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-R1043
IC: 5959A-R1040

Report Type:	**Product Type:**
Original Report	9104X

Prepared By:	Arturo Reyes Test Engineer
Report Number:	R2304281-247-DSS
Report Date:	2023-08-28
Reviewed By:	Shawn Mcmillen Engineering Manager

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	R2304281-DSS	Original Report	2023-08-28

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

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

1.2 Mechanical Description of EUT

The EUT measures approximately 15.5 cm (L), 9 cm (W), and 6 cm (H) and weigh 900 g.

The test data gathered are from typical production samples:
Radiated Sample SN: S094633S3J6T
Conducted Sample SN: S09463382PWP

1.3 Objective

This report was prepared on behalf of *Roku, Inc*, in accordance with Part 2, Subpart J, and Part 15, Subparts B and 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.

1.4 Related Submittal(s)/Grant(s)

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

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 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.

Modulation	Frequency (MHz)	Power Setting
		Ant C
DH1	2402	0x2D
	2440	0x2D
	2480	0x2D
2DH1	2402	0x35
	2440	0x35
	2480	0x35
3DH1	2402	0x35
	2440	0x35
	2480	0x35

2.3 Duty Cycle Correction Factor

According to FCC/DA-00-705, Filing and Measurement Guidelines for 15.247 Frequency Hopping Spread Spectrum (FHSS) Systems, Mar. 30, 2000, Section:

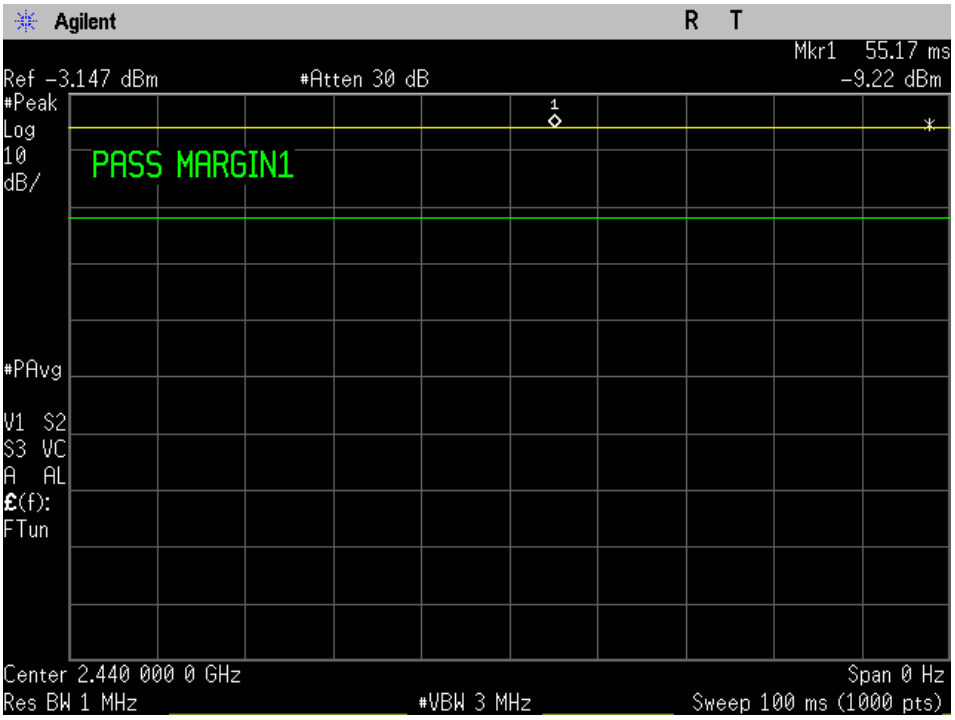
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized 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).

BTC

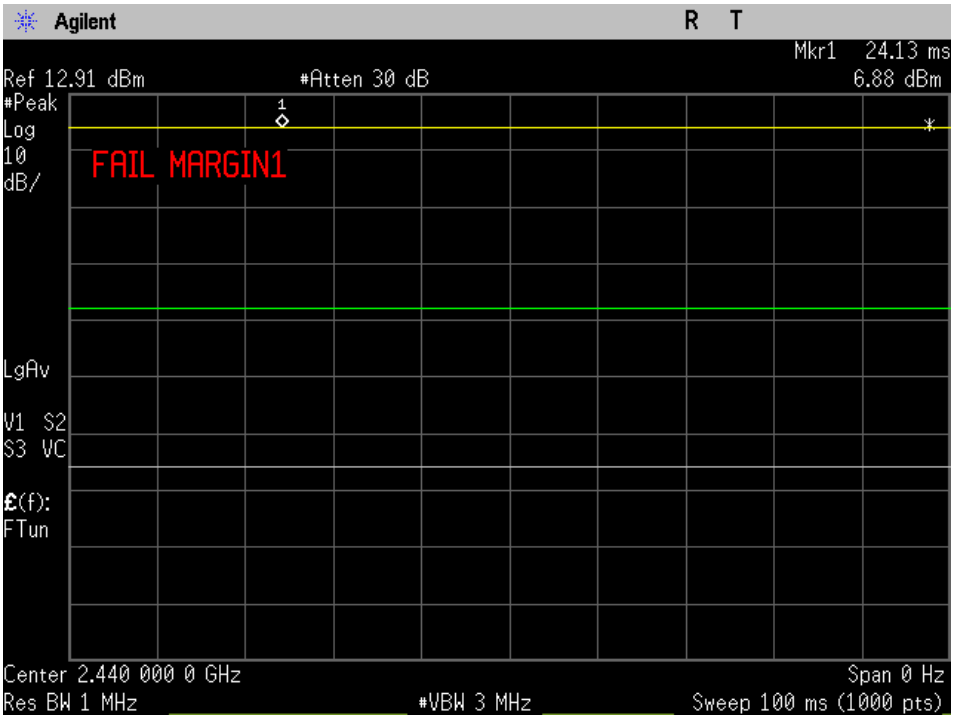
Radio Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
DH1	-	-	100	-
2DH1	-	-	100	-
3DH1	-	-	100	-

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

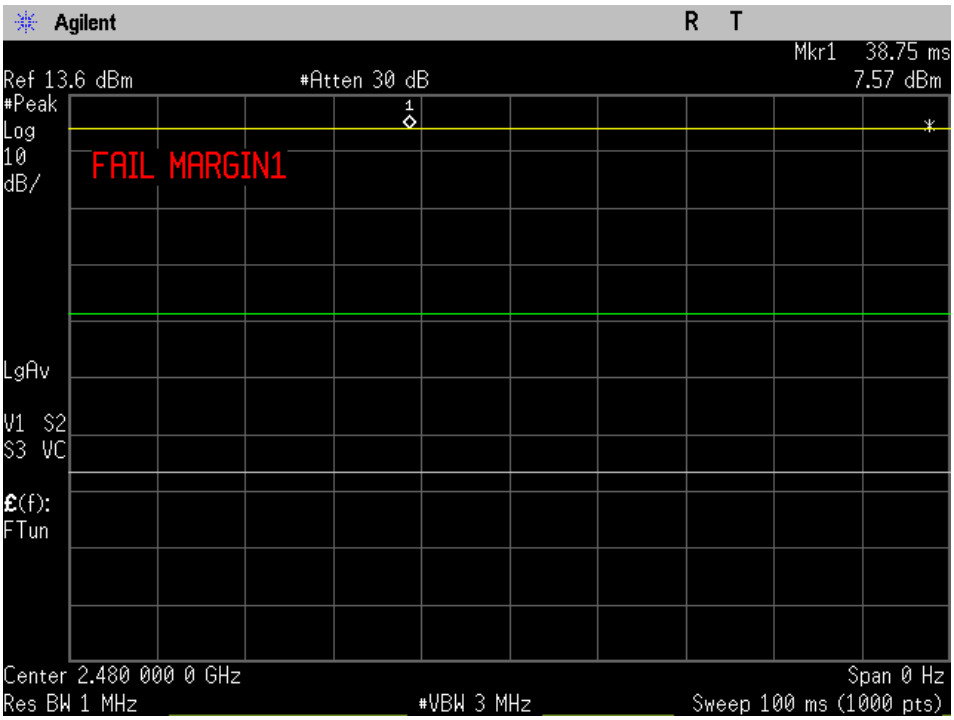
DH1



2DH1


Agilent
R T
Mkr1 24.13 ms
Ref 12.91 dBm
#Atten 30 dB
6.88 dBm
#Peak
Log
10
dB/
FAIL MARGIN1
LgAv
V1 S2
S3 VC
£(f):
FTun
Center 2.440 000 0 GHz
Span 0 Hz
Res BW 1 MHz
#VBW 3 MHz
Sweep 100 ms (1000 pts)

3DH1


Agilent
R T
Mkr1 38.75 ms
Ref 13.6 dBm
#Atten 30 dB
7.57 dBm
#Peak
Log
10
dB/
FAIL MARGIN1
LgAv
V1 S2
S3 VC
£(f):
FTun
Center 2.480 000 0 GHz
Span 0 Hz
Res BW 1 MHz
#VBW 3 MHz
Sweep 100 ms (1000 pts)

2.4 Equipment Modifications

N/A

2.5 Local Support Equipment

Manufacturer	Description	Model
Dell	Laptop	Latitude E6410

2.6 Remote Support Equipment

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

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 ISEDC RSS-Gen §6.8	Antenna Requirement	Compliant
FCC §15.207 ISEDC RSS-Gen §8.8	AC Line Conducted Emissions	Compliant
FCC §2.1091, §15.247(i) ISEDC RSS-102	RF Exposure	Compliant
FCC §2.1053, §15.205, §15.209, §15.247(d) ISEDC RSS-247 §5.5 ISEDC RSS-Gen §8.9, §8.10	Radiated Spurious Emissions	Compliant
FCC §15.247(a)(1)(i) ISEDC RSS-247 §5.1 ISEDC RSS-Gen §6.6	20 dB & 99% Emission Bandwidth	Compliant
FCC §15.247(b)(2) ISEDC RSS-247 §5.4	Maximum Peak Output Power	Compliant
FCC §15.247(d) ISEDC RSS-247 §5.5	100 kHz Bandwidth of Frequency Band Edge	Compliant
FCC §15.247(a)(1)(i) ISEDC RSS-247 §5.1(c)	Number of Hopping Channels	Compliant
FCC §15.247(a)(1) ISEDC RSS-247 §5.1(c)	Hopping Channel Separation	Compliant
FCC §15.247(a)(1)(i) ISEDC RSS-247 §5.1(c)	Dwell Time	Compliant

Note[1]: Antenna gain was obtained from antenna specification provided by Roku, Inc.

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

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

4.1 Applicable Standards

According to FCC §15.203:

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

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

According to ISEDC RSS-Gen §6.8: Transmitter Antenna

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

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

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

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

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

This radio transmitter [enter the device's ISED certification number] 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

The antennas used by the EUT have unique coupling to the intentional radiator.

Antenna usage	Frequency Range (MHz)	Maximum Antenna Gain (dBi)	Antenna Type
2.4GHz Wi-Fi Ant A	2400-2483.5	2.45	PCB
2.4GHz Wi-Fi Ant B	2400-2483.5	2.51	PCB
2.4GHz Ant C	2400-2483.5	2.35	PCB

Note: The antennas used by the EUT are permanent attached antennas.
Note: Antenna info is information provided by customer.
Note: Ant A and Ant B are Wi-Fi antennas and Ant C is Bluetooth only antenna.

5 FCC §2.1091, §15.247(i) & ISEDC RSS-102- RF Exposure

5.1 Applicable Standards

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

2.1.1 General RF Exposure Test Exemption Considerations

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

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

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

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

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

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

2.1.2 1-mW Test Exemption

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

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

2.1.3 SAR-Based Exemption

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

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

2.1.4 MPE-Based Exemption

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

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

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

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

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

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

5.2 FCC RF Exposure Exemption Evaluation Procedures

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

B.1 General

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

B.2 Blanket 1 mW Blanket Exemption

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

B.3 MPE-based Exemption

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

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

RF Source			Minimum Distance			Threshold ERP
f_L MHz		f_H MHz	$\lambda_L/2\pi$		$\lambda_H/2\pi$	W
0.3	-	1.34	159 m	-	35.6 m	1,920 R^2
1.34	-	30	35.6 m	-	1.6 m	3,450 R^2/f^2
30	-	300	1.6 m	-	159 mm	3.83 R^2
300	-	1,500	159 mm	-	31.8 mm	0.0128 $R^2 f$
1,500	-	100,000	31.8 mm	-	0.5 mm	19.2 R^2
Subscripts L and H are low and high; λ is wavelength. From § 1.1307(b)(3)(i)(C), modified by adding Minimum Distance columns.						

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

For mobile devices that are not exempt per Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] at distances from 20 cm to 40 cm and in 0.3 GHz to 6 GHz, evaluation of compliance with the exposure limits in § 1.1310 is necessary if the ERP of the device is greater than ERP20cm in Formula (B.1) [repeated from § 2.1091(c)(1) and § 1.1307(b)(1)(i)(B)].

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

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

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

B.4 SAR-based Exemption

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

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

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

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

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

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

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

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

5.3 MPE Results for the FCC

Bluetooth Classic

Prediction frequency (GHz)			2.402	
Maximum output power (dBm)			11.99	
Maximum ERP (dBm)			12.19	
Maximum ERP (mW)			16.56	
Prediction distance (cm)			20	
Maximum antenna gain (dBi)			2.35	
0.3 GHz ≤ f < 1.5 GHz	$ERP_{20\,cm}$ (mW)	x	SAR-based Exemption Threshold	
	-	-	$d \leq 20$ cm	P_{th} (mW)
				-
			20 cm < $d \leq 40$ cm	P_{th} (mW)
				-
1.5 GHz ≤ f ≤ 6 GHz	$ERP_{20\,cm}$ (mW)	x	SAR-based Exemption Threshold	
	3060	2.1232	$d \leq 20$ cm	P_{th} (mW)
				3060
			20 cm < $d \leq 40$ cm	P_{th} (mW)
				-

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

FCC Worst Case Colocation:

BTC Contribution + 2.4Wifi Contribution = 16.56/3060 + 104.95/3060 = 0.04 < 1
BTC Contribution + 5Wifi Contribution = 16.56/3060 + 1340/3060 = 0.44 < 1

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

5.4 RF exposure evaluation exemption for IC

Maximum EIRP power at 2440 MHz = 11.99 dBm + 2.35 dBi = 14.34 dBm which is lesser than $1.31\times10^{-2}f^{0.6834}$ = 2.7053 W = 34.32 dBm

The RF exposure evaluation is compliant.

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 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.

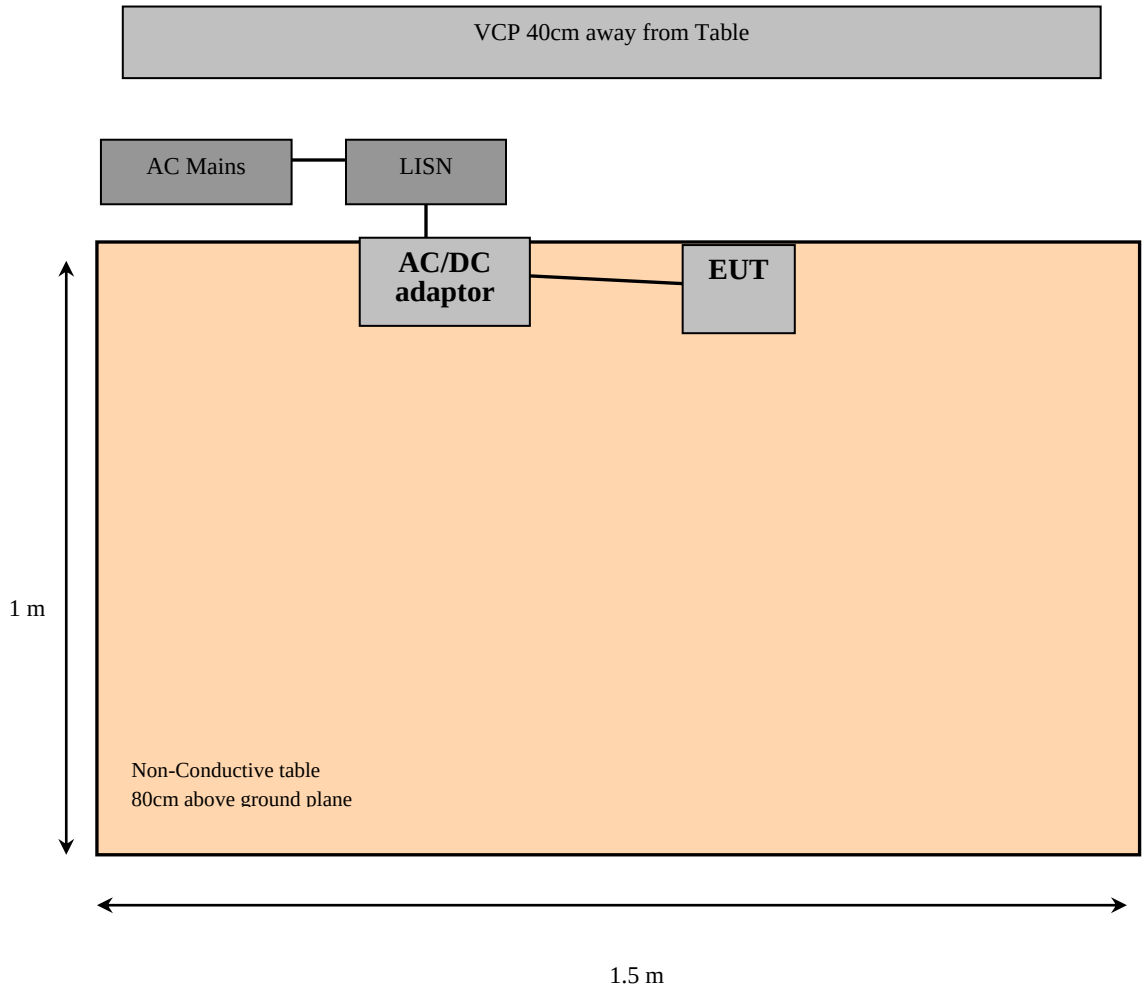
6.3 Test Procedure

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 #	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
310	Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100044	2023-05-11	1 years
680	Rohde & Schwarz	Impulse Limiter	ESH3-Z2	101964	2022-06-20	1 year
724	Solar Electronics Company	High Pass Filter	Type 7930-100	7930150203	2022-09-09	1 year
732	FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2022-09-01	1 year
1226	N/A	Ground Plane Coaxial Cable	N/A	2109241	2022-09-12	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:	23º C
Relative Humidity:	42 %
ATM Pressure:	101.31 kPa

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

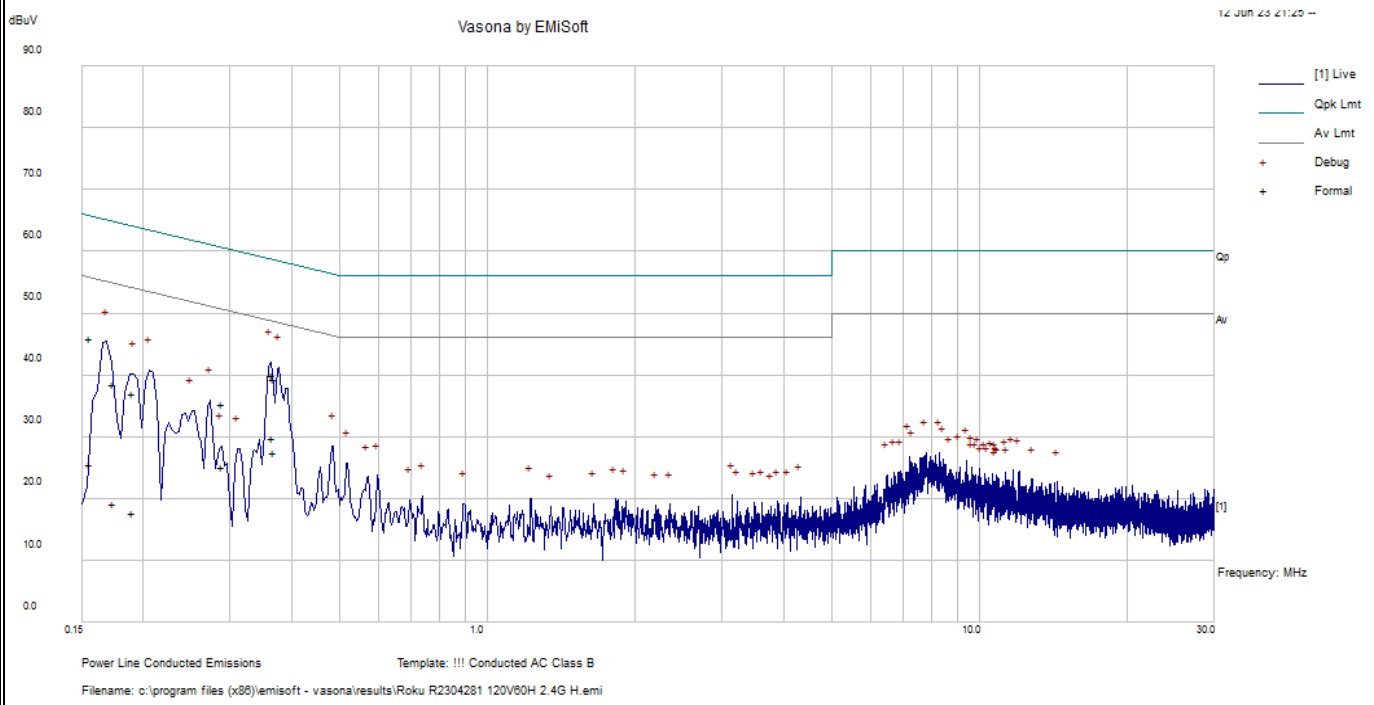
6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC 15C & 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 (Live/Neutral)**	**Range (MHz)**
-18.51	0.365846	Live	0.15-30

6.9 Conducted Emissions Test Plots and Data

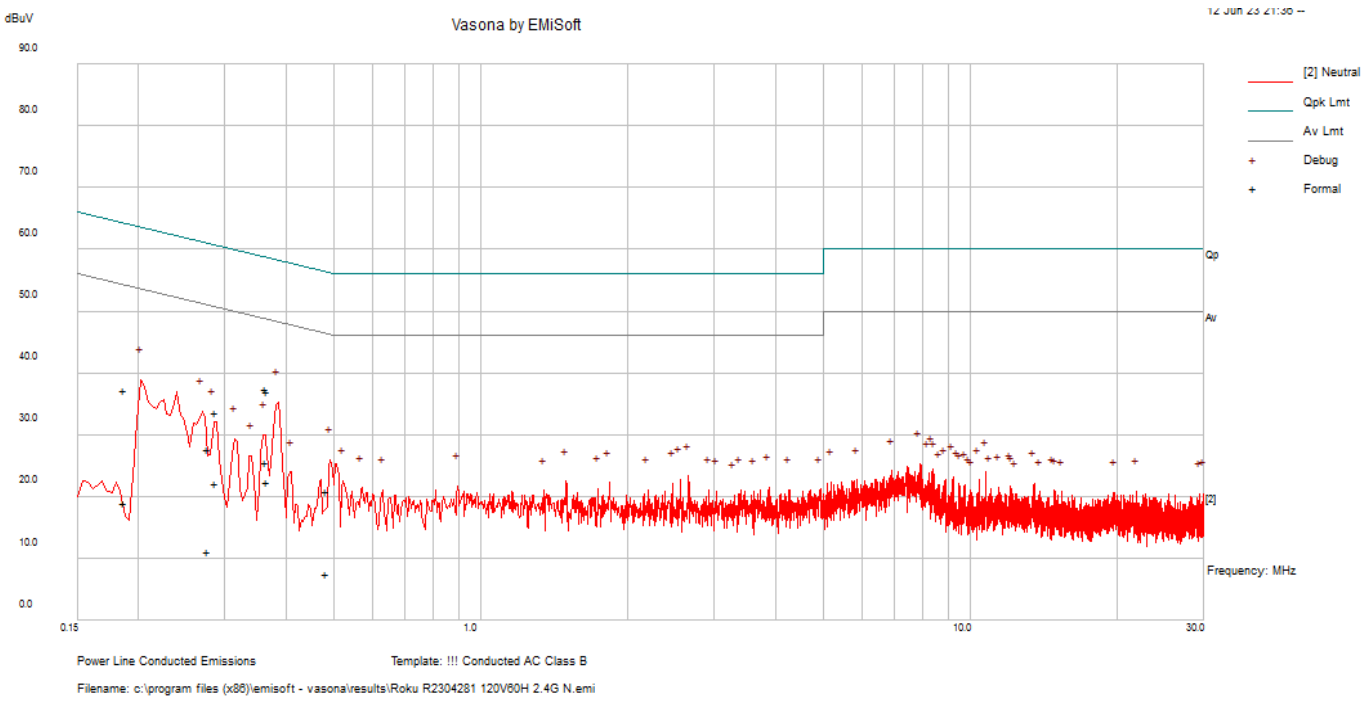
120 V, 60 Hz – Live



Frequency (MHz)	Ai Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.365846	29.28	10.81	40.09	Live	58.59	-18.51	QP
0.367524	28.51	10.81	39.32	Live	58.56	-19.24	QP
0.15613	34.84	11.01	45.85	Live	65.67	-19.81	QP
0.190007	25.96	11.01	36.97	Live	64.04	-27.07	QP
0.173641	27.57	11.01	38.58	Live	64.78	-26.2	QP
0.28934	24.48	10.94	35.42	Live	60.54	-25.13	QP

Frequency (MHz)	Ai Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.365846	18.99	10.81	29.8	Live	48.59	-18.8	Ave.
0.367524	16.61	10.81	27.42	Live	48.56	-21.14	Ave.
0.15613	14.62	11.01	25.63	Live	55.67	-30.03	Ave.
0.190007	6.66	11.01	17.67	Live	54.04	-36.37	Ave.
0.173641	8.18	11.01	19.19	Live	54.78	-35.59	Ave.
0.28934	14.11	10.94	25.05	Live	50.54	-25.51	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Ai Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.367283	26.12	10.81	36.93	Neutral	58.56	-21.64	QP
0.187139	26.11	11.01	37.12	Neutral	64.16	-27.04	QP
0.277526	16.66	10.94	27.6	Neutral	60.89	-33.29	QP
0.288078	22.65	10.94	33.59	Neutral	60.58	-26.99	QP
0.364424	26.67	10.81	37.48	Neutral	58.63	-21.14	QP
0.484676	10.19	10.63	20.82	Neutral	56.26	-35.43	QP

Frequency (MHz)	Ai Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBuV)	Conductor (Live/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.367283	11.46	10.81	22.27	Neutral	48.56	-26.29	Ave.
0.187139	8.01	11.01	19.02	Neutral	54.16	-35.15	Ave.
0.277526	0.24	10.94	11.18	Neutral	50.89	-39.7	Ave.
0.288078	11.25	10.94	22.19	Neutral	50.58	-28.4	Ave.
0.364424	14.63	10.81	25.44	Neutral	48.63	-23.19	Ave.
0.484676	-3.07	10.63	7.56	Neutral	46.26	-38.69	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 0.495 – 0.505 2.1735 – 2.1905 4.125 – 4.128 4.17725 – 4.17775 4.20725 – 4.20775 6.215 – 6.218 6.26775 – 6.26825 6.31175 – 6.31225 8.291 – 8.294 8.362 – 8.366 8.37625 – 8.38675 8.41425 – 8.41475 12.29 – 12.293 12.51975 – 12.52025 12.57675 – 12.57725 13.36 – 13.41	16.42 – 16.423 16.69475 – 16.69525 25.5 – 25.67 37.5 – 38.25 73 – 74.6 74.8 – 75.2 108 – 121.94 123 – 138 149.9 – 150.05 156.52475 – 156.52525 156.7 – 156.9 162.0125 –167.17 167.72 – 173.2 240 – 285 322 – 335.4 399.9 – 410 608 – 614	960 – 1240 1300 – 1427 1435 – 1626.5 1645.5 – 1646.5 1660 – 1710 1718.8 – 1722.2 2200 – 2300 2310 – 2390 2483.5 – 2500 2690 – 2900 3260 – 3267 3.332 – 3.339 3 3458 – 3 358 3.600 – 4.400	4. 5 – 5. 15 5. 35 – 5. 46 7.25 – 7.75 8.025 – 8.5 9.0 – 9.2 9.3 – 9.5 10.6 – 12.7 13.25 – 13.4 14.47 – 14.5 15.35 – 16.2 17.7 – 21.4 22.01 – 23.12 23.6 – 24.0 31.2 – 31.8 36.43 – 36.5 Above 38.6

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 license-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 License-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 license-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.

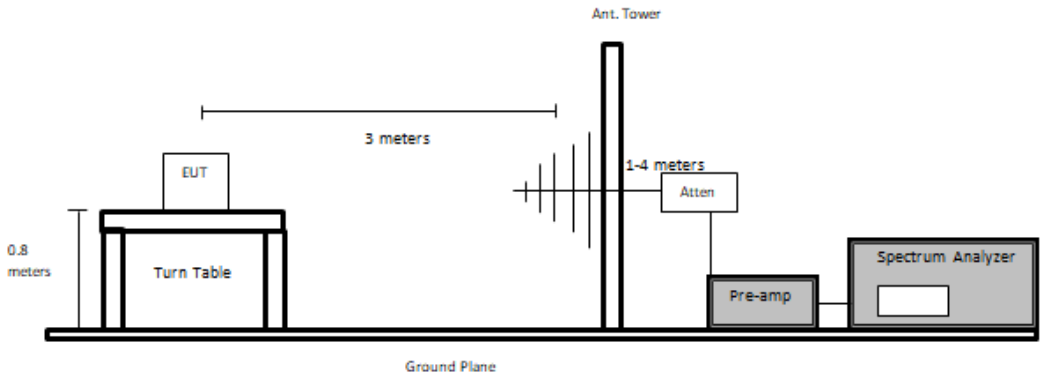
7.2 Test Setup

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.

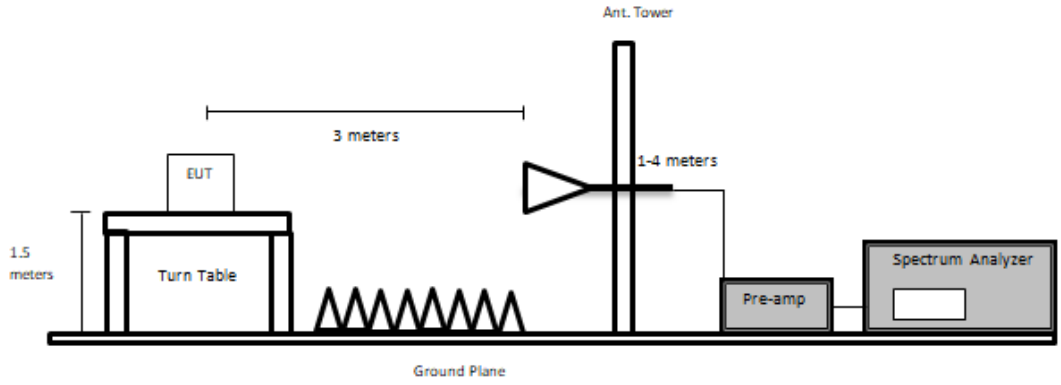
The spacing between the peripherals was 10 centimeters.

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

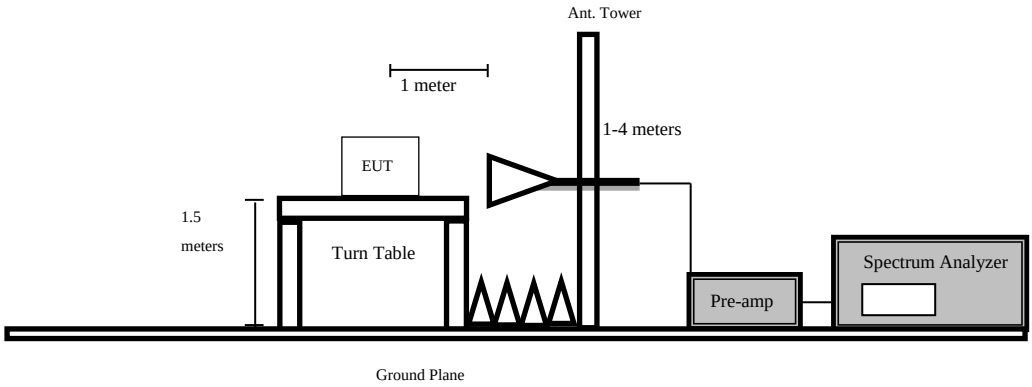
Below 1 GHz:



Above 1 GHz at 3m:



Above 1 GHz at 1m:



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

Note: Pre-scan was performed in order to determine worst-case orientation of device (shown in Test Setup Photos) with respect to measurement antenna. Plots/data shown represent measurements made in worst-case orientation.

7.4 Corrected Amplitude & Margin Calculation

For emissions below 1 GHz and for above 1GHz scans.

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 Equipment List and Details

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

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".*

7.6 Test Environmental Conditions

Temperature:	21 ºC
Relative Humidity:	44%
ATM Pressure:	102.7 kPa

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

7.7 Summary of Test Results

According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C/ISEDC RSS-247 standard's radiated emissions limits, and had the worst margin of:

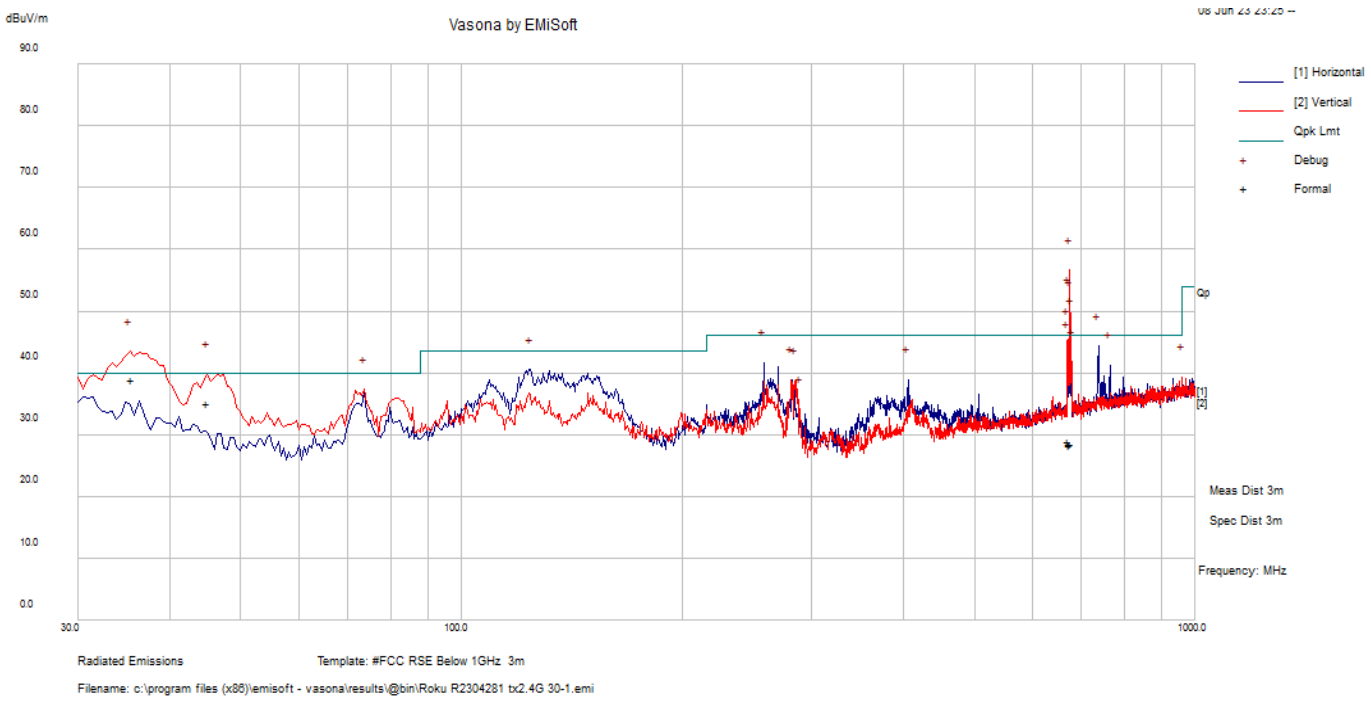
Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Transmitting Channel**
-1.16	35.57125	Vertical	DH1, 2440 MHz

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

7.8 Radiated Emissions Test Results

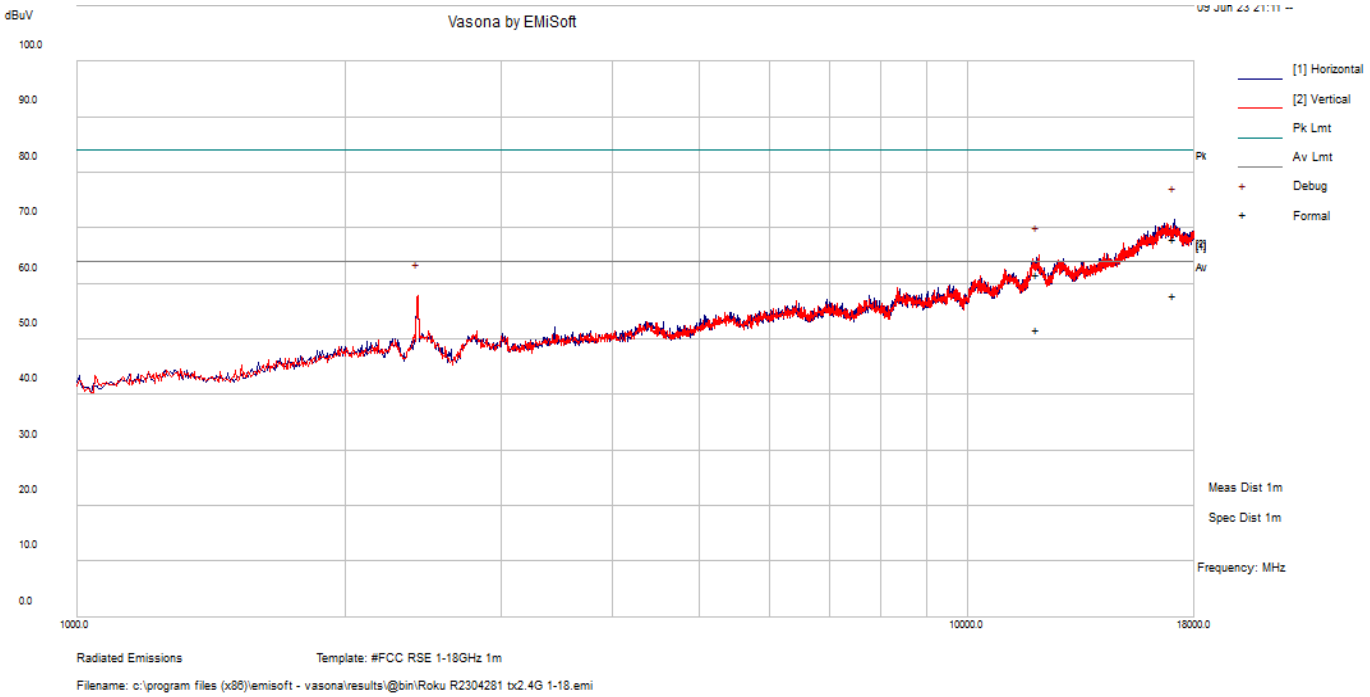
Note: Lowest Frequency emitted by the EUT is greater than 30MHz, thus spurious emission below 30MHz are not needed.

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



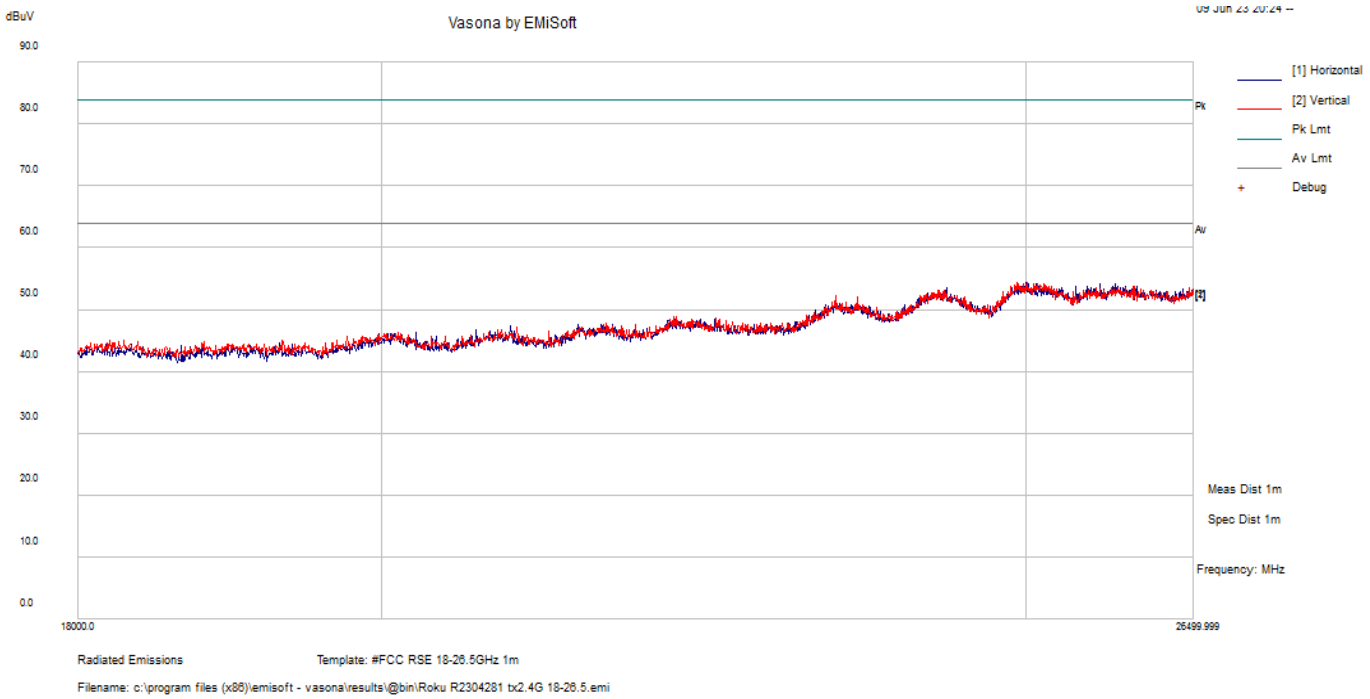
Frequency (MHz)	S.A. Reading (dBuV	Correction Factor	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµ V/m)	Margin (dB)	Comment
674.28325	27.79	0.53	28.32	101	V	231	46	-17.67	QP
672.776	28.43	0.54	28.97	201	V	182	46	-17.03	QP
675.287	27.88	0.55	28.43	102	V	230	46	-17.57	QP
35.57125	43.6	-4.76	38.84	122	V	265	40	-1.16	QP
677.7815	27.95	0.65	28.6	102	V	232	46	-17.41	QP
45.01375	45.89	-10.74	35.15	107	V	323	40	-4.84	QP

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



Frequency (MHz)	S.A. Reading (dBuV	Correction Factor	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµ V/m)	Margin (dB)	Comment
17087.458	46.95	21.01	67.96	239	H	228	84	-16.05	Peak
11982.605	45.55	16.14	61.69	225	V	143	84	-22.31	Peak
17087.458	36.84	21.01	57.85	239	H	228	64	-6.16	Ave
11982.605	35.53	16.14	51.67	225	V	143	64	-12.33	Ave

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



Note: Max Peak emission compared to average limit to show compliance.

8 FCC §15.247(a) (1)(i) & ISEDC RSS-247 §5.1, RSS-Gen §6.6- Emission Bandwidth

8.1 Applicable Standards

According to FCC §15.247(a) (1) and ISEDC RSS-247 §5.1: the maximum 20 dB bandwidth of the hopping channel shall be presented.

8.2 Measurement Procedure

Span = approximately 2 to 5 times the 99% occupied bandwidth, centered on a hopping channel

RBW = 1% to 5 % of the 99% occupied bandwidth

VBW = 3RBW

Sweep = auto

Detector function = peak

Trace = max hold

8.3 Test Equipment List and Details

BACL Number	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cables	-	-	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".*

8.4 Test Environmental Conditions

Temperature:	27º C
Relative Humidity:	39 %
ATM Pressure:	100.7 kPa

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

8.5 Test Results

Please refer to Annex A for plots for detailed test results.

GFSK

Channel	Frequency (MHz)	99% OBW (kHz)	20 dB OBW (kHz)
Low	2402	880.7981	884.3062
Middle	2440	878.8747	881.9750
High	2480	888.7122	887.9417

Π/4 DPSK

Channel	Frequency (MHz)	99% OBW (kHz)	20 dB OBW (kHz)
Low	2402	1184.3	1184.1
Middle	2440	1185.4	1185.3
High	2480	1184.9	1184.6

8DPSK

Channel	Frequency (MHz)	99% OBW (kHz)	20 dB OBW (kHz)
Low	2402	1225.8	1225.4
Middle	2440	1225.8	1224.3
High	2480	1226.5	1225.3

Please refer to Annex A for the plots for detailed test results.

9 FCC §15.247(b) (2) & ISEDC RSS-247 §5.4 - Output Power

9.1 Applicable Standards

According to FCC §15.247(b) (2): For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

According to RSS-247 §5.4: For frequency hopping systems operating in the band 902-928 MHz, For FHSs operating in the band 902-928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

9.2 Measurement Procedure

Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
RBW > the 20 dB bandwidth of the emission being measured
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

9.3 Test Equipment List and Details

BACL Number	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cables	-	-	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".*

9.4 Test Environmental Conditions

Temperature:	25º C
Relative Humidity:	29 %
ATM Pressure:	102.3 KPa

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

9.5 Test Results

Please refer to Annex B for plots for detailed test results.

GFSK

Channel	Frequency (MHz)	Conducted Output Power (dBm)	Limit (dBm)	EIRP(dBm)
Low	2402	10.09	30	12.44
Middle	2440	10.84	30	13.19
High	2480	10.25	30	12.60

Π/4 DPSK

Channel	Frequency (MHz)	Conducted Output Power (dBm)	Limit (dBm)	EIRP(dBm)
Low	2402	11.99	30	14.34
Middle	2440	8.82	30	11.17
High	2480	8.96	30	11.31

8DPSK

Channel	Frequency (MHz)	Conducted Output Power (dBm)	Limit (dBm)	EIRP(dBm)
Low	2402	5.41	30	7.76
Middle	2440	5.44	30	7.79
High	2480	6.45	30	8.80

Note 3: EIRP [dBm] = Total Power [dBm] + Antenna Gain [dBi]
Antenna Gain = 2.35 dBi

10 FCC §15.247(d) & ISEDC RSS-247 §5.5 - 100 kHz Bandwidth of Spurious Emissions and Band Edges (20dBc)

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

For hopping mode, a radiated sample was measured with horn antenna. Delta between the emission levels at fundamental frequency and band-edge frequency was measured.

10.3 Test Equipment List and Details

BACL Number	Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cables	-	-	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".*

10.4 Test Environmental Conditions

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

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

10.5 Test Results

Please refer to Annex C of plots for detailed test results.

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

11.1 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 license-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 License-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 license-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.

11.2 Measurement Procedure

The antenna-port methodology form ANSI C63.10: 2013 Section 11.12.2 was utilized as an alternative to radiated emissions in the restricted bands.

The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level. For frequencies below 1 GHz, the RBW was set to 100 kHz and the VBW was set to 3x the RBW. For frequencies above 1 GHz the RBW was set to 1 MHz and the VBW was set to 3x the RBW. The spectrum analyzer was set to an auto sweep time and a peak detector was used. The maximum antenna gain was added to the measurement trace as was the appropriate maximum ground reflection factor as outlined in section 11.12.2 of ANSI C63.10. The resultant EIRP was then converted to an equivalent electric field strength which is shown on the graphical plots which follow. Measurements were carried out at the low, mid and high channels.

In order to assess the radiated spurious emissions, a radiated scan was performed with the antenna of proper impedance installed. The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes if multiple mounting orientations are supported. Plots shown are corrected for both antenna correction factor and distance and compared to a 3m limit line. Radiated measurements below 30MHz were performed in a semi-anechoic chamber that has been correlated to an open area site.

For Peak Measurement:

11.12.2.4 Peak power measurement procedure

Peak emission levels are measured by setting the instrument as follows:

a) RBW = as specified in Table 9/

b) VBW ≥ [3 × RBW].

c) Detector = peak.

d) Sweep time = auto.

e) Trace mode = max hold.

f) Allow sweeps to continue until the trace stabilizes. (Note that the required measurement time may be lengthened for low-duty-cycle applications.)

Table 9—RBW as a function of frequency

Frequency	RBW
9 kHz to 150 kHz	200 Hz to 300 Hz
0.15 MHz to 30 MHz	9 kHz to 10 kHz
30 MHz to 1000 MHz	100 kHz to 120 kHz
>1000 MHz	1 MHz

If the peak-detected amplitude can be shown to comply with the average limit, then it is not necessary to perform a separate average measurement.

For Average Measurement:

11.12.2.5.3 Reduced VBW averaging across ON and OFF times of the EUT transmissions with max hold

If continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and the duty cycle is not constant (duty cycle variations exceed ±2%), then the following procedure shall be used:

a) RBW = 1 MHz.

b) VBW ≥ 1 / T.

c) Video bandwidth mode or display mode:

1) The instrument shall be set to ensure that video filtering is applied in the power domain. Typically, this requires setting the detector mode to RMS (power averaging) and setting the average-VBW type to power (rms).

2) As an alternative, the instrument may be set to linear detector mode. Ensure that video filtering is applied in linear voltage domain (rather than in a log or dB domain). Some instruments require linear display mode to accomplish this. Others have a setting for average-VBW type, which can be set to "voltage" regardless of the display mode.

d) Detector = peak.

e) Sweep time = auto.

f) Trace mode = max hold.

g) Allow max hold to run for at least [50 × (1 / D)] traces.

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

11.3 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cables	-	-	Each time[1]	N/A

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 A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".*

11.4 Test Environmental Conditions

Temperature:	22.8 ° C
Relative Humidity:	50 %
ATM Pressure:	101.4 KPa

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

11.5 Test Results

Please refer to Annex D of plots for detailed test data.

12 FCC §15.247(a) (1) (iii) & ISEDC RSS-247 §5.1(d) - Dwell Time

12.1 Applicable Standards

According to FCC §15.247(a) (1) (iii) and ISEDC RSS-247 §5.1(d)-: FHSS operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

12.2 Measurement Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

Span = zero span, centered on a hopping channel
RBW ≤ channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel
Sweep = as necessary to capture the entire dwell time per hopping channel
Detector function = peak
Trace = max hold

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

(Number of hops in the period specified in the requirements) =
(number of hops on spectrum analyzer) x (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

12.3 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cables	-	-	Each time[1]	N/A

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 A2LA Policy P102 (dated 02 October 2018) "A2LA Policy on Metrological Traceability".*

12.4 Test Environmental Conditions

Temperature:	22.8 º C
Relative Humidity:	50 %
ATM Pressure:	101.4 KPa

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

12.5 Test Results

Please refer to Annex E of plots for detailed test data.

GFSK

Modulation	Frequency	No. of Pulses (per 31.6 sec)	Pulse Width (ms)	Total Dwell Time (sec)	Limit (sec)	Results
DH1	2402	332	0.367	0.12	0.400	Compliant
DH3	2402	158	1.600	0.25	0.400	Compliant
DH5	2402	126	2.850	0.36	0.400	Compliant

Total Dwell Time (*sec*) = (Number of Pulses per 31.6 seconds x Pulse Width (*ms*))/1000

Π/4 DPSK

Modulation	Frequency	No. of Pulses (per 31.6 sec)	Pulse Width (ms)	Total Dwell Time (sec)	Limit (sec)	Results
2DH1	2402	332	0.400	0.13	0.400	Compliant
2DH3	2402	158	1.633	0.26	0.400	Compliant
2DH5	2402	126	2.850	0.36	0.400	Compliant

Total Dwell Time (*sec*) = (Number of Pulses per 31.6 seconds x Pulse Width (*ms*))/1000

8DPSK

Modulation	Frequency	No. of Pulses (per 31.6 sec)	Pulse Width (ms)	Total Dwell Time (sec)	Limit (sec)	Results
3DH1	2402	332	0.3833	0.13	0.400	Compliant
3DH3	2402	158	1.6170	0.26	0.400	Compliant
3DH5	2402	126	2.9000	0.37	0.400	Compliant

Total Dwell Time (*sec*) = (Number of Pulses per 31.6 seconds x Pulse Width (*ms*))/1000

13 FCC §15.247(a)(1)(iii) & ISEDC RSS-247 §5.1(d) - Number of Hopping Channels

13.1 Applicable Standards

According to FCC §15.247(a) (1) (iii) and ISEDC RSS-247 §5.1(d)-: FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

13.2 Test Procedure

Span = the frequency band of operation

RBW < 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

13.3 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cables	-	-	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".*

13.4 Test Environmental Conditions

Temperature:	22.8 º C
Relative Humidity:	50 %
ATM Pressure:	101.4kKPa

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

13.5 Test Results

Please refer to the plots in Annex E.

GFSK

Modulation	Number of Channels
DH1	79
DH3	79
DH5	79

Π/4 DPSK

Modulation	Number of Channels
2DH1	79
2DH3	79
2DH5	79

8DPSK

Modulation	Number of Channels
3DH1	79
3DH3	79
3DH5	79

14 FCC §15.247(a) (1) & ISEDC RSS-247 §5.1(b) - Hopping Channel Separation

14.1 Applicable Standards

According to FCC §15.247(a) (1) : Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

According to ISEDC RSS-247 §5.1(b): FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

14.2 Test Procedure

Span = wide enough to capture the peaks of two adjacent channels
Resolution (or IF) Bandwidth (RBW) ≈ 30% of the channel spacing, adjust as necessary to best identify the center of each individual channel
Video (or Average) Bandwidth (VBW) ≥RBW
Sweep = auto
Detector function = peak
Trace = max hold

14.3 Test Equipment List and Details

BACL No	Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
424	Agilent	Spectrum Analyzer	E440A	US45303156	2022-12-19	1 year
624	Agilent	Spectrum Analyzer	E4446A	MY48250238	2023-05-12	1 year
-	-	20dB attenuator	-	-	Each time[1]	N/A
-	-	RF cables	-	-	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".*

14.4 Test Environmental Conditions

Temperature:	22.8º C
Relative Humidity:	50 %
ATM Pressure:	101.4 KPa

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

14.5 Test Results

GFSK

Channel	Frequency (MHz)	Channel Separation (kHz)	Limit > (2/3)*OBW (kHz)
Low	2402	992	589.54
Middle	2440	1008	587.98
High	2480	1008	591.83

Π/4 DPSK

Channel	Frequency (MHz)	Channel Separation (kHz)	Limit > (2/3)*OBW (kHz)
Low	2402	992	789.40
Middle	2440	1042	790.20
High	2480	1125	789.73

8DPSK

Channel	Frequency (MHz)	Channel Separation (kHz)	Limit > (2/3)*OBW (kHz)
Low	2402	1000	816.93
Middle	2440	983	816.20
High	2480	983	816.87

For the plots of test results, refer to Annex F.

15 Annex G - Test Setup Photographs

Please refer to attachment.

16 Annex H - EUT Photographs

Please refer to attachment.

17 Annex I (Normative) - A2LA Electrical Testing Certificate

Accredited Laboratory

A2LA has accredited

BAY AREA COMPLIANCE LABORATORIES CORP.

Sunnyvale, CA

for technical competence in the field of

Electrical Testing

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

Presented this 21st day of December 2022.

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

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

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

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

--- END OF REPORT ---