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

TEST REPORT

For

Ruckus Wireless, Inc.

350 West Java Dr.
Sunnyvale, CA 94089, USA

FCC ID: S9GH550
IC: 5912A-H550

Report Type:	**Product Type:**
Original Report	Access Point

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Report Date:	2021-01-27
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ACCREDITED
CERTIFICATE #3297.02

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2007201-03	Original Report	2021-01-27

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: *H550, FCC ID: S9GH550, IC: 5912A-H550,* 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.

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.

The objective was to determine compliance with FCC Part 15.247 and ISEDC RSS-247 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)

Equipment Class: NII, FCC ID: S9GH550, IC: 5912A-H550

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.

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	Frequency (MHz)	Power Setting
BLE	2402	200
	2440	200
	2480	200
ZigBee	2405	20
	2440	20
	2475	20

2.3 Duty Cycle Correction Factor

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

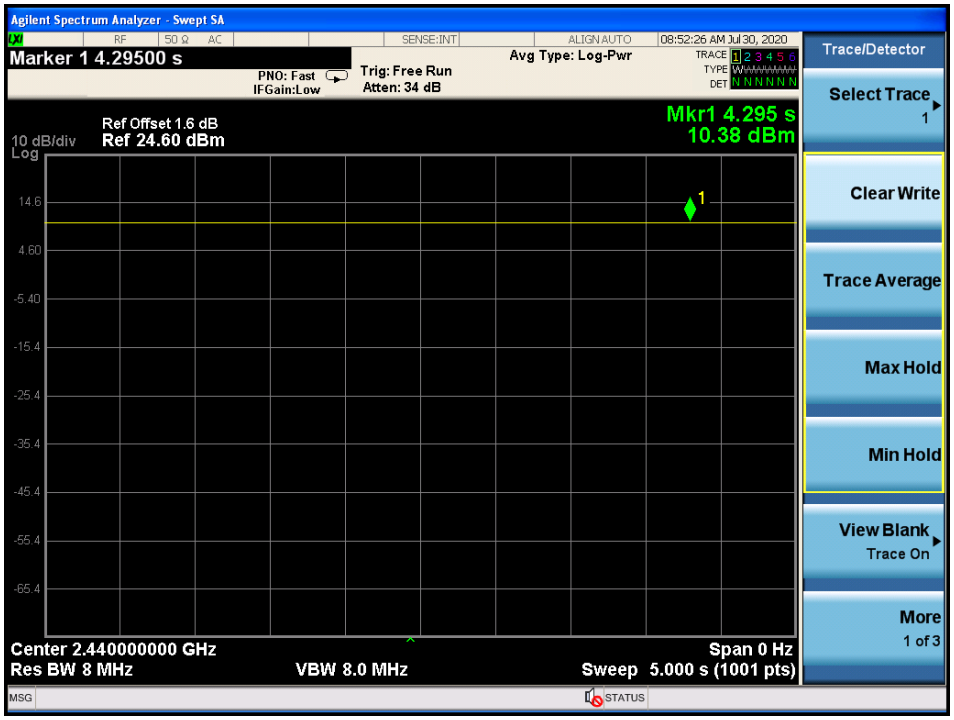
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized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

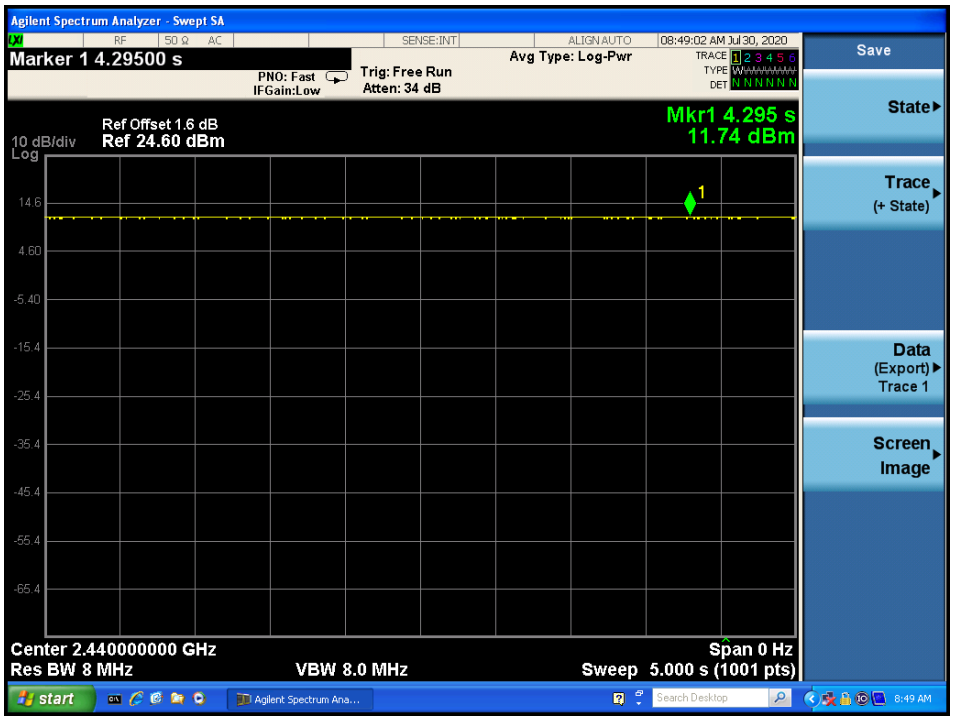
Duty Cycle = On Time (ms)/ Period (ms)
Duty Cycle Correction Factor (dB) = 10*log(1/Duty Cycle)

Please refer to the following plots.

BLE



ZigBee



2.4 Equipment Modifications

None

2.5 Local Support Equipment

Manufacturer	Description	Model	Serial Number
Dell	Laptop	Latitude E6410	3CKRAQ1

2.6 Support Equipment

N/A

2.7 Power Supply/Adapter

Manufacturer	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 and 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 and §8.10	Radiated Spurious Emissions	Compliant
FCC §15.247(a)(2) ISEDC RSS-247 §5.2(a)	6 dB and 99% Emission Bandwidth	Compliant
FCC §15.247(b)(3) ISEDC RSS-247 §5.4(d)	Output Power	Compliant
FCC §15.247(d) ISEDC RSS-247 §5.5	100 kHz Bandwidth of Frequency Band Edge	Compliant
FCC §15.247(e) ISEDC RSS-247 §5.2(b)	Power Spectral Density	Compliant

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

4.1 Applicable Standards

According to FCC §15.203:

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

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

According to ISEDC RSS-Gen §6.8: Transmitter Antenna

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

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

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

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

For 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.

4.2 Antenna Description

Antenna usage	Frequency Range (MHz)	Maximum Antenna Gain (dBi)	Antenna Type
Bluetooth & ZigBee	2400-2483.5	0	Trace Antenna
2.4GHz Wi-Fi	2400-2483.5	0	Trace Antenna
5GHz Wi-Fi	5150-5850	1	Trace Antenna

Note: The antenna gain was provided by the manufacturer.

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

5.1 Applicable Standards

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

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.

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: Low Channel 2405 MHz

Maximum output power at antenna input terminal (dBm):	19.24
Maximum output power at antenna input terminal (mW):	83.95
Prediction distance (cm):	20
Prediction frequency (MHz):	2405
Maximum Antenna Gain, typical (dBi):	0
Maximum Antenna Gain (numeric):	1
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.0167
FCC 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	8.82	100
5 GHz Wi-Fi	0.031	1	3.1		
BLE	0.0145	1	1.45		
ZigBee	0.0167	1	1.67		

5.4 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 = 19.24 dBm + 0 dBi = 19.24 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.

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

6.1 Applicable Standards

As per FCC §15.207 and ISEDC RSS GEN §8.8

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

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

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

6.2 Test Setup

The measurement was performed at shield room, using the setup per ANSI C63.10-2013 measurement procedure. The specification used was FCC §15.207 limits and and ISEDC RSS GEN §8.8.

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

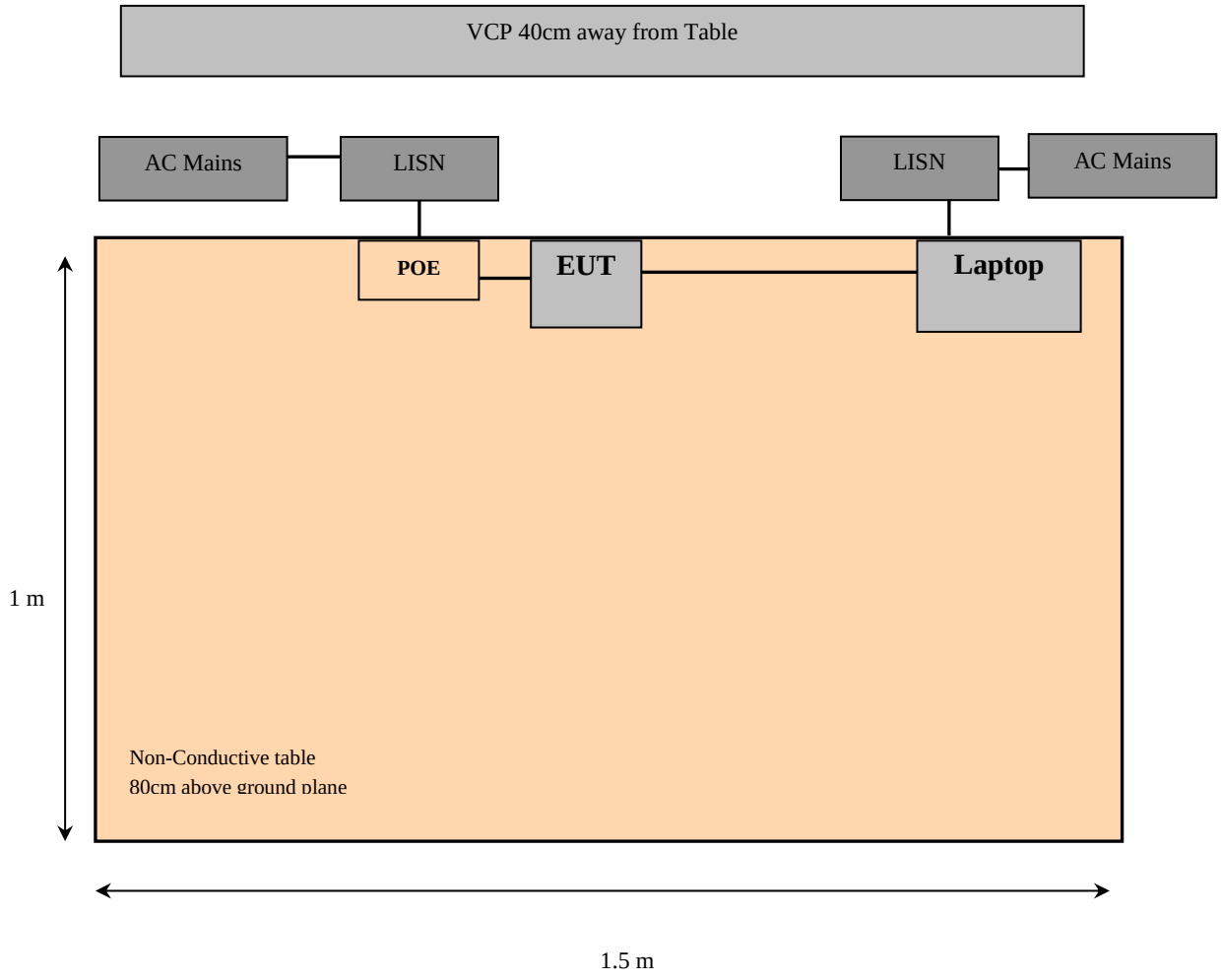
6.3 Test Procedure

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

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

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

6.4 Test Setup Block Diagram



6.5 Corrected Amplitude and Margin Calculation

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

CA = Ai + CF

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

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

CF= CL + LISN calibration factor + Attenuation

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

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

Margin = Corrected Amplitude - Limit

6.6 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2020-03-17	1 year
Rohde and Schwarz	Impulse Limiter	ESH3-Z2	101964	2020-07-01	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150204	2020-02-27	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 Zhao Zhao on 2021-01-15 in the Ground Plane test site.

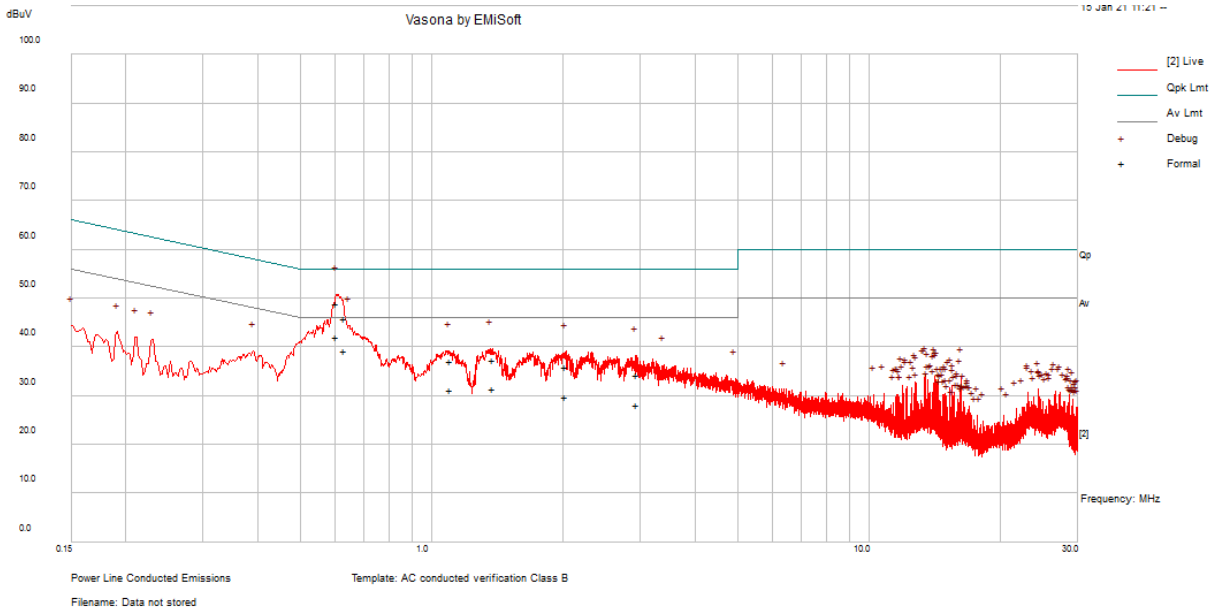
6.8 Summary of Test Results

According to the recorded data in following table, the EUT complied with the FCC Part 15 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 (Live/Neutral)**	**Range (MHz)**
-2.58	0.610931	Neutral	0.15-30

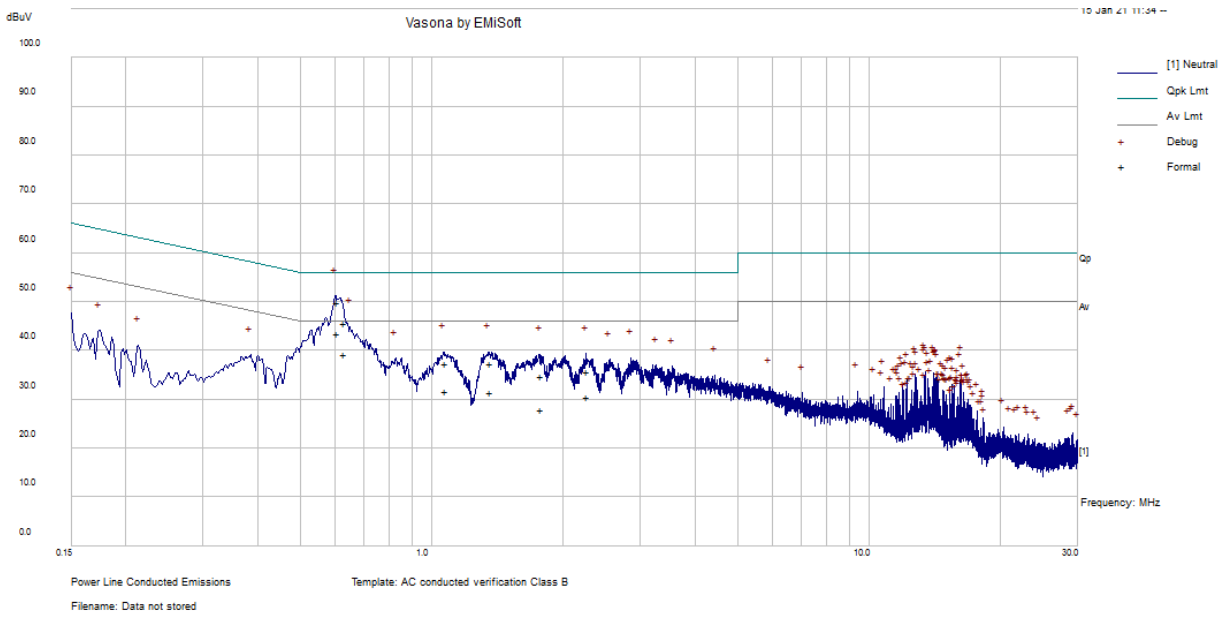
6.9 Conducted Emissions Test Plots and Data

120 V, 60 Hz – Line



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.607468	38.94	10.09	49.02	56	-6.98	QP
0.630089	35.77	10.08	45.85	56	-10.15	QP
1.378355	27.48	9.86	37.33	56	-18.67	QP
1.106087	27.24	9.94	37.18	56	-18.82	QP
2.027839	26.22	9.8	36.02	56	-19.98	QP
2.948662	24.59	9.72	34.31	56	-21.69	QP
0.607468	32.09	10.09	42.18	46	-3.82	Ave
0.630089	29.19	10.08	39.27	46	-6.73	Ave
1.378355	21.64	9.86	31.5	46	-14.5	Ave
1.106087	21.22	9.94	31.16	46	-14.84	Ave
2.027839	19.88	9.8	29.68	46	-16.32	Ave
2.948662	18.39	9.72	28.1	46	-17.9	Ave

120 V, 60 Hz – Neutral



Frequency (MHz)	Ai. Reading (dBuV)	Correction Factor (dB)	Corrected Amplitude (dBµV)	Limit (dBµV)	Margin (dB)	Detector
0.610931	39.81	10.09	49.9	56	-6.1	QP
0.631954	35.63	10.08	45.7	56	-10.3	QP
1.367276	27.52	9.86	37.38	56	-18.62	QP
1.076767	27.34	9.95	37.29	56	-18.71	QP
2.266213	26	9.76	35.76	56	-20.24	QP
1.777816	24.83	9.81	34.65	56	-21.35	QP
0.610931	33.34	10.09	43.42	46	-2.58	Ave
0.631954	29.17	10.08	39.25	46	-6.75	Ave
1.367276	21.56	9.86	31.42	46	-14.58	Ave
1.076767	21.82	9.95	31.77	46	-14.23	Ave
2.266213	20.64	9.76	30.4	46	-15.6	Ave
1.777816	18.07	9.81	27.88	46	-18.12	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(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.

7.2 Test Setup

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

The spacing between the peripherals was 10 centimeters.

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

7.3 Test Procedure

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: Peak – DC Correction

7.4 Corrected Amplitude and Margin Calculation

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

CA = Ai + AF + CL + Atten – Ga

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

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

Margin = Corrected Amplitude - Limit

7.5 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4446A	MY48250238	2019-06-26	18 months
Rhode & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100044	2018-10-26	2 years
BACL	5m3 Sensitivity Box	1	2	2019-10-02	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 years
Wisewave	Antenna, Horn	ARH-2823-02	10555-01	2020-02-05	2 years
-	SMA cable	-	-	Each time[1]	N/A
IW Microwave	150 Series 2.92mm Cable	KPS1501AN-3780-KPS	DC 1925	2019-09-11	1 year
IW Microwave	157 Series Cable Armored with 2.92mm Male Plugs on Both Sides	KPS-1571AN-2400	DC 1922	2020-06-06	1 year
MDP Digital	Times Microwave LMR 400 UltraFex Coaxial Cable 35\'	LMR400UF	BACL1904161	2020-05-20	1 year
Agilent	Preamplifier	8449B	3147A00400	2020-02-27	1 year
HP	Pre Amplifier	8447D	2443A04374	2019-08-13	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".*

7.6 Test Environmental Conditions

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

The testing was performed by Christian McCaig from 2020-07-27 to 2020-08-11 in 5m chamber 3.

7.7 Summary of Test Results

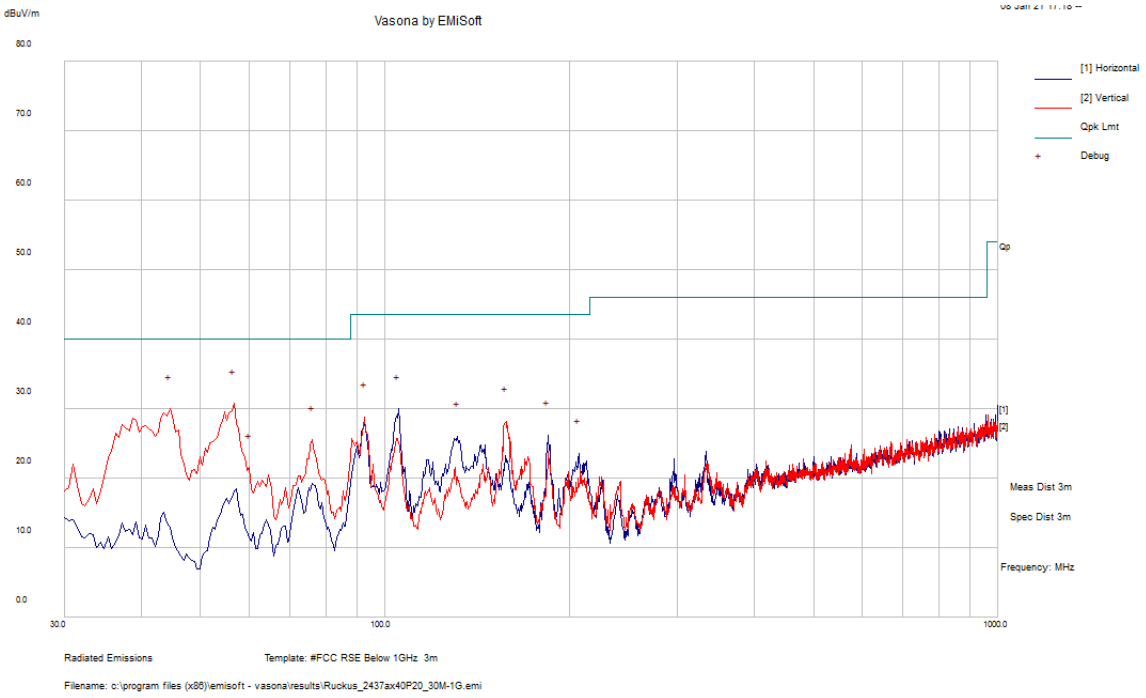
According to the data hereinafter, the EUT complied with FCC Title 47, Part 15C and ISEDC RSS-247 standard's radiated emissions limits, and had the worst margin of:

Mode: Transmitting		
Margin (dB)	**Frequency (MHz)**	**Mode, channel**
-0.37	4804	BLE, Low Channel

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

7.8 Spurious Emissions Test Results

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



Frequency (MHz)	S.A. Reading (dBuV)	Correction Factor (dB/m)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
56.702	42.24	-16.21	26.03	134	V	36	40	-13.97	Pass
44.48625	37.19	-12.99	24.19	102	V	205	40	-15.81	Pass
104.9405	36	-11.73	24.27	268	H	58	43.5	-19.23	Pass
76.06775	33.15	-15.72	17.43	107	V	352	40	-22.57	Pass
92.52925	35.11	-15.24	19.87	151	V	326	43.5	-23.63	Pass
157.90775	29.59	-10.89	18.69	127	V	167	43.5	-24.81	Pass

2) 1–26.5 GHz Measured at 3 meters

BLE

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC/ISEDC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2402 MHz											
2402	70.28			V	32.6	5.72		108.6	-	-	Peak
2402	70.44			H	32.6	5.72		108.76	-	-	Peak
2390	50.10	195	285	V	32	6.33	36.42	52.01	74	-21.99	Peak
2390	47.11	50	250	H	32	6.33	36.42	49.02	74	-24.98	Peak
2390	36.42	195	285	V	32	6.33	36.42	38.33	54	-15.67	Ave
2390	36.27	50	250	H	32	6.33	36.42	38.18	54	-15.82	Ave
4804	48.41	200	265	V	35	9.89	35.43	57.87	74	-16.13	Peak
4804	50.47	40	275	H	35	9.89	35.43	59.93	74	-14.07	Peak
4804	40.63	200	265	V	35	9.89	35.43	50.09	54	-3.91	Ave
4804	44.17	40	275	H	35	9.89	35.43	53.63	54	-0.37	Ave
7206	47.82	115	250	V	36.1	9.83	35.82	57.93	78.6	-20.67	Peak[1]
7206	48.04	210	265	H	36.1	9.83	35.82	58.15	78.76	-20.61	Peak[1]
Middle Channel 2440 MHz											
4856	45.39	350	280	V	34.6	10.96	35.43	55.52	74	-18.48	Peak
4856	45.71	40	275	H	34.6	10.96	35.43	55.84	74	-18.16	Peak
4856	35.32	350	280	V	34.6	10.96	35.43	45.45	54	-8.55	Ave
4856	36.47	40	275	H	34.6	10.96	35.43	46.6	54	-7.4	Ave
7320	48.89	170	275	V	36.1	10.95	35.82	60.12	74	-13.88	Peak
7320	48.30	120	245	H	36.1	10.95	35.82	59.53	74	-14.47	Peak
7320	39.39	170	275	V	36.1	10.95	35.82	50.62	54	-3.38	Ave
7320	38.64	120	245	H	36.1	10.95	35.82	49.87	54	-4.13	Ave
High Channel 2480 MHz											
2483.5	66.59	200	250	V	32.2	5.65	36.34	68.10	74	-5.90	Peak
2483.5	68.85	295	260	H	32.2	5.65	36.34	70.36	74	-3.64	Peak
2483.5	47.07	200	250	V	32.2	5.65	36.34	48.58	54	-5.42	Ave
2483.5	49.43	295	260	H	32.2	5.65	36.34	50.94	54	-3.06	Ave
4960	46.51	70	275	V	35.4	11.07	35.43	57.55	74	-16.45	Peak
4960	45.21	50	275	H	35.4	11.07	35.43	56.25	74	-17.75	Peak
4960	35.39	70	275	V	35.4	11.07	35.43	46.43	54	-7.57	Ave
4960	33.32	50	275	H	35.4	11.07	35.43	44.36	54	-9.64	Ave
7440	48.69	298	275	V	36.1	12.73	35.9	61.62	74	-12.38	Peak
7440	48.17	220	275	H	36.1	12.73	35.9	61.10	74	-12.90	Peak
7440	40.42	298	275	V	36.1	12.73	35.9	53.35	54	-0.65	Ave
7440	39.07	220	275	H	36.1	12.73	35.9	52.00	54	-2.00	Ave

ZigBee

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC/ISEDC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2405 MHz											
2405	71.03			V	32.6	5.72		109.35	-	-	Peak
2405	71.1			H	32.6	5.72		109.42	-	-	Peak
2390	48.43	195	285	V	32	6.33	36.42	50.34	74	-23.66	Peak
2390	48.62	150	120	H	32	6.33	36.42	50.53	74	-23.47	Peak
2390	36.54	195	285	V	32	6.33	36.42	38.45	54	-15.55	Ave
2390	36.83	150	120	H	32	6.33	36.42	38.74	54	-15.26	Ave
4810	49.87	345	285	V	35	9.89	35.43	59.33	74	-14.67	Peak
4810	50.86	315	240	H	35	9.89	35.43	60.32	74	-13.68	Peak
4810	42.19	345	285	V	35	9.89	35.43	51.65	54	-2.35	Ave
4810	43.41	315	240	H	35	9.89	35.43	52.87	54	-1.13	Ave
7215	47.27	125	240	V	36.1	9.83	35.82	57.38	79.35	-21.97	Peak[1]
7215	50.23	48	240	H	36.1	9.83	35.82	60.34	79.42	-19.08	Peak[1]
Middle Channel 2440 MHz											
4880	49.17	350	280	V	35.2	10.96	35.43	59.9	74	-14.1	Peak
4880	50.18	312	240	H	35.2	10.96	35.43	60.91	74	-13.09	Peak
4880	41.30	350	280	V	35.2	10.96	35.43	52.03	54	-1.97	Ave
4880	41.97	312	240	H	35.2	10.96	35.43	52.7	54	-1.3	Ave
7320	46.49	90	280	V	36.1	10.95	35.82	57.72	74	-16.28	Peak
7320	48.29	50	250	H	36.1	10.95	35.82	59.52	74	-14.48	Peak
7320	35.59	90	280	V	36.1	10.95	35.82	46.82	54	-7.18	Ave
7320	39.09	50	250	H	36.1	10.95	35.82	50.32	54	-3.68	Ave
High Channel 2475 MHz											
2483.5	62.05	180	285	V	32.2	5.65	36.34	63.56	74	-10.44	Peak
2483.5	61.72	250	280	H	32.2	5.65	36.34	63.23	74	-10.77	Peak
2483.5	50.64	180	285	V	32.2	5.65	36.34	52.15	54	-1.85	Ave
2483.5	50.76	250	280	H	32.2	5.65	36.34	52.27	54	-1.73	Ave
4950	45.44	350	290	V	35.4	11.07	35.43	56.48	74	-17.52	Peak
4950	46.67	310	250	H	35.4	11.07	35.43	57.71	74	-16.29	Peak
4950	34.77	350	290	V	35.4	11.07	35.43	45.81	54	-8.19	Ave
4950	36.00	310	250	H	35.4	11.07	35.43	47.04	54	-6.96	Ave
7425	44.79	100	280	V	36.1	12.73	35.9	57.72	74	-16.28	Peak
7425	44.93	50	250	H	36.1	12.73	35.9	57.86	74	-16.14	Peak
7425	32.91	100	280	V	36.1	12.73	35.9	45.84	54	-8.16	Ave
7425	33.19	50	250	H	36.1	12.73	35.9	46.12	54	-7.88	Ave

Note[1]: Outside of Restricted Bands. Limit is 30dB down from peak Fundamental Field Strength.

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

8.1 Applicable Standards

According to ECFR §15.247(a) (2) and ISEDC RSS-247 §5.2(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 Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	EXA Signal Analyzer	N9010A	MY48030852	2020-02-12	1 year
-	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".*

8.4 Test Environmental Conditions

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

The testing was performed by Christian McCaig from 2020-07-28 to 2020-07-30 in RF site.

8.5 Test Results

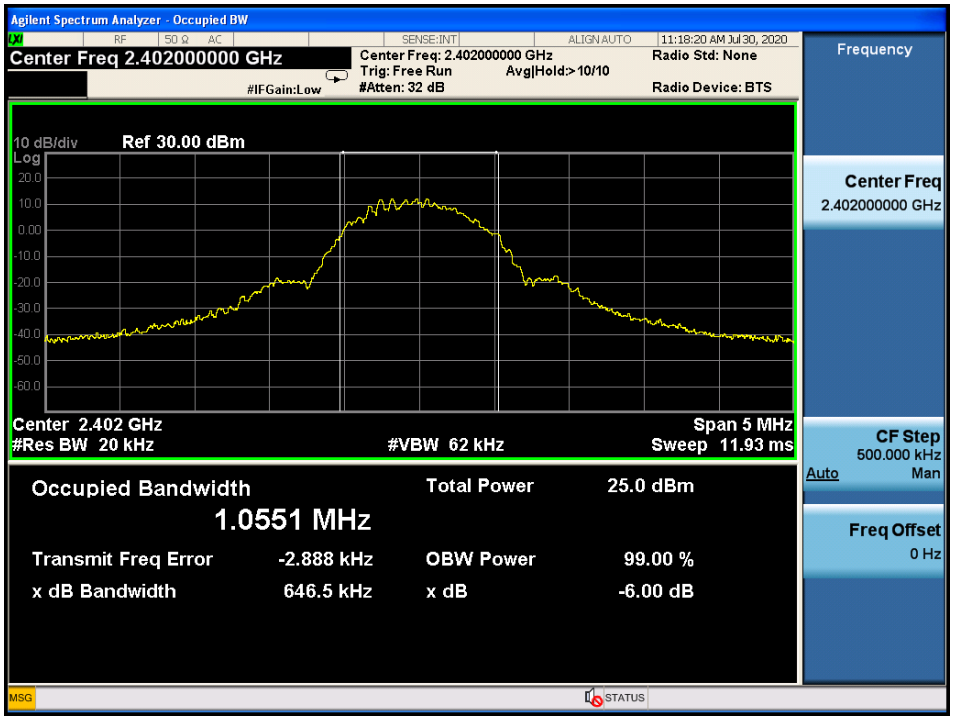
99% and 6 dB Bandwidth

Mode	Channel	Frequency (MHz)	99% OBW (MHz)	6 dB BW (kHz)	6 dB BW limit (kHz)
BLE	Low	2402	1.06	699	>500
	Middle	2440	1.05	697	>500
	High	2480	1.05	695	>500
ZigBee	Low	2405	2.23	1653	>500
	Middle	2440	2.24	1645	>500
	High	2475	2.24	1653	>500

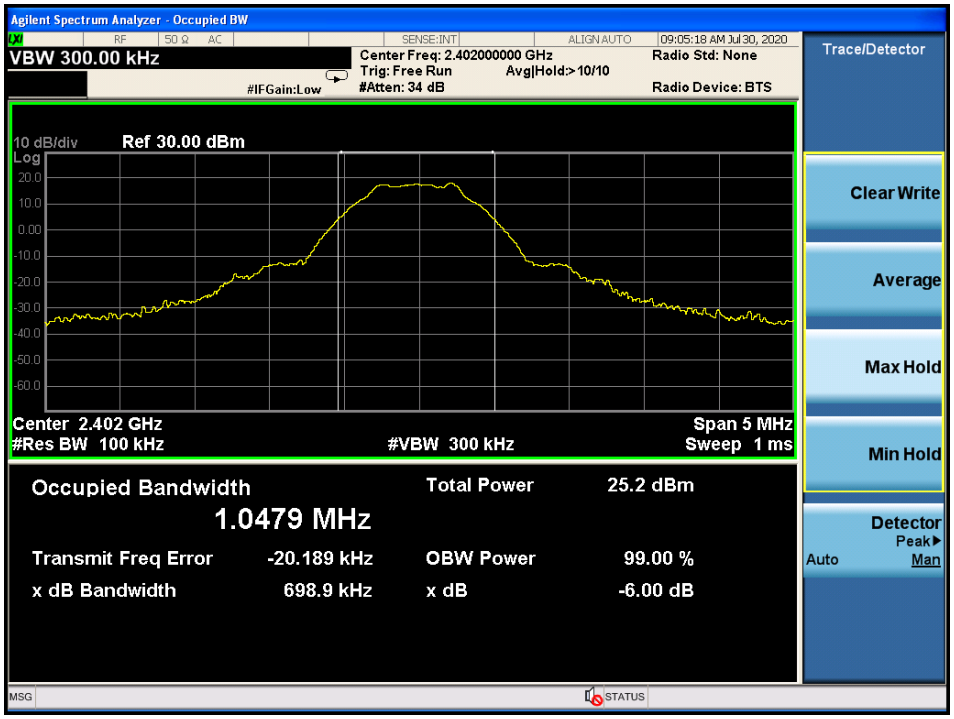
Please refer to the following plots.

BLE

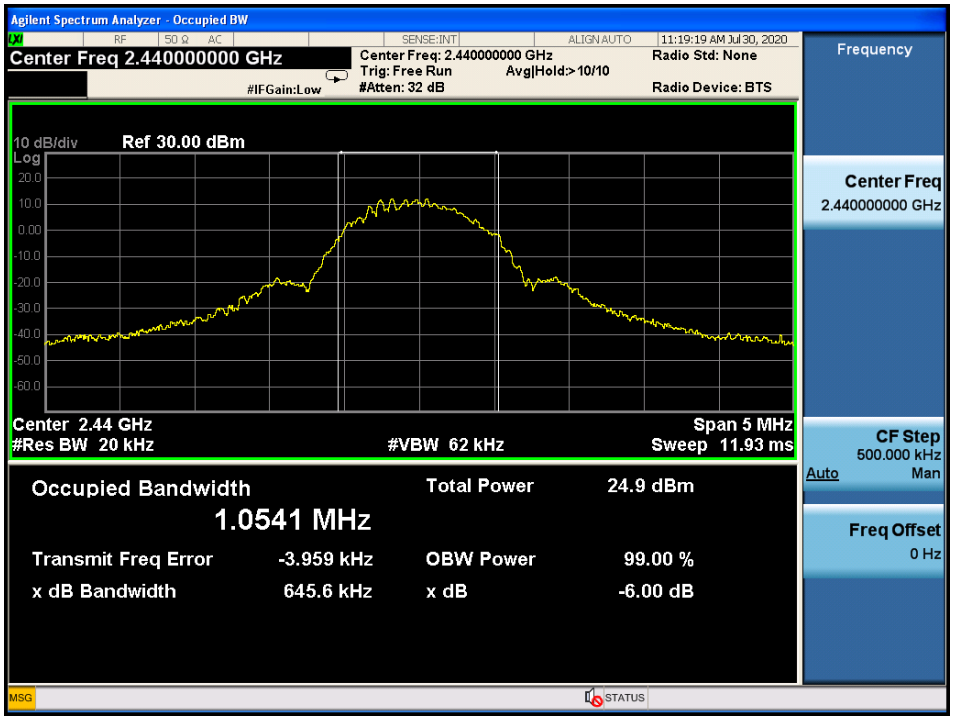
2402 MHz 99% OBW



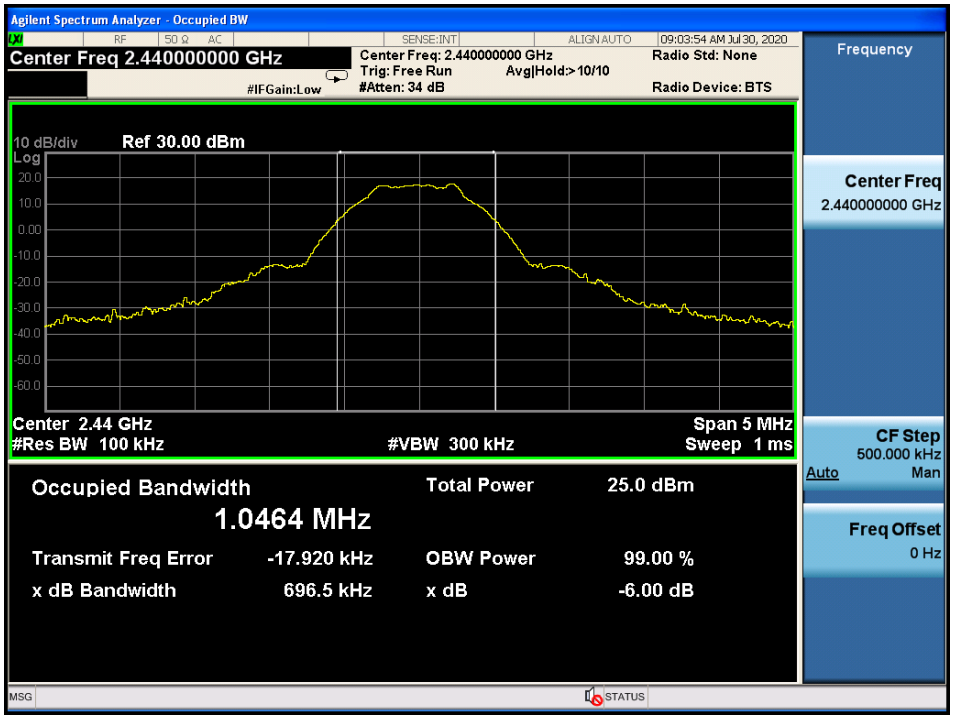
2402 MHz 6 dB OBW



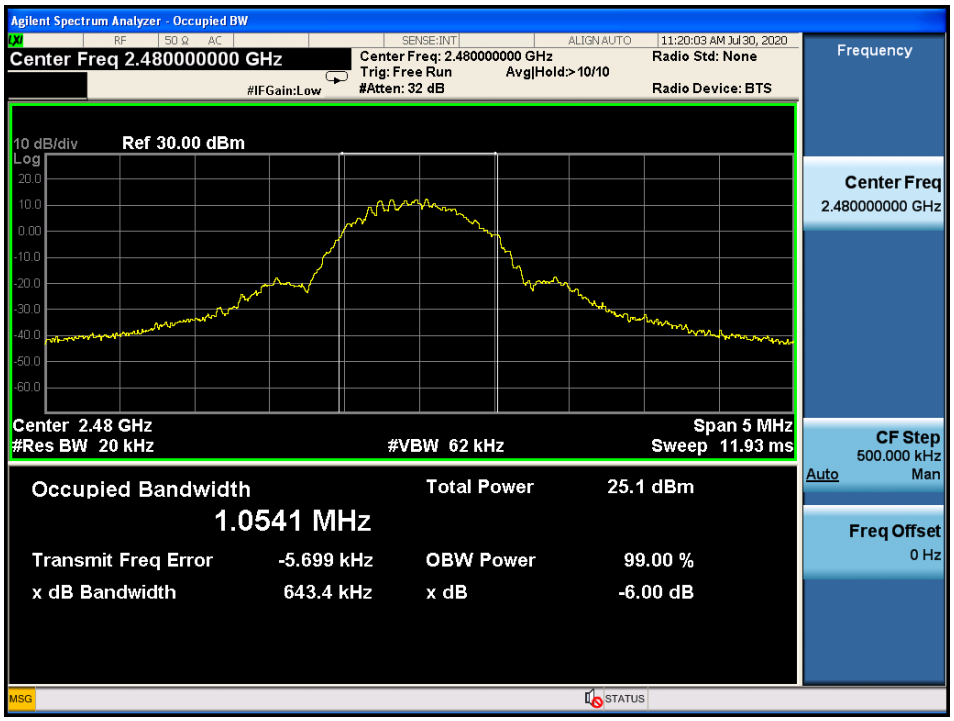
2440 MHz 99% OBW



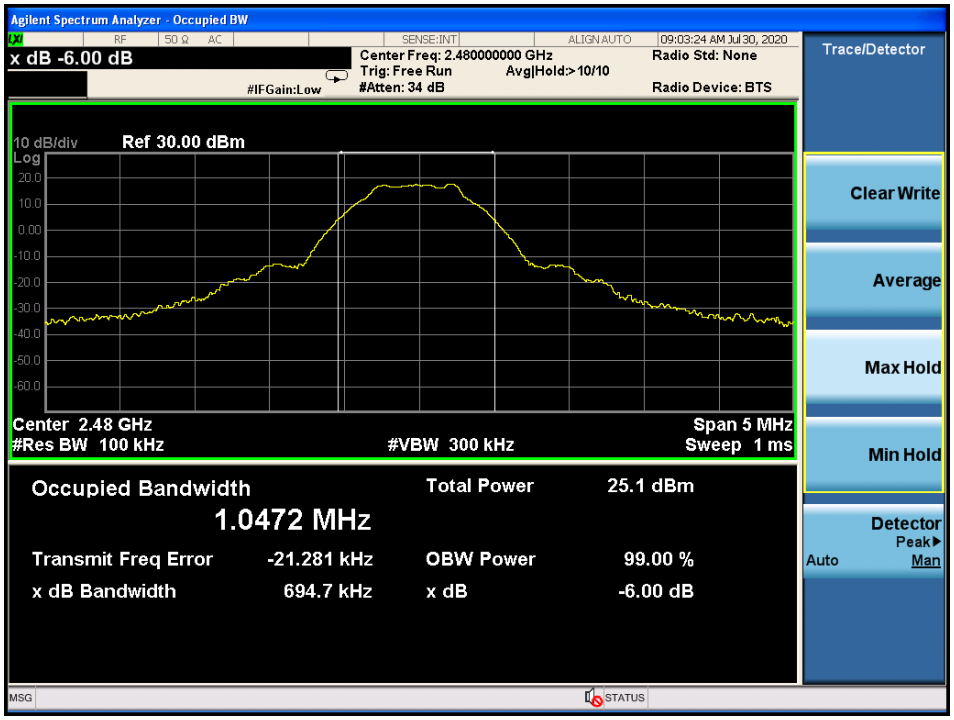
2440 MHz 6 dB OBW



2480 MHz 99% OBW



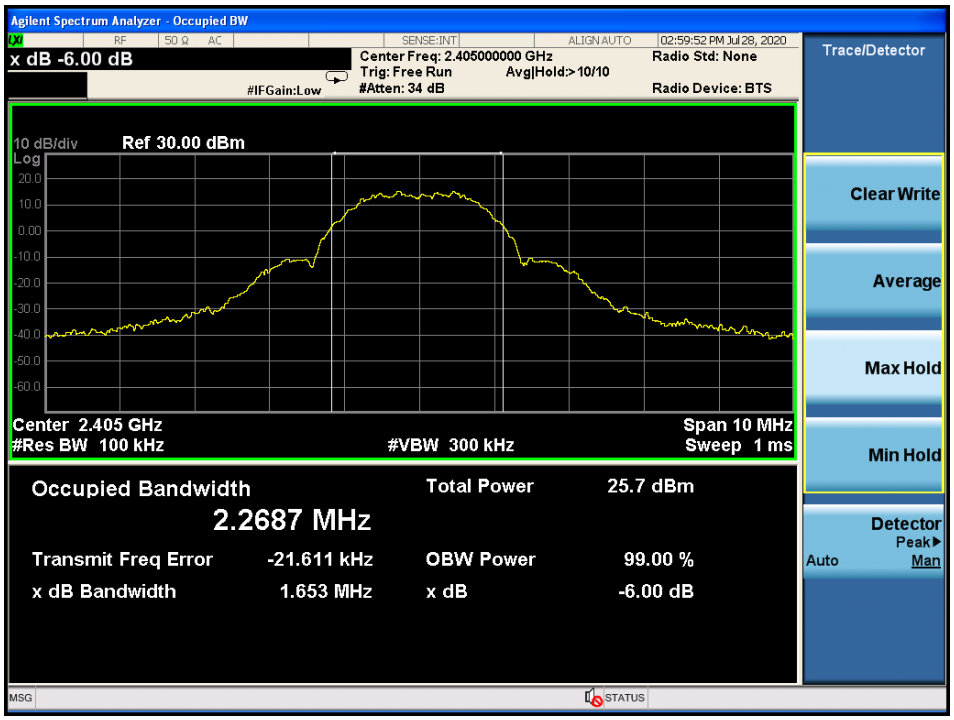
2480 MHz 6 dB OBW



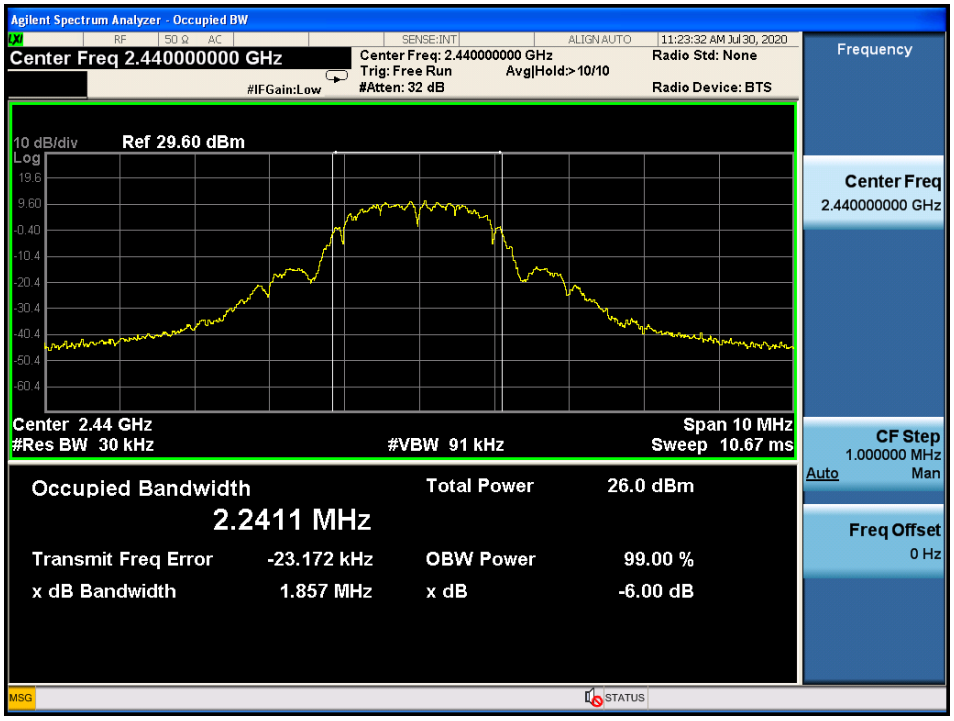
ZigBee

2402 MHz 99% OBW

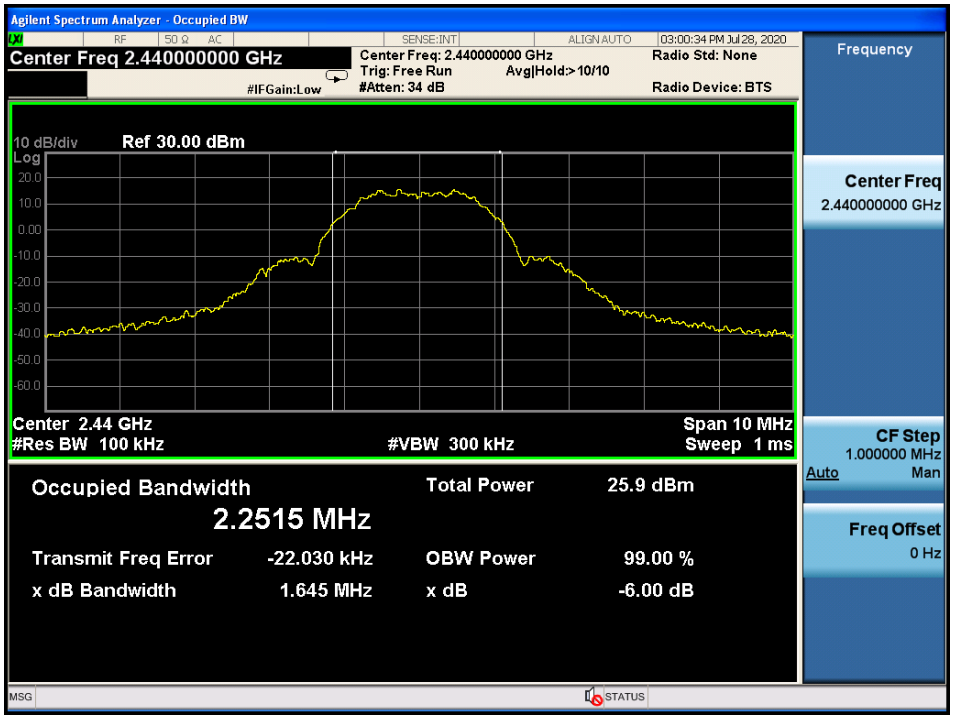
2402 MHz 6 dB OBW



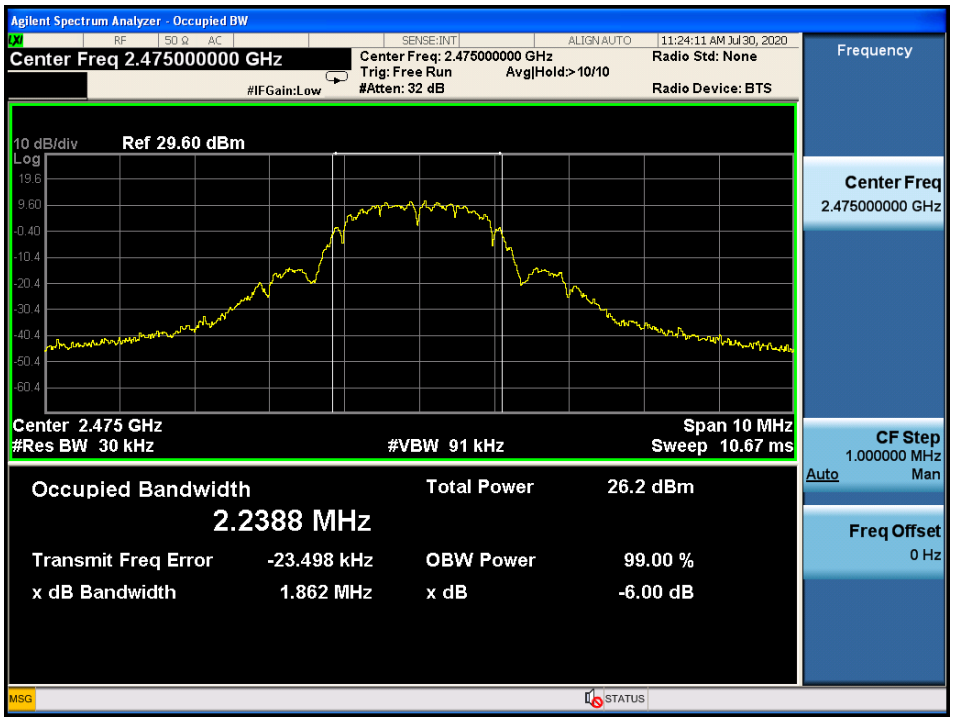
2440 MHz 99% OBW



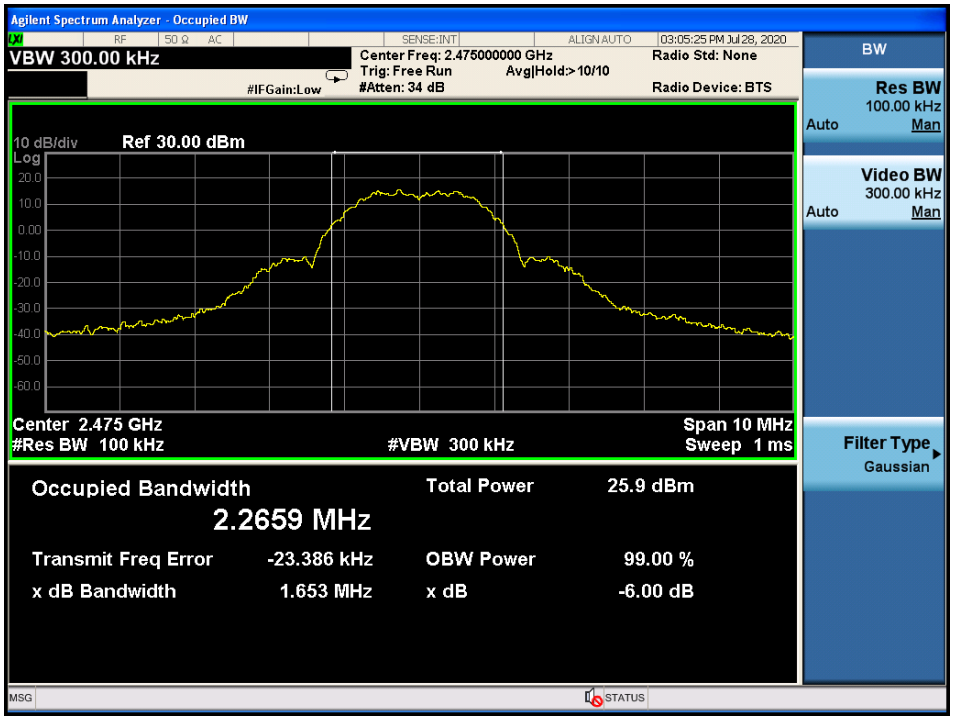
2440 MHz 6 dB OBW



2480 MHz 99% OBW



2480 MHz 6 dB OBW



9 FCC §15.247(b) (3) & ISEDC RSS-247 §5.4 (4) - 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).

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.

Corrected Average Field Strength (dBµV/m) = Measured Average Field Strength (dBµV) + Cable Loss (dB) + Antenna Factor (dB/m)

EIRP (dBm) = Field Strength (dBµV/m) + 20log(D(m)) - 104.77

Conducted Output Power = EIRP – Antenna Gain

9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	EXA Signal Analyzer	N9010A	MY48030852	2020-02-12	1 year
-	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".*

9.4 Test Environmental Conditions

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

The testing was performed by Christian McCaig on 2020-07-29 in RF site.

9.5 Test Results

BLE

Channel	Frequency (MHz)	Conducted Peak Power (dBm)	Limit (dBm)
Low	2402	18.612	30
Middle	2440	18.465	30
High	2480	18.626	30

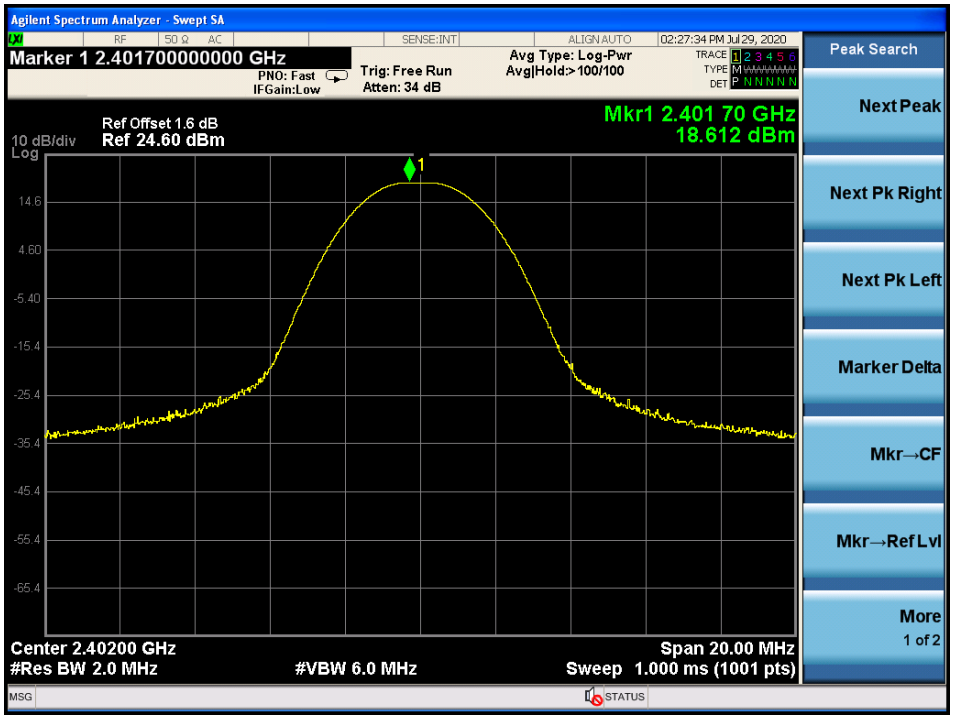
ZigBee

Channel	Frequency (MHz)	Conducted Peak Power (dBm)	Limit (dBm)
Low	2405	19.240	30
Middle	2440	18.930	30
High	2475	18.979	30

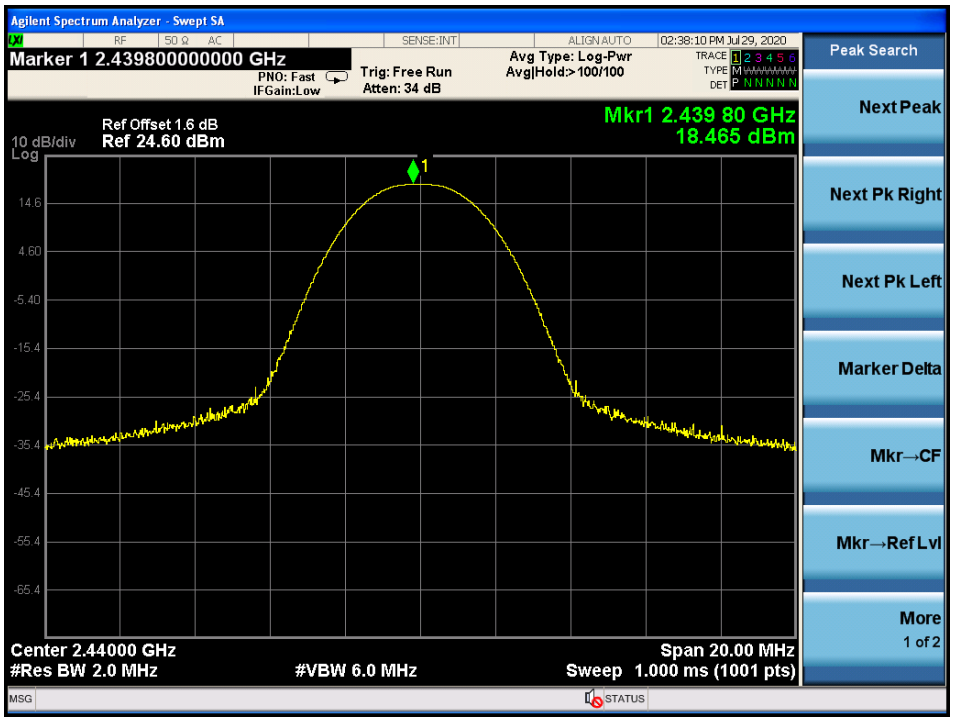
Please refer to the following plots.

BLE

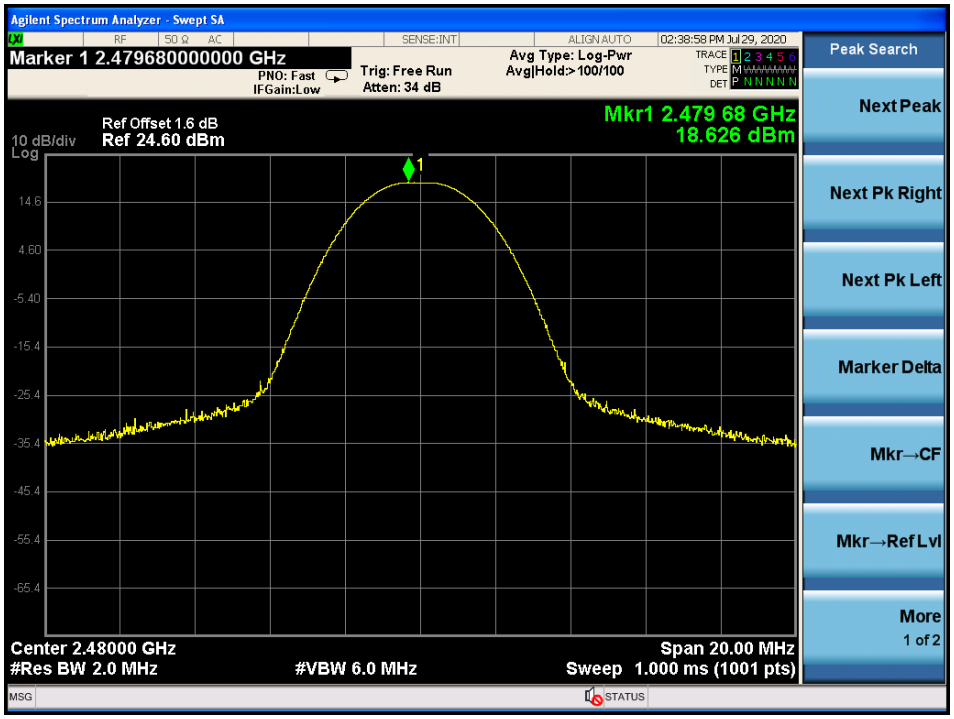
2402 MHz OP



2440 MHz OP

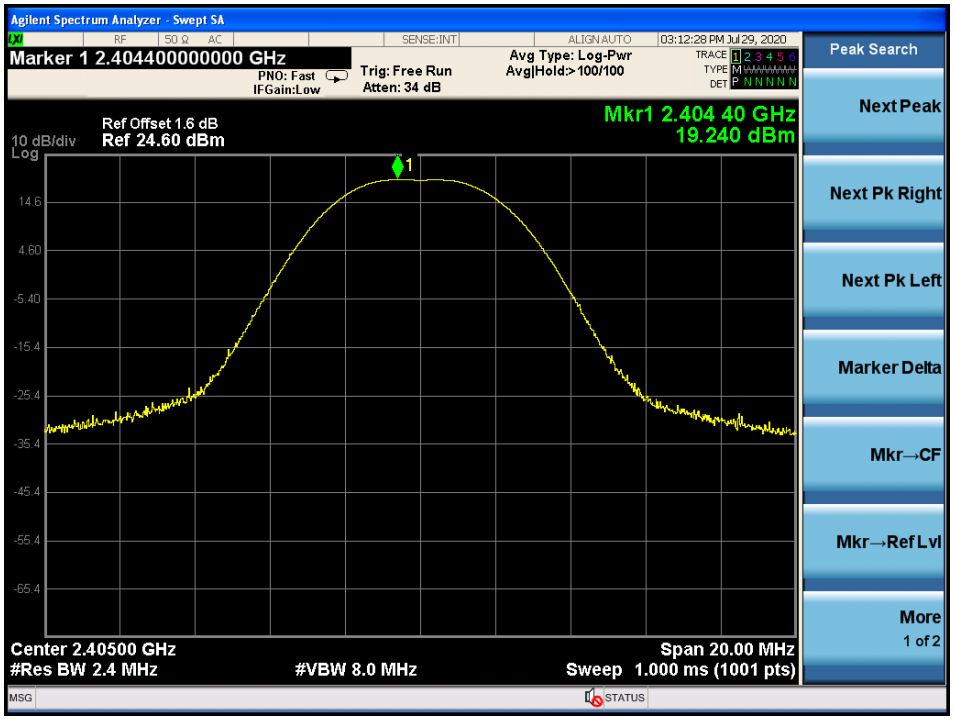


2480 MHz OP

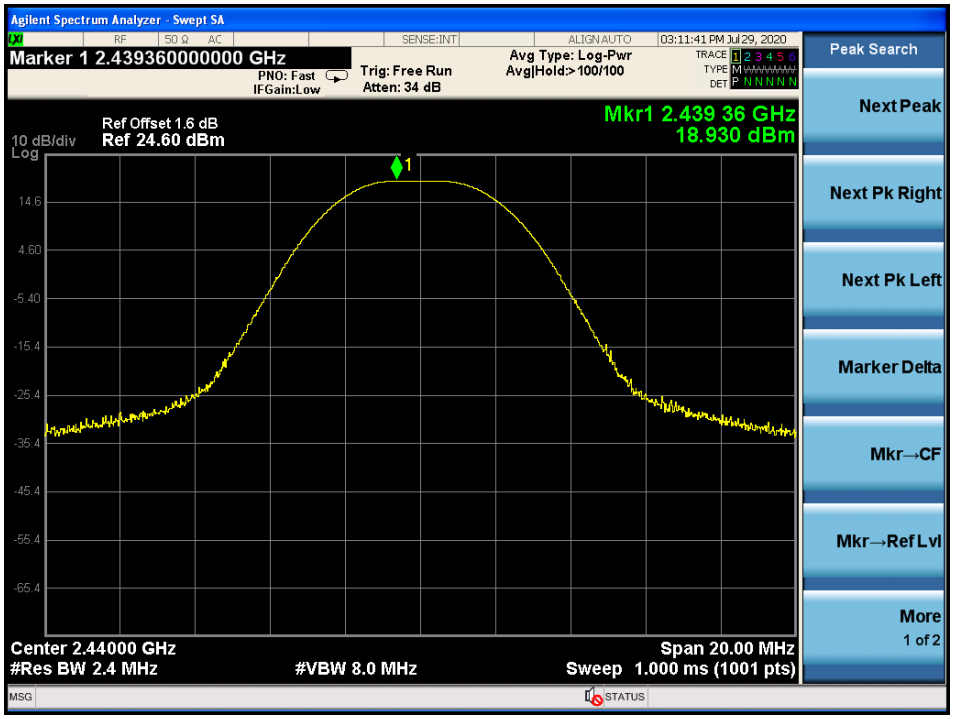


ZigBee

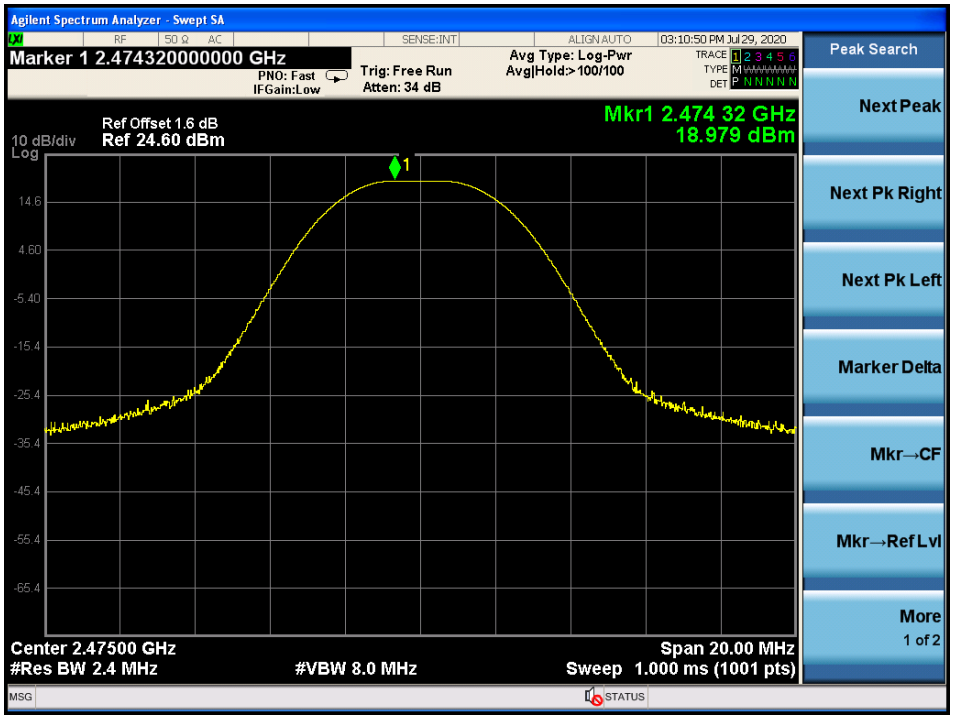
2405 MHz OP



2440 MHz OP



2475 MHz OP



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

10.1 Applicable Standards

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

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 Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	EXA Signal Analyzer	N9010A	MY48030852	2020-02-12	1 year
-	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".*

10.4 Test Environmental Conditions

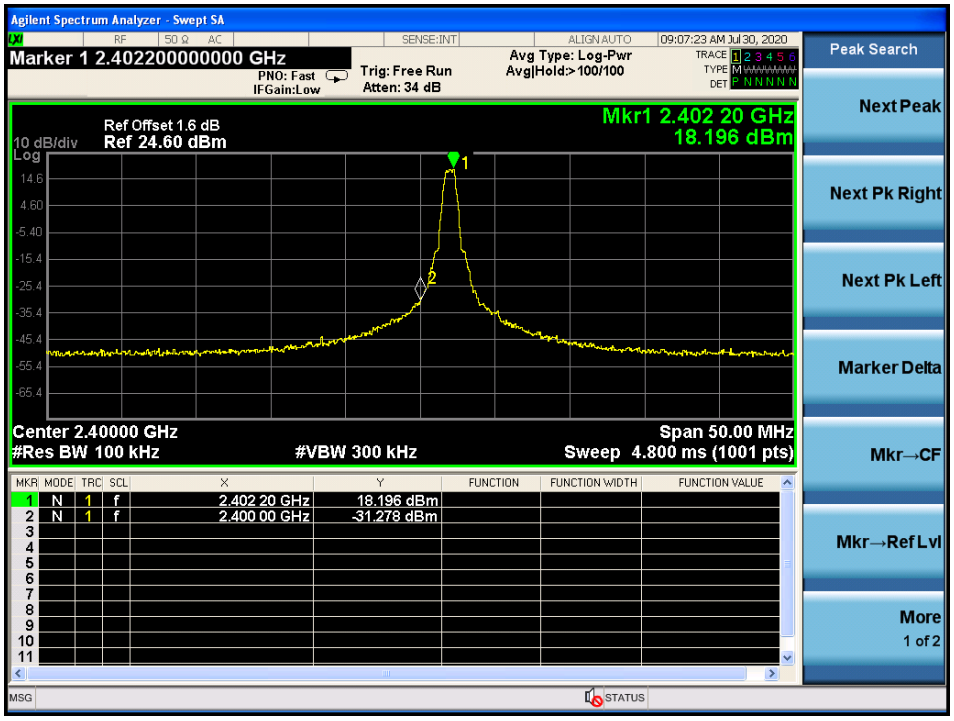
Temperature:	23º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Christian McCaig on 2020-07-29 and 2020-07-30 in RF site.

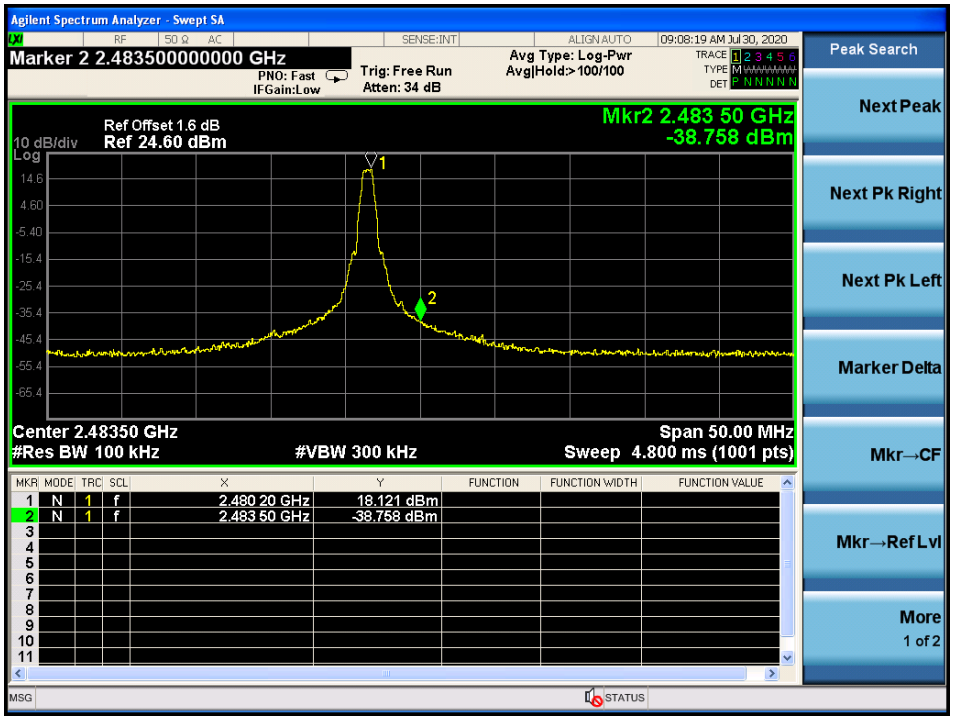
10.5 Test Results

BLE

2402 MHz

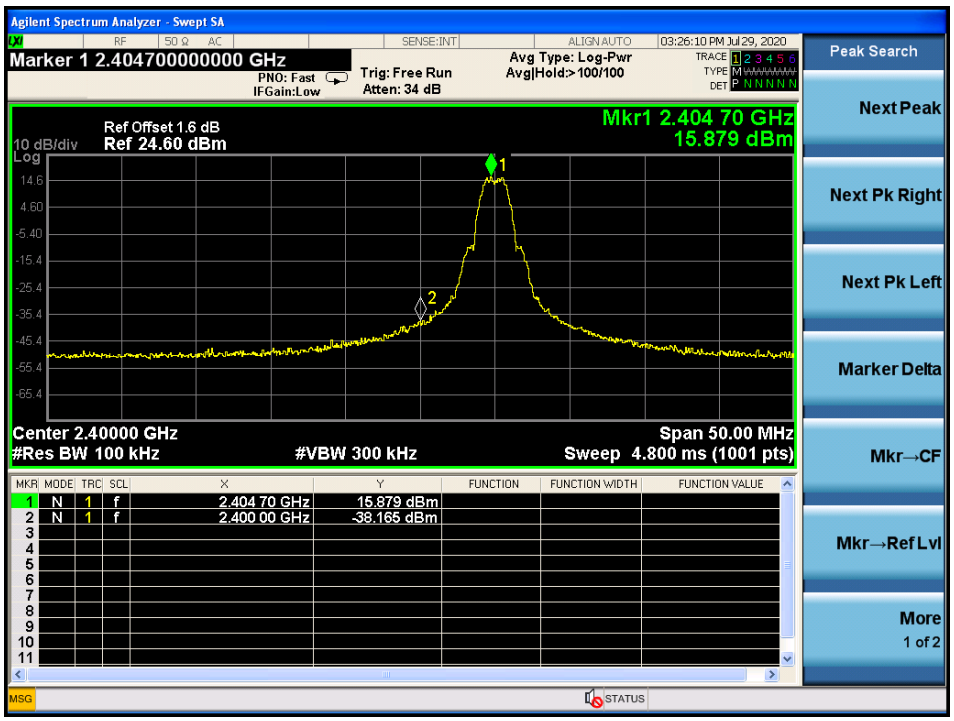


2480 MHz

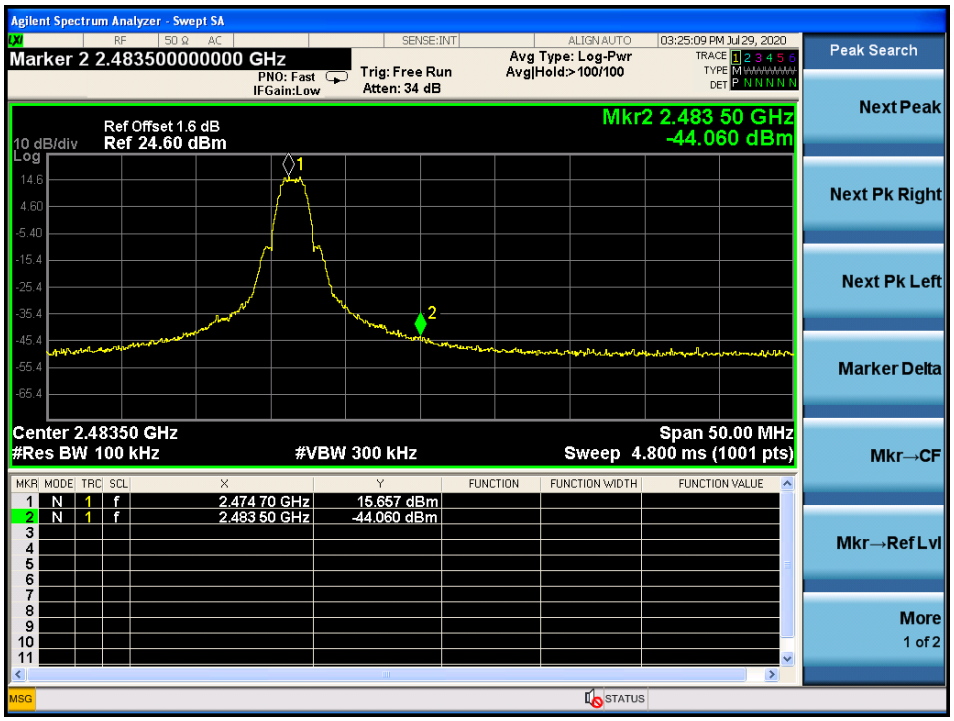


ZigBee

2405 MHz



2475 MHz



11 FCC §15.247(e) & ISEDC RSS-247 §5.2(2) - 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.

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.

Corrected Average Field Strength (dBµV/m) = Measured Average Field Strength (dBµV) + Cable Loss (dB) + Antenna Factor (dB/m)

EIRP (dBm) = Field Strength (dBµV/m) + 20log(D(m)) - 104.77

Conducted Output Power = EIRP – Antenna Gain

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	EXA Signal Analyzer	N9010A	MY48030852	2020-02-12	1 year
-	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".*

11.4 Test Environmental Conditions

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

The testing was performed by Christian McCaig on 2020-07-29 and 2020-07-30 in RF site.

11.5 Test Results

BLE

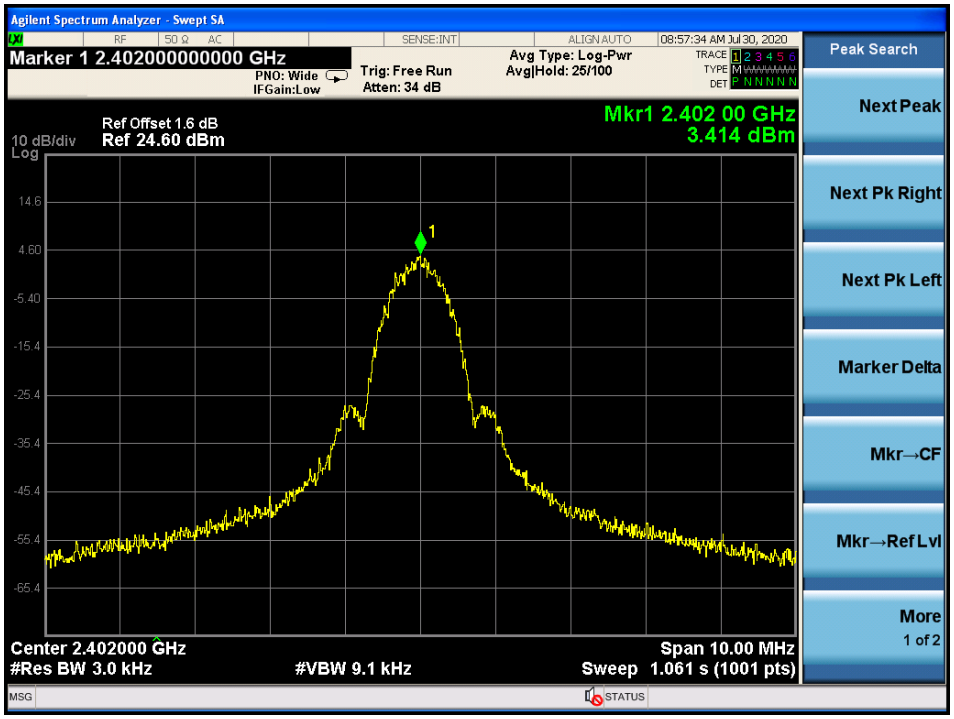
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)
Low	2402	3.414	8
Middle	2440	3.132	8
High	2480	3.465	8

ZigBee

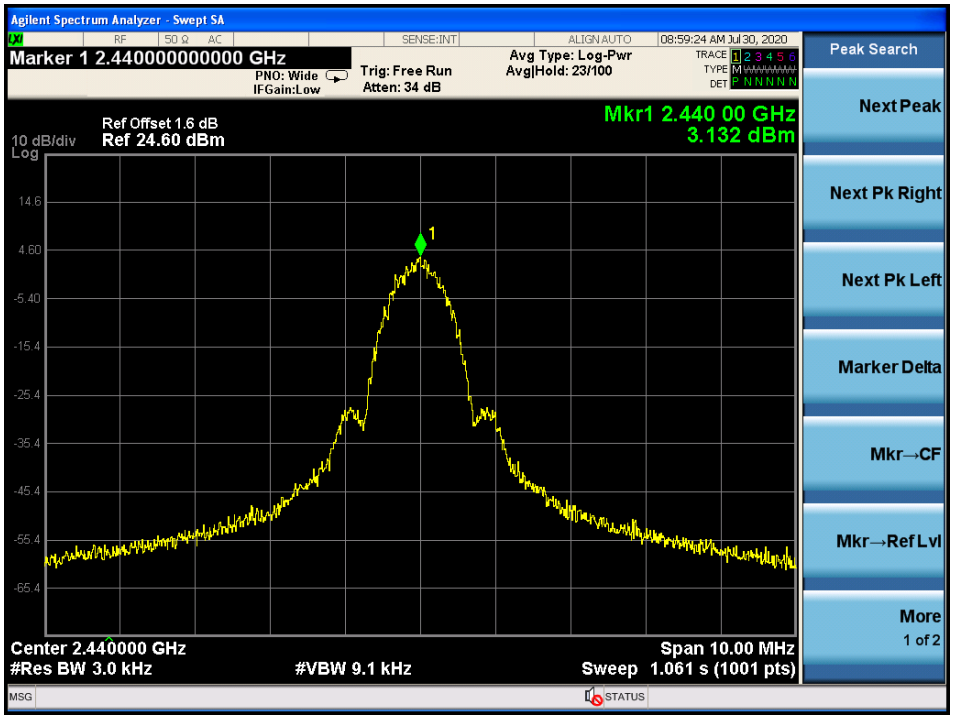
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)
Low	2405	3.595	8
Middle	2440	3.421	8
High	2475	3.770	8

BLE

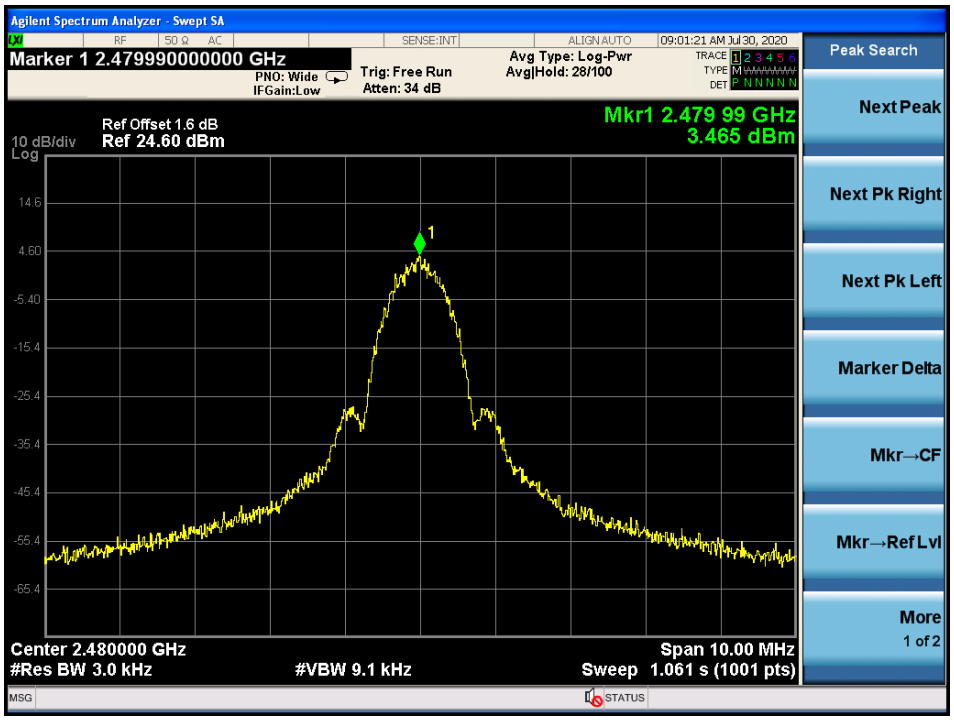
2402 MHz PSD



2440 MHz PSD

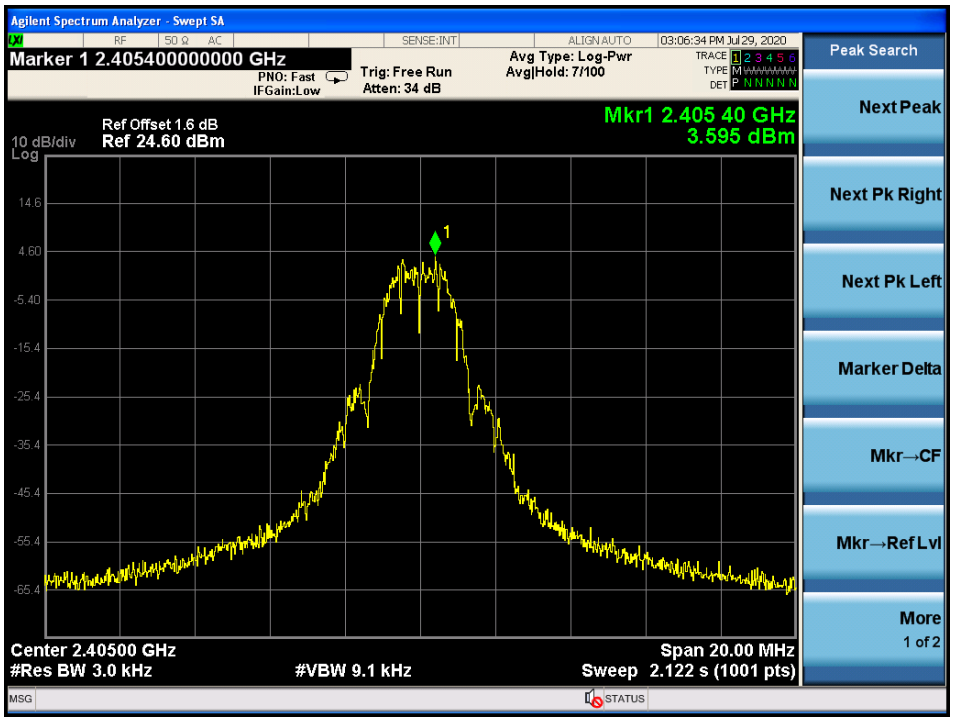


2480 MHz PSD

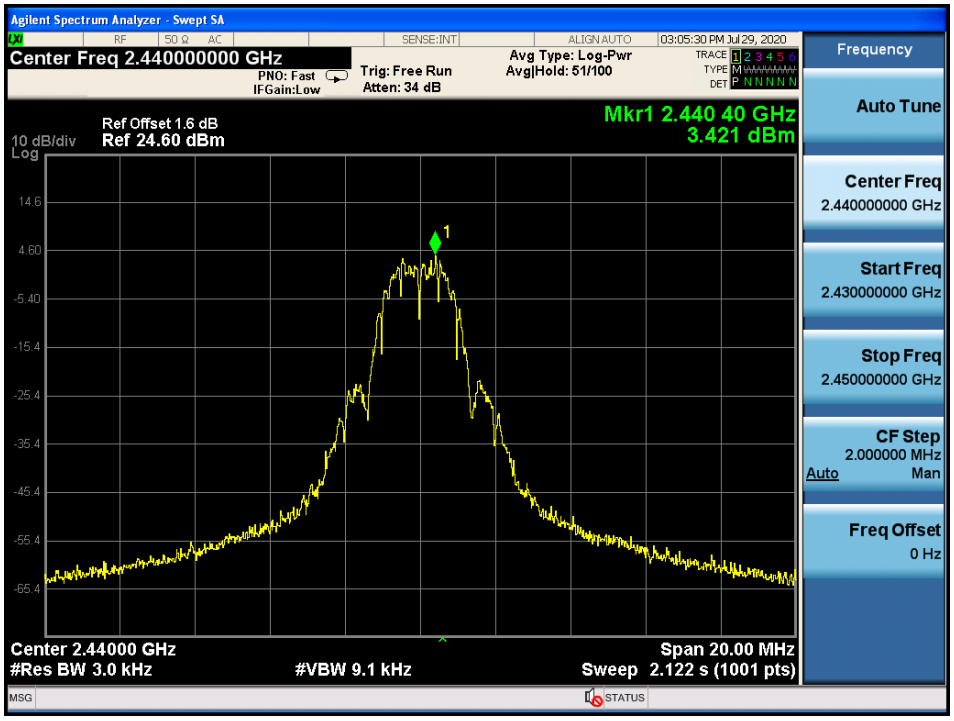


ZigBee

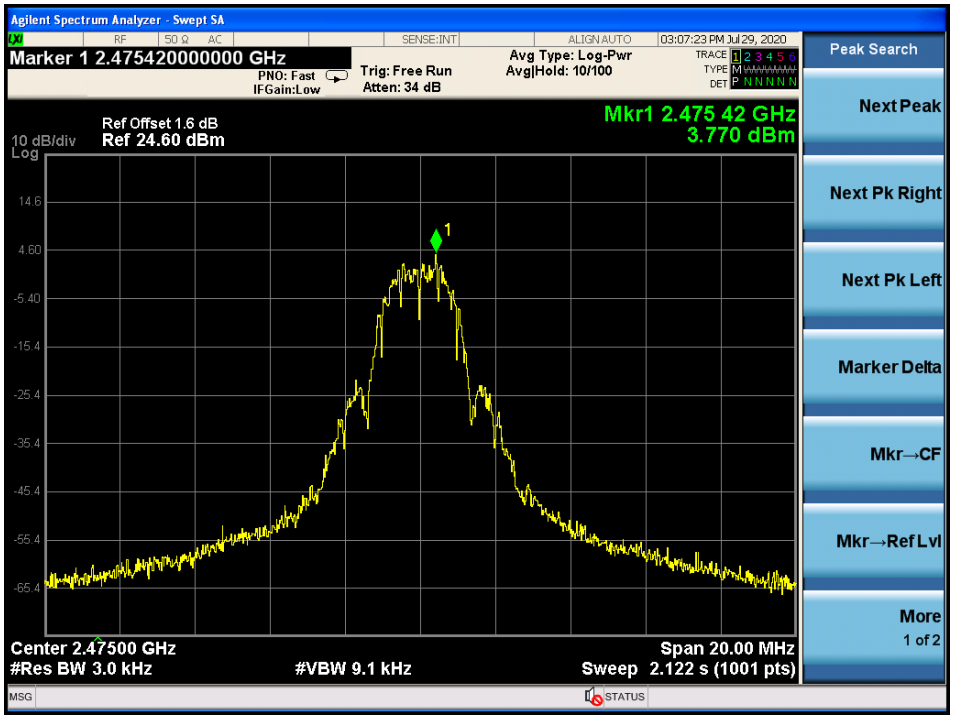
2405 MHz PSD



2440 MHz PSD



2475 MHz PSD


Agilent Spectrum Analyzer - Swept SA
RF 50 Ω AC
SENSE:INT
ALIGN AUTO
03:07:23 PM Jul 29, 2020
Marker 1 2.475420000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
Atten: 34 dB
Avg Type: Log-Pwr
Avg|Hold: 10/100
TRACE 1 2 3 4 5 6
TYPE M
DET P N N N N N
Ref Offset 1.6 dB
10 dB/div
Log
Ref 24.60 dBm
Mkr1 2.475 42 GHz
3.770 dBm
14.6
4.60
-5.40
-15.4
-25.4
-35.4
-45.4
-55.4
-65.4
Center 2.47500 GHz
#Res BW 3.0 kHz
#VBW 9.1 kHz
Span 20.00 MHz
Sweep 2.122 s (1001 pts)
MSG
STATUS
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2

12 Annex A (Normative) – EUT Test Setup Photographs

Please refer to the attachment.

13 Annex B (Normative) – EUT External Photographs

Please refer to the attachment.

14 Annex C (Normative) – EUT Internal Photographs

Please refer to the attachment.

15 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 2nd day of October 2018.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to February 28, 2021
Revised December 04, 2020

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 ---