FCC PART 15, SUBPART C
ISEDC RSS-247, ISSUE 2, FEBRUARY 2017
LP0002-2020

TEST REPORT

For

Ruckus Wireless, Inc.

350 West Java Dr.
Sunnyvale, CA 94089, USA

FCC ID: S9GH350
IC: 5912A-H350

Report Type:	**Product Type:**
Original Report	Indoor Access Point
Prepared By:	Rita Yang Test Technician
Report Number:	R2105132-02 Rev A
Report Date:	2021-06-18
Reviewed By:	Christian McCaig RF Project Engineer
Bay Area Compliance Laboratories Corp. 1274 Anvilwood Avenue, Sunnyvale, CA 94089, USA Tel: (408) 732-9162 Fax: (408) 732-9164	

A2LA ACCREDITED
CERTIFICATE #3297.02

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2105132-02	Original Report	2021-05-27
0	R2105132-02 Rev A	Added LP0002-2020 standard for Taiwan NCC approval	2021-06-18

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test report was prepared on behalf of *Ruckus Wireless, Inc.*, and their product model: *H350, FCC ID: S9GH350, IC: 5912A-H350,* or the "EUT" as referred to in this report. The EUT is an Access Point with 2.4GHz/5GHz Wi-Fi, BLE, and ZigBee capabilities.

EUT SW version: 116.0.0.0.1506

EUT Receive date: 2021-05-13

Brand/Manufacturer: Ruckus Wireless, Inc.

1.2 Objective

This report was prepared on behalf of *Ruckus Wireless, Inc.,* in accordance with Part 2, Subpart J, and Part 15, Subpart and C of the Federal Communication Commission's rules and ISEDC RSS-247 Issue 2, February 2017 and LP0002-2020.

The objective was to determine compliance with FCC Part 15.247, ISEDC RSS-247 and LP0002-2020 rules for Output Power, Antenna Requirements, 6 dB Bandwidth, Power Spectral Density, 100 kHz Bandwidth of Band Edges Measurement, and Radiated Spurious Emissions.

1.3 Related Submittal(s)/Grant(s)

N/A

1.4 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 and LP0002-2020.

1.5 Measurement Uncertainty

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

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

1.6 Test Facility Registrations

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

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

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

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

1.7 Test Facility Accreditations

Bay Area Compliance Laboratories Corp. (BACL) is:

A- ***An independent, 3rd-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2005 by A2LA (Test Laboratory Accreditation Certificate Number 3297.01),*** 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 17025:2005 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 17025:2005 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 3297.02)*** 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 3297.03)*** 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

Putty was used and software is compliant with the standard requirements being tested against.

Modulation	Channel Frequency (MHz)	Frequency (MHz)	Power Setting
ZigBee (O-QPSK)	2405-2475	2405	20
		2440	20
		2475	20

2.3 Duty Cycle Correction Factor

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

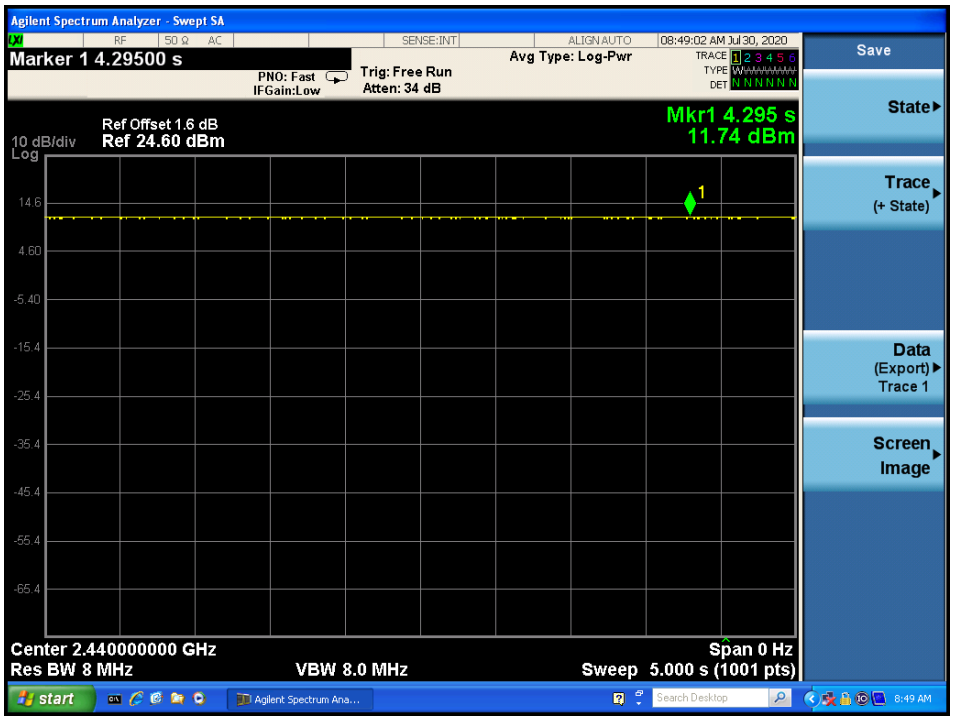
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized 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	Total On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
ZigBee	-	-	100	0

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

Please refer to the following plots.

ZigBee


Agilent Spectrum Analyzer - Swept SA
RF 50 Ω AC
SENSE:INT
ALIGN AUTO
08:49:02 AM Jul 30, 2020
Marker 1 4.29500 s
PNO: Fast
IFGain:Low
Trig: Free Run
Atten: 34 dB
Avg Type: Log-Pwr
TRACE 1 2 3 4 5 6
TYPE W
DET N N N N N
Ref Offset 1.6 dB
10 dB/div
Log
Ref 24.60 dBm
Mkr1 4.295 s
11.74 dBm
14.6
4.60
-5.40
-15.4
-25.4
-35.4
-45.4
-55.4
-65.4
Center 2.440000000 GHz
Res BW 8 MHz
VBW 8.0 MHz
Span 0 Hz
Sweep 5.000 s (1001 pts)
Save
State
Trace
(+ State)
Data
(Export)
Trace 1
Screen
Image
start
Agilent Spectrum Ana...
Search Desktop
8:49 AM

2.4 Equipment Modifications

None

2.5 Local Support Equipment

Manufacturer/Brand	Description	Model	Serial Number
Dell	Laptop	Latitude E6410	3CKRAQ1

2.6 Support Equipment

N/A

2.7 Power Supply/Adapter

Manufacturer/Brand	Description	Model
Ruckus Wireless, Inc.	PoE Injector	740-64214-001

2.8 Interface Ports and Cabling

Description	Length (m)	To	From
Ethernet Cable	2M	EUT	PoE Injector
Ethernet Cable	2M	Laptop	EUT

3 Summary of Test Results

Results reported relate only to the product tested.

FCC, ISEDC, and NCC Rules	Description of Test	Results
FCC §15.203 ISEDC RSS-Gen §6.8 LP0002-2020 §3.2	Antenna Requirement	Compliant
FCC §15.207 ISEDC RSS-Gen §8.8 LP0002-2020 §3.3	AC Line Conducted Emissions	Compliant
FCC §2.1091, §15.247(i) ISEDC RSS-102 LP0002-2020 §6.20.2	RF Exposure	Compliant
FCC §2.1053, §15.205, §15.209, §15.247 (d) ISEDC RSS-247 §5.5 ISEDC RSS-Gen §8.9 and §8.10 LP0002-2020 §3.5, §3.6, §3.7, §3.9	Radiated Spurious Emissions	Compliant
FCC §15.247(a)(2) ISEDC RSS-247 §5.2(a) LP0002-2020 §4.10.1.6(2)(A)	6 dB and 99% Emission Bandwidth	Compliant
FCC §15.247(b)(3) ISEDC RSS-247 §5.4(d) LP0002-2020 §4.10.1.2	Output Power	Compliant
FCC §15.247(d) ISEDC RSS-247 §5.5 LP0002-2020 §4.10.1.5	100 kHz Bandwidth of Frequency Band Edge	Compliant
FCC §15.247(e) ISEDC RSS-247 §5.2(b) LP0002-2020 §4.10.1.6(2)(B)	Power Spectral Density	Compliant

4 FCC §15.203, ISEDC RSS-Gen §6.8 & LP0002-2020 §3.2 - 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 licence-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.

According to LP0002-2018 §2.2,

Antenna requirement: Low-power radio frequency transmitter or transceiver (receiver) shall utilize a permanently, semi-permanently attached antenna or uses a unique coupling of the antenna and at any cable connector between the transmitter and the antenna. The antenna shall be an omni-directional type. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector or other than authorized is prohibited. Such standard connectors are for example: BNC, F type, N type, M type, UG type, RCA, SMA, SMB, and other standard type antenna connectors.

4.2 Antenna Description

Antenna Usage	Manufacturer/ Brand	Model*	Frequency Range (MHz)	Maximum Antenna Gain (dBi)	Antenna Type
ZigBee	Ruckus Wireless, Inc.	-	2400-2483.5	0	Trace Antenna

Note: The antenna gain was provided by the manufacturer.
Note*: The antenna is Ruckus design on PCB, no model number assigned.

5 FCC §2.1091, §15.247(i), ISEDC RSS-102 & LP0002-2020 §6.20.2 - 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.

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

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

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.

According to LP0002-2020 §6.20.2: For purposes of RF exposure assessment requirements, Maximum Permissible Exposure (MPE) shall be measured, if separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. Limits are as follows:

6.20.2.2 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

Note 1: asterisk (*) is plane-wave equivalent power density.
Note 2: f is the testing frequency in MHz.

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

5.3 MPE Results

Radio Standalone RF Exposure Configuration

2.4 GHz Wi-Fi: 802.11n40, Mid Channel 2437 MHz

Maximum output power at antenna input terminal (dBm):	21.18
Maximum output power at antenna input terminal (mW):	131.22
Prediction distance (cm):	20
Prediction frequency (MHz):	2437
Maximum Antenna Gain, typical (dBi):	0
Maximum Antenna Gain (numeric):	1
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.026
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

5 GHz Wi-Fi: 802.11ac80, Mid Channel 5610 MHz

Maximum output power at antenna input terminal (dBm):	20.90
Maximum output power at antenna input terminal (mW):	123.03
Prediction distance (cm):	20
Prediction frequency (MHz):	5610
Maximum Antenna Gain, typical (dBi):	1
Maximum Antenna Gain (numeric):	1.26
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.031
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

BLE: High Channel 2480 MHz

Maximum output power at antenna input terminal (dBm):	18.626
Maximum output power at antenna input terminal (mW):	72.88
Prediction distance (cm):	20
Prediction frequency (MHz):	2480
Maximum Antenna Gain, typical (dBi):	0
Maximum Antenna Gain (numeric):	1
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.0145
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

ZigBee: High Channel 2475 MHz

Maximum output power at antenna input terminal (dBm):	19.74
Maximum output power at antenna input terminal (mW):	94.19
Prediction distance (cm):	20
Prediction frequency (MHz):	2475
Maximum Antenna Gain, typical (dBi):	0
Maximum Antenna Gain (numeric):	1
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.0187
MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0

The device is compliant with the requirement MPE limit for uncontrolled exposure at 20 cm distance.

Radio Co-location RF Exposure Configuration

Radio	Standalone MPE (mW/cm^2)	Standalone MPE Limit (mW/cm^2)	Ratio (%)	Total Ratio for Radio Co-location Configuration (%)	Radio Co-location Limit (%)
2.4 GHz Wi-Fi	0.026	1	2.6	9.02	100
5 GHz Wi-Fi	0.031	1	3.1		
BLE	0.0145	1	1.45		
ZigBee	0.0187	1	1.87		

3.1 RF exposure evaluation exemption for IC

2.4 GHz Wi-Fi: 802.11n40, Mid Channel 2437 MHz

Maximum EIRP power = 21.18 dBm + 0 dBi = 21.18 dBm, which is less than $1.31\times10^{-2}f^{0.6834}$ = 2.70 W = 34.31 dBm

5 GHz Wi-Fi: 802.11ac80, Mid Channel 5610 MHz

Maximum EIRP power = 20.90dBm + 1 dBi = 21.90 dBm, which is less than $1.31\times10^{-2}f^{0.6834}$ = 4.88 W = 36.88 dBm

BLE: High Channel 2480 MHz

Maximum EIRP power = 18.626 dBm + 0 dBi = 18.626 dBm, which is less than $1.31\times10^{-2}f^{0.6834}$ = 2.74 W = 34.4 dBm

Zigbee: Low Channel 2405 MHz

Maximum EIRP power = 19.74 dBm + 0 dBi = 19.74 dBm, which is less than $1.31\times10^{-2}f^{0.6834}$ = 2.68 W = 34.3 dBm

Therefore, the RF exposure Evaluation is not required.

Note:
The 2.4 GHz Wi-Fi output power was referenced from report number: R2007201-01 issued by BACL on 01-27-2021.
The 5 GHz Wi-Fi output power was referenced from report number: R2007201-02 issued by BACL on 02-09-2021.
The BLE output power was referenced from report number R2007201-03 issued by BACL on 01-27-2021.

6 FCC §15.207, ISEDC RSS-Gen §8.8 & LP0002-2020 §3.3 - AC Power Line Conducted Emissions

6.1 Applicable Standards

As per FCC §15.207, ISEDC RSS GEN §8.8 & LP0002-2020§3.3:

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, ISEDC RSS GEN §8.8 and LP0002-2020 §3.3.

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 or 110 V/60 Hz AC power.

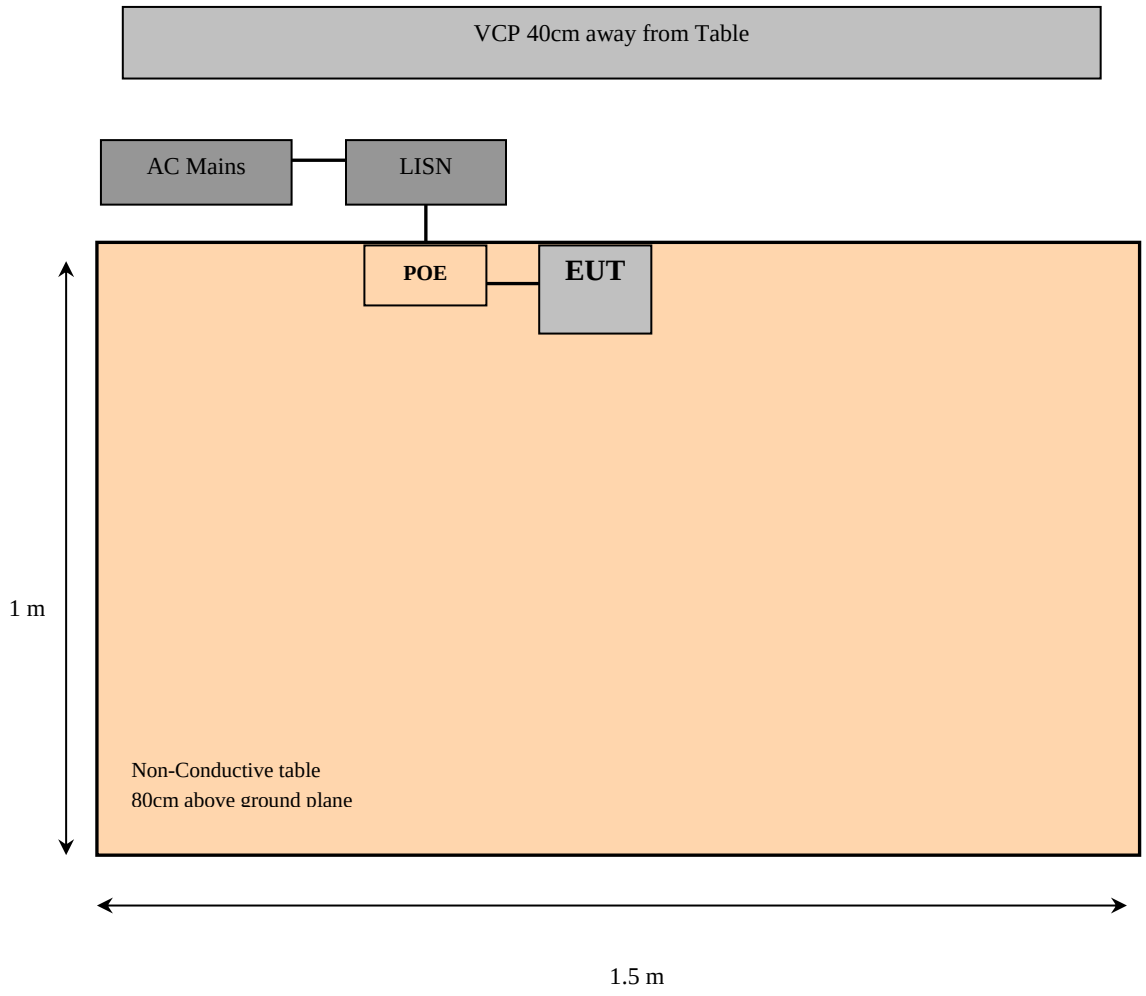
6.3 Test Procedure

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

Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2020-03-17	18 months
Rohde and Schwarz	Impulse Limiter	ESH3-Z2	101964	2020-07-01	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150204	2020-11-12	1 year
Suirong	30 ft conductive emission cable	LMR 400	-	N/R	N/A
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160130	2020-10-13	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

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

6.7 Test Environmental Conditions

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

The testing was performed by Christian McCaig on 2021-06-10 in the Ground Plane test site, and by Giriraj Gurjar on 2021-06-16 in 5m chamber 3.

6.8 Summary of Test Results

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

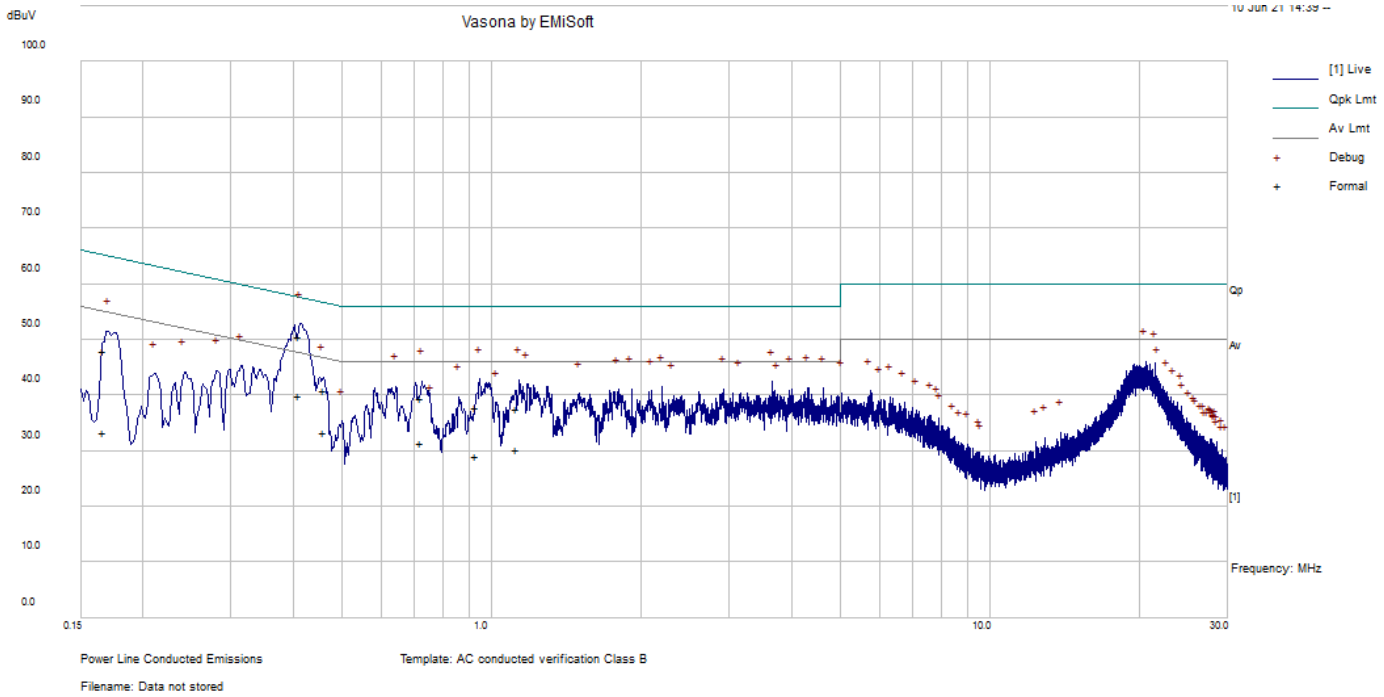
Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-7.09	0.410784	Neutral	0.15-30

According to the recorded data in following table, the EUT complied with the FCC Part 15, RSS-Gen & LP0002-2020 standards' conducted emissions limits, with the margin reading of:

Connection: AC/DC adapter connected to 110 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-6.3	0.408354	Line	0.15-30

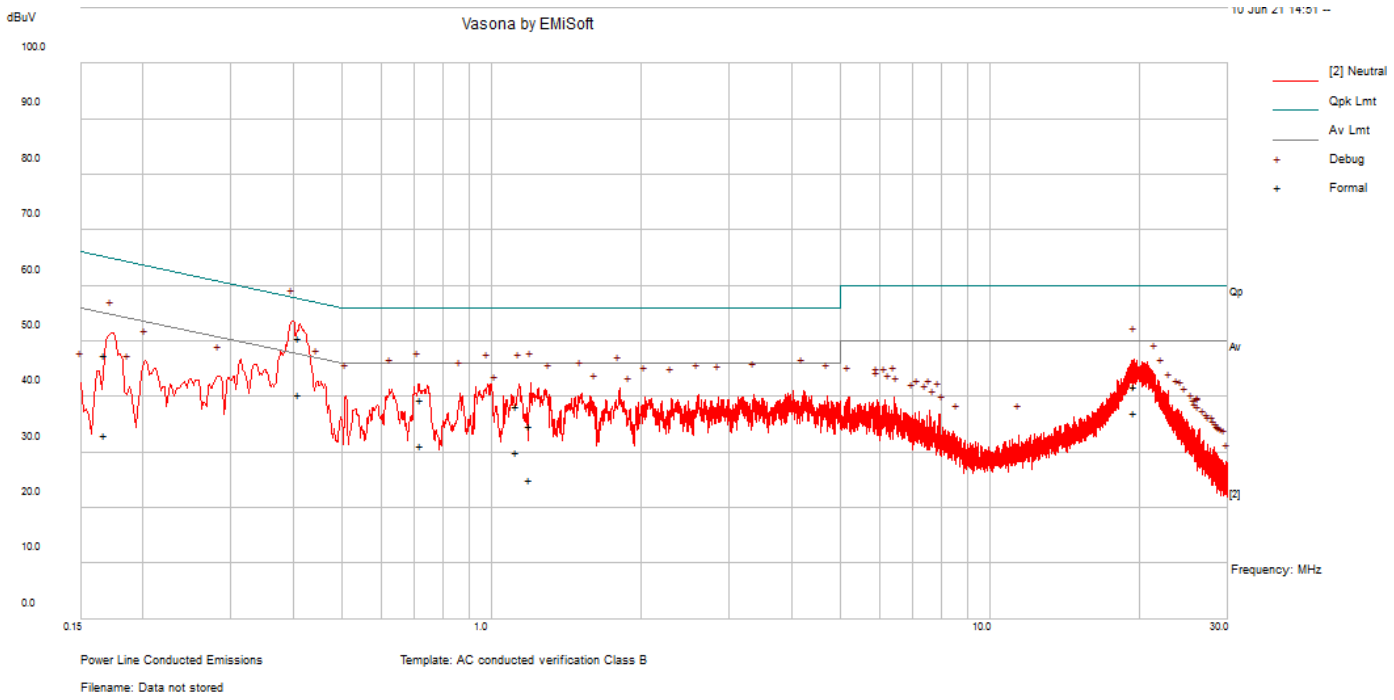
6.9 Conducted Emissions Test Plots and Data

120 V, 60 Hz – Line



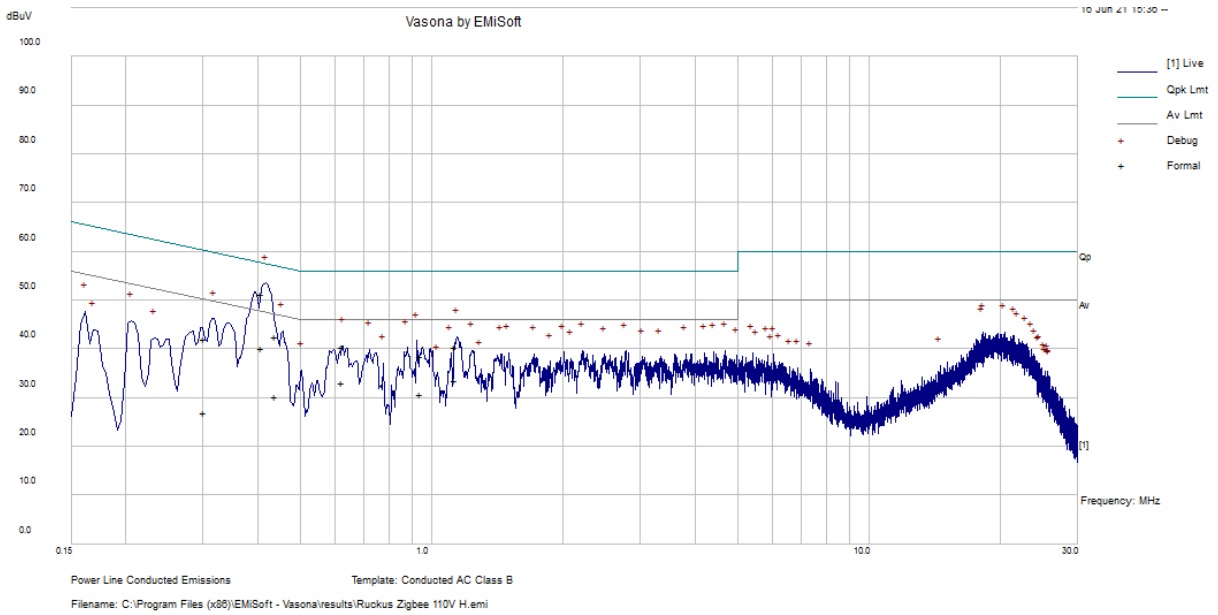
Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.40994	40.07	10.39	50.46	57.65	-7.19	QP
0.931881	27.61	10.12	37.73	56	-18.27	QP
1.121448	27.43	10.07	37.5	56	-18.5	QP
0.166831	37.33	10.7	48.03	65.12	-17.09	QP
0.462553	30.59	10.33	40.92	56.65	-15.73	QP
0.723116	29.34	10.19	39.53	56	-16.47	QP
0.40994	29.61	10.39	40	47.65	-7.65	Ave
0.931881	18.91	10.12	29.03	46	-16.97	Ave
1.121448	20.22	10.07	30.29	46	-15.71	Ave
0.166831	22.63	10.69	33.32	55.12	-21.79	Ave
0.462553	23.08	10.33	33.41	46.65	-13.24	Ave
0.723116	21.15	10.19	31.34	46	-14.66	Ave

120 V, 60 Hz – Neutral



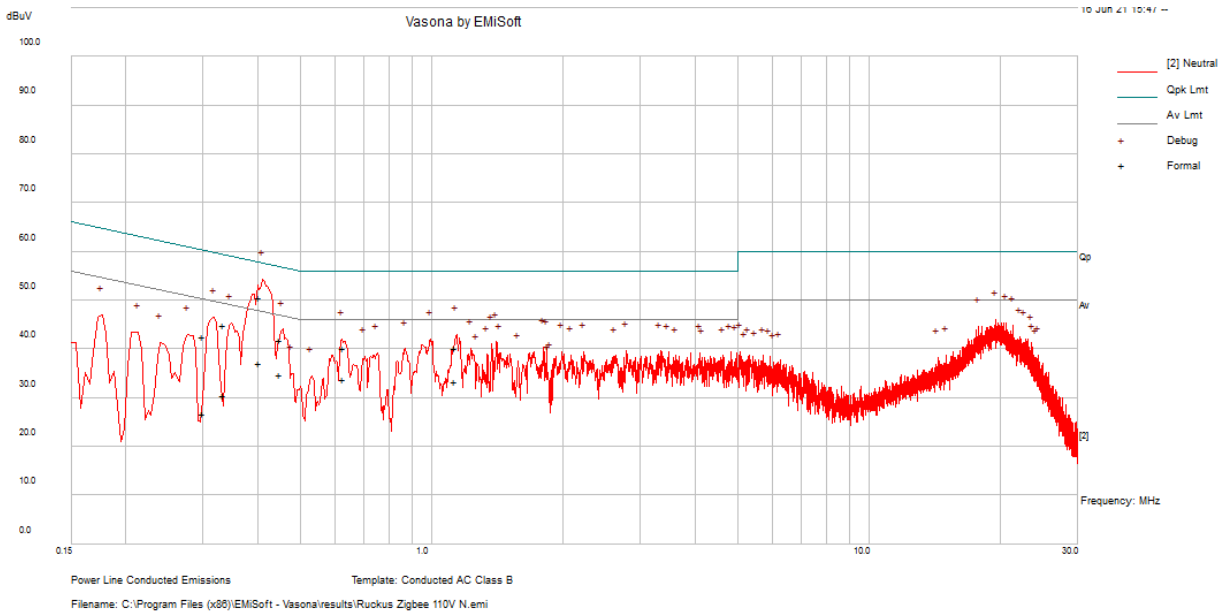
Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.410784	40.16	10.38	50.54	57.63	-7.09	QP
0.16722	36.69	10.69	47.38	65.1	-17.71	QP
19.494314	31.38	10.47	41.85	60	-18.15	QP
1.190851	24.65	10.05	34.7	56	-21.3	QP
0.723455	29.26	10.19	39.45	56	-16.55	QP
1.127154	28.13	10.07	38.2	56	-17.8	QP
0.410784	29.96	10.38	40.34	47.63	-7.29	Ave
0.16722	22.35	10.7	33.05	55.1	-22.05	Ave
19.494314	26.63	10.47	37.1	50	-12.9	Ave
1.190851	15.05	10.06	25.11	46	-20.89	Ave
0.723455	20.92	10.19	31.11	46	-14.89	Ave
1.127154	20.04	10.07	30.11	46	-15.89	Ave

110 V, 60 Hz – Line



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.408354	41.01	10.38	51.39	57.68	-6.3	QP
0.438433	32.21	10.35	42.56	57.09	-14.54	QP
1.132571	30.35	10.05	40.4	56	-15.6	QP
0.302402	31.57	10.51	42.08	60.18	-18.1	QP
0.941884	28.38	10.1	38.48	56	-17.52	QP
0.625364	30.24	10.22	40.46	56	-15.54	QP
0.408354	29.84	10.38	40.22	47.68	-7.46	Ave
0.438433	20.01	10.34	30.35	47.09	-16.74	Ave
1.132571	23.5	10.05	33.55	46	-12.45	Ave
0.302402	16.35	10.5	26.85	50.18	-23.32	Ave
0.941884	20.65	10.1	30.75	46	-15.25	Ave
0.625364	22.87	10.22	33.09	46	-12.91	Ave

110 V, 60 Hz – Neutral



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.404797	40.13	10.38	50.51	57.75	-7.24	QP
0.451411	31.47	10.33	41.8	56.85	-15.05	QP
1.130496	30.24	10.06	40.3	56	-15.7	QP
0.300656	32.02	10.51	42.53	60.22	-17.7	QP
0.334414	34.46	10.47	44.93	59.34	-14.41	QP
0.629265	30.07	10.22	40.29	56	-15.71	QP
0.404797	26.67	10.38	37.05	47.75	-10.7	Ave
0.451411	24.32	10.33	34.65	46.85	-12.2	Ave
1.130496	23.32	10.05	33.37	46	-12.63	Ave
0.300656	16.25	10.5	26.75	50.22	-23.47	Ave
0.334414	20.08	10.46	30.54	49.34	-18.8	Ave
0.629265	23.67	10.22	33.89	46	-12.11	Ave

7 FCC §15.209, §15.247(d), ISEDC RSS-247 §5.5, RSS-Gen §8.9, §8.10 & LP0002-2020 §3.5, §3.6, §3.7, & §3.9 - Spurious Radiated Emissions

7.1 Applicable Standards

As per FCC §15.35(b): 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 3332 – 3339 3345.8 – 3358 3600 – 4400	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 where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in the table below. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

General Field Strength Limits 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

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(d), 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.

As Per LP0002-2018 §3.5: Additional regulations shall apply except for this standard. The fundamental frequency of any low-power radio-frequency devices shall be restricted in any of the operation bands listed below; spurious emissions shall be permitted in any of frequency band listed below and shall meet the field strength requirement of 3.6:

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)
0.090 ~ 0.110	322.00 ~ 335.40	3500.0 ~ 4400.0
0.490 ~ 0.510	399.90 ~ 410.00	4500.0 ~ 5250.0
2.172 ~ 2.198	485.00 ~ 510.00	5350.0 ~ 5460.0
3.013 ~ 3.033	608.00 ~ 614.00	7250.0 ~ 7750.0
4.115 ~ 4.198	703.00 ~ 748.00	8025.0 ~ 8500.0
5.670 ~ 5.690	758.00 ~ 803.00	9000.0 ~ 9200.0
6.200 ~ 6.300	825.00 ~ 915.00	9300.0 ~ 9500.0
8.230 ~ 8.400	930.00 ~ 1240.0	10600 ~ 12700
12.265 ~ 12.600	1300.0 ~ 1427.0	13250 ~ 13400
13.340 ~ 13.430	1435.0 ~ 1626.5	14470 ~ 14500
14.965 ~ 15.020	1660.0 ~ 1785.0	15350 ~ 16200

16.700 ~ 16.755	1805.0 ~ 1880.0	17700 ~ 21400
19.965 ~ 20.020	1885.0 ~ 1900.0	22010 ~ 23120
25.500 ~ 25.700	1905.0 ~ 1985.0	23600 ~ 24000
37.475 ~ 38.275	2010.0 ~ 2025.0	31200 ~ 31800
73.500 ~ 75.400	2110.0 ~ 2170.0	36430 ~ 36500
108.00 ~ 138.00	2200.0 ~ 2300.0	38600 +
149.90 ~ 150.05	2310.0 ~ 2390.0	
156.70 ~ 156.90	2483.5 ~ 2900.0	
162.01 ~ 167.17	3260.0 ~ 3267.0	
167.72 ~ 173.20	3332.0 ~ 3339.0	
240.00 ~ 285.00	3345.8 ~ 3358.0	)

As Per LP0002-2018 §3.6: Additional regulations shall applyexcept for this standard, the emissions from the low-power radio-frequency devices shall be less than or equal the field strength levels specified in the following table and the level of any unwanted emissions shall not exceed the level of the fundamental emission.

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 ≤ f ≤ 0.490	2400/Freq.(kHz)	300
0.490 < f ≤ 1.705	24000/Freq.(kHz)	30
1.705 < f ≤ 30.0	30	30
30 ≤ f ≤ 88	100	3
88 < f ≤ 216	150	3
216 < f ≤ 960	200	3
960 < f	500	3

As Per LP0002-2018 §3.7: The field strength radio frequency 9-90 kHz, 110-490 kHz and 1000 MHz above stipulated in the above table shall be measured according to an average detector and comply with Section 6.15.2, while others shall be measured using a CISPR quasi-peak detector. Those not specified above shall comply with Section 6.5 and the frequency bands measurement of radiated emission shall accord with Section 6.14.

As Per LP0002-2018 §3.9: If the transmitter and receiver of the low-power radio-frequency device are sold in one set, the corresponding type approval review documents shall be submitted; otherwise the transmitter and receiver should be applied for approval together. The receiver radiated field strength must not exceed the emission specified in Section 3.6 and the receiver shall not receive, demodulate frequency listed in Section 3.5.

7.2 Test Setup

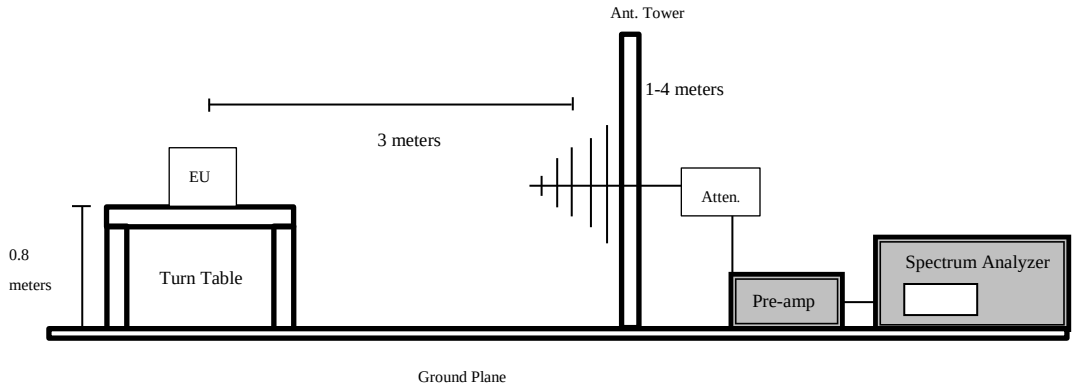
The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the FCC 15 Subpart C, ISEDC RSS-247 & LP0002-2020 limits.

The spacing between the peripherals was 10 centimeters.

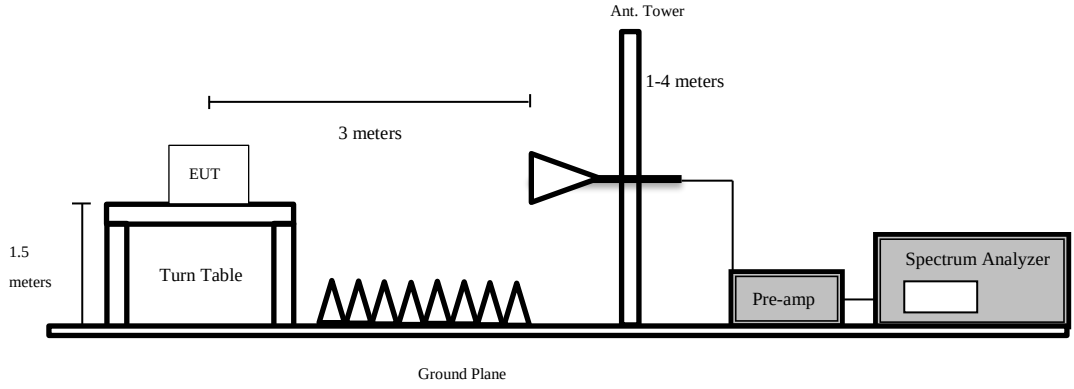
External I/O cables were draped along the edge of the test table and bundle when necessary.

7.3 Test Setup Block Diagrams

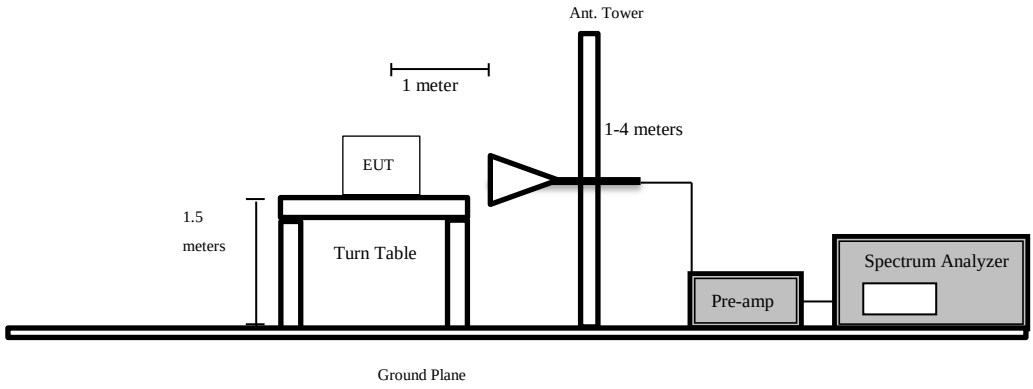
Test Setup for Below 1 GHz at 3 meters



Test Setup for Above 1 GHz at 3 meters



Test Setup for Above 1 GHz at 1 meter



7.4 Test Procedure

The EUT host, and all support equipment power cords were connected to the AC floor outlet.

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

For radiated testing 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's polarity should be changed between horizontal and vertical.

The spectrum analyzer or receiver was set as:

Below 1000 MHz:

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

Above 1000 MHz:

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

7.5 Corrected Amplitude and 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:

$$Margin = Corrected\ Amplitude – Limit$$

7.6 Test Equipment List and Details

Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4446A	MY48250238	2021-02-12	1 year
Rhode & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100044	2021-05-14	2 years
BACL	5m3 Sensitivity Box	1	2	2020-10-27	1 year
Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
Sunol Sciences	Biconilog Antenna	JB3	A020106-2	2019-11-20	2 years
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2.5 years
Wisewave	Antenna, Horn	ARH-2823-02	10555-01	2020-02-05	2 years
-	SMA cable	-	-	Each time[1]	N/A
IW Incorporated	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1571AN-3960-KPS	DC 1917	2021-03-03	1 year
IW Incorporated	157 Series Cable Armored with 2.92mm Male Plugs on Both Sides	KPS-1571AN-2400	DC 1922	2020-06-06	18 months
MDP Digital	Times Microwave LMR 400 UltraFex Coaxial Cable 35'	LMR400UF	BACL1904161	2020-05-20	18 months
Agilent	Preamplifier	8449B	3147A00400	2021-03-02	1 year
AH Systems	Pre-Amplifier	PAM 1840 VH	170	2020-11-09	1 year
HP	Pre Amplifier	8447D	2443A04374	2020-08-17	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Note[1]: cables and notch filter 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 Rita Yang from 2021-05-18 to 2021-06-07 in 5m chamber 3.

7.8 Summary of Test Results

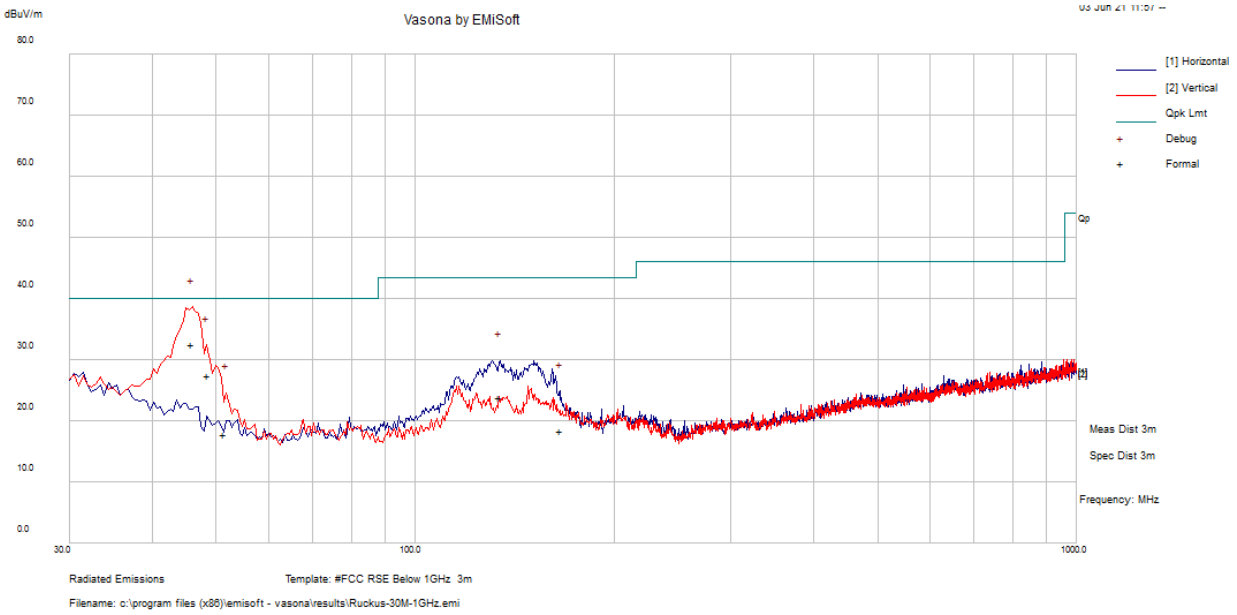
According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C, ISEDC RSS-247 and LP0002-2020 §3.6 standards' radiated emissions limits, and had the worst margin of:

Mode: Transmitting		
Margin (dB)	**Frequency (MHz)**	**Measurement, Channel**
-4.11	4950	Ave, High Channel

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

7.9 Spurious Emissions Test Results

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



Frequency (MHz)	Raw (dBuV)	Correction Factor (dB)	Level (dBuV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
45.95	41.65	-9.12	32.53	113	V	35	40	-7.47	Pass
48.648	37.71	-10.29	27.41	107	V	169	40	-12.59	Pass
134.2598	28.64	-4.79	23.84	210	H	41	43.5	-19.66	Pass
51.3585	28.86	-10.99	17.88	118	V	135	40	-22.12	Pass
165.6052	24.54	-6.13	18.41	203	H	164	43.5	-25.09	Pass

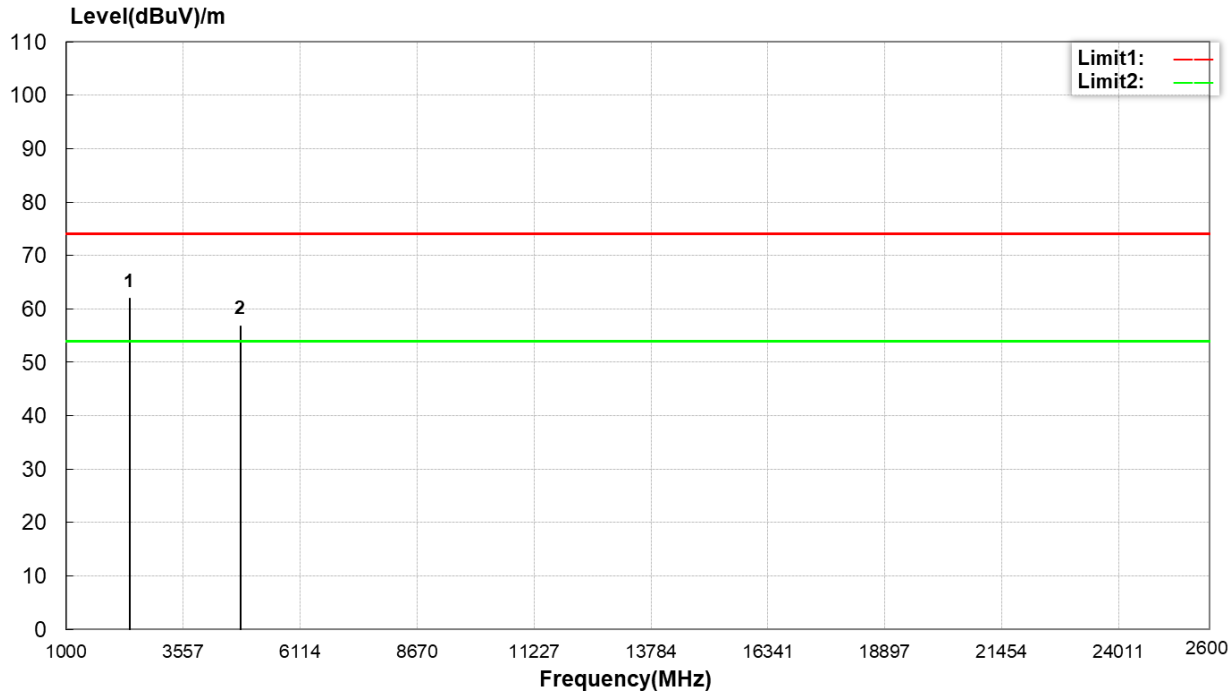
2) 1–18 GHz Measured at 3 meters

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC/ISEDC/LP0002-2020		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2405 MHz											
2390	61.25	230	150	H	32.6	4.913	36.863	61.90	74	-12.10	Peak
2390	57.45	170	130	V	32.6	4.913	36.863	58.10	74	-15.90	Peak
2390	43.25	230	150	H	32.6	4.913	36.863	43.90	54	-10.10	Ave
2390	40.18	170	130	V	32.6	4.913	36.863	40.83	54	-13.17	Ave
4810	49.18	230	100	H	35	8.336	35.707	56.81	74	-17.19	Peak
4810	48.84	244	101	V	35	8.336	35.707	56.47	74	-17.53	Peak
4810	41.16	230	100	H	35	8.336	35.707	48.79	54	-5.21	Ave
4810	40.28	244	101	V	35	8.336	35.707	47.91	54	-6.09	Ave
Middle Channel 2440 MHz											
4880	48.23	240	110	H	35.3	8.336	35.707	56.159	74	-17.841	Peak
4880	47.85	240	110	V	35.3	8.336	35.707	55.779	74	-18.221	Peak
4880	38.83	240	110	H	35.3	8.336	35.707	46.762	54	-7.238	Ave
4880	38.11	240	110	V	35.3	8.336	35.707	46.039	54	-7.961	Ave
High Channel 2475MHz											
2483.5	56.20	220	125	H	33	4.913	36.863	57.25	74	-16.75	Peak
2483.5	54.59	50	140	V	33	4.913	36.863	55.64	74	-18.36	Peak
2483.5	45.25	220	125	H	33	4.913	36.863	46.30	54	-7.70	Ave
2483.5	44.10	50	140	V	33	4.913	36.863	45.15	54	-8.85	Ave
4950	50.35	240	130	H	35.4	8.336	35.707	58.38	74	-15.62	Peak
4950	49.94	180	170	V	35.4	8.336	35.707	57.97	74	-16.03	Peak
4950	41.86	240	130	H	35.4	8.336	35.707	49.89	54	-4.11	Ave
4950	40.84	180	170	V	35.4	8.336	35.707	48.87	54	-5.13	Ave

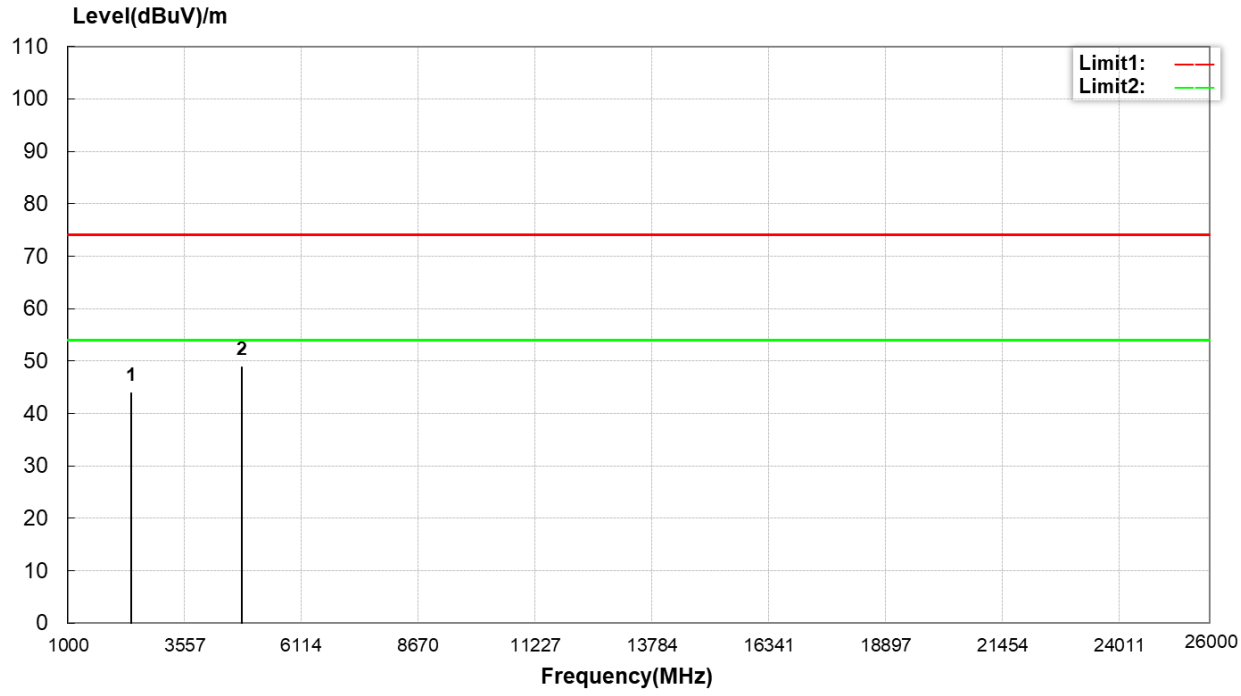
Low channel

Horizontal

Peak

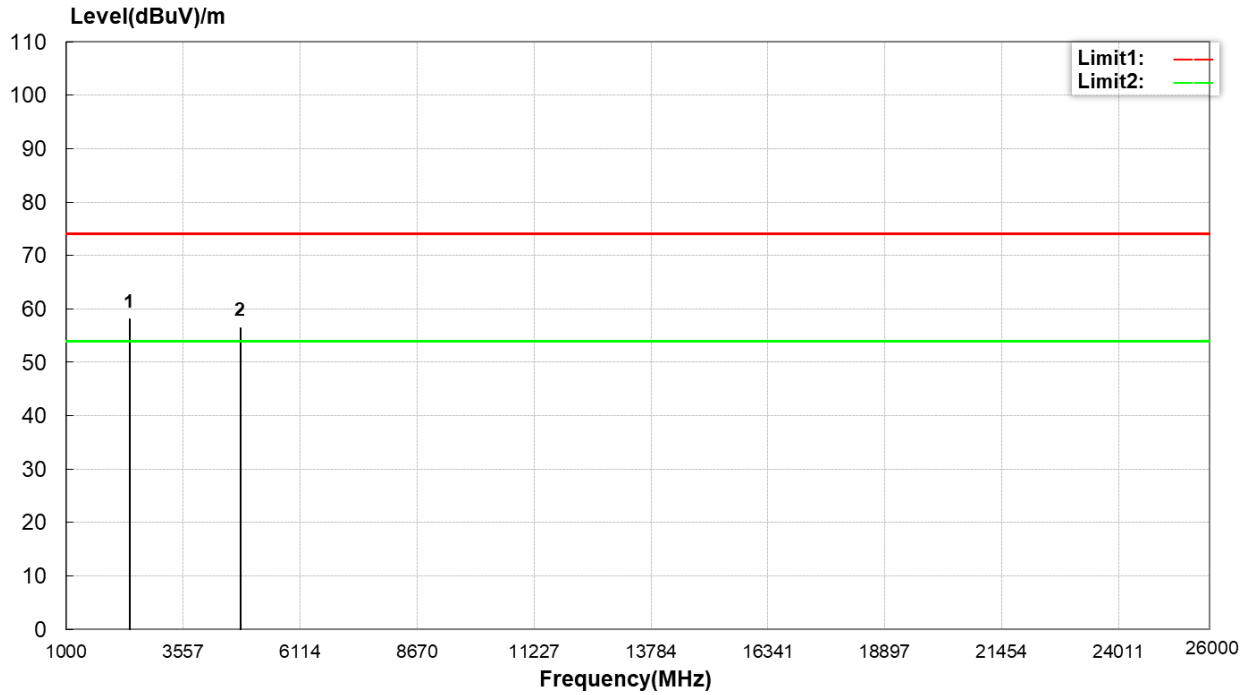


Ave.

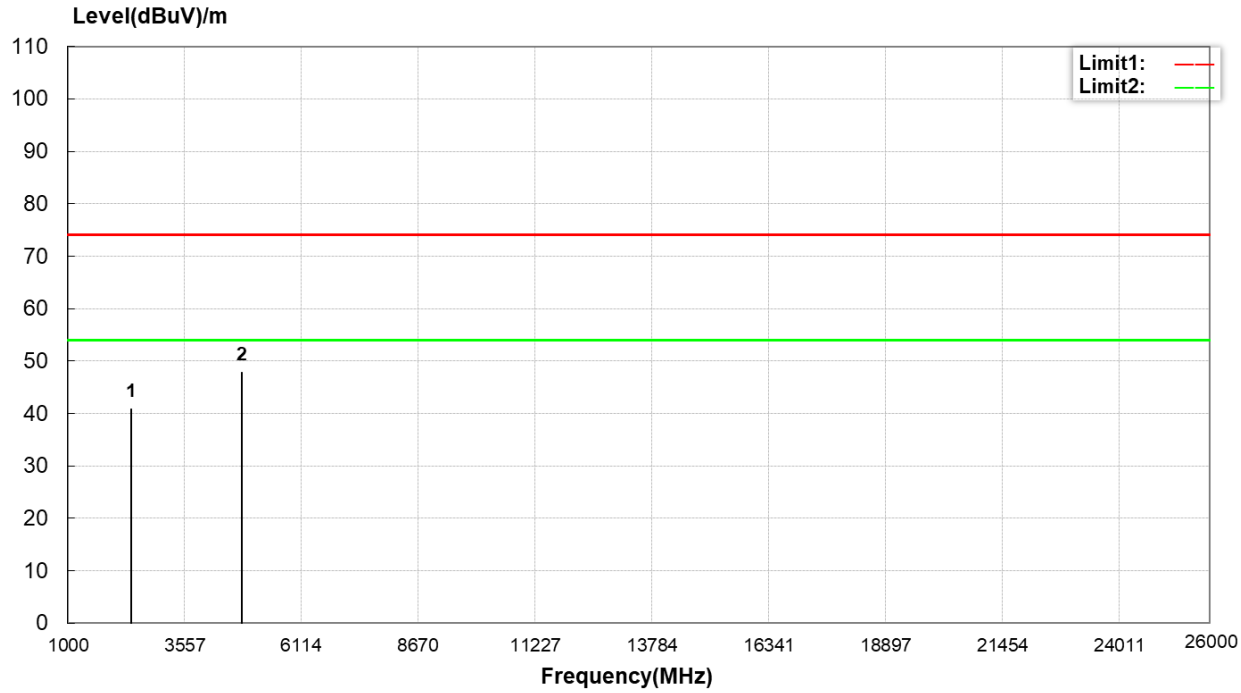


Vertical

Peak



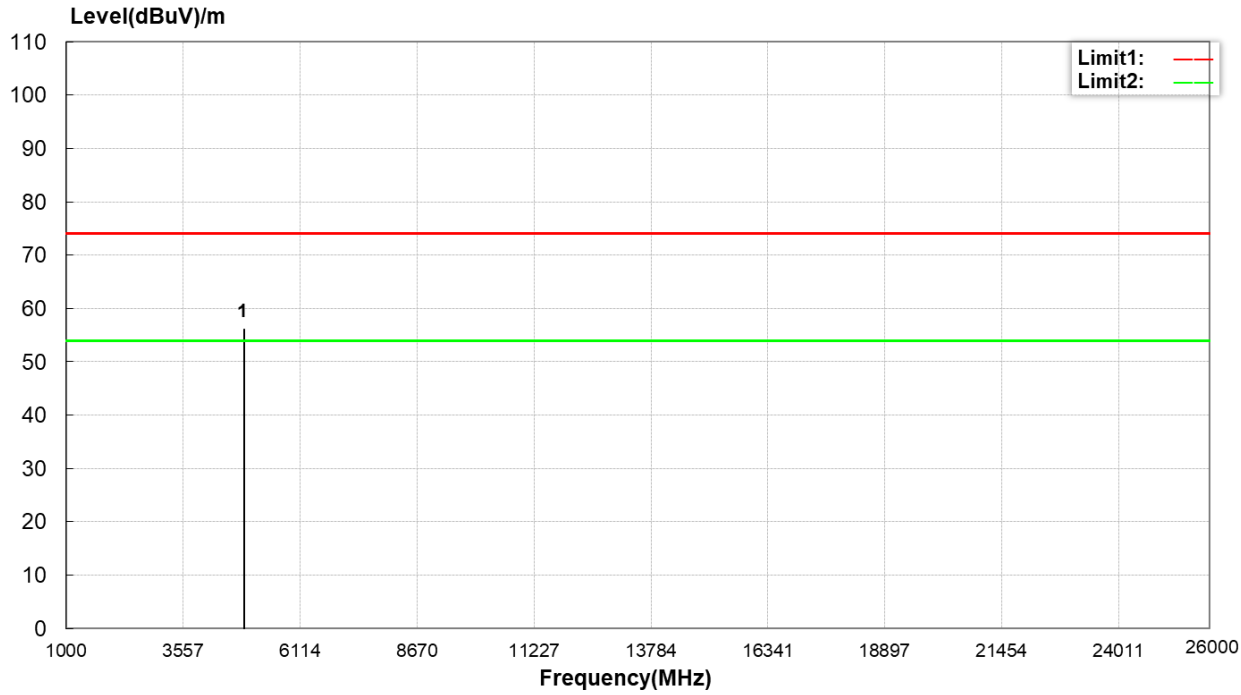
Ave.



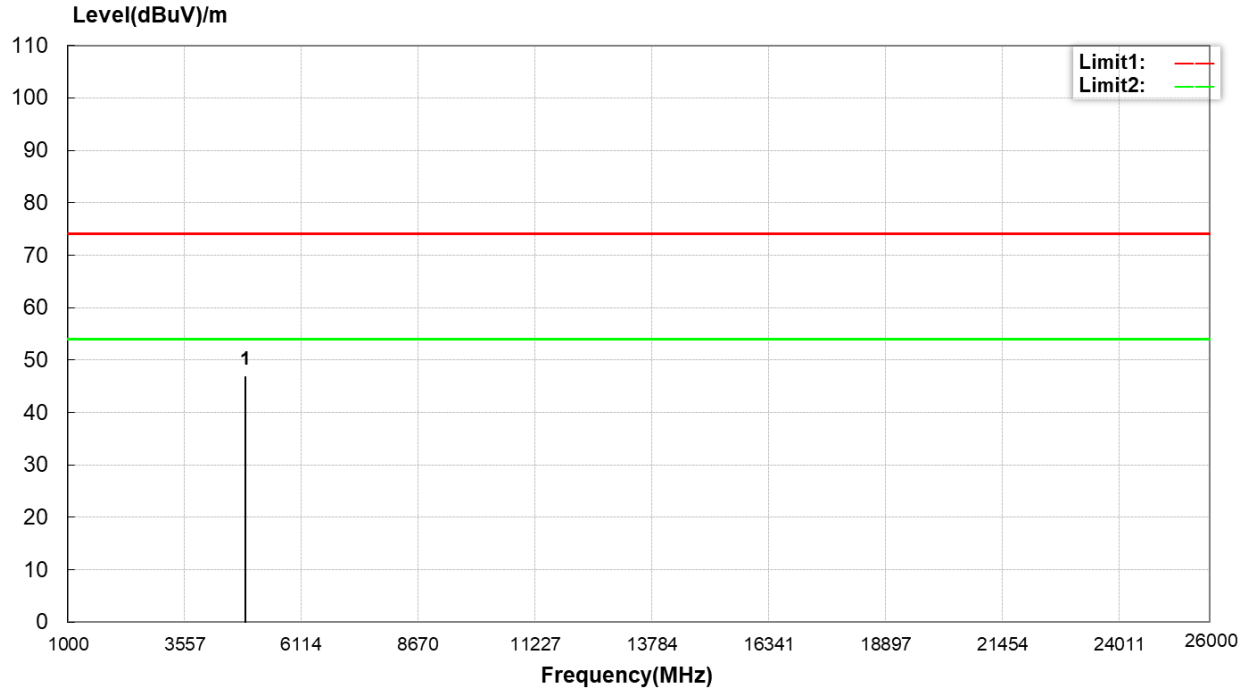
Mid channel

Horizontal

Peak

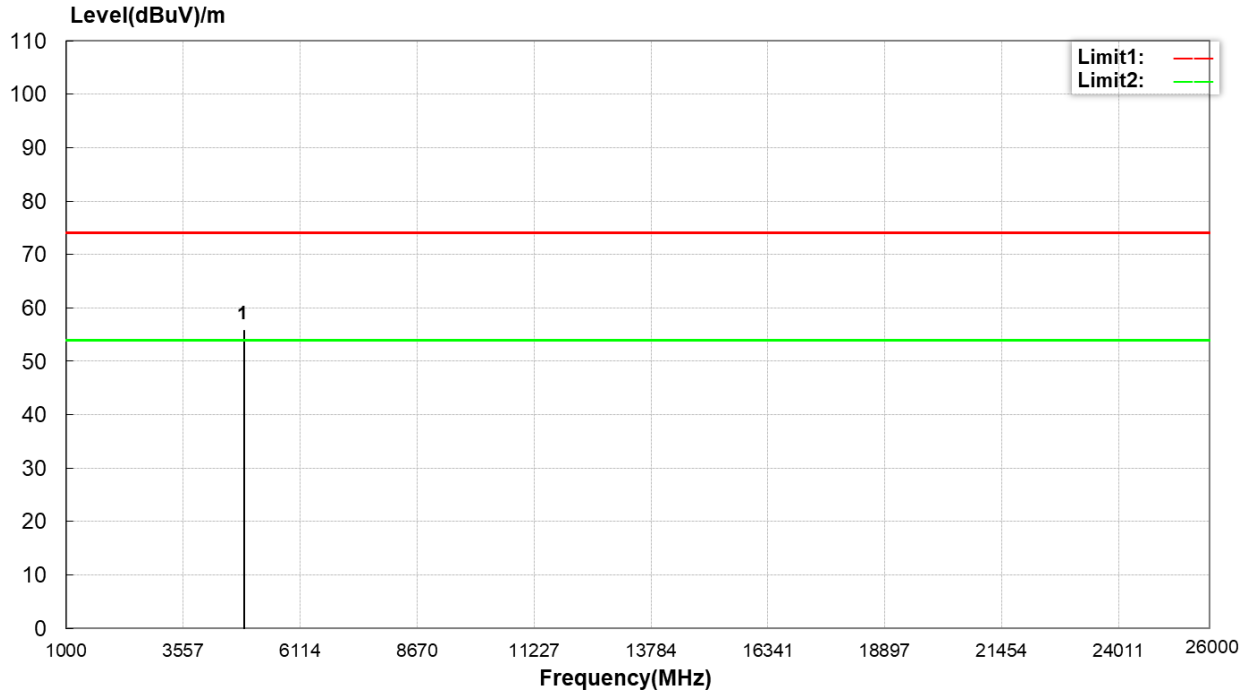


Ave.

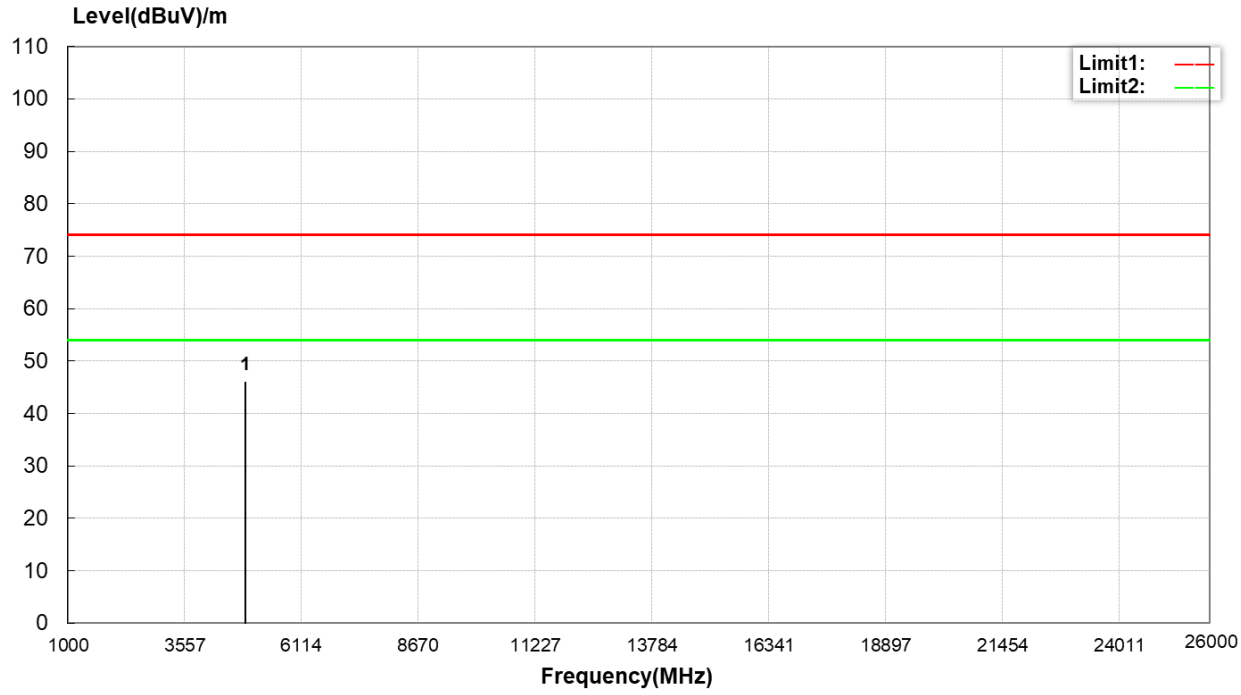


Vertical

Peak



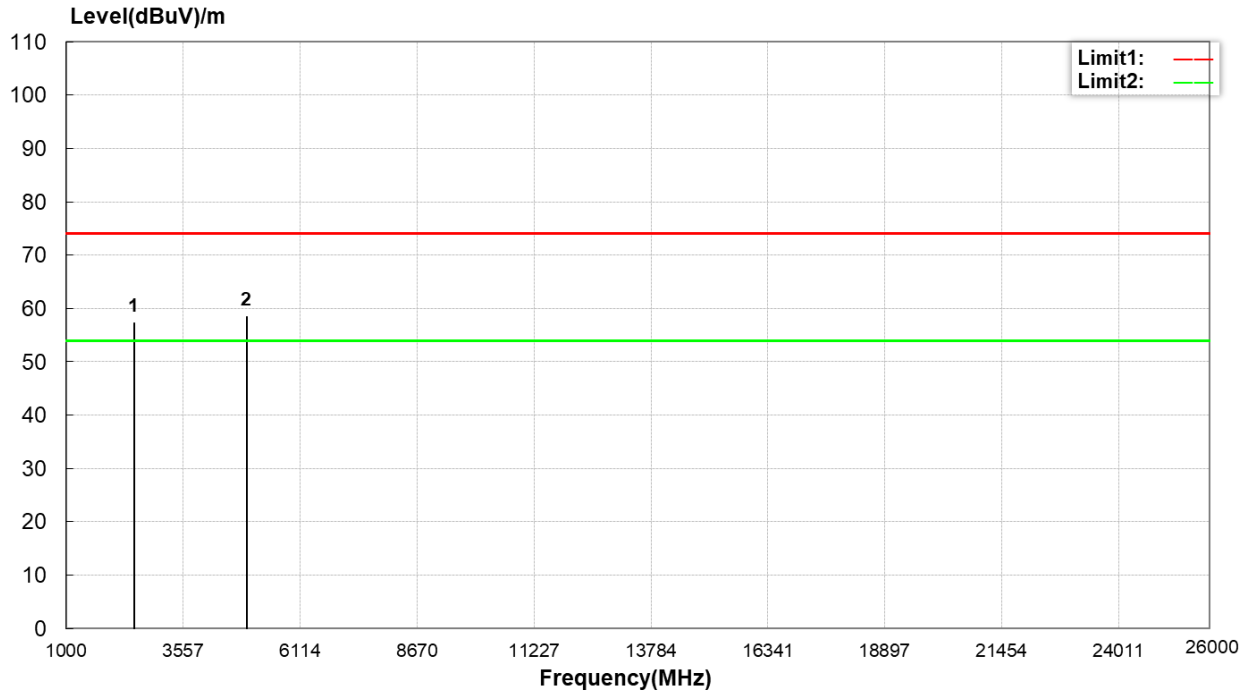
Ave.



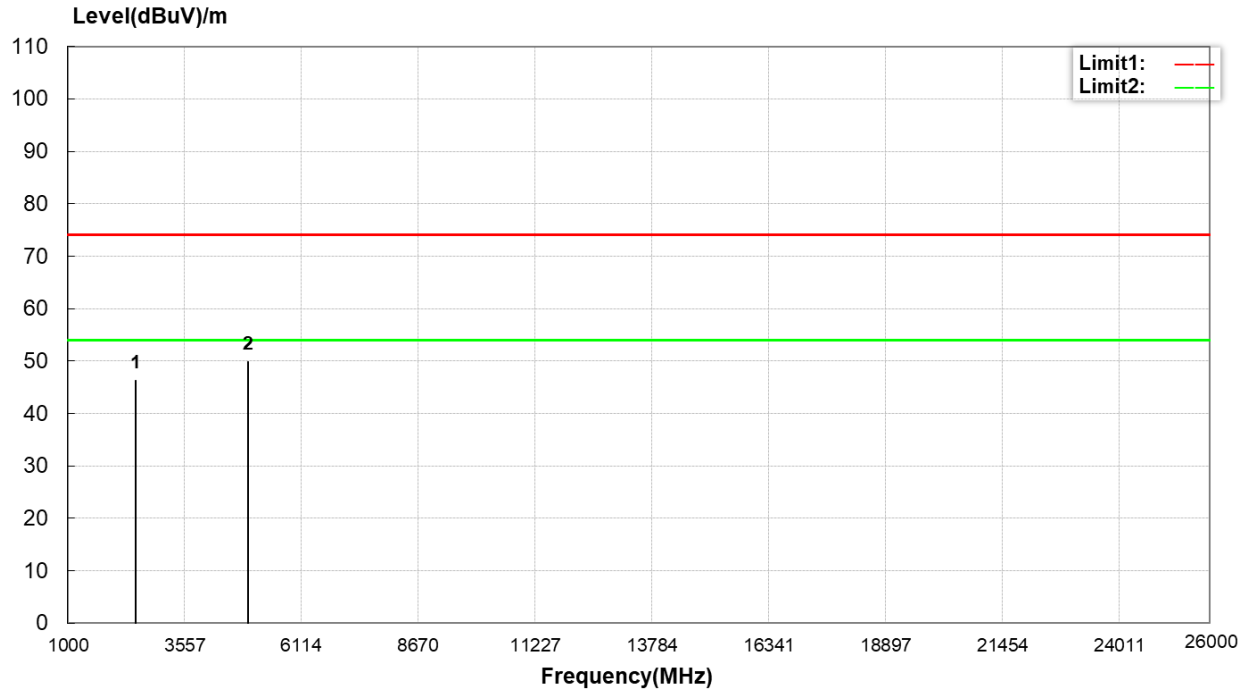
High channel

Horizontal

Peak

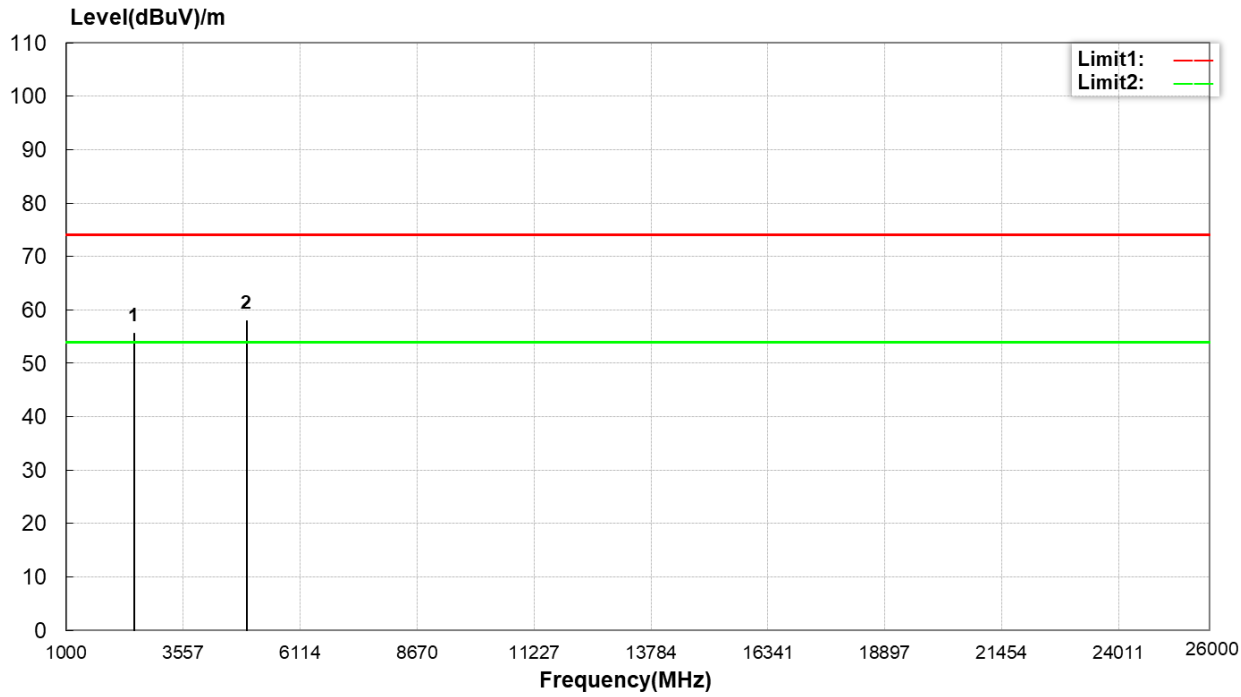


Ave.

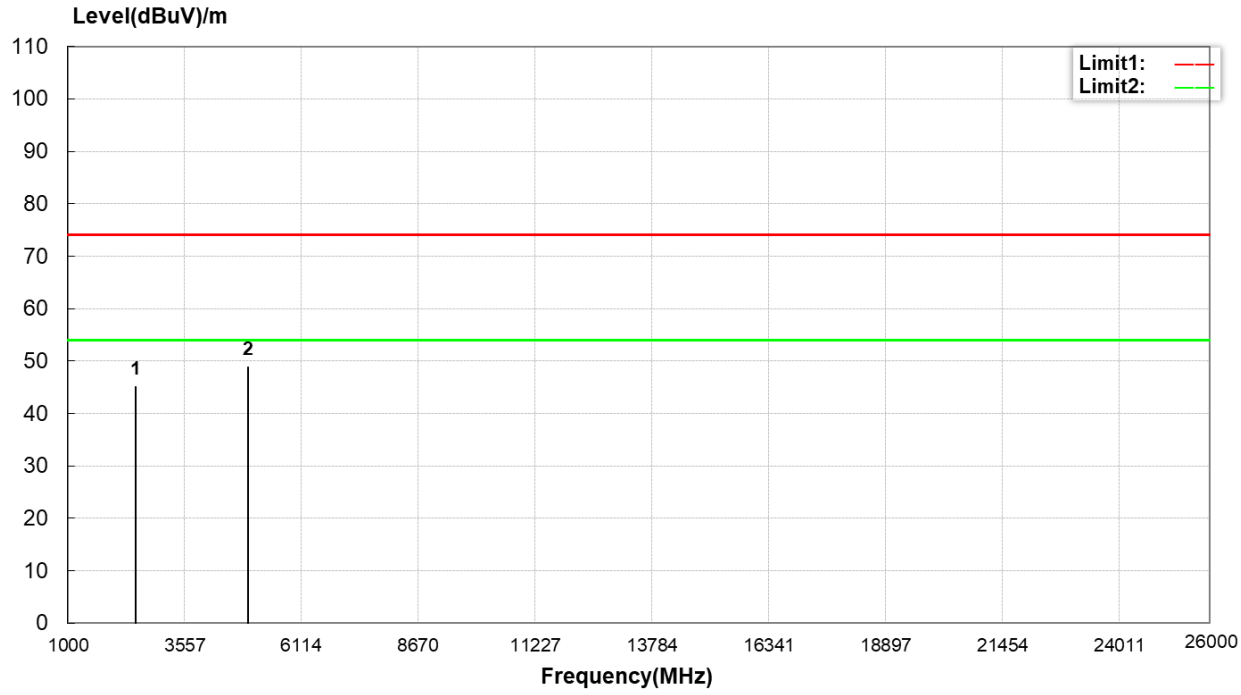


Vertical

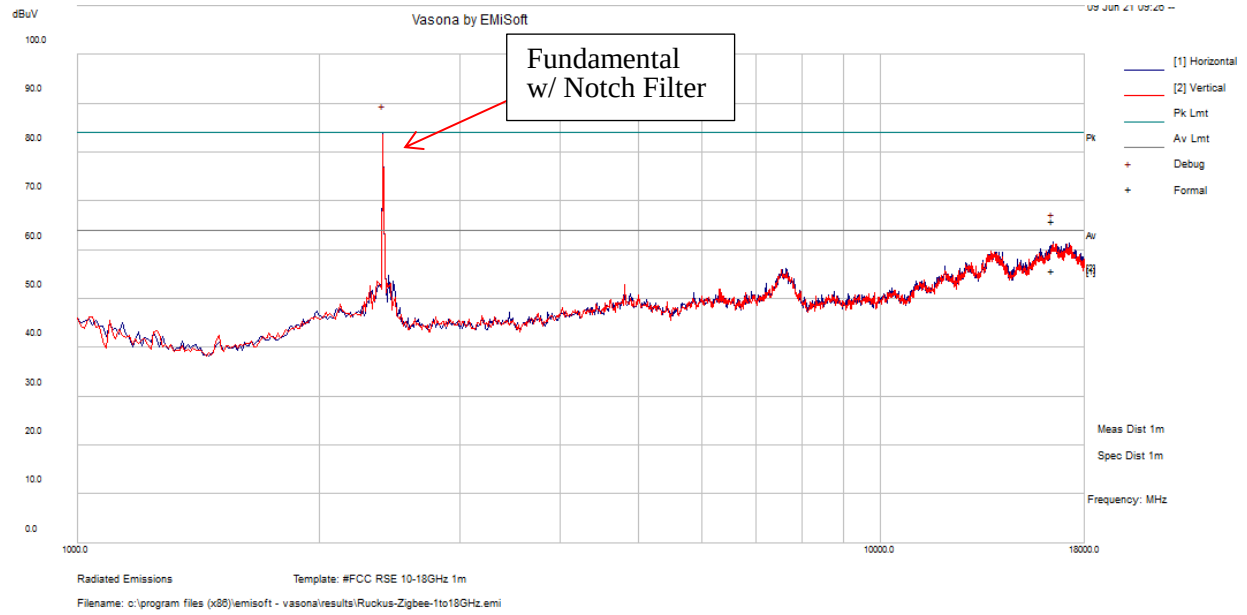
Peak



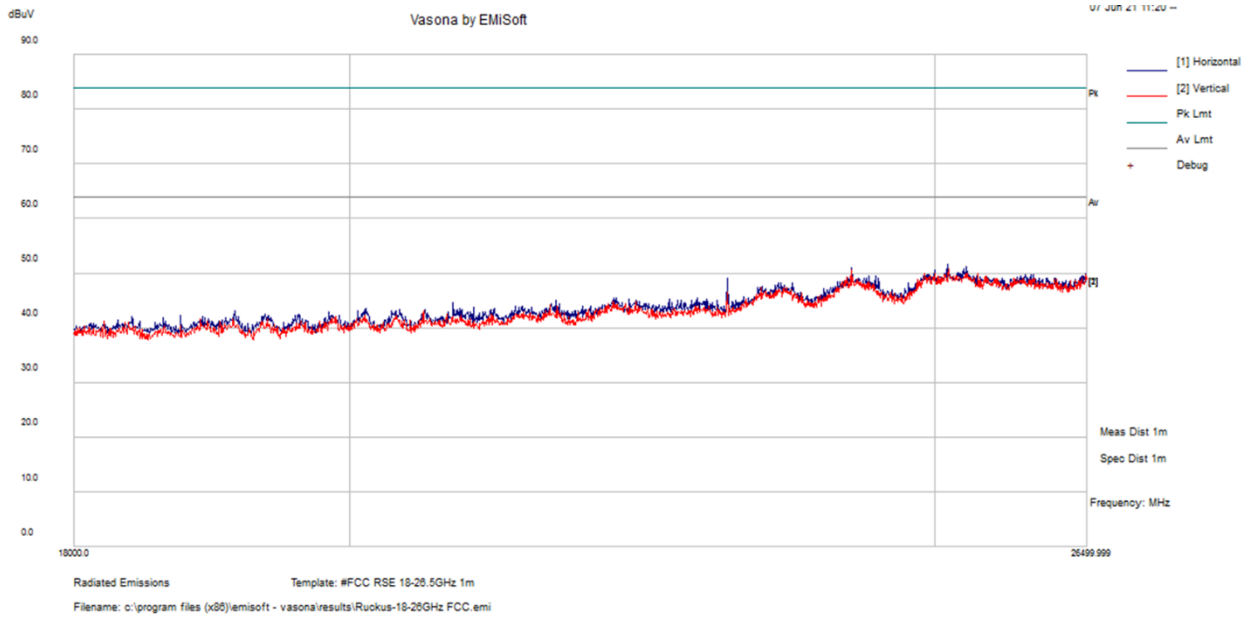
Ave.



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



4) 18-26GHz Worst Case, Measured at 1 meter



7.10 Rx Radiated Emissions Test Results

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	LP0002-2020		Note
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
ZigBee Receiver											
830	30.45	0	100	H	27.5	1.98	30.194	37.2	46	-8.8	Peak
830	30.86	0	100	V	27.5	1.98	30.194	34.69	46	-11.31	Peak
1500	49.84	0	100	H	28	4.136	37.589	45.4	54	-8.6	Peak
1500	49.77	0	100	V	28	4.136	37.589	46.09	54	-7.91	Peak

Note: the peak measurements were recorded and compared with QP (below 1 GHz) and Average (above 1 GHz) limits.

8 FCC §15.247(a) (2), ISEDC RSS-247 §5.2 & LP0002-2020 §4.10.1.6(2)(A) - Emission Bandwidth

8.1 Applicable Standards

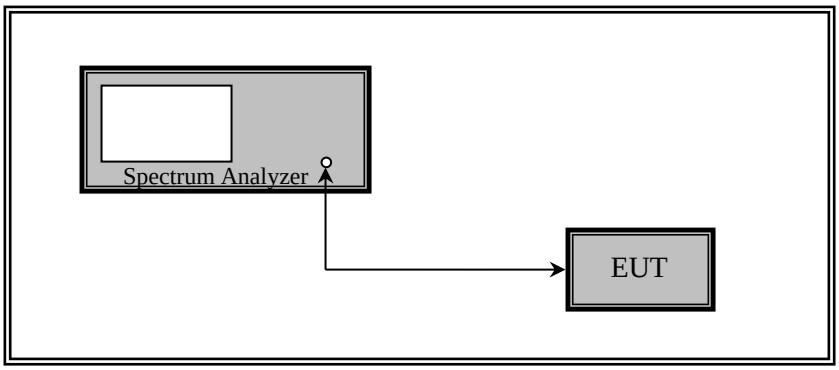
According to ECFR §15.247(a) (2), ISEDC RSS-247 §5.2(a) & LP0002-2020 §4.10.1.6(2)(A), systems using digital modulation techniques may operate in the 902~928 MHz, 2400~2483.5 MHz, and 5725~5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz

8.2 Measurement Procedure

The 6 dB bandwidth, i.e., DTS bandwidth, measurements were 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 8.2: DTS bandwidth.

The 99% occupied bandwidth was measured in accordance with IC RSS-Gen Issue 5, Section 6.7.

8.3 Test Block Diagram



8.4 Test Equipment List and Details

Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer 46GHz	E4446A	US44300386	2021-04-27	12 Months
-	RF Cable	-	-	Each time[1]	N/A

Note[1]: Equipment was calibrated for each test.
***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 Rita Yang from 2021-05-18 to 2020-05-20 in RF site.

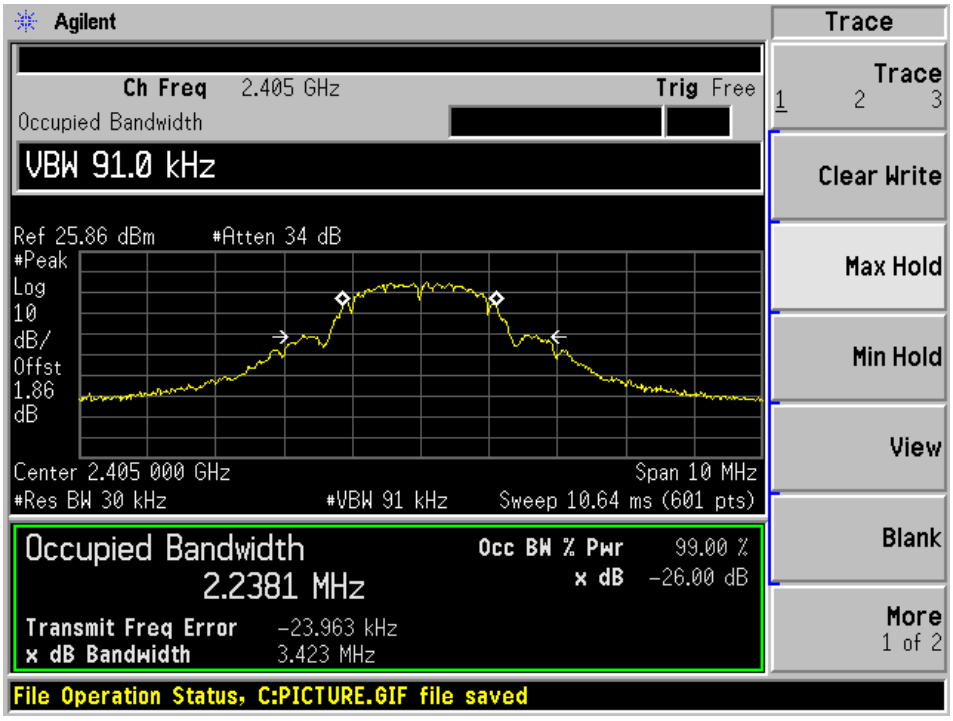
8.6 Test Results

99% and 6 dB Bandwidth

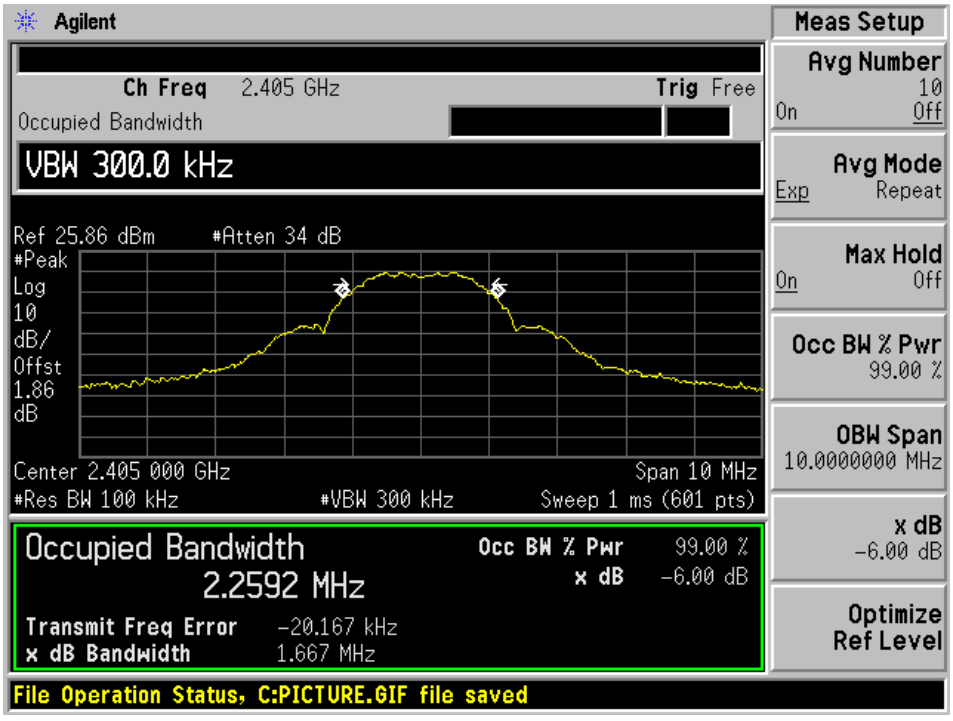
Mode	Channel	Frequency (MHz)	99% OBW (MHz)	6 dB BW (kHz)	6 dB BW limit (kHz)
ZigBee	Low	2405	2.2381	1667	>500
	Middle	2440	2.2429	1668	>500
	High	2475	2.2412	1667	>500

Please refer to the following plots.

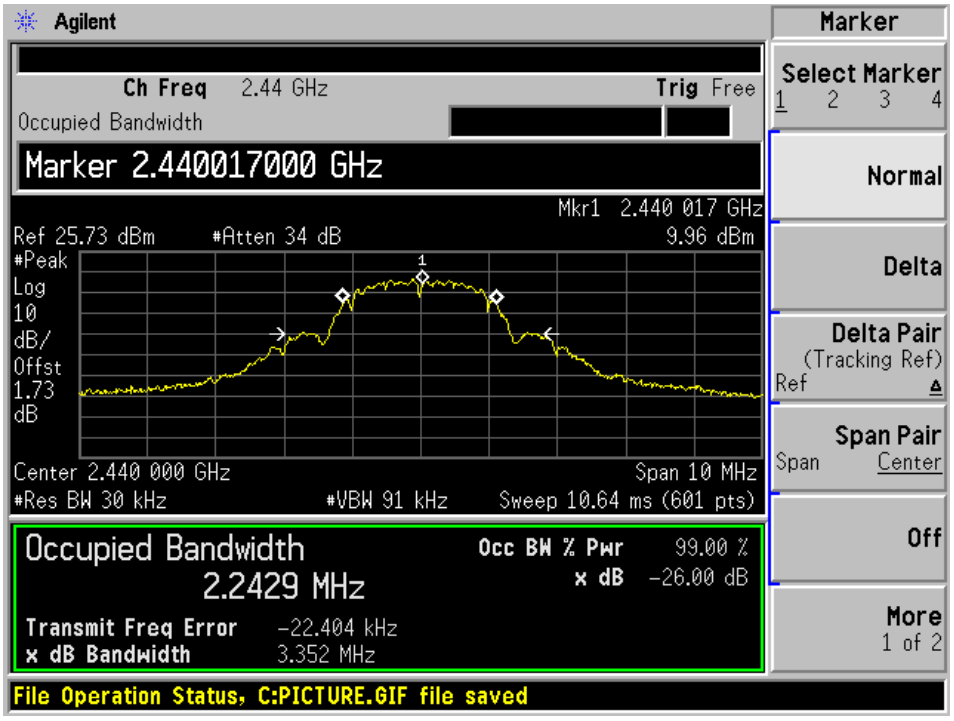
2405 MHz 99% OBW



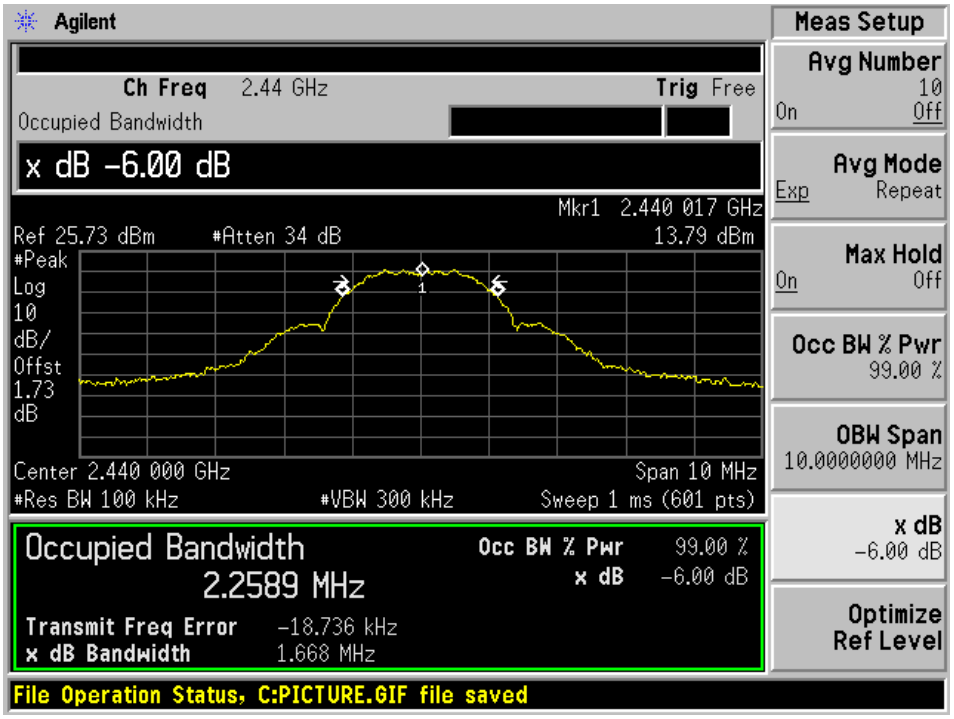
2405 MHz 6 dB OBW



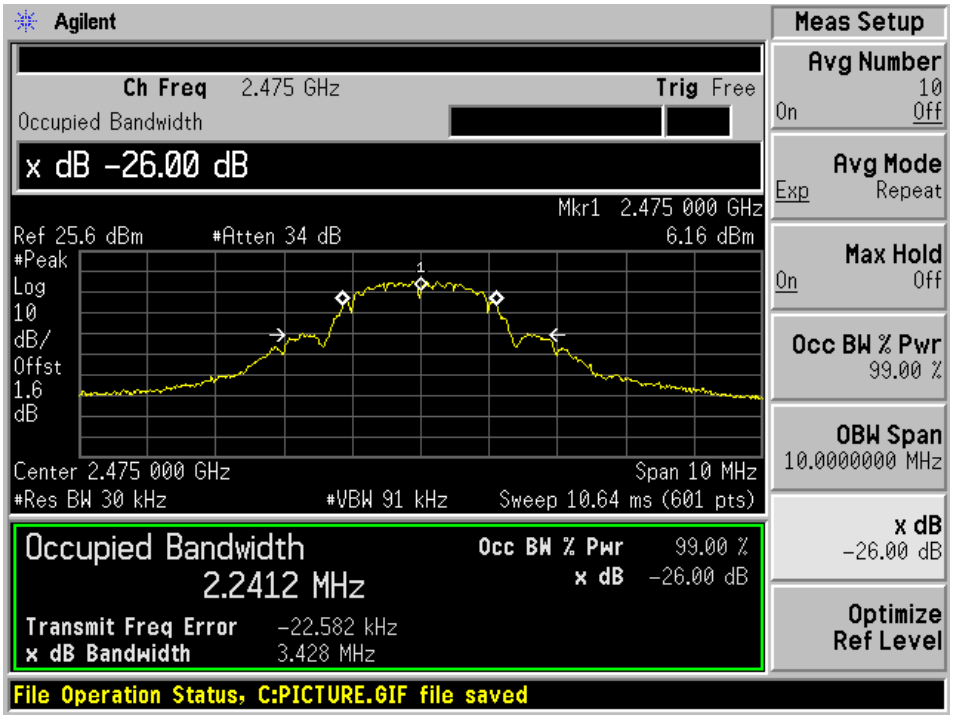
2440 MHz 99% OBW



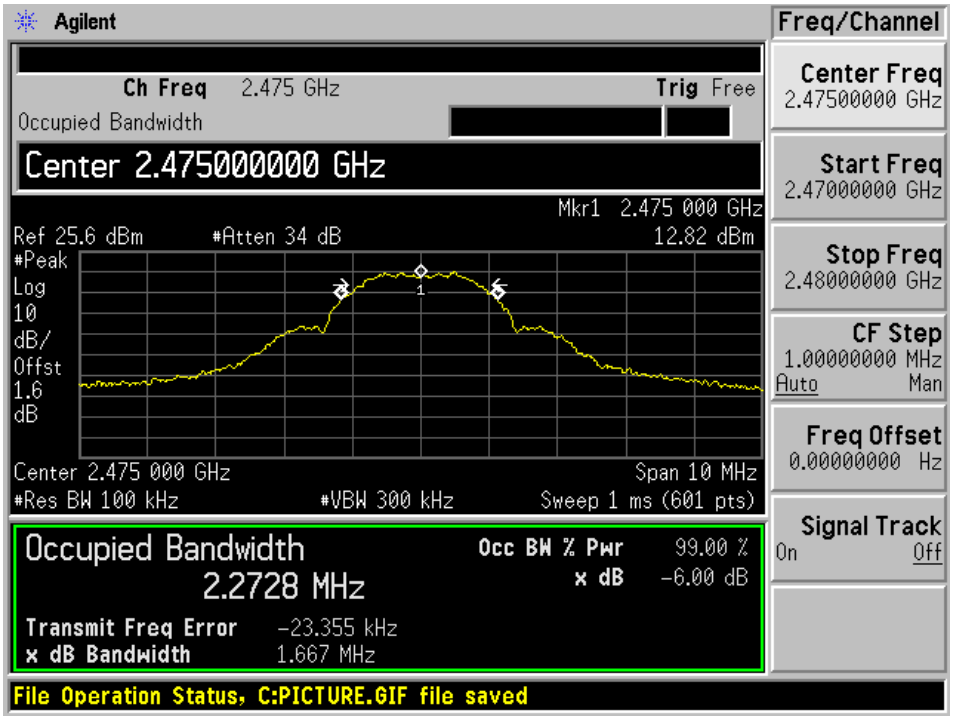
2440 MHz 6 dB OBW



2475 MHz 99% OBW



2475 MHz 6 dB OBW



9 FCC §15.247(b) (3), ISEDC RSS-247 §5.4 (4) & LP0002-2020 §4.10.1.2 - Output Power Measurement

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.

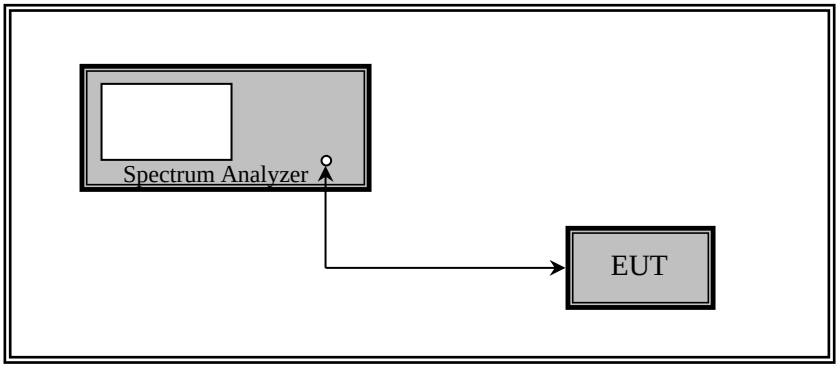
According to RSS-247 §5.4(d): For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

According to LP0002-2020 §4.10.1.2, for systems using digital modulation: below 1 Watt(inclusive).

9.2 Measurement Procedure

The measurements were 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 8.3: DTS fundamental emission output power.

9.3 Test Block Diagram



9.4 Test Equipment List and Details

Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer 46GHz	E4446A	US44300386	2021-04-27	12 Months
-	RF Cable	-	-	Each time[1]	N/A

Note[1]: Equipment 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

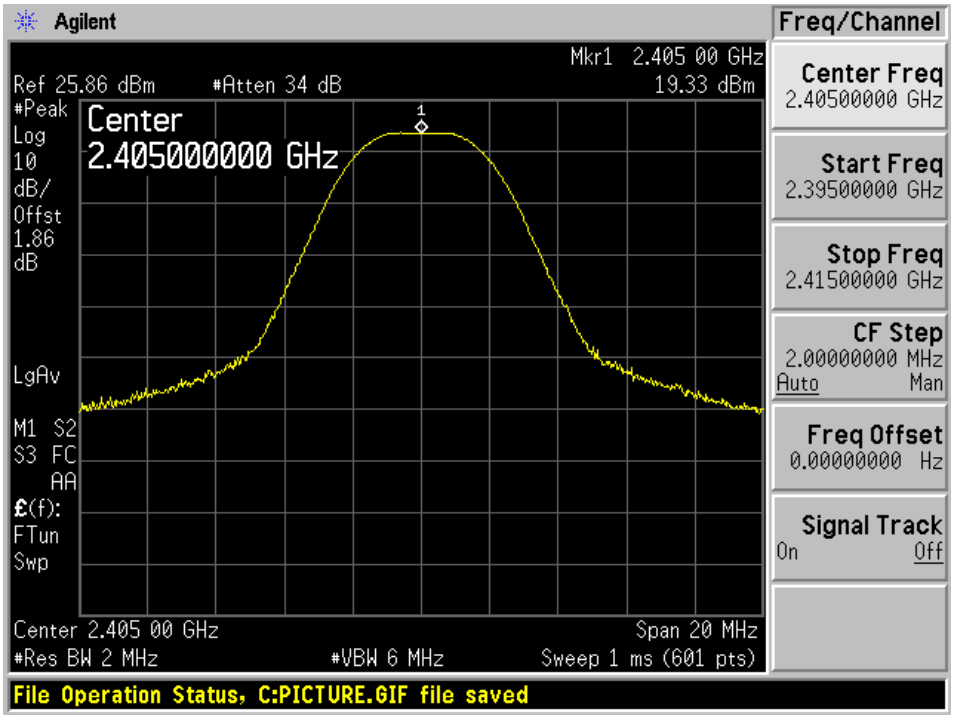
The testing was performed by Rita Yang on 2021-05-18 in RF site.

9.6 Test Results

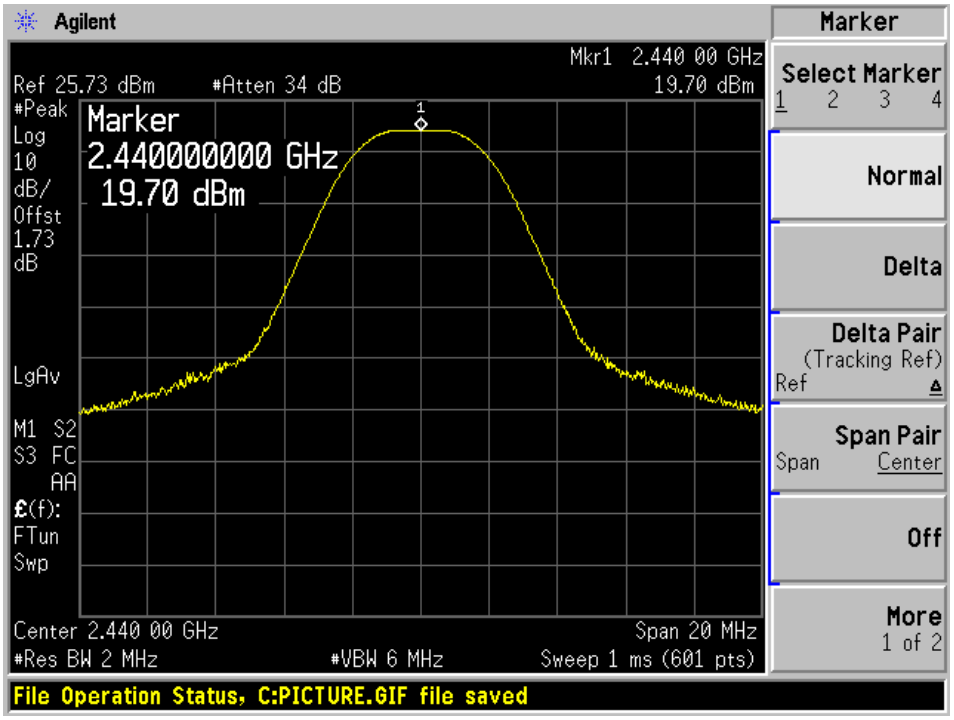
Channel	Frequency (MHz)	Conducted Peak Power (dBm)	Limit (dBm)
Low	2405	19.33	30
Middle	2440	19.70	30
High	2475	19.74	30

Please refer to the following plots.

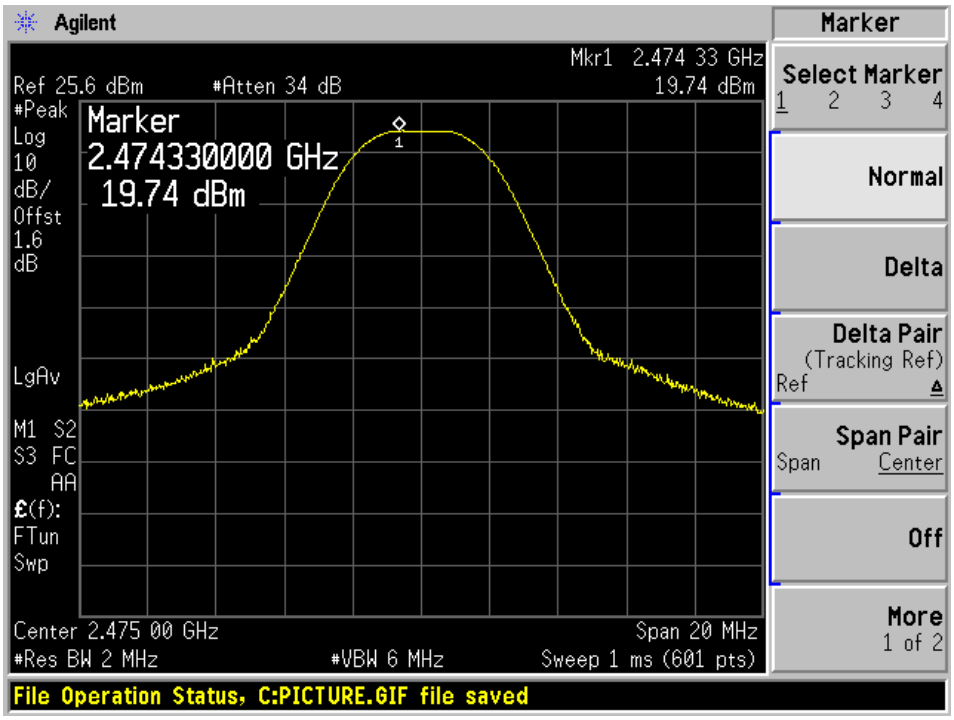
2405 MHz



2440 MHz



2475 MHz


Agilent
Marker
Mkr1 2.474 33 GHz
Ref 25.6 dBm
#Atten 34 dB
19.74 dBm
#Peak
Log
10
dB/
Offst
1.6
dB
Marker
2.474330000 GHz
19.74 dBm
LgAv
M1 S2
S3 FC
AA
£(f):
FTun
Swp
Center 2.475 00 GHz
#Res BW 2 MHz
#VBW 6 MHz
Span 20 MHz
Sweep 1 ms (601 pts)
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref
Span Pair
Span Center
Off
More
1 of 2
File Operation Status, C:PICTURE.GIF file saved

10 FCC FCC §15.247(d), ISEDC RSS-247 §5.5 & LP0002-2020 §4.10.1.5 – 100 kHz Bandwidth of Band Edges

10.1 Applicable Standards

According to FCC §15.247(d), in any 100 kHz bandwidth outside the frequency 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)).

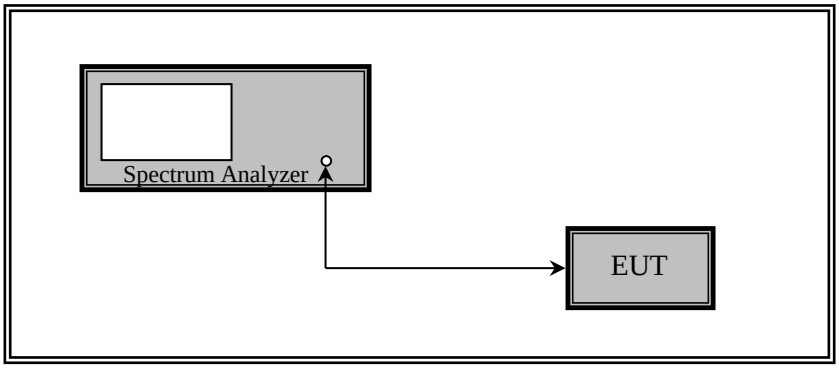
According to ISEDC RSS-247 §5.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the 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.

According to LP0002-2020 §4.10.1.5, in any 100kHz 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:
(1) The attenuation shall be at least 20dB when the conducted power is measured according to 12 Appendix II of this section, based on either an RF conducted or a radiated measurement.
(2) The attenuation shall be at least 30dB when the conducted power is measured according to the paragraph (1)(C) of this section 4.10.1.2.
In addition, radiated emissions that fall under Section 3.5 the restricted bands must also comply with the radiated emission limit specified in Section 3.6.

10.2 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 8.7: DTS band-edge emission measurements.

10.3 Test Block Diagram



10.4 Test Equipment List and Details

Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer 46GHz	E4446A	US44300386	2021-04-27	12 Months
-	RF Cable	-	-	Each time[1]	N/A

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".*

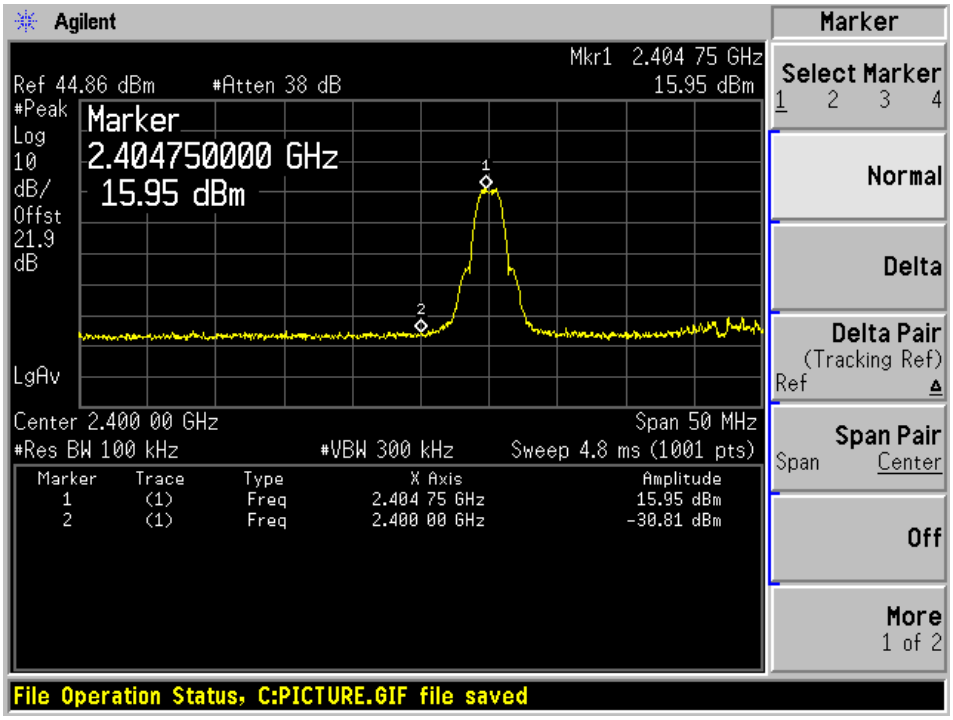
10.5 Test Environmental Conditions

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

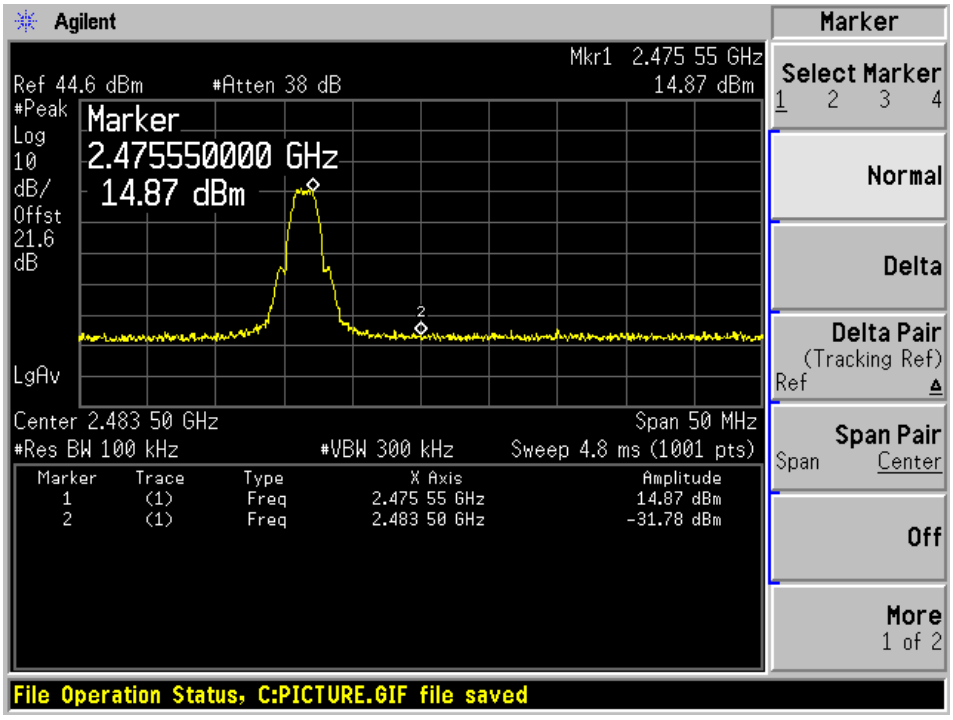
The testing was performed by Rita Yang on 2021-05-18 and 2021-05-20 in RF site.

10.6 Test Results

2405 MHz



2475 MHz



11 FCC §15.247(e), ISEDC RSS-247 §5.2(2) & LP0002-2020 §4.10.1.6(2)(B) - Power Spectral Density

11.1 Applicable Standards

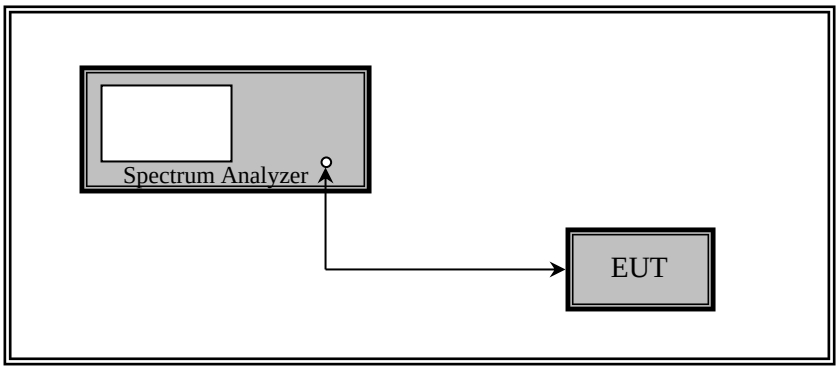
According to FCC §15.247(e) and RSS-247 §5.2(b), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

According to LP0002-2020 §4.10.1.6(2)(B), for digitally modulated systems, the minimum 6dB bandwidth shall be at least 500 kHz

11.2 Measurement Procedure

The measurements were 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 8.4: DTS maximum power spectral density level in the fundamental emission.

11.3 Test Setup Block Diagram



11.4 Test Equipment List and Details

Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer 46GHz	E4446A	US44300386	2021-04-27	12 Months
-	RF Cable	-	-	Each time[1]	N/A

Note[1]: cables 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 Rita Yang on 2021-05-18 and 2021-05-20 in RF site.

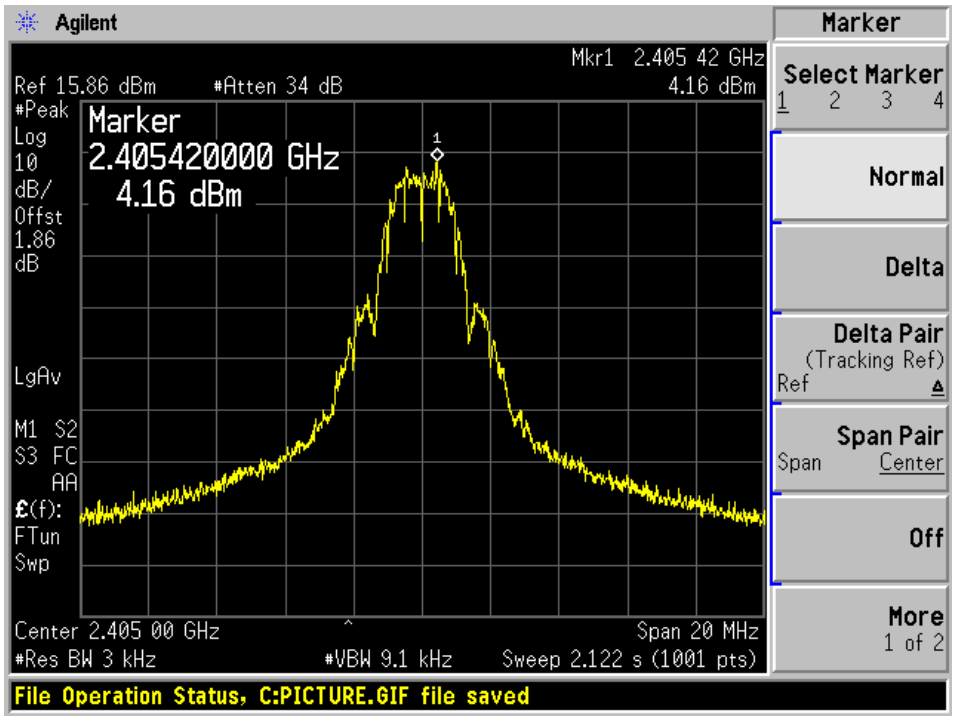
11.6 Test Results

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)
Low	2405	4.16	8
Middle	2440	4.21	8
High	2475	3.95	8

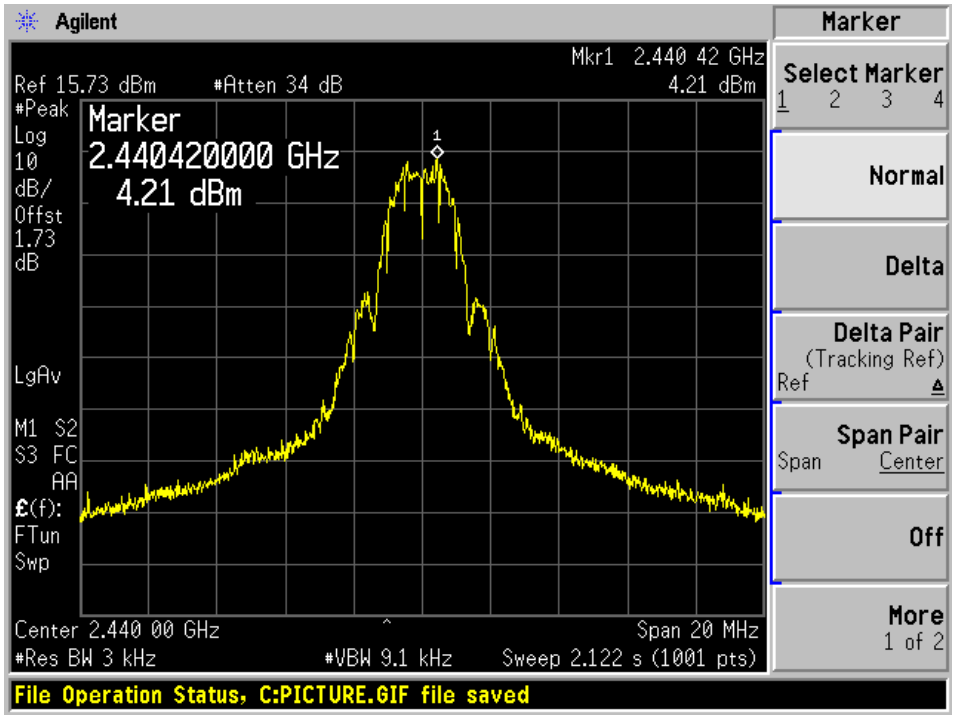
Please refer to the following plots,

ZigBee

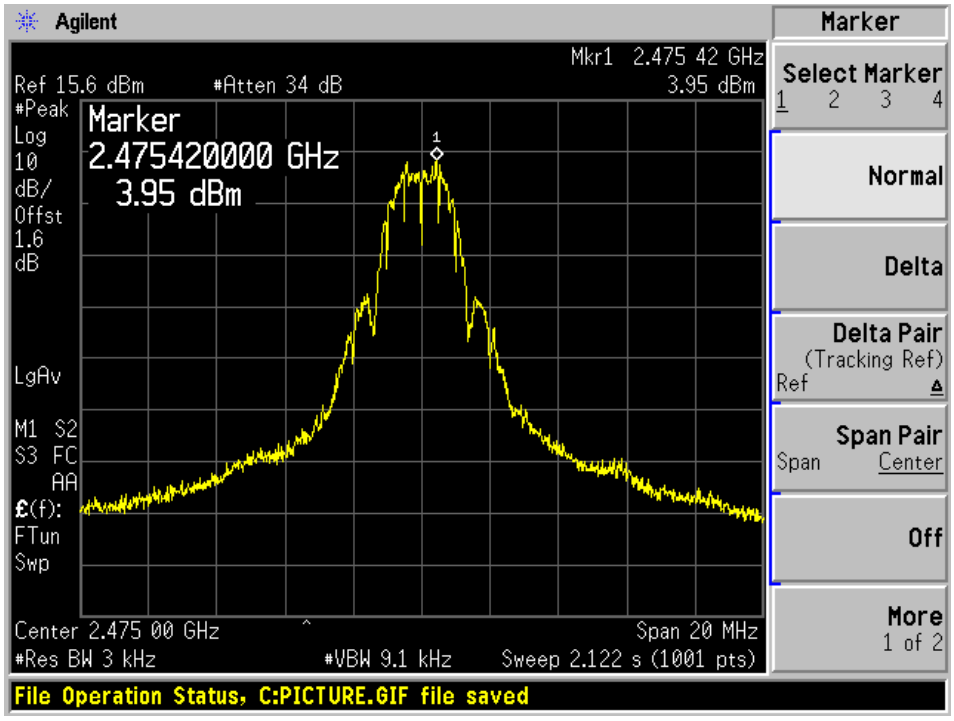
2405 MHz PSD



2440 MHz PSD



2475 MHz PSD


Agilent
Marker
Mkr1 2.475 42 GHz
3.95 dBm
Ref 15.6 dBm
#Atten 34 dB
#Peak
Log
10
dB/
Offst
1.6
dB
Marker
2.475420000 GHz
3.95 dBm
LgAv
M1 S2
S3 FC
AA
£(f):
FTun
Swp
Center 2.475 00 GHz
#Res BW 3 kHz
#VBW 9.1 kHz
Span 20 MHz
Sweep 2.122 s (1001 pts)
Select Marker
1 2 3 4
Normal
Delta
Delta Pair
(Tracking Ref)
Ref
Span Pair
Span Center
Off
More
1 of 2
File Operation Status, C:PICTURE.GIF file saved

12 FCC §15.247(d), ISEDC RSS-247 §5.5 & LP0002-2020 §4.10.1.5 - Spurious Emissions at Antenna Terminals

12.1Applicable 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)).

For LP0002-2020 §4.10.1.5, in any 100kHz 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 below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, the attenuation shall be as below:

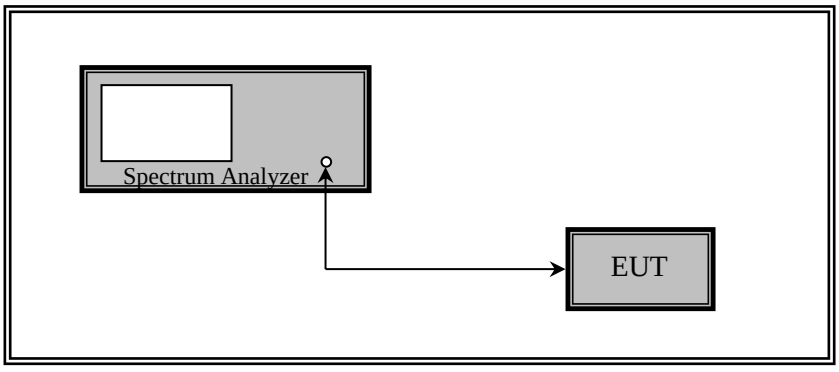
(1) The attenuation shall be at least 20dB when the conducted power is measured according to Appendix II of this section, based on either an RF conducted or a radiated measurement.
(2) The attenuation shall be at least 30dB when the conducted power is measured according to the paragraph (1) (C) of this section 4.10.1.2.

In addition, radiated emissions that fall under Section 3.5 the restricted bands must also comply with the radiated emission limit specified in Section 3.6.

12.2Test 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.

12.3Test Setup Block Diagram



12.4Test Equipment List and Details

Manufacturer/ Brand	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer 46GHz	E4446A	US44300386	2021-04-27	12 Months
-	RF Cable	-	-	Each time[1]	N/A

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

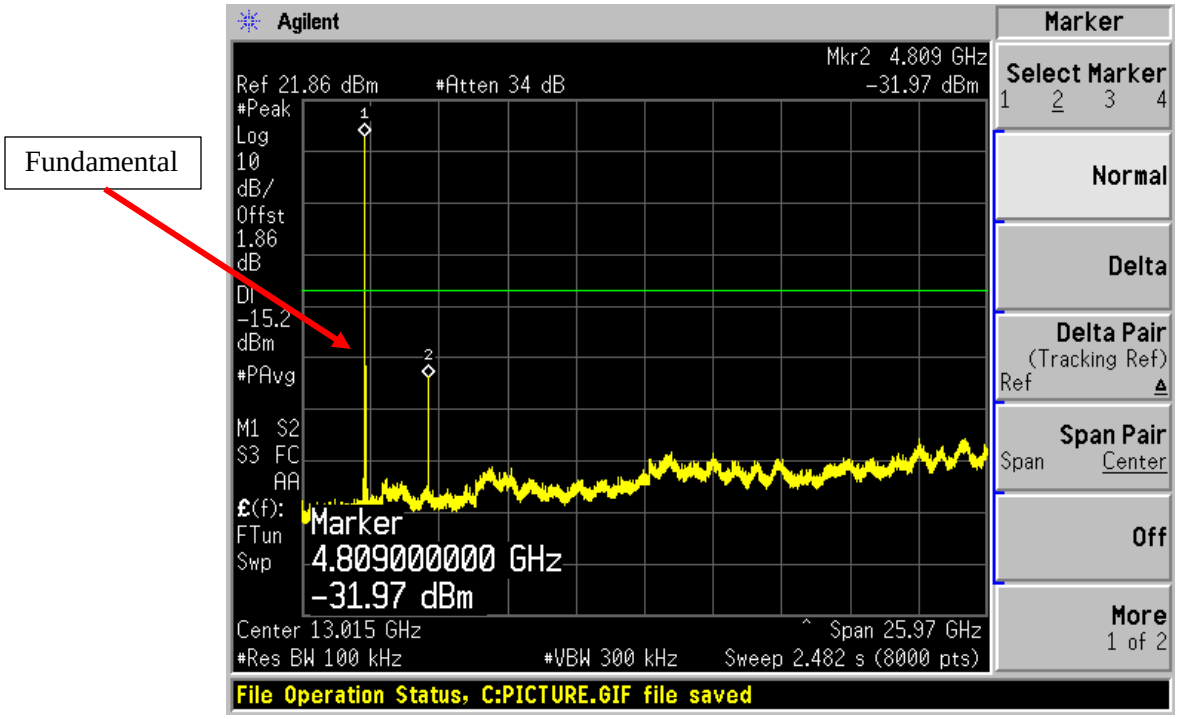
12.5 Test Environmental Conditions

Temperature:	21º C
Relative Humidity:	39 %
ATM Pressure:	102.0 KPa

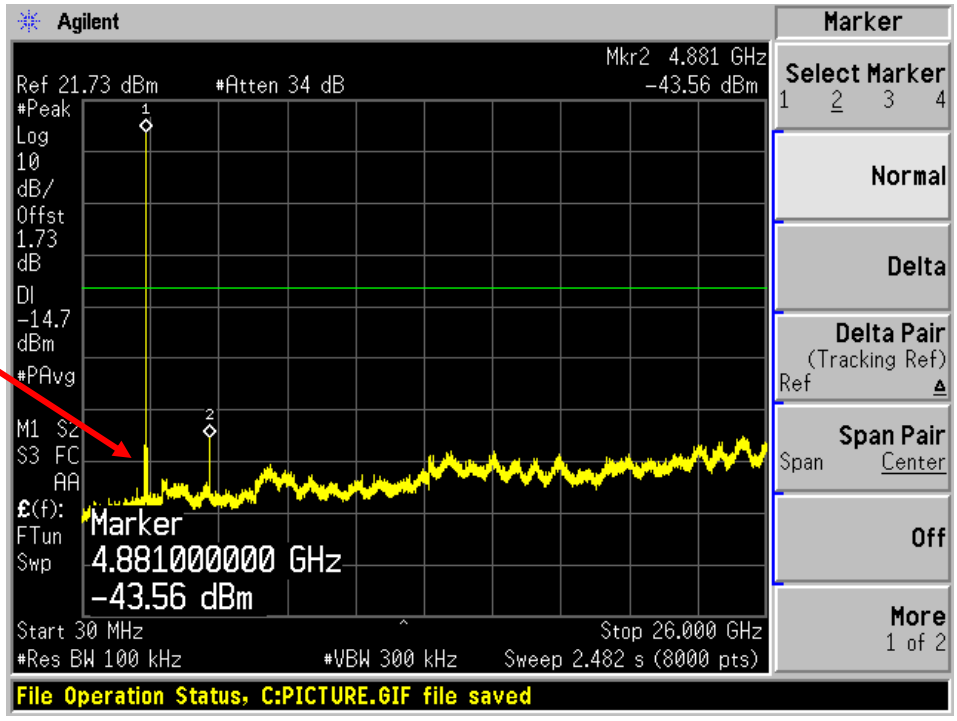
The testing was performed by Rita Yang on 2021-05-18 at RF test site.

12.6 Test Results

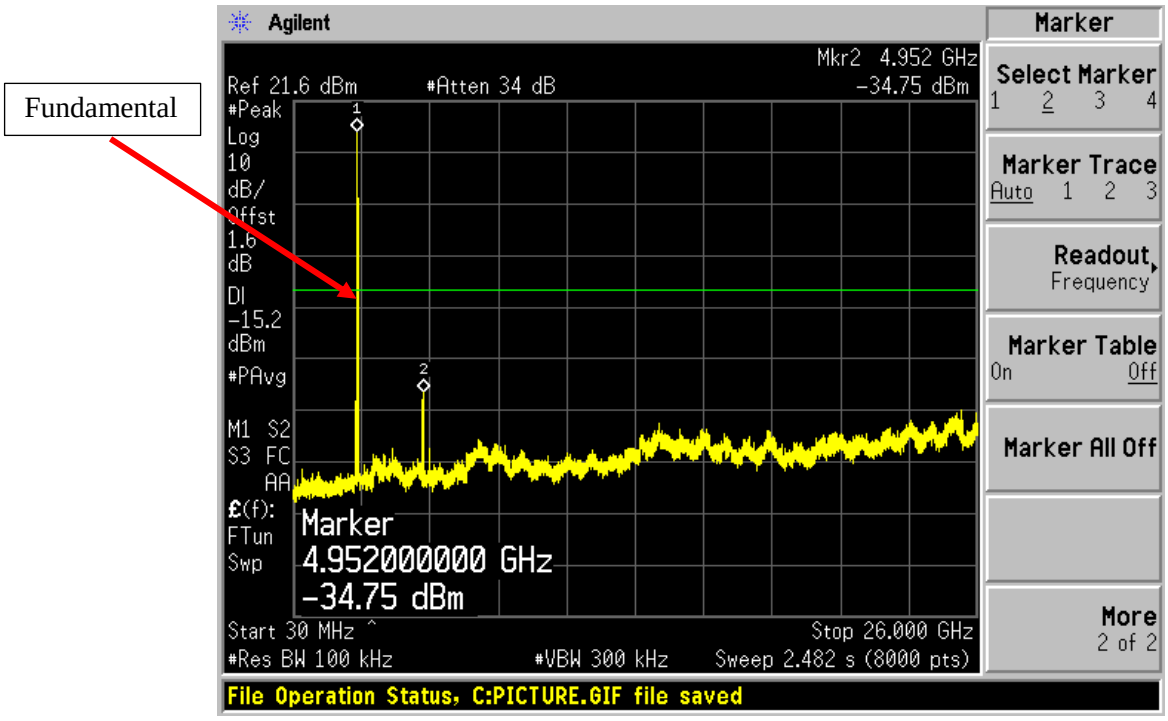
2405 MHz



2440 MHz



2475 MHz



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) - 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 ---