FCC PART 15, SUBPART E

TEST REPORT

For

Roku, Inc.

1155 Coleman Avenue, San Jose, CA 95110, USA

FCC ID: TC2-R1023

Report Type:	**Model:**
Class II Permissive Change	9030X

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Report Number:	R2302152-407	
Report Date:	2023-03-23	
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ACCREDITED
CERTIFICATE #3297.02

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

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2302152-407	Class II Permissive Change	2023-03-20
1	R2302152-407	Update based on TCB review	2023-03-23

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: 9030X, 9020X, 100002419, FCC ID: TC2-R1023, or the "EUT" as referred to in this report. It is a Wi-Fi Speaker.

9030X, 9020X and 100002419 have been declared by manufacturer to be electrically identical and 9030X was selected for testing. Please refer to the manufacturer declaration of similarity letter in Annex H of this test report.

1.2 Mechanical Description of EUT

The EUT measures approximately: 190 (H), *100 (W), *100 (L) mm weighs approximately 1.8 kg

1.3 Objective

This report was prepared on behalf of *Roku, Inc* in accordance with FCC CFR47 §15.407.

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

This project is a Permissive Change II submission for the purpose of enabling DFS bands (5.3 GHz and 5.6GHz).

1.4 Related Submittal(s)/Grant(s)

N/A

1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard 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.

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Parameter	Measurement uncertainty
Occupied Channel Bandwidth	±5 %
RF output power, conducted	±0.57 dB
Power Spectral Density, conducted	±1.48dB
Unwanted Emissions, conducted	±1.57dB
All emissions, radiated	±4.0 dB
AC power line Conducted Emission	±2.0 dB
Temperature	±2 º C
Humidity	±5 %
DC and low frequency voltages	±1.0 %
Time	±2 %
Duty Cycle	±3 %

1.7 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.

1.8 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):
  - BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
  - NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
  - EMC Directive 2014/30/EU US-EU EMC & Telecom MRA CAB (NB)
  - Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
  - Low Voltage Directive (LVD) 2014/35/EU
- Hong Kong Special Administrative Region: (Office of the Telecommunications Authority – OFTA) APEC Tel MRA -Phase I & Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Media Development Authority - IMDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - Telecommunications Certification Body (TCB) – US FCC;
  - Nationally Recognized Test Laboratory (NRTL) – US OSHA
- Vietnam: APEC Tel MRA -Phase I;

2 EUT Test Configuration

2.1 Justification

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

The EUT was tested in a testing mode to represent worst-case results during the final qualification test.

The worst-case data rates are determined by measuring the average power, peak power and PPSD across all data rates bandwidths, and modulations.

2.2 EUT Exercise Software

The test software used was TeraTerm. The software is compliant with the standard requirements being tested against.

Please refer to the following power setting table.

5250MHz-5350MHz

Modulation	Frequency (MHz)	Power Setting	
		Ant A	Ant B
802.11a	5260	54	
	5300	54	
	5320	45	
802.11n/ac20	5260	39	
	5300	39	
	5320	32	

5470MHz-5725MHz

Modulation	Frequency (MHz)	Power Setting	
		Ant A	Ant B
802.11a	5500	45	
	5580	54	
	5700	40	
	5720	54	
802.11n/ac20	5500	46	
	5580	46	
	5700	46	
	5720	46	

*Data rates tested:
802.11a mode: 6 Mbps
802.11n/ac HT/VHT: MCS0

2.3 Duty Cycle Correction Factor

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

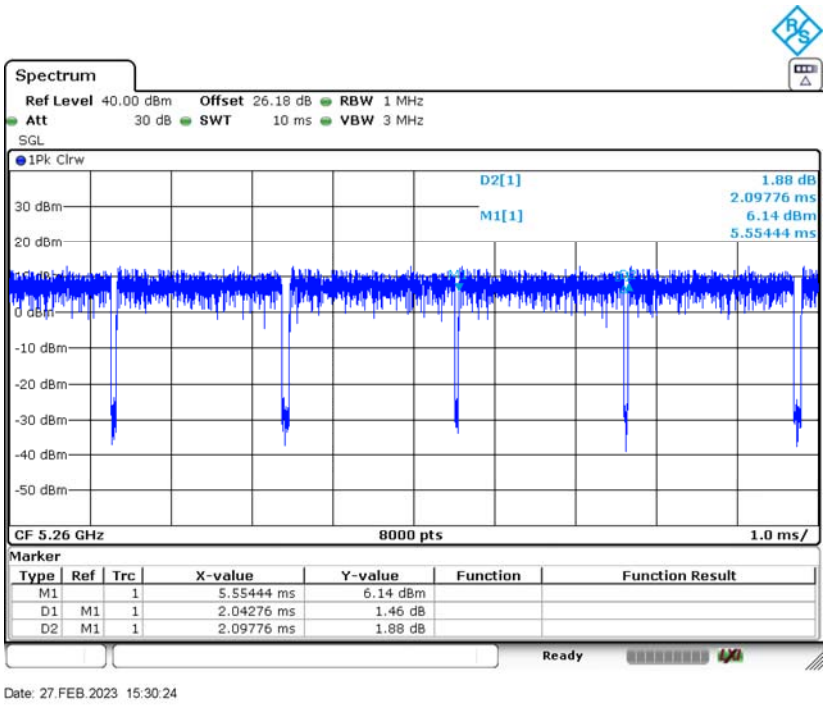
All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximum-power transmission duration, T, are required for each tested mode of operation.

Radio Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11a	2.032	2.4725	82%	0.86
802.11n/ac20	1.8919	2.1522	88%	0.55

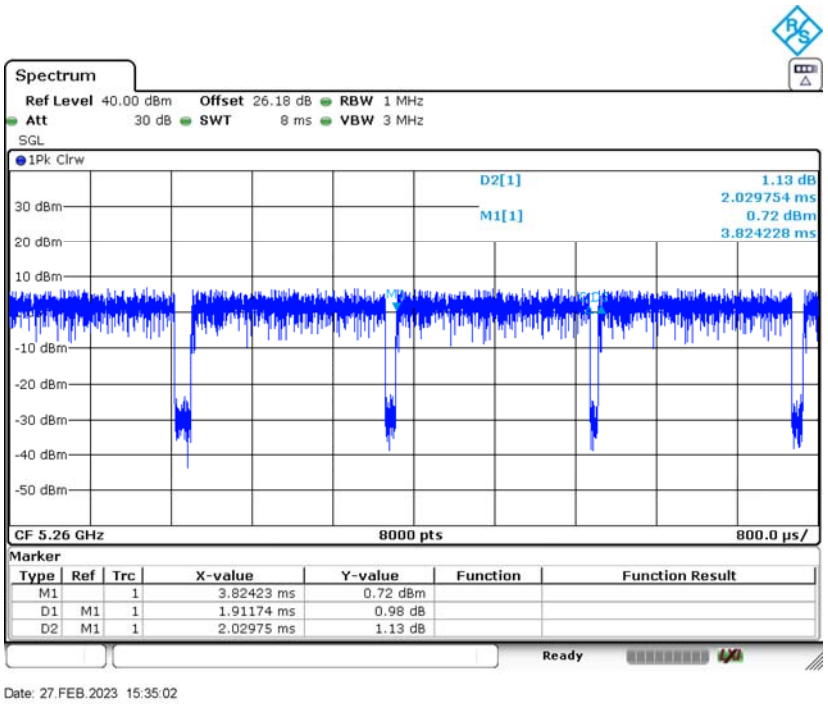
Note: Duty Cycle Correction Factor = 10*log(1/duty cycle)

Please refer to the following plots.

802.11a mode



802.11n20/ac20 mode



2.4 Equipment Modifications

N/A

2.5 Local Support Equipment

Manufacturer	Description	Model
Dell	Laptop	Latitude E6410
Dell	TV Monitor	S3221QS

2.6 Support Equipment

Manufacturer	Description	Model
Roku, Inc.	Debug Board	-

2.7 Interface Ports and Cabling

Cable Description	Length (m)	To	From
USB Cable	< 1 m	Laptop	EUT
HDMI Cable	0.5	EUT	Monitor
RF Cable	< 1 m	EUT	PSA

3 Summary of Test Results

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

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 §2.1091 & §15.407(f) - RF Exposure

4.1 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.[8] 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.[9]

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 its 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.

4.2 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 ERP20cm in Formula (B.1) [repeated from § 2.1091(c)(1) and § 1.1307(b)(1)(i)(B)].

$$P_{th}\,(\text{mW}) = ERP_{20\,\text{cm}}\,(\text{mW}) = 2040f \quad 0.3\ \text{GHz} \le f < 1.5\ \text{GHz}$$
$$P_{th}\,(\text{mW}) = ERP_{20\,\text{cm}}\,(\text{mW}) = 3060 \quad 1.5\ \text{GHz} \le f \le 6\ \text{GHz} \qquad \text{(B.1)}$$

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 λ/4 where the gain is not well defined, but always less than that of a half-wave dipole (length λ/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).

$$P_{th}\ (\text{mW}) = ERP_{20\ \text{cm}}\,(d/20\ \text{cm})^{x} \quad d \le 20\ \text{cm}$$
$$P_{th}\ (\text{mW}) = ERP_{20\ \text{cm}} \quad 20\ \text{cm} < d \le 40\ \text{cm} \qquad \text{(B.2)}$$

Where

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

and f is in GHz, d is the separation distance (cm), and EPR20cm 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

4.3 RF exposure evaluation exemption for FCC

5GHz Wifi:

Prediction frequency (GHz)	5.500
Maximum output power (dBm)	21.18
Maximum ERP (dBm)	25.53
Maximum ERP (mW)	357.3
Prediction distance (cm)	20
Maximum antenna gain (dBi)	6.5
1500 MHz ≤ f < 10000 MHz	Option C Exemption Threshold
	P_{th} (W)
	$19.2R^2 = 0.768$

As shown in the table above, the EUT's Max ERP is lower than the Exemption Threshold. . RF Exposure evaluation for this device is exempted.

Worst Case Colocation Bluetooth and 5 GHz Wi-Fi:

Frequency Band	Max Conducted Power(dBm)	Evaluated Distance (cm)	ERP (mW)	ERP Threshold (mW)	Ratios	Sum of Ratios	Limit
Worst Case							
Bluetooth	12.87	20	23.50	768	3.1%	49.6%	100%
5 GHz Wi-Fi	21.18	20	357.3	768	46.5%		

Note: BT data referenced from report number R1808081-247 DTS issued by BACL on 2018-09-17

5 FCC §15.203 - Antenna Requirements

5.1 Applicable Standards

According to FCC §15.203:

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

And according to FCC §15.247 (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.

5.2 Antenna List

The antennas used by the EUT are permanent attached antennas.

Antenna usage	Frequency Range (MHz)	Maximum Antenna Gain (dBi)
BT Antenna	2400-2500	2.99
WiFi Antenna 1	5250-5750	3.17
Wifi Antenna 2	5250-5750	3.77

6 FCC §15.207 - AC Power Line Conducted Emissions

6.1 Applicable Standards

As per FCC §15.207

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

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

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

6.2 Test Setup

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

External I/O cables were draped along the edge of the test table and bundle when necessary.
The AC/DC power adapter of the EUT was connected with LISN-1 which provided 120 V / 60 Hz AC power.

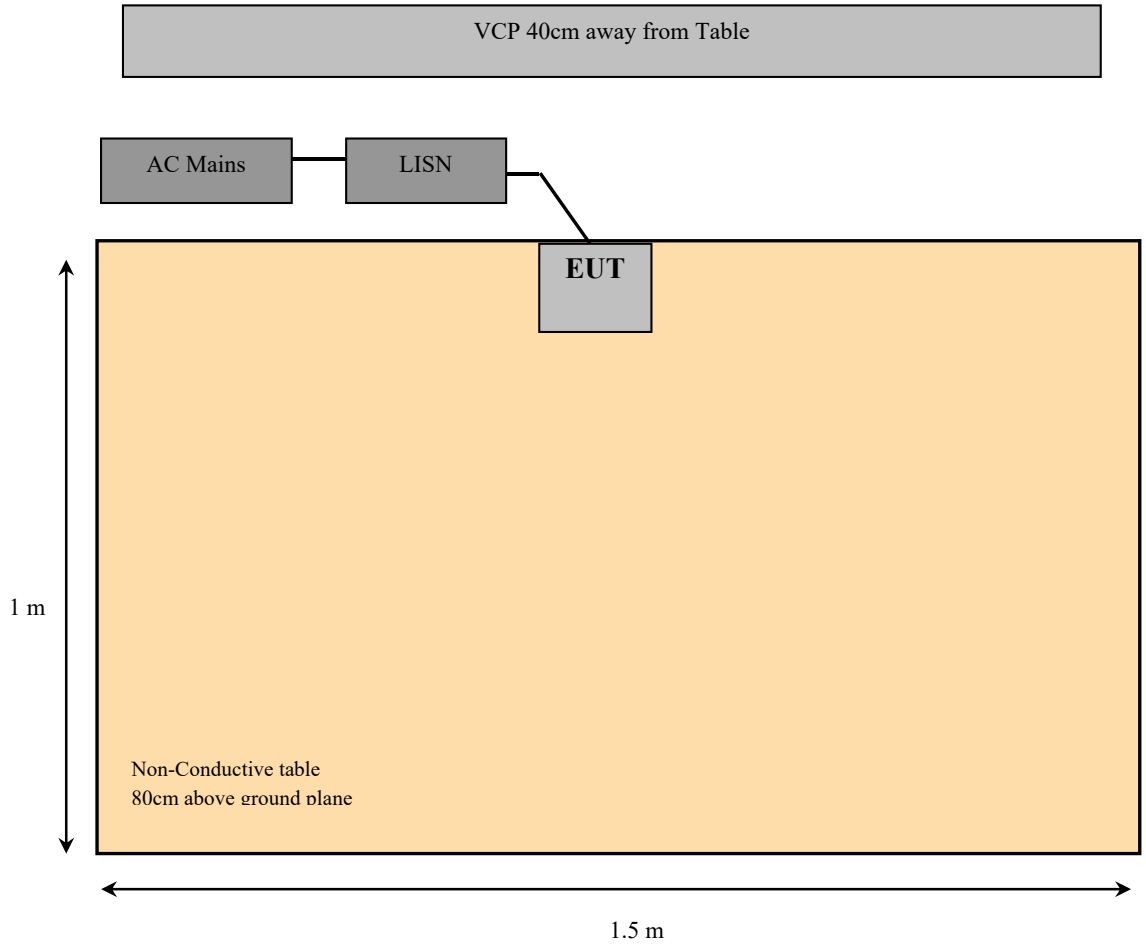
6.3 Test Procedure

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

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

All data was 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 Test Setup Block Diagram



6.5 Corrected Amplitude and Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the Correction Factor (CF) to indicated Amplitude (Ai) reading. The basic equation is as follows:

CA = Ai + CF

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Correction Factor (13.7 dB)

The Correction Factor is calculated by adding Cable loss (CL), LISN calibration factor, and attenuation of the impulse limiter and the high pass filter. The basic equation is as follows:

CF= CL + LISN calibration factor + Attenuation

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Cable Loss (3.5 dB) + LISN calibration factor (0.2 dB) + Attenuator (10 dB)

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

Margin = Corrected Amplitude - Limit

6.6 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
124	Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100044	2021-05-14	2 years
681	Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101962	2022-09-12	1 year
725	Solar Electronics Company	High Pass Filter	Type 7930-100	7930150203	2022-03-18	1 year
732	FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2022-09-01	1 year
1226	Fairview Microwave	Coaxial Cable	PE3C2220-1250CM	2109241	2022-09-12	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:	20º C
Relative Humidity:	55 %
ATM Pressure:	102.1 kPa

The testing was performed by Kevin Nguyen on 2023-03-15 in the Ground Plane test site.

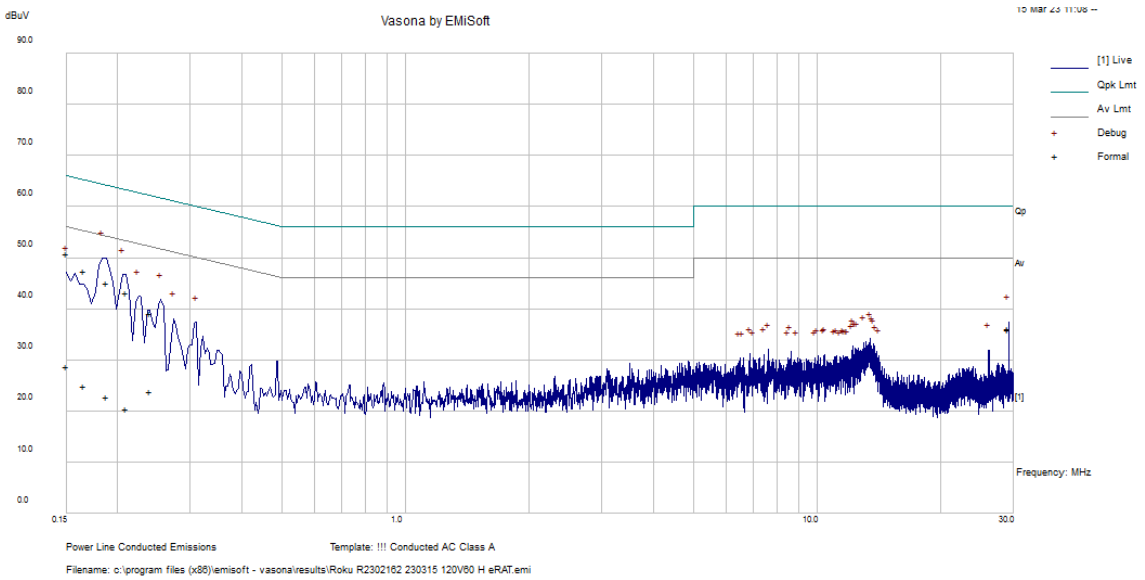
6.8 Summary of Test Results

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

Connection: 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-13.73	29.183852	Neutral	0.15-30

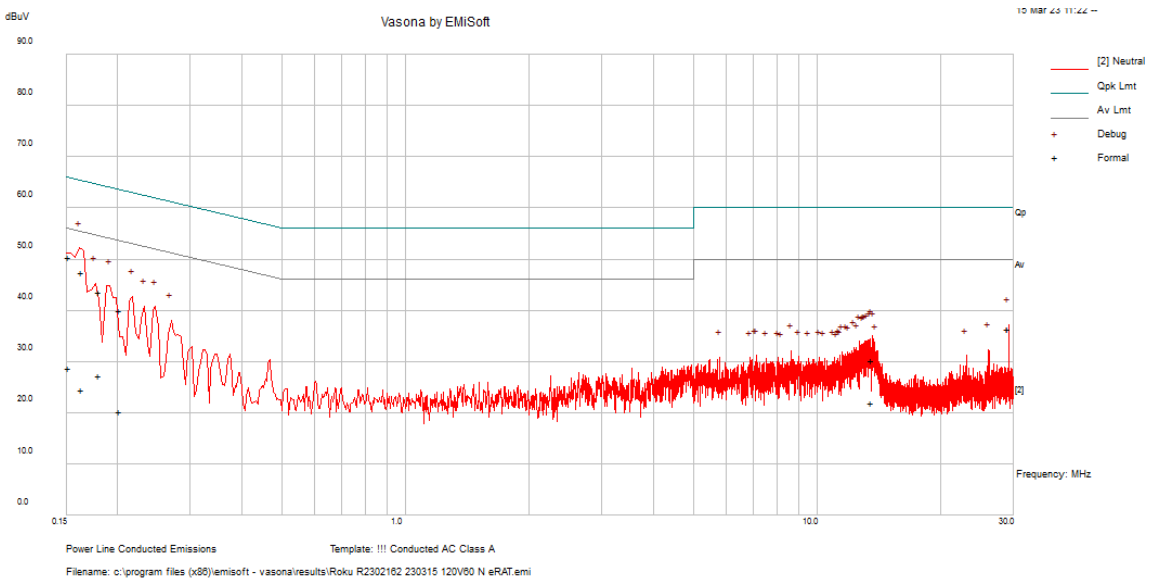
6.9 Conducted Emissions Test Plots and Data

120 V, 60 Hz – Line



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.16562	36.42	11	47.42	65.18	-17.76	QP
0.150224	39.94	10.99	50.93	65.99	-15.06	QP
0.188567	34.03	11	45.03	64.1	-19.07	QP
29.183636	25.1	10.96	36.06	60	-23.94	QP
0.209204	32.16	10.98	43.14	63.24	-20.1	QP
0.23947	28.19	10.96	39.15	62.11	-22.96	QP
0.16562	13.89	11	24.89	55.18	-30.29	Ave
0.150224	17.78	10.99	28.77	55.99	-27.22	Ave
0.188567	11.77	11	22.77	54.1	-31.33	Ave
29.183636	24.97	10.96	35.93	50	-14.07	Ave
0.209204	9.54	10.98	20.52	53.24	-32.72	Ave
0.23947	12.97	10.96	23.93	52.11	-28.18	Ave

120 V, 60 Hz – Neutral



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.152591	39.39	10.99	50.38	65.86	-15.48	QP
0.163809	36.44	11	47.44	65.27	-17.83	QP
0.180769	32.68	10.98	43.66	64.45	-20.79	QP
29.183852	25.43	10.96	36.39	60	-23.61	QP
0.202623	28.95	10.98	39.93	63.5	-23.57	QP
13.597936	19.83	10.32	30.15	60	-29.85	QP
0.152591	17.7	11	28.7	55.86	-27.16	Ave
0.163809	13.41	11	24.41	55.27	-30.86	Ave
0.180769	16.16	10.99	27.15	54.45	-27.3	Ave
29.183852	25.31	10.96	36.27	50	-13.73	Ave
0.202623	9.22	10.99	20.21	53.5	-33.29	Ave
13.597936	11.51	10.32	21.83	50	-28.17	Ave

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

7.1 Applicable Standard

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

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

As per FCC §15.209: The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100 Note 1	3
88 - 216	150 Note 1	3
216 - 960	200 Note 1	3
Above 960	500	3

Note 1: Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per FCC Part 15.407 (b)

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

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

(3) For transmitters operating in the 5.47 -5.725 GHz band: All emissions outside of the 5.47-5725 GHz band shall not exceed an ei.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 noet 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.

7.2 Test Setup

The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the FCC 15.407 limits.

The spacing between the peripherals was 10 centimeters.

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

7.3 Test Procedure

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

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

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

The spectrum analyzer or receiver is set as:

Below 1000 MHz:

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

Above 1000 MHz:

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

7.4 Corrected Amplitude and Margin Calculation

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

CA = Ai + AF + CL + Atten – Ga

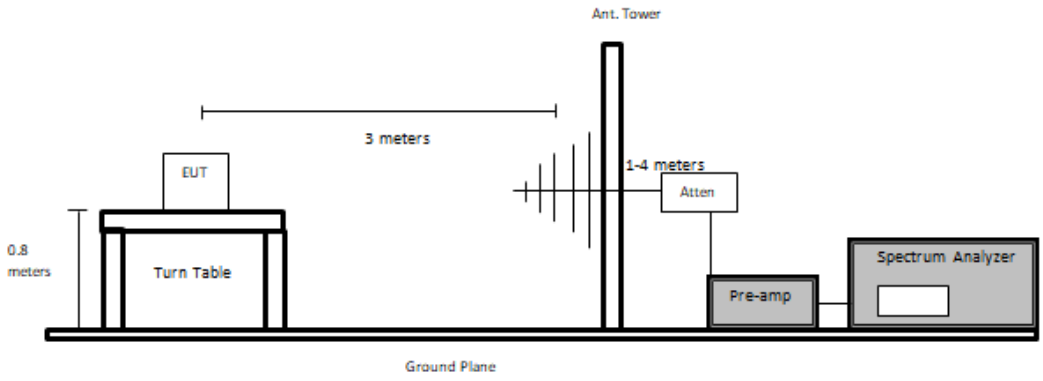
For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

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

Margin = Corrected Amplitude – Limit

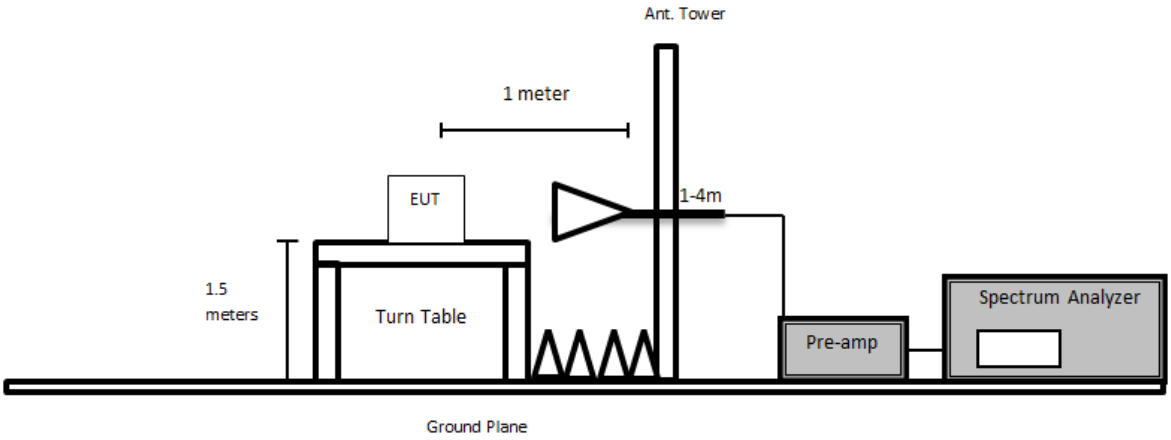
7.5 Test Setup Block Diagram

Below 1 GHz:

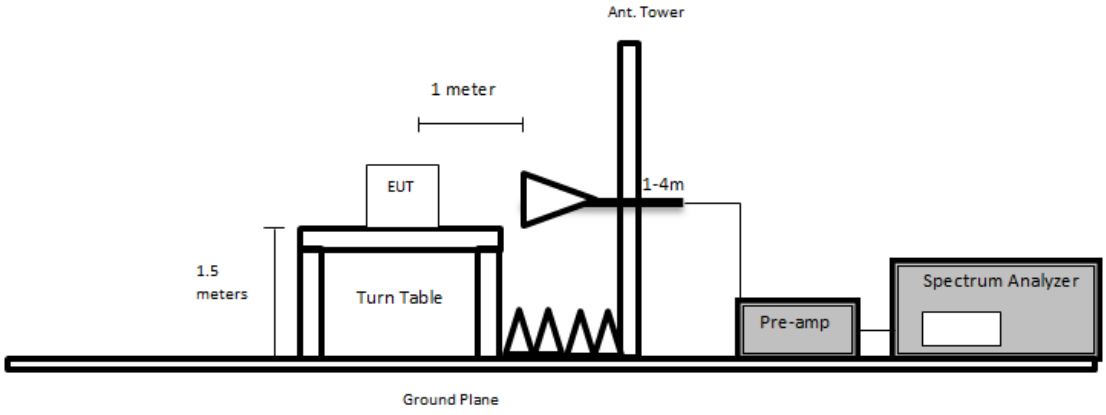


Above 1 GHz:

Using Asset #1192



Using Asset #91&#230



7.6 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
124	Rhode & Schwarz	EMI Test Receiver	ESCI 1166.5950 K03	100044	2021-05-14	2 years
287	HP/Agilent	PSA spectrum analyzer 3HZ to 44 GHZ	E4446A	US44300386	2022-05-05	1 year
424	Agilent	Spectrum Analyzer	E4440A	US45303156	2022-12-19	1 year
655	Rohde & Schwarz	Signal Analyzer	FSQ26	200749	2022-02-07	2 years
327	Sunol Science Corp	System Controller	SC110V	122303-1	N/R	N/A
316	Sonoma Instruments	Preamplifier 10 kHz - 2.5 GHz	317	260406	2022-05-12	1 year
658	HP/Agilent	Pre-Amplifier	8449B OPT HO2	3008A01103	2022-07-22	1 year
827	AH Systems	Preamplifier	PAM 1840 VH	170	2022-06-21	1 year
91	Wisewave	Antenna, Horn	ARH-4223-02	10555-02	2022-03-08	2 years
230	Wisewave	Antenna, Horn	ARH-2823-02	10555-02	2022-03-08	2 years
321	Sunol Sciences	Biconilog Antenna	JB3	A020106-2; 1504	2021-11-22	2 years
1192	ETS Lindgren	Horn Antenna	3117	00218973	2022-29-09	2 years
1186	Pasternack	Coaxial Cable, RG214	PE3062-1050CM	1	2022-09-26	1 year
1247	Uti flex	Micro - Coax	-	-	2022-07-22	1 year
1248	Pasternack	RG214 COAX Cable	PE3062	-	2022-04-12	1 year
1249	Time Microwave	LMR-400 Cable Dc-3 Ghz	AE13684	2k80612-5 6fts	2022-04-12	1 year
1295	Carlisle	10m Ultra Low Loss Coaxial Cable	UFB142A-1-3937-200200	64639890912-001	2022-10-28	6 months
1328	Centric RF	2.92mm short coaxial cable	C547-107-12B	CW10S34123	2022-12-14	6 months
387	Micro-Tronics	5150-5350 MHz Notch Filter	BRC50703	006	2022-03-31	1 year
389	Micro-Tronics	5.6 GHz Notch Filter	BRC 50704	003	2022-06-13	1 year
1245	-	6dB Atennuator	PE7390-6	01182018A	2022-11-22	1 year
1246	HP	RF Limiter	11867A	01734	2022-04-12	1 year
-	Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Note[1]: equipment 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".*

7.7 Test Environmental Conditions

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

The testing was performed by Deeapk Mishra and Arturo Reyes from 2023-02-24 to 2023-03-17 in 5m chamber 3.

7.8 Summary of Test Results

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

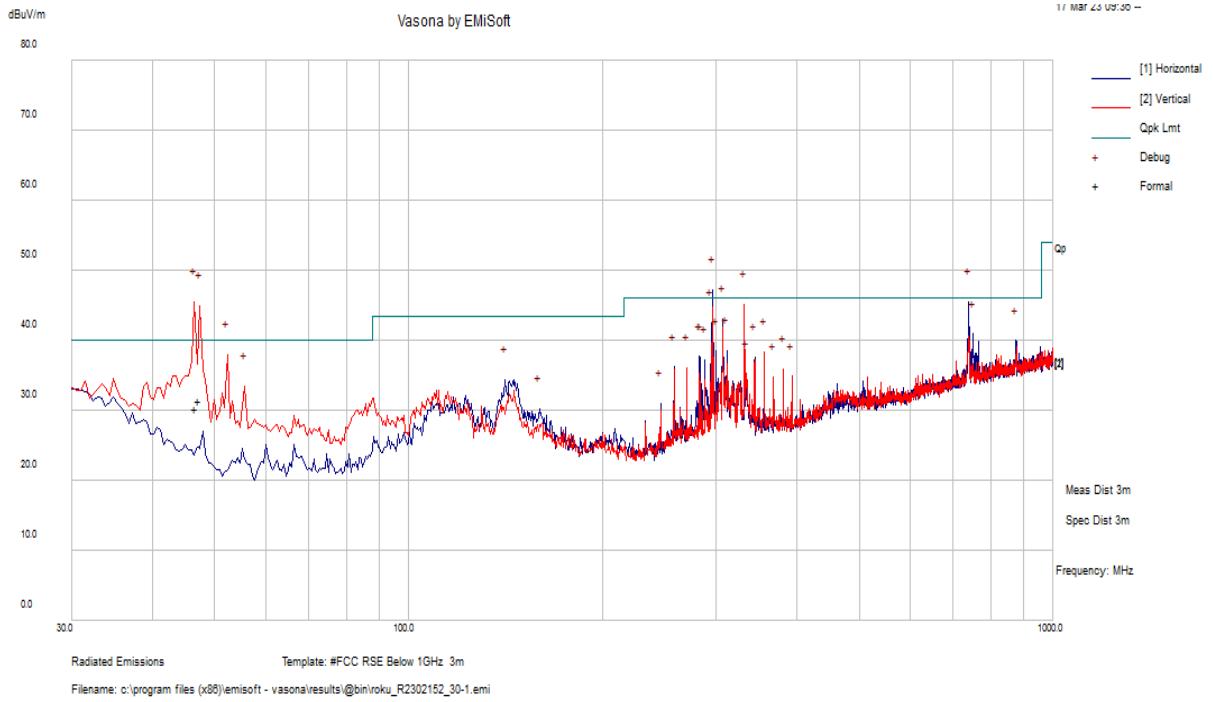
Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Mode, Channel**
-0.307	5470	Horizontal	802.11n/ac20 mode, MIMO, 5500 MHz

Please see following plots and data tables.

7.9 Radiated Emissions Test Result Data

1) 30 MHz – 1 GHz at 3 meters

Worst Case scan:



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)	Comment
46.6765	41.86	-11.57	30.29	113	V	115	40	-9.7	QP
47.31475	43.29	-11.84	31.45	130	V	96	40	-8.55	QP
296.7065	53.14	-7.45	45.69	101	H	276	46	-0.31	QP
739.6195	34.8	1.73	36.53	170	H	169	46	-9.46	QP
331.7825	52.6	-6.93	45.67	173	V	17	46	-0.33	QP
52.44275	37.78	-13.35	24.43	101	V	289	40	-15.57	QP

FCC Limits for 1 GHz to 40 GHz				
Applicablity	**(dBm)**	**(uV/m at 3meters)**	**(dBuV/m at 3meters)**	**(dBuV/m at 1meter)[2]**
Restricted Band Average Limit	-	500	54	64
Restricted Band Peak Limit[1]	-	-	74	84
FCC §15.407(b) Defined Unwanted Emissions Limit	-27	-	68	78

Note[1]: Restricted Band Peak Limit is defined to be 20dB higher than Average Limit.
Note[2]: Limits at 1 meter are determined by applying a Distance correction factor accounts for extrapolation from 1 meters to 3 meters. Formula used is as follows: 20*log(3meters/1meter) = 9.54 (According to ANSI C63.10-2013 Section 9.4)
Note[3]: Where Restricted Band Peak Limit is replaced with stricter 78 dBµV/m at 1 meter, compliance is being shown for unwmated emissions per FCC §15.407(b)

2) 1 – 18 GHz measured at 1 meter

5250 - 5350 MHz

802.11a mode, Antenna A

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel: 5260 MHz											
10520	57.590	48	243	H	38.30	11.16	36.31	70.730	78	-7.270	Peak
10520	48.286	48	243	H	38.30	11.16	36.31	61.426	64	-2.574	Ave
15780	48.580	184	115	H	41.92	15.94	36.74	69.701	84	-14.299	Peak
15780	38.604	184	115	H	41.92	15.94	36.74	59.725	64	-4.275	Ave
Middle Channel: 5280 MHz											
10560	58.160	57	156	H	38.37	11.11	36.23	71.421	78	-6.579	Peak
10560	48.497	57	156	H	38.37	11.11	36.23	61.758	64	-2.242	Ave
15840	49.260	234	145	H	41.68	15.41	36.76	69.593	84	-14.407	Peak
15840	39.279	234	145	H	41.68	15.41	36.76	59.612	64	-4.388	Ave
High Channel: 5320 MHz											
5350	70.670	241	196	H	36.088	7.580	36.650	77.688	78	-0.312	Peak
5350	55.266	241	196	H	36.088	7.580	36.650	62.284	64	-1.716	Ave
10640	57.600	31	232	H	38.473	11.067	36.205	70.935	84	-13.065	Peak
10640	46.357	31	232	H	38.473	11.067	36.205	59.692	64	-4.308	Ave
15960	50.385	180	204	H	41.758	14.913	36.531	70.525	84	-13.475	Peak
15960	39.273	180	204	H	41.758	14.913	36.531	59.413	64	-4.587	Ave

5250 - 5350 MHz

802.11a mode, Antenna B

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel: 5260 MHz											
10520	47.770	20	152	H	38.30	11.16	36.31	60.910	78	-17.090	Peak
10520	37.658	20	152	H	38.30	11.16	36.31	50.798	64	-13.202	Ave
15780	49.590	202	229	H	41.92	15.94	36.74	70.711	84	-13.289	Peak
15780	39.278	202	229	H	41.92	15.94	36.74	60.399	64	-3.601	Ave
Middle Channel: 5280 MHz											
10560	47.670	307	194	H	38.37	11.11	36.23	60.931	78	-17.069	Peak
10560	37.478	307	194	H	38.37	11.11	36.23	50.739	64	-13.261	Ave
15840	49.490	71	151	H	41.68	15.41	36.76	69.823	84	-14.177	Peak
15840	39.350	71	151	H	41.68	15.41	36.76	59.683	64	-4.317	Ave
High Channel: 5320 MHz											
5350	48.460	83	282	H	36.09	7.58	36.65	55.478	78	-22.522	Peak
5350	37.265	83	282	H	36.09	7.58	36.65	44.283	64	-19.717	Ave
10640	47.750	321	173	H	38.47	11.07	36.21	61.085	84	-22.915	Peak
10640	37.361	321	173	H	38.47	11.07	36.21	50.696	64	-13.304	Ave
15960	50.187	180	204	H	41.76	14.91	36.53	70.327	84	-13.673	Peak
15960	38.718	180	204	H	41.76	14.91	36.53	58.858	64	-5.142	Ave

802.11n/ac20 mode, MIMO

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel: 5260 MHz											
10520	48.100	263	149	H	38.30	11.16	36.31	61.240	78	-16.760	Peak
10520	38.021	263	149	H	38.30	11.16	36.31	51.161	64	-12.839	Ave
15780	49.400	40	172	H	41.92	15.94	36.74	70.521	84	-13.479	Peak
15780	38.632	40	172	H	41.92	15.94	36.74	59.753	64	-4.247	Ave
Middle Channel: 5280 MHz											
10560	53.330	23	269	H	38.37	11.11	36.23	66.591	78	-11.409	Peak
10560	41.360	23	269	H	38.37	11.11	36.23	54.621	64	-9.379	Ave
15840	49.490	80	275	H	41.68	15.41	36.76	69.823	84	-14.177	Peak
15840	39.734	80	275	H	41.68	15.41	36.76	60.067	64	-3.933	Ave
High Channel: 5320 MHz											
5350	47.470	238	256	H	36.09	7.58	36.65	54.488	78	-23.512	Peak
5350	37.195	238	256	H	36.09	7.58	36.65	44.213	64	-19.787	Ave
10640	45.990	309	166	H	38.47	11.07	36.21	59.325	84	-24.675	Peak
10640	36.586	309	166	H	38.47	11.07	36.21	49.921	64	-14.079	Ave
15960	49.320	306	191	H	41.76	14.91	36.53	69.460	84	-14.540	Peak
15960	39.110	306	191	H	41.76	14.91	36.53	59.250	64	-4.750	Ave

5470 - 5725 MHz

802.11a mode, Antenna A

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel: 5500 MHz											
5470	62.510	298	170	H	36.22	7.66	36.63	69.763	78	-8.237	Peak
5470	55.533	298	170	H	36.22	7.66	36.63	62.786	64	-1.214	Ave
11000	56.170	313	257	H	38.47	11.28	35.98	69.943	84	-14.057	Peak
11000	45.441	313	257	H	38.47	11.28	35.98	59.214	64	-4.786	Ave
16500	49.670	344	180	H	42.34	13.97	35.87	70.114	78	-7.886	Peak
16500	38.581	344	180	H	42.34	13.97	35.87	59.025	64	-4.975	Ave
Middle Channel: 5580 MHz											
11160	53.631	337	163	H	38.38	11.39	35.87	67.536	84	-16.464	Peak
11160	42.606	337	163	H	38.38	11.39	35.87	56.511	64	-7.489	Ave
16740	49.100	132	281	H	42.51	14.65	35.61	70.651	78	-7.349	Peak
16740	38.666	132	281	H	42.51	14.65	35.61	60.217	64	-3.783	Ave
High Channel: 5700 MHz											
5725	70.207	53	148	H	35.61	7.84	36.69	76.969	78	-1.031	Peak
5725	53.357	53	148	H	35.61	7.84	36.69	60.119	64	-3.881	Ave
11400	48.380	8	234	H	38.57	11.43	35.89	62.493	84	-21.507	Peak
11400	37.234	8	234	H	38.57	11.43	35.89	51.347	64	-12.653	Ave
17100	49.180	12	231	H	42.15	15.92	35.98	71.258	78	-6.742	Peak
17100	38.392	12	231	H	42.15	15.92	35.98	60.470	64	-3.530	Ave
High Channel: 5720 MHz											
11440	49.358	8	234	H	38.57	11.43	35.89	63.471	84	-20.529	Peak
11440	37.500	8	234	H	38.57	11.43	35.89	51.613	64	-12.387	Ave
17160	50.873	12	231	H	42.15	15.92	35.98	72.951	78	-5.049	Peak
17160	39.058	12	231	H	42.15	15.92	35.98	61.136	64	-2.864	Ave

802.11a mode, Antenna B

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel: 5500 MHz											
5470	48.440	50	255	H	36.22	7.66	36.63	55.693	78	-22.307	Peak
5470	37.921	50	255	H	36.22	7.66	36.63	45.174	64	-18.826	Ave
11000	48.280	70	120	H	38.47	11.28	35.98	62.053	84	-21.947	Peak
11000	37.451	70	120	H	38.47	11.28	35.98	51.224	64	-12.776	Ave
16500	48.760	28	151	H	42.34	13.97	35.87	69.204	78	-8.796	Peak
16500	38.308	28	151	H	42.34	13.97	35.87	58.752	64	-5.248	Ave
Middle Channel: 5580 MHz											
11160	47.150	296	228	H	38.38	11.39	35.87	61.055	84	-22.945	Peak
11160	37.858	296	228	H	38.38	11.39	35.87	51.763	64	-12.237	Ave
16740	48.440	84	233	H	42.51	14.65	35.61	69.991	78	-8.009	Peak
16740	38.140	84	233	H	42.51	14.65	35.61	59.691	64	-4.309	Ave
High Channel: 5700 MHz											
5725	48.170	166	202	H	35.61	7.84	36.69	54.932	78	-23.068	Peak
5725	37.749	166	202	H	35.61	7.84	36.69	44.511	64	-19.489	Ave
11400	46.900	25	161	H	38.57	11.43	35.89	61.013	84	-22.987	Peak
11400	36.348	25	161	H	38.57	11.43	35.89	50.461	64	-13.539	Ave
17100	49.600	288	125	H	42.15	15.92	35.98	71.678	78	-6.322	Peak
17100	38.541	288	125	H	42.15	15.92	35.98	60.619	64	-3.381	Ave
High Channel: 5720 MHz											
11440	47.287	25	161	H	38.57	11.43	35.89	61.400	84	-22.600	Peak
11440	36.706	25	161	H	38.57	11.43	35.89	50.819	64	-13.181	Ave
17160	50.348	288	125	H	42.15	15.92	35.98	72.426	78	-5.574	Peak
17160	39.905	288	125	H	42.15	15.92	35.98	61.983	64	-2.017	Ave

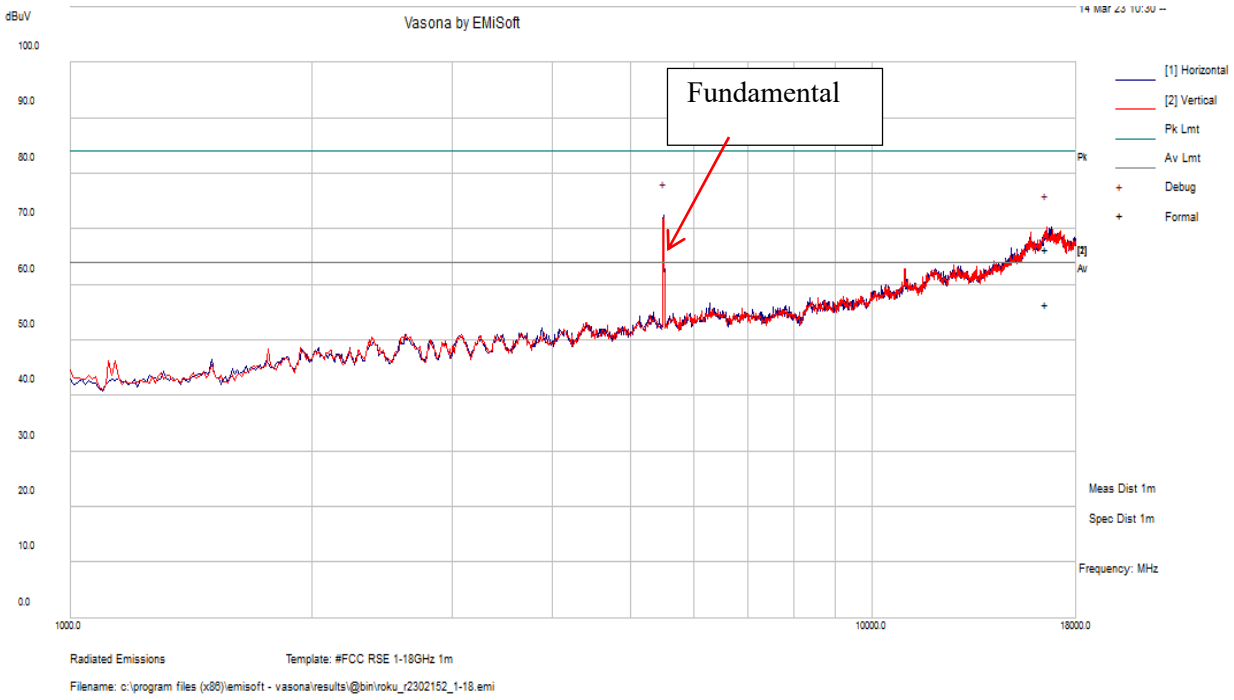
5470 - 5725 MHz

802.11n/ac20 mode, MIMO

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel: 5500 MHz											
5470	70.440	292	196	H	36.22	7.66	36.63	77.693	78	-0.307	Peak
5470	51.955	292	196	H	36.22	7.66	36.63	59.208	64	-4.792	Ave
11000	53.100	313	267	H	38.47	11.28	35.98	66.873	84	-17.127	Peak
11000	40.961	313	267	H	38.47	11.28	35.98	54.734	64	-9.266	Ave
16500	49.130	195	182	H	42.34	13.97	35.87	69.574	78	-8.426	Peak
16500	38.566	195	182	H	42.34	13.97	35.87	59.010	64	-4.990	Ave
Middle Channel: 5580 MHz											
11160	52.230	316	110	H	38.38	11.39	35.87	66.135	84	-17.865	Peak
11160	41.343	316	110	H	38.38	11.39	35.87	55.248	64	-8.752	Ave
16740	48.630	21	213	H	42.51	14.65	35.61	70.181	78	-7.819	Peak
16740	38.471	21	213	H	42.51	14.65	35.61	60.022	64	-3.978	Ave
High Channel: 5700 MHz											
5725	64.290	57	156	H	35.61	7.84	36.69	71.052	78	-6.948	Peak
5725	51.022	57	156	H	35.61	7.84	36.69	57.784	64	-6.216	Ave
11400	51.520	303	133	H	38.57	11.43	35.89	65.633	84	-18.367	Peak
11400	40.546	303	133	H	38.57	11.43	35.89	54.659	64	-9.341	Ave
17100	49.310	288	125	H	42.145	15.915	35.982	71.388	78	-6.612	Peak
17100	38.105	288	125	H	42.145	15.915	35.982	60.183	64	-3.817	Ave
High Channel: 5720 MHz											
11440	51.892	303	133	H	38.57	11.43	35.89	66.005	84	-17.995	Peak
11440	40.609	303	133	H	38.57	11.43	35.89	54.722	64	-9.278	Ave
17160	50.264	288	125	H	42.145	15.915	35.982	72.342	78	-5.658	Peak
17160	38.539	288	125	H	42.145	15.915	35.982	60.617	64	-3.383	Ave

3) 1 to 18 GHz Vasona scan at 1 meter

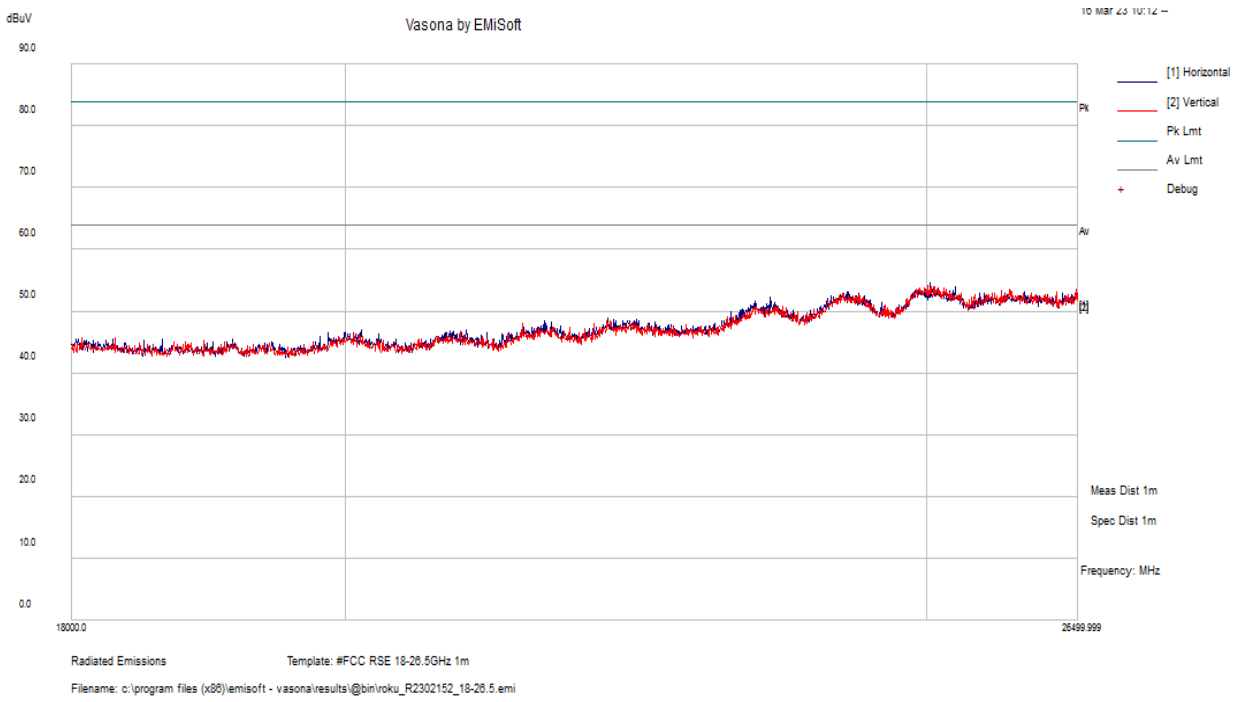
Worst Case scan:



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)	Comment
16521.74	46.29	20.12	66.41	177	V	134	84	-17.59	Peak
16521.74	36.31	20.12	56.43	177	V	134	64	-7.57	Avg

4) 18 – 26.5 GHz Worst Case Scan at 1 Meter

Worst Case scan:

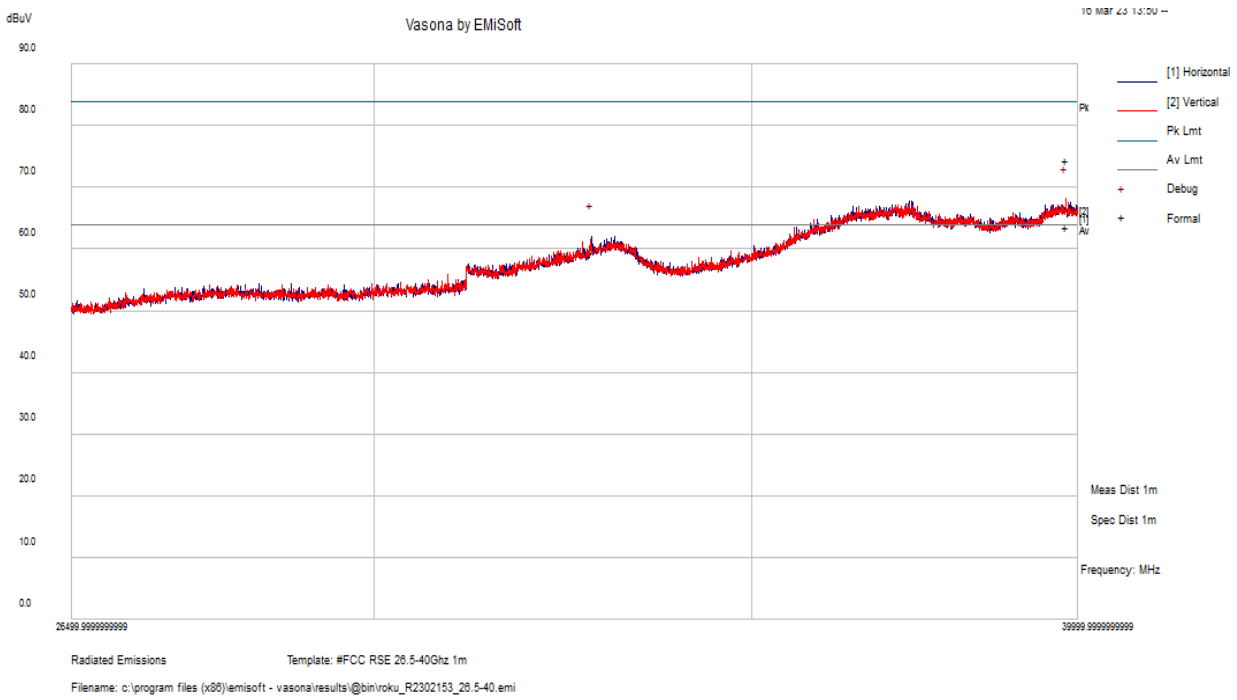


Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
24895.346	38.42	14.75	53.17	100	V	7	64	-10.83	Peak

Note: Worst case peak emission compared to average limit to show compliance.

5) 26.5 – 40 GHz Worst Case Scan at 1 Meter

Worst Case scan:



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)	Comment
39802.194	51.43	22.97	74.4	149	V	254	84	-9.6	Peak
39802.194	40.66	22.97	63.63	149	V	254	64	-0.37	Avg

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

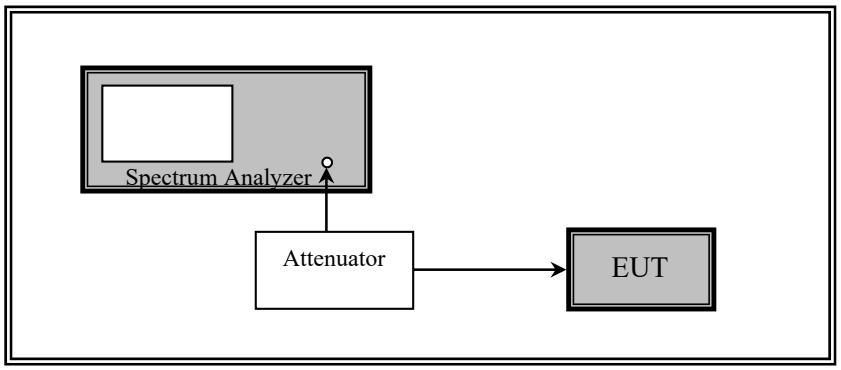
8.1 Applicable Standards

For reference purposes.

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 Number	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
912	Rhode & Schwarz	Signal Analyzer	FSV40	1321.3008k39-101203-UW	2022-05-05	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cable	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
Statement of Traceability: BACL Corp. *attests that all 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:	22-24 ºC
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

Testing was performed by Christian Schwartz on 2023-02-27 at the RF site.

8.6 Test Results

Please refer to the following tables and plots.

5250 - 5350 MHz
Ant A

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
52	5260	25.8	39.35
56	5280	23.96	39.15
64	5320	18.28	21.85
802.11n/ac20 mode			
52	5260	22.84	22.7
56	5280	24.32	21.65
64	5320	25.92	21.55

Note: See Annex A for 99% OBW test results
Note: See Annex B for 26 dB OBW test results

5250 - 5350 MHz
Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
52	5260	19.12	21.9
56	5280	18.76	22.75
64	5320	18.76	21.5
802.11n/ac20 mode			
52	5260	26.24	22.45
56	5280	30.32	22.15
64	5320	29.36	21.55

Note: See Annex A for 99% OBW test results
Note: See Annex B for 26 dB OBW test results

5470 - 5725 MHz
Ant A

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
100	5500	19.76	27.15
116	5580	23.88	36.8
140	5700	19.04	21.3
144	5720	21.12	39.95
802.11n/ac20 mode			
100	5500	19.84	27.25
116	5580	19.88	28.55
140	5700	19.48	31.7
144	5720	19.08	22.35

Note: See Annex A for 99% OBW test results
Note: See Annex B for 26 dB OBW test results

5470 - 5725 MHz
Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
100	5500	19.44	21.7
116	5580	24.64	39.75
140	5700	28.92	21.85
144	5720	18.44	22.3
802.11n/ac20 mode			
100	5500	19.48	21.7
116	5580	20.8	26.75
140	5700	20.4	22
144	5720	19.48	22.45

Note: See Annex A for 99% OBW test results
Note: See Annex B for 26 dB OBW test results

9 FCC §407(a) - Output Power

9.1 Applicable Standards

According to FCC §15.407(a):

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

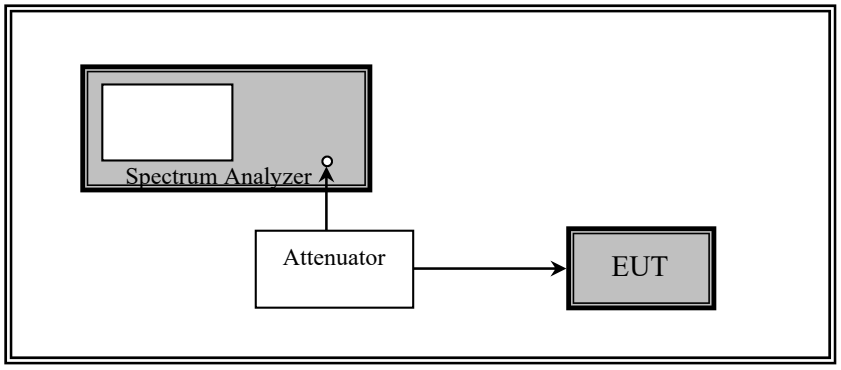
For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11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

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

9.2 Measurement Procedure

(i) Set span to encompass the entire emission bandwidth (EBW) (or, alternatively, the entire 99% occupied bandwidth) of the signal.
(ii) Set RBW = 1 MHz.
(iii) Set VBW ≥ 3 MHz.
(iv) Number of points in sweep ≥ 2 × span / RBW. (This ensures that bin-to-bin spacing is ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
(v) Sweep time = auto.
(vi) Detector = power averaging (rms), if available. Otherwise, use sample detector mode.
(vii) If transmit duty cycle < 98%, 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 ≥ 98%, 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 (rms) mode.
(ix) Compute power by integrating the spectrum across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the signal using the instrument's band power measurement function with band limits set equal to the EBW (or occupied bandwidth) band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at 1 MHz intervals extending across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the spectrum.

9.3 Test Setup Block Diagram



9.4 Test Equipment List and Details

BACL Number	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
912	Rhode & Schwarz	Signal Analyzer	FSV40	1321.3008k39 -101203-UW	2022-05-05	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
655	Rohde & Schwarz	Signal Analyzer	FSQ26	200749	2022-02-07	2 years
-	-	RF cable	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
Statement of Traceability: BACL Corp. *attests that all 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:	23º C
Relative Humidity:	55 %
ATM Pressure:	102.2 KPa

Testing was performed by Christian Schwartz on 2023-02-27 at the RF site.

9.6 Test Results

5250 - 5350 MHz

Uncorrected data:

Channel	Frequency (MHz)	Output Power (dBm)	
		ANT A	ANT B
802.11a mode			
52	5260	18.28	17.79
56	5280	17.09	17.21
64	5320	16.18	15.36
802.11n/ac20 mode			
52	5260	12.16	9.80
56	5280	10.87	9.68
64	5320	12.01	9.10

Corrected Data:

Channel	Frequency (MHz)	Duty Cycle Correction Factor (dB)	Corrected Output Power (dBm)		Corrected Total Power (dBm)	FCC Limit (dBm)
			ANT A	ANT B		
802.11a mode						
52	5260	0.86	19.14	18.65	-	24
56	5280	0.86	17.95	18.07	-	24
64	5320	0.86	17.04	16.22	-	24
802.11n/ac20 mode						
52	5260	0.55	12.71	10.35	14.70	23.5
56	5280	0.55	11.42	10.23	13.88	23.5
64	5320	0.55	12.56	9.65	14.35	23.5

Note: See Annex C for test results
Note: Total power (dBm) =10*Log(Ant A(mw)+Ant B(mw))
Note: Second table includes Duty cycle correction factor added to the measurement plots in order to compare to limits. (i.e. Corrected Output Power (dBm) = Output Power(dBm) + DCCF(dB)
Note: For FCC: the maximum conducted output power shall not exceed 250 mW or 11 + 10 log10B, dBm, whichever is less. Here B is the 26dB bandwidth in megahertz. In this instance B was chosen to be the lowest measured BW rounded down to represent the worst case limit.
Note: Where applicable, limits are reduced (in dB) by amount that antenna gain exceeds 6dBi. (The directional antenna gain is 6.5 dBi calculated based on method specified in KDB 662911 D01)

5470 - 5725 MHz

Uncorrected Data:

Channel	Frequency (MHz)	Output Power (dBm)	
		ANT A	ANT B
802.11a mode			
100	5500	15.37	16.28
116	5580	19.31	19.38
140	5700	14.49	12.86
144	5710-5725	13.26	9.69
144	5725-5730	6.30	4.63
802.11n/ac20 mode			
100	5500	18.44	16.62
116	5580	17.92	16.19
140	5700	18.33	15.43
144	5710-5725	9.94	6.55
144	5725-5730	4.20	4.63

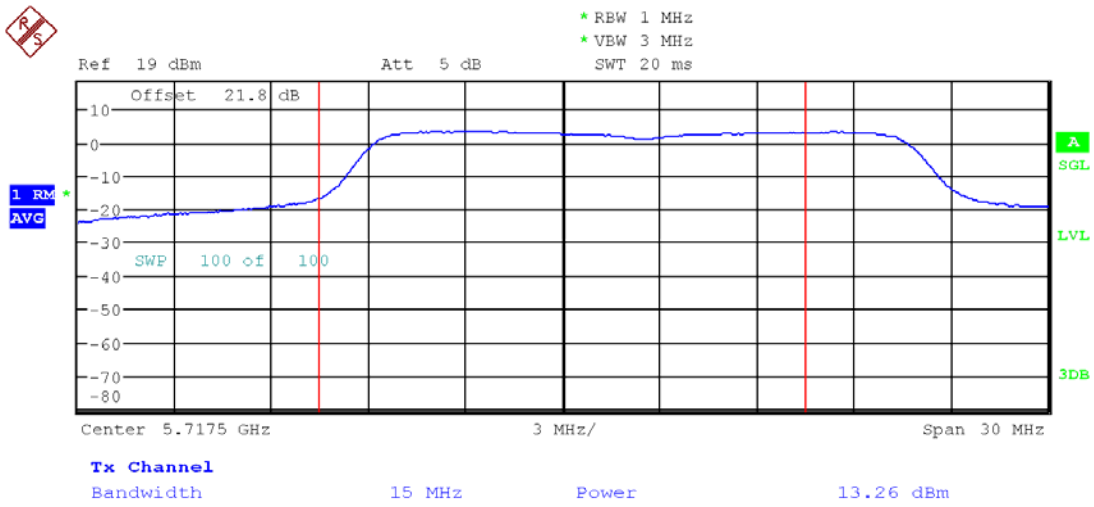
Corrected Data:

Channel	Frequency (MHz)	Duty Cycle Correction Factor (dB)	Corrected Output Power (dBm)		Corrected Total Power (dBm)	FCC Limit (dBm)
			ANT A	ANT B		
802.11a mode						
100	5500	0.86	16.23	17.14	-	24
116	5580	0.86	20.17	20.24	-	24
140	5700	0.86	15.35	13.72	-	24
144	5710-5725	0.86	14.12	10.55	-	24
144	5725-5730	0.86	7.16	5.49	-	30
802.11n/ac20 mode						
100	5500	0.55	18.99	17.17	21.18	23.5
116	5580	0.55	18.47	16.74	20.70	23.5
140	5700	0.55	18.88	15.98	20.68	23.5
144	5710-5725	0.55	10.49	7.10	12.13	23.5
144	5725-5730	0.55	4.75	5.18	7.98	29.5

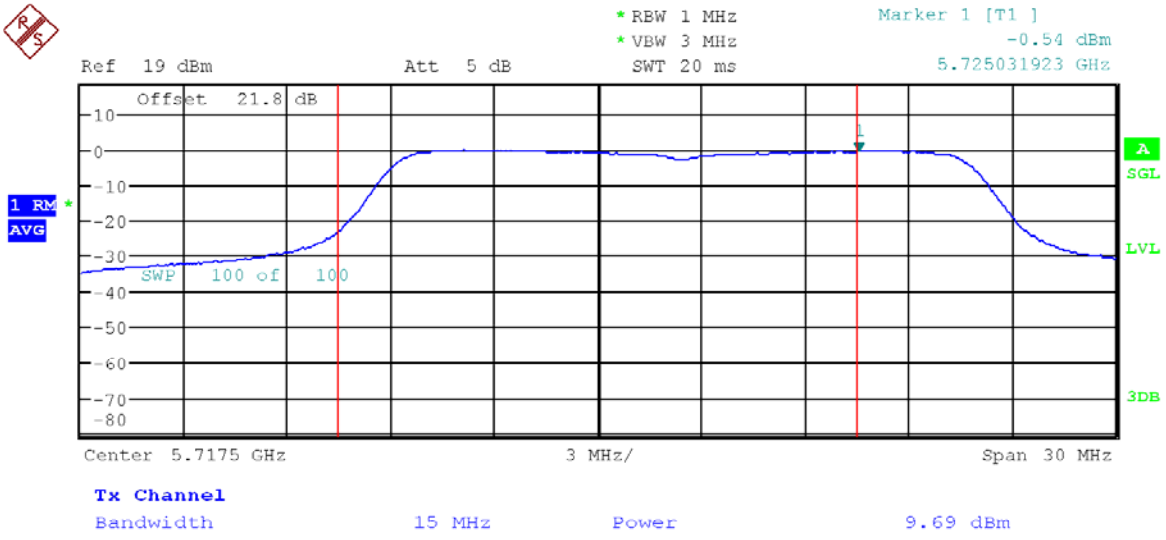
Note: See Annex C for test results
Note: See results below for 5720(MHz)
Note: Total power (dBm) =10*Log(Ant A(mw)+Ant B(mw))
Note: Second table includes Duty cycle correction factor added to the measurement plots in order to compare to limits. (i.e. Corrected Output Power (dBm) = Output Power(dBm) + DCCF(dB)
Note: For FCC: the maximum conducted output power shall not exceed 250 mW or 11 + 10 log10B, dBm, whichever is less. Here B is the 26dB bandwidth in megahertz. In this instance B was chosen to be the lowest measured BW rounded down to represent the worst case limit.
Note: Where applicable, limits are reduced (in dB) by amount that antenna gain exceeds 6dBi. (The directional antenna gain is 6.5 dBi calculated based on method specified in KDB 662911 D01)

Note: For straddle channels (i.e. Ch. 144), see below screenshots for test results.

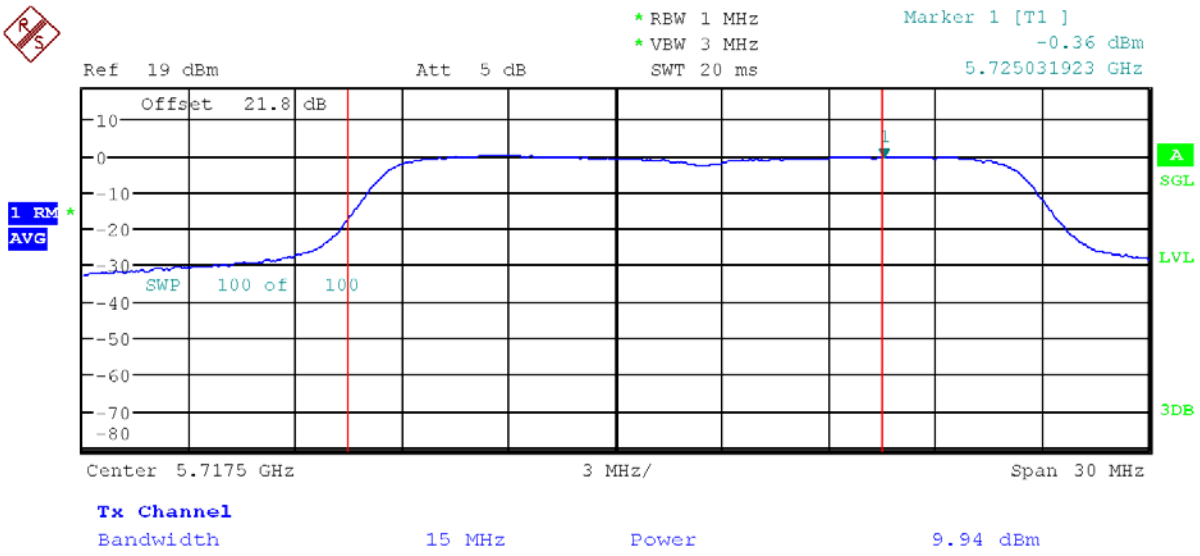
802.11a mode
5710-5725 MHz Ant A



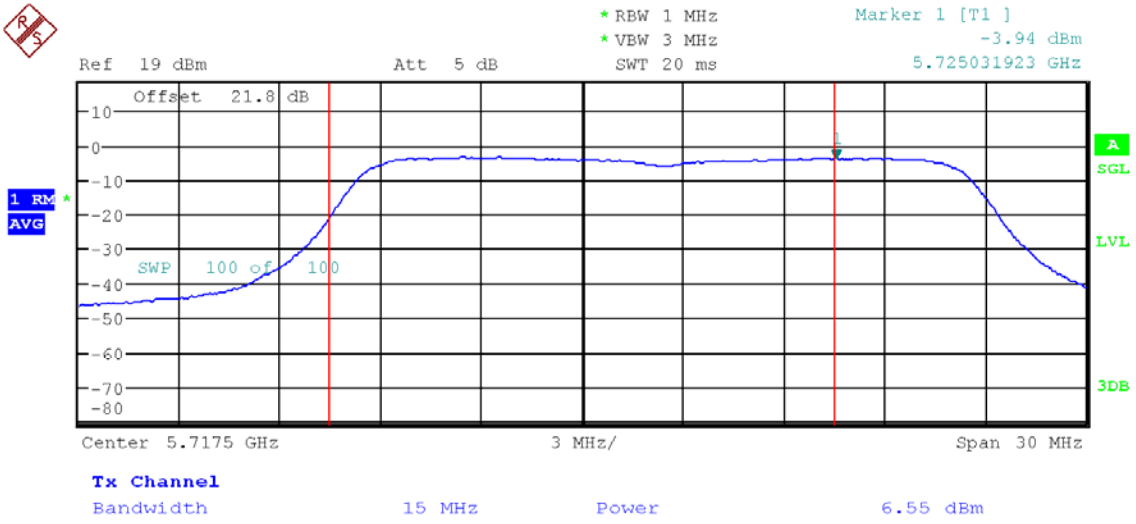
802.11a mode
5710-5725 MHz Ant B



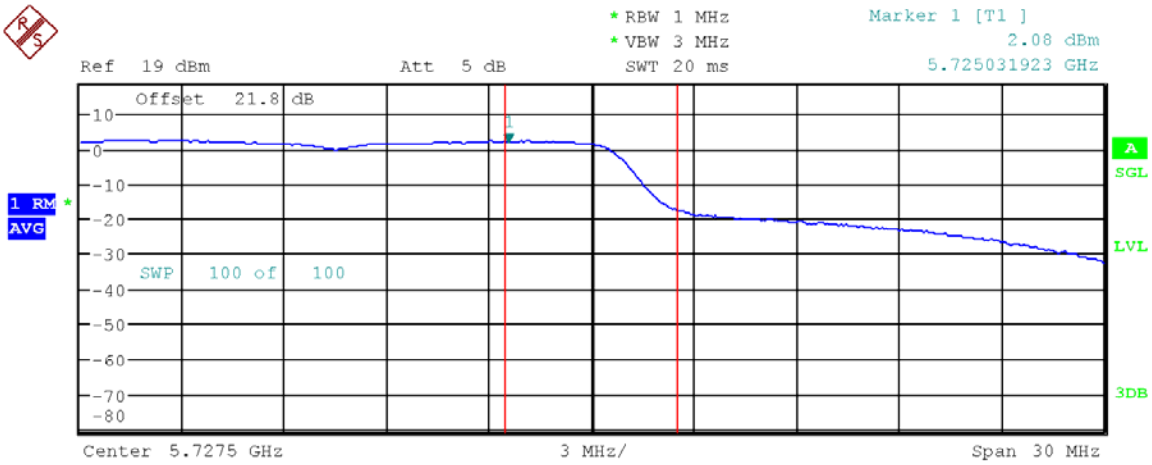
802.11ac/n20 mode
5710-5725 MHz Ant A



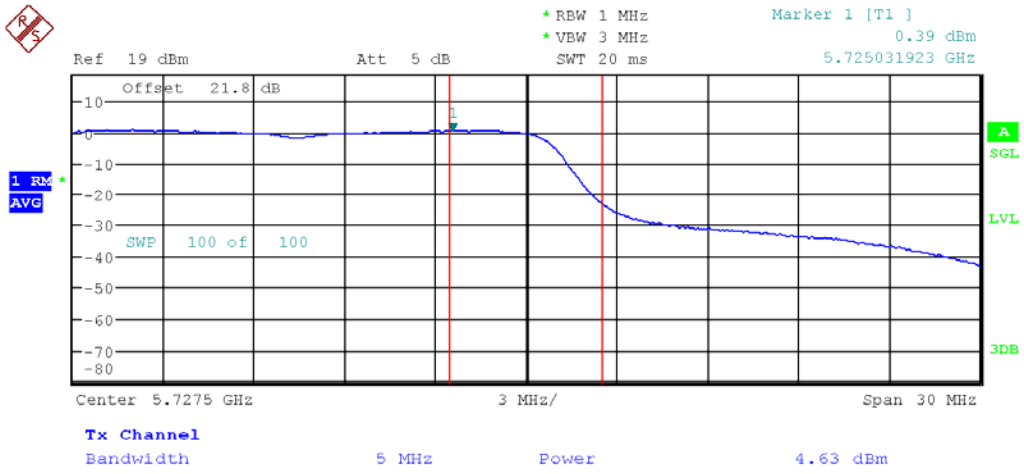
802.11ac/nN20 mode
5710-5725 MHz Ant B



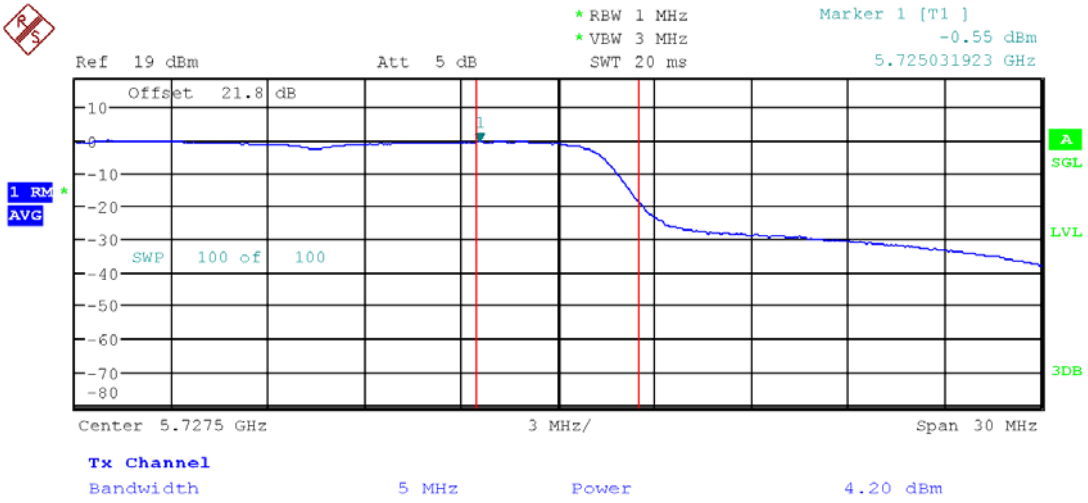
802.11a mode
5725-5730 MHz Ant A



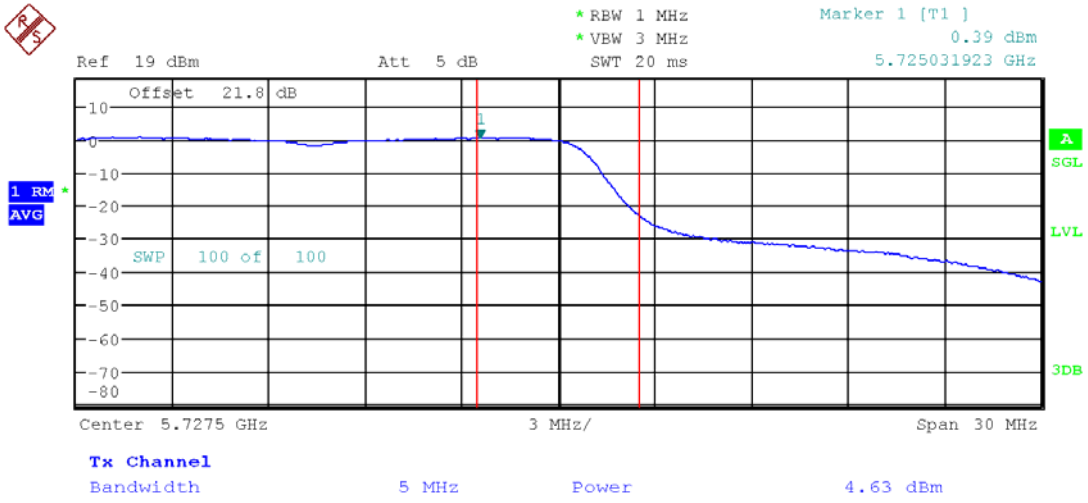
802.11a mode
5725-5730 MHz Ant B



802.11ac/n20 mode
5725-5730 MHz Ant A



802.11ac/n20 mode
5725-5730 MHz Ant B



10 FCC §15.407(a) - Power Spectral Density

10.1 Applicable Standards

According to FCC §15.407(a):

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

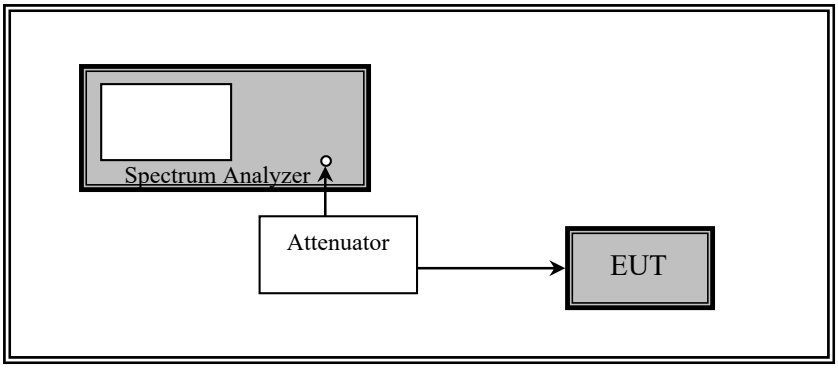
For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11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

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

10.2 Measurement Procedure

(i) Set span to encompass the entire emission bandwidth (EBW) of the signal.
(ii) Set RBW = 1 MHz.
(iii) Set VBW ≥ 3 MHz.
(iv) Number of points in sweep ≥ 2 Span / RBW. (This ensures that bin-to-bin spacing is ≤ 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 ≥ 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 Number	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
912	Rhode & Schwarz	Signal Analyzer	FSV40	1321.3008k39 -101203-UW	2022-05-05	1 year
655	Rohde & Schwarz	Signal Analyzer	FSQ26	200749	2022-02-07	2 years
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cable	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
Statement of Traceability: BACL Corp. *attests that all 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:	22-24 ºC
Relative Humidity:	50-55 %
ATM Pressure:	102.1-102.7 kPa

Testing was performed by Christian Schwartz on 2023-02-27 at the RF site.

10.6 Test Results

5250 - 5350 MHz

Uncorrected Data:

Channel	Frequency (MHz)	PSD (dBm/MHz)	
		ANT A	ANT B
802.11a mode			
52	5260	7.03	6.77
56	5280	6.90	6.34
64	5320	4.68	4.41
802.11n/ac20 mode			
52	5260	1.57	-1.27
56	5280	0.87	-1.50
64	5320	-0.59	-2.05

Corrected Data:

Channel	Frequency (MHz)	Duty Cycle Correction Factor (dB)	Corrected PSD (dBm/MHz)		Corrected Total PSD (dBm/MHz)	FCC Limit (dBm/MHz)
			ANT A	ANT B		
802.11a mode						
52	5260	0.86	7.89	7.63	-	11
56	5280	0.86	7.76	7.2	-	11
64	5320	0.86	5.54	5.27	-	11
802.11n/ac20 mode						
52	5260	0.55	2.12	-0.72	3.94	10.5
56	5280	0.55	1.42	-0.95	3.41	10.5
64	5320	0.55	-0.04	-1.5	2.30	10.5

Note: See Annex D for test results
Note: Total PSD (dBm/MHz) =10*Log(Ant A(mw)+Ant B(mw))
Note: Second table includes Duty cycle correction factor added to the measurement plots in order to compare to limits. (i.e. Corrected PSD (dBm/MHz) = PSD(dBm/MHz) + DCCF(dB)
Note: Where applicable, limits are reduced (in dB) by amount that antenna gain exceeds 6dBi. (The directional antenna gain is 6.5 dBi calculated based on method specified in KDB 662911 D01)

5470 - 5725 MHz

Uncorrected Data:

Channel	Frequency (MHz)	PSD (dBm/MHz)	
		ANT A	ANT B
802.11a mode			
100	5500	6.50	5.41
116	5580	9.46	8.38
140	5700	4.66	2.06
144	5710-5725	3.48	0.62
144*	5725-5730	0.37	-1.89
802.11n/ac20 mode			
100	5500	6.99	4.73
116	5580	6.42	4.34
140	5700	6.56	3.91
144	5710-5725	-0.76	-2.01
144*	5725-5730	-2.02	-6.25

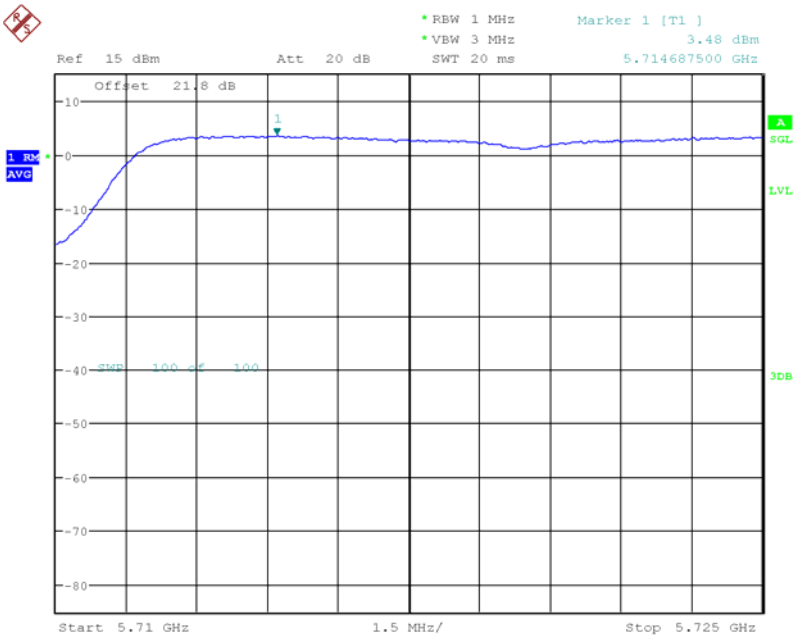
Corrected Data:

Channel	Frequency (MHz)	Duty Cycle Correction Factor (dB)	Corrected PSD (dBm/MHz)		Corrected Total PSD (dBm/MHz)	FCC Limit (dBm/MHz)
			ANT A	ANT B		
802.11a mode						
100	5500	0.86	7.48	6.39	-	11
116	5580	0.86	10.44	9.35	-	11
140	5700	0.86	5.64	3.18	-	11
144	5710-5725	0.86	4.34	1.48	-	11
144*	5725-5730	0.86	1.23	-1.03	-	30
802.11n/ac20 mode						
100	5500	0.55	7.8	5.55	9.83	10.5
116	5580	0.55	7.23	5.15	9.32	10.5
140	5700	0.55	7.37	4.72	9.25	10.5
144	5710-5725	0.55	-0.21	-1.46	2.22	10.5
144*	5725-5730	0.55	-1.47	-5.7	-0.08	29.5

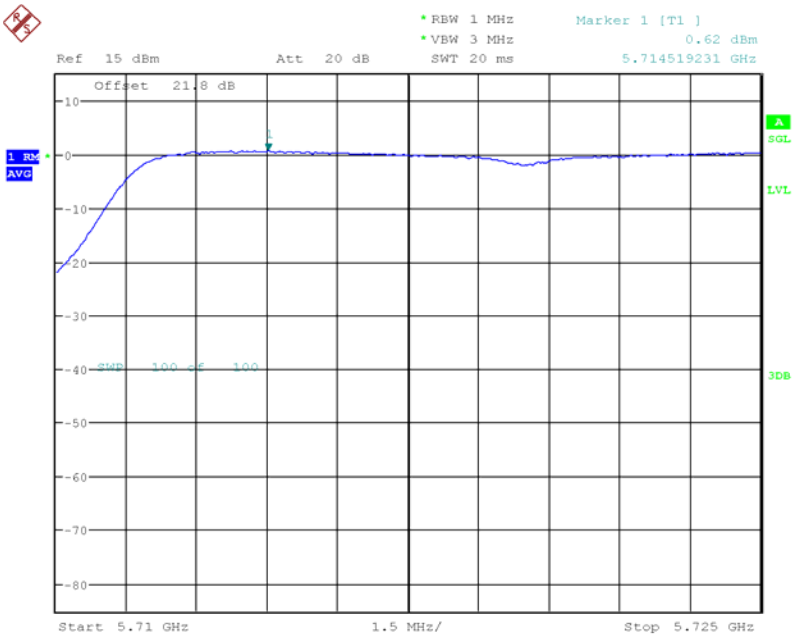
Note: See Annex D for test results
Note: Total PSD (dBm/MHz) =10*Log(Ant A(mw)+Ant B(mw))
Note: Second table includes Duty cycle correction factor added to the measurement plots in order to compare to limits.
Note: Where applicable, limits are reduced (in dB) by amount that antenna gain exceeds 6dBi. (The directional antenna gain is 6.5 dBi calculated based on method specified in KDB 662911 D01)
Note*: Unit for PSD and Limit is dBm/500kHz.

Note: For straddle channels (i.e. Ch. 144), see below screenshots for test results.

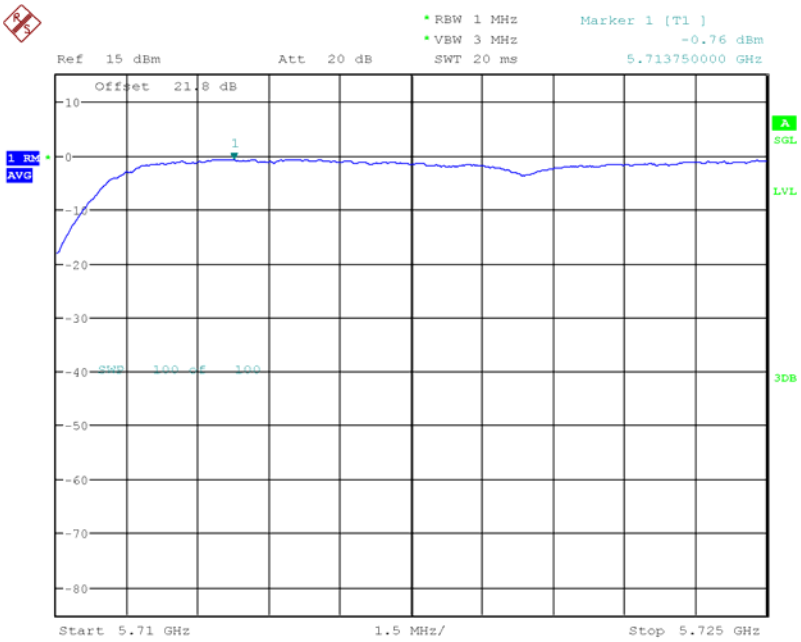
802.11a mode
5710-5725 MHz Ant A



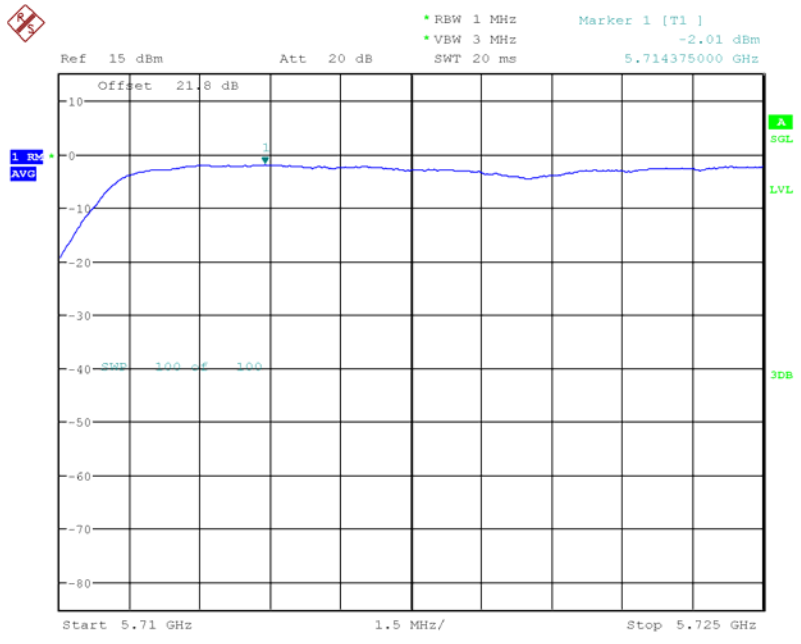
802.11a mode
5710-5725 MHz Ant B



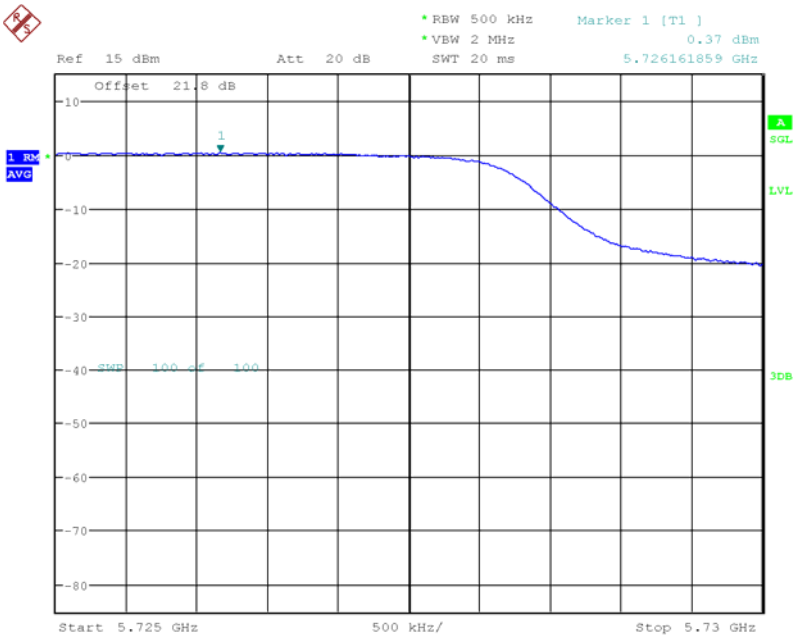
802.11ac/n20 mode
5710-5725 MHz Ant A



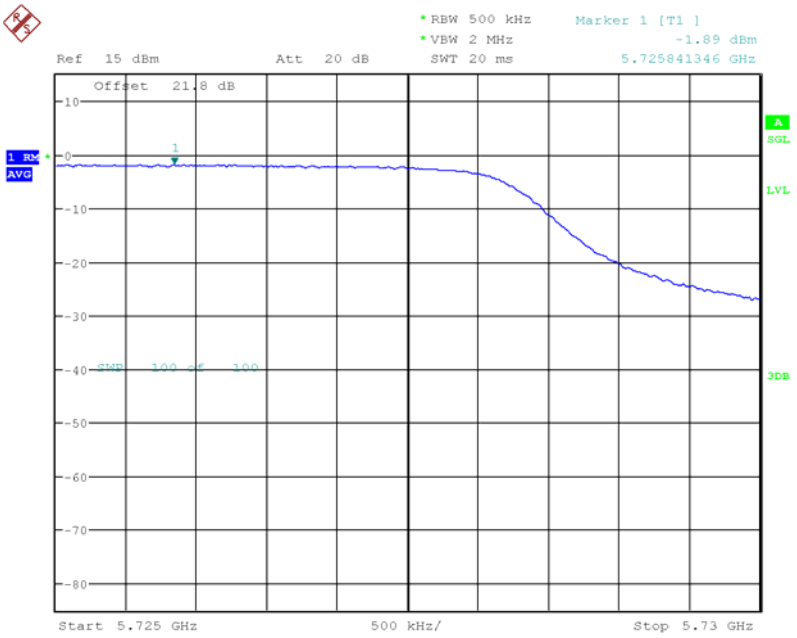
802.11ac/n20 mode
5710-5725 MHz Ant B



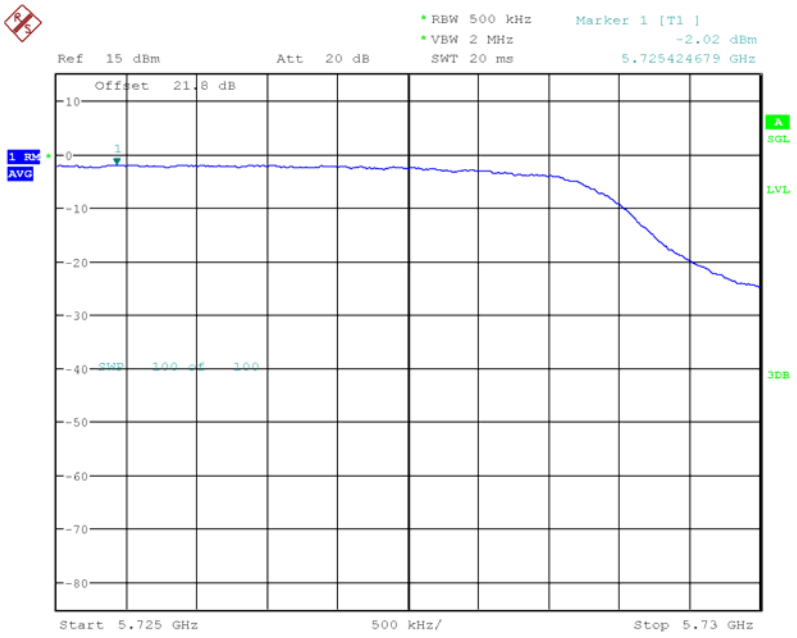
802.11a mode
5725-5730 MHz Ant A



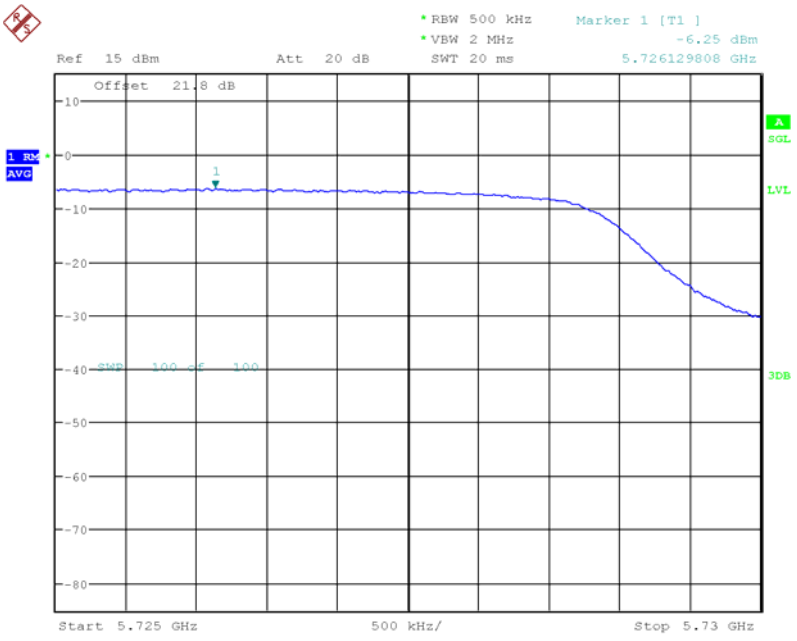
8802.11a mode
5725-5730 MHz Ant B



802.11ac/n20 mode
5725-5730 MHz Ant A



802.11ac/n20 mode
5725-5730 MHz Ant B



11 FCC §15.407(h) – Dynamic Frequency Selection

11.1 Applicable Standards

FCC CFR47 §15.407 (h) 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
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.		

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

Maximum Transmit Power	Value (See Notes 1, 2 and 3)
EIRP≥ 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.
Note3: 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 ***See Note 1***.
Channel Closing Transmission Time	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. ***See Notes 1 and 2***.
U-NII Detection Bandwidth	Minimum 100% of the UNII 99% transmission power bandwidth. ***See Note 3***.

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 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	$\text{Roundup}\left\{\left(\frac{1}{360}\right)\cdot\left(\frac{19\cdot 10^6}{PRI_{\mu sec}}\right)\right\}$	60%	30
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

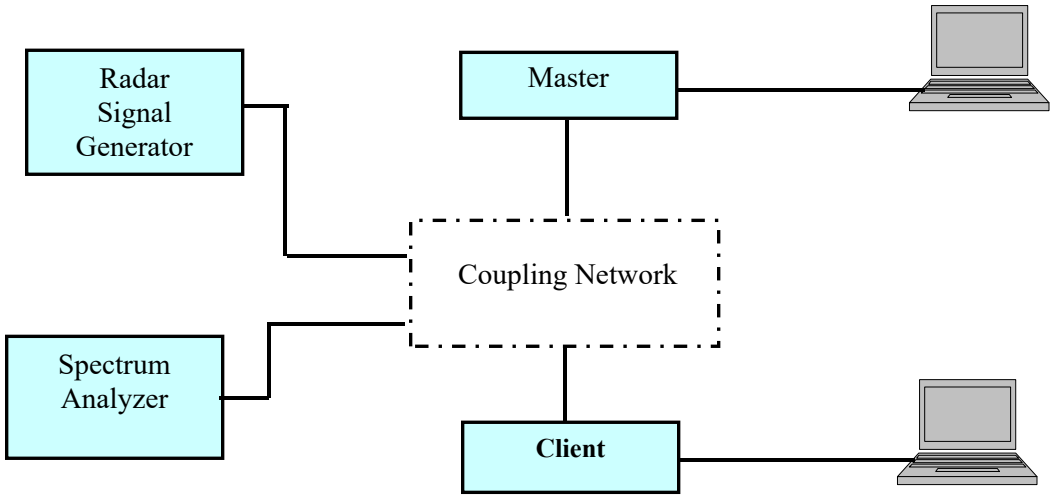
Table 7: Frequency Hopping Radar Test Signal

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

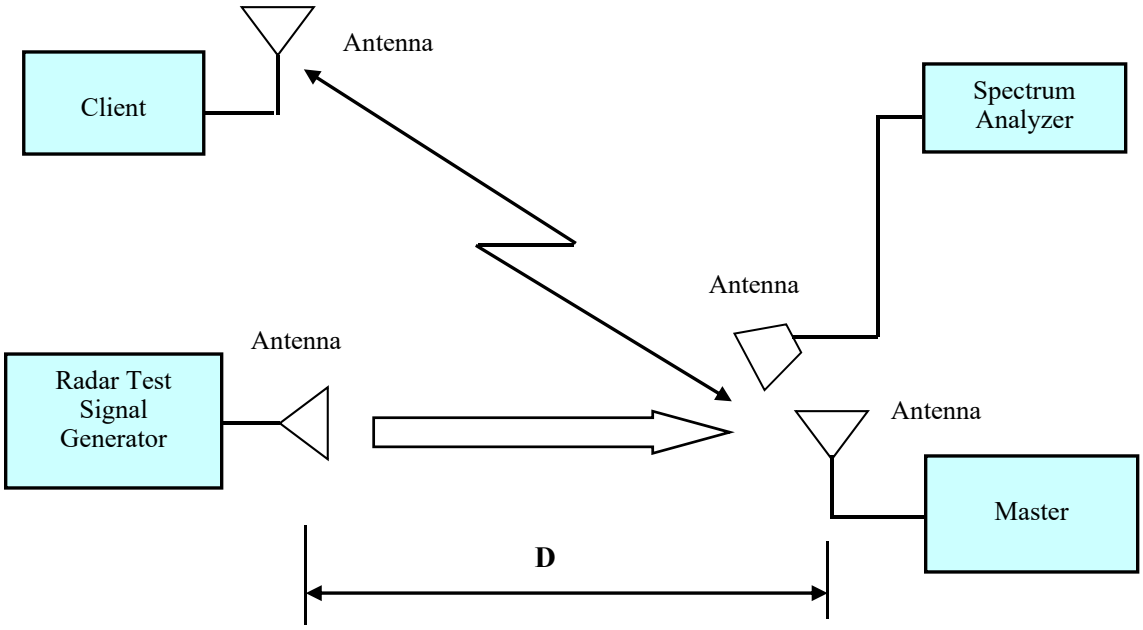
11.2 DFS Measurement System

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

11.3 System Block Diagram



11.4 Radiated Method



11.5 Test Procedure

The EUT was connected to a certified master device (FCC ID: S9GH350, IC: 5912A-H350). A spectrum analyzer was used as a monitor that verifies the EUT's status, which includes the Channel Closing Transmission Time and the Channel Move Time.

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)

11.6 Test Equipment List and Details

Bacl No.	Manufacturer	Equipment Description	Model	S/N	Calibration Date	Calibration Interval
547	National Instruments	NI PXI-1042 8-Slot chassis	PXI-1042	V08X01EE1	N/A	N/A
-	National Instruments	Arbitrary Waveform Generator	PXI-5421	N/A	N/A	N/A
-	National Instruments	RF Upconverter	PXI-5610	N/A	N/A	N/A
-	ASCOR	Upconverter	AS-7206	N/A	N/A	N/A
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

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
Statement of Traceability: BACL Corp. *attests that all 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".*

11.7 Test Environmental Conditions

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

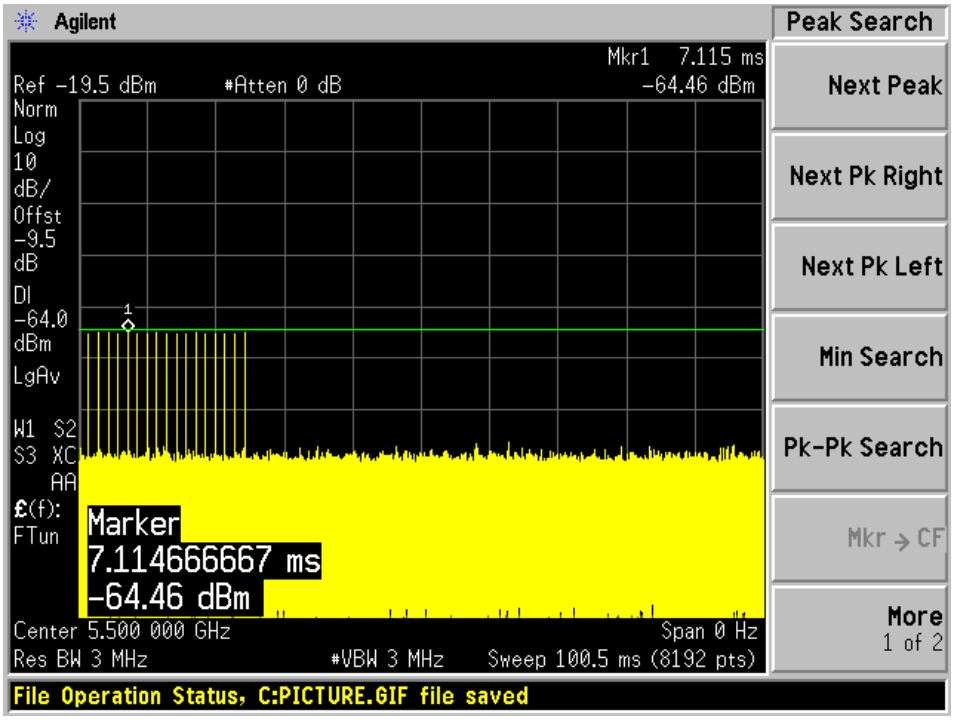
Testing was performed by Simon Ma on 2023-02-16 at the DFS testing site.

11.8 Test Results

Plots of Radar Waveforms

Radar Type 0

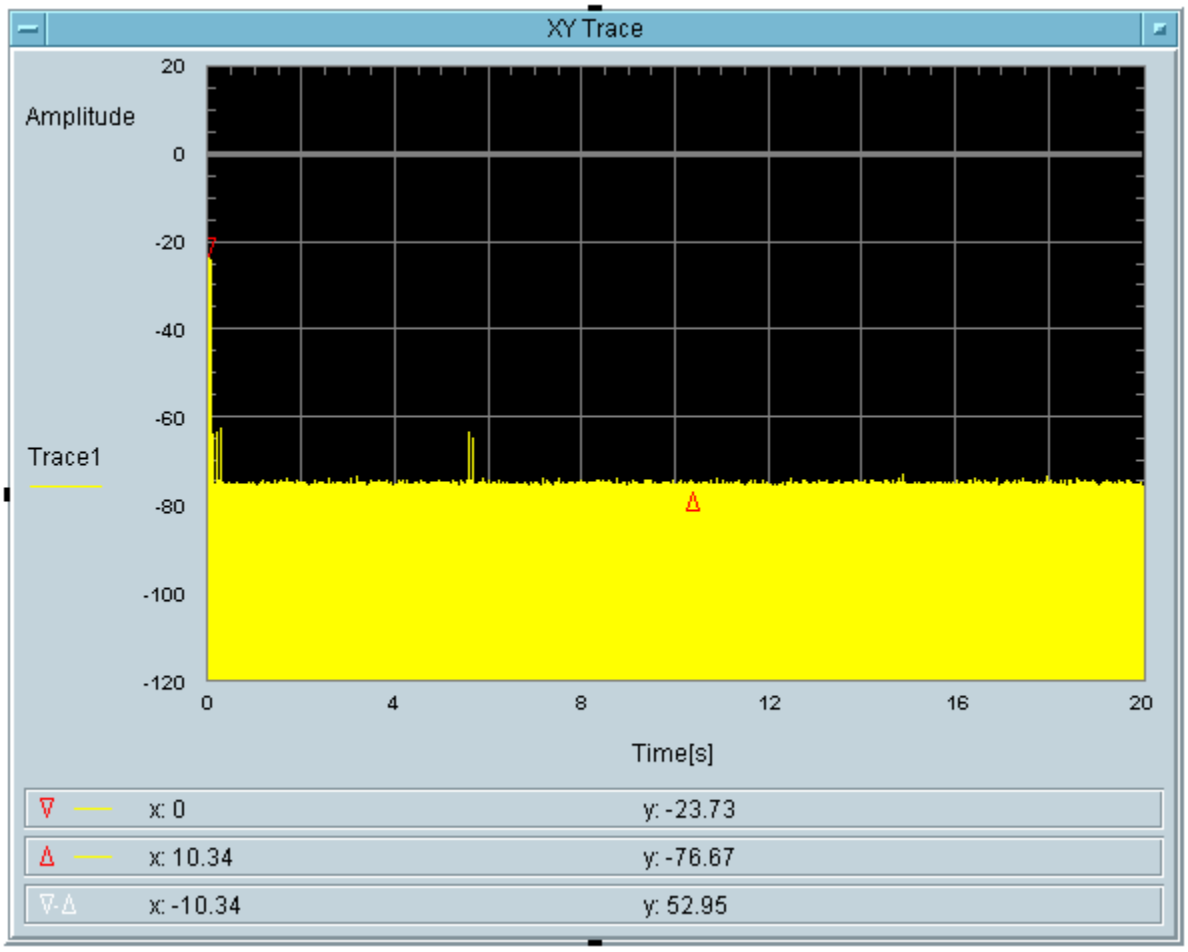
5500 MHz



Frequency (MHz)	Bandwidth (MHz)	Radar Type	Results
5500	20	Type 0	Compliant

5500 MHz 20 MHz Bandwidth

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

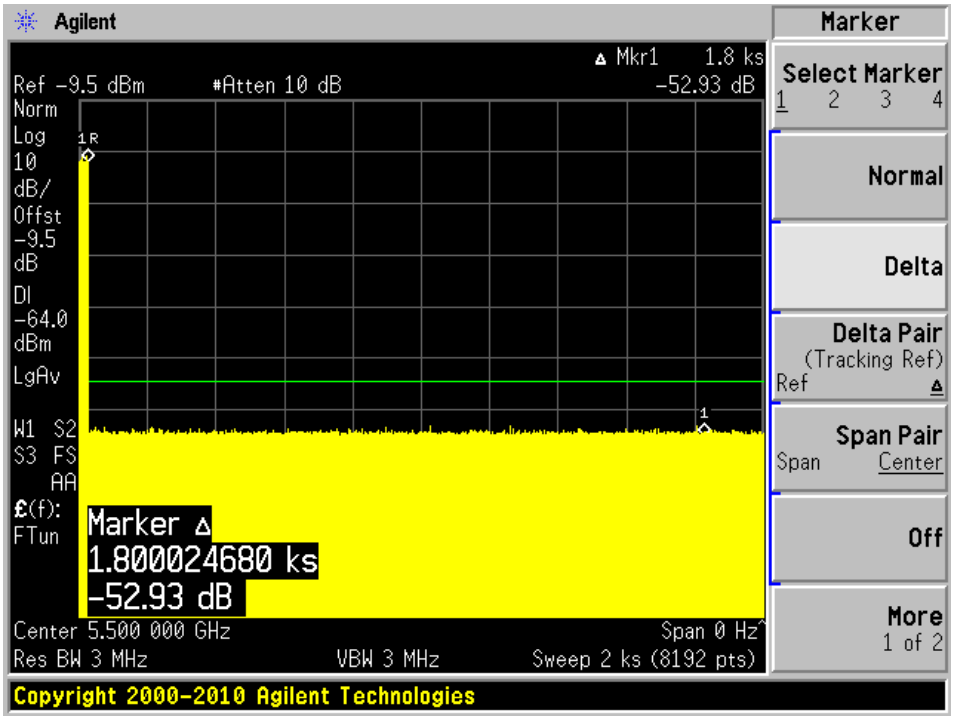


Type 0 radar channel closing transmission time result:

Channel closing transmitting time (ms)	Limit (ms)	Result
29.3+9.766	200	Pass

Non-occupancy Time

5500 MHz for 20 MHz channel bandwidth



12 Annex E (Normative) – EUT Test Setup Photographs

Please refer to the attachment.

13 Annex F(Normative) – EUT External Photographs

Please refer to the attachment.

14 Annex G (Normative) – EUT Internal Photographs

Please refer to the attachment.

15 Annex H (Informative) –Declaration of Similarity

DECLARATION OF SIMILARITY

March 11, 2023

To:

FEDERAL COMMUNICATIONS COMMISSIONS
Authorization and Evaluation Division
7435 Oakland Mills Road
Columbia, MD 21046

Dear Sir or Madam:

We, *Roku, Inc.* hereby declare that product: *Wireless Speakers,* model: 9020X and 100002419 *(FCC ID: TC2-R1023)* are electrically identical with the same electromagnetic emissions and electromagnetic compatibility characteristics as model: *9030X tested* by BACL, the results of which are featured in BACL project: *R2302152*

A description of the differences between the tested model and those that are declared similar are as follows:

Model		Difference
Tested Model	9030X	
Similar Model	9020X	Modified Encloser
	100002420	Modified Encloser with ONN marking

Please contact me should there be need for any additional clarification or information.

Sincerely,

Robert Curtis

Robert Curtis (Mar 13, 2023 16:55 PDT)

Robert Curtis/ Sr. Director SW Eng
Roku, Inc.
1155 Coleman Ave
San Jose, CA 95110

16 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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