FCC PART 15, SUBPART E

TEST REPORT

For

Roku, Inc.

1155 Coleman Avenue, San Jose, CA 95110, USA

FCC ID: TC2-R1036

Report Type:	Model:
Original Report	4802X
Prepared By:	Christian Schwartz Test Engineer
Report Number:	R2211306-NII-03
Report Date:	2023-02-06
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CERTIFICATE #3297.02

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2211306-NII-03	Original Report	2023-02-06

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: 4802X, FCC ID: TC2-R1036, or the "EUT" as referred to in this report. It is a Set-Top-Box.

1.2 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.

1.3 Related Submittal(s)/Grant(s)

Equipment Class: DSS with FCC ID: TC2-R1036
Equipment Class: DTS with FCC ID: TC2-R1036

1.4 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz, and FCC KDB 789033 D02 General UNII Test Procedure New Rules v02r01.

1.5 Measurement Uncertainty

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

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

1.6 Test Facility Registrations

BACLs test facilities that are used to perform Radiated and Conducted Emissions tests are currently recognized by the Federal Communications Commission as Accredited with NIST Designation Number US1129.

BACL's test facilities that are used to perform Radiated and Conducted Emissions tests are currently registered with Industry Canada under Registration Numbers: 3062A-1, 3062A-2, and 3062A-3.

BACL is a Chinese Taipei Bureau of Standards Metrology and Inspection (BSMI) validated Conformity Assessment Body (CAB), under Appendix B, Phase I Procedures of the APEC Mutual Recognition Arrangement (MRA). BACL's BSMI Lab Code Number is: SL2-IN-E-1002R

BACL's test facilities that are used to perform AC Line Conducted Emissions, Telecommunications Line Conducted Emissions, Radiated Emissions from 30 MHz to 1 GHz, and Radiated Emissions from 1 GHz to 6 GHz are currently recognized as Accredited in accordance with the Voluntary Control Council for Interference [VCCI] Article 15 procedures under Registration Number A-0027.

1.7 Test Facility Accreditations

Bay Area Compliance Laboratories Corp. (BACL) is:

A- ***An independent, 3rd-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2017 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	96	
	5300	96	
	5320	84	
802.11n/ac20	5260	78	
	5300	78	
	5320	75	
802.11n/ac40	5270	84	
	5310	69	
802.11ac80	5290	69	

5470MHz-5725MHz

Modulation	Frequency (MHz)	Power Setting	
		Ant A	Ant B
802.11a	5500	98	
	5580	94	
	5700	94	
	5720	94	
802.11n/ac20	5500	77	
	5580	74	
	5700	78	
	5720	78	
802.11n/ac40	5510	69	
	5590	82	
	5670	84	
	5710	92	
802.11ac80	5530	69	
	5610	84	
	5690	100	

*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:

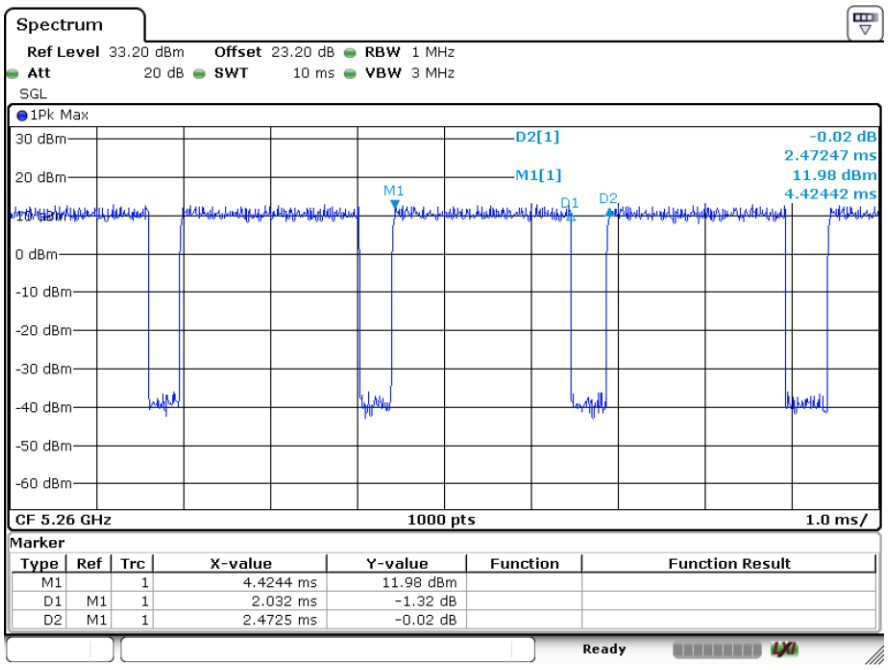
All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximum-power transmission duration, T, are required for each tested mode of operation.

Radio Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11a	2.032	2.4725	82%	.86
802.11n/ac20	1.8919	2.1522	88%	0.55
802.11n/ac40	.91091	1.16116	78%	1.07
802.11ac80	.42485	.66533	64%	1.9

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

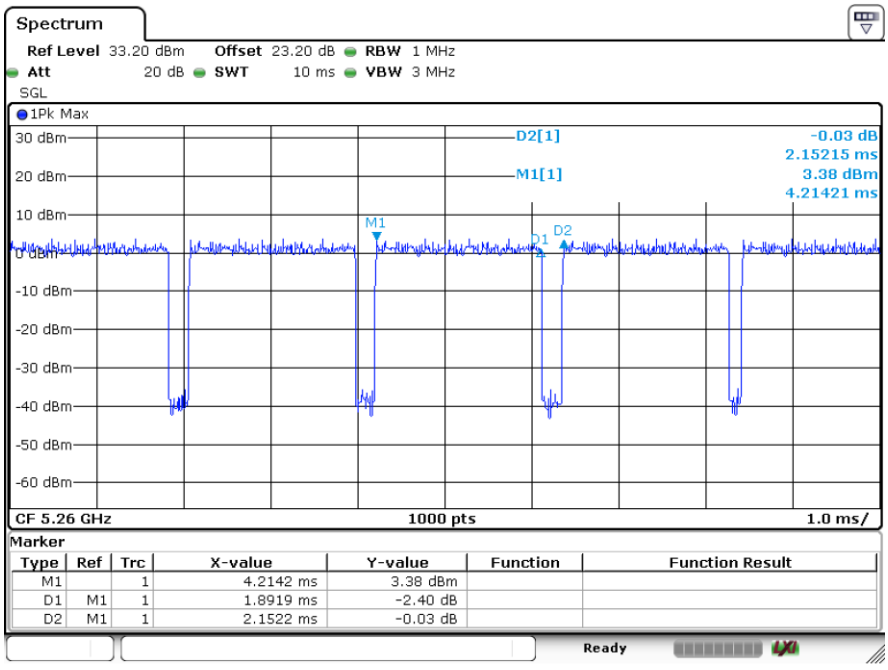
Please refer to the following plots.

802.11a mode



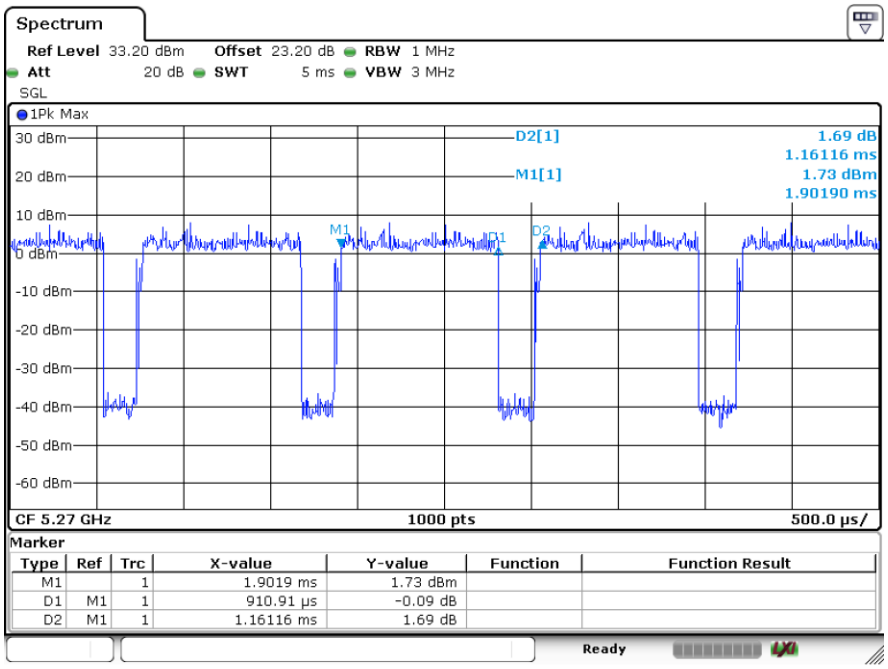
Date: 30.DEC.2022 09:54:33

802.11n20/ac20 mode



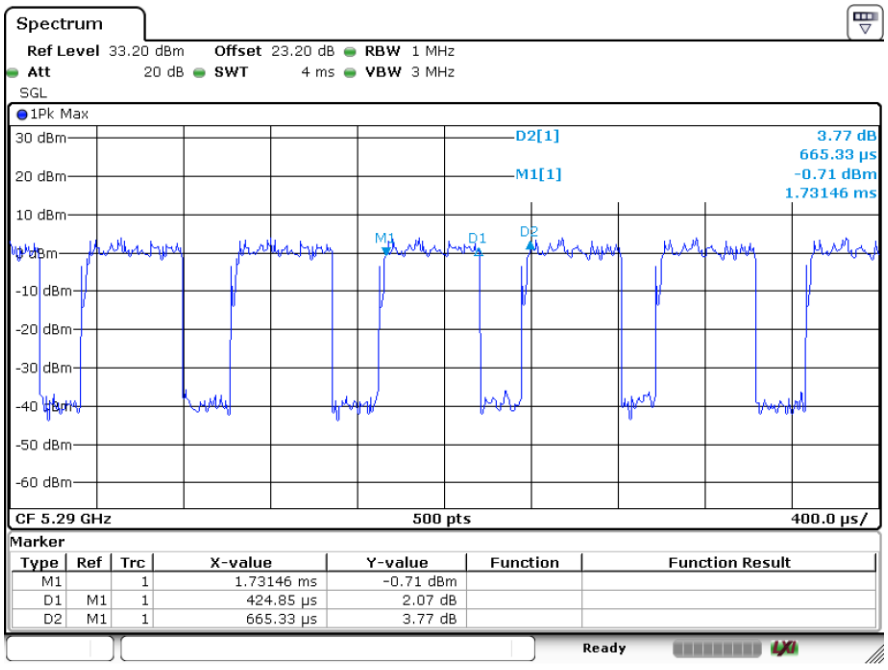
Date: 30.DEC.2022 09:58:15

802.11n40/ac40 mode



Date: 30.DEC.2022 10:03:34

802.11ac80



Date: 30.DEC.2022 10:09:31

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(a)	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 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S = power density
P = power input to antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

Note: According to MIMOFCC KDB 662911 D02 MIMO with Cross Polarized Antenna v01, Where an FCC rule specifies limits in radiated terms such as EIRP or ERP, the limits apply to the maximum emission that would be observed by a linearly polarized measurement antenna. Therefore, the highest output power from single antenna power was selected to calculate in this section.

4.4 RF exposure evaluation exemption for FCC

5GHz Wifi:

Prediction frequency (GHz)	5.690
Maximum output power (dBm)	21.86
Maximum ERP (dBm)	27.21
Maximum ERP (mW)	526.02
Prediction distance (cm)	20
Maximum antenna gain (dBi)	7.5
1500MHz ≤ *f* < 10000MHz	Option C Exemption Threshold
	P_{th} (W)
	$19.2R^2 = 0.768W$

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.

Bluetooth:

Prediction frequency (GHz)	2.402
Maximum output power (dBm)	14.577
Maximum ERP (dBm)	15.127
Maximum ERP (mW)	32.56
Prediction distance (cm)	20
Maximum antenna gain (dBi)	2.7
1500MHz ≤ *f* < 10000MHz	Option C Exemption Threshold
	P_{th} (W)
	$19.2R^2 = 0.768W$

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	14.577	20	32.56	768	4.2%	72.7%	100%
5 GHz Wi-Fi	21.86	20	526.02	768	68.5%		

Note: 2.4GHz Wifi and 5GHz Wifi can not co-locate.

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)
5GHz Wi-Fi Metal Antenna (Ant A)	5250-5725	4.5
5GHz Wi-Fi PCB Antenna (Ant B)	5250-5725	4.5

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.

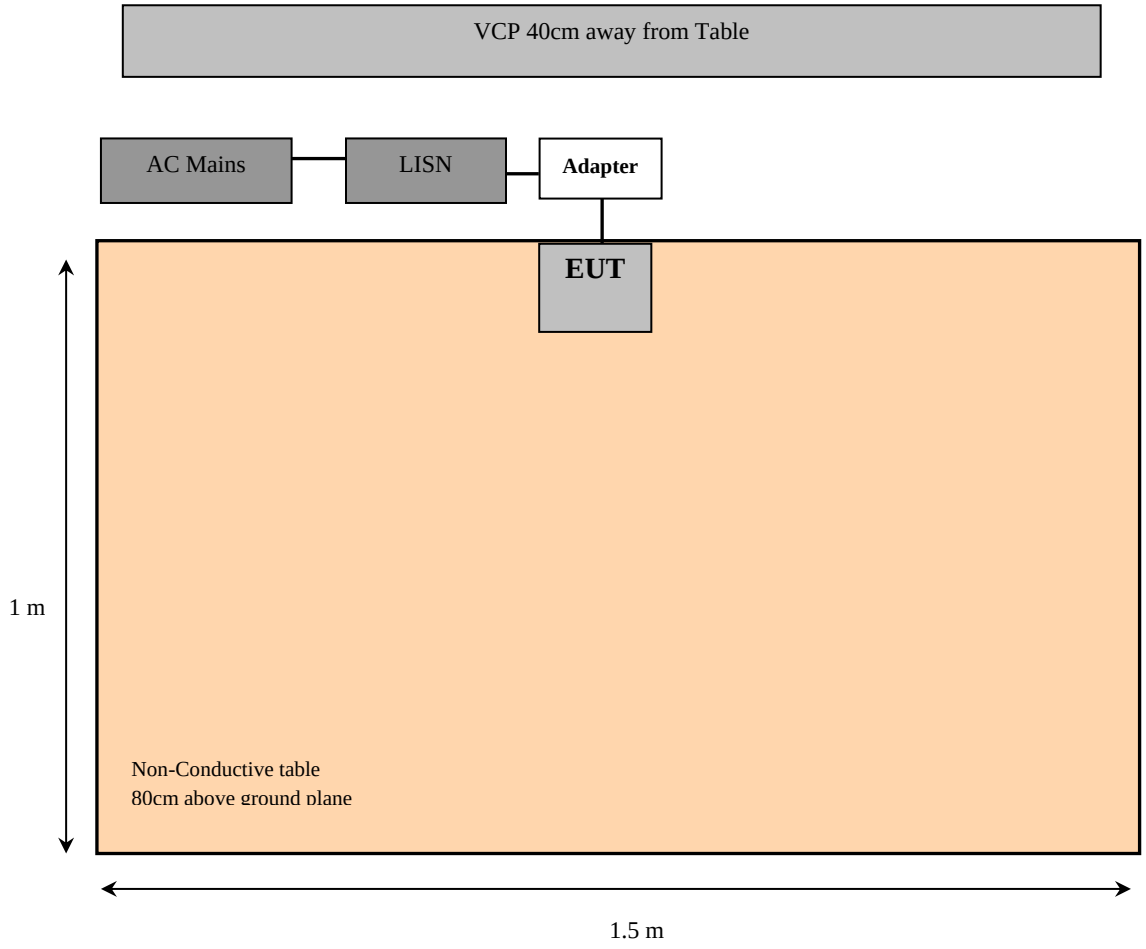
6.3 Test Procedure

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 Tyler Dorsey on 2023-01-25 in the Ground Plane test site.

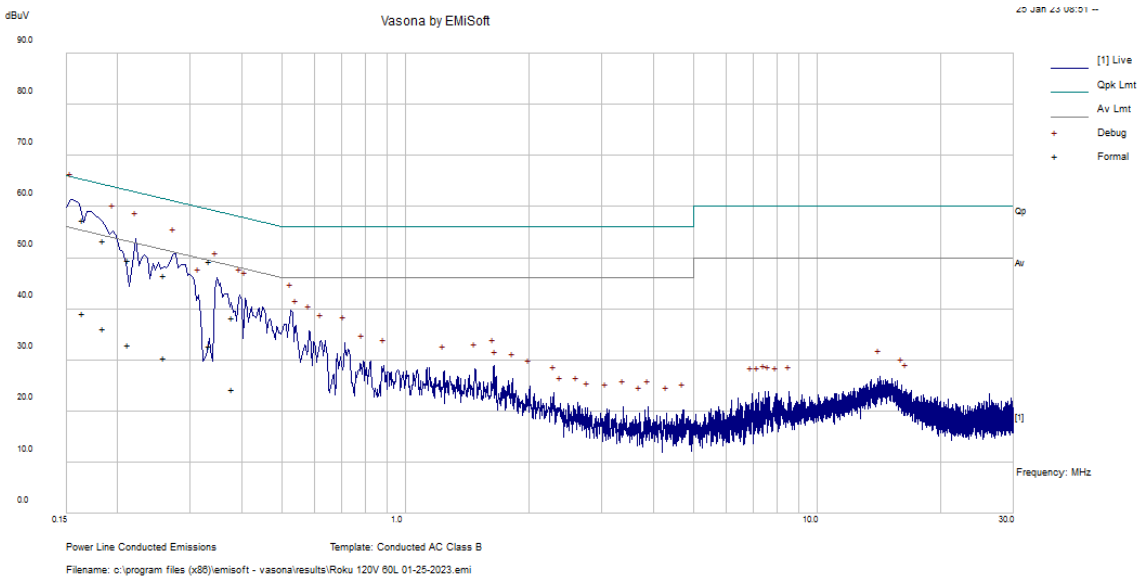
6.8 Summary of Test Results

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

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-7.87	0.16446	Line	0.15-30

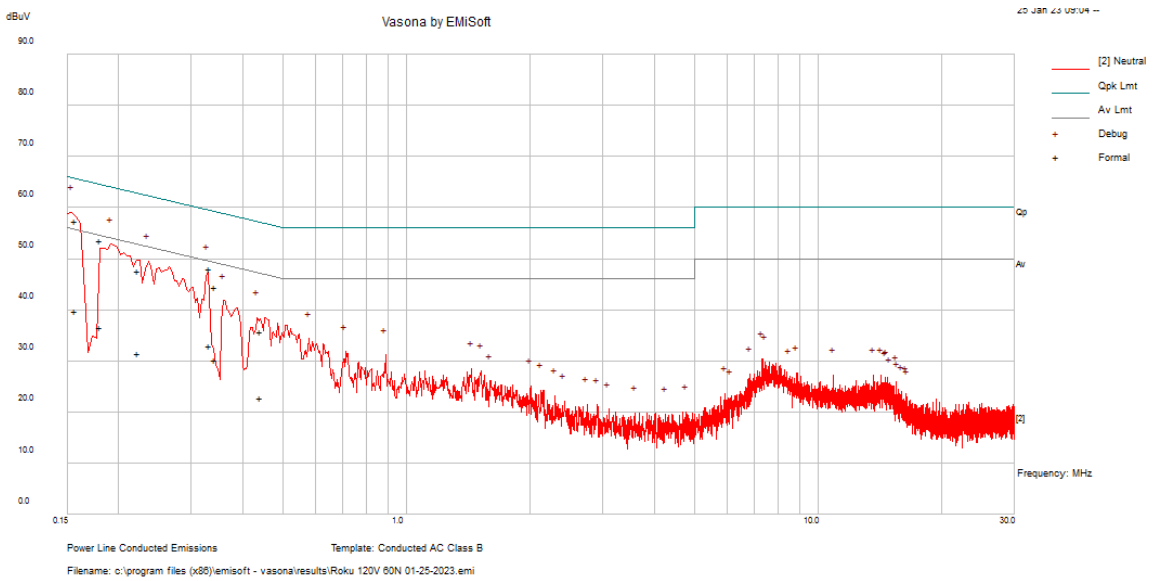
6.9 Conducted Emissions Test Plots and Data

120 V, 60 Hz – Line



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.16446	45.81	11.56	57.37	65.24	-7.87	QP
0.18486	41.91	11.49	53.4	64.26	-10.86	QP
0.212061	38.16	11.41	49.57	63.12	-13.55	QP
0.258776	35.18	11.3	46.48	61.47	-15	QP
0.33373	38.24	11.13	49.37	59.36	-9.98	QP
0.378837	27.18	11.04	38.22	58.3	-20.08	QP
0.16446	27.56	11.56	39.12	55.24	-16.11	Ave
0.18486	24.7	11.5	36.2	54.26	-18.07	Ave
0.212061	21.48	11.41	32.89	53.12	-20.23	Ave
0.258776	19.07	11.29	30.36	51.47	-21.11	Ave
0.33373	21.53	11.13	32.66	49.36	-16.69	Ave
0.378837	13.12	11.04	24.16	48.3	-24.14	Ave

120 V, 60 Hz – Neutral



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.156378	45.81	11.59	57.4	65.65	-8.25	QP
0.180211	42.12	11.51	53.63	64.48	-10.85	QP
0.332442	36.89	11.13	48.02	59.39	-11.37	QP
0.222937	36.26	11.38	47.64	62.71	-15.06	QP
0.342026	33.28	11.11	44.39	59.15	-14.76	QP
0.44254	24.78	10.94	35.72	57.01	-21.3	QP
0.156378	28.21	11.59	39.8	55.65	-15.85	Ave
0.180211	25.08	11.5	36.58	54.48	-17.89	Ave
0.332442	21.88	11.13	33.01	49.39	-16.38	Ave
0.222937	20.11	11.38	31.49	52.71	-21.22	Ave
0.342026	18.99	11.11	30.1	49.15	-19.05	Ave
0.44254	11.79	10.94	22.73	47.01	-24.28	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

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

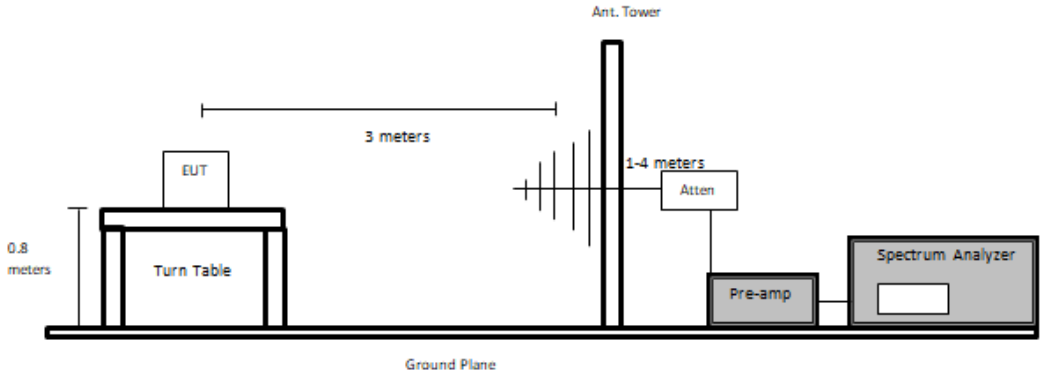
For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

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

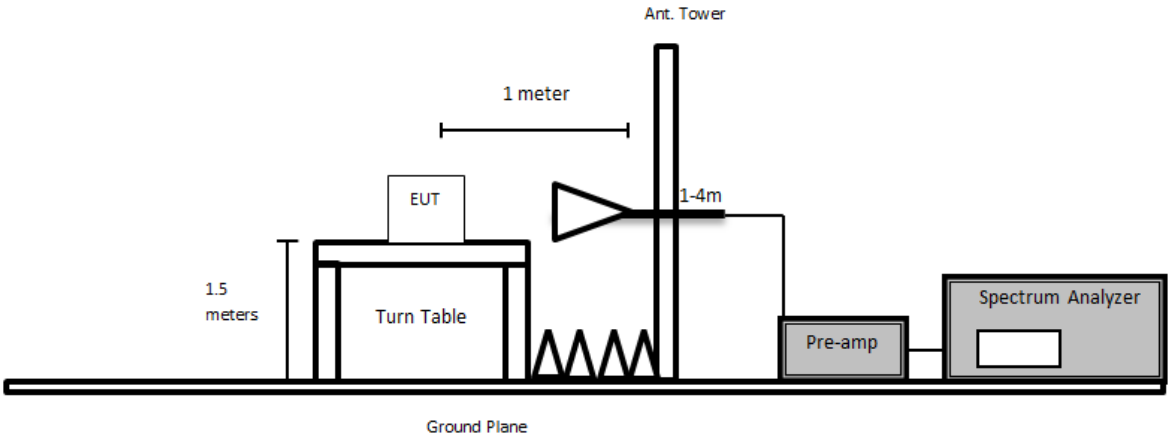
7.5 Test Setup Block Diagram

Below 1GHz:

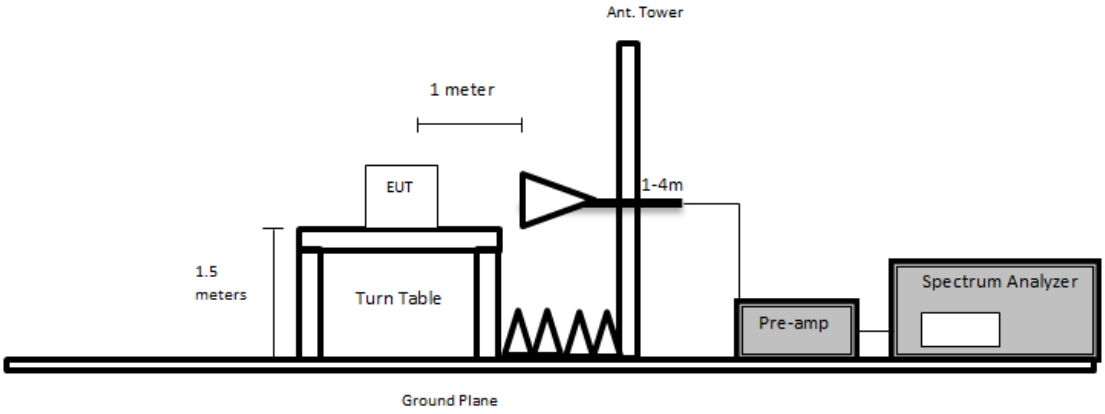


Above 1GHz:

Using Asset #1192



Using Asset #91&#92



7.6 Test Equipment List and Details

BACL No.	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
287	HP/Agilent	PSA spectrum analyzer 3HZ to 44 GHZ	E4446A	US44300386	2022-05-05	1 year
310	Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2022-04-19	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	2023-06-21	1 year
91	Wisewave	Antenna, Horn	ARH-4223-02	10555-02	2022-03-08	2 years
92	Wisewave	Antenna, Horn	ARH-2823-02	10555-01	2022-03-17	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
1228	Pasternack	Coaxial Cable, RG213	PE3496-800CM	2111301	2022-04-12	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
811	Keysight	RF Limiter	11867A	MY42243052	2022-07-27	1 year
1245	-	6dB Atennuator	PE7390-6	01182018A	2022-11-22	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 Arturo Reyes on 2022-12-21 and from 2023-01-04 to 2023-01-05 in 5m chamber 3.

7.8 Summary of Test Results

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

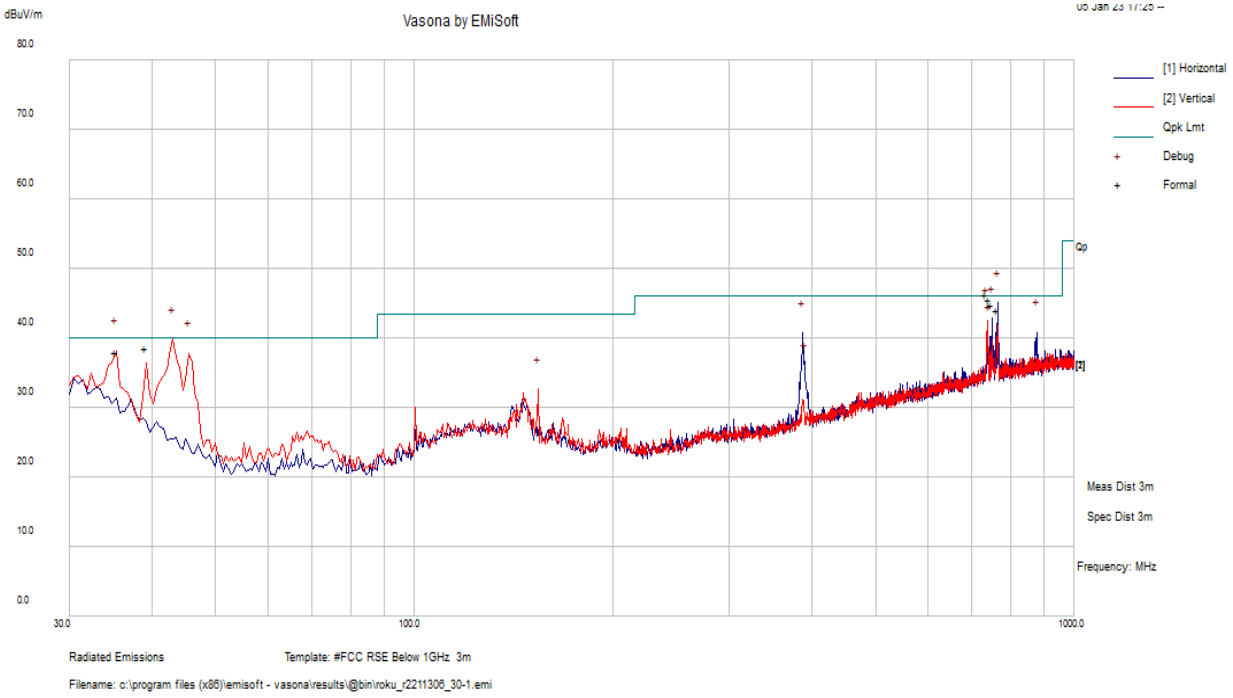
Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Mode, Channel**
-0.616	15840	Horizontal	802.11a mode, Antenna A, 5320 MHz

Please see following plots and data tables.

7.9 Radiated Emissions Test Result Data

1) 30 MHz – 1 GHz at 3 meters

Worst Case



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
42.9285	37.36	-9.21	28.15	148	V	119	40	-11.85	QP
766.74675	34.51	2.03	36.54	262	H	303	46	-9.46	QP
35.515	32.16	-4.42	27.74	118	V	7	40	-12.26	QP
45.71	47.02	-10.7	36.32	124	V	165	40	-3.67	QP
751.5855	36.55	1.85	38.4	144	H	290	46	-7.6	QP
737.55475	38.54	1.59	40.13	107	V	238	46	-5.87	QP

FCC/IC 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	49.128	271	131	H	38.297	10.700	36.314	61.811	84	-22.189	Peak
10520	37.009	271	131	H	38.297	10.700	36.314	49.692	64	-14.308	Ave
15780	56.024	36	113	H	41.748	13.350	36.742	74.380	84	-9.620	Peak
15780	43.002	36	113	H	41.748	13.350	36.742	61.358	64	-2.642	Ave
Middle Channel: 5280 MHz											
10560	48.089	207	234	H	38.373	10.700	36.225	60.937	84	-23.063	Peak
10560	35.667	207	234	H	38.373	10.700	36.225	48.515	64	-15.485	Ave
15840	56.170	35	122	H	41.675	13.340	36.756	74.429	84	-9.571	Peak
15840	43.540	35	122	H	41.675	13.340	36.756	61.799	64	-2.201	Ave
High Channel: 5320 MHz											
10640	47.290	360	150	H	38.473	10.770	36.205	60.328	84	-23.672	Peak
10640	36.480	360	150	H	38.473	10.770	36.205	49.518	64	-14.482	Ave
15960	48.740	360	150	H	41.758	13.370	36.531	67.337	84	-16.663	Peak
15960	37.684	360	150	H	41.758	13.370	36.531	56.281	64	-7.719	Ave
5350	72.450	345	108	H	35.974	7.580	36.650	79.354	84	-4.646	Peak
5350	**56.480**	**345**	**108**	**H**	**35.974**	**7.580**	**36.650**	**63.384**	**64**	**-0.616**	**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	49.396	179	144	V	38.297	10.70	36.314	62.079	84	-21.921	Peak
10520	39.523	179	144	V	38.297	10.70	36.314	52.206	64	-11.794	Ave
15780	49.856	31	120	V	41.748	13.35	36.742	68.212	84	-15.788	Peak
15780	39.969	31	120	V	41.748	13.35	36.742	58.325	64	-5.675	Ave
Middle Channel: 5280 MHz											
10560	48.074	350	191	V	38.373	10.70	36.225	60.922	84	-23.078	Peak
10560	36.707	350	191	V	38.373	10.70	36.225	49.555	64	-14.445	Ave
15840	48.071	360	150	V	41.675	13.34	36.756	66.330	84	-17.670	Peak
15840	38.056	360	150	V	41.675	13.34	36.756	56.315	64	-7.685	Ave
High Channel: 5320 MHz											
10640	46.915	360	150	V	38.473	10.77	36.205	59.953	84	-24.047	Peak
10640	36.463	360	150	V	38.473	10.77	36.205	49.501	64	-14.499	Ave
15960	49.975	22	137	V	41.758	13.37	36.531	68.572	84	-15.428	Peak
15960	39.472	22	137	V	41.758	13.37	36.531	58.069	64	-5.931	Ave
5350	49.830	21	297	V	35.974	7.580	36.650	56.734	84	-27.266	Peak
5350	39.100	21	297	V	35.974	7.580	36.650	46.004	64	-17.996	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	47.380	217	186	V	38.297	10.700	36.314	60.063	84	-23.937	Peak
10520	36.765	217	186	V	38.297	10.700	36.314	49.448	64	-14.552	Ave
15780	48.365	315	209	V	41.748	13.350	36.742	66.721	84	-17.279	Peak
15780	38.010	315	209	V	41.748	13.350	36.742	56.366	64	-7.634	Ave
Middle Channel: 5280 MHz											
10560	47.119	96	148	V	38.373	10.700	36.225	59.967	84	-24.033	Peak
10560	36.645	96	148	V	38.373	10.700	36.225	49.493	64	-14.507	Ave
15840	48.849	244	193	V	41.675	13.340	36.756	67.108	84	-16.892	Peak
15840	38.101	244	193	V	41.675	13.340	36.756	56.360	64	-7.640	Ave
High Channel: 5320 MHz											
10640	47.108	142	277	V	38.473	10.770	36.205	60.146	84	-23.854	Peak
10640	36.514	142	277	V	38.473	10.770	36.205	49.552	64	-14.448	Ave
15960	49.216	257	106	V	41.758	13.370	36.531	67.813	84	-16.187	Peak
15960	37.832	257	106	V	41.758	13.370	36.531	56.429	64	-7.571	Ave
5350	67.750	339	207	V	35.974	7.580	36.65	74.654	84	-9.346	Peak
5350	49.758	339	207	V	35.974	7.580	36.65	56.662	64	-7.338	Ave

5250 - 5350 MHz

802.11n/ac40 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: 5270 MHz											
10540	47.478	360	150	V	38.373	10.700	36.260	60.291	84	-23.709	Peak
10540	37.727	360	150	V	38.373	10.700	36.260	50.540	64	-13.460	Ave
15810	49.694	360	150	V	41.922	13.340	36.746	68.210	84	-15.790	Peak
15810	39.476	360	150	V	41.922	13.340	36.746	57.992	64	-6.008	Ave
High Channel: 5310 MHz											
10620	47.110	360	150	V	38.393	10.740	36.260	59.983	84	-24.017	Peak
10620	36.070	360	150	V	38.393	10.740	36.260	48.943	64	-15.057	Ave
15930	48.890	360	150	V	41.758	13.390	36.512	67.526	84	-16.474	Peak
15930	35.265	360	150	V	41.758	13.390	36.512	53.901	64	-10.099	Ave
5350	69.200	345	169	V	35.974	7.580	36.65	76.104	84	-7.896	Peak
5350	55.479	345	169	V	35.974	7.580	36.65	62.383	64	-1.617	Ave

802.11ac80 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: 5270 MHz											
10580	46.988	360	150	V	38.393	10.710	36.267	59.824	84	-24.176	Peak
10580	37.031	360	150	V	38.393	10.710	36.267	49.867	64	-14.133	Ave
15870	48.024	360	150	V	42.199	13.340	36.711	66.852	84	-17.148	Peak
15870	38.603	360	150	V	42.199	13.340	36.711	57.431	64	-6.569	Ave
5350	74.900	345	188	V	35.974	7.580	36.650	81.804	84	-2.196	Peak
5350	55.678	345	188	V	35.974	7.580	36.650	62.582	64	-1.418	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											
5460	63.700	345	122	H	35.889	7.650	36.60	70.639	84	-13.361	Peak
5460	53.579	345	122	H	35.889	7.650	36.60	60.518	64	-3.482	Ave
11000	47.747	360	150	H	38.474	10.990	35.981	61.230	84	-22.770	Peak
11000	37.049	360	150	H	38.474	10.990	35.981	50.532	64	-13.468	Ave
16500	49.260	140	120	H	42.340	13.460	35.866	69.194	84	-14.806	Peak
16500	38.701	140	120	H	42.340	13.460	35.866	58.635	64	-5.365	Ave
Middle Channel: 5580 MHz											
11160	47.265	360	150	H	38.378	11.000	35.867	60.776	84	-23.224	Peak
11160	37.082	360	150	H	38.378	11.000	35.867	50.593	64	-13.407	Ave
16740	49.228	238	245	H	42.587	13.640	35.607	69.848	84	-14.152	Peak
16740	38.725	238	245	H	42.587	13.640	35.607	59.345	64	-4.655	Ave
High Channel: 5720 MHz											
11440	47.658	360	150	H	38.574	11.160	35.940	61.452	84	-22.548	Peak
11440	36.114	360	150	H	38.574	11.160	35.940	49.908	64	-14.092	Ave
17160	49.380	339	224	H	41.908	13.830	35.846	69.272	84	-14.728	Peak
17160	39.473	339	224	H	41.908	13.830	35.846	59.365	64	-4.635	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											
5460	47.080	61	130	V	35.889	7.650	36.60	54.019	84	-29.981	Peak
5460	36.780	61	130	V	35.889	7.650	36.60	43.719	64	-20.281	Ave
11000	47.860	360	150	V	38.474	10.990	35.981	61.343	84	-22.657	Peak
11000	36.930	360	150	V	38.474	10.990	35.981	50.413	64	-13.587	Ave
16500	51.130	14	137	V	42.340	13.460	35.866	71.064	84	-12.936	Peak
16500	40.283	14	137	V	42.340	13.460	35.866	60.217	64	-3.783	Ave
Middle Channel: 5580 MHz											
11160	47.225	360	150	V	38.378	11.000	35.867	60.736	84	-23.264	Peak
11160	37.392	360	150	V	38.378	11.000	35.867	50.903	64	-13.097	Ave
16740	48.330	360	150	V	42.587	13.640	35.607	68.950	84	-15.050	Peak
16740	38.661	360	150	V	42.587	13.640	35.607	59.281	64	-4.719	Ave
High Channel: 5720 MHz											
11440	46.107	360	150	V	38.574	11.160	35.940	59.901	84	-24.099	Peak
11440	35.880	360	150	V	38.574	11.160	35.940	49.674	64	-14.326	Ave
17160	52.500	323	266	V	41.908	13.830	35.846	72.392	84	-11.608	Peak
17160	41.088	323	266	V	41.908	13.830	35.846	60.980	64	-3.020	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											
5460	68.970	69	104	V	35.889	7.650	36.60	75.909	84	-8.091	Peak
5460	50.637	69	104	V	35.889	7.650	36.60	57.576	64	-6.424	Ave
11000	47.349	360	150	V	38.474	10.990	35.981	60.832	84	-23.168	Peak
11000	37.078	360	150	V	38.474	10.990	35.981	50.561	64	-13.439	Ave
16500	49.630	360	150	V	42.340	13.460	35.866	69.564	84	-14.436	Peak
16500	38.470	360	150	V	42.340	13.460	35.866	58.404	64	-5.596	Ave
Middle Channel: 5580 MHz											
11160	47.106	360	150	V	38.378	11.000	35.867	60.617	84	-23.383	Peak
11160	36.962	360	150	V	38.378	11.000	35.867	50.473	64	-13.527	Ave
16740	48.711	360	150	V	42.587	13.640	35.607	69.331	84	-14.669	Peak
16740	38.299	360	150	V	42.587	13.640	35.607	58.919	64	-5.081	Ave
High Channel: 5720 MHz											
11440	46.390	360	150	V	38.574	11.160	35.940	60.184	84	-23.816	Peak
11440	36.012	360	150	V	38.574	11.160	35.940	49.806	64	-14.194	Ave
17160	49.070	360	150	V	41.908	13.830	35.846	68.962	84	-15.038	Peak
17160	38.403	360	150	V	41.908	13.830	35.846	58.295	64	-5.705	Ave

802.11n/ac40 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: 5510 MHz											
5460	69.390	346	179	V	35.889	7.650	36.60	76.329	84	-7.671	Peak
5460	53.982	346	179	V	35.889	7.650	36.60	60.921	64	-3.079	Ave
11020	69.040	62	150	H	35.21	9.185	36.57	76.864	84	-7.136	Peak
11020	53.883	62	150	H	35.21	9.185	36.57	61.707	64	-2.293	Ave
16530	46.790	56	120	H	38.63	13.52	36.15	62.797	84	-21.203	Peak
16530	34.578	56	120	H	38.63	13.52	36.15	50.585	64	-13.415	Ave
Middle Channel: 5590 MHz (FCC only)											
11180	47.290	360	150	V	38.557	11.020	35.888	60.979	84	-23.021	Peak
11180	36.726	360	150	V	38.557	11.020	35.888	50.415	64	-13.585	Ave
16770	48.640	360	150	V	42.510	13.680	35.650	69.180	84	-14.820	Peak
16770	38.485	360	150	V	42.510	13.680	35.650	59.025	64	-4.975	Ave
High Channel: 5710 MHz											
11420	46.316	360	150	V	38.574	11.150	35.911	60.129	84	-23.871	Peak
11420	36.121	360	150	V	38.574	11.150	35.911	49.934	64	-14.066	Ave
17130	49.070	360	150	V	42.145	13.810	35.636	69.389	84	-14.611	Peak
17130	38.636	360	150	V	42.145	13.810	35.636	58.955	64	-5.045	Ave

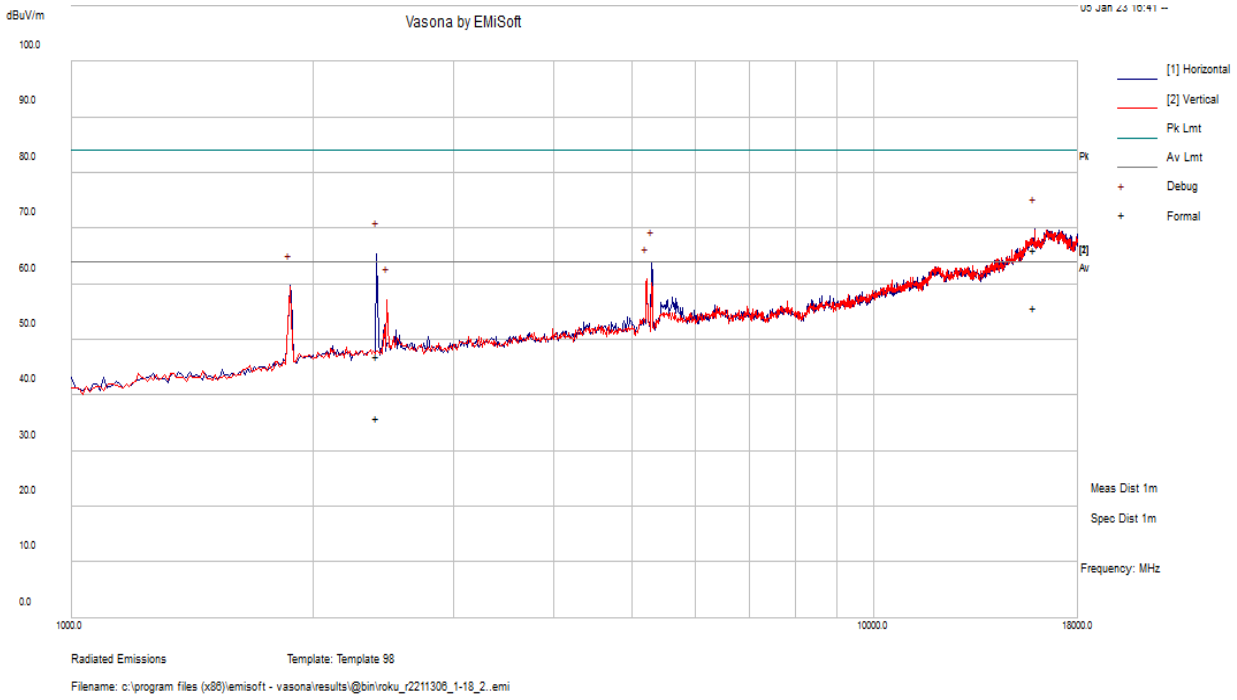
5470 - 5725 MHz

802.11ac80 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: 5530 MHz											
5460	65.480	19	122	V	35.889	7.650	36.60	72.419	84	-11.581	Peak
5460	52.098	19	122	V	35.889	7.650	36.60	59.037	64	-4.963	Ave
11060	48.184	360	150	V	38.314	11.000	35.887	61.611	84	-22.389	Peak
11060	37.699	360	150	V	38.314	11.000	35.887	51.126	64	-12.874	Ave
16590	48.150	360	150	V	42.398	13.570	35.788	68.330	84	-15.670	Peak
16590	38.432	360	150	V	42.398	13.570	35.788	58.612	64	-5.388	Ave
Middle Channel: 5610 MHz (FCC only)											
11220	47.066	360	150	V	38.557	11.030	35.936	60.717	84	-23.283	Peak
11220	36.777	360	150	V	38.557	11.030	35.936	50.428	64	-13.572	Ave
16830	49.096	360	150	V	42.508	13.700	35.496	69.808	84	-14.192	Peak
16830	38.568	360	150	V	42.508	13.700	35.496	59.280	64	-4.720	Ave
High Channel: 5690 MHz											
11380	46.680	360	150	V	38.560	11.100	35.917	60.423	84	-23.577	Peak
11380	36.392	360	150	V	38.560	11.100	35.917	50.135	64	-13.865	Ave
17070	49.039	360	150	V	42.157	13.780	35.557	69.419	84	-14.581	Peak
17070	38.214	360	150	V	42.157	13.780	35.557	58.594	64	-5.406	Ave

3) 1 to 18 GHz Vasona scan at 1 meter

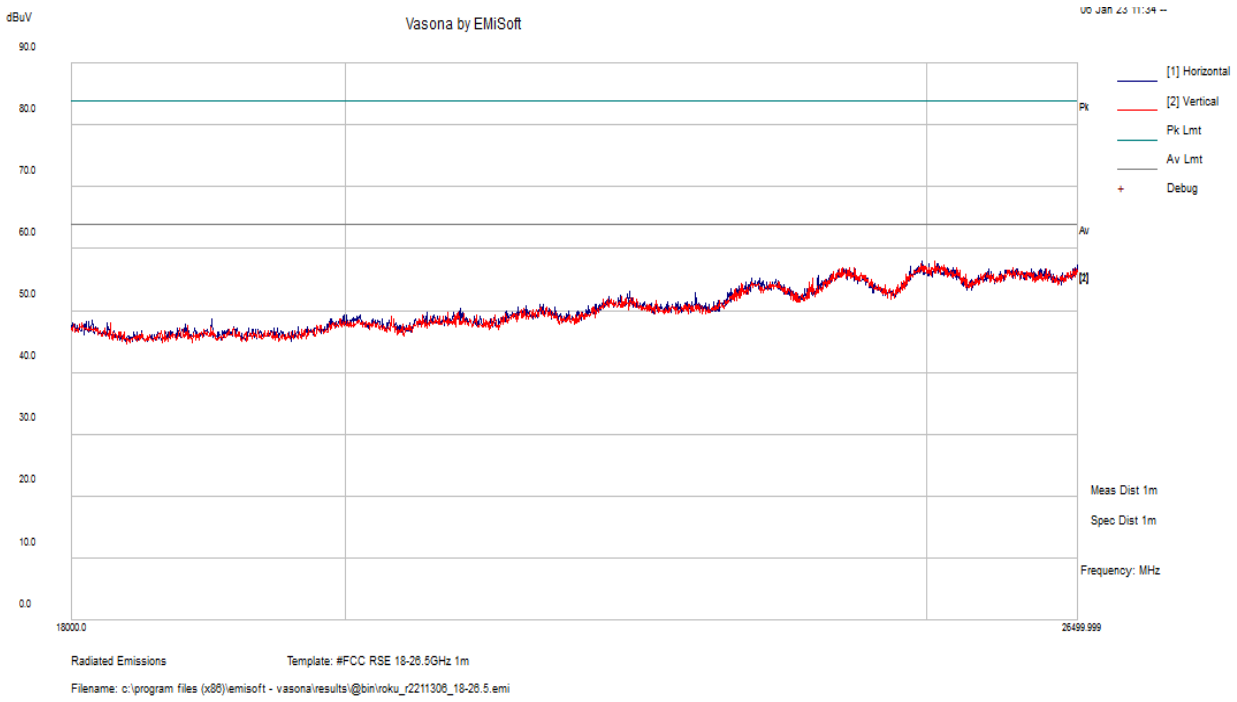
Worst Case



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
15886.775	47.57	18.61	66.18	206	H	63	84	-17.81	Peak
2402.5875	47.66	-0.75	46.91	187	H	142	84	-37.09	Peak
15886.775	37.25	18.61	55.86	206	H	63	64	-8.14	Avg
2402.5875	36.72	-0.75	35.97	187	H	142	64	-28.03	Avg

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

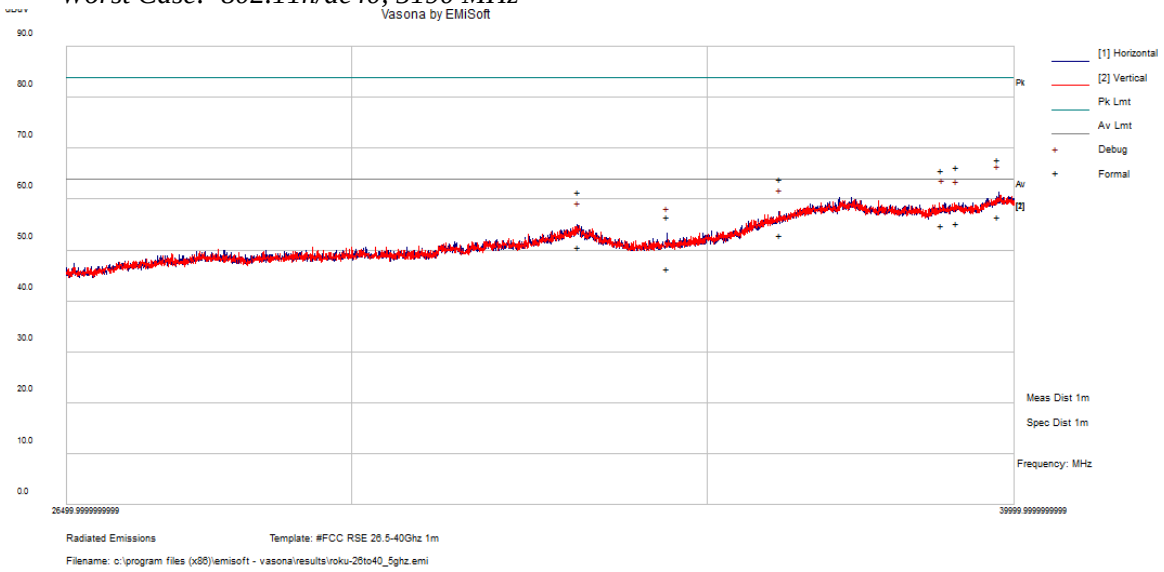
Worst Case



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
26499.999	35.83	20.56	56.39	100	V	352	64	-7.61	Peak
18174.892	33.01	13.91	46.92	100	V	352	64	-17.08	Peak

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

Worst Case: 802.11n/ac40, 5190 MHz



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
39727	53.17	15.69	68.86	150	H	250	84	-15.14	Peak
39727	42.22	15.69	57.91	150	H	250	64	-6.09	Avg

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

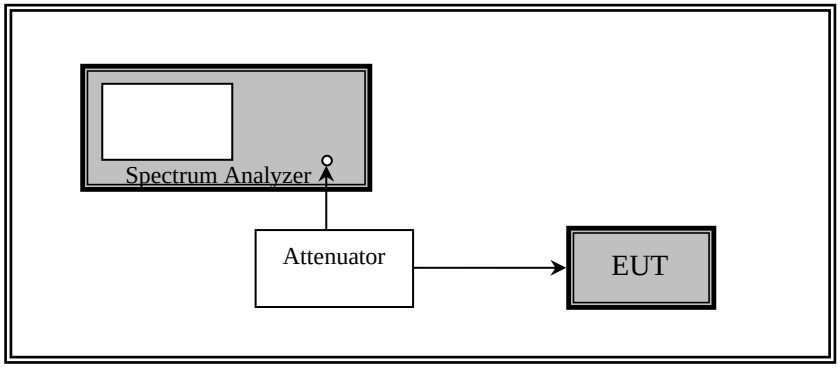
8.1 Applicable Standards

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
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".*

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 from 2022-07-08 to 2023-02-06 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	20.72	34.05
60	5300	21.28	34.65
64	5320	17.16	20.55
802.11n/ac20 mode			
52	5260	17.92	20
60	5300	17.88	20.3
64	5320	17.96	19.85
802.11n/ac40 mode			
54	5270	37.44	41.9
62	5310	37.2	41.8
802.11ac80 mode			
58	5290	76.16	81.2

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

5250 - 5350 MHz
Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
52	5260	19.24	34.8
60	5300	20.64	35.7
64	5320	17.36	27.45
802.11n/ac20 mode			
52	5260	17.96	19.8
60	5300	18.2	20.35
64	5320	17.96	19.9
802.11n/ac40 mode			
54	5270	37.2	41.9
62	5310	37.04	41.7
802.11ac80 mode			
58	5290	76.64	82.2

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

5470MHz - 5725 MHz
Ant A

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
100	5500	18.92	39.1
116	5580	19.24	34.8
140	5700	17.00	24.35
144	5720	17.28	22.8
802.11n/ac20 mode			
100	5500	16.84	20.75
116	5580	17.88	19.8
140	5700	17.88	19.85
144	5720	17.92	19.7
802.11n/ac40 mode			
102	5510	37.28	41.8
118(FCC only)	5590	37.36	42.2
134	5670	37.04	41.7
142	5710	37.12	49.4
802.11ac80 mode			
106	5530	76.48	82.2
122(FCC only)	5610	77.6	82.2
138	5690	76.8	132.4

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

5470MHz - 5725 MHz
Ant B

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB OBW (MHz)
802.11a mode			
100	5500	22.28	36.15
116	5580	20.16	32.4
140	5700	17.88	27.7
144	5720	18.08	23.1
802.11n/ac20 mode			
100	5500	18.00	20.7
116	5580	17.88	20.15
140	5700	17.88	19.9
144	5720	17.88	19.75
802.11n/ac40 mode			
102	5510	36.96	42.1
118(FCC only)	5590	37.68	50.7
134	5670	37.12	42
142	5710	37.52	56.8
802.11ac80 mode			
106	5530	76.48	82.4
122(FCC only)	5610	84.8	83.8
138	5690	77.6	138.6

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

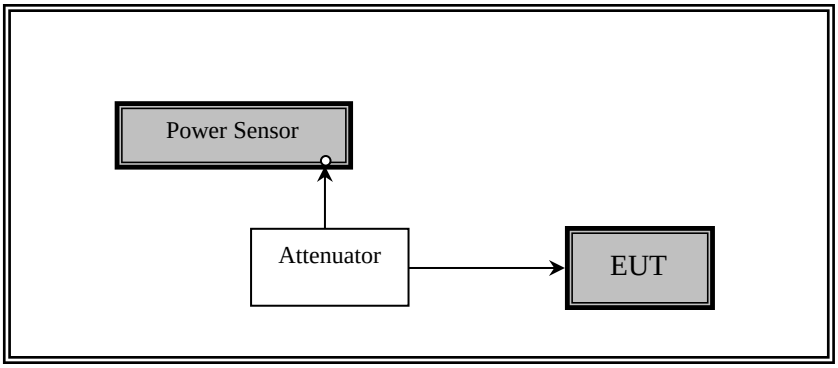
For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11 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

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 Number	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
-	-	20dB attenuator	-	-	Each time1	N/A
-	-	RF cable	-	-	Each time[1]	N/A
697	ETS- Lindgren	Power Sensor	7002-006	160097	2021-02-12	2 years

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 from 2022-07-08 to 2022-07-28 at the RF site.

9.6 Test Results

5250 - 5350 MHz

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total Power (dBm)	Limit (dBm)
		ANT A	ANT B		
802.11a mode					
52	5260	21.21	22.02	-	24
56	5280	21.33	22.12	-	24
64	5320	18.82	19.81	-	24
802.11n/ac20 mode					
52	5260	17.24	18.03	20.66	22.5
56	5280	17.36	18.12	20.76	22.5
64	5320	16.75	17.69	20.26	22.5
802.11n/ac40 mode					
54	5270	18.07	18.17	21.13	22.5
62	5310	14.88	15.56	18.24	22.5
802.11ac80 mode					
58	5290	14.64	15.19	17.93	22.5

Note: Total power (dBm) =10*Log(Ant A(mw)+Ant B(mw))
Note: Duty cycle correction factor has already been added to the measurements
Note: For 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 7.5 dBi calculated based on method specified in KDB 662911 D01)

5470MHz - 5725 MHz

Channel	Frequency (MHz)	Conducted Output Power (dBm)		Total Power (dBm)	Limit (dBm)
		ANT A	ANT B		
802.11a mode					
100	5500	21.31	22.84	-	24
116	5580	20.9	22.4	-	24
140	5700	19.62	21.53	-	24
144	5720	16.52	17.93	-	24
802.11n/ac20 mode					
100	5500	17.23	19.04	21.24	22.5
116	5580	16.94	18.48	20.78	22.5
140	5700	16.25	18.3	20.4	22.5
144	5720	12.87	14.6	16.83	22.5
802.11n/ac40 mode					
102	5510	15	16.46	18.8	22.5
118	5590	18.71	18.72	21.73	22.5
134	5670	17.31	18.11	20.74	22.5
142	5710	15.9	17.74	19.92	22.5
802.11ac80 mode					
106	5530	15.02	16.44	18.79	22.5
122	5610	17.05	18.22	20.68	22.5
138	5690	17.87	19.66	21.86	22.5

Note: Total power (dBm) =10*Log(Ant A(mw)+Ant B(mw))
Note: Duty cycle correction factor has already been added to the measurements
Note: For 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 7.5 dBi calculated based on method specified in KDB 662911 D01)

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.

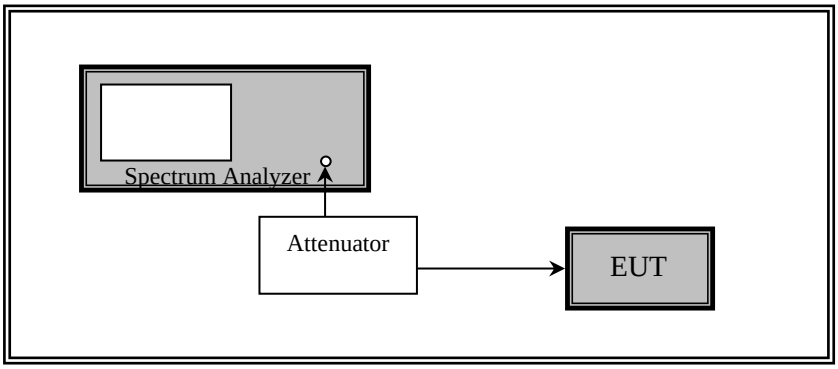
For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum 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.

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 ≥ 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 from 2022-07-08 to 2022-07-28 at the RF site.

10.6 Test Results

5250MHz - 5350 MHz

Channel	Frequency (MHz)	PSD (dBm/MHz)		Total PSD(dBm/MHz)	Limit (dBm/MHz)
		ANT A	ANT B		
802.11a mode					
52	5260	10.53	10.97	-	11
60	5300	10.06	10.29	-	11
64	5320	8.66	8.98	-	11
802.11n/ac20 mode					
52	5260	6.02	6.3	9.17	9.5
60	5300	5.99	6.06	9.03	9.5
64	5320	5.92	6.56	9.26	9.5
802.11n/ac40 mode					
54	5270	4.03	4.06	7.05	9.5
62	5310	1.85	2.07	4.97	9.5
802.11ac80 mode					
58	5290	-1.15	-.87	2.02	9.5

Note:See Annex C for test results
Note: Total PSD (dBm/MHz) =10*Log(Ant A(mw)+Ant B(mw))
Note: Duty cycle correction factor has been added to the measurements in the data table
Note: Where applicable, limits are reduced (in dB) by amount that antenna gain exceeds 6dBi. (The directional antenna gain is 7.5 dBi calculated based on method specified in KDB 662911 D01)

5470MHz - 5725 MHz

Channel	Frequency (MHz)	PSD (dBm/MHz)		Total PSD(dBm/MHz)	Limit (dBm/MHz)
		ANT A	ANT B		
802.11a mode					
100	5500	10.64	10.92	-	11
116	5580	10.88	10.21	-	11
140	5700	9.33	9.78		11
144	5720	8.2	9.72	-	11
802.11n/ac20 mode					
100	5500	5.68	5.37	8.54	9.5
116	5580	6.19	6.04	9.13	9.5
140	5700	5.31	5.96	8.67	9.5
144	5720	3.48	5.06	7.36	9.5
802.11n/ac40 mode					
102	5510	1.37	1.93	4.67	9.5
118(FCC only)	5590	4.08	4.47	7.29	9.5
134	5670	2.97	4.34	6.72	9.5
142	5710	4.2	5.84	8.11	9.5
802.11ac80 mode					
106	5530	-.99	-.32	2.37	9.5
122(FCC only)	5610	1.05	2.12	4.63	9.5
138	5690	3.53	5.16	7.43	9.5

Note:See Annex C for test results
Note: Total PSD (dBm/MHz) =10*Log(Ant A(mw)+Ant B(mw))
Note: Duty cycle correction factor has been added to the measurements in the data table
Note: Where applicable, limits are reduced (in dB) by amount that antenna gain exceeds 6dBi. (The directional antenna gain is 7.5 dBi calculated based on method specified in KDB 662911 D01)

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

11.1 Applicable Standards

According to FCC §15.407(b):

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

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

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

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

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

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

11.2 Measurement Procedure

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

Unwanted Emission Measurement:

Maximum emission levels are measured by setting the analyzer as follows:

i. RBW = 1 MHz
ii. VBW ≥ 3 MHz
iii. Detector = Peak
iv. Sweep time = auto
v. Trace mode = max hold

Integration Method:

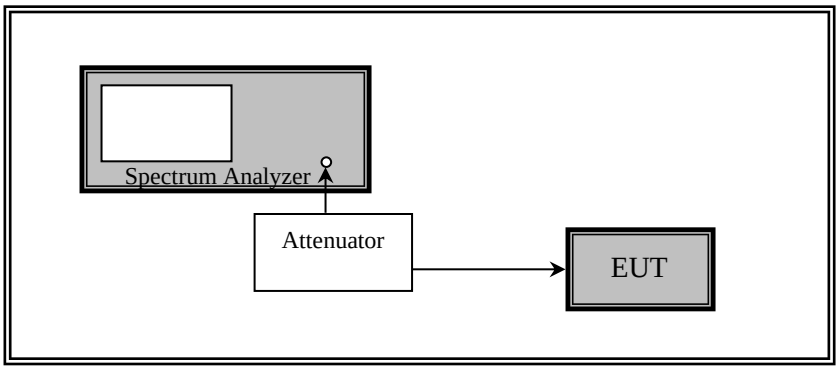
1. For peak emissions measurements, follow the procedures described in section H)5), "Procedures for Peak Unwanted Emissions Measurements above 1000 MHz", except for the following changes:

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

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

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

11.3 Test Setup Block Diagram



11.4 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".*

11.5 Test Environmental Conditions

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

Testing was performed by Christian Schwartz from 2022-07-08 to 2022-07-28 at the RF site.

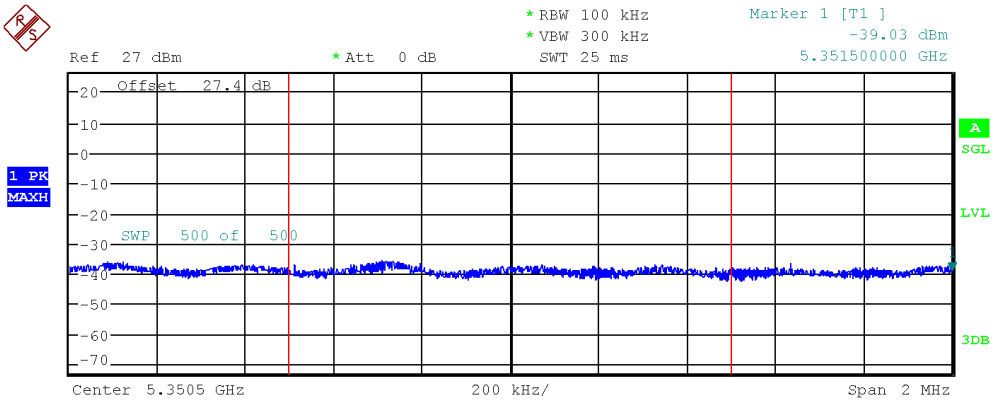
11.6 Test Results

See Annex D for Spurrious Emission Test Results

Please refer to the following plots for bandedge measurements

Note: applicable directional antenna gain was applied to offset in measurements.
Note: For MIMO configurations, an additional 3dB=10*log(N_{ANT}) was added to offset in measurements.

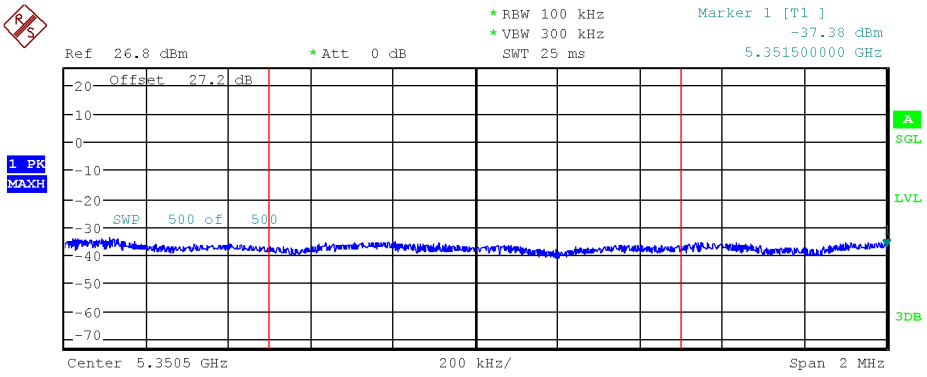
A 5320MHz Ant A



Tx Channel

Bandwidth	1 MHz	Power	-29.43 dBm

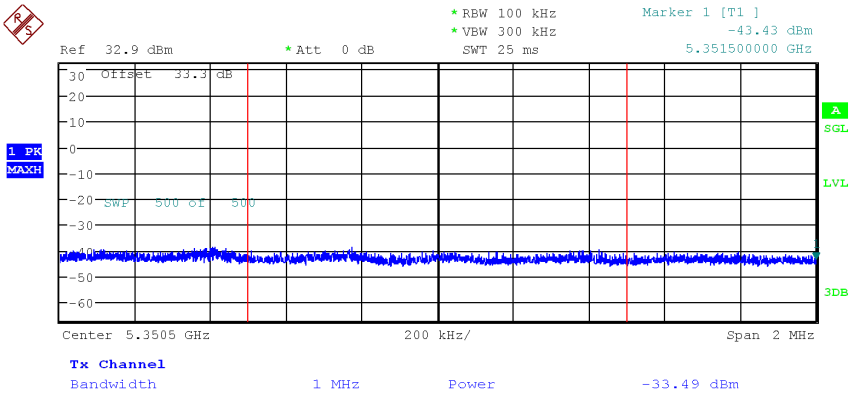
A 5320MHz Ant B



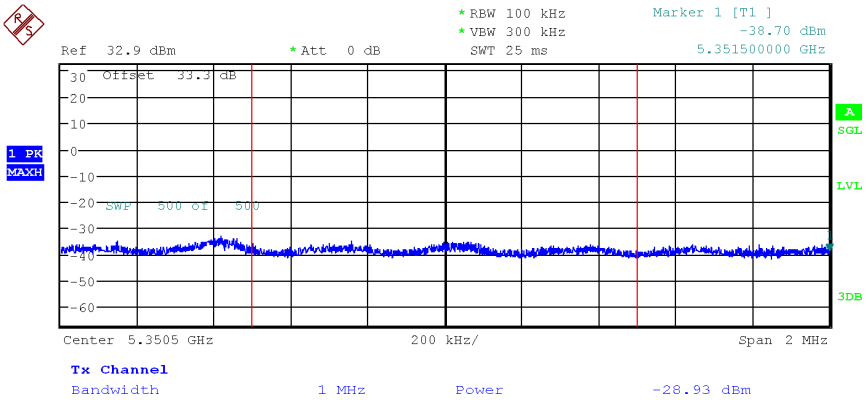
Tx Channel

Bandwidth	1 MHz	Power	-28.32 dBm

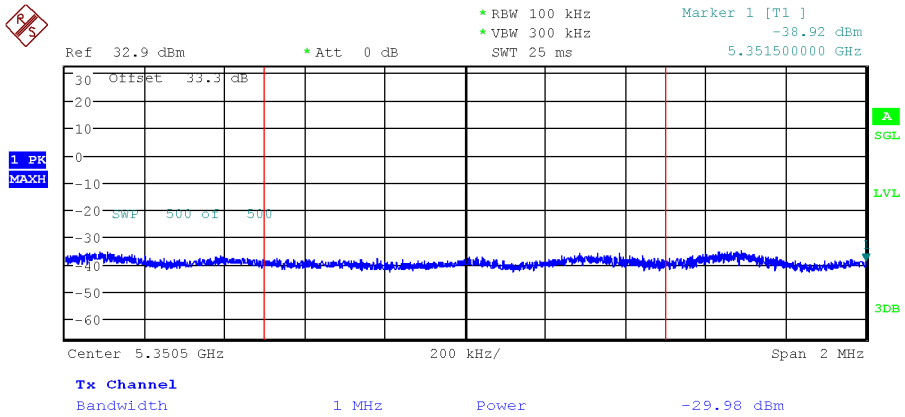
N/ac20 5320MHz Ant A



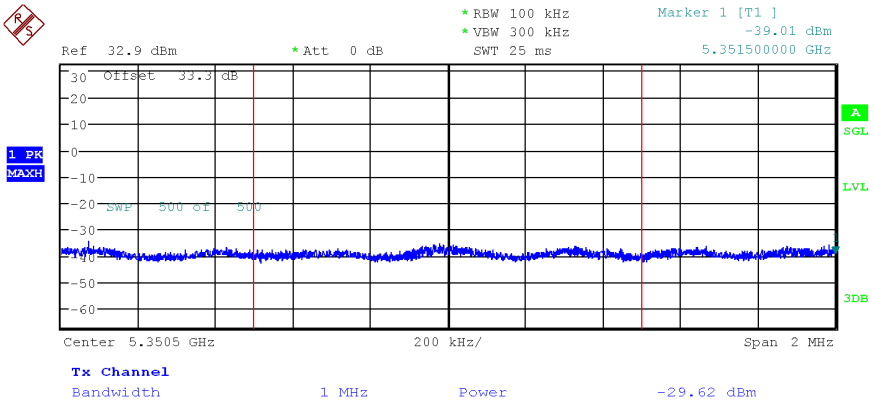
N/ac20 5320MHz Ant A



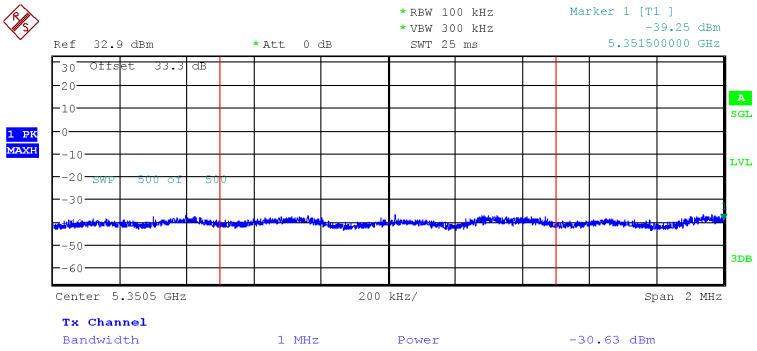
N/ac40 5310MHz Ant A



N/ac40 5310MHz Ant B



AC80 5290MHz Ant A



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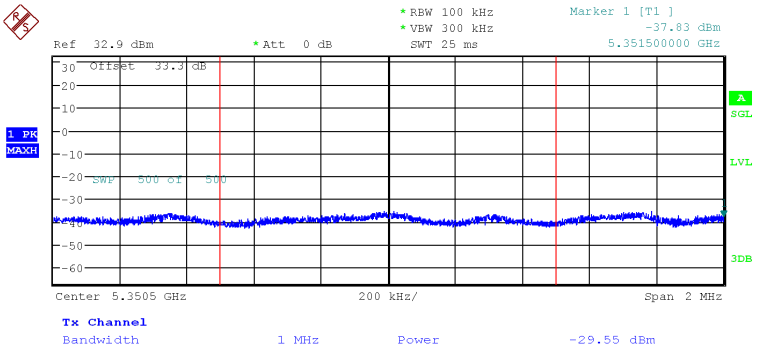
AC80 5290MHz Ant B



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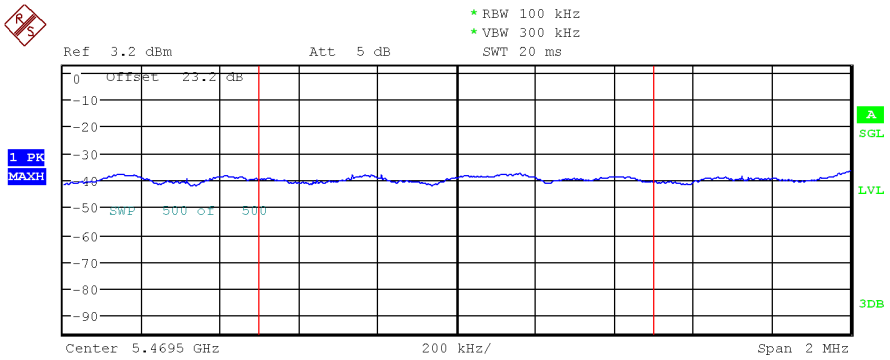
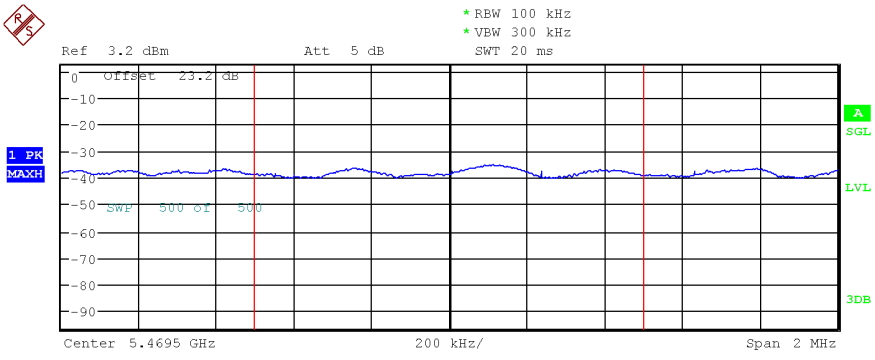
A 5500MHz Ant A



Tx Channel

Bandwidth	1 MHz	Power	-29.80 dBm

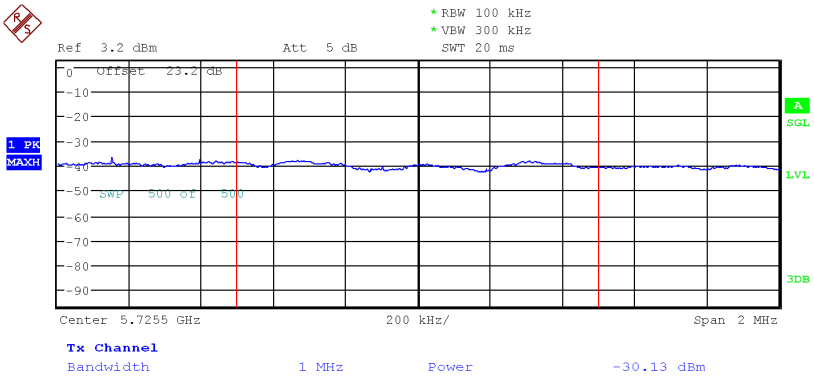
A 5500MHz Ant B



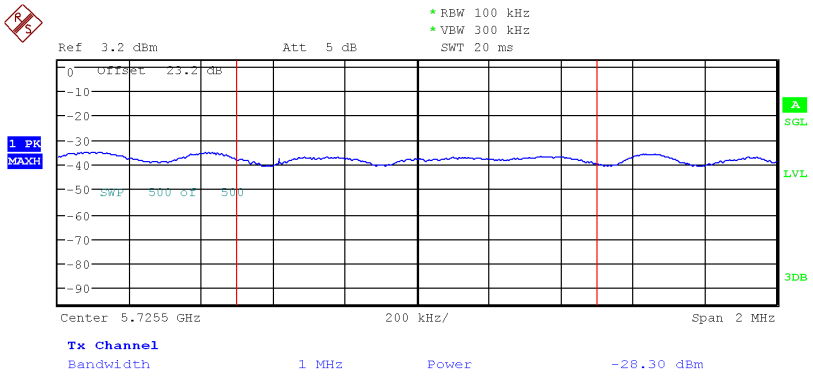
Tx Channel

Bandwidth	1 MHz	Power	-28.27 dBm

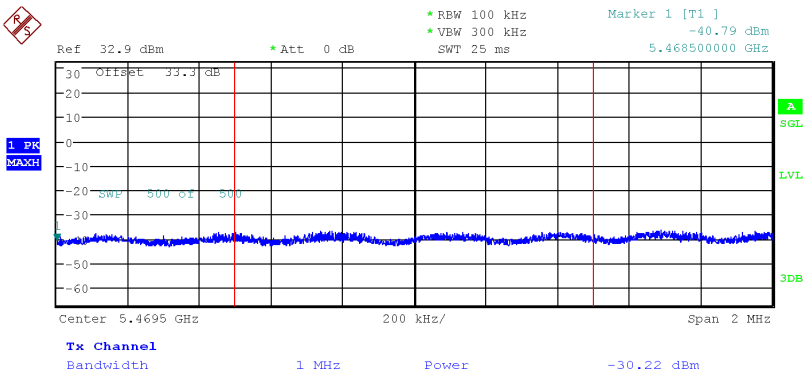
A 5700MHz Ant A



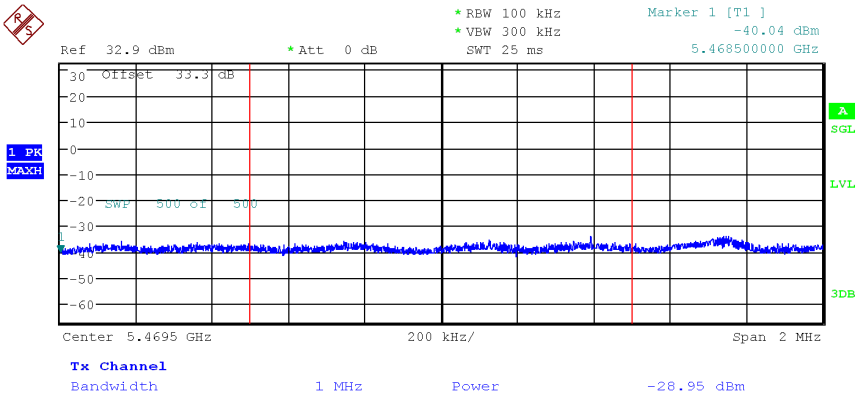
A 5700MHz Ant B



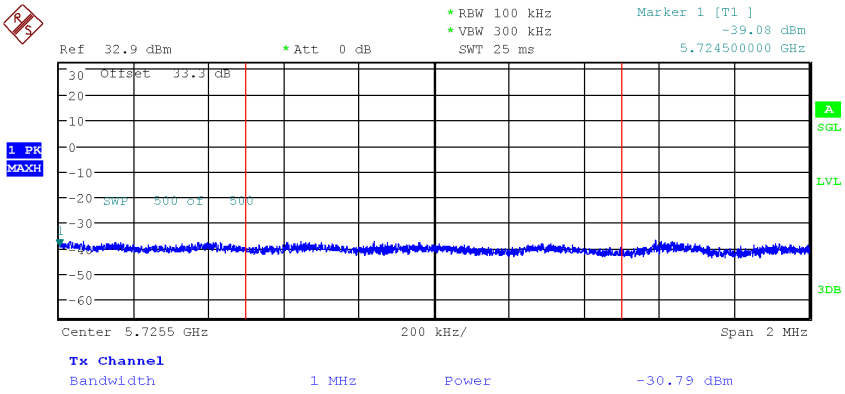
N/ac20 5500MHz Ant A



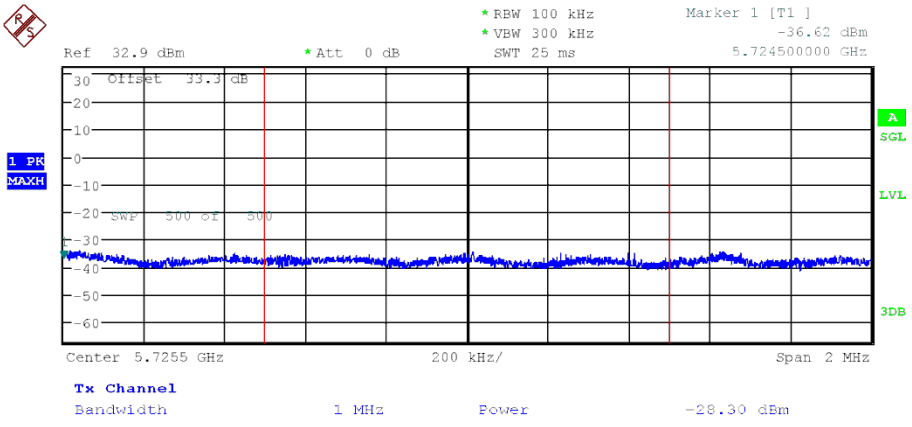
N/ac20 5500MHz Ant B



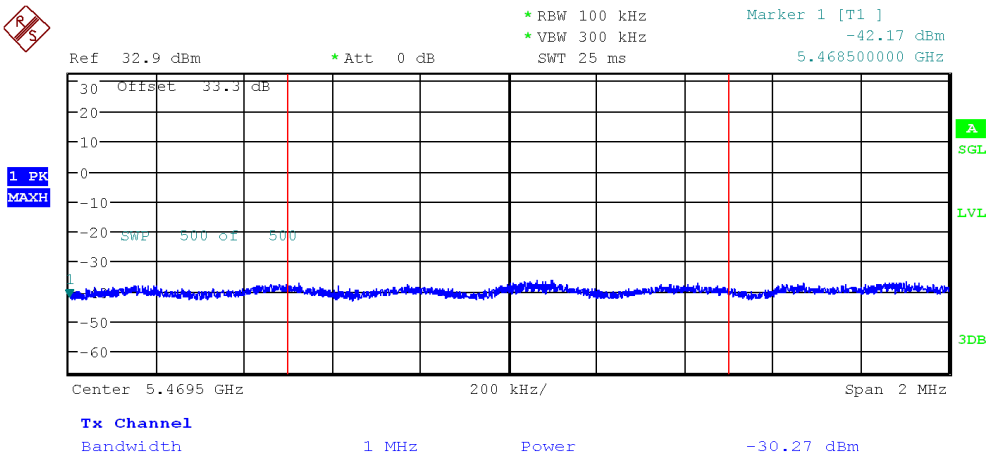
N/ac20 5700MHz Ant A



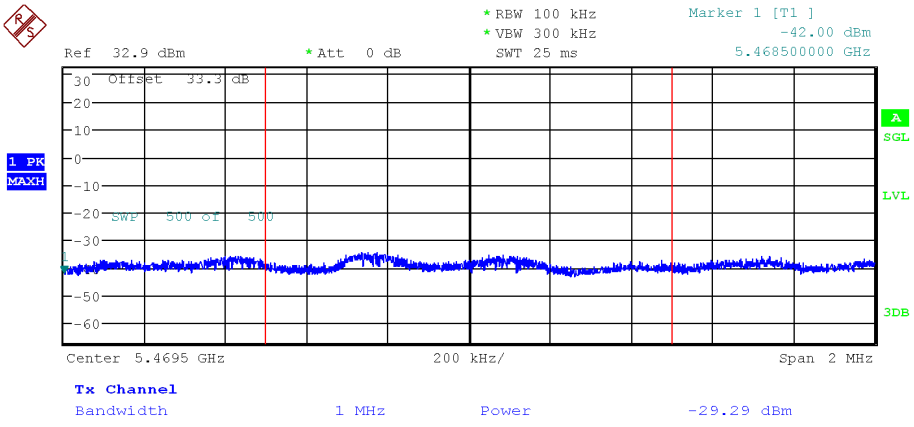
N/ac20 5700MHz Ant B



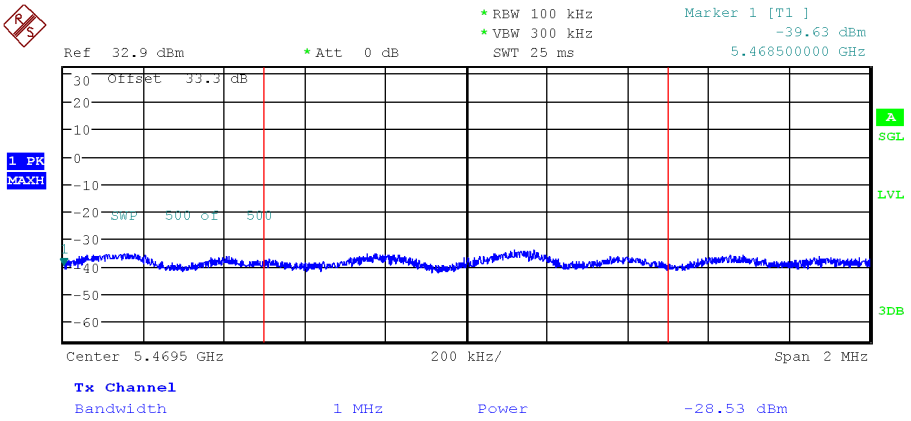
N/ac40 5510MHz Ant A



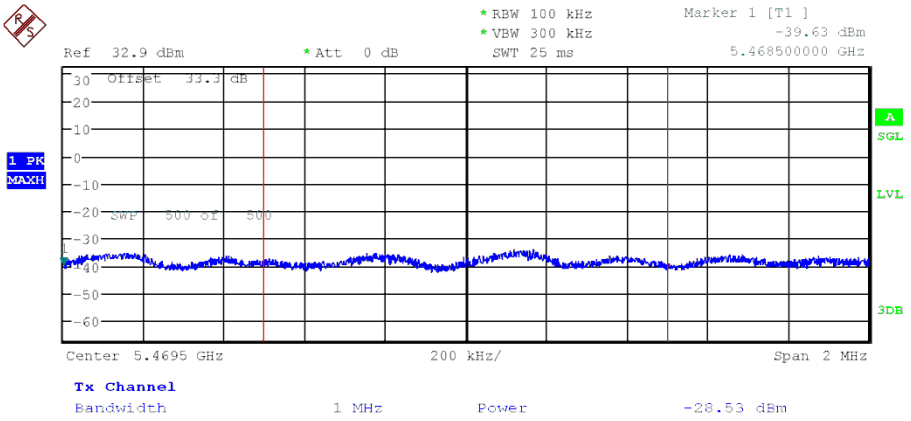
N/ac40 5510MHz Ant B



AC80 5510MHz Ant A



AC80 5510MHz Ant B



12 FCC §15.407(h)– Dynamic Frequency Selection

12.1 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

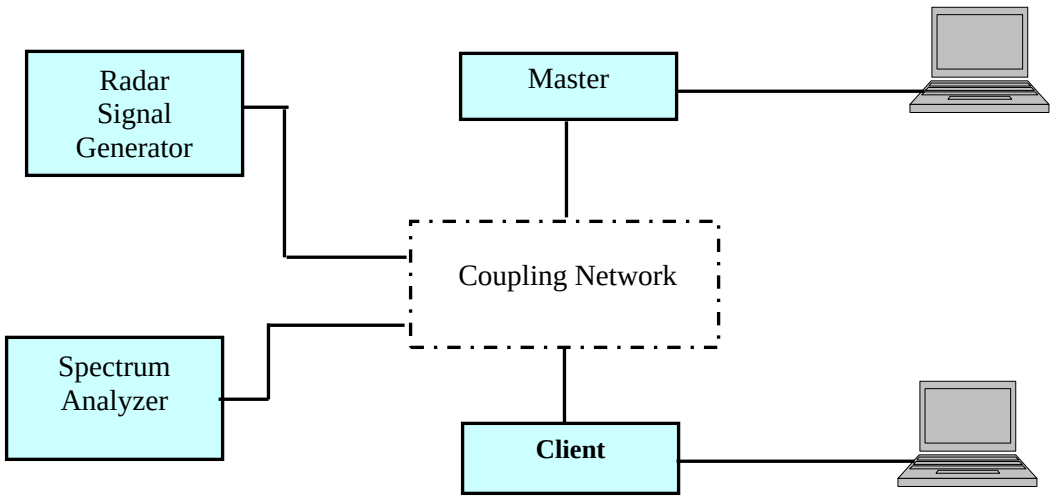
Table 7: Frequency Hopping Radar Test Signal

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

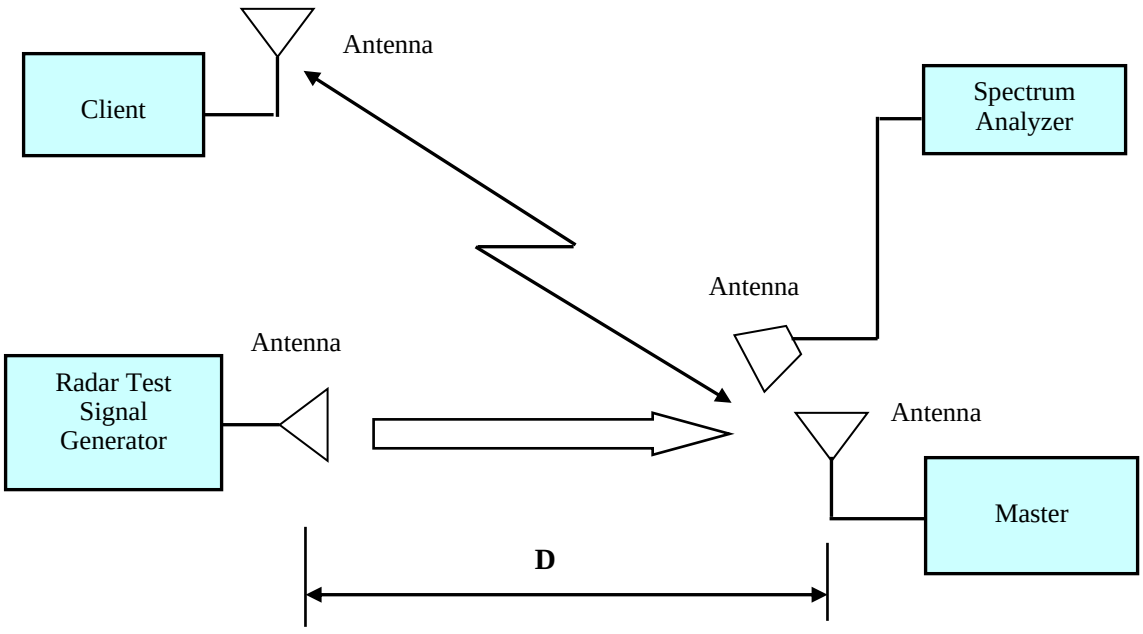
12.2 DFS Measurement System

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

12.3 System Block Diagram



12.4 Radiated Method



12.5 Test Procedure

The EUT was connected to a certified master device (FCC ID: S9GH350). 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)

12.6 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".*

12.7 Test Environmental Conditions

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

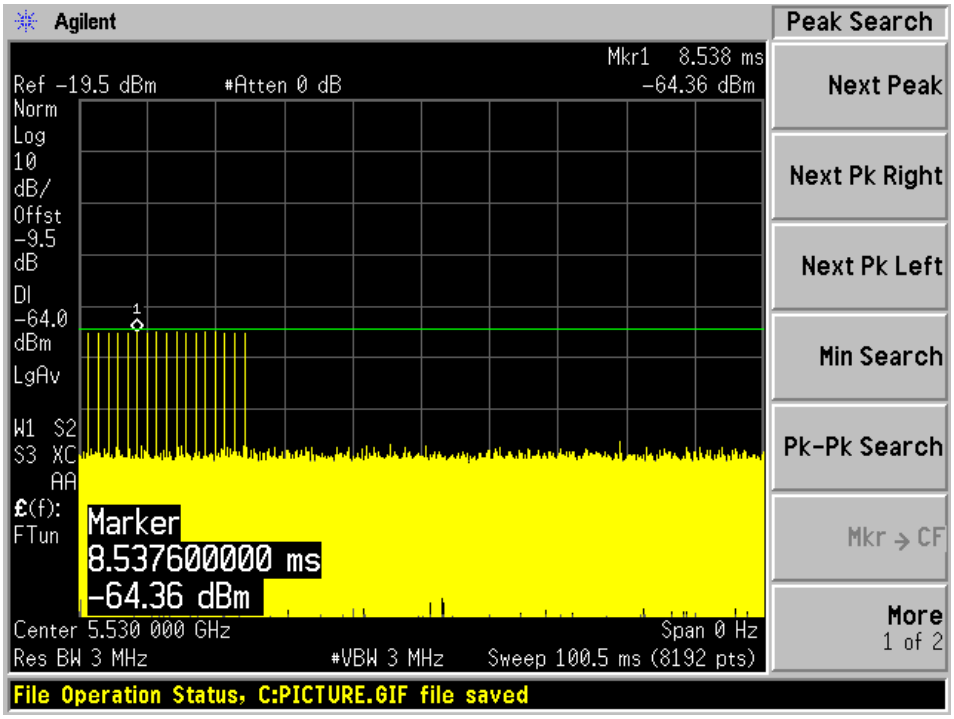
Testing was performed by Simon Ma on 2023-01-24 at the DFS testing site.

12.8 Test Results

Plots of Radar Waveforms

Radar Type 0

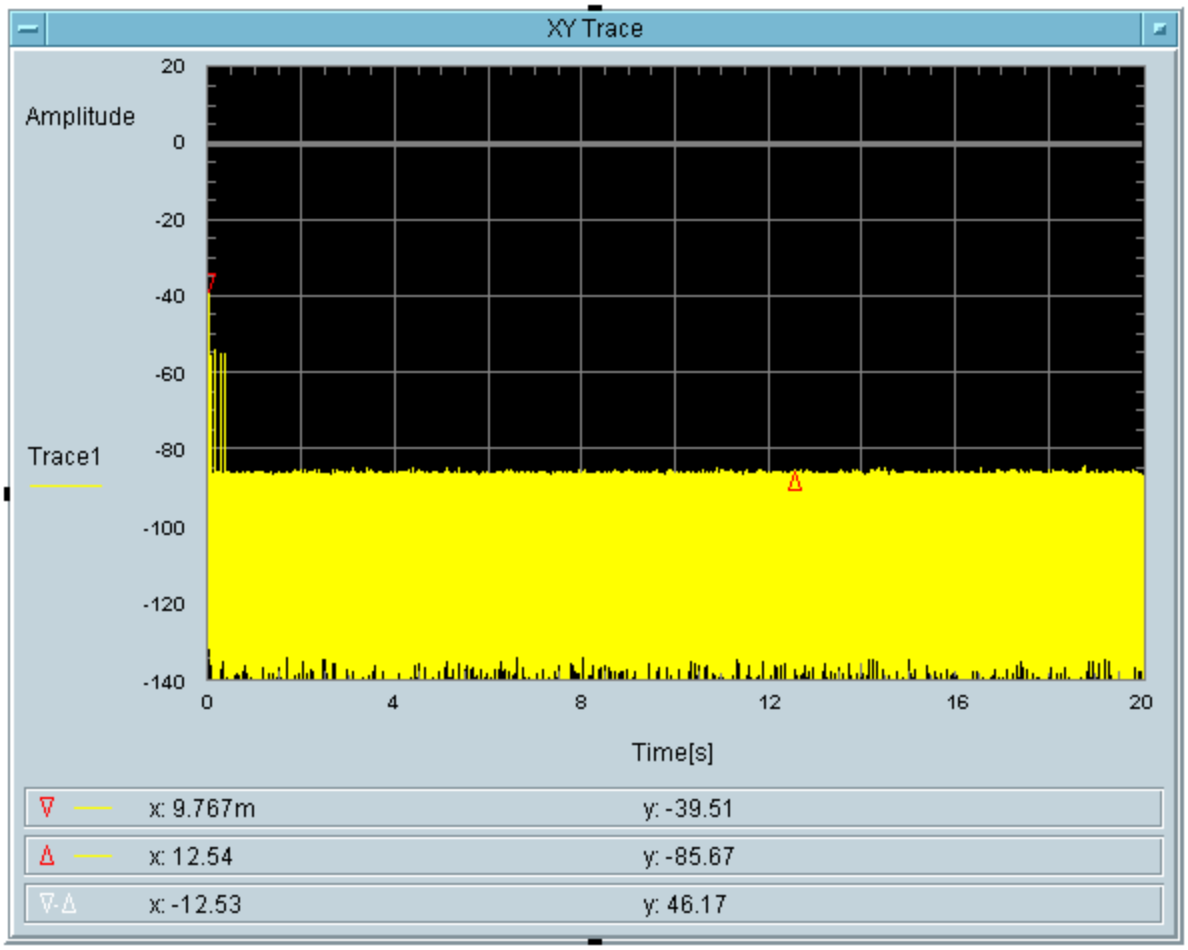
5530 MHz



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

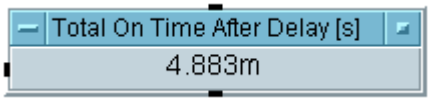
5530 MHz 80 MHz Bandwidth

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



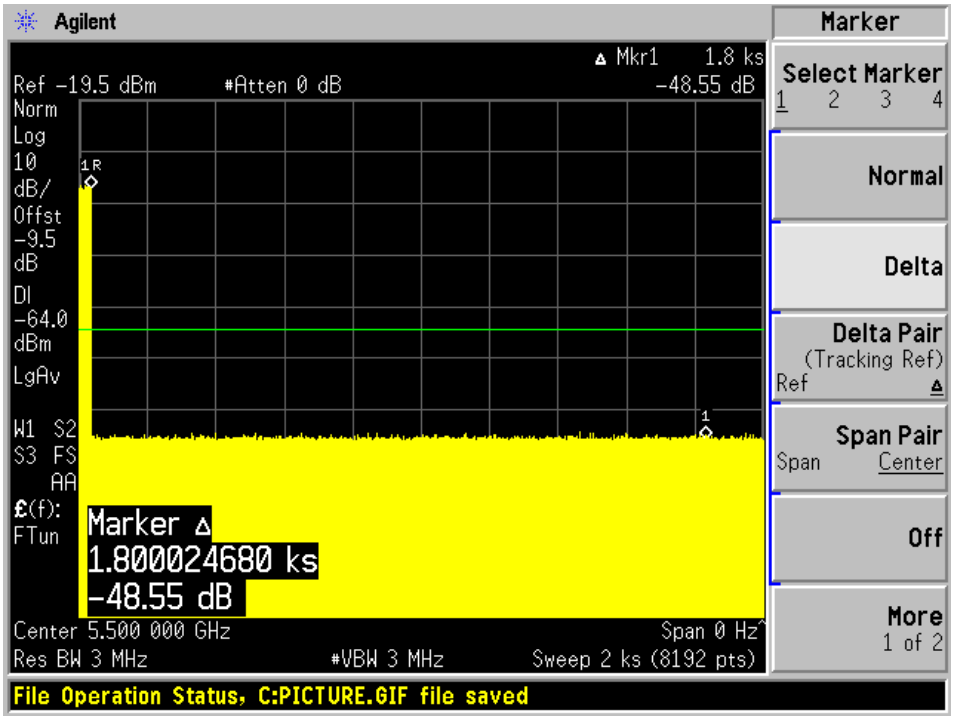
Type 0 radar channel closing transmission time result:

Channel closing transmitting time (ms)	Limit (ms)	Result
14.65+4.883	200	Pass



Non-occupancy Time

5530 MHz for 80 MHz channel bandwidth



Note: Channel 5500 MHz was the primary channel that contains beacon signal. Therefore, frequency 5500 MHz was monitored for the non-occupancy time.

13 Annex E (Normative) – EUT Test Setup Photographs

Please refer to the attachment.

14 Annex F (Normative) – EUT External Photographs

Please refer to the attachment.

15 Annex G (Normative) – EUT Internal Photographs

Please refer to the attachment.

16 Annex H (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

--- END OF REPORT ---