# FCC PART 15, SUBPART E

## TEST REPORT

For

# Roku, Inc.

1155 Coleman Avenue, San Jose, CA 95110, USA

**FCC ID: TC2-R1032**

| **Report Type:** | **Model:** |
|---|---|
| Class II Permissive Change | 100002420 |

| | |
|---|---|
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| **Report Number:** | R2302153-407 |
| **Report Date:** | 2023-03-24 |
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ACCREDITED
CERTIFICATE #3297.02

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# DOCUMENT REVISION HISTORY

| Revision Number | Report Number | Description of Revision | Date of Revision |
|---|---|---|---|
| 0 | R230215p3-407 | Class II Permissive Change | 2023-03-24 |

# 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: 100002420, FCC ID: TC2-R1032 or the "EUT" as referred to in this report. It is a Wireless Speaker.

## 1.2 Mechanical Description of EUT

The EUT measures approximately: 280 (H), *300 (W), *300 (L) mm weighs approximately 7.15 kg

## 1.3 Objective

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

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

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

## 1.4 Related Submittal(s)/Grant(s)

N/A

## 1.5 Test Methodology

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

## 1.6 Measurement Uncertainty

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

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

## 1.7 Test Facility Registrations

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

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

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

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

## 1.8 Test Facility Accreditations

Bay Area Compliance Laboratories Corp. (BACL) is:

**A-** ***An independent, 3rd-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2017 by A2LA (Test Laboratory Accreditation Certificate Number 3297.02)*****,** in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2017 Scope of Accreditation includes all of the Test Method Standards and/or the Product Family Standards detailed in this Test Report.

BACL's ISO/IEC 17025:2017 Scope of Accreditation includes a comprehensive suite of EMC Emissions, EMC Immunity, Radio, RF Exposure, Safety and wireline Telecommunications test methods applicable to a wide range of product categories. These product categories include Central Office Telecommunications Equipment [including NEBS - Network Equipment Building Systems], Unlicensed and Licensed Wireless and RF devices,

Information Technology Equipment (ITE); Telecommunications Terminal Equipment (TTE); Medical Electrical Equipment; Industrial, Scientific and Medical Test Equipment; Professional Audio and Video Equipment; Industrial and Scientific Instruments and Laboratory Apparatus; Cable Distribution Systems, and Energy Efficient Lighting.

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

- For the USA (Federal Communications Commission):
  - 1- All Unlicensed radio frequency devices within FCC Scopes A1, A2, A3, and A4;
  - 2- All Licensed radio frequency devices within FCC Scopes B1, B2, B3, and B4;
  - 3- All Telephone Terminal Equipment within FCC Scope C.
- For the Canada (Industry Canada):
  - 1 All Scope 1-Licence-Exempt Radio Frequency Devices;
  - 2 All Scope 2-Licensed Personal Mobile Radio Services;
  - 3 All Scope 3-Licensed General Mobile & Fixed Radio Services;
  - 4 All Scope 4-Licensed Maritime & Aviation Radio Services;
  - 5 All Scope 5-Licensed Fixed Microwave Radio Services
  - 6 All Broadcasting Technical Standards (BETS) in the Category I Equipment Standards List.
- For Singapore (Info-Communications Development Authority (IDA)):
  - 1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
  - 2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2
- For the Hong Kong Special Administrative Region:
  - 1 All Radio Equipment, per KHCA 10XX-series Specifications;
  - 2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
  - 3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.
- For Japan:
  - 1 MIC Telecommunication Business Law (Terminal Equipment):
    - All Scope A1 - Terminal Equipment for the Purpose of Calls;
    - All Scope A2 - Other Terminal Equipment
  - 2 Radio Law (Radio Equipment):
    - All Scope B1 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 1 of the Radio Law
    - All Scope B2 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 2 of the Radio Law
    - All Scope B3 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 3 of the Radio Law

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

1 Electronics and Office Equipment:
- for Telephony (ver. 3.0)
- for Audio/Video (ver. 3.0)
- for Battery Charging Systems (ver. 1.1)
- for Set-top Boxes & Cable Boxes (ver. 4.1)
- for Televisions (ver. 6.1)
- for Computers (ver. 6.0)
- for Displays (ver. 6.0)
- for Imaging Equipment (ver. 2.0)
- for Computer Servers (ver. 2.0)

2 Commercial Food Service Equipment
- for Commercial Dishwashers (ver. 2.0)
- for Commercial Ice Machines (ver. 2.0)
- for Commercial Ovens (ver. 2.1)
- for Commercial Refrigerators and Freezers

3 Lighting Products
- For Decorative Light Strings (ver. 1.5)
- For Luminaires (including sub-components) and Lamps (ver. 1.2)
- For Compact Fluorescent Lamps (CFLs) (ver. 4.3)
- For Integral LED Lamps (ver. 1.4)

4 Heating, Ventilation, and AC Products
- for Residential Ceiling Fans (ver. 3.0)
- for Residential Ventilating Fans (ver. 3.2)

5 Other
- For Water Coolers (ver. 3.0)

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

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

# 2 EUT Test Configuration

## 2.1 Justification

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

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

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

## 2.2 EUT Exercise Software

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

Please refer to the following power setting table.

**5250-5350 MHz**

| Modulation | Frequency (MHz) | Power Setting |
|---|---|---|
| 802.11a | 5260 | 43 |
| | 5280 | 41 |
| | 5320 | 41 |
| 802.11n/ac20 | 5260 | 44 |
| | 5280 | 41 |
| | 5320 | 41 |

**5470-5725 MHz**

| Modulation | Frequency (MHz) | Power Setting |
|---|---|---|
| 802.11a | 5500 | 40 |
| | 5580 | 54 |
| | 5700 | 43 |
| | 5720 | 51 |
| 802.11n/ac20 | 5500 | 43 |
| | 5580 | 54 |
| | 5700 | 45 |
| | 5720 | 51 |

*Data rates tested:
802.11a mode: 6 Mbps
802.11n/ac20 HT20/VHT20: MCS0

## 2.3 Duty Cycle Correction Factor

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

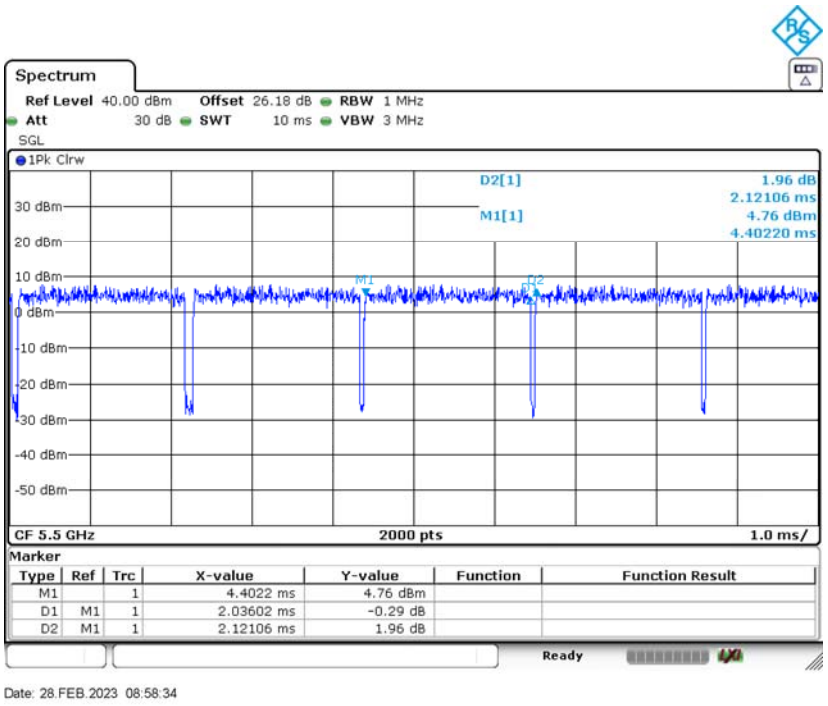
All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximum-power transmission duration, T, are required for each tested mode of operation.

| Radio Mode | On Time (ms) | Period (ms) | Duty Cycle (%) | Duty Cycle Correction Factor (dB) |
|---|---|---|---|---|
| 802.11a | 2.03602 | 2.12106 | 95.9 | 0.18 |
| 802.11n/ac20 | 1.87594 | 2.01101 | 93.2 | 0.31 |

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

Please refer to the following plots.

802.11a mode

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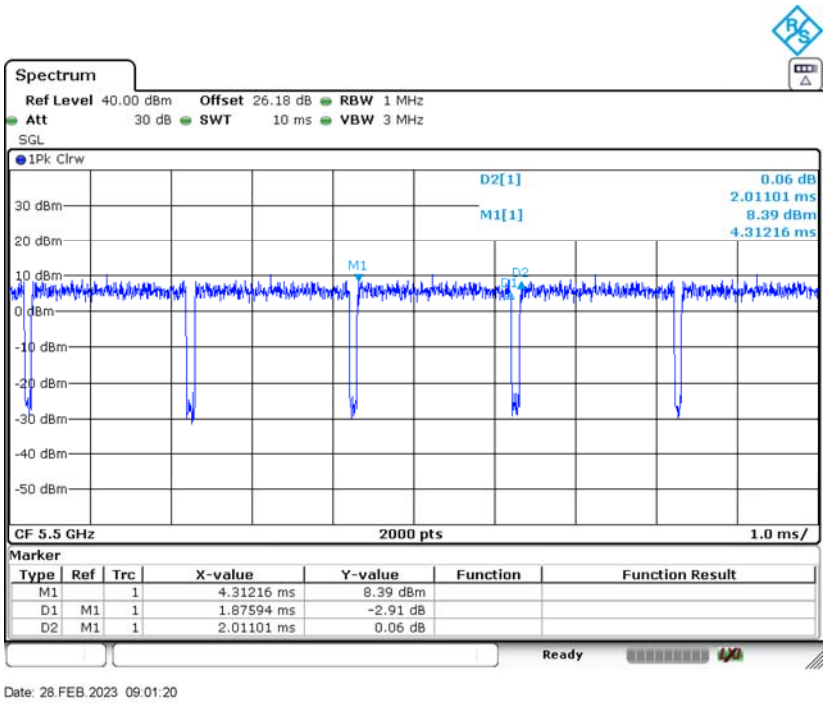
802.11n20/ac20 mode

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## 2.4 Equipment Modifications

N/A

## 2.5 Local Support Equipment

| Manufacturer | Description | Model |
|---|---|---|
| Dell | Laptop | Latitude E6410 |
| Dell | TV Monitor | S3221QS |

## 2.6 Support Equipment

| Manufacturer | Description | Model |
|---|---|---|
| Roku, Inc. | Debug Board | - |

## 2.7 Interface Ports and Cabling

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

# 3 Summary of Test Results

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

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

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

## 4.1 Applicable Standards

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

### 2.1.1 General RF Exposure Test Exemption Considerations

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

Test exemptions apply for devices used in general population/uncontrolled exposure environments, according to the SAR-based, or MPE-based exemption thresholds.[8] However, it is always possible, especially when the potential for exposure cannot be easily determined, that an RF exposure evaluation may become required according §§ 1.1307(c) and (d).

As detailed in Section 2.1.2, the 1 mW and SAR-based test exemption conditions are in terms of source-based available maximum time-averaged (matched conducted) output power for all operating configurations, adjusted for tune-up tolerance, and at the minimum *test separation distance* required for the particular RF exposure scenario under consideration. This minimum *test separation distance* is determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander. To qualify for SAR test exemption, the *test separation distances* applied must be fully explained and justified (typically in the SAR measurement, or SAR analysis report, according to KDB Pub. 865664) by showing the actual operating configurations and exposure conditions of the transmitter, and applicable host platform requirements (e.g., KDB Pubs. 648474, 616217, 941225)

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

If RF exposure testing requirements for a specific device are covered in a KDB Publication, those requirements must be satisfied before applying any SAR test exemption provisions. For example, this is the case for handheld PTT two-way radios, handsets, laptops, and tablets, etc.[9]

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

### 2.1.2 1-mW Test Exemption

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

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

#### 2.1.3 SAR-Based Exemption

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

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

#### 2.1.4 MPE-Based Exemption

An alternative to the SAR-based exemption is provided in §1.1307(b)(3)(ii)(C), for a much wider frequency range, from 300 kHz to 100 GHz, applicable for separation distances greater or equal to $\lambda/2\pi$, where $\lambda$ 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.<br>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 λ/4.

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

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

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

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

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

Where

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

and f is in GHz, d is the separation distance (cm), and EPR20cm is per Formula (B.1).

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

Table B.2 – Example Power Thresholds (mW)

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

## 4.3 RF exposure evaluation exemption for FCC

| | |
|---|---|
| **Prediction frequency (GHz)** | 5.580 |
| **Maximum output power (dBm)** | 20.83 |
| **Maximum ERP (dBm)** | 24.47 |
| **Maximum ERP (mW)** | 279.9 |
| **Prediction distance (cm)** | 20 |
| **Maximum antenna gain (dBi)** | 5.79 |
| 1500 MHz ≤ $f$ < 10000 MHz | Option C (MPE based) Exemption Threshold |
| | $P_{th}$ (W) |
| | $19.2R^2 = 0.768$ |

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

# 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

| Radio | Frequency Range (MHz) | Maximum Antenna Gain (dBi) |
|---|---|---|
| 5.3/5.6 GHz Wi-Fi | 5250-5725 | 5.79 |

Note: The antennas used by the EUT are permanent attached antennas.
Note: Antenna gain info provided by client.

# 6 FCC §15.207 - AC Power Line Conducted Emissions

## 6.1 Applicable Standards

As per FCC §15.207

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

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

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

## 6.2 Test Setup

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

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

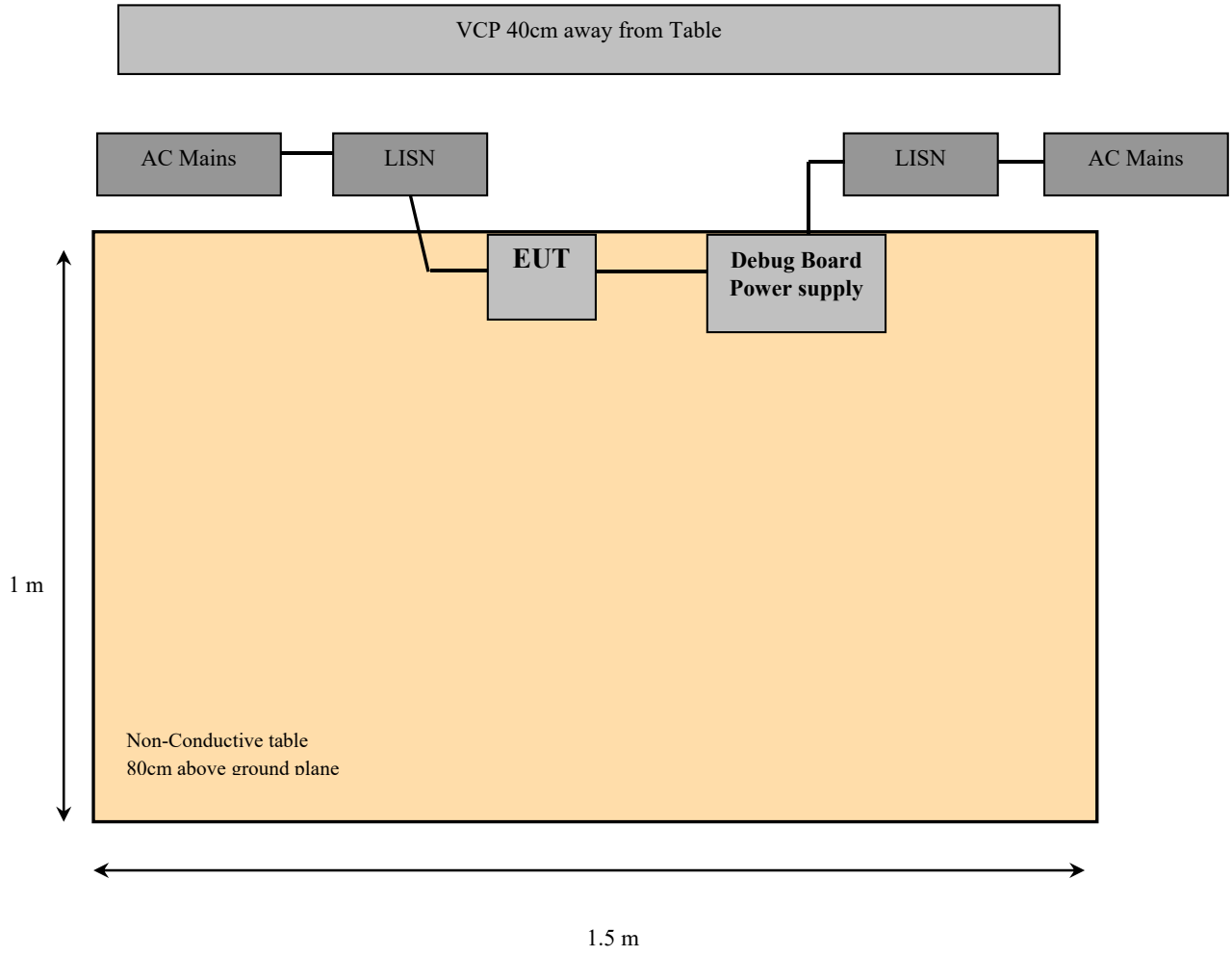
## 6.3 Test Procedure

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

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

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

## 6.4 Test Setup Block Diagram



## 6.5 Corrected Amplitude and Margin Calculation

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

CA = Ai + CF

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

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

CF= CL + LISN calibration factor + Attenuation

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

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

Margin = Corrected Amplitude - Limit

## 6.6 Test Equipment List and Details

| BACL No. | Manufacturer | Description | Model | Serial Number | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 124 | Rohde & Schwarz | Receiver, EMI Test | ESCI 1166.5950K03 | 100044 | 2021-05-14 | 2 years |
| 681 | Rohde & Schwarz | Impulse Limiter | ESH3-Z2 | 101962 | 2022-09-12 | 1 year |
| 725 | Solar Electronics Company | High Pass Filter | Type 7930-100 | 7930150203 | 2022-03-18 | 1 year |
| 732 | FCC | LISN | FCC-LISN-50-25-2-10-CISPR16 | 160129 | 2022-09-01 | 1 year |
| 1226 | Fairview Microwave | Coaxial Cable | PE3C2220-1250CM | 2109241 | 2022-09-12 | 1 year |
| - | Vasona | Test software | V6.0 build 11 | 10400213 | N/R | N/R |

***Statement of Traceability: BACL Corp.*** *attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

## 6.7 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 20º C |
| **Relative Humidity:** | 55 % |
| **ATM Pressure:** | 102.1 kPa |

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

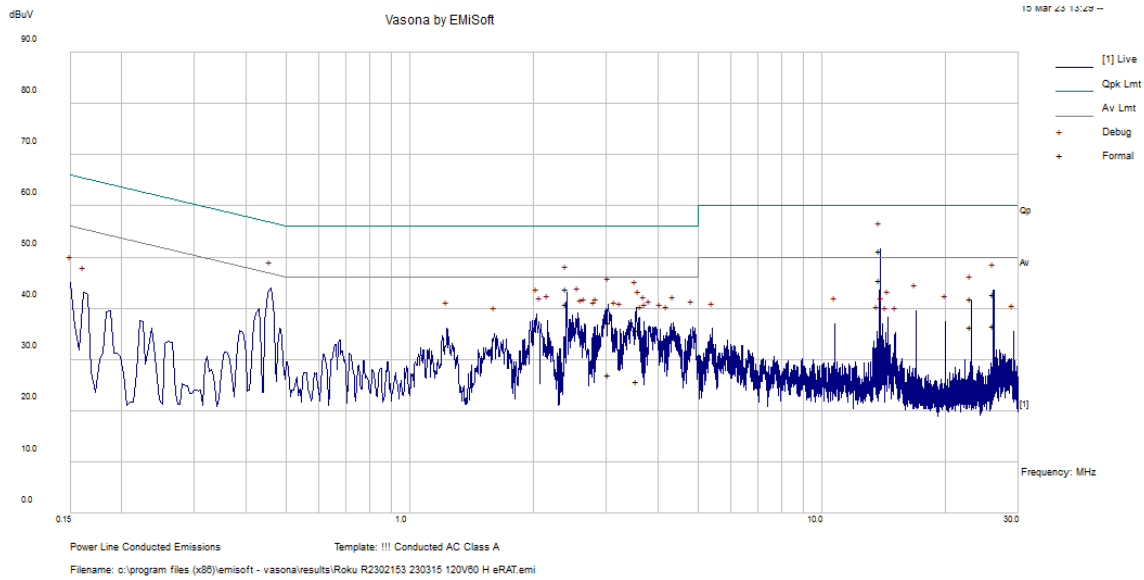
## 6.8 Summary of Test Results

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

| **Connection: AC/DC adapter connected to 120 V/60 Hz, AC** | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Conductor Mode (Line/Neutral)** | **Range (MHz)** |
| -3.92 | 13.823446 | Neutral | 0.15-30 |

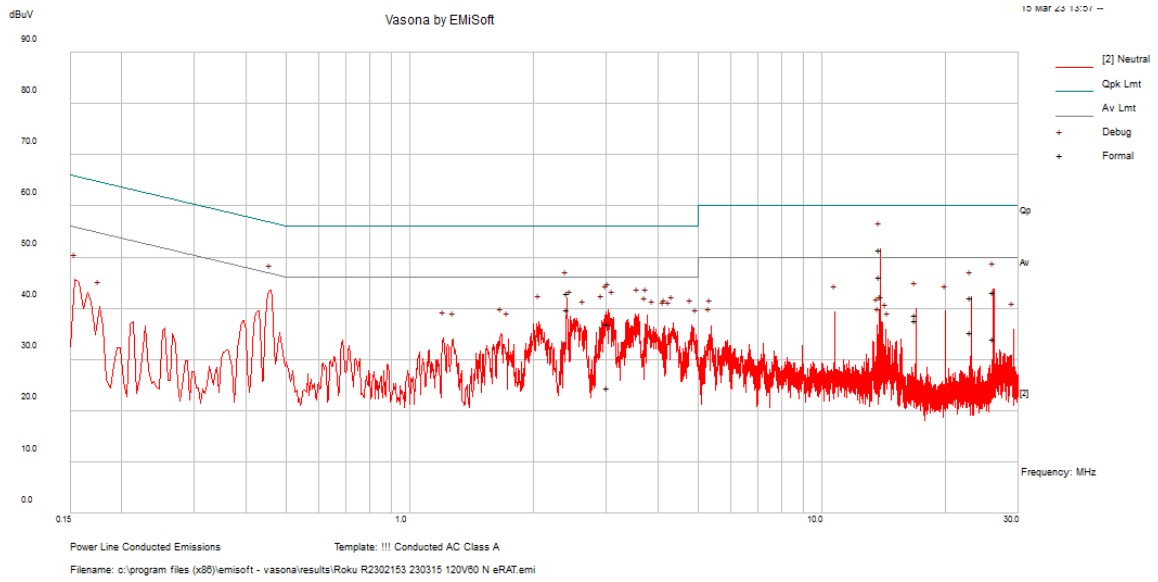
## 6.9 Conducted Emissions Test Plots and Data

**120 V, 60 Hz – Line**




| Frequency (MHz) | Ai. Reading (dBuV) | Correction Factor (dB) | Corrected Amplitude (dBµV) | Limit (dBµV) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|
| 13.824071 | 40.94 | 10.33 | 51.27 | 60 | -8.73 | QP |
| 2.402422 | 33.62 | 10.16 | 43.78 | 56 | -12.22 | QP |
| 26.111506 | 31.94 | 10.86 | 42.8 | 60 | -17.2 | QP |
| 23.040011 | 31.11 | 10.69 | 41.8 | 60 | -18.2 | QP |
| 3.031415 | 27.01 | 10.16 | 37.17 | 56 | -18.83 | QP |
| 3.555794 | 25.54 | 10.18 | 35.72 | 56 | -20.28 | QP |
| 13.824071 | 35.13 | 10.33 | 45.46 | 50 | -4.54 | Ave |
| 26.111506 | 25.76 | 10.85 | 36.61 | 50 | -13.39 | Ave |
| 2.402422 | 30.59 | 10.16 | 40.75 | 46 | -5.25 | Ave |
| 23.040011 | 25.76 | 10.69 | 36.45 | 50 | -13.55 | Ave |
| 3.031415 | 16.76 | 10.17 | 26.93 | 46 | -19.07 | Ave |
| 3.555794 | 15.49 | 10.18 | 25.67 | 46 | -20.33 | Ave |

## 120 V, 60 Hz – Neutral




| Frequency (MHz) | Ai. Reading (dBuV) | Correction Factor (dB) | Corrected Amplitude (dBµV) | Limit (dBµV) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|
| 13.823446 | 41.11 | 10.32 | 51.43 | 60 | -8.57 | QP |
| 26.111452 | 32.22 | 10.86 | 43.08 | 60 | -16.92 | QP |
| 23.040245 | 31.32 | 10.69 | 42.01 | 60 | -17.99 | QP |
| 2.40694 | 32.76 | 10.15 | 42.91 | 56 | -13.09 | QP |
| 16.89536 | 28.32 | 10.48 | 38.8 | 60 | -21.2 | QP |
| 3.024087 | 26.77 | 10.17 | 36.94 | 56 | -19.06 | QP |
| 13.823446 | 35.75 | 10.33 | 46.08 | 50 | -3.92 | Ave |
| 26.111452 | 23.27 | 10.86 | 34.13 | 50 | -15.87 | Ave |
| 23.040245 | 24.58 | 10.69 | 35.27 | 50 | -14.73 | Ave |
| 2.40694 | 29.71 | 10.16 | 39.87 | 46 | -6.13 | Ave |
| 16.89536 | 27.07 | 10.48 | 37.55 | 50 | -12.45 | Ave |
| 3.024087 | 14.4 | 10.17 | 24.57 | 46 | -21.43 | Ave |

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

## 7.1 Applicable Standard

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

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

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

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

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

As per FCC Part 15.407 (b)

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

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

(3) For transmitters operating in the 5.47 -5.725 GHz band: All emissions outside of the 5.47-5725 GHz band shall not exceed an ei.r.p. of -27 dBm/MHz.

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

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

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

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

## 7.2 Test Setup

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

The spacing between the peripherals was 10 centimeters.

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

## 7.3 Test Procedure

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

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

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

The spectrum analyzer or receiver is set as:

Below 1000 MHz:

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

Above 1000 MHz:

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

## 7.4 Corrected Amplitude and Margin Calculation

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

CA = Ai + AF + CL + Atten – Ga

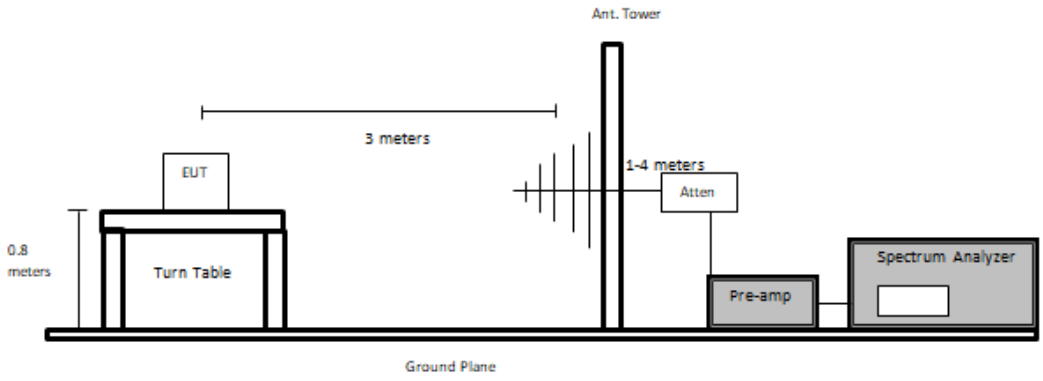
For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

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

Margin = Corrected Amplitude – Limit

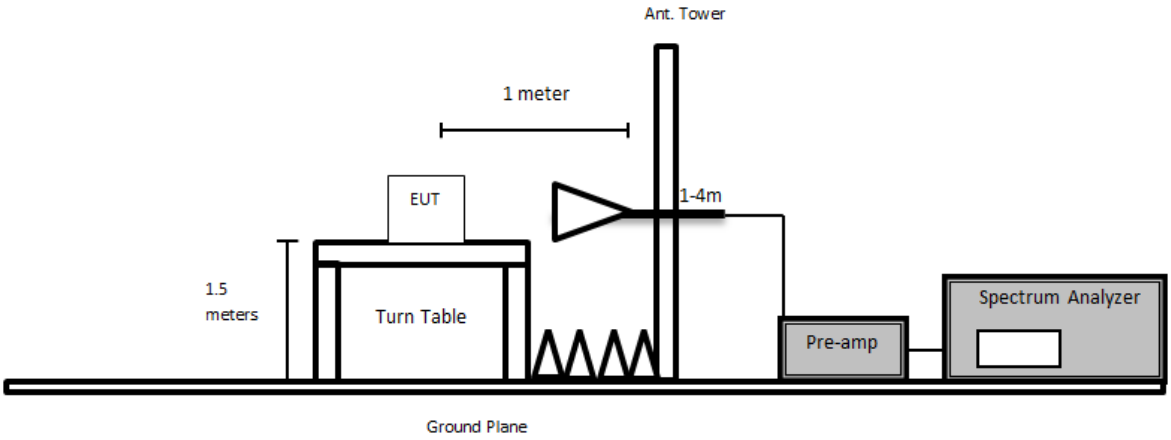
## 7.5 Test Setup Block Diagram

Below 1 GHz:

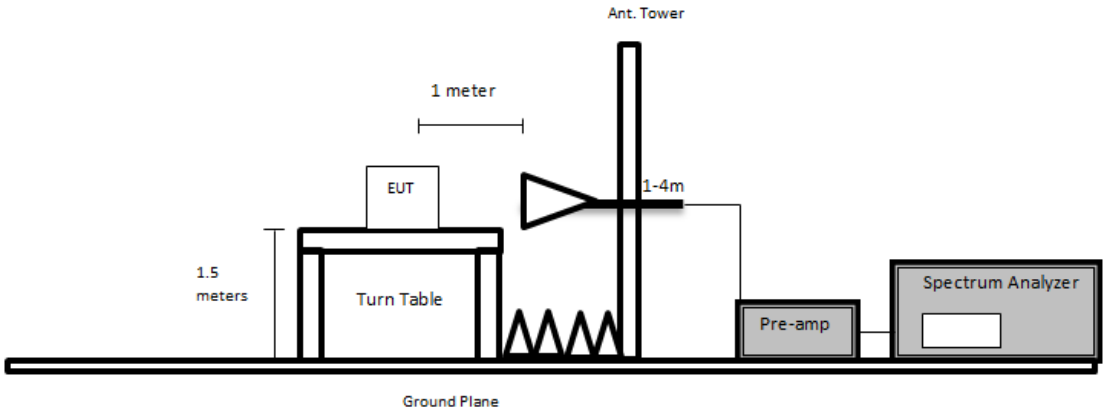


Above 1 GHz:

Using Asset #1192




Using Asset #91&#230



## 7.6 Test Equipment List and Details

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

Note[1]: equipment included in the test set-up will be checked each time before testing.
***Statement of Traceability: BACL Corp.*** *attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

## 7.7 Test Environmental Conditions

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

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

## 7.8 Summary of Test Results

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

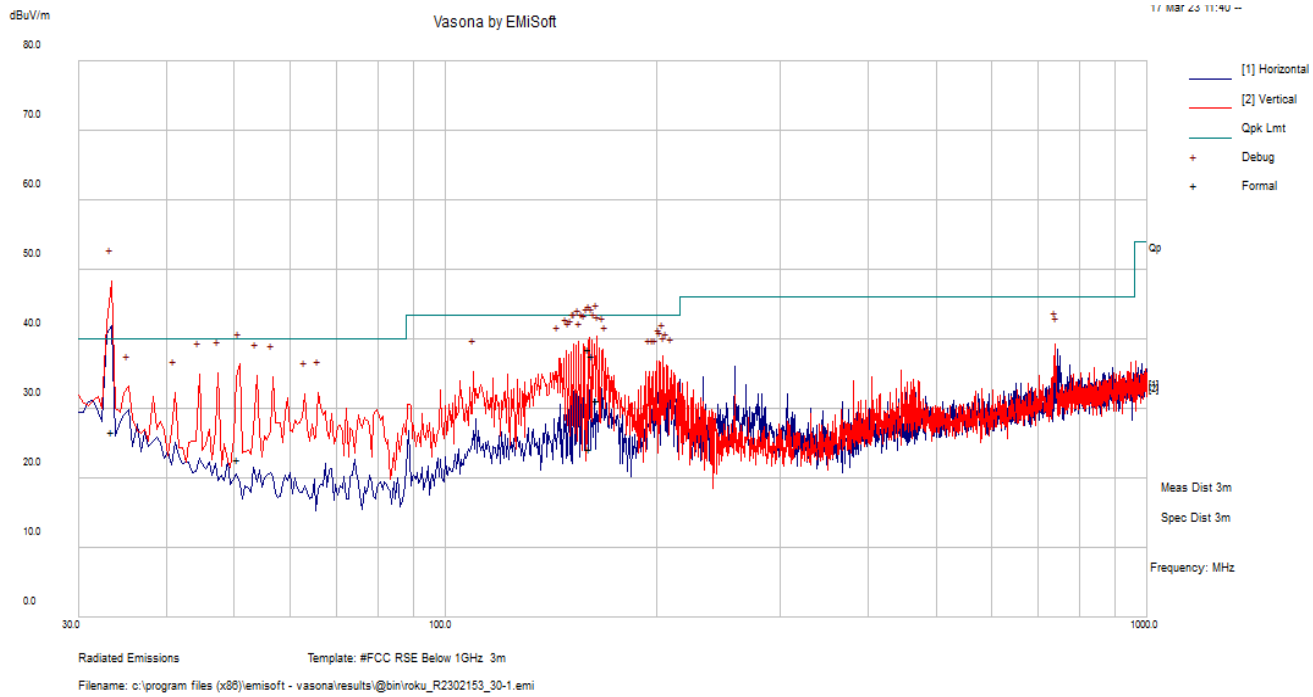
| **Mode: Transmitting** | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Polarization (Horizontal/Vertical)** | **Mode, Channel** |
| -0.828 | 5725 | Horizontal | 802.11n/ac20 mode, 5700 MHz |

Please see the 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 |
|---|---|---|---|---|---|---|---|---|---|
| 33.454 | 29.92 | -3.27 | 26.65 | 247 | V | 26 | 40 | -13.35 | QP |
| 164.31275 | 39.91 | -8.8 | 31.11 | 130 | V | 14 | 43.5 | -12.39 | QP |
| 160.70975 | 32.84 | -8.61 | 24.23 | 165 | V | 85 | 43.5 | -19.27 | QP |
| 162.1075 | 46.29 | -8.7 | 37.59 | 126 | V | 352 | 43.5 | -5.91 | QP |
| 50.677 | 35.61 | -12.96 | 22.65 | 127 | V | 7 | 40 | -17.35 | QP |
| 159.743 | 47.06 | -8.57 | 38.49 | 113 | V | 54 | 43.5 | -5.01 | QP |

| FCC Limits for 1 GHz to 40 GHz | | | | |
|---|---|---|---|---|
| **Applicablity** | **(dBm)** | **(uV/m at 3meters)** | **(dBuV/m at 3meters)** | **(dBuV/m at 1meter)[2]** |
| Restricted Band Average Limit | - | 500 | 54 | 64 |
| Restricted Band Peak Limit[1] | - | - | 74 | 84 |
| FCC §15.407(b) §6.2 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, Band Edges, Harmonics & Emission Masks measured at 1 meter**

**5250 - 5350 MHz**

802.11a mode

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| Low Channel: 5260 MHz | | | | | | | | | | | |
| 5150 | 53.520 | 349 | 151 | H | 38.30 | 11.16 | 36.31 | 66.660 | 78 | -11.340 | Peak |
| 5150 | 43.719 | 349 | 151 | H | 38.30 | 11.16 | 36.31 | 56.859 | 64 | -7.141 | Ave |
| 10520 | 48.820 | 46 | 196 | H | 38.30 | 11.16 | 36.31 | 61.960 | 78 | -16.040 | Peak |
| 10520 | 37.958 | 46 | 196 | H | 38.30 | 11.16 | 36.31 | 51.098 | 64 | -12.902 | Ave |
| 15780 | 49.500 | 360 | 257 | H | 41.92 | 15.94 | 36.74 | 70.621 | 84 | -13.379 | Peak |
| 15780 | 39.656 | 360 | 257 | H | 41.92 | 15.94 | 36.74 | 60.777 | 64 | -3.223 | Ave |
| Middle Channel: 5280 MHz | | | | | | | | | | | |
| 10560 | 48.100 | 82 | 188 | H | 38.37 | 11.11 | 36.23 | 61.361 | 78 | -16.639 | Peak |
| 10560 | 37.918 | 82 | 188 | H | 38.37 | 11.11 | 36.23 | 51.179 | 64 | -12.821 | Ave |
| 15840 | 49.740 | 246 | 246 | H | 41.68 | 15.41 | 36.76 | 70.073 | 84 | -13.927 | Peak |
| 15840 | 39.583 | 246 | 246 | H | 41.68 | 15.41 | 36.76 | 59.916 | 64 | -4.084 | Ave |
| High Channel: 5320 MHz | | | | | | | | | | | |
| 5350 | 63.880 | 349 | 148 | H | 36.09 | 7.58 | 36.65 | 70.898 | 78 | -7.102 | Peak |
| 5350 | 47.866 | 349 | 148 | H | 36.09 | 7.58 | 36.65 | 54.884 | 64 | -9.116 | Ave |
| 10640 | 47.580 | 319 | 215 | H | 38.47 | 11.07 | 36.21 | 60.915 | 84 | -23.085 | Peak |
| 10640 | 37.762 | 319 | 215 | H | 38.47 | 11.07 | 36.21 | 51.097 | 64 | -12.903 | Ave |
| 15960 | 49.320 | 359 | 284 | H | 41.76 | 14.91 | 36.53 | 69.460 | 84 | -14.540 | Peak |
| 15960 | 39.368 | 359 | 284 | H | 41.76 | 14.91 | 36.53 | 59.508 | 64 | -4.492 | Ave |

802.11ac20/n20 mode

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| Low Channel: 5260 MHz | | | | | | | | | | | |
| 5150 | 54.570 | 1 | 150 | H | 38.30 | 11.16 | 36.31 | 67.710 | 78 | -10.290 | Peak |
| 5150 | 43.692 | 1 | 150 | H | 38.30 | 11.16 | 36.31 | 56.832 | 64 | -7.168 | Ave |
| 10520 | 48.370 | 165 | 112 | H | 38.30 | 11.16 | 36.31 | 61.510 | 78 | -16.490 | Peak |
| 10520 | 38.261 | 165 | 112 | H | 38.30 | 11.16 | 36.31 | 51.401 | 64 | -12.599 | Ave |
| 15780 | 49.990 | 85 | 147 | H | 41.92 | 15.94 | 36.74 | 71.111 | 84 | -12.889 | Peak |
| 15780 | 39.250 | 85 | 147 | H | 41.92 | 15.94 | 36.74 | 60.371 | 64 | -3.629 | Ave |
| Middle Channel: 5280 MHz | | | | | | | | | | | |
| 10560 | 47.100 | 82 | 228 | H | 38.37 | 11.11 | 36.23 | 60.361 | 78 | -17.639 | Peak |
| 10560 | 37.538 | 82 | 228 | H | 38.37 | 11.11 | 36.23 | 50.799 | 64 | -13.201 | Ave |
| 15840 | 49.750 | 212 | 214 | H | 41.68 | 15.41 | 36.76 | 70.083 | 84 | -13.917 | Peak |
| 15840 | 39.271 | 212 | 214 | H | 41.68 | 15.41 | 36.76 | 59.604 | 64 | -4.396 | Ave |
| High Channel: 5320 MHz | | | | | | | | | | | |
| 5350 | 68.100 | 348 | 144 | H | 36.09 | 7.58 | 36.65 | 75.118 | 78 | -2.882 | Peak |
| 5350 | 49.376 | 348 | 144 | H | 36.09 | 7.58 | 36.65 | 56.394 | 64 | -7.606 | Ave |
| 10640 | 47.980 | 74 | 135 | H | 38.47 | 11.07 | 36.21 | 61.315 | 84 | -22.685 | Peak |
| 10640 | 37.536 | 74 | 135 | H | 38.47 | 11.07 | 36.21 | 50.871 | 64 | -13.129 | Ave |
| 15960 | 50.170 | 346 | 130 | H | 41.76 | 14.91 | 36.53 | 70.310 | 84 | -13.690 | Peak |
| 15960 | 38.828 | 346 | 130 | H | 41.76 | 14.91 | 36.53 | 58.968 | 64 | -5.032 | Ave |

**5470 - 5725 MHz**

802.11a mode

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| Low Channel: 5500 MHz | | | | | | | | | | | |
| 5470 | 68.790 | 351 | 152 | H | 36.22 | 7.66 | 36.63 | 76.043 | 78 | -1.957 | Peak |
| 5470 | 48.408 | 351 | 152 | H | 36.22 | 7.66 | 36.63 | 55.661 | 64 | -8.339 | Ave |
| 11000 | 48.440 | 359 | 294 | H | 38.47 | 11.28 | 35.98 | 62.213 | 84 | -21.787 | Peak |
| 11000 | 37.523 | 359 | 294 | H | 38.47 | 11.28 | 35.98 | 51.296 | 64 | -12.704 | Ave |
| 16500 | 48.940 | 187 | 114 | H | 42.34 | 13.97 | 35.87 | 69.384 | 78 | -8.616 | Peak |
| 16500 | 39.235 | 187 | 114 | H | 42.34 | 13.97 | 35.87 | 59.679 | 64 | -4.321 | Ave |
| Middle Channel: 5580 MHz | | | | | | | | | | | |
| 11160 | 50.410 | 265 | 149 | H | 38.38 | 11.39 | 35.87 | 64.315 | 84 | -19.685 | Peak |
| 11160 | 40.187 | 265 | 149 | H | 38.38 | 11.39 | 35.87 | 54.092 | 64 | -9.908 | Ave |
| 16740 | 48.640 | 225 | 193 | H | 42.51 | 14.65 | 35.61 | 70.191 | 78 | -7.809 | Peak |
| 16740 | 38.743 | 225 | 193 | H | 42.51 | 14.65 | 35.61 | 60.294 | 64 | -3.706 | Ave |
| High Channel: 5700 MHz | | | | | | | | | | | |
| 5725 | 68.760 | 335 | 162 | H | 35.61 | 7.84 | 36.69 | 75.522 | 78 | -2.478 | Peak |
| 5725 | 48.384 | 335 | 162 | H | 35.61 | 7.84 | 36.69 | 55.146 | 64 | -8.854 | Ave |
| 11400 | 46.800 | 23 | 147 | H | 38.57 | 11.43 | 35.89 | 60.913 | 84 | -23.087 | Peak |
| 11400 | 37.318 | 23 | 147 | H | 38.57 | 11.43 | 35.89 | 51.431 | 64 | -12.569 | Ave |
| 17100 | 49.500 | 72 | 246 | H | 42.15 | 15.92 | 35.98 | 71.578 | 78 | -6.422 | Peak |
| 17100 | 35.937 | 72 | 246 | H | 42.15 | 15.92 | 35.98 | 58.015 | 64 | -5.985 | Ave |
| High Channel: 5720 MHz | | | | | | | | | | | |
| 11440 | 47.610 | 23 | 147 | H | 38.57 | 11.43 | 35.89 | 61.723 | 84 | -22.277 | Peak |
| 11440 | 38.204 | 23 | 147 | H | 38.57 | 11.43 | 35.89 | 52.317 | 64 | -11.683 | Ave |
| 17160 | 49.284 | 72 | 246 | H | 42.15 | 15.92 | 35.98 | 71.362 | 78 | -6.638 | Peak |
| 17160 | 36.583 | 72 | 246 | H | 42.15 | 15.92 | 35.98 | 58.661 | 64 | -5.339 | Ave |

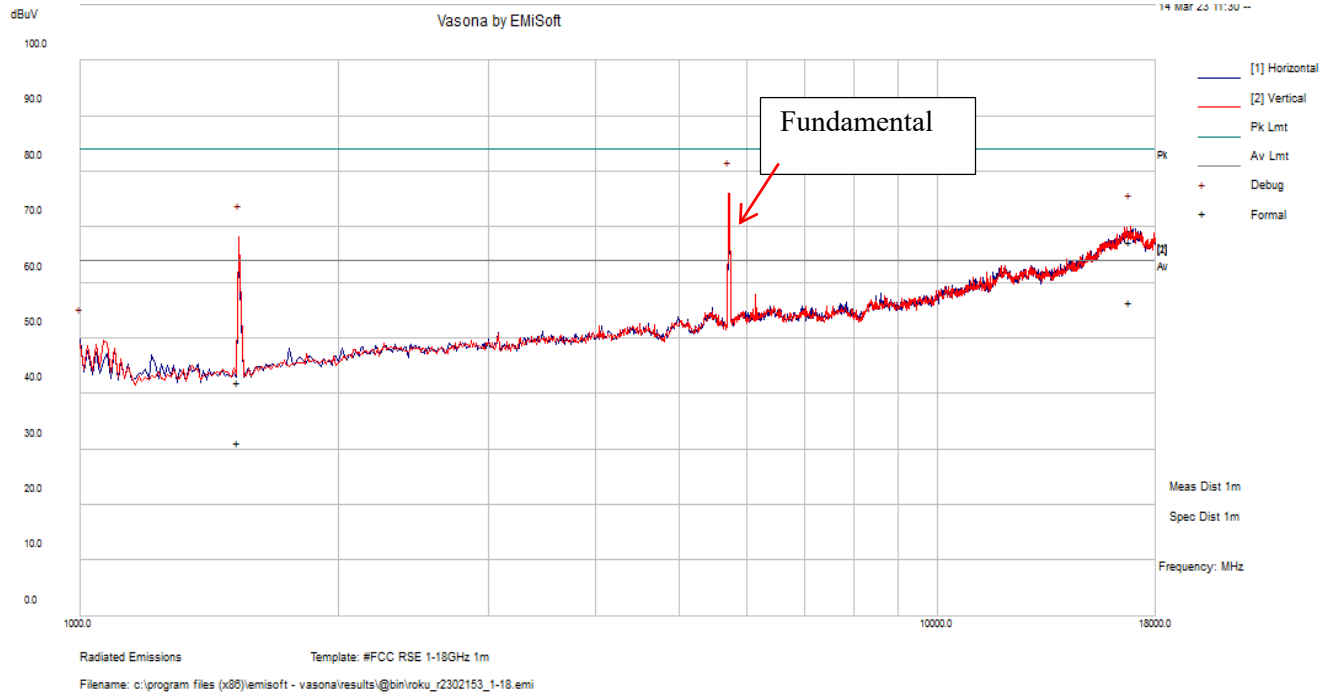
802.11ac20/n20 mode

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| Low Channel: 5500 MHz | | | | | | | | | | | |
| 5470 | 68.630 | 353 | 142 | H | 36.22 | 7.66 | 36.63 | 75.883 | 78 | -2.117 | Peak |
| 5470 | 47.851 | 353 | 142 | H | 36.22 | 7.66 | 36.63 | 55.104 | 64 | -8.896 | Ave |
| 11000 | 47.720 | 108 | 107 | H | 38.47 | 11.28 | 35.98 | 61.493 | 84 | -22.507 | Peak |
| 11000 | 37.683 | 108 | 107 | H | 38.47 | 11.28 | 35.98 | 51.456 | 64 | -12.544 | Ave |
| 16500 | 49.590 | 327 | 174 | H | 42.34 | 13.97 | 35.87 | 70.034 | 78 | -7.966 | Peak |
| 16500 | 38.858 | 327 | 174 | H | 42.34 | 13.97 | 35.87 | 59.302 | 64 | -4.698 | Ave |
| Middle Channel: 5580 MHz | | | | | | | | | | | |
| 11160 | 49.387 | 153 | 159 | H | 38.38 | 11.39 | 35.87 | 63.292 | 84 | -20.708 | Peak |
| 11160 | 39.961 | 153 | 159 | H | 38.38 | 11.39 | 35.87 | 53.866 | 64 | -10.134 | Ave |
| 16740 | 48.510 | 181 | 173 | H | 42.51 | 14.65 | 35.61 | 70.061 | 78 | -7.939 | Peak |
| 16740 | 38.365 | 181 | 173 | H | 42.51 | 14.65 | 35.61 | 59.916 | 64 | -4.084 | Ave |
| High Channel: 5700 MHz | | | | | | | | | | | |
| 5725 | 70.410 | 24 | 159 | H | 35.61 | 7.84 | 36.69 | 77.172 | 78 | -0.828 | Peak |
| 5725 | 48.936 | 24 | 159 | H | 38.57 | 11.43 | 35.89 | 63.049 | 64 | -0.951 | Ave |
| 11400 | 47.980 | 74 | 102 | H | 38.57 | 11.43 | 35.89 | 62.093 | 84 | -21.907 | Peak |
| 11400 | 36.856 | 74 | 102 | H | 38.57 | 11.43 | 35.89 | 50.969 | 64 | -13.031 | Ave |
| 17100 | 49.530 | 279 | 300 | H | 42.15 | 15.92 | 35.98 | 71.608 | 78 | -6.392 | Peak |
| 17100 | 39.148 | 279 | 300 | H | 38.57 | 11.43 | 35.89 | 53.261 | 64 | -10.739 | Ave |
| High Channel: 5720 MHz | | | | | | | | | | | |
| 11440 | 48.485 | 74 | 102 | H | 38.57 | 11.43 | 35.89 | 62.598 | 84 | -21.402 | Peak |
| 11440 | 37.027 | 74 | 102 | H | 38.57 | 11.43 | 35.89 | 51.140 | 64 | -12.860 | Ave |
| 17160 | 50.284 | 279 | 300 | H | 42.15 | 15.92 | 35.98 | 72.362 | 78 | -5.638 | Peak |
| 17160 | 39.929 | 279 | 300 | H | 38.57 | 11.43 | 35.89 | 54.042 | 64 | -9.958 | Ave |

### 3) 1 to 18 GHz Vasona scan at 1 meter

*Worst Case:*

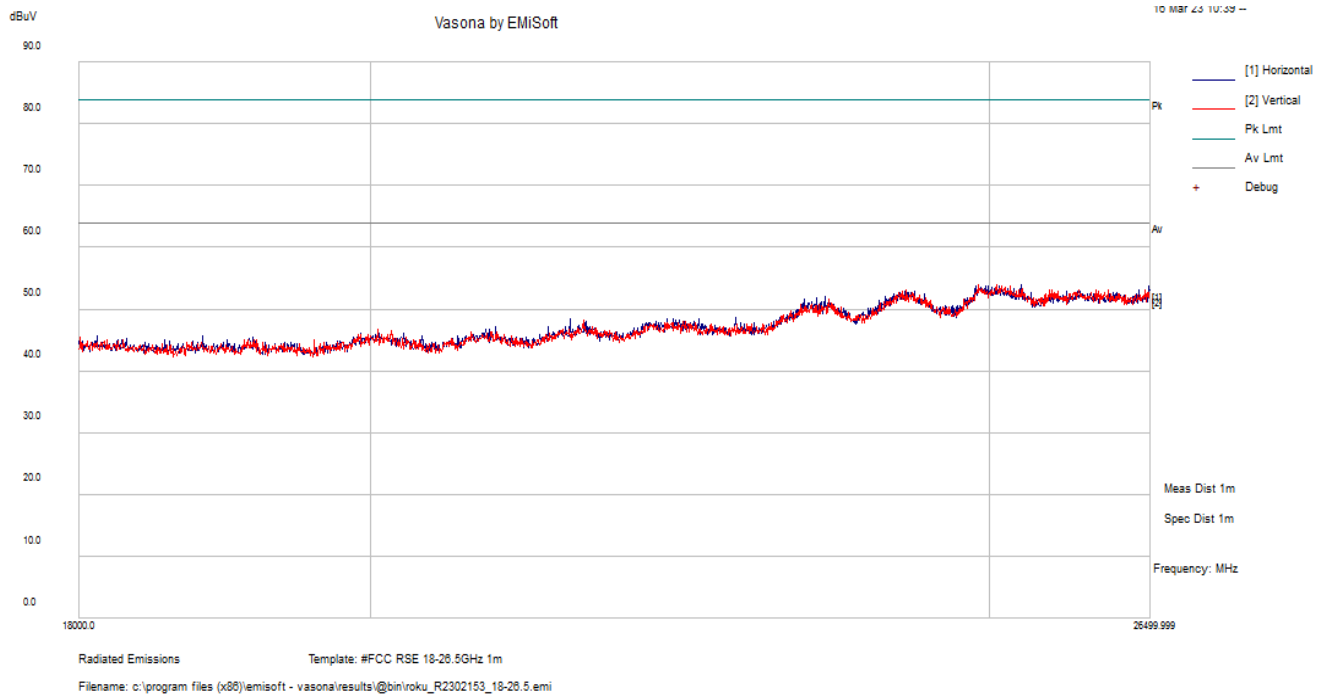
`




| 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 |
|---|---|---|---|---|---|---|---|---|---|
| 16810.61 | 46.52 | 20.79 | 67.31 | 189 | V | 51 | 84 | -16.69 | Peak |
| 1530.44 | 48.69 | -6.74 | 41.95 | 232 | V | 207 | 84 | -42.05 | Peak |
| 16810.61 | 35.75 | 20.79 | 56.54 | 189 | V | 51 | 64 | -7.46 | Avg |
| 1530.44 | 38.02 | -6.74 | 31.28 | 232 | V | 207 | 64 | -32.72 | Avg |

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

*Worst Case:*

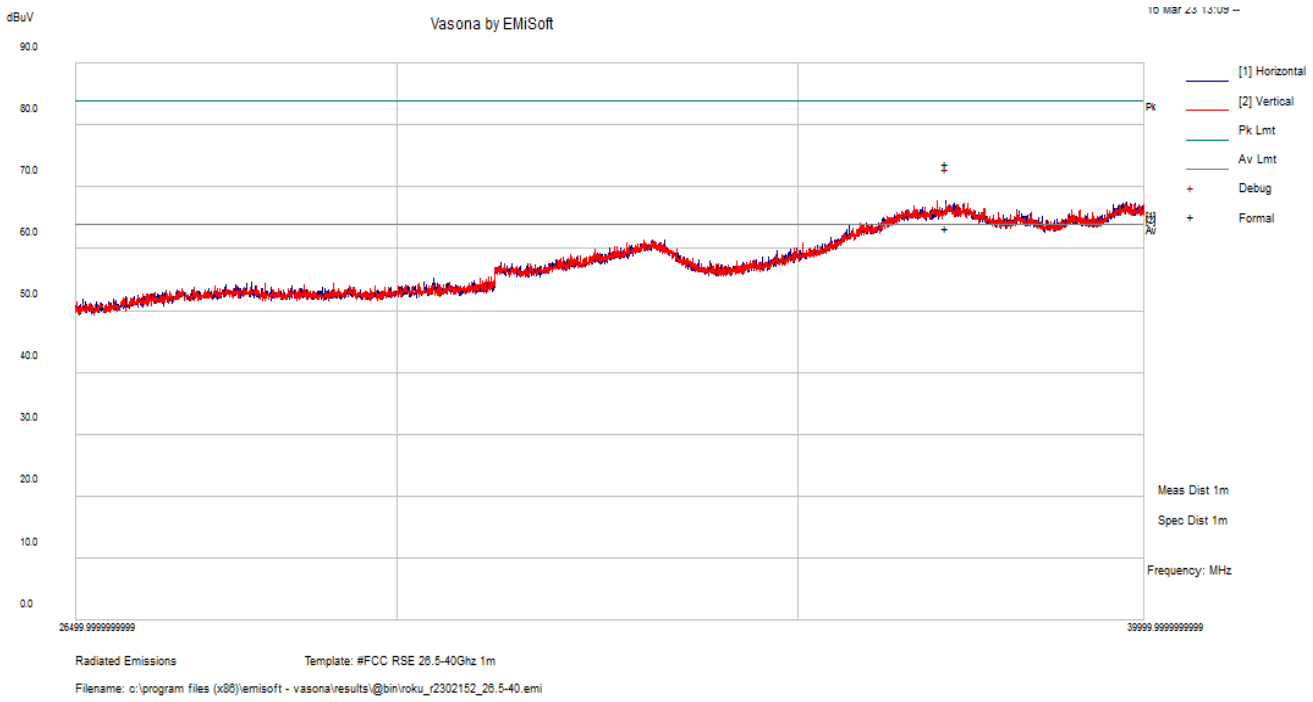



| Frequency (MHz) | S.A. Reading (dBuV) | Correction Factor (dB/m) | Corrected Amplitude (dBµV/m) | Antenna Height (cm) | Antenna Polarity (H/V) | Turntable Azimuth (degrees) | Limit (dBµV/m) | Margin (dB) | Comment |
|---|---|---|---|---|---|---|---|---|---|
| 24924.249 | 38.66 | 14.8 | 53.46 | 100 | V | 7 | 64 | -10.54 | Peak |

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

## 5) 26.5 – 40 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 |
|---|---|---|---|---|---|---|---|---|---|
| 37056.823 | 54.78 | 18.95 | 73.73 | 238 | 249 | H | 249 | 84 | Peak |
| 37056.823 | 44.52 | 18.95 | 63.47 | 238 | 249 | H | 249 | 64 | Avg |

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

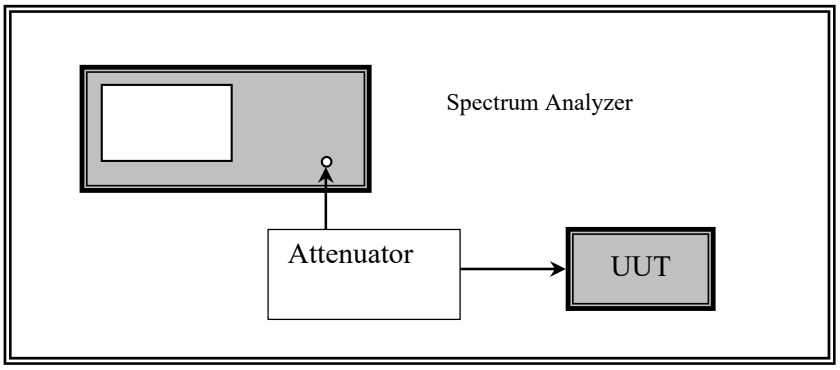
## 8.1 Applicable Standards

For reference purposes.

## 8.2 Measurement Procedure

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

## 8.3 Test Setup Block Diagram



## 8.4 Test Equipment List and Details

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

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability: BACL Corp.*** *attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability"*

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## 8.5 Test Environmental Conditions

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

*Testing was performed by Christian Schwartz on 2023-02-28 at the RF site.*

## 8.6 Test Results

Please refer to the following tables and plots.

**5250 - 5350 MHz**

| Channel | Frequency (MHz) | 99% OBW (MHz) | 26 dB OBW (MHz) |
|---|---|---|---|
| **802.11a mode** | | | |
| 52 | 5260 | 19.6 | 24.95 |
| 56 | 5280 | 20.52 | 22.3 |
| 64 | 5320 | 18.56 | 21.25 |
| **802.11n/ac20 mode** | | | |
| 52 | 5260 | 19.76 | 23 |
| 56 | 5280 | 20.92 | 21.8 |
| 64 | 5320 | 19.04 | 21.45 |

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

**5470 - 5725 MHz**

| Channel | Frequency (MHz) | 99% OBW (MHz) | 26 dB OBW (MHz) |
|---|---|---|---|
| **802.11a mode** | | | |
| 100 | 5500 | 22.92 | 21 |
| 116 | 5580 | 27.04 | 41.6 |
| 140 | 5700 | 17.72 | 21.4 |
| 144 | 5720 | 19.2 | 30.55 |
| **802.11n/ac20 mode** | | | |
| 100 | 5500 | 19.84 | 22.1 |
| 116 | 5580 | 27.8 | 42.4 |
| 140 | 5700 | 19.04 | 21.2 |
| 144 | 5720 | 19.88 | 30.65 |

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

# 9 FCC §407(a) - Output Power

## 9.1 Applicable Standards

According to FCC §15.407(a):

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

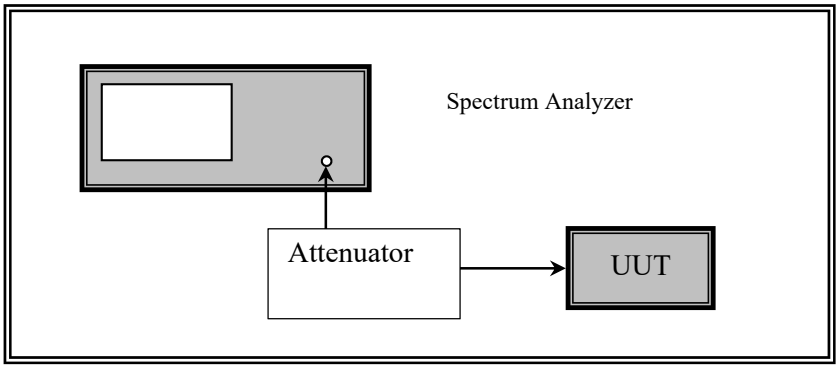
For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11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

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

## 9.2 Measurement Procedure

(i) Set span to encompass the entire emission bandwidth (EBW) (or, alternatively, the entire 99% occupied bandwidth) of the signal.
(ii) Set RBW = 1 MHz.
(iii) Set VBW ≥ 3 MHz.
(iv) Number of points in sweep ≥ 2 × span / RBW. (This ensures that bin-to-bin spacing is ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
(v) Sweep time = auto.
(vi) Detector = power averaging (rms), if available. Otherwise, use sample detector mode.
(vii) If transmit duty cycle < 98%, use a video trigger with the trigger level set to enable triggering only on full power pulses. Transmitter must operate at maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no off intervals) or at duty cycle ≥ 98%, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to "free run."
(viii) Trace average at least 100 traces in power averaging (rms) mode.
(ix) Compute power by integrating the spectrum across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the signal using the instrument's band power measurement function with band limits set equal to the EBW (or occupied bandwidth) band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at 1 MHz intervals extending across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the spectrum.

## 9.3 Test Setup Block Diagram



## 9.4 Test Equipment List and Details

| BACL Number | Manufacturer | Description | Model | Serial Number | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 912 | Rhode & Schwarz | Signal Analyzer | FSV40 | 1321.3008k39-101203-UW | 2022-05-05 | 1 year |
| 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".*

## 9.5 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23º C |
| **Relative Humidity:** | 55 % |
| **ATM Pressure:** | 102.2 KPa |

*Testing was performed by Christian Schwartz on 2023-02-28 at the RF site.*

## 9.6 Test Results

**5250 - 5350 MHz**

| Channel | Frequency (MHz) | Conducted Output Power (dBm) | Corrected Output Power (dBm) | FCC Limit (dBm) |
|---|---|---|---|---|
| **802.11a mode** | | | | |
| 52 | 5260 | 15.42 | 15.6 | 24 |
| 56 | 5280 | 15.38 | 15.56 | 24 |
| 64 | 5320 | 16.14 | 16.32 | 24 |
| **802.11n/ac20 mode** | | | | |
| 52 | 5260 | 15.6 | 15.91 | 24 |
| 56 | 5280 | 15.15 | 15.46 | 24 |
| 64 | 5320 | 15.98 | 16.29 | 24 |

Note: See Annex C for Conducted Output Power results
Note: Corrected Output Power(dBm)= Conducted Output Power(dBm) + Duty Cycle Correction Factor(dB)
Note: For 5250MHz-5350MHz for FCC: the maximum conducted output power shall not exceed 250 mW or 11 + 10 log10B, dBm, whichever is less. Here B is the 26dB bandwidth in megahertz. In this instance B was chosen to be the lowest measured BW rounded down to represent the worst case limit.

**5470 - 5725 MHz**

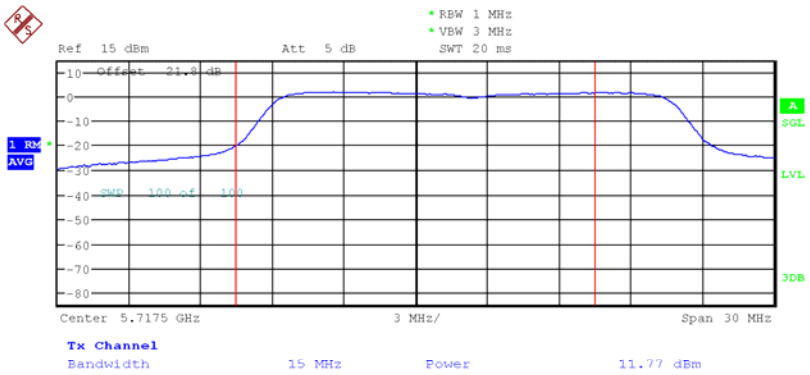
| Channel | Frequency (MHz) | Conducted Output Power (dBm) | Corrected Output Power (dBm) | FCC Limit (dBm) |
|---|---|---|---|---|
| **802.11a mode** | | | | |
| 100 | 5500 | 14.06 | 14.24 | 24 |
| 116 | 5580 | 20.65 | 20.83 | 24 |
| 140 | 5700 | 17.48 | 17.66 | 24 |
| 144 | 5710-5725 | 11.77 | 11.95 | 24 |
| 144 | 5725-5730 | 5.82 | 6 | 30 |
| **802.11n/ac20 mode** | | | | |
| 100 | 5500 | 15.19 | 15.5 | 24 |
| 116 | 5580 | 20.48 | 20.79 | 24 |
| 140 | 5700 | 18.18 | 18.49 | 24 |
| 144 | 5710-5725 | 11.82 | 12.13 | 24 |
| 144 | 5725-5730 | 5.48 | 5.79 | 30 |

Note: See Annex C for Conducted Output Power results
Note: Corrected Output Power(dBm)= Conducted Output Power(dBm) + Duty Cycle Correction Factor(dB)
Note: For 5470MHz-5725MHz for FCC: the maximum conducted output power shall not exceed 250 mW or 11 + 10 log10B, dBm, whichever is less. Here B is the 26dB bandwidth in megahertz. In this instance B was chosen to be the lowest measured BW rounded down to represent the worst case limit.

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

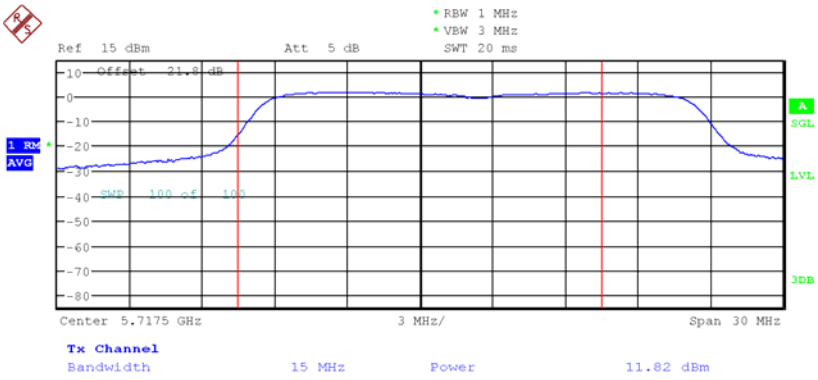
802.11a mode

5710-5725 MHz



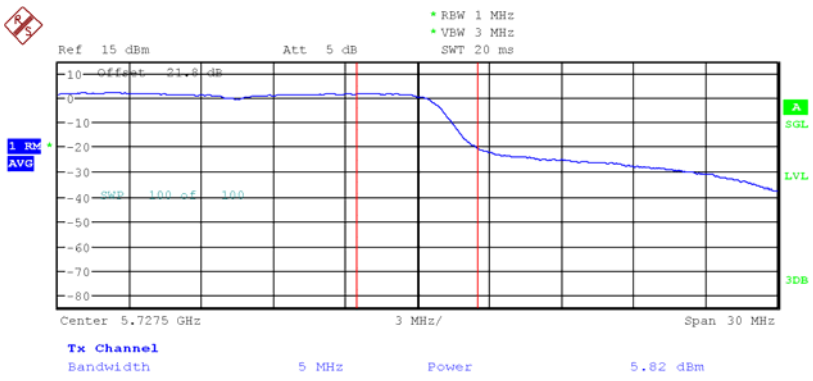

802.11ac/n20 mode

5710-5725 MHz



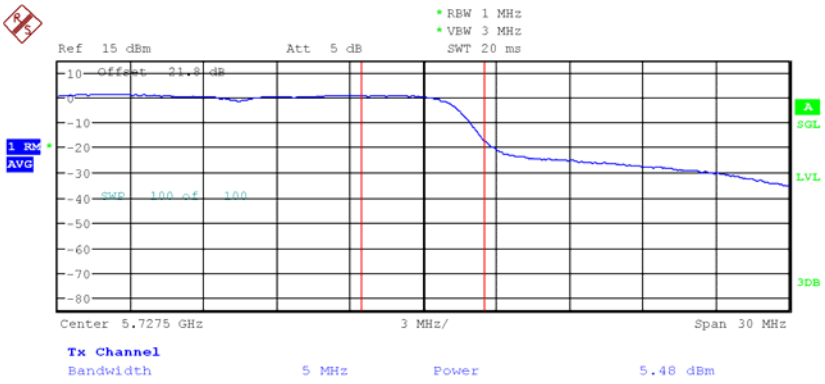
802.11a mode

5725-5730 MHz




802.11ac/n20 mode

5725-5730 MHz



# 10 FCC §15.407(a) - Power Spectral Density

## 10.1 Applicable Standards

According to FCC §15.407(a):

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

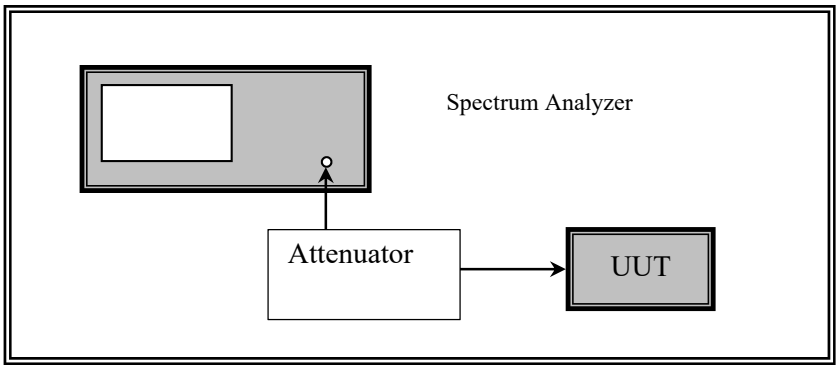
For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11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

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

## 10.2 Measurement Procedure

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

## 10.3 Test Setup Block Diagram



## 10.4 Test Equipment List and Details

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

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability: BACL Corp.*** *attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

## 10.5 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 22-24 ºC |
| **Relative Humidity:** | 50-55 % |
| **ATM Pressure:** | 102.1-102.7 kPa |

*Testing was performed by Christian Schwartz on 2023-02-28 at the RF site.*

## 10.6 Test Results

**5250 - 5350 MHz**

| Channel | Frequency (MHz) | PSD (dBm/MHz) | Corrected PSD (dBm/MHz) | FCC Limit (dBm/MHz) |
|---|---|---|---|---|
| **802.11a mode** | | | | |
| 52 | 5260 | 4.17 | 4.35 | 11 |
| 56 | 5280 | 4.6 | 4.78 | 11 |
| 64 | 5320 | 5.37 | 5.55 | 11 |
| **802.11n/ac20 mode** | | | | |
| 52 | 5260 | 4.11 | 4.42 | 11 |
| 56 | 5280 | 4.19 | 4.5 | 11 |
| 64 | 5320 | 4.95 | 5.26 | 11 |

Note: See Annex D for test results
Note: Corrected PSD(dBm/MHz)= PSD(dBm/MHz) + Duty Cycle Correction Factor(dB)

**5470 - 5725 MHz**

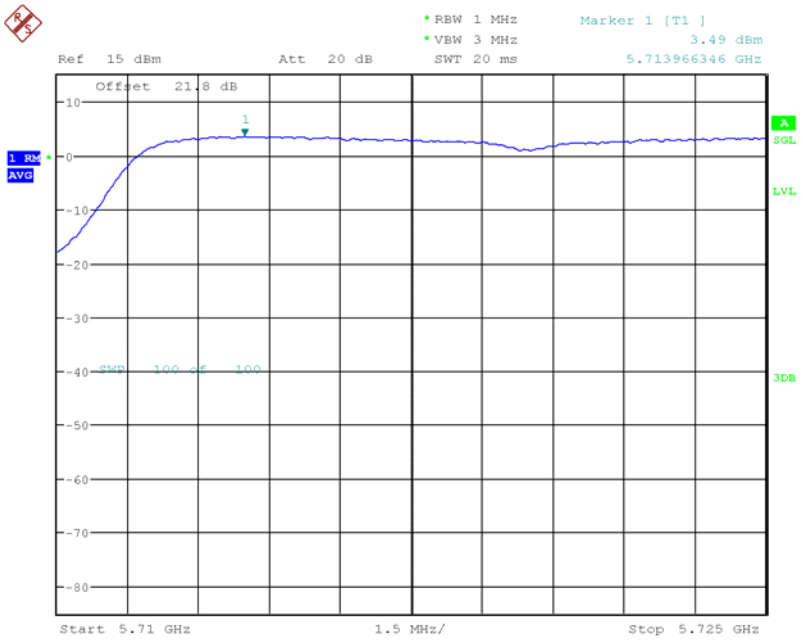
| Channel | Frequency (MHz) | PSD (dBm/MHz) | Corrected PSD (dBm/MHz) | FCC Limit (dBm/MHz) |
|---|---|---|---|---|
| **802.11a mode** | | | | |
| 100 | 5500 | 3.33 | 3.51 | 11 |
| 116 | 5580 | 9.48 | 9.66 | 11 |
| 140 | 5700 | 6.32 | 6.5 | 11 |
| 144 | 5710-5725 | 3.49 | 3.67 | 11 |
| 144* | 5725-5730 | 0.00 dBm/500 kHz | 0.18 dBm/500 kHz | 30 dBm/500 kHz |
| **802.11n/ac20 mode** | | | | |
| 100 | 5500 | 4.15 | 4.46 | 11 |
| 116 | 5580 | 9.08 | 9.39 | 11 |
| 140 | 5700 | 6.74 | 7.05 | 11 |
| 144 | 5710-5725 | 3.41 | 3.51 | 11 |
| 144* | 5725-5730 | 0.01 dBm/500 kHz | 0.19 dBm/500 kHz | 30 dBm/500 kHz |

Note: See Annex D for test results
Note: Corrected PSD(dBm/MHz)= PSD(dBm/MHz) + Duty Cycle Correction Factor(dB)
Note*: Due to channel being in U-NII-3 band, PSD and Limit is dBm/500kHz.

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

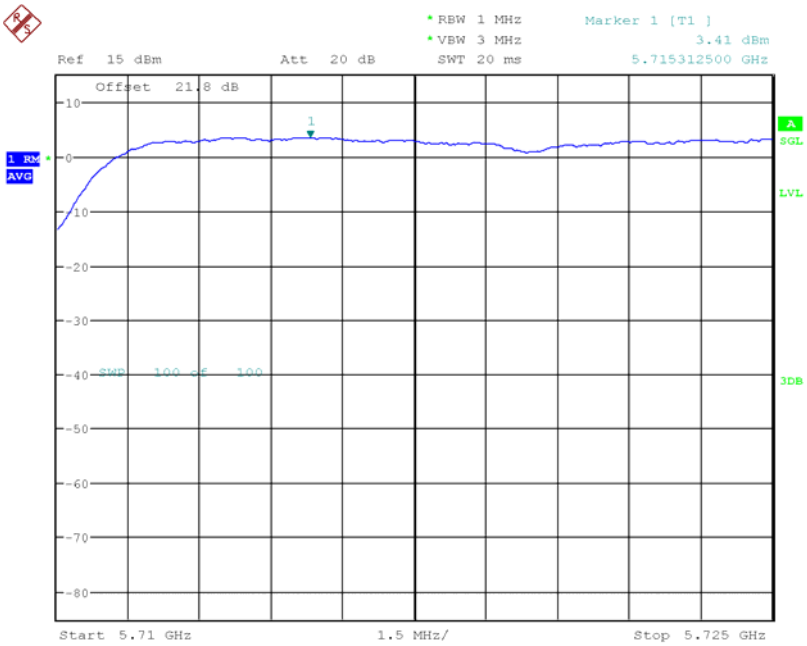
802.11a mode

5710-5725 MHz



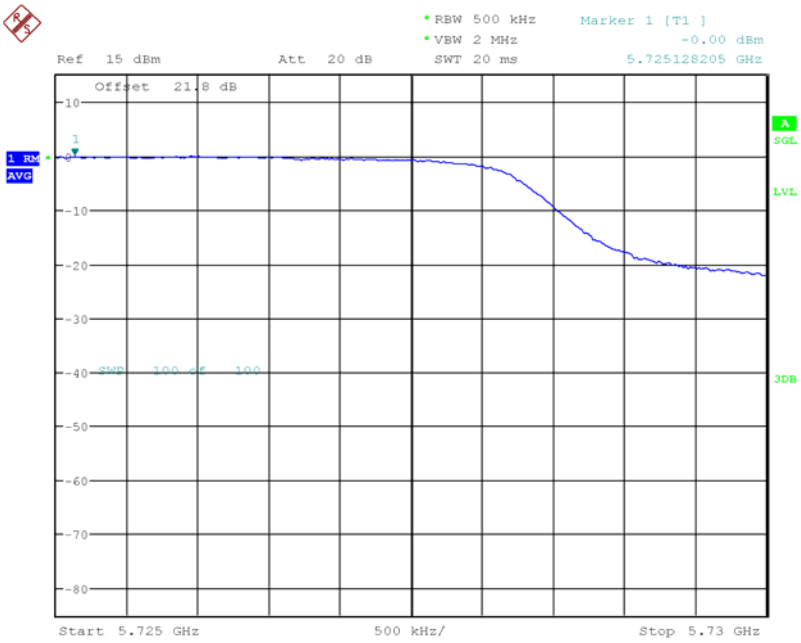

802.11ac/n20 mode

5710-5725 MHz



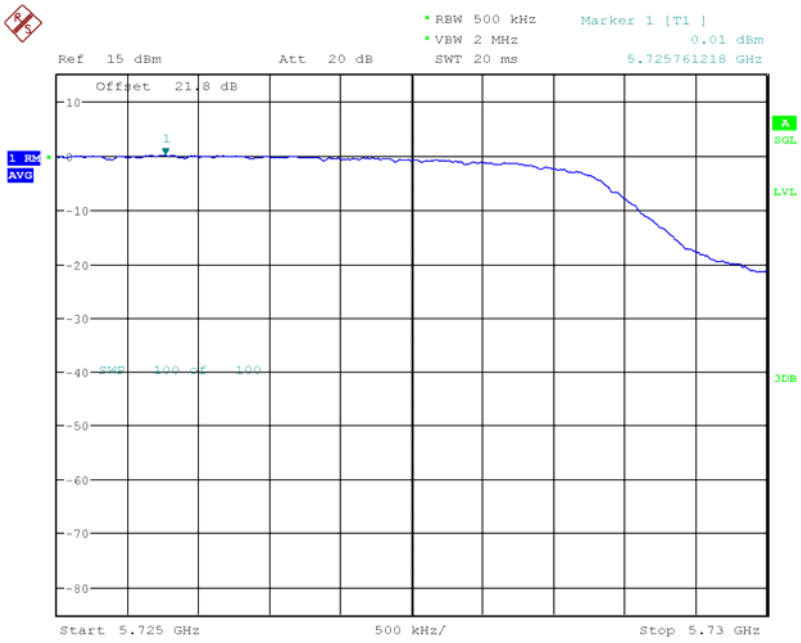
802.11a mode

5725-5730 MHz




802.11ac/n20 mode

5725-5730 MHz



# 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

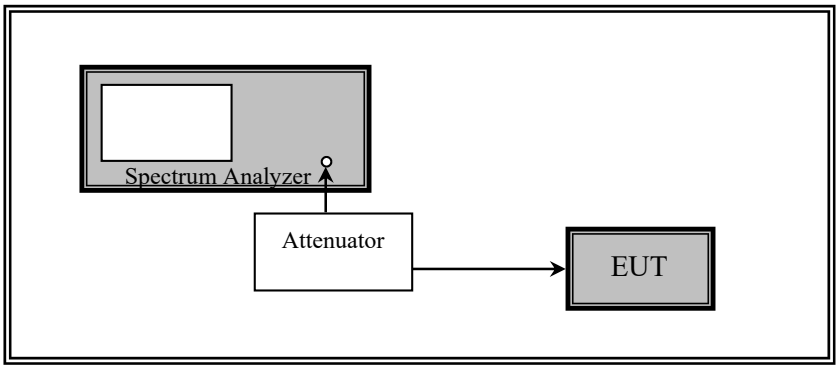
Add a correction factor (antenna gain+ Attenuator loss+cable loss) to the offset of the spectrum analyzer.

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

## 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 |
| - | - | 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 2023-02-28 to 2023-03-09 at the RF site.*

## 11.6 Test Results

Note: See Annex E for test results
Note: Antenna Gain is considered into offset.
Note: Bandedges are covered in Radiated Spurious Emisisons (Section 7)

# 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<br>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 |

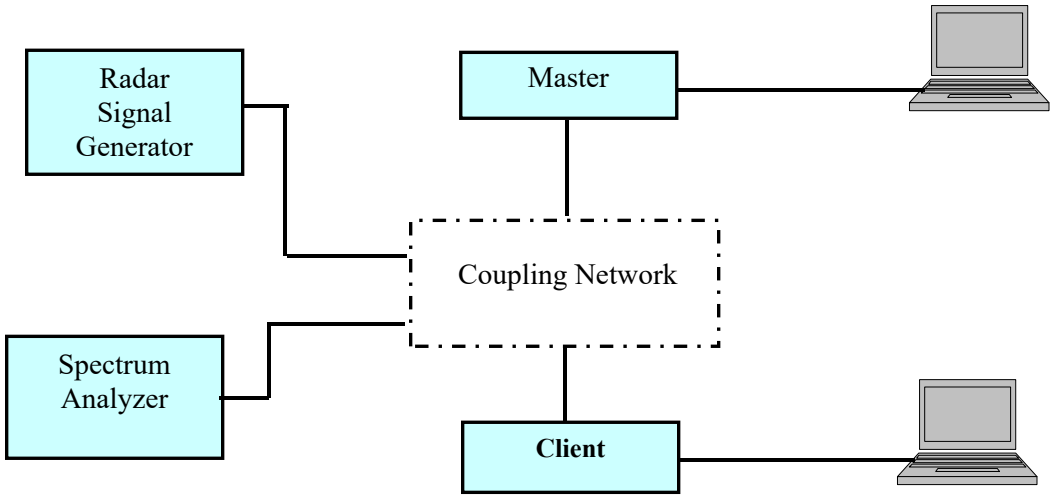
**Table 7: Frequency Hopping Radar Test Signal**

| 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 |

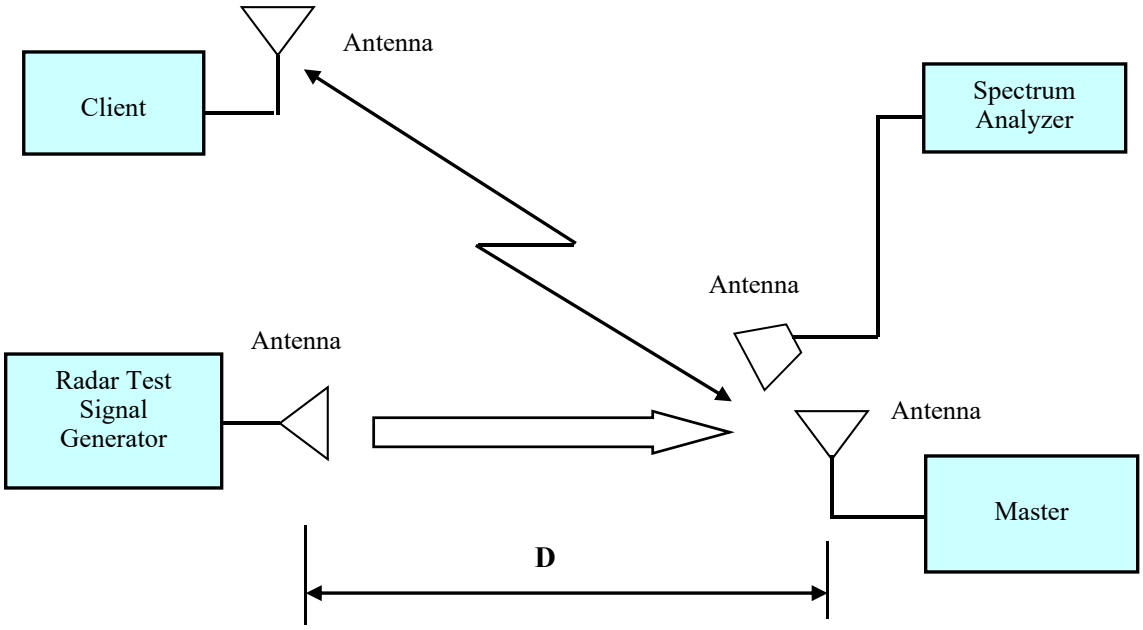
## 12.2 DFS Measurement System

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, IC: 5912A-H350). A spectrum analyzer was used as a monitor that verifies the EUT's status, which includes the Channel Closing Transmission Time and the Channel Move Time.

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

The aggregate channel closing transmission time is calculated as follows:

Aggregate Transmission Time = N * Dwell Time

N is the number of spectrum analyzer bins showing a device transmission
Dwell Time is the dwell time per bin (i.e. Dwell Time = S/B, S is the sweep time and B is the number of bin, i.e. 8192)

## 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 |

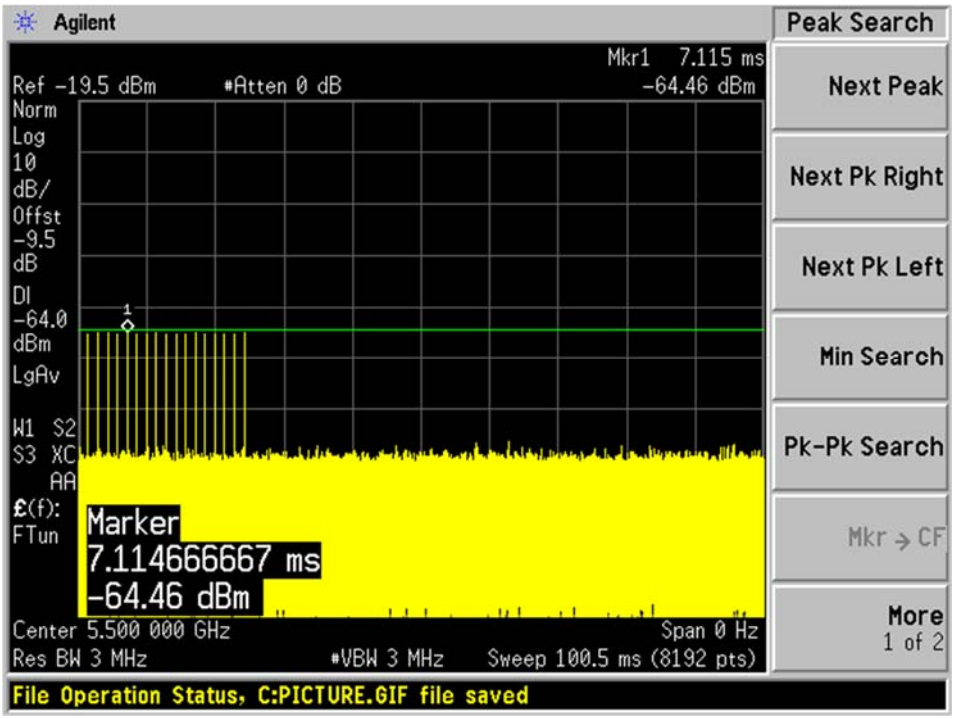
*Testing was performed by Simon Ma on 2023-02-16 at the DFS testing site.*

## 12.8 Test Results

**Plots of Radar Waveforms**

**Radar Type 0**

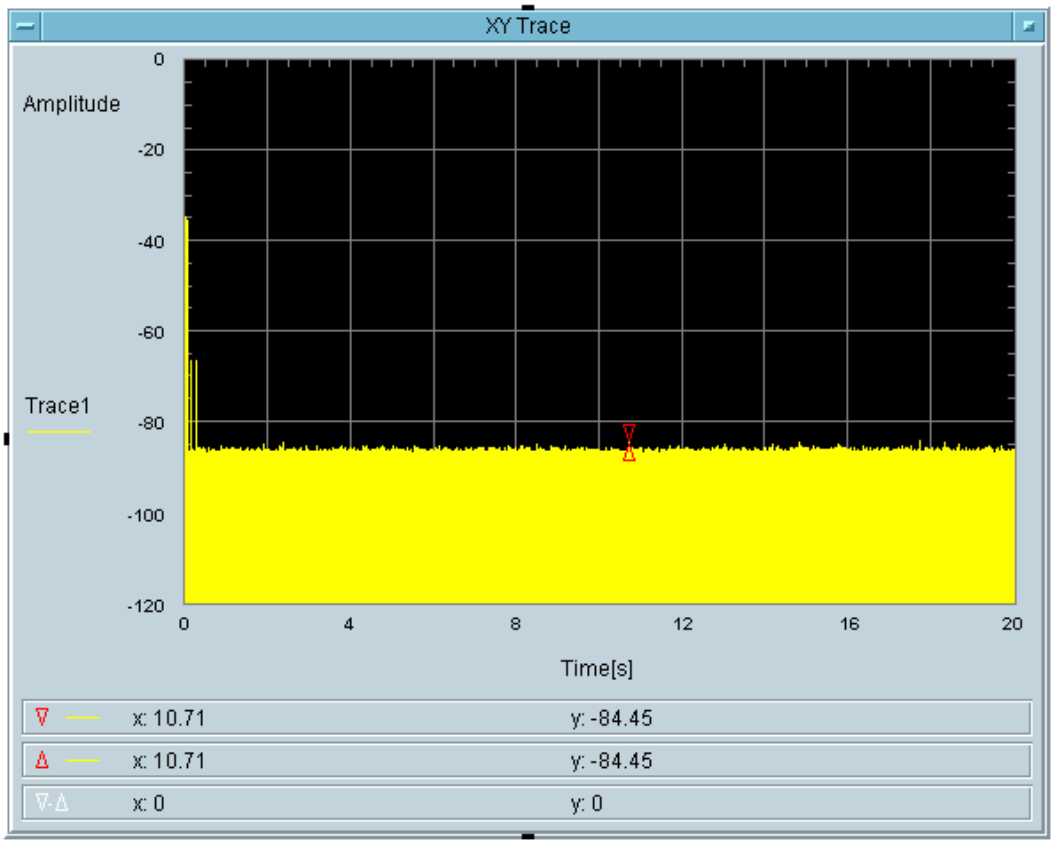
5500 MHz




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

5500 MHz 20 MHz Bandwidth

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

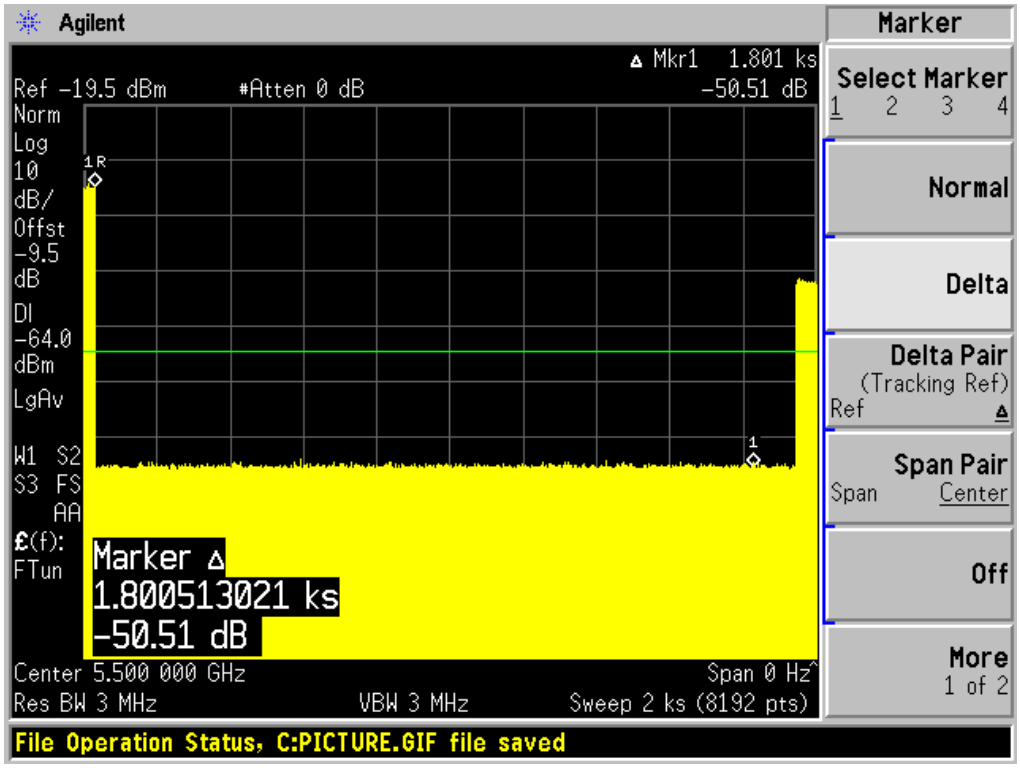



Type 0 radar channel closing transmission time result:

| Channel closing transmitting time (ms) | Limit (ms) | Result |
|---|---|---|
| 29.3+2.441 | 200 | Pass |


Non-occupancy Time

5500 MHz for 20 MHz channel bandwidth



# 13 Annex A (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 ---**