# FCC PART 15, SUBPART C
# ISEDC RSS-247, ISSUE 2, FEBRUARY 2017

## TEST REPORT

For

## Roku, Inc.

1155 Coleman Avenue,
San Jose, CA 95110, USA

**FCC ID: TC2-R1016**
**IC: 5959A-R1016**

| **Report Type:** | **Product Type:** |
|---|---|
| Class II Permissive Change Report | IP-STB |

| | | |
|---|---|---|
| **Prepared By:** | Christian McCaig<br>RF Lead Engineer |  |
| **Report Number:** | R2111301-247 | |
| **Report Date:** | 2022-02-18 | |
| **Reviewed By:** | Zhao Zhao<br>RF Project Engineer |  |

Bay Area Compliance Laboratories Corp.
1274 Anvilwood Avenue,
Sunnyvale, CA 94089, USA
Tel: +1 (408) 732-9162 Fax: +1 (408) 732-9164

ACCREDITED
CERTIFICATE #3297.02

# TABLE OF CONTENTS

# DOCUMENT REVISION HISTORY

| Revision Number | Report Number | Description of Revision | Date of Revision |
|---|---|---|---|
| 0 | R2111301-247 | CIIPC Report | 2022-02-18 |

# 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: *4670X, FCC ID: TC2-R1016, IC: 5959A-R1016*, or the "EUT" as referred to in this report. The EUT has 2.4 GHz/5 GHz Wi-Fi capabilities. The previous model: 4660X and the updated tested model: 4670X were declared to be electrically identical. Please refer to the manufacturer declaration of similarity letter in Annex D of this report.

## 1.2 Mechanical Description of EUT

4670X measures approximately 12.4 cm (Length), 12.4 cm (Width), and 1.9 cm (Height) and weighs approximately 0.2 kg.

*The data gathered are from a production sample provided by Roku, Inc. with BACL assigned serial numbers: KWA036914655 & KWA034762617.*

## 1.3 Objective

This report was prepared on behalf of *Roku, Inc.* in accordance with Part 2, Subpart J, and Part 15, Subpart C of the Federal Communication Commission's rules and ISEDC RSS-247 Issue 2, February 2017.

The objective was to determine compliance with FCC Part 15.247 and ISEDC RSS-247 for Antenna Requirement, RF Exposure, AC Line Conducted Emissions, Emission Bandwidth, Radiated & Conducted Spurious Emissions, 100 kHz Band Edges, Maximum Output Power, and Peak Power Spectrum Density

This report was for a Permissive Change II submission for the purpose of enabling 40MHz and 80MHz bandwidth capabilities and adding additional memory.

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

Equipment Class: NII, FCC ID: TC2-R1016, IC: 5959A-R1016

## 1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

## 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 | ±0.86 dB |
| Power Spectral Density, conducted | ±0.86 dB |
| Unwanted Emissions, conducted | ±2.76 dB |
| All emissions, radiated | ±4.94 dB |
| AC power line Conducted Emission | ±2.0 dB |
| Temperature | ±2 ° C |
| Humidity | ±5 % |
| DC and low frequency voltages | ±1.0 % |
| Time | ±2 % |
| Duty Cycle | ±3 % |

## 1.7 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 System Test Configuration

## 2.1 Justification

The EUT was configured for testing according to ANSI C63.10-2013 and FCC KDB 558074 D01 DTS Meas Guidance v05r02.

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 to be as follows for each mode based upon investigation 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 PuTTy. The software is compliant with the standard requirements being tested against.

FCC/IC power settings:

| Modulation | Frequency (MHz) | Power Setting | |
|---|---|---|---|
| | | Ant A | Ant B |
| 802.11 n40 | 2422 | 53 | 53 |
| | 2437 | 62 | 62 |
| | 2452 | 52 | 52 |

Data Rates Tested:
802.11n HT20 mode: MCS0

## 2.3 Duty Cycle Correction Factor

According to KDB 558074 D01 DTS Meas Guidance v05r02 section 6.0:

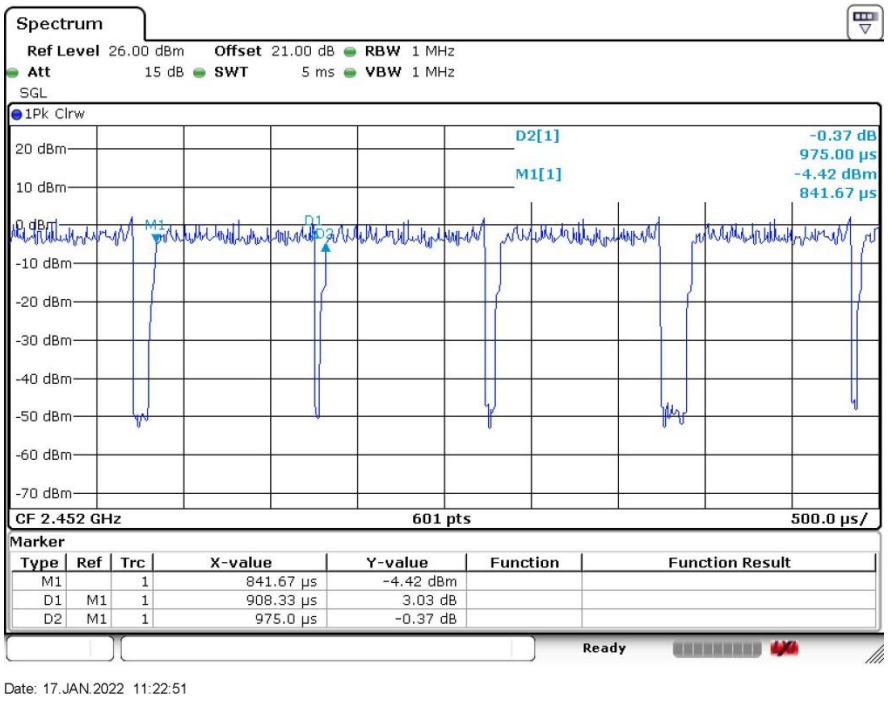
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data is being acquired (i.e., no transmitter off-time is to be considered).

| Radio Mode | On Time (ms) | Period (ms) | Duty Cycle (%) | Duty Cycle Correction Factor (dB) |
|---|---|---|---|---|
| 802.11n40 | 0.908 | 0.975 | 93.13 | 0.31 |

Duty Cycle = On Time (ms)/ Period (ms)
Duty Cycle Correction Factor (dB) = 10*log(1/Duty Cycle)

Please refer to the following plot.

802.11n40 mode



## 2.4 Equipment Modifications

N/A

## 2.5 Local Support Equipment

| Manufacturer | Description | Model |
|---|---|---|
| Dell | Laptop | Latitude E6410 |

## 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 |
| RF Cable | < 1 m | EUT | PSA |

# 3 Summary of Test Results

Results reported relate only to the product tested.

| FCC/ISEDC Rules | Description of Test | Results |
|---|---|---|
| FCC §15.203<br>ISEDC RSS-Gen §6.8 | Antenna Requirements | Compliant |
| FCC §2.1091, §15.247(i)<br>ISEDC RSS-102 | RF Exposure | Compliant |
| FCC §15.207<br>ISEDC RSS-Gen §8.8 | AC Line Conducted Emissions | Compliant |
| FCC §15.209, §15.247(d)<br>ISEDC RSS-247 §5.5<br>RSS-Gen §8.9, §8.10 | Radiated Spurious Emissions | Compliant |
| FCC §15.247(a)(2)<br>ISEDC RSS-247 §5.2<br>RSS-Gen §6.7 | 6 dB & 99% Emission Bandwidth | Compliant |
| FCC §15.247(b)(3)<br>ISEDC RSS-247 §5.4 | Maximum Output Power | Compliant |
| FCC §15.247(e)<br>ISEDC RSS-247 §5.2(2) | Peak Power Spectral Density | Compliant |
| FCC §15.247(d)<br>ISEDC RSS-247 §5.5 | 100 kHz Bandwidth of Frequency Band Edge | Compliant |
| FCC §2.1051, §15.247 (d)<br>ISEDC RSS-247 §5.5 | Spurious Emissions at Antenna Port | Compliant |

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

## 4.1 Applicable Standards

According to FCC §15.203:

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

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

According to ISEDC RSS-Gen §6.8: Transmitter Antenna

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

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

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

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

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

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

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

## 4.2 Antenna Description

| Antenna usage | Frequency Range (MHz) | Maximum Antenna Gain (dBi) |
|---|---|---|
| 2.4GHz Wi-Fi Metal Antenna (2 Antennas) | 2400-2483.5 | 2.6 |

Note: The antennas used by the EUT are permanent attached antennas.
Note: Antenna info is information provided by customer.

# 5 FCC §2.1091, §15.407(f) & ISEDC RSS-102 - RF Exposure

## 5.1 Applicable Standards

According to FCC §15.247(i) and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

According to KDB 447 498 Section (7.2), "simultaneous transmission of MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on calculated or measured field strengths or power density, is ≤ 1.0. The MPE ratio of each antenna is determined at the minimum *test separation distance* required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to MPE limit, at the test frequency.

Limits for General Population/Uncontrolled Exposure

| Frequency Range (MHz) | Electric Field Strength (V/m) | Magnetic Field Strength (A/m) | Power Density ($mW/cm^2$) | Averaging Time (minutes) |
|---|---|---|---|---|
| Limits for General Population/Uncontrolled Exposure | | | | |
| 0.3-1.34 | 614 | 1.63 | * (100) | 30 |
| 1.34-30 | 824/f | 2.19/f | * ($180/f^2$) | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | / | / | f/1500 | 30 |
| 1500-100,000 | / | / | 1.0 | 30 |

Where: f = frequency in MHz
* = Plane-wave equivalent power density

Before equipment certification is granted, the procedure of IC RSS-102 must be followed concerning the exposure of humans to RF field.

According to ISED RSS-102 Issue 5:

### 2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

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

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

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

## 5.2 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.

## 5.3 MPE Results

*Worst Case: 802.11n40, 2437 MHz*

| | |
|---|---|
| Maximum peak output power at antenna input terminal (dBm): | 19.85 |
| Maximum peak output power at antenna input terminal (mW): | 96.605 |
| Prediction distance (cm): | 20 |
| Prediction frequency (MHz): | 2437 |
| Maximum Directional Antenna Gain, typical (dBi): | 5.6 |
| Maximum Antenna Gain (numeric): | 3.63 |
| Power density of prediction frequency at 20.0 cm ($mW/cm^2$): | 0.0698 |
| FCC MPE limit for uncontrolled exposure at prediction frequency ($mW/cm^2$): | 1.0 |

The device is compliant with the requirement FCC MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.0698 $mW/cm^2$. Limit is 1.0 $mW/cm^2$.

Note: Maximum Antenna Gain used is based on Combined Antenna Gain calculation for MIMO transmitting usage (i.e. Combined Antenna Gain (dBi) = Single Antenna Gain (dBi) + 10*log (Number of Antennas)). In this case the Combined Antenna Gain is 5.6 dBi = 2.6 dBi +10*log(2).

**Radio Co-location**

2.4 GHz Wi-Fi and 5 GHz Wi-Fi simultaneous transmission is not supported.

## 5.4 RF exposure evaluation exemption for IC

*Worst Case: 802.11n40, 2437 MHz*

Maximum EIRP power = 19.85dBm + 5.6 dBi = 25.45 dBm which is less than $1.31\times10^{-2}f^{0.6834}$ = 2.703 W = 34.32 dBm

Therefore the RF exposure Evaluation is not required.

Note: Maximum Antenna Gain used is based on Combined Antenna Gain calculation for MIMO transmitting usage (i.e. Combined Antenna Gain (dBi) = Single Antenna Gain (dBi) + 10*log (Number of Antennas)). In this case the Combined Antenna Gain is 5.6 dBi = 2.6 dBi +10*log(2).

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

## 6.1 Applicable Standards

As per FCC §15.207 and ISEDC RSS GEN §8.8

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 and and ISEDC RSS GEN §8.8.

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

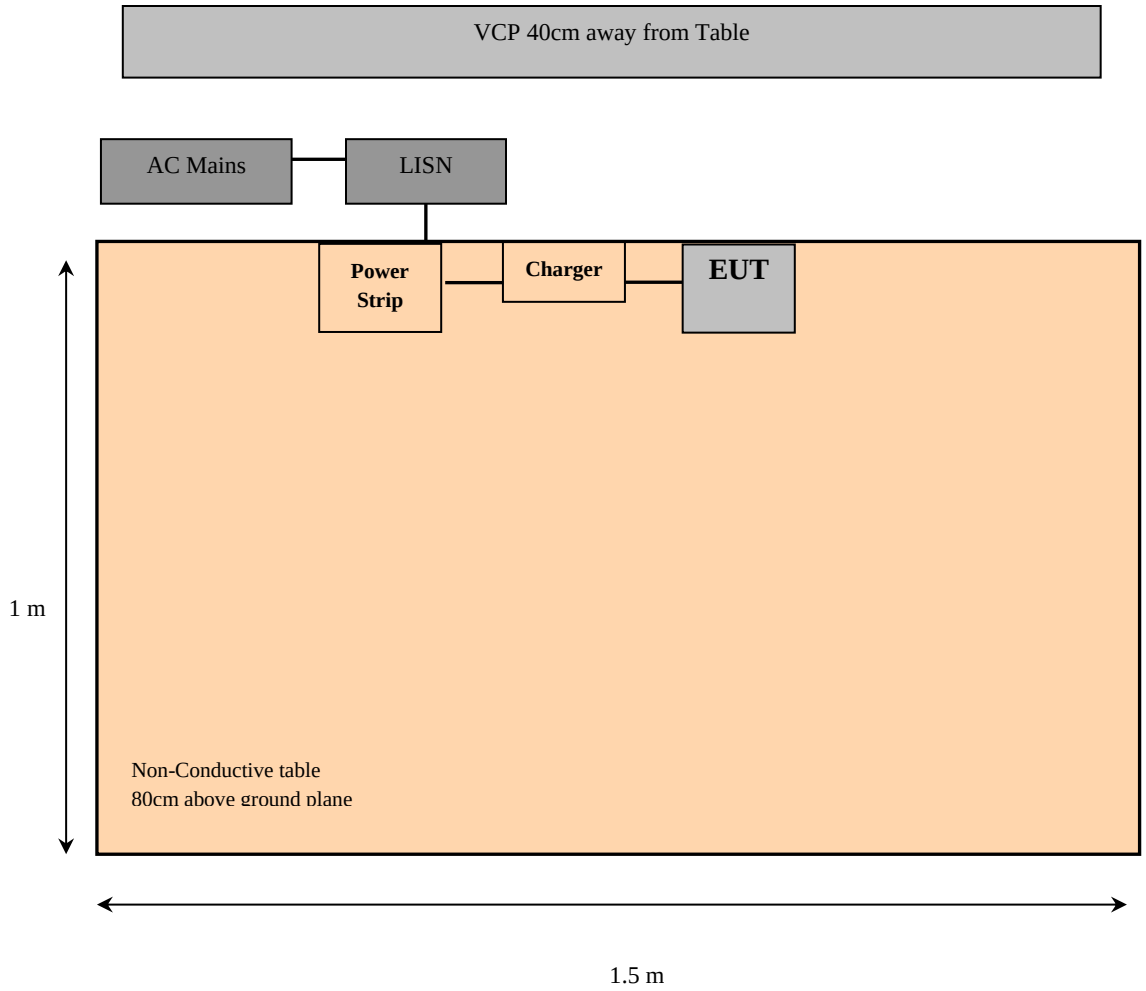
## 6.3 Test Procedure

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

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

All data 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 No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 831 | Rohde & Schwarz | EMI Test Receiver | ESU-40 | 100433 | 2021-09-20 | 1 year |
| 679 | Rohde and Schwarz | Impulse Limiter | ESH3-Z2 | 101964 | 2021-07-07 | 1 year |
| 725 | Solar Electronics Company | High Pass Filter | Type 7930-100 | 7930150202 | 2021-03-02 | 1 year |
| 1226 | Suirong | 30 ft conductive emission cable | LMR 400 | - | N/R | N/A |
| 733 | FCC | LISN | FCC-LISN-50-25-2-10-CISPR16 | 160130 | 2021-11-24 | 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:** | 23º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 101.31 kPa |

*The testing was performed by Harsh Chokshi on 2021-01-21 in the Ground Plane test site.*

## 6.8 Summary of Test Results

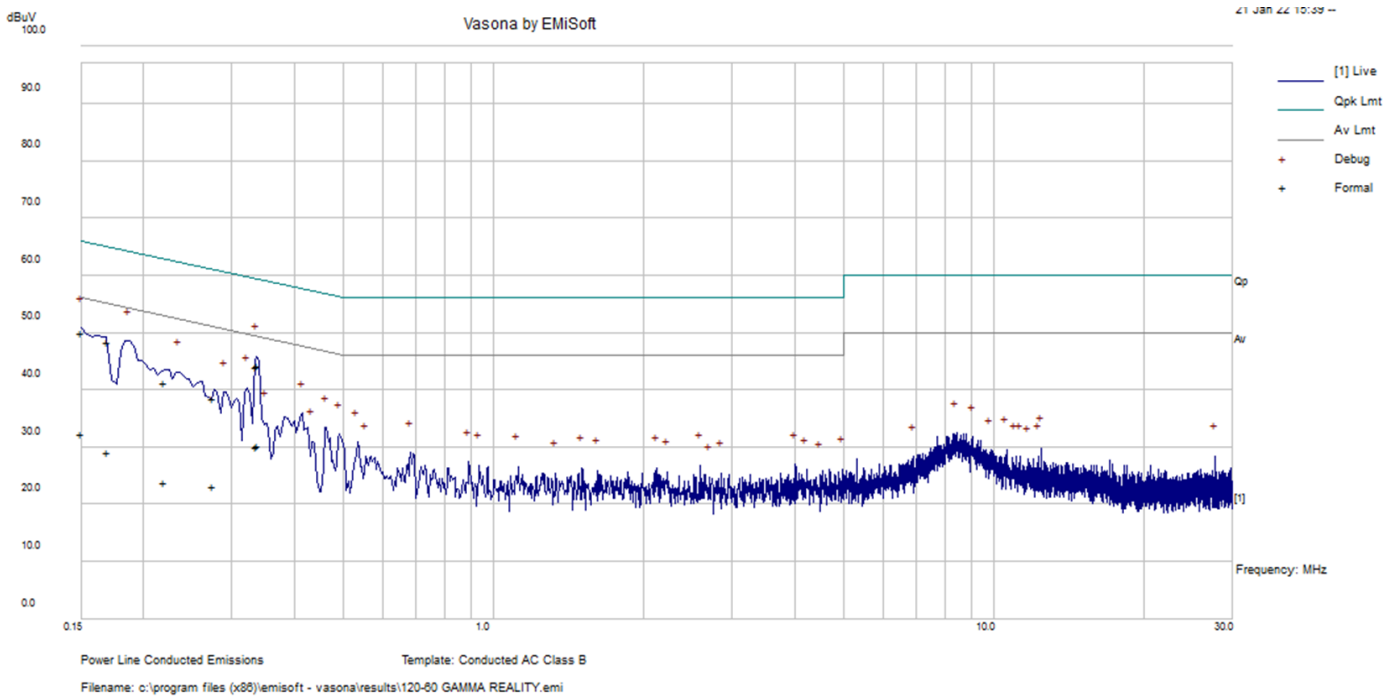
According to the recorded data in following table, the EUT complied with the FCC 15C & ISEDC standard's conducted emissions limits, with the margin reading of:

| **Connection: AC/DC adapter connected to 120 V/60 Hz, AC** | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Conductor Mode (Line/Neutral)** | **Range (MHz)** |
| -13.32 | 0.338807 | Neutral | 0.15-30 |

## 6.9 Conducted Emissions Test Plots and Data

Worst Case: 802.11n40 mode – 2437 MHz

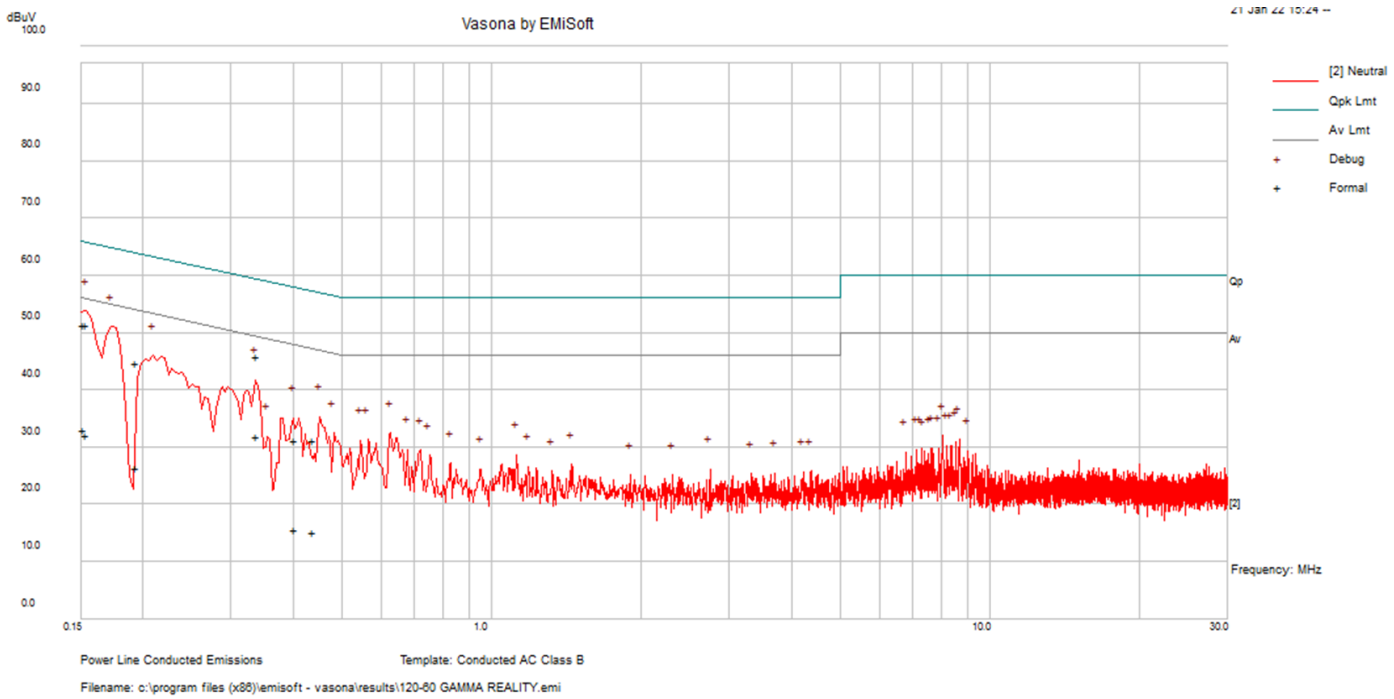
**120 V, 60 Hz – Line**




| Frequency (MHz) | Ai Reading (dBuV) | Correction Factor (dB) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|---|---|
| 0.338663 | 34.33 | 9.89 | 44.22 | Line | 59.24 | -15.02 | QP |
| 0.150172 | 40.32 | 9.72 | 50.04 | Line | 65.99 | -15.95 | QP |
| 0.169585 | 38.55 | 9.75 | 48.3 | Line | 64.98 | -16.68 | QP |
| 0.220633 | 31.45 | 9.81 | 41.26 | Line | 62.8 | -21.53 | QP |
| 0.337075 | 34.01 | 9.89 | 43.9 | Line | 59.28 | -15.38 | QP |
| 0.275777 | 28.61 | 9.86 | 38.47 | Line | 60.94 | -22.47 | QP |

| Frequency (MHz) | Ai Reading (dBuV) | Correction Factor (dB) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|---|---|
| 0.338663 | 20.4 | 9.88 | 30.28 | Line | 49.24 | -18.95 | Ave. |
| 0.150172 | 22.7 | 9.72 | 32.42 | Line | 55.99 | -23.57 | Ave. |
| 0.169585 | 19.43 | 9.75 | 29.18 | Line | 54.98 | -25.8 | Ave. |
| 0.220633 | 14.04 | 9.82 | 23.86 | Line | 52.8 | -28.94 | Ave. |
| 0.337075 | 20.22 | 9.89 | 30.11 | Line | 49.28 | -19.17 | Ave. |
| 0.275777 | 13.35 | 9.86 | 23.21 | Line | 50.94 | -27.73 | Ave. |

## 120 V, 60 Hz – Neutral




| Frequency (MHz) | Ai Reading (dBuV) | Correction Factor (dB) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|---|---|
| 0.152112 | 41.57 | 9.73 | 51.3 | Neutral | 65.88 | -14.58 | QP |
| 0.154443 | 41.69 | 9.73 | 51.42 | Neutral | 65.76 | -14.34 | QP |
| 0.194044 | 34.83 | 9.78 | 44.61 | Neutral | 63.86 | -19.25 | QP |
| 0.338807 | 36.02 | 9.89 | 45.91 | Neutral | 59.23 | -13.32 | QP |
| 0.440372 | 21.21 | 9.9 | 31.11 | Neutral | 57.05 | -25.95 | QP |
| 0.403935 | 21.31 | 9.89 | 31.2 | Neutral | 57.77 | -26.57 | QP |

| Frequency (MHz) | Ai Reading (dBuV) | Correction Factor (dB) | Corrected Amplitude (dBuV) | Conductor (Line/Neutral) | Limit (dBuV) | Margin (dB) | Detector (QP/Ave.) |
|---|---|---|---|---|---|---|---|
| 0.152112 | 23.25 | 9.73 | 32.98 | Neutral | 55.88 | -22.91 | Ave. |
| 0.154443 | 22.42 | 9.73 | 32.15 | Neutral | 55.76 | -23.61 | Ave. |
| 0.194044 | 16.64 | 9.79 | 26.43 | Neutral | 53.86 | -27.43 | Ave. |
| 0.338807 | 22.06 | 9.89 | 31.95 | Neutral | 49.23 | -17.28 | Ave. |
| 0.440372 | 5.14 | 9.9 | 15.04 | Neutral | 47.05 | -32.02 | Ave. |
| 0.403935 | 5.63 | 9.89 | 15.52 | Neutral | 47.77 | -32.25 | Ave. |

# 7 FCC §15.209, §15.247(d) & ISEDC RSS-247 §5.5, RSS-Gen §8.9, §8.10 - Spurious Radiated Emissions

## 7.1 Applicable Standards

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

As Per FCC §15.205(a) and RSS-Gen 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(a): Except as provided elsewhere in this Subpart, 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** | 3 |
| 88 - 216 | 150** | 3 |
| 216 - 960 | 200** | 3 |
| Above 960 | 500 | 3 |

** 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 §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c).

As per ISEDC RSS-Gen 8.9,

Except when the requirements applicable to a given device state otherwise, emission from licence-exempt transmitters shall company with the field strength limits shown in the table below. Additional, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

General Field Strength Limits for Licence-Exemption Transmitters at Frequencies above 30 MHz

| Frequency (MHz) | Field Strength (µv/m at 3 meters) |
|---|---|
| 30-88 | 100 |
| 88-216 | 150 |
| 216-960 | 200 |
| Above 960* | 500 |

* Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.

As per ISEDC RSS-247 §5.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

## 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 Subpart C and ISEDC RSS-247 limits.

The spacing between the peripherals was 10 centimeters.

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

## 7.3 Test Procedure

For the radiated emissions test, the EUT host, and all support equipment power cords was 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 was set 3 meter away from the testing antenna, which was varied from 1-4 meter, and the EUT was placed on a turntable, which was 0.8 meter and 1.5 meter above the ground plane for below and above 1000 MHz measurements, 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 = 1MHz / Sweep = Auto
(2) Average: RBW = 1MHz / VBW = 10Hz / Sweep = Auto

## 7.4 Corrected Amplitude & Margin Calculation

For emissions below 1 GHz,

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

CA = S.A. Reading + Correction Factor

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

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

Correction Factor = AF + CL + Atten – Ga

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

Margin = Corrected Amplitude – Limit

For emission above 1 GHz,

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

CA = Ai + AF + CL + Atten – Ga

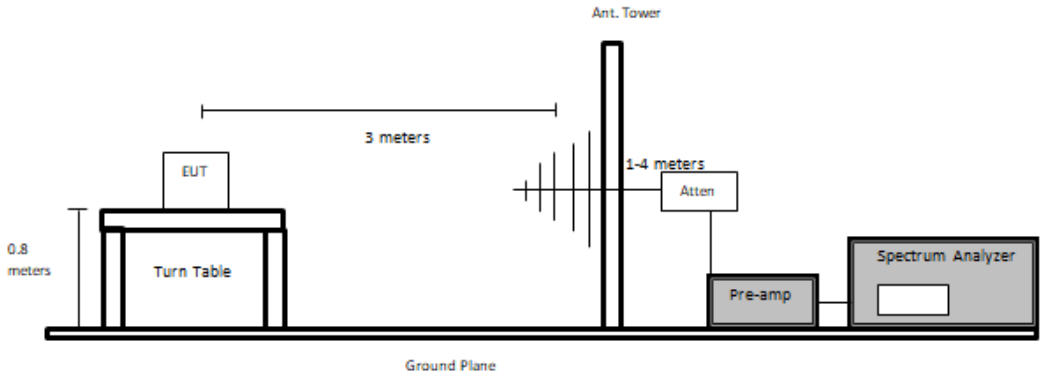
For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

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. The equation for margin calculation is as follows:

Margin = Corrected Amplitude – Limit

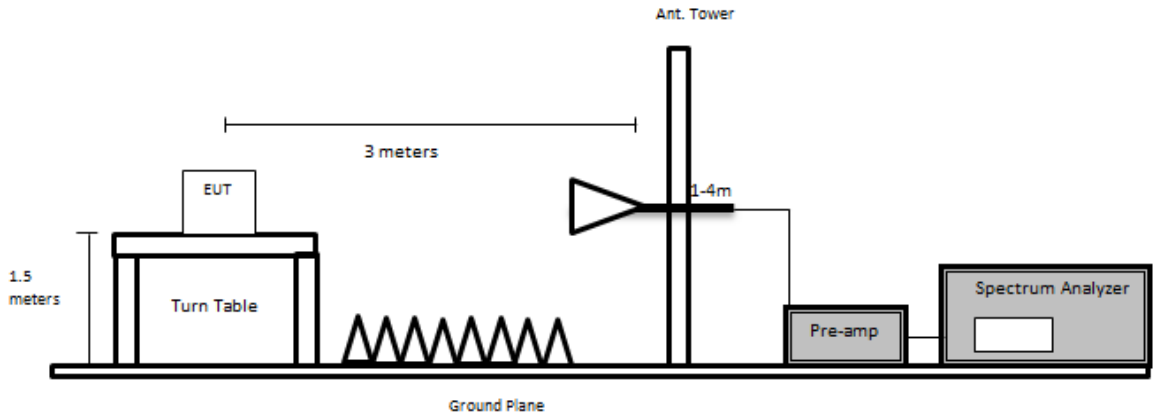
## 7.5 Test Setup Block Diagram

Below 1GHz:

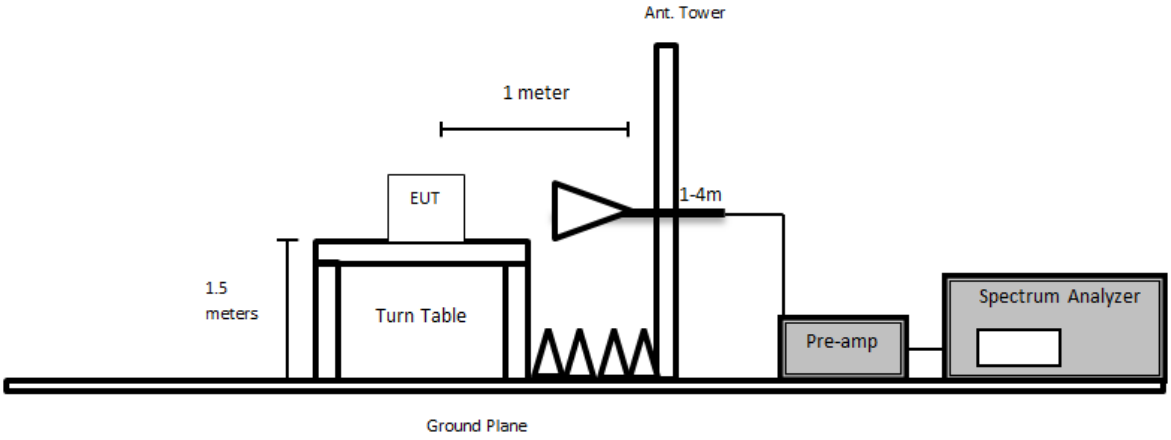



1 GHz to 18 GHz (Asset #1192 Antenna used):

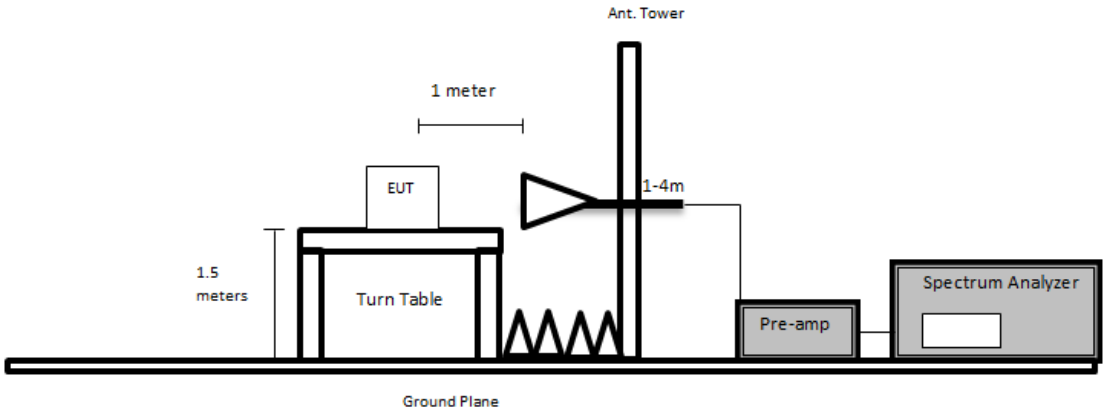
At 3 meters:



At 1 meter:




18 GHz to 26 GHz (Asset #91 Antenna used):



## 7.6 Test Equipment List and Details

| BACL No. | Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 831 | Rohde & Schwarz | EMI Test Receiver | ESU-40 | 100433 | 2021-09-20 | 1 year |
| 287 | Agilent | Spectrum Analyzer | E4446A | US44300386 | 2021-04-27 | 1 year |
| - | Sunol Science Corp | System Controller | SC110V | 122303-1 | N/R | N/A |
| 459 | HP | Pre-Amplifier | 8447D | 2443A04374 | 2021-11-02 | 1 year |
| 658 | HP | Pre-Amplifier | 8449B OPT HO2 | 3008A0113 | 2021-05-06 | 1 year |
| 91 | Wisewave | Horn Antenna | ARH-4223-02 | 10555-02 | 2020-02-05 | 2 years |
| 827 | AH Systems | Preamplifier | PAM 1840 VH | 170 | 2021-08-03 | 1 year |
| 1192 | ETS Lindgren | Horn Antenna | 3117 | 00218973 | 2021-09-14 | 2 years |
| 321 | Sunol Sciences | Biconilog Antenna | JB3 | A020106-2 | 2021-11-22 | 2 years |
| - | - | RF cable | - | - | Each time[1] | N/A |
| - | - | Notch Filter | - | - | Each time[1] | N/A |
| 1077 | Insulted Wire Corp. | 157 Series 2.92 SM (x2) Armored 33 ft. Cable | KPS-1571AN-3960-KPS | DC 1917 | 2021-03-03 | 1 year |
| 1081 | MDP Digital | Times Microwave LMR 400 UltraFex Coaxial Cable 35\' | LMR400UF | BACL1904161 | 2021-06-18 | 1 year |
| 1101 | IW Microwave | 157 Series Cable Armored with 2.92mm Male Plugs | KPS-1571AN-2400 | DC 1922 | 2021-07-06 | 1 year |

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 Christian McCaig from 2021-12-09 to 2022-01-13 in 5m chamber 3.*

## 7.8 Summary of Test Results

According to the data hereinafter, the EUT complied with FCC Part 15C and ISEDC RSS-247 standard's radiated emissions limits, and had the worst margin of:

**2.4 GHz Wi-Fi**

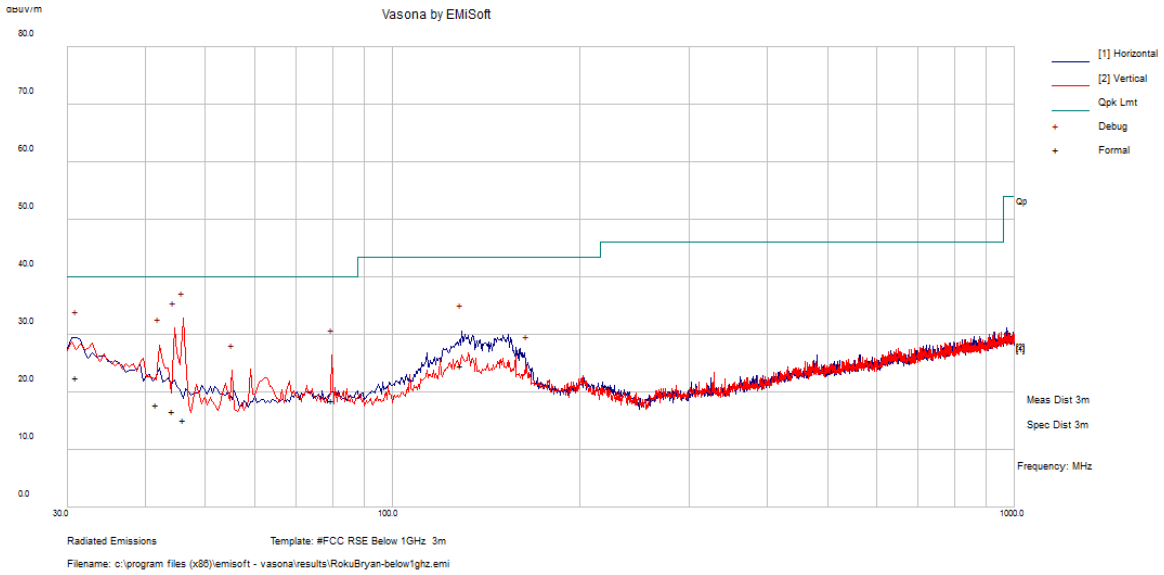
| **Mode: Transmitting** | | | |
|---|---|---|---|
| **Margin (dB)** | **Frequency (MHz)** | **Polarization (Horizontal/Vertical)** | **Configuration** |
| -0.37 | 4924 | H | n40 mode, 2452 MHz, Antenna A+B |

Please refer to the following table and plots for specific test result details

## 7.9 Radiated Emissions Test Results

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

*Worst Case: 2437 MHz, n40 mode, Antenna A+B*




| Frequency (MHz) | S.A. Reading (dBuV) | Correction Factor (dB/m) | Corrected Amplitude (dBµV/m) | Antenna Height (cm) | Antenna Polarity (H/V) | Turntable Azimuth (degrees) | Limit (dBµV/m) | Margin (dB) | Comment |
|---|---|---|---|---|---|---|---|---|---|
| 46.216 | 24.37 | -9.26 | 15.11 | 201 | H | 282 | 40 | -24.89 | Pass |
| 44.2605 | 24.74 | -8.12 | 16.62 | 211 | H | 231 | 40 | -23.38 | Pass |
| 31.072 | 20.84 | 1.69 | 22.53 | 167 | H | 344 | 40 | -17.47 | Pass |
| 41.7755 | 24.31 | -6.52 | 17.79 | 256 | H | 272 | 40 | -22.21 | Pass |
| 129.0695 | 28.8 | -4.28 | 24.52 | 223 | H | 241 | 43.5 | -18.98 | Pass |
| 79.99925 | 29.37 | -10.86 | 18.51 | 294 | V | 167 | 40 | -21.49 | Pass |

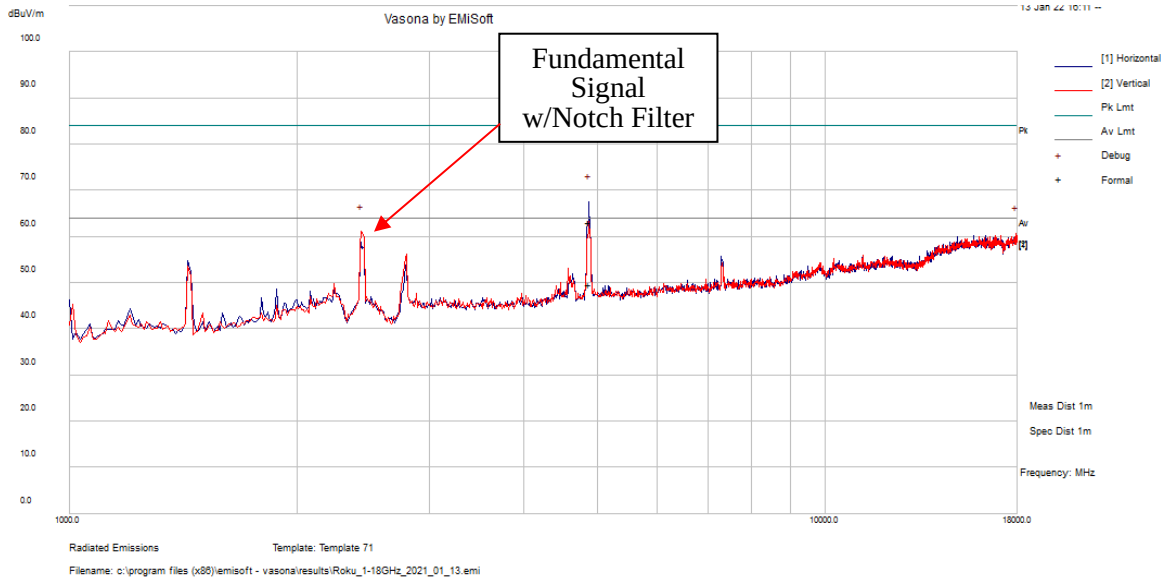
**2) 1–18 GHz Measured at 3 meters**

**802.11n40 mode, Antenna A+B**

| Frequency (MHz) | S.A. Reading (dBµV) | Turntable Azimuth (degrees) | Test Antenna | | | Cable Loss (dB) | Pre-Amp. (dB) | Cord. Reading (dBµV/m) | FCC/IC | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Polarity (H/V) | Factor (dB/m) | | | | Limit (dBµV/m) | Margin (dB) | |
| Low Channel 2422 MHz | | | | | | | | | | | |
| 2390 | 74.660 | 132 | 150 | H | 27.923 | 4.913 | 39.35942 | 68.14 | 74 | -5.86 | Peak |
| 2390 | 74.920 | 82 | 294 | V | 27.923 | 4.913 | 39.35942 | 68.40 | 74 | -5.60 | Peak |
| 2390 | 58.776 | 132 | 150 | H | 27.923 | 4.913 | 39.35942 | 52.25 | 54 | -1.75 | Ave |
| 2390 | 58.554 | 82 | 294 | V | 27.923 | 4.913 | 39.35942 | 52.03 | 54 | -1.97 | Ave |
| 4844 | 51.75 | 355 | 117 | H | 34.71 | 9.336 | 38.302 | 57.49 | 74 | -16.51 | Peak |
| 4844 | 44.500 | 355 | 117 | H | 34.71 | 9.336 | 38.302 | 50.24 | 54 | -3.76 | Ave |
| 4844 | 52.500 | 21 | 235 | V | 34.71 | 9.336 | 38.302 | 58.24 | 74 | -15.76 | Peak |
| 4844 | 43.320 | 21 | 235 | V | 34.71 | 9.336 | 38.302 | 49.06 | 54 | -4.94 | Ave |
| Middle Channel 2437 MHz | | | | | | | | | | | |
| 4874 | 51.78 | 360 | 115 | H | 34.68 | 8.936 | 38.25 | 57.14 | 74 | -16.86 | Peak |
| 4874 | 43.860 | 360 | 115 | H | 34.68 | 8.936 | 38.25 | 49.22 | 54 | -4.78 | Ave |
| 4874 | 50.480 | 210 | 115 | V | 34.68 | 8.936 | 38.25 | 55.84 | 74 | -18.16 | Peak |
| 4874 | 41.440 | 210 | 115 | V | 34.68 | 8.936 | 38.25 | 46.80 | 54 | -7.20 | Ave |
| High Channel 2452 MHz | | | | | | | | | | | |
| 2483.5 | 72.110 | 285 | 115 | H | 28.752 | 4.913 | 39.35942 | 66.42 | 74 | -7.58 | Peak |
| 2483.5 | 70.450 | 215 | 115 | V | 28.752 | 4.913 | 39.35942 | 64.76 | 74 | -9.24 | Peak |
| 2483.5 | 58.090 | 285 | 115 | H | 28.752 | 4.913 | 39.35942 | 52.40 | 54 | -1.60 | Ave |
| 2483.5 | 55.790 | 285 | 115 | V | 28.752 | 4.913 | 39.35942 | 50.10 | 54 | -3.90 | Ave |
| 4924 | 57.59 | 7 | 115 | H | 34.71 | 9.146 | 38.302 | 63.14 | 74 | -10.86 | Peak |
| 4924 | 48.080 | 7 | 115 | H | 34.71 | 9.146 | 38.302 | 53.63 | 54 | -0.37 | Ave |
| 4924 | 57.410 | 210 | 115 | V | 34.71 | 9.146 | 38.302 | 62.96 | 74 | -11.04 | Peak |
| 4924 | 47.570 | 210 | 115 | V | 34.71 | 9.146 | 38.302 | 53.12 | 54 | -0.88 | Ave |

### 3) 1 GHz – 18 GHz Worst Case Scan at 1 Meter

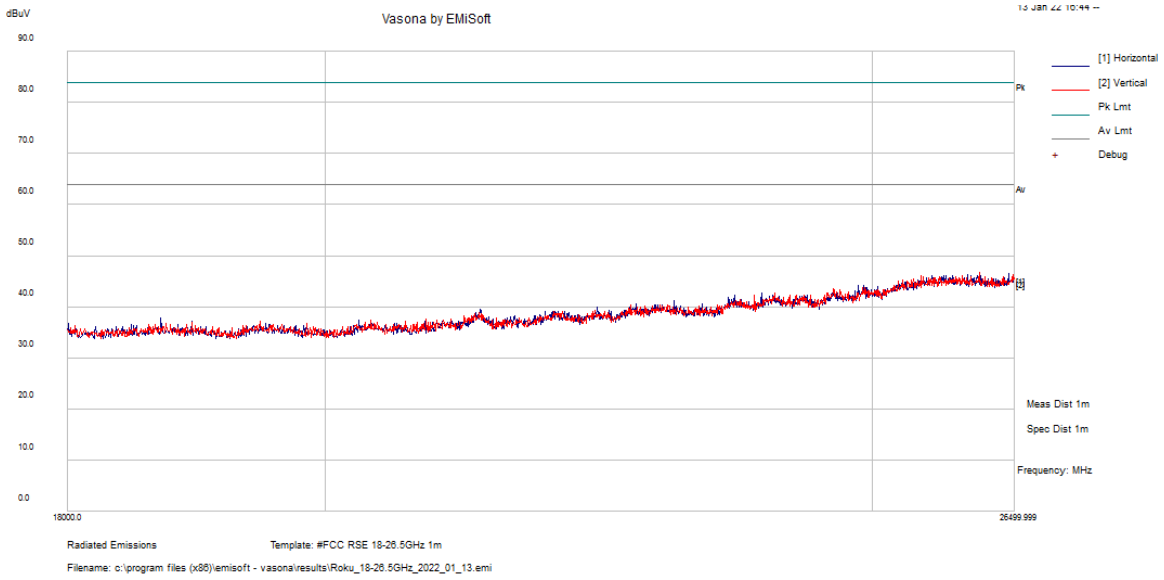
*Worst Case: 2437 MHz, n40 mode*




| Frequency (MHz) | S.A. Reading (dBµV) | Correction Factor (dB/m) | Corrected Amplitude (dBµV/m) | Antenna Height (cm) | Antenna Polarity (H/V) | Turntable Azimuth (degrees) | Limit (dBµV/m) | Margin (dB) | Comment |
|---|---|---|---|---|---|---|---|---|---|
| 4877.885 | 61.55 | 1.53 | 63.08 | 101 | H | 343 | 84 | -20.92 | Peak |
| 4877.885 | 47.99 | 1.53 | 49.52 | 101 | H | 343 | 64 | -14.48 | Average |

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

*Worst Case: 2437 MHz, n40 mode*



# 8 FCC §15.247(a) (2) & ISEDC RSS-247 §5.2, RSS-Gen §6.7 - Emission Bandwidth

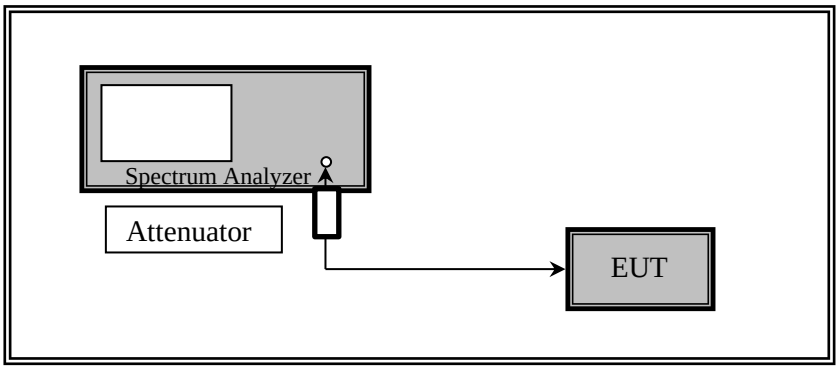
## 8.1 Applicable Standards

According to FCC §15.247(a) (2) and ISEDC RSS-247 §5.2: the minimum 6 dB bandwidth shall be 500 kHz.

## 8.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8: DTS bandwidth.

## 8.3 Test Setup Block Diagram




## 8.4 Test Equipment List and Details

| BACL No. | Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 287 | Agilent | Spectrum Analyzer | E4446A | US44300386 | 2021-04-27 | 1 year |
| 912 | Rhode & Schwarz | Signal Analyzer | FSV40 | 101203 | 2021-04-26 | 1 year |
| - | - | RF cable | - | - | Each time[1] | N/A |
| - | - | 20 dB attenuator | - | - | 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:** | 23º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

*The testing was performed by Christian McCaig on 2022-01-17 in RF site.*

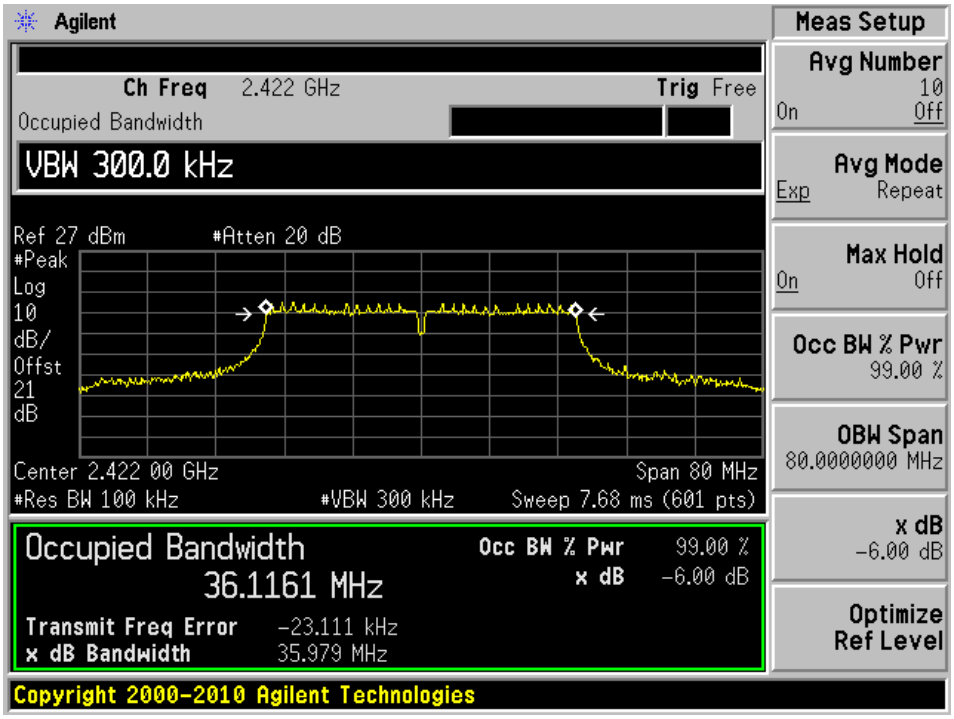
## 8.6 Test Results

| Channel | Frequency (MHz) | 6 dB OBW (MHz) | | 99% OBW (MHz) | | 6 dB OBW Limit (kHz) | Result |
|---|---|---|---|---|---|---|---|
| | | Antenna A | Antenna B | Antenna A | Antenna B | | |
| 802.11n40 | | | | | | | |
| Low | 2422 | 35.979 | 36.096 | 37.173 | 37.120 | ≥ 500 | Pass |
| Middle | 2437 | 36.095 | 36.117 | 38.480 | 38.160 | ≥ 500 | Pass |
| High | 2452 | 35.639 | 35.994 | 37.013 | 37.067 | ≥ 500 | Pass |

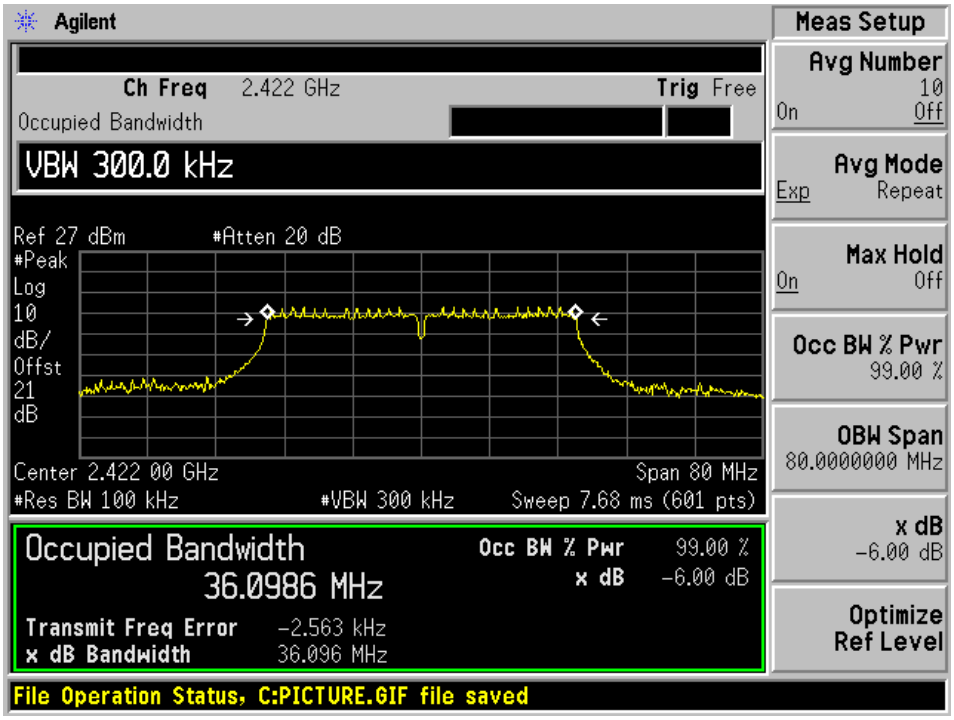
Please refer to the following plots for detailed test results:

**802.11n40 mode**

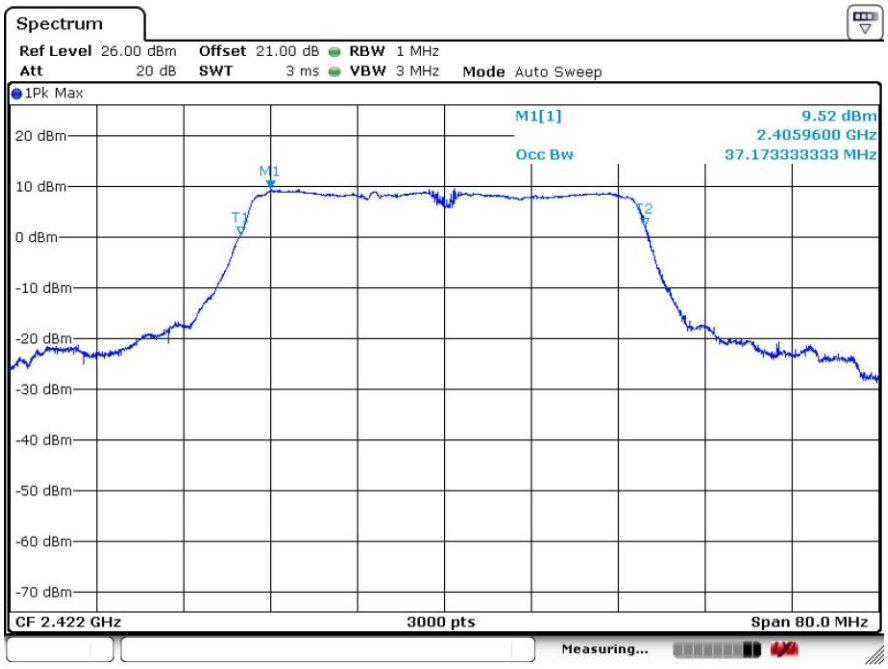
Low Channel, 6 dB OBW, Antenna A




Low Channel, 6 dB OBW, Antenna B

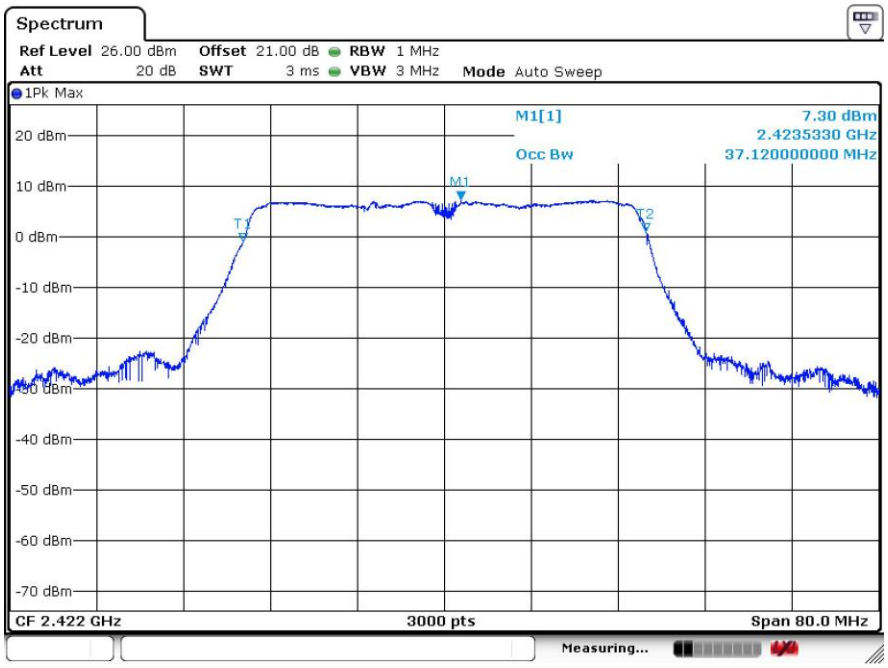


Low Channel, 99% OBW, Antenna A



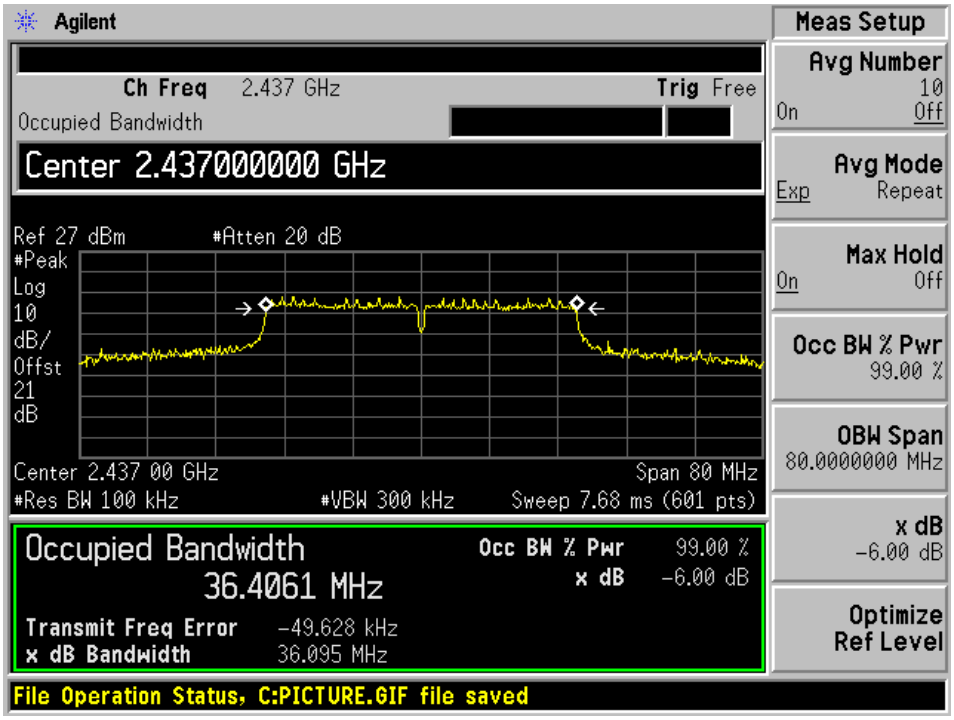

Date: 17.JAN.2022 10:54:46

Low Channel, 99% OBW, Antenna B

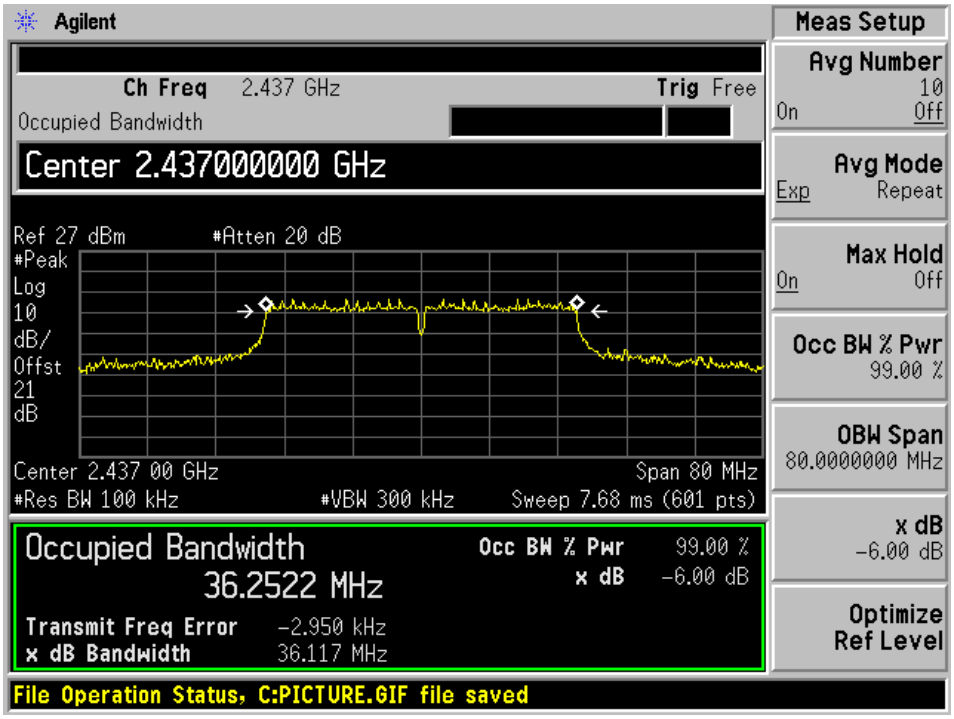



Date: 17.JAN.2022 10:56:27

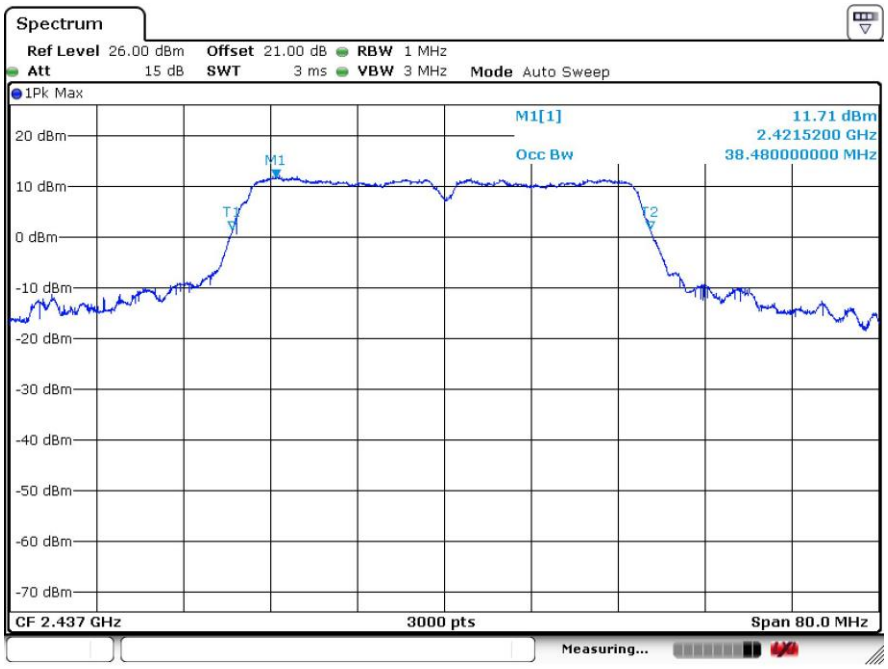
Middle Channel, 6 dB OBW, Antenna A



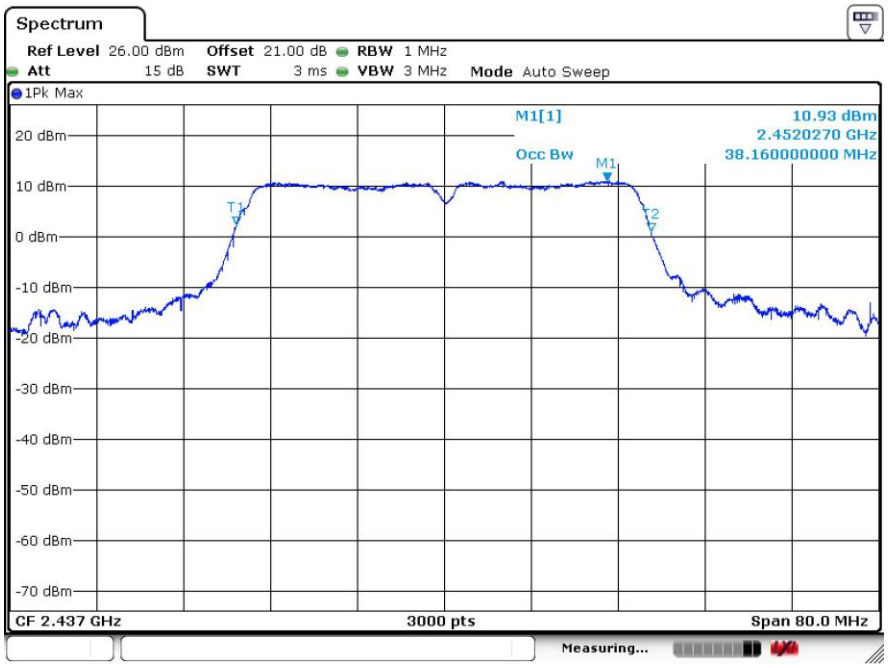

Middle Channel, 6 dB OBW, Antenna B



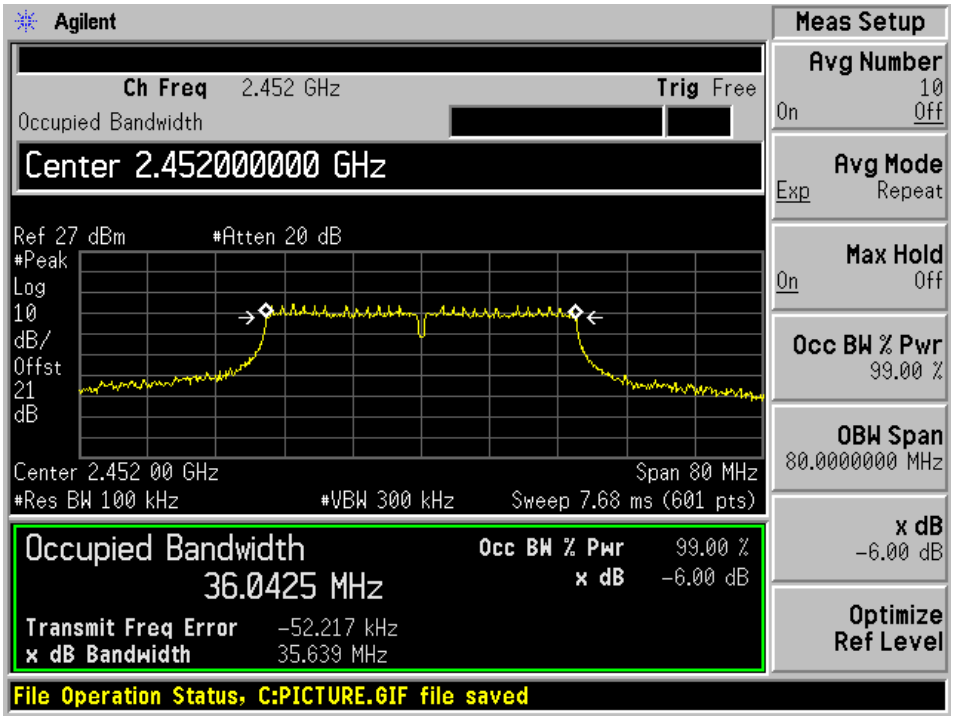
Middle Channel, 99% OBW, Antenna A



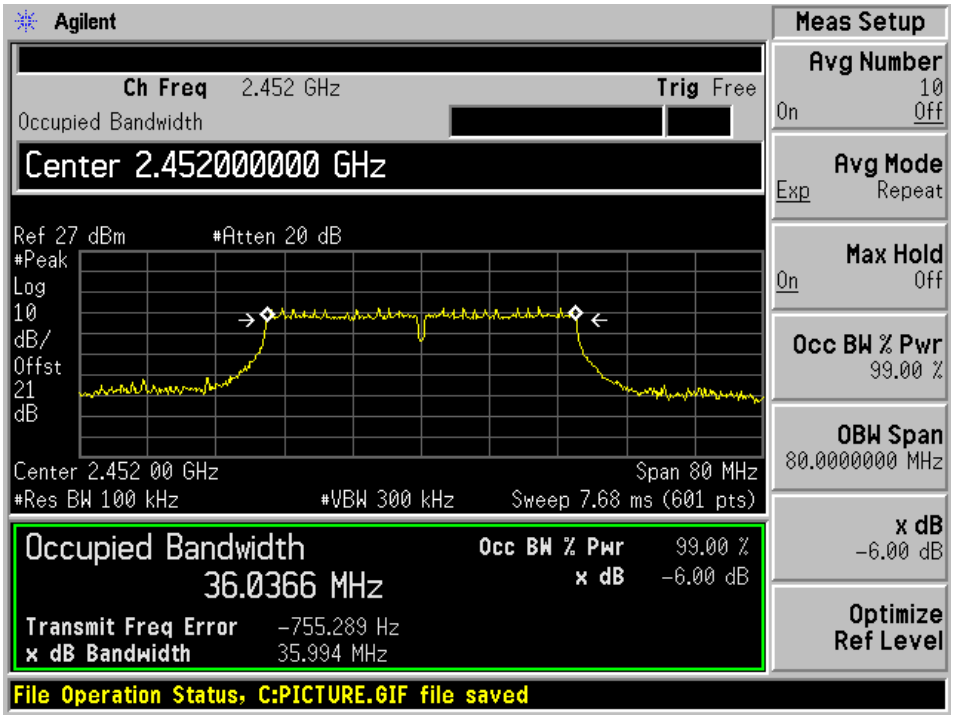

Middle Channel, 99% OBW, Antenna B



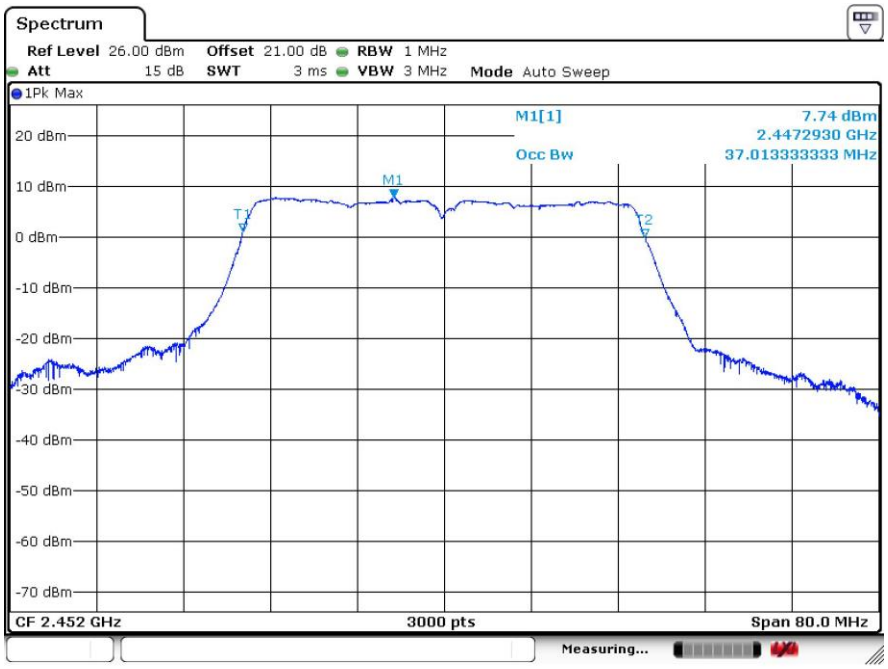
High Channel, 6 dB OBW, Antenna A



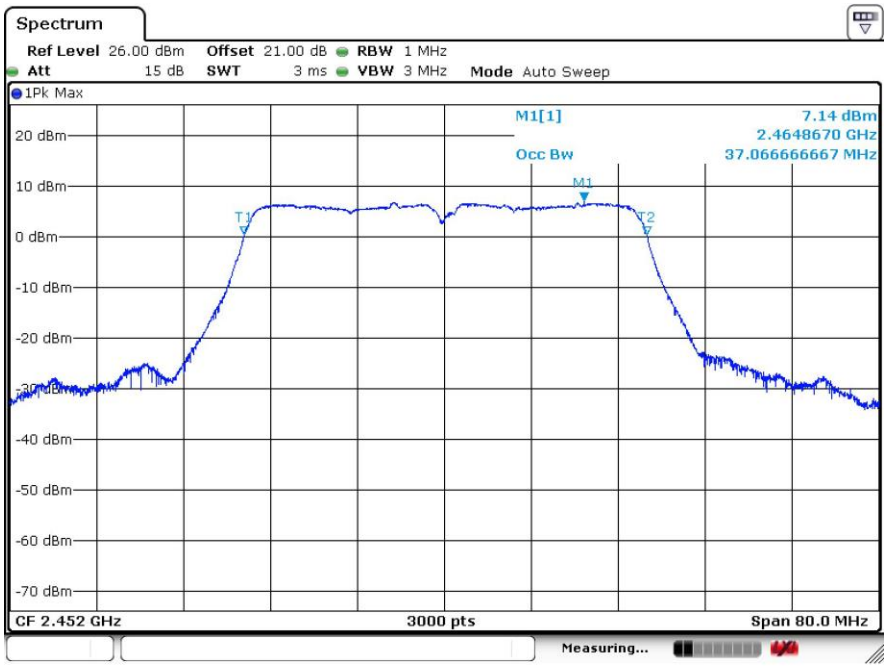

High Channel, 6 dB OBW, Antenna B



High Channel, 99% OBW, Antenna A




High Channel, 99% OBW, Antenna B



# 9 FCC §15.247(b) (3) & ISEDC RSS-247 §5.4 - Maximum Output Power

## 9.1 Applicable Standards

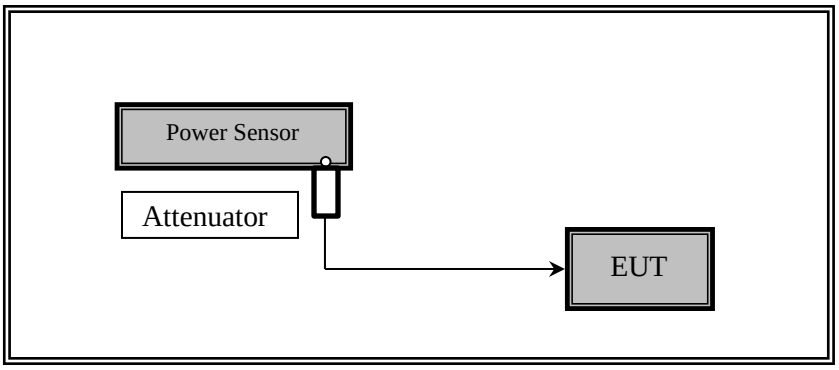
According to FCC §15.247(b) (3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

According to RSS-247 §5.4: For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

## 9.2 Measurement Procedure

The measurements are based on ANSI C63.10-2013, Section 11.9.2.2.2.

## 9.3 Test Setup Block Diagram




## 9.4 Test Equipment List and Details

| BACL No. | Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 697 | ETS-LINDGREN | Power Sensor | 7002-006 | 160097 | 2021-02-23 | 1 year |
| - | - | RF cable | - | - | Each time[1] | N/A |
| - | - | 20 dB attenuator | - | - | 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:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

*The testing was performed by Christian McCaig on 2022-01-17 in RF site.*

## 9.6 Test Results

| Channel | Frequency (MHz) | Conducted Output Power (dBm) | | | Output Power Limit (dBm) | Result |
|---|---|---|---|---|---|---|
| | | Antenna A | Antenna B | Total | | |
| 802.11 n40 | | | | | | |
| Low | 2422 | 14.34 | 13.56 | 16.98 | < 30 | Pass |
| Middle | 2437 | 17.19 | 16.46 | 19.85 | < 30 | Pass |
| High | 2452 | 13.51 | 12.78 | 16.17 | < 30 | Pass |

Note: Total power (dBm) =10*Log(10^(Ant A[dBm]/10)+ 10^(Ant B[dBm]/10))
Note: Duty Cycle correction factor has already been added to the measurement.

# 10 FCC §15.247(d) & ISEDC RSS-247 §5.5 - 100 kHz Bandwidth of Band Edges

## 10.1 Applicable Standards

According to FCC §15.247(d), in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emissions limits specified in §15.209(a) see §15.205(c).

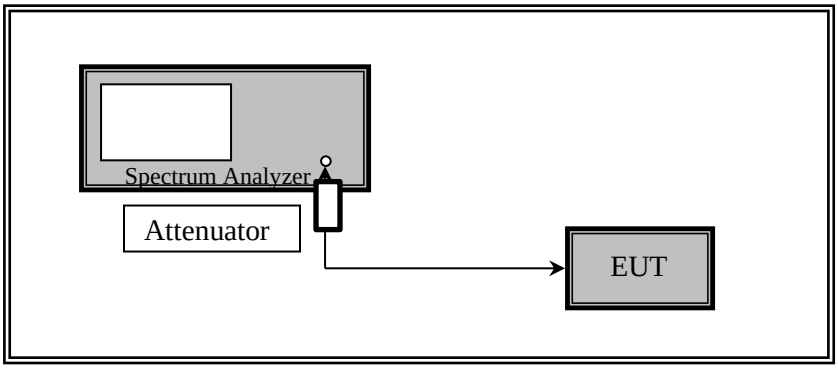
According to ISEDC RSS-247 §5.5.In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

## 10.2 Measurement Procedure

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

RBW = 100 kHz
VBW = 300 kHz
Sweep = coupled
Detector function = peak
Trace = max hold

## 10.3 Test Setup Block Diagram



## 10.4 Test Equipment List and Details

| BACL No. | Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 912 | Rhode & Schwarz | Signal Analyzer | FSV40 | 101203 | 2021-04-26 | 1 year |
| - | - | RF cable | - | - | Each time[1] | N/A |
| - | - | 20 dB attenuator | - | - | 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:** | 23º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

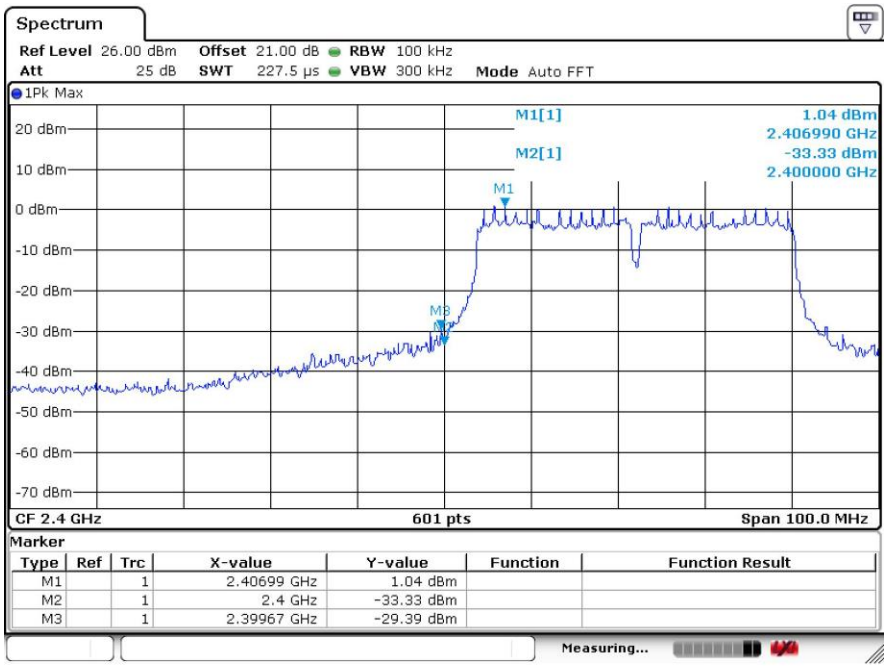
*The testing was performed by Christian McCaig on 2021-01-17 in RF site.*

## 10.6 Test Results

Please refer to the following plots for detailed test results

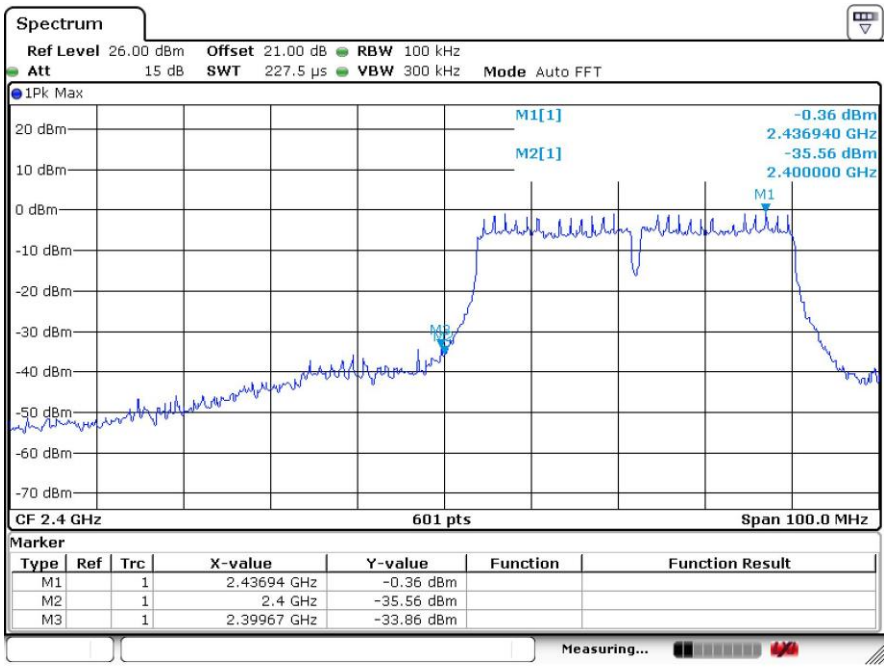
## 802.11 n40 mode

Low Channel, Antenna A




Date: 17.JAN.2022 11:03:21

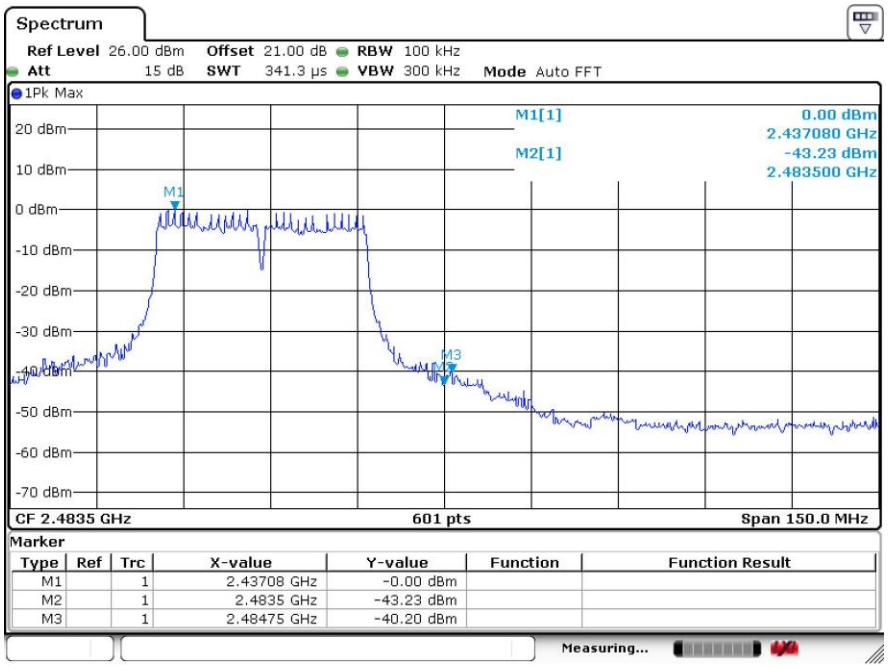
Low Channel, Antenna B




Date: 17.JAN.2022 11:14:52

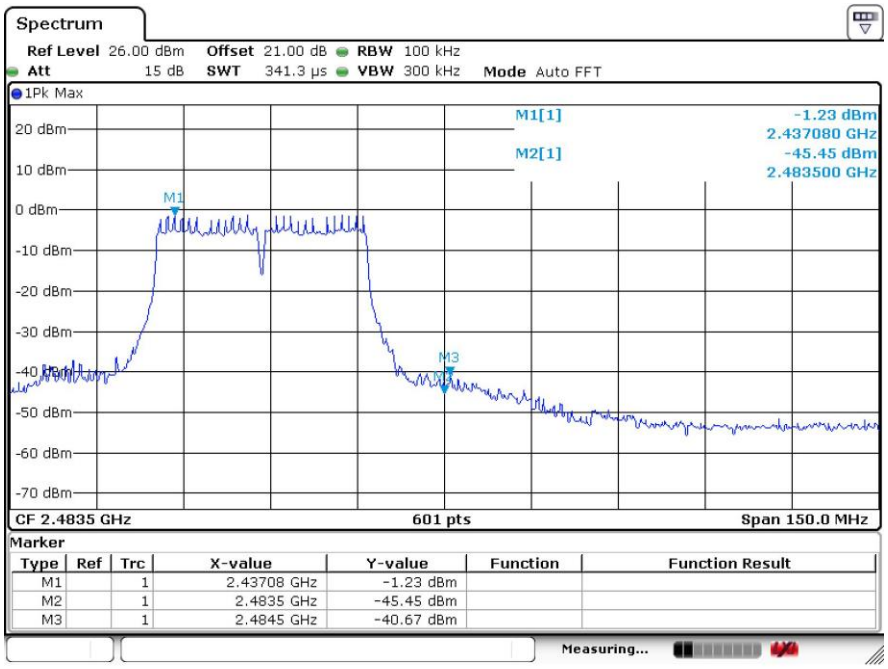
## 802.11 n40 mode

High Channel, Antenna A




Date: 17.JAN.2022 11:18:07

High Channel, Antenna B




Date: 17.JAN.2022 11:16:34

# 11 FCC §15.247(e) & ISEDC RSS-247 §5.2(2) – Peak Power Spectral Density

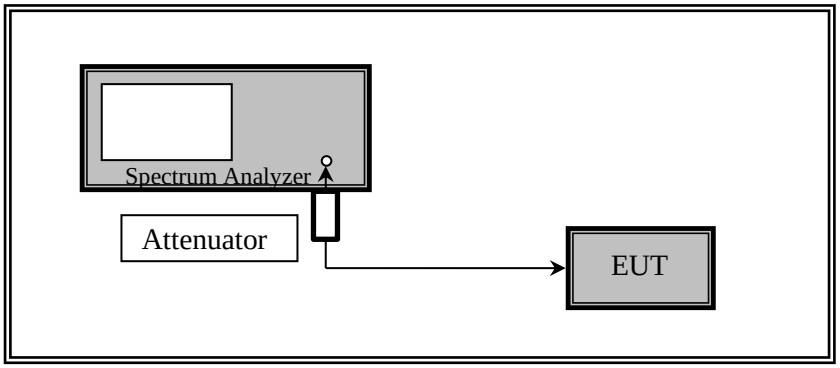
## 11.1 Applicable Standards

According to ECFR §15.247(e) and RSS-247 §5.2 ( 2) , for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

## 11.2 Measurement Procedure

The measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 10: Maximum power spectral density level in the fundamental emission.

## 11.3 Test Setup Block Diagram




## 11.4 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Rhode & Schwarz | Signal Analyzer | FSV40 | 101203 | 2021-04-26 | 1 year |
| - | RF cable | - | - | Each time[1] | N/A |
| - | 20 dB attenuator | - | - | 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:** | 23º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

*The testing was performed by Christian McCaig on 2022-01-17 in RF site.*

## 11.6 Test Results

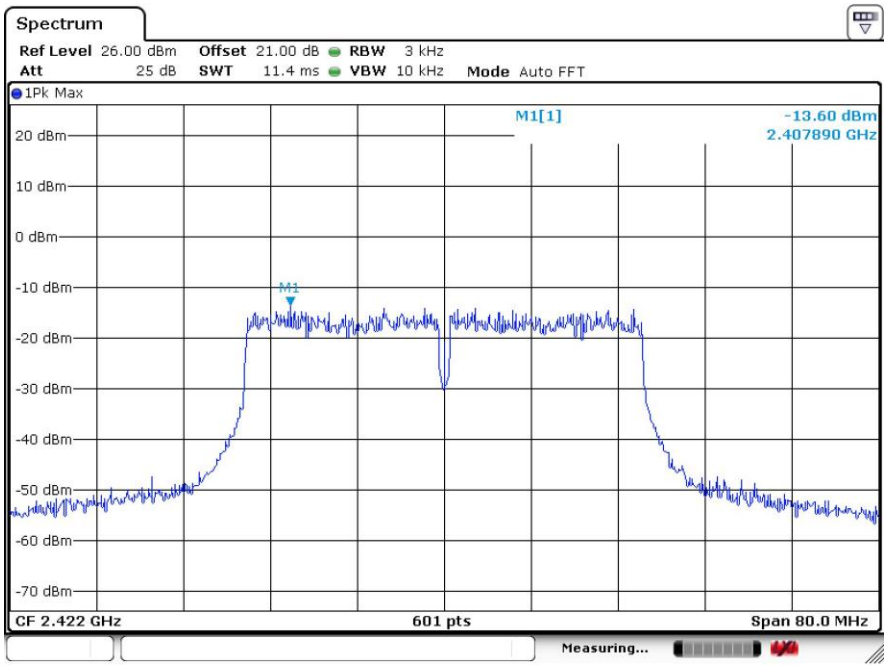
| Channel | Frequency (MHz) | PSD (dBm/3kHz) | | Total PSD (dBm/3kHz) | Limit (dBm/3kHz) |
|---|---|---|---|---|---|
| | | Antenna A | Antenna B | | |
| 802.11n40 mode | | | | | |
| Low | 2422 | -13.60 | -15.69 | -11.20 | < 8 |
| Middle | 2437 | -10.42 | -10.76 | -7.27 | < 8 |
| High | 2452 | -15.18 | -15.70 | -12.11 | < 8 |

Note: Total PSD (dBm/3kHz) =10*Log(10^(Ant A[dBm/3kHz]/10)+ 10^(Ant B[dBm/3kHz]/10))

Please refer to the following plots for detailed test results

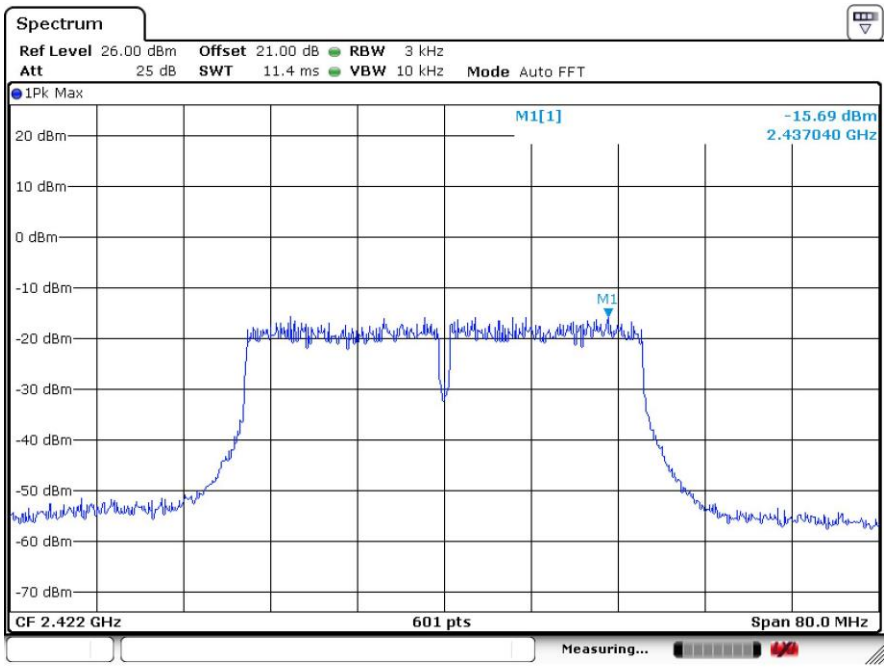
**802.11n40 mode**

Low Channel, Antenna A



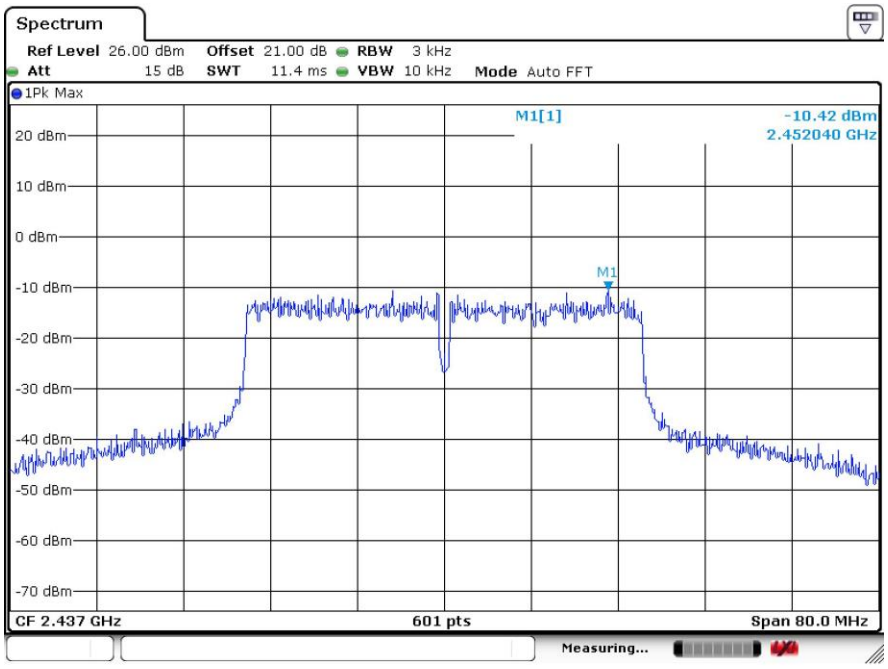

Date: 17.JAN.2022 11:00:10

Low Channel, Antenna B



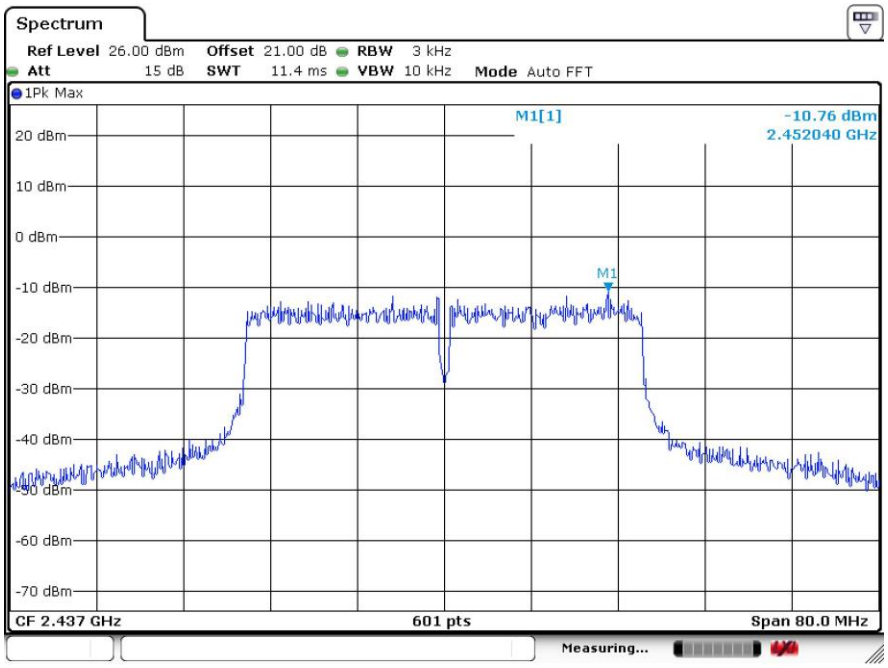

Date: 17.JAN.2022 10:59:24

Middle Channel, Antenna A



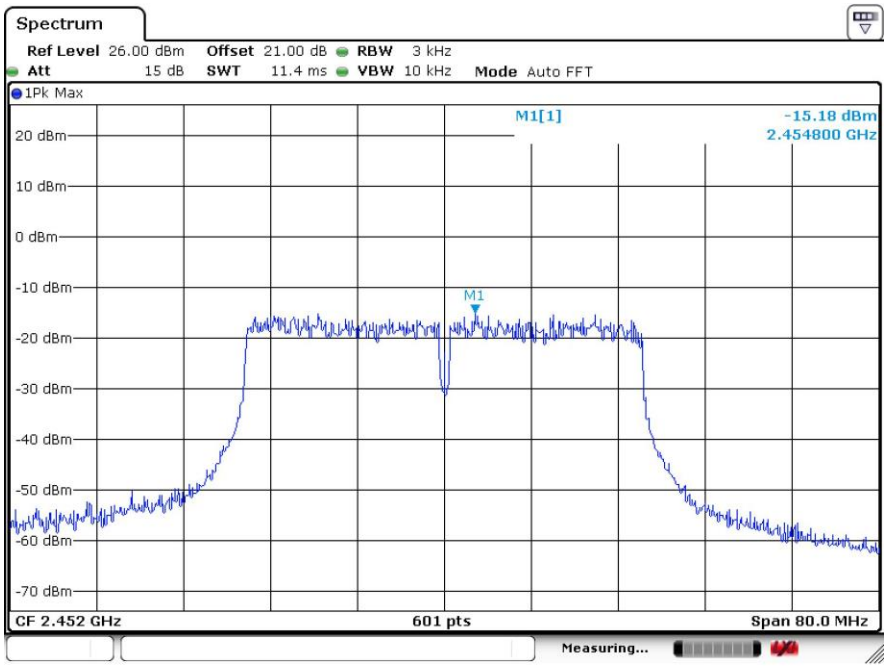

Date: 17.JAN.2022 11:29:13

Middle Channel, Antenna B

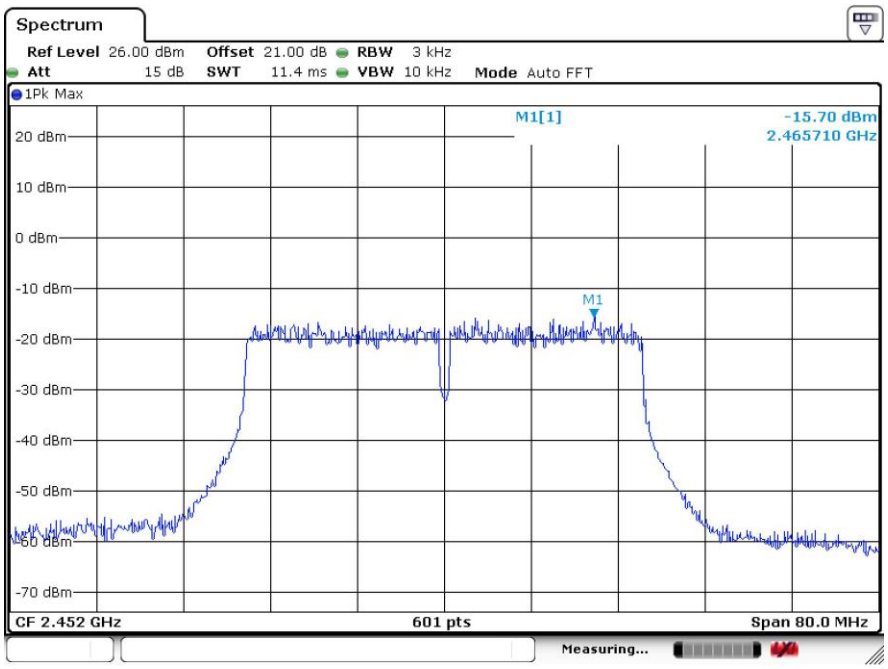



Date: 17.JAN.2022 11:29:54

High Channel, Antenna A




High Channel, Antenna B



# 12 FCC §15.247(d) & ISEDC RSS-247 §5.5 - Spurious Emissions at Antenna Terminals

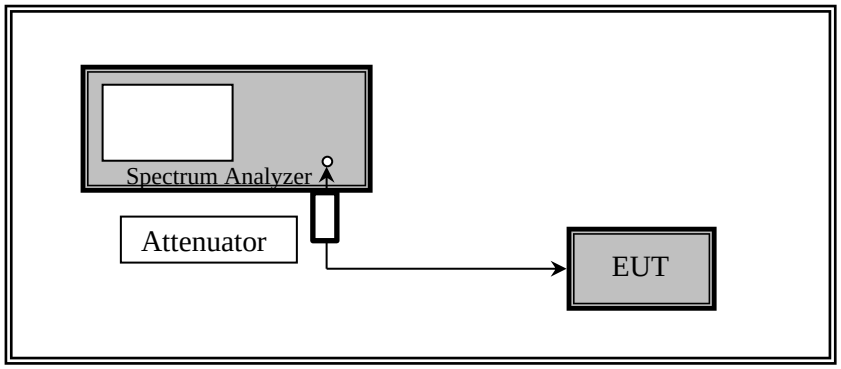
## 12.1 Applicable Standards

For FCC §15.247(d) and ISEDC RSS-247 §5.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

## 12.2 Test Procedure

The RF output of the EUT was connected to a spectrum analyzer through appropriate attenuation. The resolution bandwidth of the spectrum analyzer was set at 100 kHz. Sufficient scans were taken to show any out of band emissions up to 10th harmonic.

## 12.3 Test Setup Block Diagram



## 12.4 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|
| Rhode & Schwarz | Signal Analyzer | FSV40 | 101203 | 2021-04-26 | 1 year |
| - | RF cable | - | - | Each time[1] | N/A |
| - | 10 dB attenuator | - | - | 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".*

## 12.5 Test Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23º C |
| **Relative Humidity:** | 42 % |
| **ATM Pressure:** | 102.7 KPa |

*The testing was performed by Christian McCaig on 2022-01-17 in RF site.*

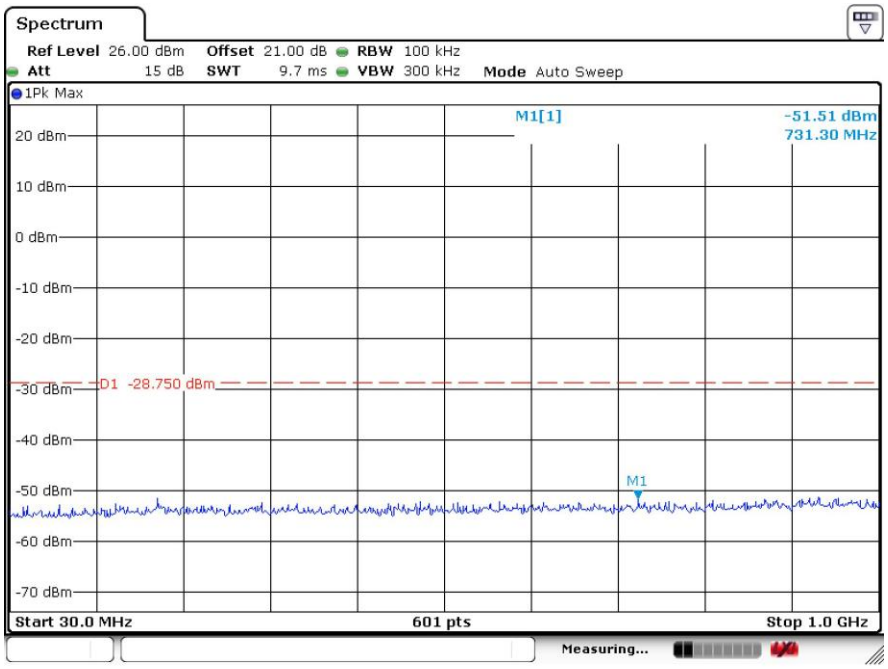
## 12.6 Test Results

Please refer to following plots.

**802.11 n40 mode**

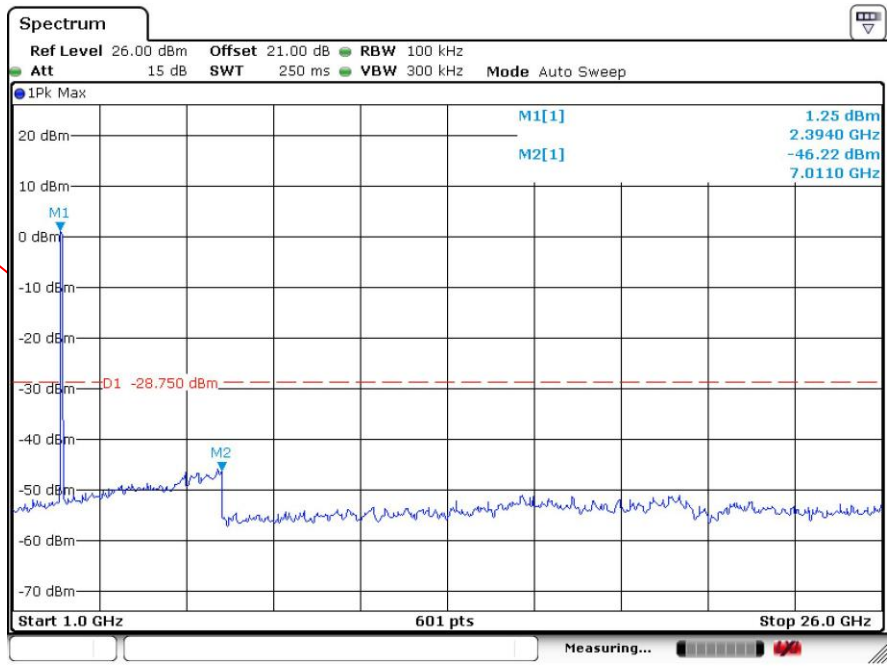
Antenna A, Low Channel 2422MHz

30MHz – 1GHz



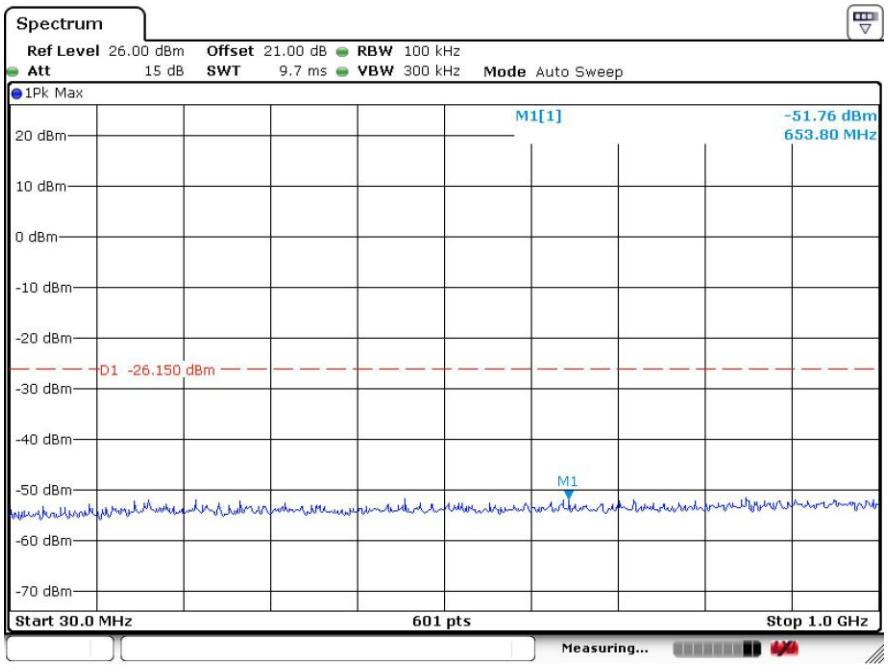

1GHz – 26GHz

Fundamental



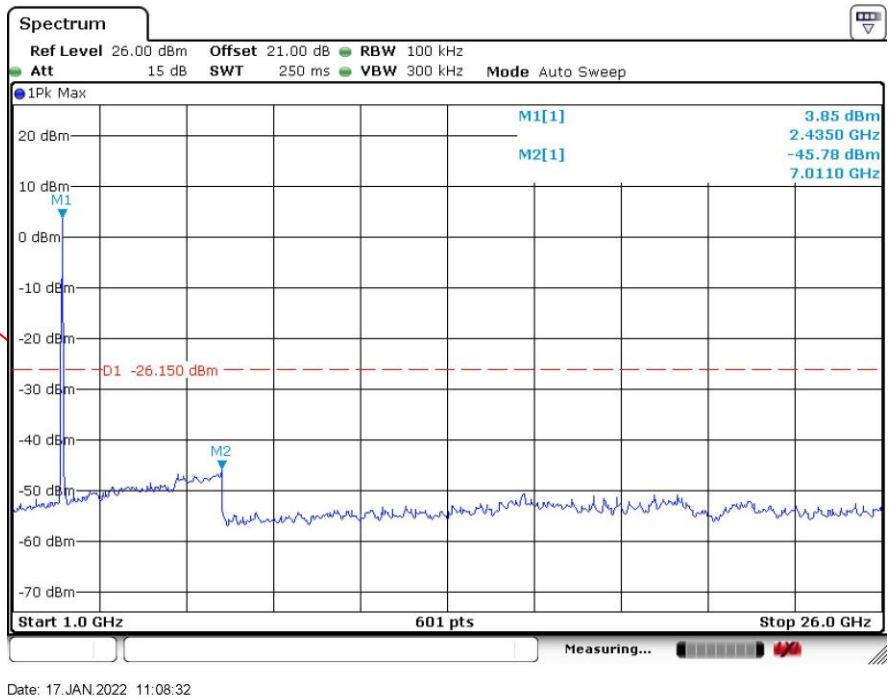
Antenna A, Mid Channel 2437MHz

30MHz – 1GHz



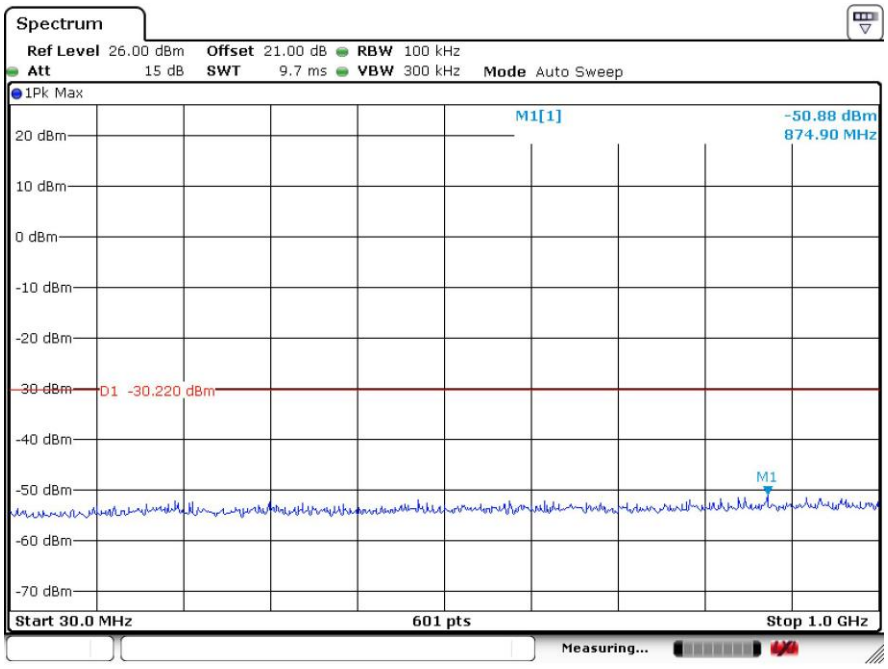

1GHz – 26GHz

Fundamental

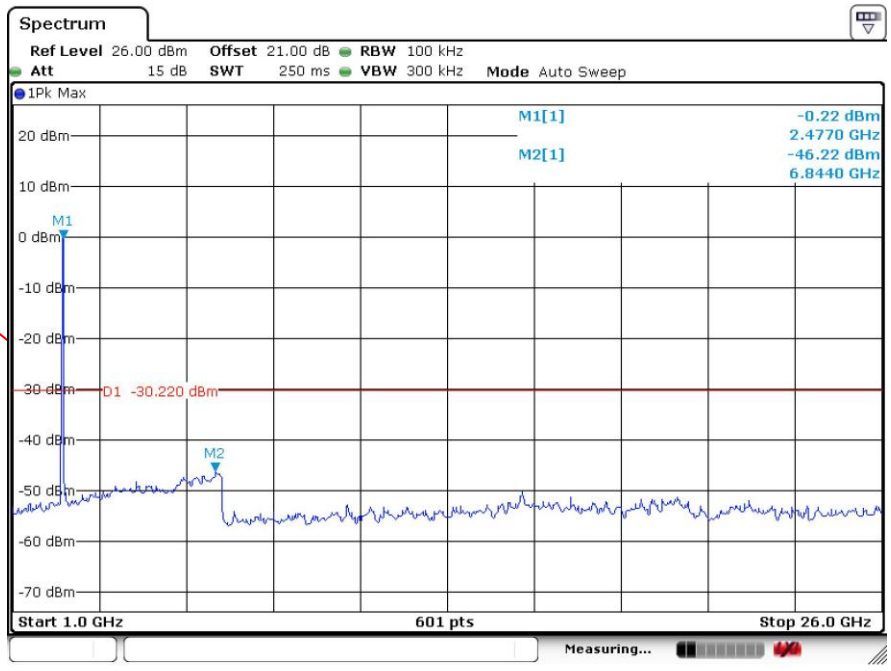


Antenna A, High Channel 2452MHz

30MHz – 1GHz




1GHz – 26GHz

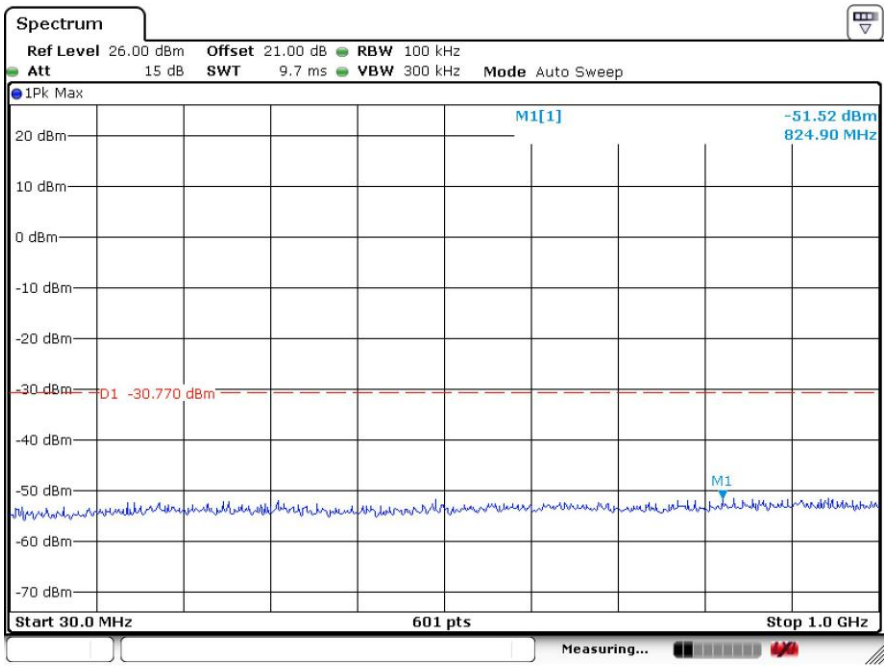



Fundamental

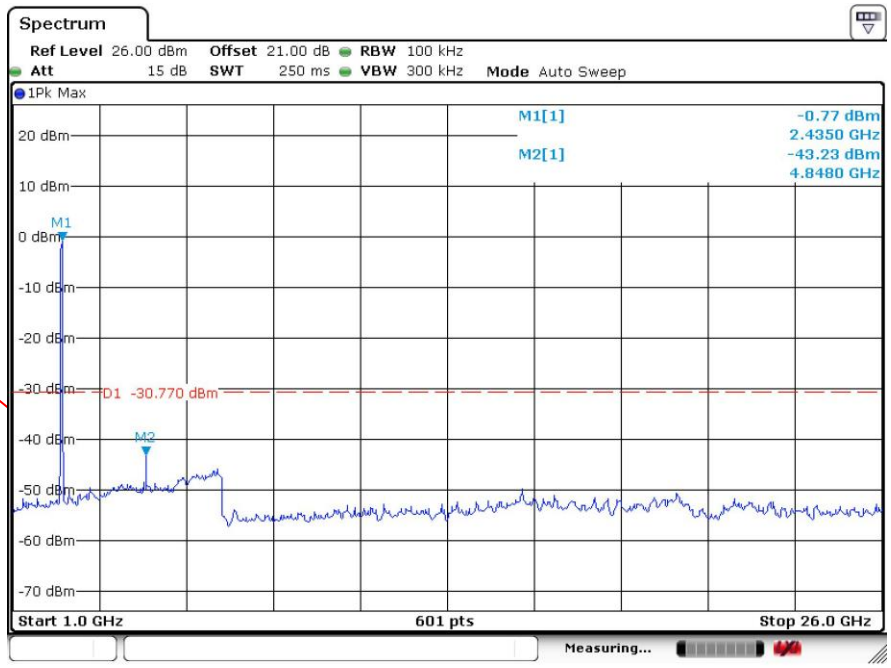
**802.11 n40 mode**

Antenna B, Low Channel 2422MHz

30MHz – 1GHz



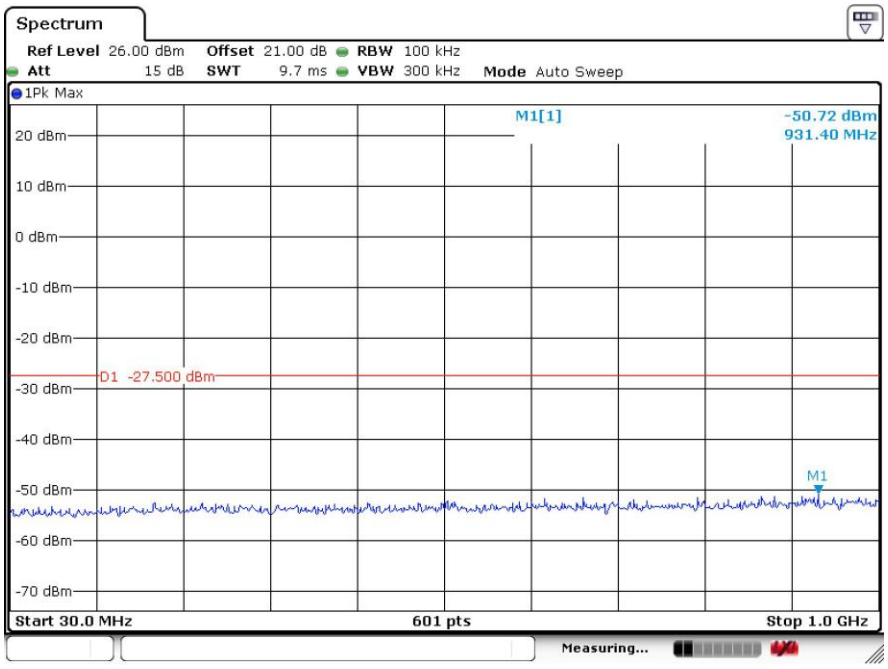

1GHz – 26GHz




Fundamental

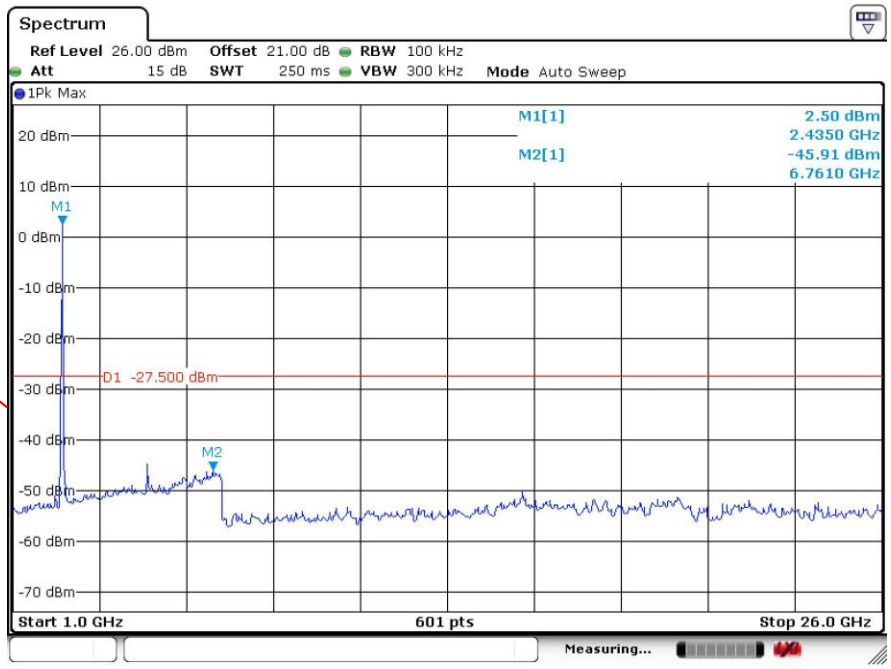
Antenna B, Mid Channel 2437MHz

30MHz – 1GHz




Date: 17.JAN.2022 11:11:36

1GHz – 26GHz

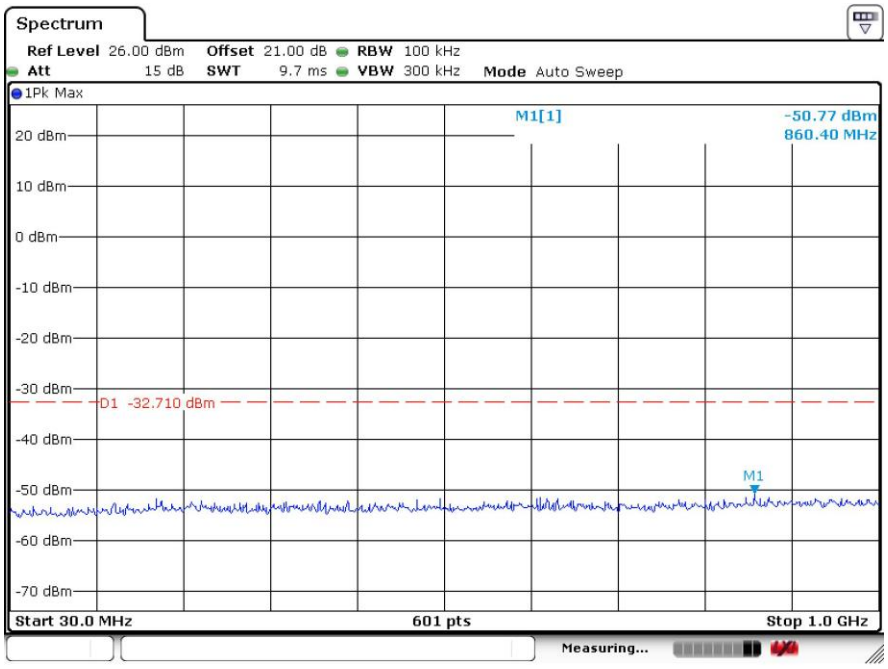



Fundamental

Date: 17.JAN.2022 11:10:59

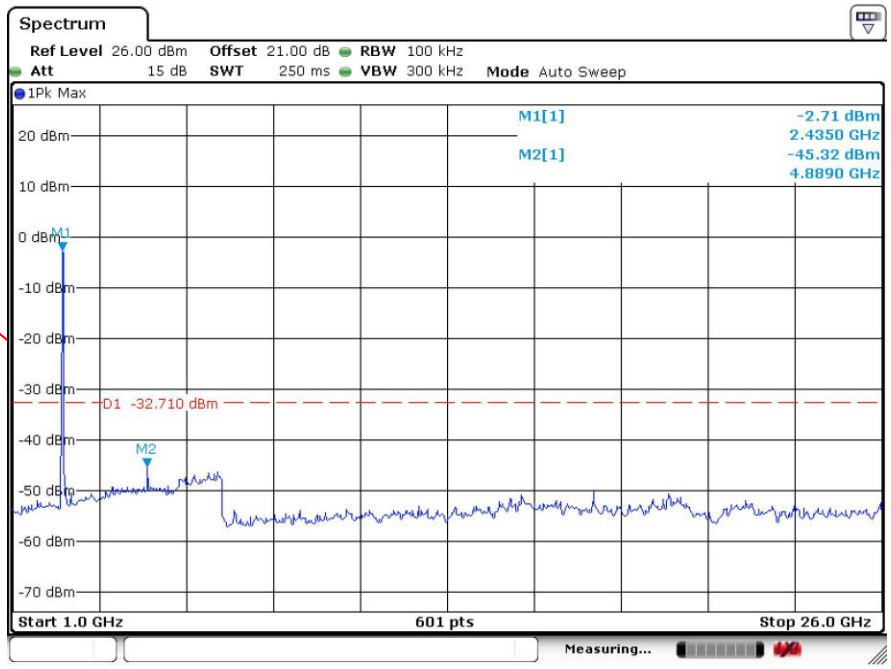
Antenna B, High Channel 2452MHz

30MHz – 1GHz




Date: 17.JAN.2022 11:21:20

1GHz – 26GHz




Fundamental

Date: 17.JAN.2022 11:20:34

# 13 Annex A (Normative) – EUT Test Setup Photographs

Please refer to the attachment.

# 14 Annex B (Normative) – EUT External Photographs

Please refer to the attachment.

# 15 Annex C (Normative) – EUT Internal Photographs

Please refer to the attachment.

# 16 Annex D (Normative) – Declaration of Similarity

**Roku, Inc.** 1155 Coleman Ave. San Jose, CA 95110 USA

## DECLARATION OF SIMILARITY

February 14, 2022

To:

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

Dear Sir or Madam:

We *Roku, Inc.* hereby declare that the products below are electrically identical with the same electromagnetic emissions and electromagnetic compatibility characteristics as model: 4670X as tested by BACL, the results of which are featured in BACL Project: R2111301. The differences are also described:

| Product Type: IP-STB | | |
|---|---|---|
| | **Model** | **Differences** |
| Original Model | 4660X2 | |
| Tested Model | 4670X | Different memory configuration |

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

Best Regards,

Robert Curtis

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

# 17 Annex E (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 10th day of March 2021.

Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2022

*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 ---**