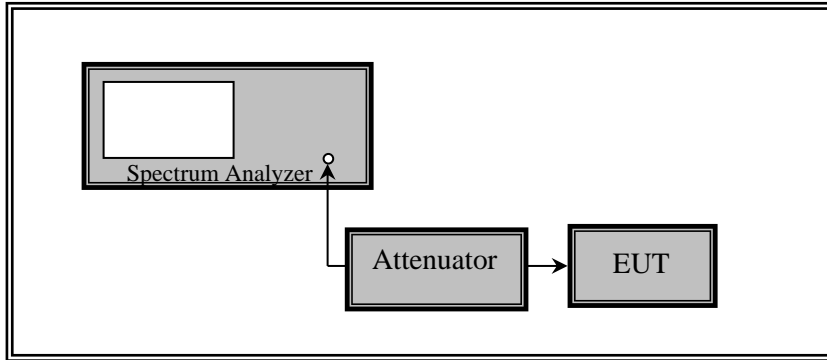
12.7.7.3 Method VB-A (Alternative)

Method VB-A is averaging using reduced video bandwidth. The procedure for this method is as follows:

- a) RBW = 1 MHz.
- b) Video bandwidth:
 - 1) If the EUT is configured to transmit with $D \geq 98\%$, then set $VBW \leq RBW / 100$ (i.e., 10 kHz), but not less than 10 Hz.
 - 2) If the EUT D is $< 98\%$, then set $VBW \geq 1 / T$, where T is defined in item a1) of 12.2.
- c) Video bandwidth mode or display mode:
 - 1) The instrument shall be set with video filtering applied in the power domain. Typically, this requires setting the detector mode to RMS (power averaging) and setting the average-VBW type to power (rms).
 - 2) As an alternative, the instrument may be set to linear detector mode. Video filtering shall be applied in linear voltage domain (rather than in a log or dB domain). Some instruments require linear display mode to accomplish this. Others have a setting for average-VBW type, which can be set to “voltage” regardless of the display mode.
- d) Detector = peak.
- e) Sweep time = auto.
- f) Trace mode = max hold.
- g) Allow max hold to run for at least 50 traces if the transmitted signal is continuous or has at least 98% duty cycle. For lower duty cycles, increase the minimum number of traces by a factor of $1/x$, where D is the duty cycle. For example, use at least 200 traces if the duty cycle is 25%. (If a specific emission is demonstrated to be continuous—i.e., 100% duty cycle—then rather than turning ON and OFF with the transmit cycle, at least 50 traces should be averaged.)

Note: for above average procedure, to meet VBW requirement both 10 kHz and 1 kHz were used depending on span of frequency being evaluated.

12.3 Test Setup Block Diagram



12.4 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E4440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time ¹	N/A
-	-	RF cable	-	-	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 the latest version of A2LA policy P102 “A2LA Policy on Metrological Traceability”.

12.5 Test Environmental Conditions

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

The testing was performed by Christian Schwartz from 2023-05-24 to 2023-06-06 in RF site.

12.6 Test Results

Please refer to Annex E – UNII-1, UNII-2A, UNII-2C, and UNII-3 for the Spurious Emissions plots for detailed test results.

13 FCC §15.407(h) & ISED RSS-247 §6.3 – Dynamic Frequency Selection

13.1 Applicable Standards

FCC CFR47 §15.407 (h), ISED RSS-247 §6.3, and KDB: 905462 D02 UNII DFS Compliance Procedures New Rules v02.

Table 1: Applicability of DFS requirements prior to use of a channel

Requirement	Operational Mode		
	Master	Client (Without radar detection)	Client (With radar detection)
Non-Occupancy Period	Yes	Not Required	Yes
DFS Detection Threshold	Yes	Not Required	Yes
Channel Availability Check Time	Yes	Not Required	Not Required
U-NII Detection Bandwidth	Yes	Not Required	Yes

Table 2: Applicability of DFS requirements during normal operation

Requirement	Operational Mode	
	Master Device or Client with Radar Detection	Client Without Radar Detection
DFS Detection Threshold	Yes	Not Required
Channel Closing Transmission Time	Yes	Yes
Channel Move Time	Yes	Yes
U-NII Detection Bandwidth	Yes	Not Required

Additional requirements for devices with multiple bandwidth modes	Master Device or Client with Radar Detection	Client Without Radar Detection
U-NII Detection Bandwidth and Statistical Performance Check	All BW modes must be tested	Not required
Channel Move Time and Channel Closing Transmission Time	Test using widest BW mode available	Test using the widest BW mode available for the link
All other tests	Any single BW mode	Not required
<p>Note: Frequencies selected for statistical performance check (Section 7.8.4) should include several frequencies within the radar detection bandwidth and frequencies near the edge of the radar detection bandwidth. For 802.11 devices it is suggested to select frequencies in each of the bonded 20 MHz channels and the channel center frequency.</p>		

Table 3: Interference Threshold for Master and Client with Radar Detection

Maximum Transmit Power	Value (See Notes 1, 2 and 3)
EIRP \geq 200 milliwatt	-64 dBm
EIRP $<$ 200 milliwatt and power spectral density $<$ 10dBm/MHz	-62 dBm
EIRP $<$ 200 milliwatt that do not meet the power spectral density requirement	-64 dBm

Note 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna.
Note 2: Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response.
Note 3: EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.

Table 4: DFS Response Requirement Values

Parameter	Value
Non-occupancy period	Minimum 30 minutes
Channel Availability Check Time	60 seconds
Channel Move Time	10 seconds <i>See Note 1.</i>
Channel Closing Transmission Time	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. <i>See Notes 1 and 2.</i>
U-NII Detection Bandwidth	Minimum 100% of the UNII 99% transmission power bandwidth. <i>See Note 3.</i>

Note 1: Channel Move Time and the Channel Closing Transmission Time should be performed with Radar Type 0. The measurement timing begins at the end of the Radar Type 0 burst.

Note 2: The Channel Closing Transmission Time is comprised of 200 milliseconds starting at the beginning of the Channel Move Time plus any additional intermittent control signals required to facilitate a Channel move (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.

Note 3: During the U-NII Detection Bandwidth detection test, radar type 0 should be used. For each frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.

Table 5: Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (Microseconds)	PRI (Microseconds)	Pulses	Minimum Percentage of Successful Detection	Minimum Number of Trials
0	1	1428	18	See Note 1	See Note 1
1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	Roundup $\left(\frac{1}{360} \right)$ $\left(\frac{19 \cdot 10^6}{PRI_{\mu sec}} \right)$	60%	30
		Test B: 15 unique PRI values randomly selected within the range of 518-3066 μsec , with a minimum increment of 1 μsec , excluding PRI values selected in Test A			
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120
Note 1: Short Pulse Radar Type 0 should be used for the detection bandwidth test, channel move time, and channel closing time tests.					

Table 6: Long Pulse Radar Test Signal

Radar Type	Bursts	Chirp Width (MHz)	PRI (usec)	Number of Pulses per Burst	Number of Bursts	Minimum Percentage of Successful Detection	Minimum Number of Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

Table 7: Frequency Hopping Radar Test Signal

Radar Type	Pulse Width (usec)	PRI (usec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Number of Trials
6	1	333	9	0.333	300	70%	30

According to ISED RSS-247 §6.3.1:

Devices shall employ a DFS radar detection mechanism to detect the presence of radar systems and to avoid co-channel operation with radar systems. The device must detect radar signals within its entire emission bandwidth. The minimum DFS radar signal detection threshold is described below in Table 1.

Table 1: DFS Detection threshold for master devices and client devices with radar detection	
Devices	DFS Threshold
Devices with an EIRP < 200 mW and power spectral density < 10dBm/MHz	-62 dBm
Devices with $200 \text{ mW} \leq \text{EIRP} \leq 1 \text{ W}$	-64 dBm
Note: The detection threshold power is the received power, averaged over a 1 microsecond reference to a 0 dBi antenna.	

According to ISED RSS-247 §6.3.2:

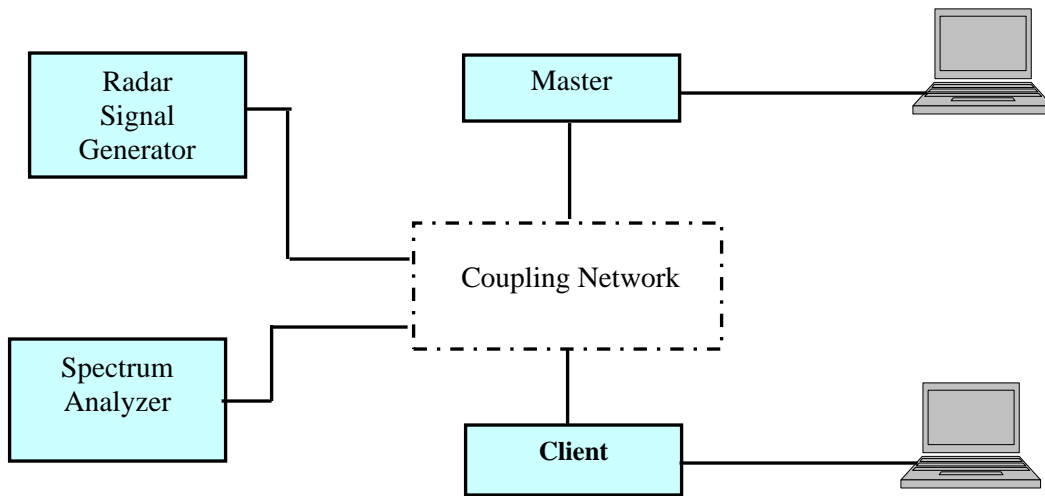
Devices shall comply with the following requirements, however, the requirement for in-service monitoring does not apply to client devices without radar detection.

- a. In-service monitoring: an LE-LAN device shall be able to monitor the operating channel to check that a co-channel radar has not moved or started operation within range of the LE-LAN device. During in-service monitoring, the LE-LAN radar detection function continuously searches for radar signals between normal LE-LAN transmissions.
- b. Channel availability check time: the device shall check whether there is a radar system already operating on the channel before it initiates a transmission on a channel and when it moves to a channel. The device may start using the channel if no radar signal with a power level greater than the interference threshold value specified in Section 6.3.1 above is detected within 60 seconds. This requirement only applies in the master operational mode.
- c. Channel move time: after a radar signal is detected, the device shall cease all transmissions on the operating channel within 10 seconds.
- d. Channel closing transmission time: is comprised of 200 ms starting at the beginning of the channel move time plus any additional intermittent control signals required to facilitate a channel move (an aggregate of 60 ms) over the remaining 10-second period of the channel move time.
- e. Non-occupancy period: a channel that has been flagged as containing a radar signal, either by a channel availability check or in-service monitoring, is subject to a 30-minute non-occupancy period where the channel cannot be used by the LE-LAN device. The non-occupancy period starts from the time that the radar signal is detected.

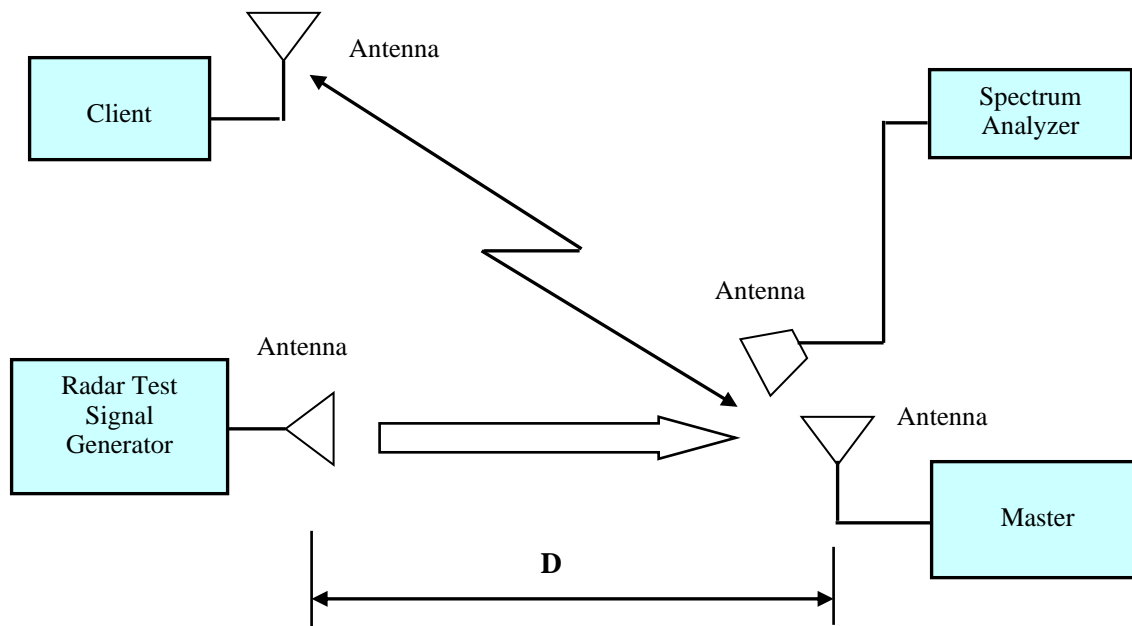
13.2 DFS Measurement System

BACL DFS measurement system consists of two subsystems: (1) The radar signal generating subsystem and (2) the traffic monitoring subsystem.

13.3 System Block Diagram



13.4 Radiated Method



13.5 Test Procedure

The EUT was connected to a certified master device (FCC ID: TE7C7V2, IC:8853A-C7). A spectrum analyzer was used as a monitor that verifies the EUT's status, which includes the Channel Closing Transmission Time, the Channel Move Time, and Non-occupancy Period.

BACL use type 0 radar signal to test the channel move time and channel closing transmission time.

The aggregate channel closing transmission time is calculated as follows:

Aggregate Transmission Time = N * Dwell Time

N is the number of spectrum analyzer bins showing a device transmission

Dwell Time is the dwell time per bin (i.e. Dwell Time = S/B, S is the sweep time and B is the number of bin, i.e. 8192)

13.6 Test Equipment List and Details

Bacl No.	Manufacturer	Equipment Description	Model	S/N	Calibration Date	Calibration Interval
688	Keysight Technologies	Vector Signal Generator	N5182B	MY51350070	2022-07-28	1 year
424	Agilent	Analyzer, Spectrum	E4440A	US45303156	2022-12-19	1 year
188	Sunol Sciences	Antenna, Horn	DRH-118	A052704	2021-10-07	2 years
110	A. H. Systems	Antenna, Horn	SAS-200/571	261	Each Time	Each Time
-	-	RF Cable	-	-	Each Time	Each Time

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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

13.7 Test Environmental Conditions

Temperature:	20° C
Relative Humidity:	30 %
ATM Pressure:	102.9 kPa

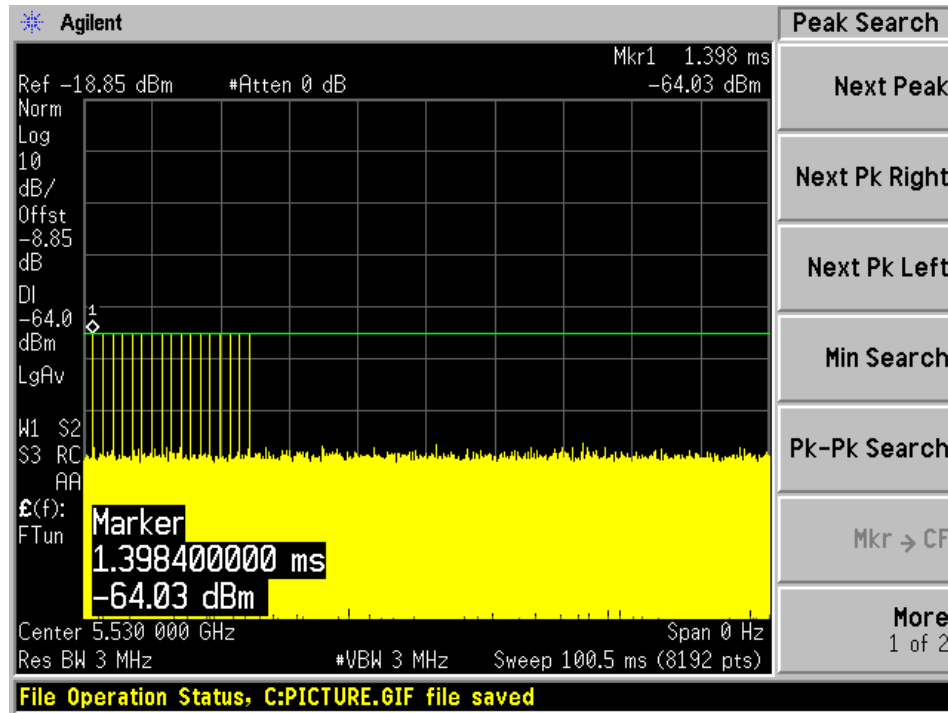
Testing was performed by Tao Jin on 2023-06-30 at the DFS testing site.

13.8 Test Results

Plots of Radar Waveforms

Radar Type 0

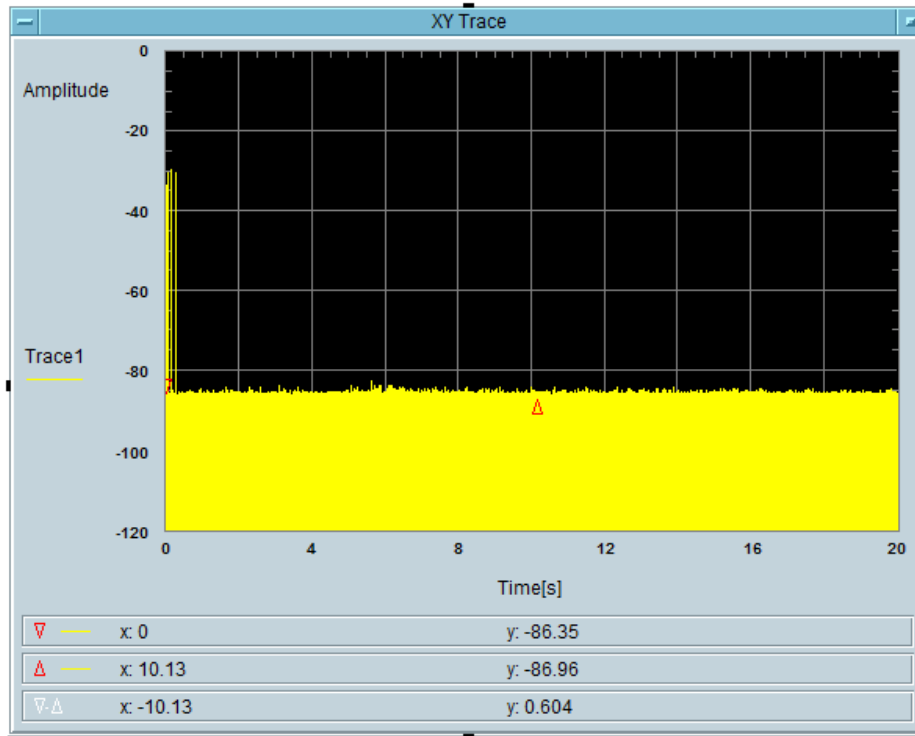
5530 MHz



Frequency (MHz)	Bandwidth (MHz)	Radar Type	Results
5530	80	Type 0	Compliant

5530 MHz 80 MHz Bandwidth

Type 0 radar channel move time less than 10s result:



Type 0 radar channel closing transmission time result:

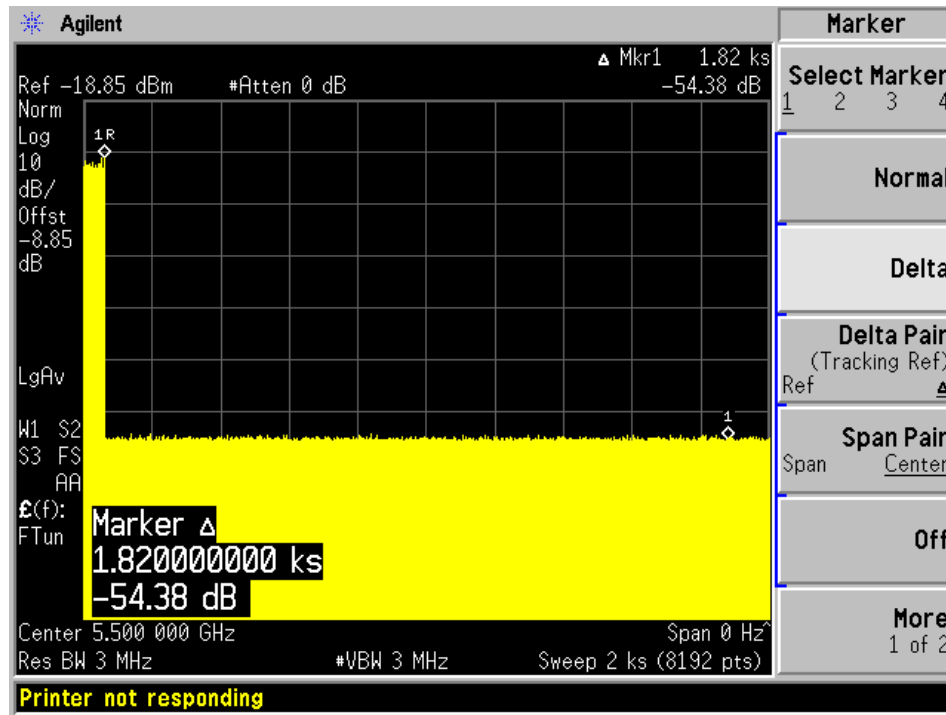
Channel closing transmitting time (ms)	Limit (ms)	Result
17.09+2.441	200	Pass

Total On Time [s]
17.09m

Total On Time After Delay [s]
2.441m

Non-occupancy Time

5530 MHz for 80 MHz channel bandwidth



Note: the communication between EUT and router was set to 5530 MHz and 80 MHz channel bandwidth. However, 5500 MHz is the primary channel that contains the control signal. Therefore, it was monitored for the non-occupancy period.

14 Annex F – EUT Test Setup Photographs

Please refer to the attachment.

15 Annex G –External Photographs

Please refer to the attachment.

16 Annex H –Internal Photographs

Please refer to the attachment.

17 Annex I (Normative) - A2LA Electrical Testing Certificate



Accredited Laboratory

A2LA has accredited

BAY AREA COMPLIANCE LABORATORIES CORP.

Sunnyvale, CA

for technical competence in the field of

Electrical Testing

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

Presented this 21st day of December 2022.



Mr. Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2024

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

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

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

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