FCC PART 15, SUBPART C

TEST REPORT

For

Roku, Inc.

150 Winchester Cir

Los Gatos, CA 95032, USA

FCC ID: TC2-R1022

Report Type: Original Report	**Model:** 2200X
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Report Number:	R1903224-247
Report Date:	2019-04-20
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ACCREDITED
CERTIFICATE #3297.02

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* This test report may contain data and test methods that are not covered by BACL's scope of accreditation as of the test report date shown above. These items are marked within the test report text with an asterisk "*"

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1903224-247	Original Report	2019-04-20

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

Manufacturer:	Roku, Inc.
EUT Model(s):	2200X
FCC ID:	TC2-R1022
Serial Number(s):	R1903244-1 and R1903244-2

1.2 Objective

This report is prepared on behalf of *Roku, Inc.* in accordance with Part 2, Subpart J, and Part 15, Subparts B and C of the Federal Communication Commission's rules.

The objective is to determine compliance with FCC Part 15.247 for Output Power, Antenna Requirements, 6 dB Bandwidth, Power Spectral Density, 100 kHz Bandwidth of Band Edges Measurement, Conducted and Radiated Spurious Emissions.

1.3 Related Submittal(s)/Grant(s)

R1903224-407

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 3279.02),*** in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2005 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 3279.03)*** to certify

- For the USA (Federal Communications Commission):
  1- All Unlicensed radio frequency devices within FCC Scopes A1, A2, A3, and A4;
  2- All Licensed radio frequency devices within FCC Scopes B1, B2, B3, and B4;
  3- All Telephone Terminal Equipment within FCC Scope C.
- For the Canada (Industry Canada):
  1 All Scope 1-Licence-Exempt Radio Frequency Devices;
  2 All Scope 2-Licensed Personal Mobile Radio Services;
  3 All Scope 3-Licensed General Mobile and Fixed Radio Services;
  4 All Scope 4-Licensed Maritime and 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 3279.01)*** to certify Products to USA's Environmental Protection Agency (EPA) ENERGY STAR Product Specifications for:

1 Electronics and Office Equipment:
- for Telephony (ver. 3.0)
- for Audio/Video (ver. 3.0)
- for Battery Charging Systems (ver. 1.1)
- for Set-top Boxes and 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: (Industry Canada - ISEDC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I and 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 2004/108/EC US-EU EMC and Telecom MRA CAB
  - 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 and Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Development Authority - IDA) APEC Tel MRA -Phase I and Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - Telecommunications Certification Body (TCB) – US FCC
  - Nationally Recognized Test Laboratory (NRTL) – US OSHA
- Vietnam: APEC Tel MRA -Phase I;

2 System Test Configuration

2.1 Justification

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

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

The worst-case data rates are determined to be as follows for each mode based upon investigation by measuring the average power, peak power and PPSD across all data rates bandwidths, and modulations.

2.2 EUT Exercise Software

The software used in testing to configure the EUT was Tera Term. The software is compliant with the standard requirements being tested against.

Radio 1

Modulation	Frequency (MHz)	Power Setting
802.11b	2412	39
	2437	39
	2462	39
802.11g	2412	26
	2437	26
	2462	26
802.11n20	2412	30
	2437	30
	2462	30
802.11n40	2422	30
	2437	30
	2452	30

Radio 2

Modulation	Frequency (MHz)	Power Setting
BLE	2402	Max
	2440	Max
	2480	Max

Data Rates Tested:
802.11b mode: 1Mbps
802.11g mode: 6Mbps
802.11n HT20/HT40 mode: HTMCS0

2.3 Duty Cycle Correction Factor

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

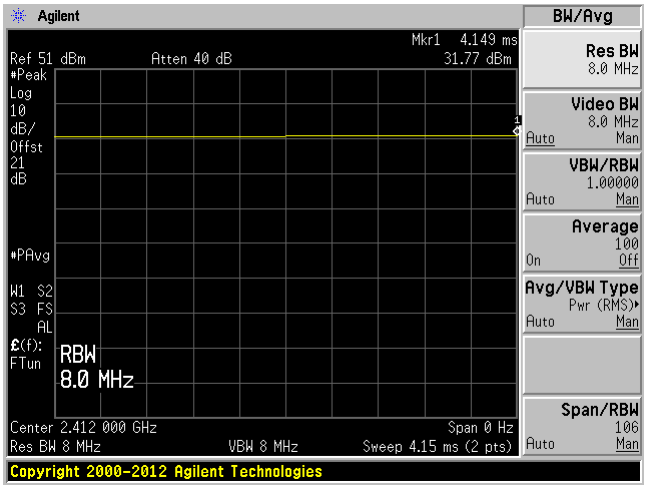
Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized 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	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11b	100	0
802.11g	100	0
802.11n20	100	0
802.11n40	100	0
BLE	100	0

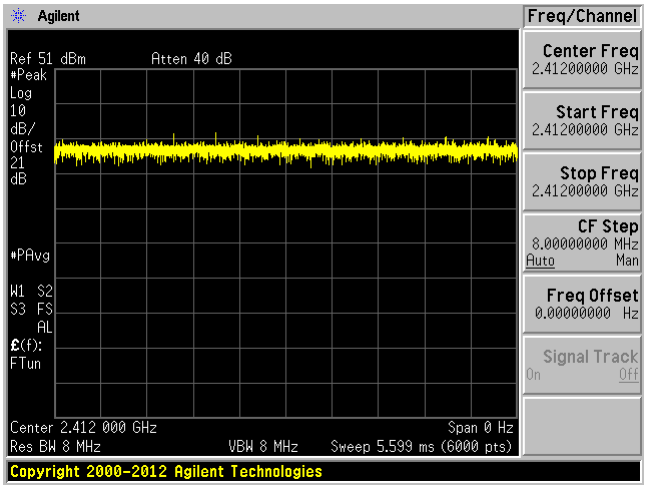
Duty Cycle = On Time (ms)/ Period (ms)
Duty Cycle Correction Factor (dB) = 10*log(1/Duty Cycle)

Please refer to the following plots.

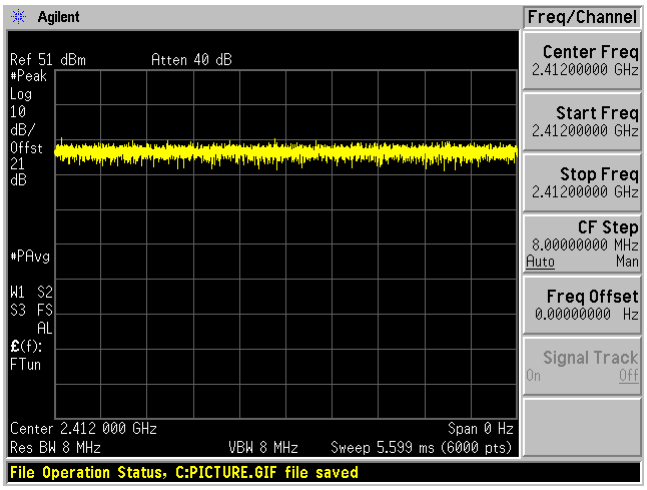
802.11b mode



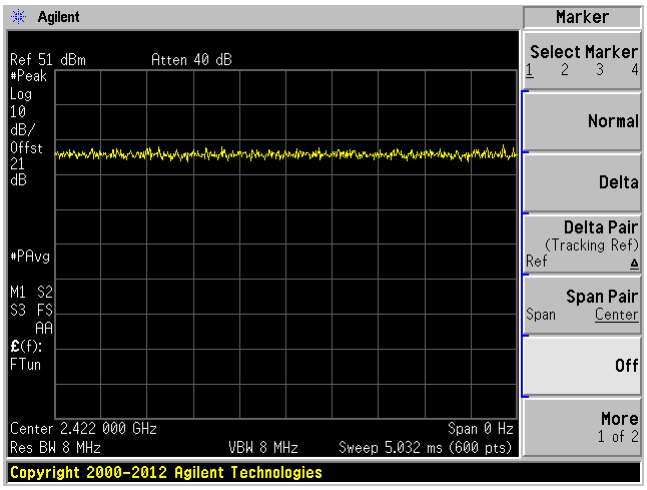
802.11g mode



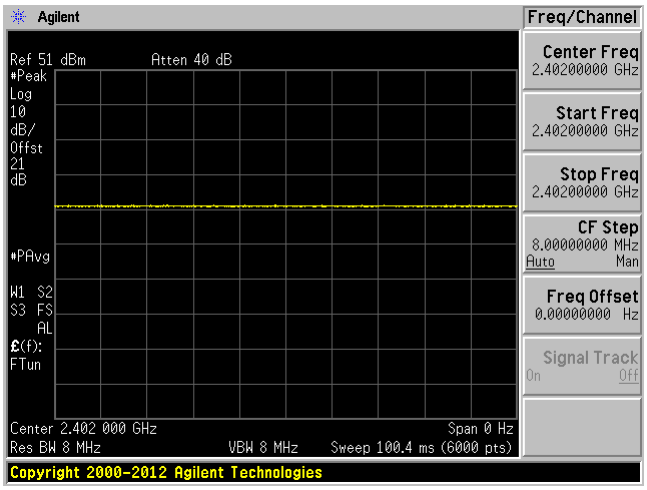
802.11n20 mode



802.11n40 mode



BLE



2.4 Equipment Modifications

N/A

2.5 Local Support Equipment

Manufacturer	Description	Model	Serial Number
Dell	Laptop	Latitude E6410	3CKRAQ1

2.6 Support Equipment

Manufacturer	Description	Model
Roku, Inc.	Debug Board	2000000093 Rev. D1

2.7 Interface Ports and Cabling

Cable Description	Length (m)	To	From
RF Cable	< 1m	EUT	PSA
Power Extension Cord	< 1m	EUT	Outlet
USB Type-A to USB Type B	< 1m	Laptop	Debug Board

3 Summary of Test Results

Results reported relate only to the product tested.

FCC Rules	Description of Test	Results
FCC §15.203	Antenna Requirement	Compliant
FCC §15.207	AC Line Conducted Emissions	Compliant
§2.1091, §15.247(i)	RF Exposure	Compliant
FCC §2.1051, §15.247 (d)	Spurious Emissions at Antenna Port	Compliant
FCC §2.1053, §15.205, §15.209, §15.247(d)	Radiated Spurious Emissions	Compliant
FCC §15.247(a)(2)	6 dB and 99% Emission Bandwidth	Compliant
FCC §15.247(b)(3)	Maximum Peak Output Power	Compliant
FCC §15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliant
FCC §15.247(e)	Power Spectral Density	Compliant

4 FCC §15.203 - 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.

4.2 Antenna Description

The antennas used by the EUT are permanent attached antennas. The following antenna specifications were provided by the applicant.

Radio	Antenna Usage	Frequency Range (MHz)	Antenna Gain (dBi)
Radio 1	2.4 GHz Wi-Fi and 5 GHz Wi-Fi	2400-2483.5 5150-5250 & 5725-5850	1.5
Radio 2	5 GHz Wi-Fi and BLE	2400-2483.5 5150-5250 & 5725-5850	1.5

5 FCC §2.1091 & §15.247(i) – 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

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

2.4 GHz Wi-Fi

Maximum output power at antenna input terminal (dBm):	26.0103
Maximum output power at antenna input terminal (mW):	399.052467
Tuned up output power at antenna input terminal (dBm):	27.0103
Tuned up output power at antenna input terminal (mW):	502.3772913
Prediction distance (cm):	20
Prediction frequency (MHz):	2412
Maximum Antenna Gain, typical (dBi):	1.5
Maximum Antenna Gain (numeric):	1.4125375
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.141247365
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. The tuned up power density at the distance of 20 cm is 0.1412 mW/cm^2. Limit is 1.0 mW/cm^2.

2.4 GHz BLE

Maximum peak output power at antenna input terminal (dBm):	13.2
Maximum peak output power at antenna input terminal (mW):	20.892961
Tuned up output power at antenna input terminal (dBm):	14.2
Tuned up output power at antenna input terminal (mW):	26.30267992
Prediction distance (cm):	20
Prediction frequency (MHz):	2402
Maximum Antenna Gain, typical (dBi):	1.5
Maximum Antenna Gain (numeric):	1.4125375
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.007395207
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. The tuned up power density at the distance of 20 cm is 0.0074 mW/cm^2. Limit is 1.0 mW/cm^2.

5GHz Wi-Fi Radio 1

Maximum peak output power at antenna input terminal (dBm):	22.09899
Maximum peak output power at antenna input terminal (mW):	162.143297
Tuned up output power at antenna input terminal (dBm):	23.09899
Tuned up output power at antenna input terminal (mW):	204.1263171
Prediction distance (cm):	20
Prediction frequency (MHz):	5240
Maximum Antenna Gain, typical (dBi):	1.5
Maximum Antenna Gain (numeric):	1.4125375
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.057391735
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. The tuned up power density at the distance of 20 cm is 0.0574 mW/cm^2. Limit is 1.0 mW/cm^2.

5GHz Wi-Fi Radio 2

Maximum peak output power at antenna input terminal (dBm):	22.66065
Maximum peak output power at antenna input terminal (mW):	184.52916
Tuned up output power at antenna input terminal (dBm):	23.66065
Tuned up output power at antenna input terminal (mW):	232.3084462
Prediction distance (cm):	20
Prediction frequency (MHz):	5795
Maximum Antenna Gain, typical (dBi):	1.5
Maximum Antenna Gain (numeric):	1.4125375
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.065315365
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. The tuned up power density at the distance of 20 cm is 0.0653 mW/cm^2. Limit is 1.0 mW/cm^2.

Worst case colocation

2.4 GHz Wi-Fi, b mode, 2412 MHz, Radio 1; and BLE, 2402 MHz, Radio 2

Sum of MPE Ratios: 0.1412/1+0.0074/1=0.1486<1

5.2 GHz Wi-Fi, a mode, 5240 MHz, Radio 1; and 5.8 GHz Wi-Fi, ac40 mode, 5795 MHz, Radio 2

Sum of MPE Ratios: 0.0574/1+0.0653/1=0.1227<1

5.2 GHz Wi-Fi, a mode, 5240 MHz, Radio 1; and BLE, 2402 MHz, Radio 2

Sum of MPE Ratios: : 0.0574/1+0.0074/1=0.0648<1

2.4 GHz Wi-Fi, b mode, 2412 MHz, Radio 1; and 5.8 GHz Wi-Fi, ac40 mode, 5795 MHz, Radio 2

Sum of MPE Ratios: 0.1412/1+0.0653/1=0.2065<1

6 FCC §15.207 - AC Line Conducted Emissions

6.1 Applicable Standards

As per FCC §15.207 Conducted limits:

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

6.1 Test Setup

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

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.

6.2 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 were 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”.

6.3 Corrected Amplitude and Margin Calculation

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

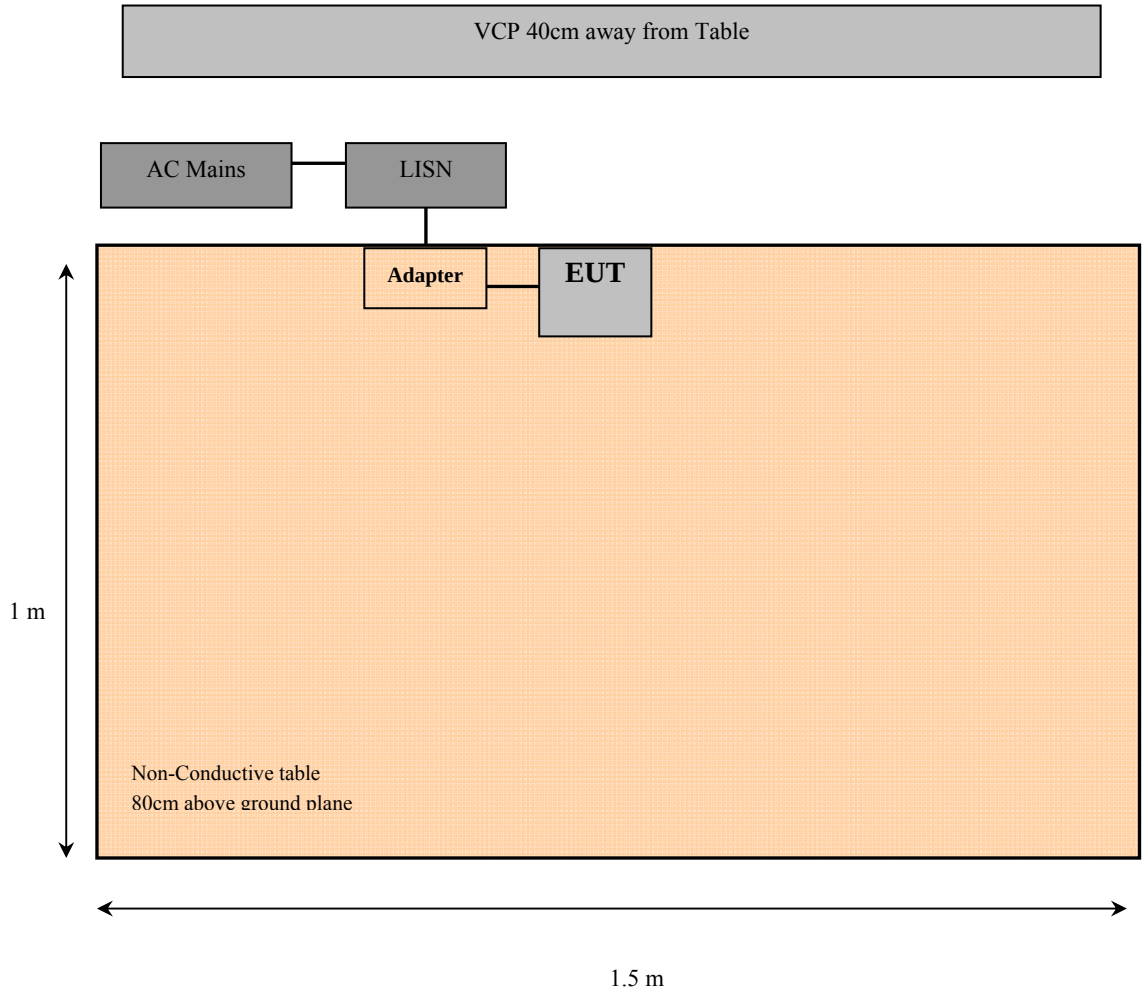
CA = Ai + CL + Atten

For example, a corrected amplitude of 46.2 dBuV = Indicated Reading (32.5 dBuV) + Cable Loss (3.7 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

6.4 Test Setup Block Diagram



6.5 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde and Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100338	2018-07-05	2 years
Rohde and Schwarz	Impulse Limiter	ESH3-Z2	101964	2018-07-27	1 year
Keysight Technologies	RF Limiter	11867A	MY42242931	2018-09-04	1 year
Solar Electronics Company	High Pass Filter	Type 7930-100	7930150204	2019-02-25	1 year
Suirong	30 ft conductive emission cable	LMR 400	-	N/R	N/A
FCC	LISN	FCC-LISN-50-25-2-10-CISPR16	160129	2019-04-04	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 A2LA Policy P102 (dated 9 June 2016) "A2LA Policy on Metrological Traceability".

6.6 Test Environmental Conditions

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

The testing was performed by Alexandrae Duran on 2019-04-16 in 5 chamber 3.

6.7 Summary of Test Results

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

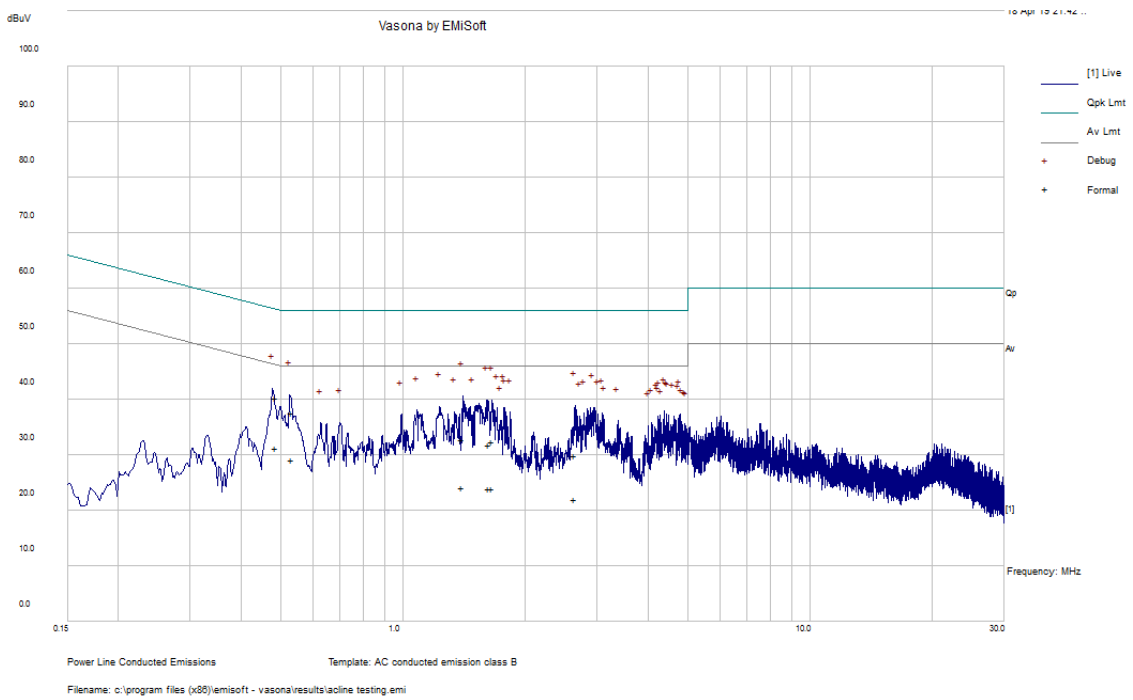
Transmitting simultaneously: 2.4 GHz Wi-Fi, b mode, 2412 MHz, Radio 1; and BLE, 2402 MHz, Radio 2

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Line/Neutral)**	**Range (MHz)**
-12.01	0.495365	Neutral	0.15-30

6.8 Conducted Emissions Test Plots and Data

2.4 GHz Wi-Fi, b mode, 2412 MHz Radio 1 and BLE, 2402MHz Radio 2

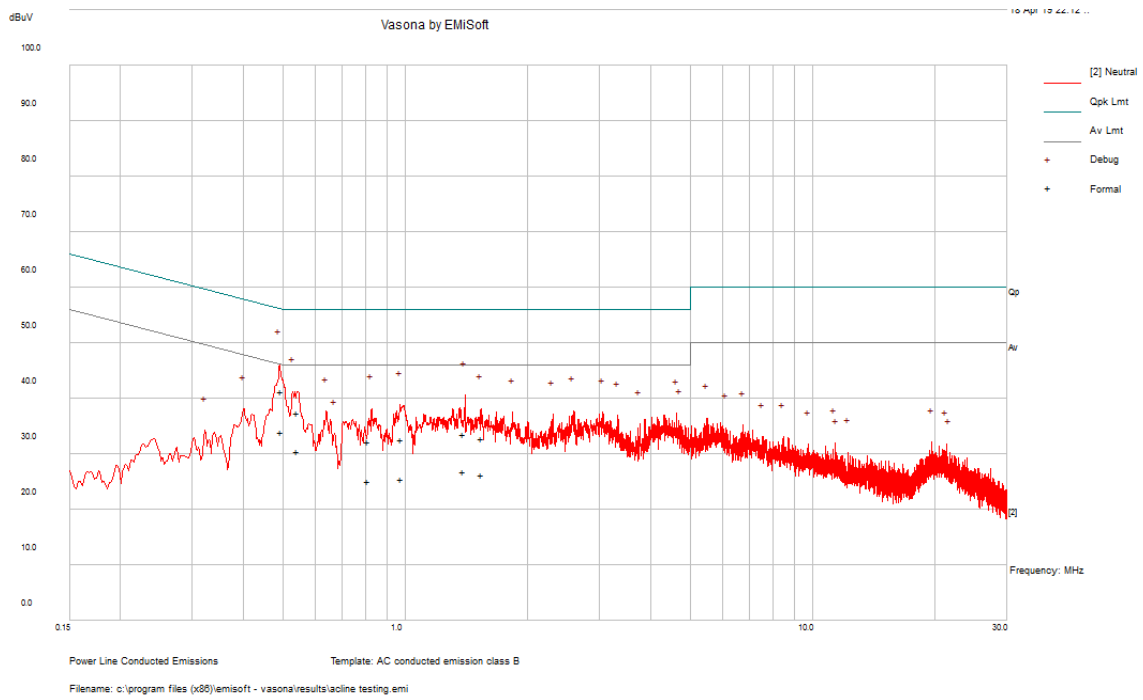
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.486212	40.33	Line	56.23	-15.9	QP
0.532015	37.61	Line	56	-18.39	QP
1.401703	32.79	Line	56	-23.21	QP
1.624841	31.78	Line	56	-24.22	QP
1.652752	32.43	Line	56	-23.57	QP
2.641269	29.86	Line	56	-26.14	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.486212	31.22	Line	46.23	-15.01	Ave
0.532015	29.23	Line	46	-16.77	Ave
1.401703	24.26	Line	46	-21.74	Ave
1.624841	23.94	Line	46	-22.06	Ave
1.652752	23.97	Line	46	-22.03	Ave
2.641269	22.01	Line	46	-23.99	Ave

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.495365	41.2	Neutral	56.08	-14.88	QP
0.544627	37.4	Neutral	56	-18.6	QP
1.389931	33.54	Neutral	56	-22.46	QP
0.980241	32.72	Neutral	56	-23.28	QP
0.812255	32.16	Neutral	56	-23.84	QP
1.535522	32.82	Neutral	56	-23.18	QP

Frequency (MHz)	Corrected Amplitude (dBuV)	Conductor (Line/Neutral)	Limit (dBuV)	Margin (dB)	Detector (QP/Ave.)
0.495365	34.07	Neutral	46.08	**-12.01**	Ave
0.544627	30.5	Neutral	46	-15.5	Ave
1.389931	26.89	Neutral	46	-19.11	Ave
0.980241	25.58	Neutral	46	-20.42	Ave
0.812255	25.04	Neutral	46	-20.96	Ave
1.535522	26.29	Neutral	46	-19.71	Ave

7 FCC §15.209 & §15.247(d) - Spurious Radiated Emissions

7.1 Applicable Standards

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

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

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

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).

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.

The spacing between the peripherals was 10 centimeters.

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

7.3 Test Procedure

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

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

The EUT 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 = 1MHz / Sweep = Auto
(2) Average: RBW = 1MHz / VBW = 10Hz or 1/T / Sweep = Auto

7.4 Corrected Amplitude and Margin Calculation

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

CA = Ai + AF + CL + Atten – Ga

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

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. 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
Rohde and Schwarz	Receiver, EMI Test	ESCI 1166.5950K03	100338	2018-07-05	2 years
-	2.4GHz Notch Filter	-	-	N/R	N/A
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
Sunol Sciences	System Controller	SC99V	011003-1	N/R	N/A
Sunol Sciences	Antenna, Biconi-Log	JB1	A013105-3	2018-02-26	2 years
Wisewave	Antenna, Horn	ARH-4223-02	10555-02	2018-02-14	2 years
Wisewave	Antenna, Horn	ARH-4223-02	10555-01	2018-02-14	2 years
Agilent	Amplifier, Pre	8447D	2443A04374	2018-08-09	1 year
Insulated Wire INC	2.92mm (M) X2, 1501 Armor Neoprene, 396	KPS-1501AN-3960-KPS	DC 1807	2018-03-13	2 years
-	SMA cable	-	C00011	Each time[1]	N/A
-	N-Type Cable	-	C00012	Each time[1]	N/A
-	N-Type Cable	-	C00014	Each time[1]	N/A
HP	Pre-Amplifier	8449B	3008A01978	2018-08-10	1 year
Sunol Sciences	Antenna, Horn	DRH-118	A052704	2019-04-02	2 years
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 A2LA Policy P102 (dated 9 June 2016) "A2LA Policy on Metrological Traceability".

7.6 Test Environmental Conditions

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

The testing was performed by Alexandrae Duran 2019-03-26 to 2019-04-17 in 5 m chamber 3.

7.7 Summary of Test Results

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

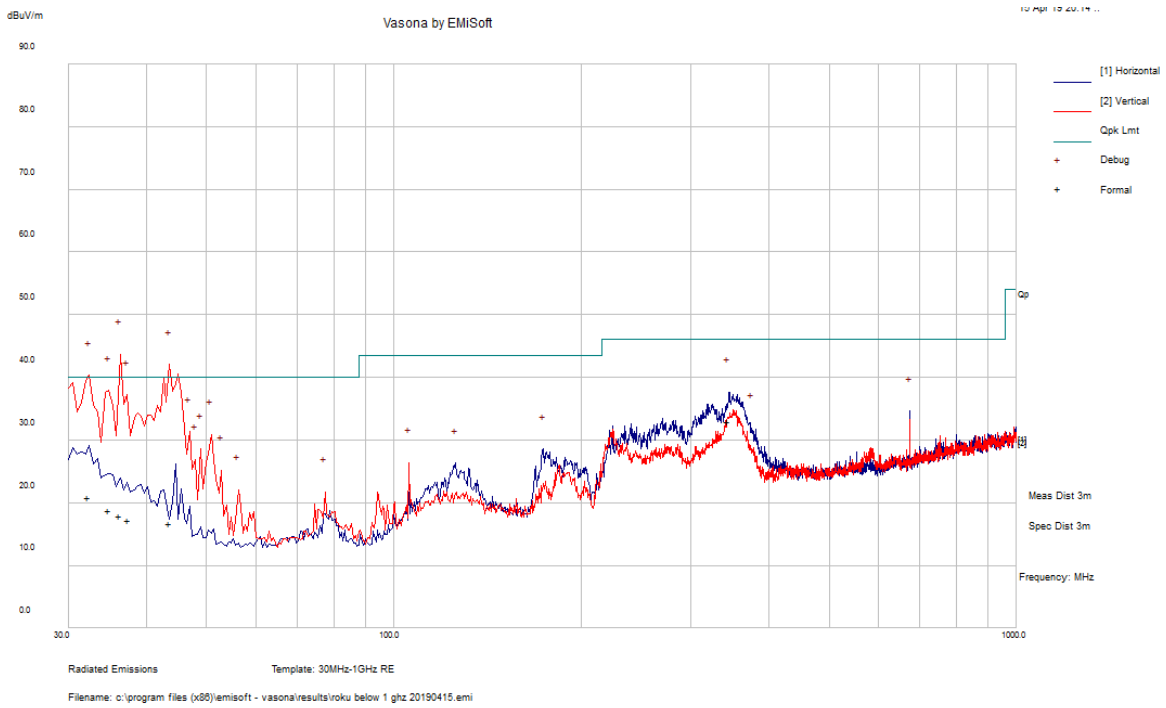
Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Mode, channel**
-0.39	7440	Horizontal	BLE, 2480 MHz

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

7.8 Radiated Emissions Test Results

1) 30 MHz – 1 GHz

2.4 GHz Wi-Fi, b mode, 2412 MHz, Radio 1; and BLE, 2402MHz, Radio 2



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
36.25775	17.92	242	V	242	40	-22.08	QP
43.6905	16.67	122	V	122	40	-23.33	QP
32.286	20.94	112	V	112	40	-19.06	QP
34.78275	18.89	217	V	217	40	-21.11	QP
37.40125	17.3	289	V	289	40	-22.7	QP
344.7178	33.03	107	H	107	46	-12.97	QP

2) 1–18 GHz Measured at 3 meters

802.11b mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2412 MHz											
2390	28.93	287	110	H	28.07	6.846	0.00	63.84	74	-10.16	PK
2390	16.44	287	110	H	28.07	6.846	0.00	51.35	54	-2.65	AV
2390	28.47	167	100	V	28.07	6.846	0.00	63.38	74	-10.62	PK
2390	15.45	167	100	V	28.07	6.846	0.00	50.36	54	-3.64	AV
4824	51.32	217	143	H	33.14	10.354	35.66	59.15	74	-14.85	PK
4824	44.73	217	143	H	33.14	10.354	35.66	52.56	54	-1.44	AV
4824	51.13	324	222	V	33.14	10.354	35.66	58.96	74	-15.04	PK
4824	43.65	324	222	V	33.14	10.354	35.66	51.48	54	-2.52	AV
7236	45.35	0	100	H	37.53	12.24	35.67	59.45	74	-14.55	PK
7236	34.74	0	100	H	37.53	12.24	35.67	48.84	54	-5.16	AV
7236	45.01	0	100	V	37.53	12.24	35.67	59.11	74	-14.89	PK
7236	34.56	0	100	V	37.53	12.24	35.67	48.66	54	-5.34	AV
Mid Channel 2437 MHz											
4874	49.94	257	156	H	33.39	10.341	35.66	58.02	74	-15.99	PK
4874	40.29	257	156	H	33.39	10.341	35.66	48.37	54	-5.64	AV
4874	49.91	229	171	V	33.39	10.341	35.66	57.99	74	-16.02	PK
4874	40.22	229	171	V	33.39	10.341	35.66	48.30	54	-5.71	AV
7311	44.98	0	100	H	37.52	12.757	35.67	59.59	74	-14.41	PK
7311	34.52	0	100	H	37.52	12.757	35.67	49.13	54	-4.87	AV
7311	44.54	0	100	V	37.52	12.757	35.67	59.15	74	-14.85	PK
7311	34.60	0	100	V	37.52	12.757	35.67	49.21	54	-4.79	AV
High Channel 2462 MHz											
2483.5	28.17	296	115	H	28.72	6.85	0.00	63.74	74	-10.26	PK
2483.5	16.34	296	115	H	28.72	6.85	0.00	51.91	54	-2.09	AV
2483.5	27.82	170	100	V	28.72	6.85	0.00	63.39	74	-10.61	PK
2483.5	16.29	170	100	V	28.72	6.85	0.00	51.86	54	-2.14	AV
4924	48.81	0	143	H	33.60	8.52	35.66	55.27	74	-18.73	PK
4924	39.31	0	143	H	33.60	8.52	35.66	45.77	54	-8.23	AV
4924	48.86	38	146	V	33.60	8.52	35.66	55.32	74	-18.68	PK
4924	38.99	38	146	V	33.60	8.52	35.66	45.45	54	-8.55	AV
7386	46.40	0	100	H	37.40	12.757	35.67	60.89	74	-13.11	PK
7386	34.83	0	100	H	37.40	12.757	35.67	49.32	54	-4.68	AV
7386	46.75	0	100	V	37.40	12.757	35.67	61.24	74	-12.76	PK
7386	34.24	0	100	V	37.40	12.757	35.67	48.73	54	-5.27	AV

802.11g mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2412 MHz											
2390	27.81	296	110	H	28.07	6.846	0.00	62.72	74	-11.28	PK
2390	16.05	296	110	H	28.07	6.846	0.00	50.96	54	-3.04	AV
2390	27.41	165	100	V	28.07	6.846	0.00	62.32	74	-11.68	PK
2390	16.14	165	100	V	28.07	6.846	0.00	51.05	54	-2.95	AV
4824	47.71	210	140	H	33.14	10.354	35.66	55.54	74	-18.46	PK
4824	36.56	210	140	H	33.14	10.354	35.66	44.39	54	-9.61	AV
4824	47.24	320	220	V	33.14	10.354	35.66	55.07	74	-18.93	PK
4824	36.33	320	220	V	33.14	10.354	35.66	44.16	54	-9.84	AV
7236	46.42	0	100	H	37.53	12.24	35.67	60.52	74	-13.48	PK
7236	34.57	0	100	H	37.53	12.24	35.67	48.67	54	-5.33	AV
7236	46.59	0	100	H	37.53	12.24	35.67	60.69	74	-13.31	PK
7236	34.61	0	100	H	37.53	12.24	35.67	48.71	54	-5.29	AV
Mid Channel 2437 MHz											
4874	47.67	254	156	H	33.39	10.341	35.66	55.75	74	-18.26	PK
4874	35.63	254	156	H	33.39	10.341	35.66	43.71	54	-10.30	AV
4874	46.51	220	165	V	33.39	10.341	35.66	54.59	74	-19.42	PK
4874	34.22	220	165	V	33.39	10.341	35.66	42.30	54	-11.71	AV
7311	46.62	0	100	H	37.52	12.757	35.67	61.23	74	-12.77	PK
7311	34.64	0	100	H	37.52	12.757	35.67	49.25	54	-4.75	AV
7311	46.89	0	100	V	37.52	12.757	35.67	61.50	74	-12.50	PK
7311	34.52	0	100	V	37.52	12.757	35.67	49.13	54	-4.87	AV
High Channel 2462 MHz											
2483.5	28.16	285	115	H	28.72	6.85	0.00	63.73	74	-10.27	PK
2483.5	15.47	285	115	H	28.72	6.85	0.00	51.04	54	-2.96	AV
2483.5	28.31	165	100	V	28.72	6.85	0.00	63.88	74	-10.12	PK
2483.5	14.99	165	100	V	28.72	6.85	0.00	50.56	54	-3.44	AV
4924	47.24	0	143	H	33.60	8.52	35.66	53.70	74	-20.30	PK
4924	35.62	0	143	H	33.60	8.52	35.66	42.08	54	-11.92	AV
4924	48.21	0	120	H	33.60	8.52	35.66	54.67	74	-19.33	PK
4924	35.23	0	120	H	33.60	8.52	35.66	41.69	54	-12.31	AV
7386	46.83	0	100	H	37.40	12.757	35.67	61.32	74	-12.68	PK
7386	34.47	0	100	H	37.40	12.757	35.67	48.96	54	-5.04	AV
7386	46.74	0	100	H	37.40	12.757	35.67	61.23	74	-12.77	PK
7386	34.91	0	100	H	37.40	12.757	35.67	49.40	54	-4.60	AV

802.11n20 mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2412 MHz											
2390	28.16	287	110	H	28.07	6.846	0.00	63.07	74	-10.93	PK
2390	16.14	287	110	H	28.07	6.846	0.00	51.05	54	-2.95	AV
2390	28.67	167	100	V	28.07	6.846	0.00	63.58	74	-10.42	PK
2390	16.22	167	100	V	28.07	6.846	0.00	51.13	54	-2.87	AV
4824	48.27	217	143	H	33.14	10.354	35.66	56.10	74	-17.90	PK
4824	36.39	217	143	H	33.14	10.354	35.66	44.22	54	-9.78	AV
4824	47.25	324	222	V	33.14	10.354	35.66	55.08	74	-18.92	PK
4824	35.28	324	222	V	33.14	10.354	35.66	43.11	54	-10.89	AV
7236	47.24	0	100	H	37.53	12.24	35.67	61.34	74	-12.66	PK
7236	35.63	0	100	H	37.53	12.24	35.67	49.73	54	-4.27	AV
7236	47.19	0	100	H	37.53	12.24	35.67	61.29	74	-12.71	PK
7236	35.22	0	100	H	37.53	12.24	35.67	49.32	54	-4.68	AV
Mid Channel 2437 MHz											
4874	48.60	257	156	H	32.81	10.341	35.66	56.09	74	-17.91	PK
4874	36.27	257	156	H	32.81	10.341	35.66	43.76	54	-10.24	AV
4874	48.30	229	171	V	32.81	10.341	35.66	55.79	74	-18.21	PK
4874	36.11	229	171	V	32.81	10.341	35.66	43.60	54	-10.40	AV
7311	46.23	0	100	H	37.06	12.757	35.67	60.37	74	-13.63	PK
7311	34.58	0	100	H	37.06	12.757	35.67	48.72	54	-5.28	AV
7311	46.63	0	100	V	37.06	12.757	35.67	60.77	74	-13.23	PK
7311	34.86	0	100	V	37.06	12.757	35.67	49.00	54	-5.00	AV
High Channel 2462 MHz											
2483.5	28.02	296	100	H	28.72	6.85	0.00	63.59	74	-10.41	PK
2483.5	16.55	296	100	H	28.72	6.85	0.00	52.12	54	-1.88	AV
2483.5	27.73	170	100	V	28.72	6.85	0.00	63.30	74	-10.70	PK
2483.5	16.38	170	100	V	28.72	6.85	0.00	51.95	54	-2.05	AV
4924	47.45	0	100	H	33.60	8.52	35.66	53.91	74	-20.09	PK
4924	35.09	0	100	H	33.60	8.52	35.66	41.55	54	-12.45	AV
4924	47.50	38	100	H	33.60	8.52	35.66	53.96	74	-20.04	PK
4924	35.16	38	100	H	33.60	8.52	35.66	41.62	54	-12.38	AV
7386	46.87	0	100	H	37.40	12.757	35.67	61.36	74	-12.64	PK
7386	33.89	0	100	H	37.40	12.757	35.67	48.38	54	-5.62	AV
7386	46.25	0	100	H	37.40	12.757	35.67	60.74	74	-13.26	PK
7386	33.61	0	100	H	37.40	12.757	35.67	48.10	54	-5.90	AV

802.11n40 mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2422 MHz											
2390	34.84	290	110	H	28.07	6.846	0.00	69.75	74	-4.25	PK
2390	18.35	290	110	H	28.07	6.846	0.00	53.26	54	-0.74	AV
2390	26.62	170	100	V	28.07	6.846	0.00	61.53	74	-12.47	PK
2390	16.05	170	100	V	28.07	6.846	0.00	50.96	54	-3.04	AV
4844	47.80	195	140	H	33.14	10.354	35.66	55.63	74	-18.37	PK
4844	36.01	195	140	H	33.14	10.354	35.66	43.84	54	-10.16	AV
4844	46.97	320	180	V	33.14	10.354	35.66	54.80	74	-19.20	PK
4844	35.71	320	180	V	33.14	10.354	35.66	43.54	54	-10.46	AV
Mid Channel 2437 MHz											
4874	47.93	260	150	H	33.60	8.52	35.66	54.39	74	-19.61	PK
4874	38.60	260	150	H	33.60	8.52	35.66	45.06	54	-8.94	AV
4874	46.89	215	170	H	33.60	8.52	35.66	53.35	74	-20.65	PK
4874	38.62	215	170	H	33.60	8.52	35.66	45.08	54	-8.92	AV
High Channel 2452 MHz											
2483.5	28.53	290	120	H	28.72	6.85	0.00	64.10	74	-9.90	PK
2483.5	16.20	290	120	H	28.72	6.85	0.00	51.77	54	-2.23	AV
2483.5	27.78	160	100	V	28.72	6.85	0.00	63.35	74	-10.65	PK
2483.5	15.94	160	100	V	28.72	6.85	0.00	51.51	54	-2.49	AV
4904	47.12	0	100	H	33.60	8.52	35.66	53.58	74	-20.42	PK
4904	36.17	0	100	H	33.60	8.52	35.66	42.63	54	-11.37	AV
4904	47.60	38	100	V	33.60	8.52	35.66	54.06	74	-19.94	PK
4904	36.18	38	100	V	33.60	8.52	35.66	42.64	54	-11.36	AV

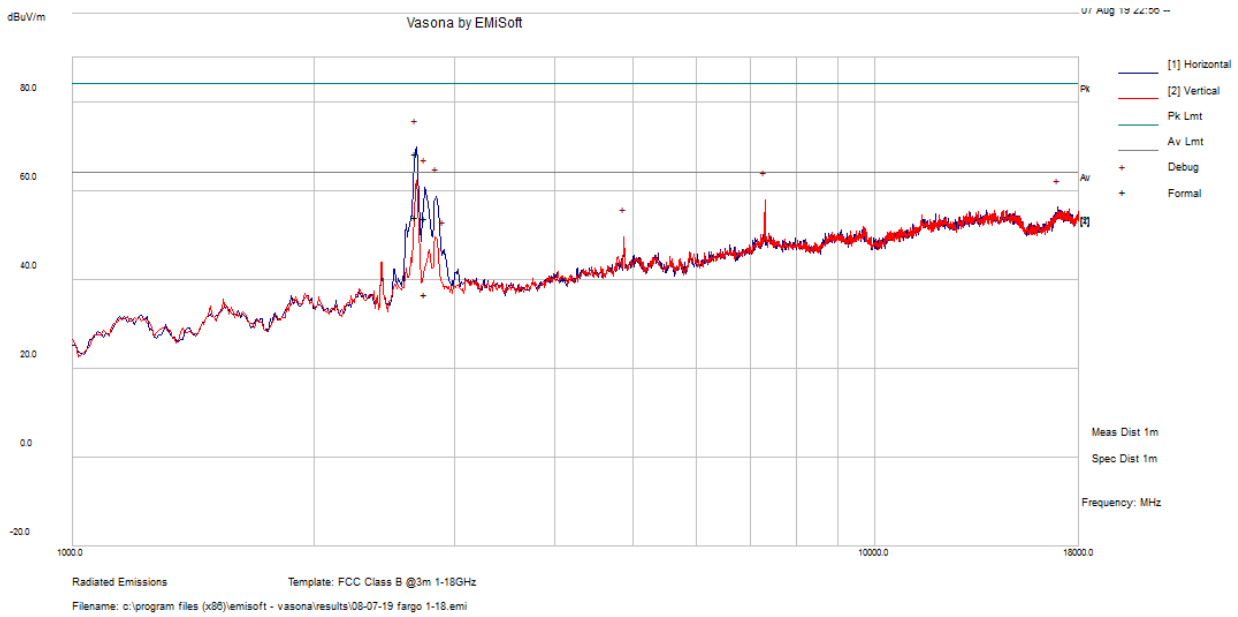
BLE mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 2402 MHz											
2390	28.80	0	100	H	28.94	2.50	0.00	60.24	74	-13.76	PK
2390	15.70	0	100	H	28.94	2.50	0.00	47.14	54	-6.86	AV
2390	28.24	0	100	V	28.93	2.50	0.00	59.67	74	-14.33	PK
2390	15.44	0	100	V	28.93	2.50	0.00	46.87	54	-7.13	AV
4804	48.08	144	151	H	32.56	10.54	35.66	55.53	74	-18.47	PK
4804	38.01	144	151	H	32.56	10.54	35.66	45.46	54	-8.54	AV
4804	48.27	122	100	V	32.56	10.54	35.66	55.72	74	-18.28	PK
4804	36.88	122	100	V	32.56	10.54	35.66	44.33	54	-9.67	AV
7206	48.14	0	100	H	36.73	12.49	35.67	61.69	74	-12.31	PK
7206	36.11	0	100	H	36.73	12.49	35.67	49.66	54	-4.34	AV
7206	47.96	0	100	V	36.73	12.49	35.67	61.51	74	-12.49	PK
7206	36.59	0	100	V	36.73	12.49	35.67	50.14	54	-3.86	AV
Mid Channel 2440 MHz											
4880	49.63	144	186	H	32.56	10.54	35.66	57.08	74	-16.92	PK
4880	39.98	144	186	H	32.56	10.54	35.66	47.43	54	-6.57	AV
4880	48.59	126	116	V	32.56	10.54	35.66	56.04	74	-17.96	PK
4880	37.94	126	116	V	32.56	10.54	35.66	45.39	54	-8.61	AV
7320	49.22	0	100	H	36.73	12.49	35.67	62.77	74	-11.23	PK
7320	38.25	0	100	H	36.73	12.49	35.67	51.80	54	-2.20	AV
7320	49.08	0	100	V	36.73	12.49	35.67	62.63	74	-11.37	PK
7320	38.66	0	100	V	36.73	12.49	35.67	52.21	54	-1.79	AV
High Channel 2480 MHz											
2483.5	28.45	0	100	H	28.94	7.21	0.00	64.60	74	-9.40	PK
2483.5	15.11	0	100	H	28.94	7.21	0.00	51.26	54	-2.74	AV
2483.5	27.99	0	100	V	28.93	7.21	0.00	64.13	74	-9.87	PK
2483.5	14.87	0	100	V	28.93	7.21	0.00	51.01	54	-2.99	AV
4960	49.47	144	168	H	32.56	10.54	35.66	56.92	74	-17.08	PK
4960	40.67	144	168	H	32.56	10.54	35.66	48.12	54	-5.88	AV
4960	48.77	128	113	V	32.56	10.54	35.66	56.22	74	-17.78	PK
4960	37.65	128	113	V	32.56	10.54	35.66	45.10	54	-8.90	AV
7440	49.66	0	100	H	36.73	12.49	35.67	63.21	74	-10.79	PK
7440	40.06	0	100	H	36.73	12.49	35.67	53.61	54	-0.39	AV
7440	48.77	0	100	V	36.73	12.49	35.67	62.32	74	-11.68	PK
7440	38.54	0	100	V	36.73	12.49	35.67	52.09	54	-1.91	AV

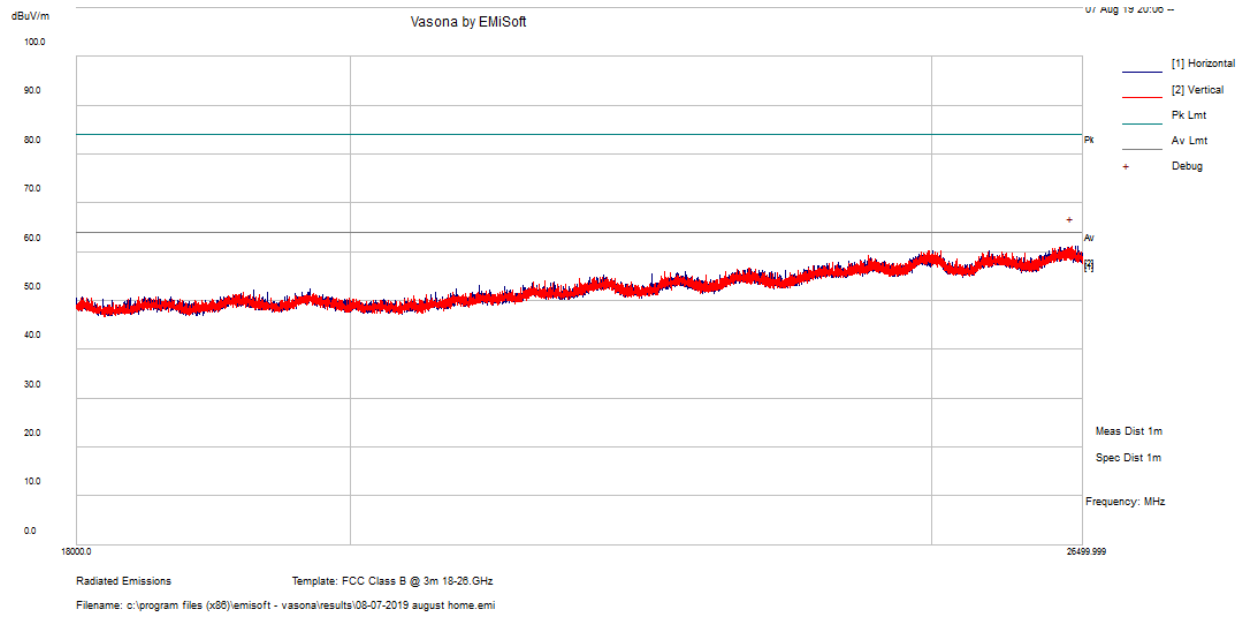
2.4 GHz Wi-Fi, b mode, 2412 MHz, Radio 1 and BLE, 2402MHz, Radio 2

1 GHz – 18 GHz Scan at 1 Meter

Notch Filter has been added



18 GHz – 26.5 GHz Scan at 1 Meter



8 FCC §15.247(a)(2) - Emission Bandwidth

8.1 Applicable Standards

According to ECFR §15.247(a)(2), 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 measurements are based on FCC KDB 558074 D01 DTS Meas Guidance v05r02: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 section 8: DTS bandwidth

8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	RF cable	-	-	Each time[1]	N/A
-	20dB attenuator	-	-	Each time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability*:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "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 Alexandrae Duran on 2019-03-28 in RF site.

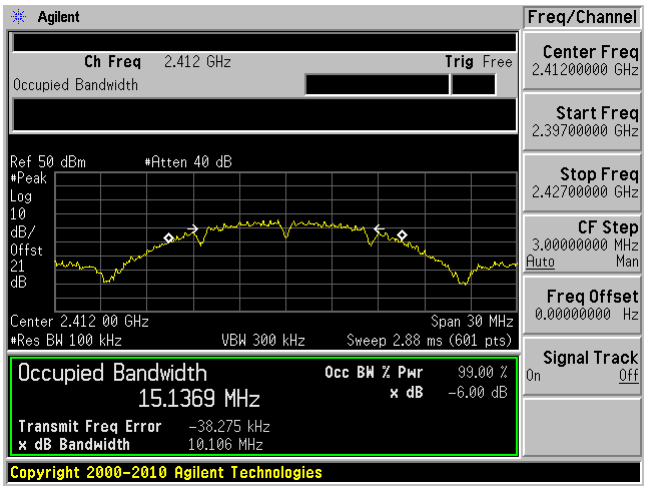
8.5 Test Results

Channel	Frequency (MHz)	6 dB OBW (MHz)		6 dB OBW Limit (kHz)	Result
		Chain 0	Chain 1		
802.11b					
Low	2412	10.106	10.122	≥ 500	Pass
Middle	2437	9.492	9.610	≥ 500	Pass
High	2462	10.044	9.613	≥ 500	Pass
802.11g					
Low	2412	16.506	16.532	≥ 500	Pass
Middle	2437	16.538	16.533	≥ 500	Pass
High	2462	16.476	16.529	≥ 500	Pass
802.11n20					
Low	2412	17.734	17.757	≥ 500	Pass
Middle	2437	17.723	17.736	≥ 500	Pass
High	2462	17.710	17.687	≥ 500	Pass
802.11n40					
Low	2422	36.556	36.571	≥ 500	Pass
Middle	2437	36.562	36.559	≥ 500	Pass
High	2452	36.594	36.595	≥ 500	Pass
BLE					
Low	2402	0.783880	-	≥ 500	Pass
Middle	2440	0.779005	-	≥ 500	Pass
High	2480	0.779179	-	≥ 500	Pass

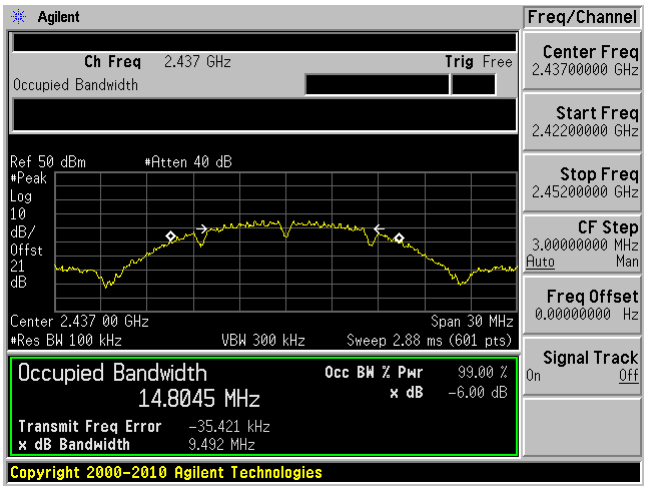
Please refer to the following plots for detailed test results.

802.11b mode Chain 0

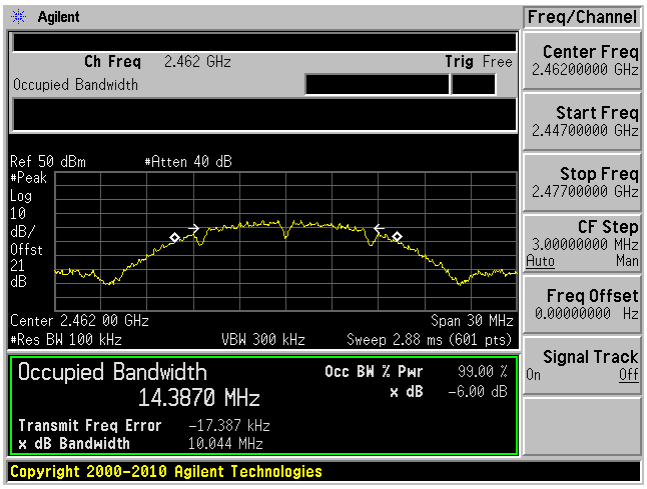
Low Channel 2412 MHz



Middle Channel 2437 MHz

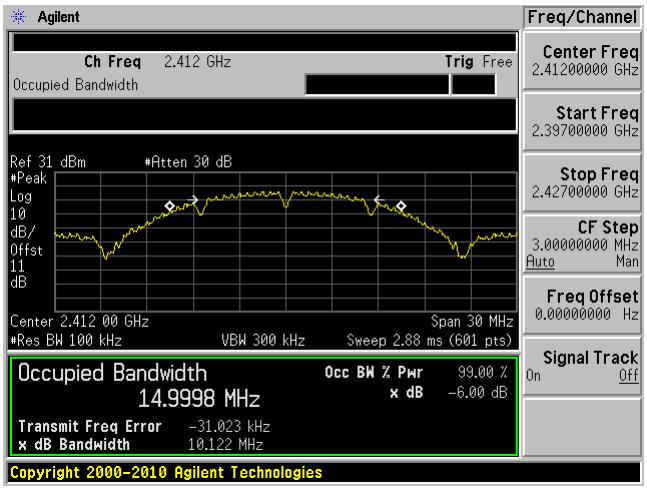


High Channel 2462 MHz

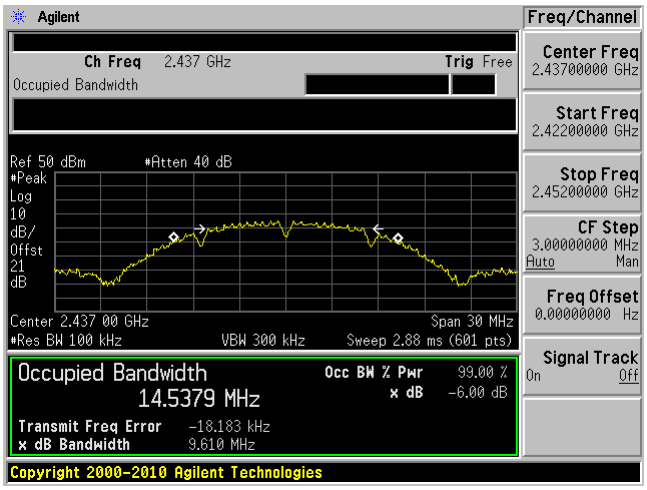


802.11b mode Chain 1

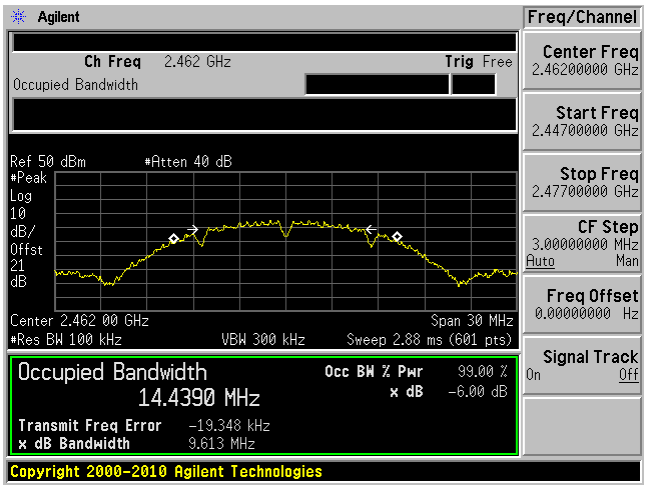
Low Channel 2412 MHz



Middle Channel 2437 MHz

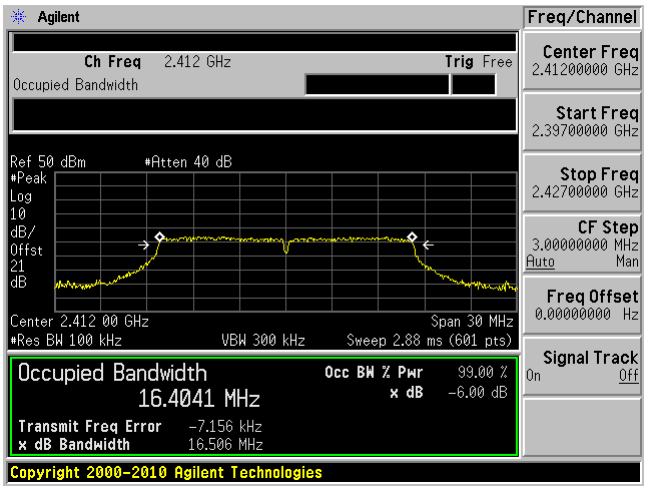


High Channel 2462 MHz

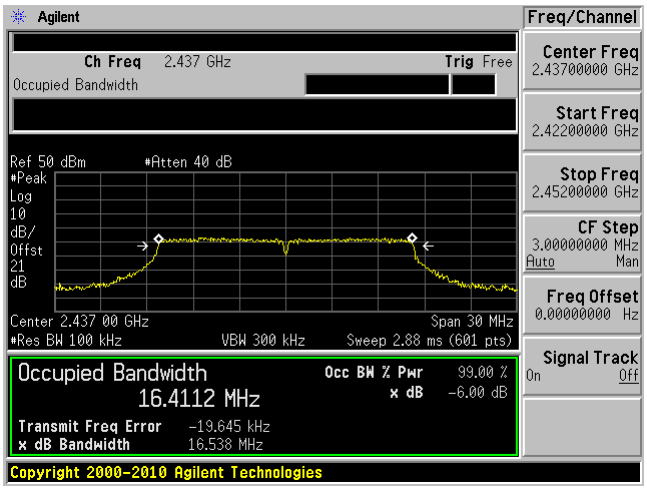


802.11g mode Chain 0

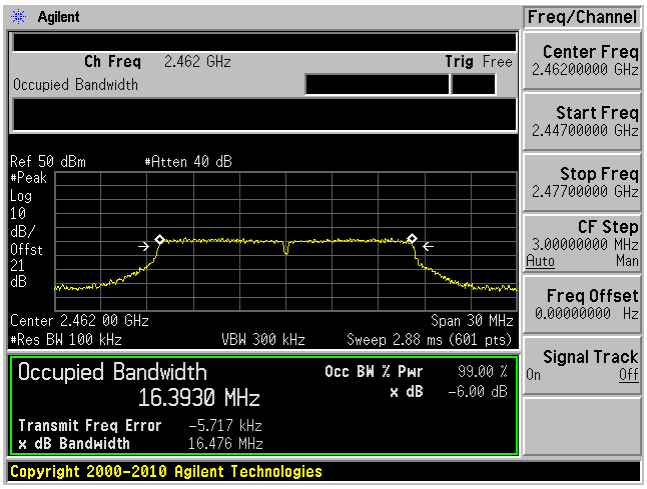
Low Channel 2412 MHz



Middle Channel 2437 MHz

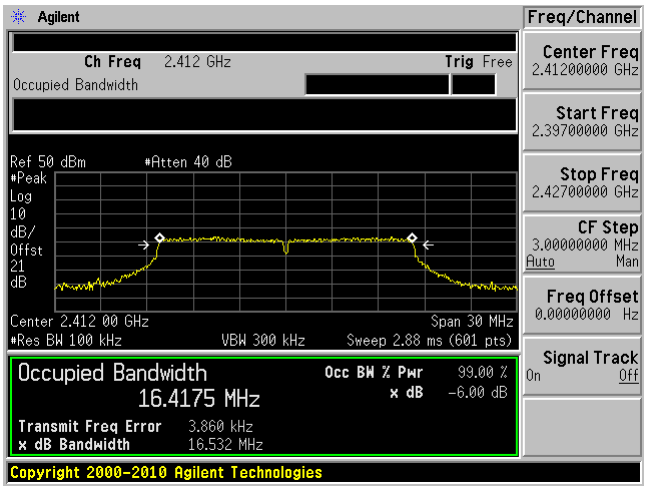


High Channel 2462 MHz

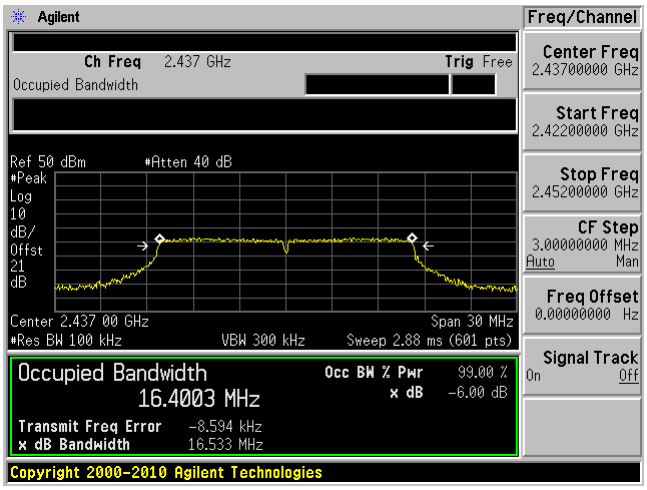


802.11g mode Chain 1

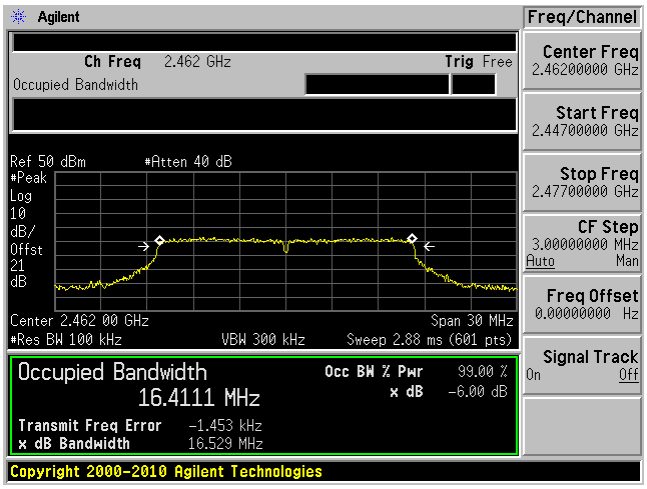
Low Channel 2412 MHz



Middle Channel 2437 MHz

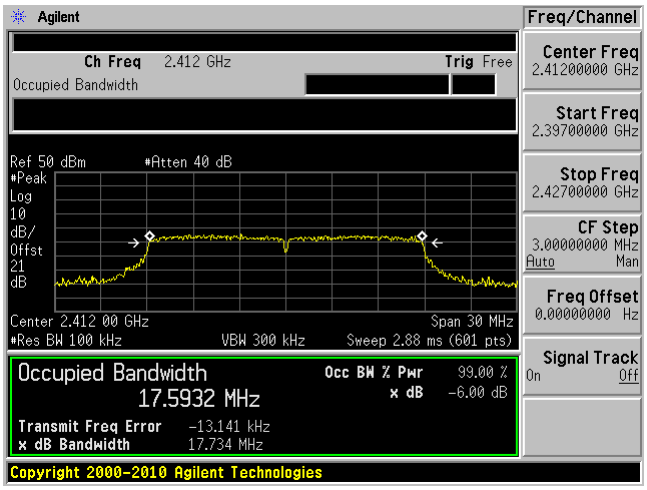


High Channel 2462 MHz

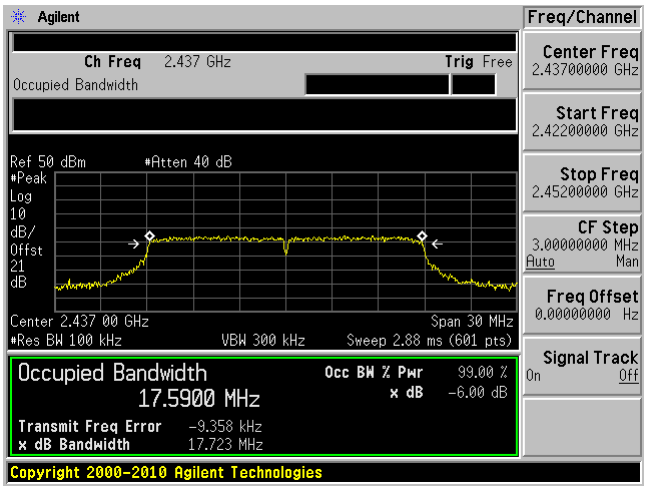


802.11n20 mode Chain 0

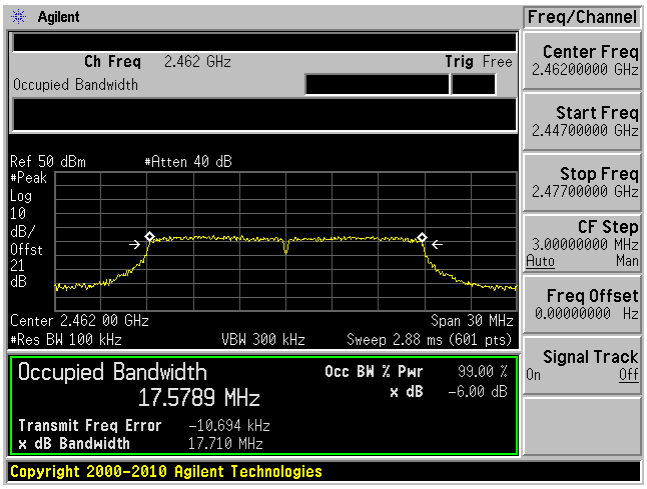
Low Channel 2412 MHz



Middle Channel 2437 MHz

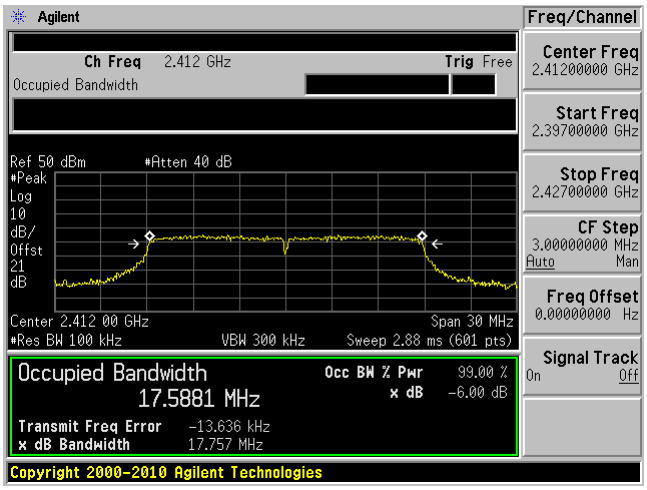


High Channel 2462 MHz

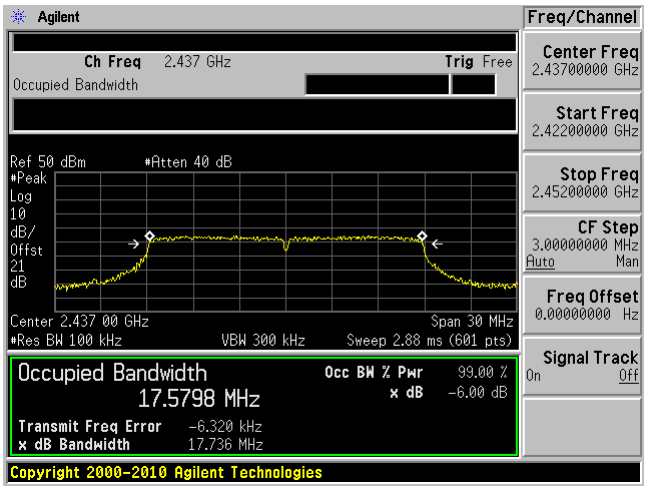


802.11n20 mode Chain 1

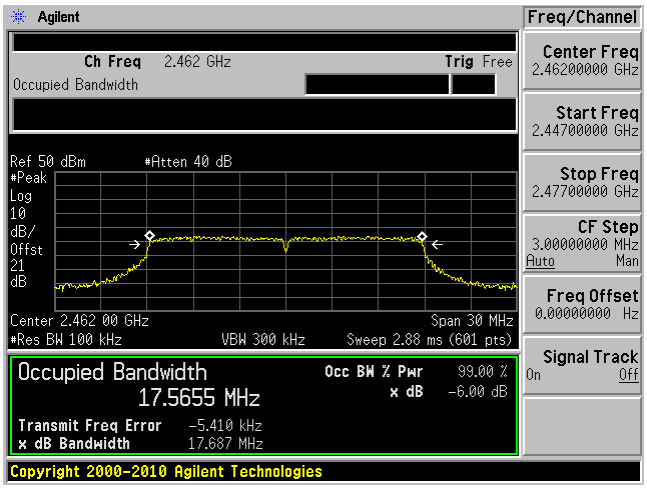
Low Channel 2412 MHz



Middle Channel 2437 MHz

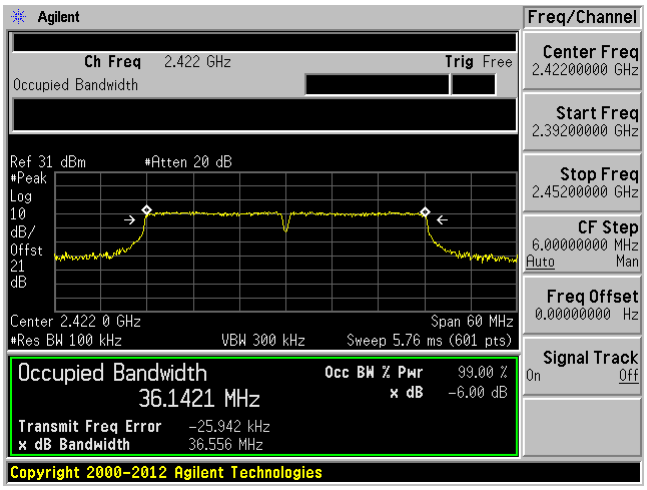


High Channel 2462 MHz

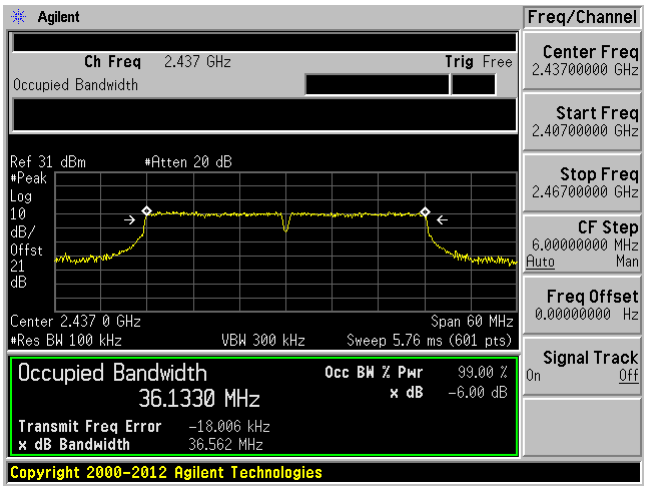


802.11n40 mode Chain 0

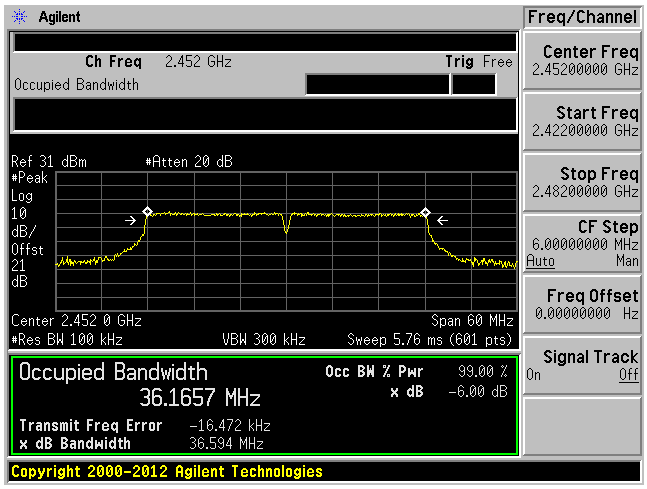
Low Channel 2422 MHz



Middle Channel 2437 MHz

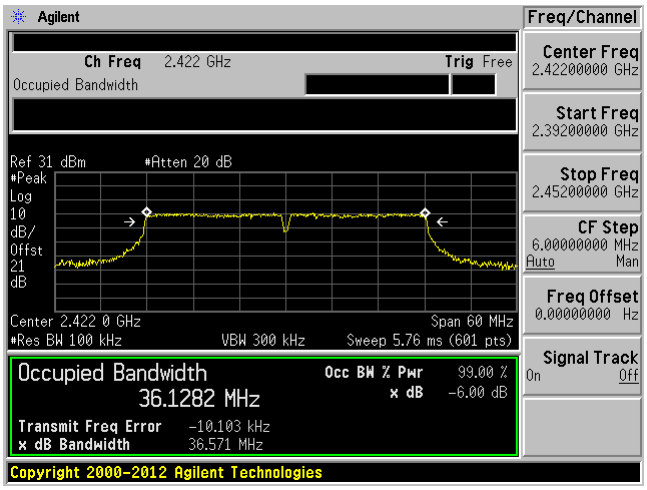


High Channel 2452 MHz

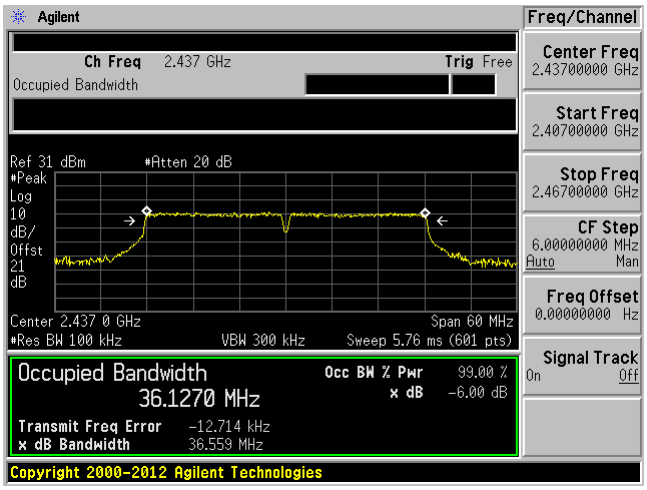


802.11n40 mode Chain 1

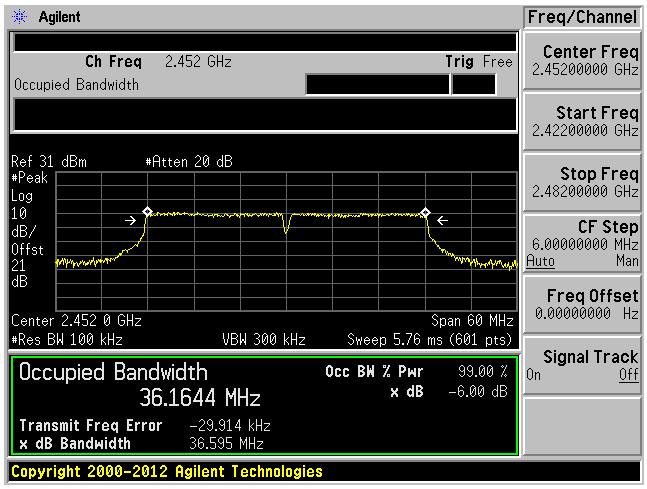
Low Channel 2422 MHz



Middle Channel 2437 MHz

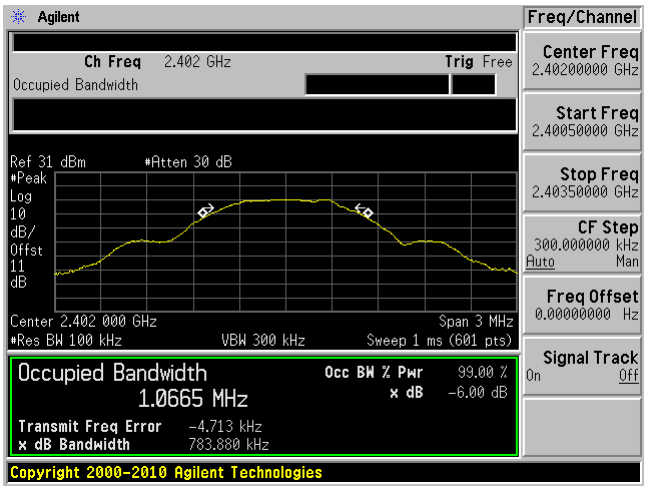


High Channel 2452 MHz

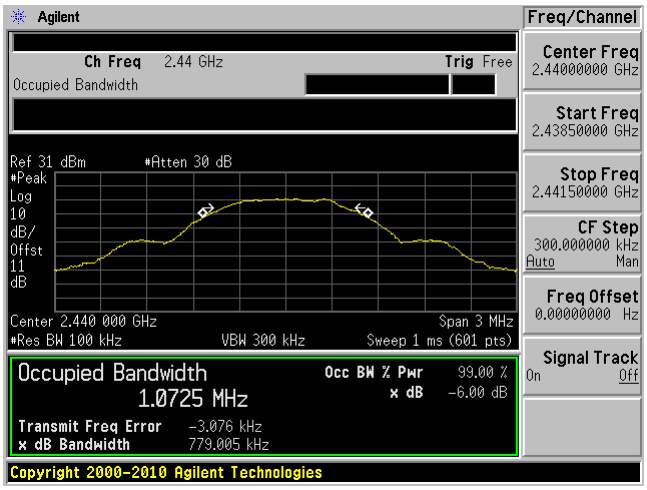


BLE mode Chain 0

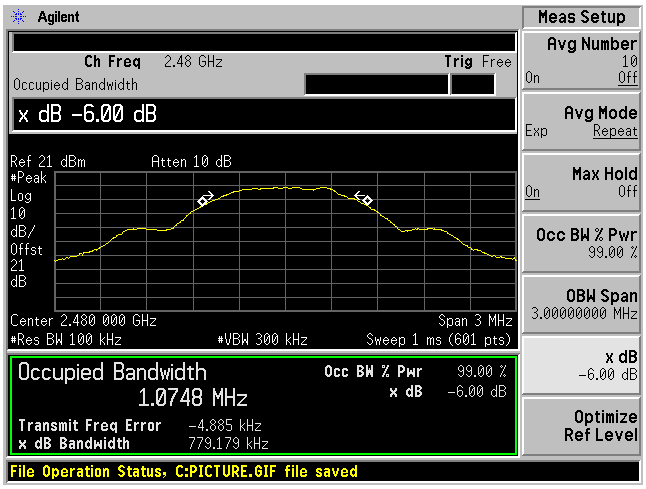
Low Channel 2402 MHz



Middle Channel 2440 MHz



High Channel 2480 MHz



9 FCC §15.247(b)(3) - Output Power Measurement

9.1 Applicable Standards

According to ECFR §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.

9.2 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 9: Fundamental emission output power

9.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
ETS- Lingerin	Power Sensor	7002-006	160097	2018-12-31	2 years
-	RF Cable	-	-	Each time[1]	N/A
-	20dB attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability*:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "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 Alexandrae Duran on 2019-03-29 and 2019-04-15 in RF site.

9.5 Test Results

Average Output Power

Channel	Frequency (MHz)	Conducted Output Power (dBm)			Output Power Limit (dBm)	Result
		Chain 0	Chain 1	Total		
802.11b						
Low	2412	23	23	26.0103	30	Pass
Middle	2437	23	23	26.0103	30	Pass
High	2462	22.99	23	26.0053	30	Pass
802.11g						
Low	2412	18.63	18.5	21.57579	30	Pass
Middle	2437	18.19	17.91	21.06256	30	Pass
High	2462	17.76	17.7	20.7404	30	Pass
802.11n20						
Low	2412	20.34	20.12	23.24169	30	Pass
Middle	2437	19.76	19.73	22.75533	30	Pass
High	2462	19	19.12	22.07071	30	Pass
802.11n40						
Low	2422	20.27	19.25	22.800	30	Pass
Middle	2437	19.99	19.64	22.829	30	Pass
High	2452	19.63	19.41	22.532	30	Pass

Peak Output Power

Channel	Frequency (MHz)	Conducted Output Power (dBm)	Output Power Limit (dBm)	Result
BLE				
Low	2402	13.2	30	Pass
Middle	2440	12.6	30	Pass
High	2480	11.42	30	Pass

Note: the directional gain is less than 6 dBi, thus no reduction to the limit.

10 FCC §15.247(d) - 100 kHz Bandwidth of Band Edges

10.1 Applicable Standards

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

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 13: Band-edge measurements

10.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	RF Cable	-	-	Each time[1]	N/A
-	20dB attenuator	-	-	Each time[1]	N/A
-	10dB attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability*:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "A2LA Policy on Metrological Traceability".

10.4 Test Environmental Conditions

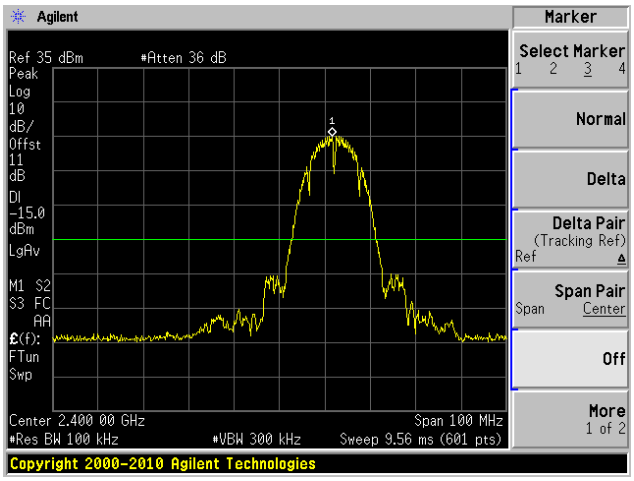
Temperature:	23º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Alexandrae Duran 2019-03-26, and 2019-03-27 in RF site.

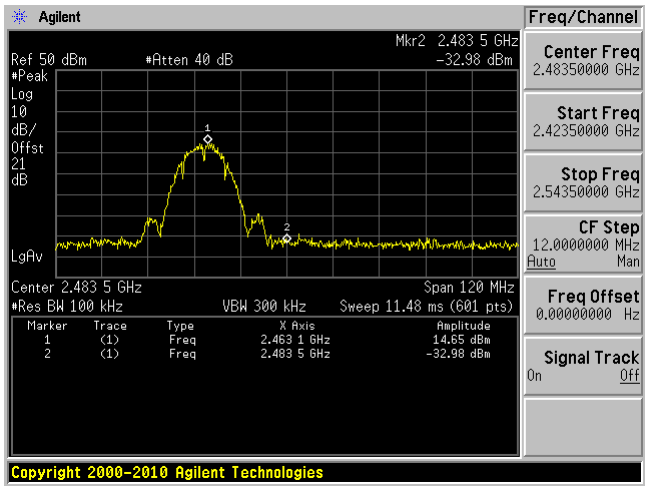
10.5 Test Results

802.11b mode Chain 0

Low Channel 2412 MHz

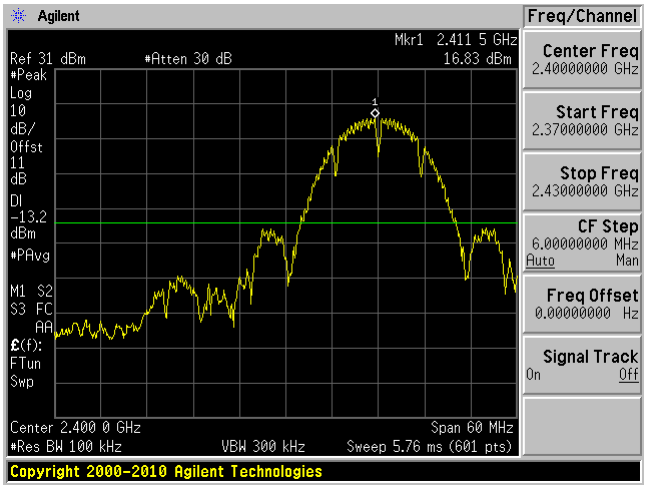


High Channel 2462 MHz

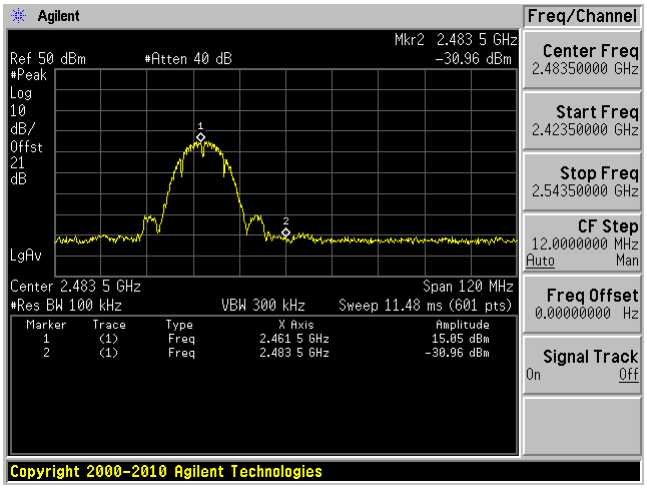


802.11b mode Chain 1

Low Channel 2412 MHz

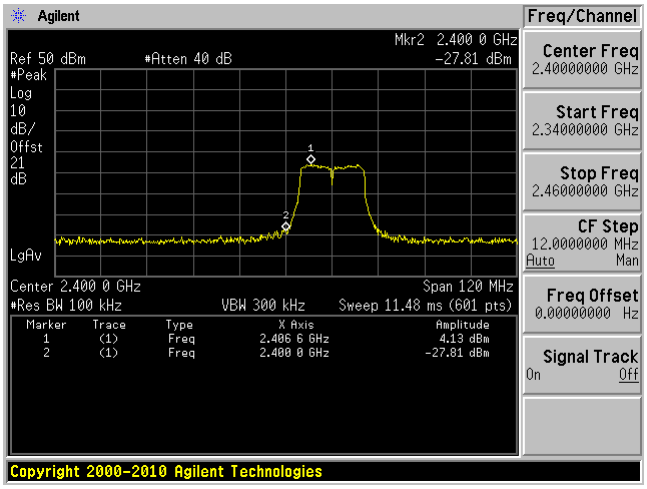


High Channel 2462 MHz

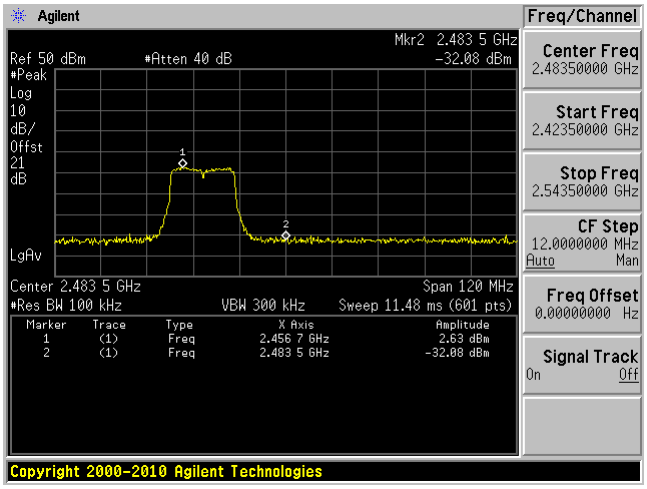


802.11g mode Chain 0

Low Channel 2412 MHz

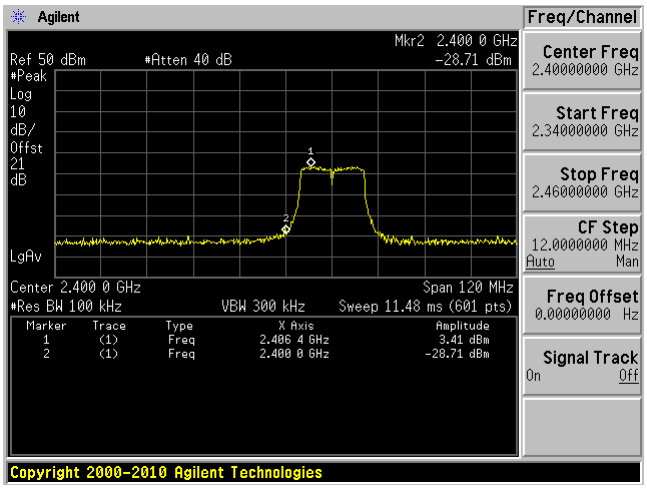


High Channel 2462 MHz

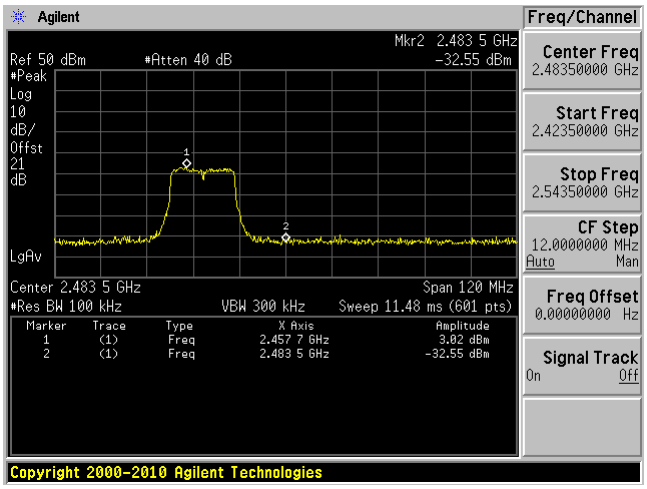


802.11g mode Chain 1

Low Channel 2412 MHz

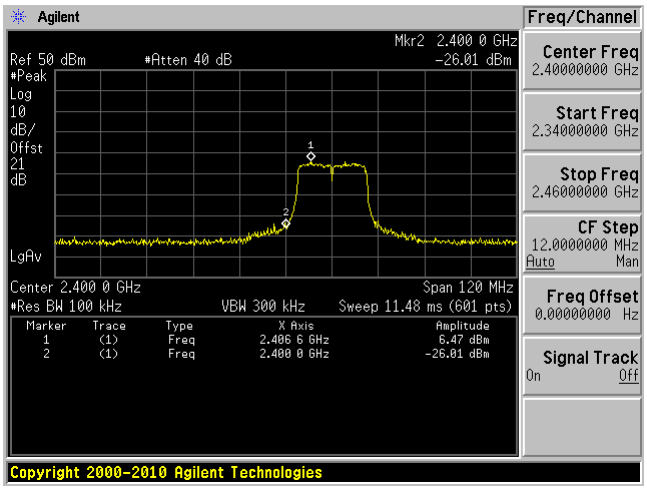


High Channel 2462 MHz

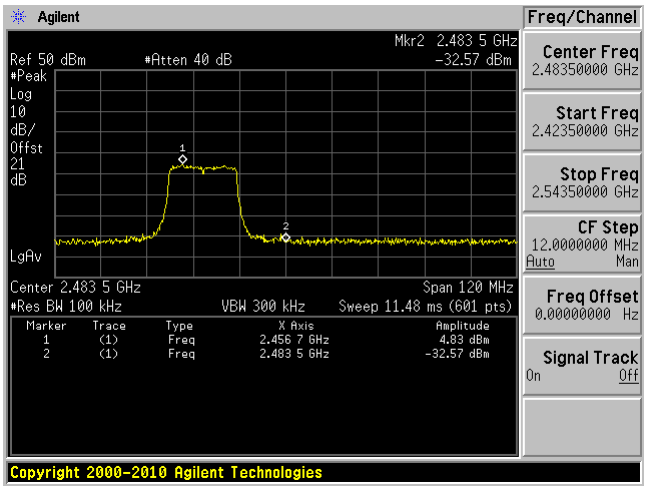


802.11n20 mode Chain 0

Low Channel 2412 MHz

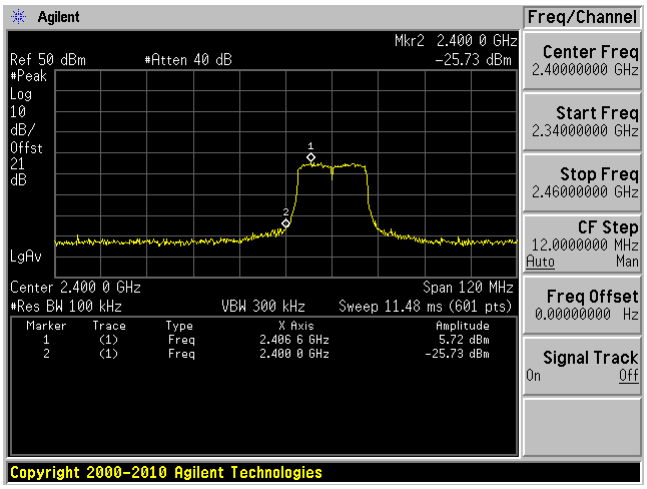


High Channel 2462 MHz

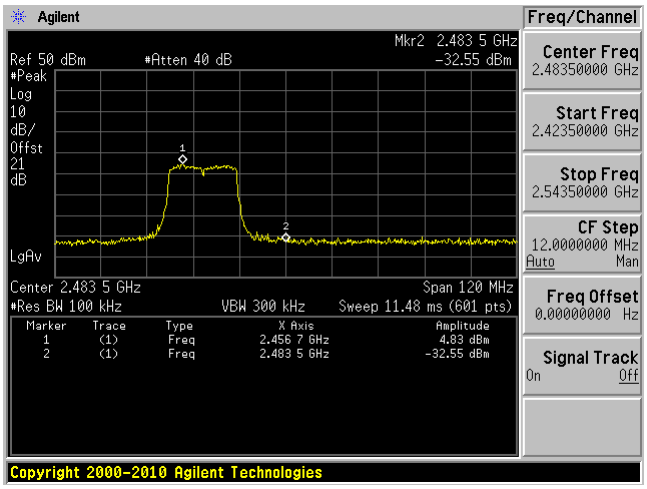


802.11n20 mode Chain 1

Low Channel 2412 MHz

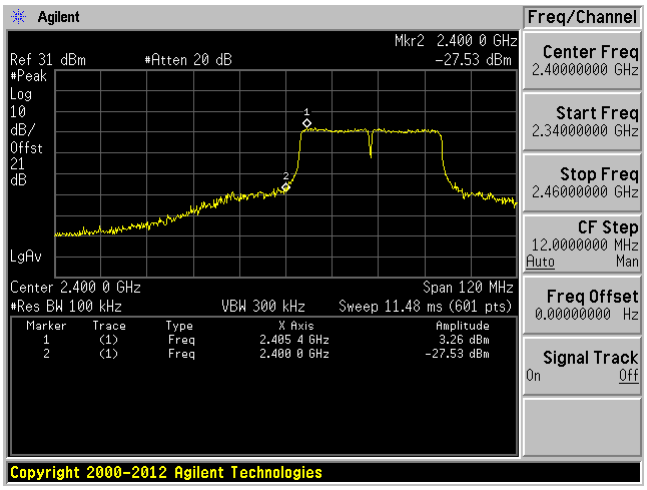


High Channel 2462 MHz

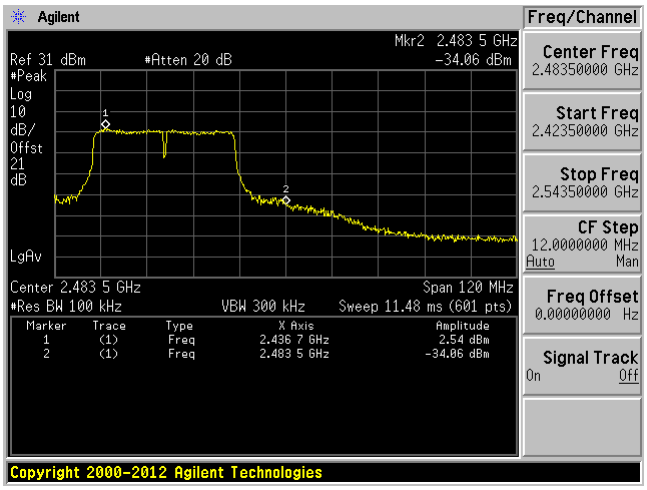


802.11n40 mode Chain 0

Low Channel 2422 MHz

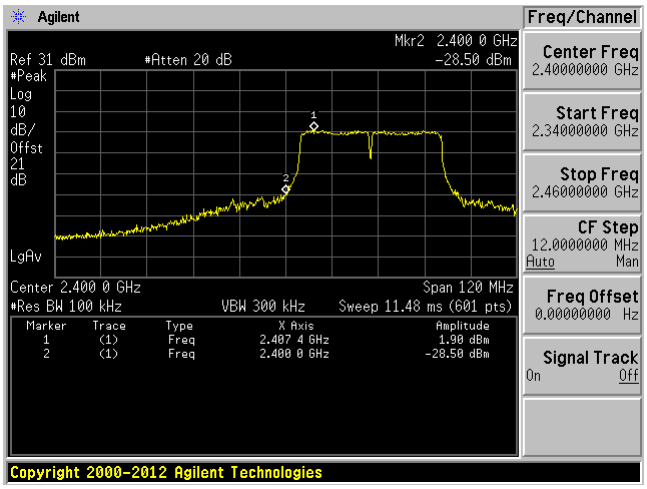


High Channel 2452 MHz

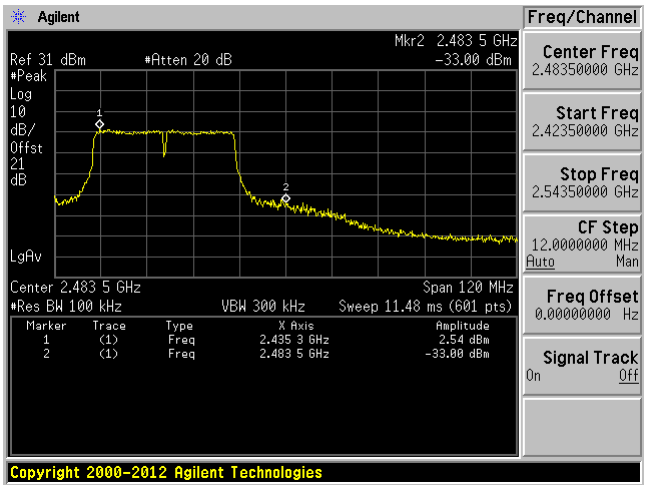


802.11n40 mode Chain 1

Low Channel 2422 MHz

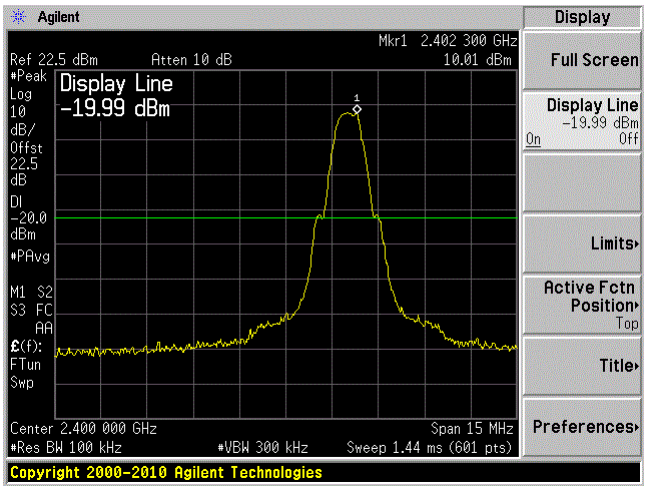


High Channel 2452 MHz

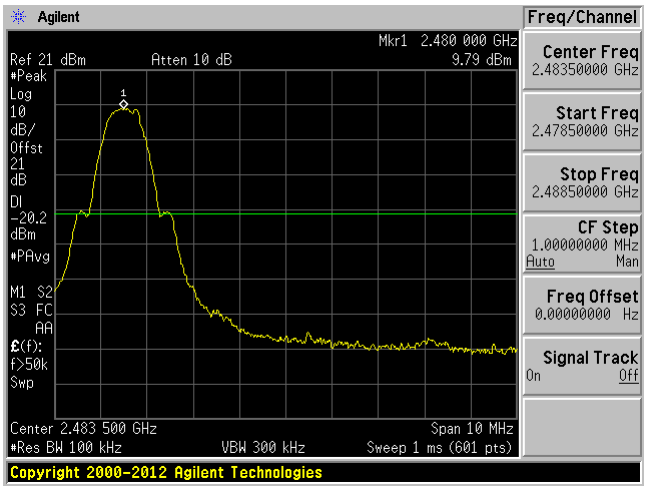


BLE mode Chain 0

Low Channel 2402 MHz



High Channel 2480 MHz



11 FCC §15.247(e) - Power Spectral Density

11.1 Applicable Standards

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

11.2 Measurement Procedure

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

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	RF Cable	-	-	Each time[1]	N/A
-	20dB attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability*:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "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 Alexandrae Duran 2019-03-26 and 2019-03-27 in RF site.

11.5 Test Results

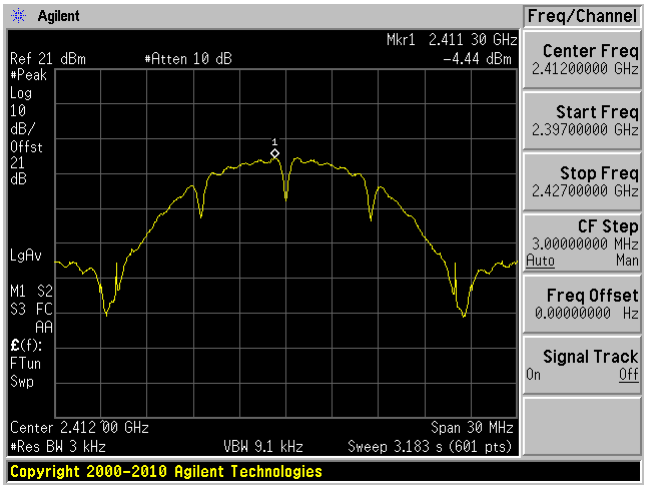
Channel	Frequency (MHz)	Power Spectral Density (dBm/3 kHz)			Limit (dBm/3 kHz)
		Chain 0	Chain 1	Total	
802.11b					
Low	2412	-4.44	-6.22	-2.22914	8
Middle	2437	-4.65	-4.65	-1.6397	8
High	2462	-4.86	-4.81	-1.82463	8
802.11g					
Low	2412	-10.22	-10.91	-7.54101	8
Middle	2437	-11.04	-10.6	-7.80413	8
High	2462	-11.54	-11.04	-8.27251	8
802.11n20					
Low	2412	-8.14	-7.46	-4.7764	8
Middle	2437	-8.51	-8.98	-5.72835	8
High	2462	-9.09	-9.03	-6.0496	8
802.11n40					
Low	2422	-10.20	-11.41	-7.753	8
Middle	2437	-9.57	-8.60	-6.048	8
High	2452	-9.79	-11.50	-7.551	8
BLE					
Low	2402	-5.33	-	-5.33	8
Middle	2440	-4.7	-	-4.7	8
High	2480	-5.35	-	-5.35	8

Note: the directional gain is less than 6 dBi, thus no reduction to the limit.

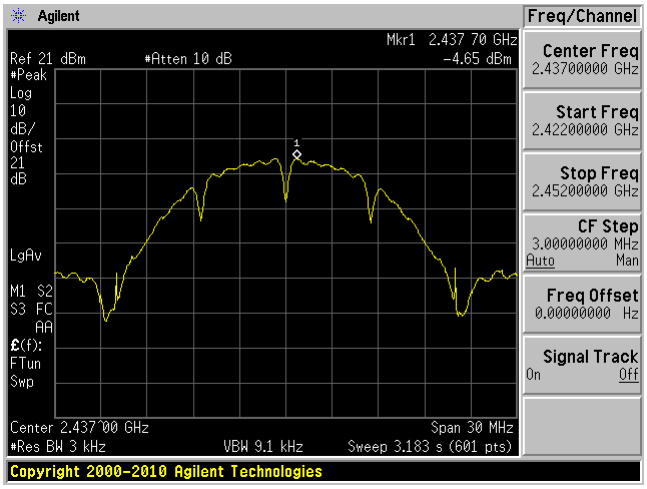
Please refer to the following plots for detailed test results

802.11b mode Chain 0

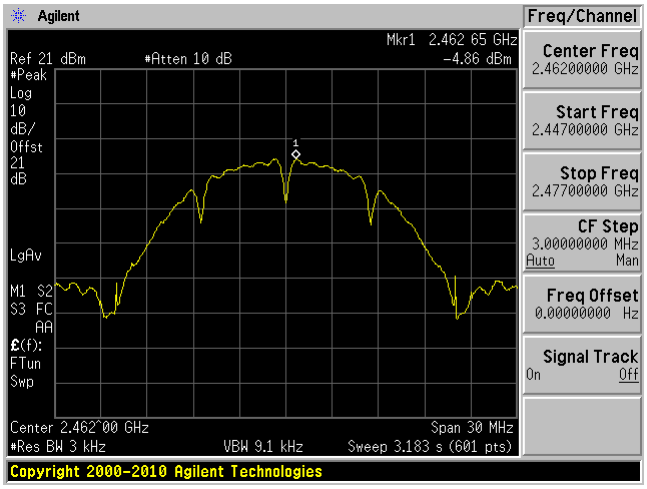
Low Channel 2412 MHz



Middle Channel 2437 MHz

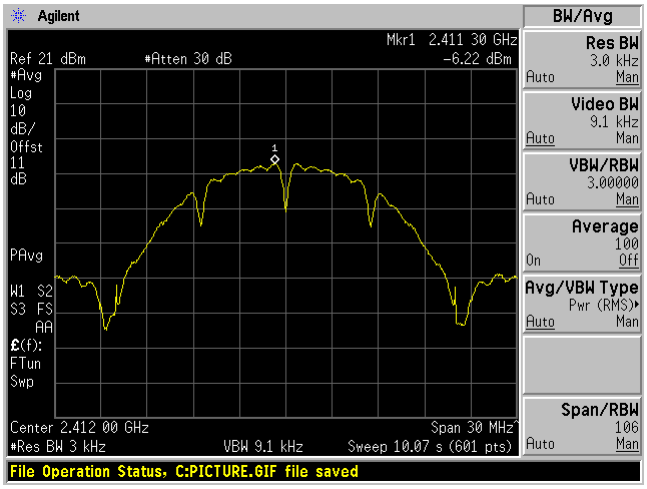


High Channel 2462 MHz

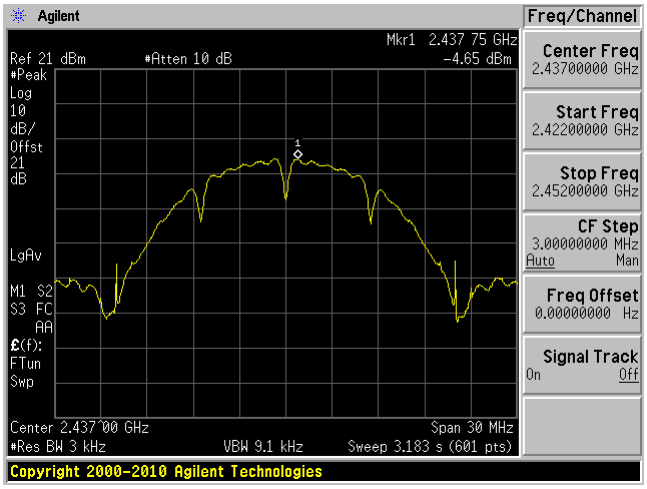


802.11b mode Chain 1

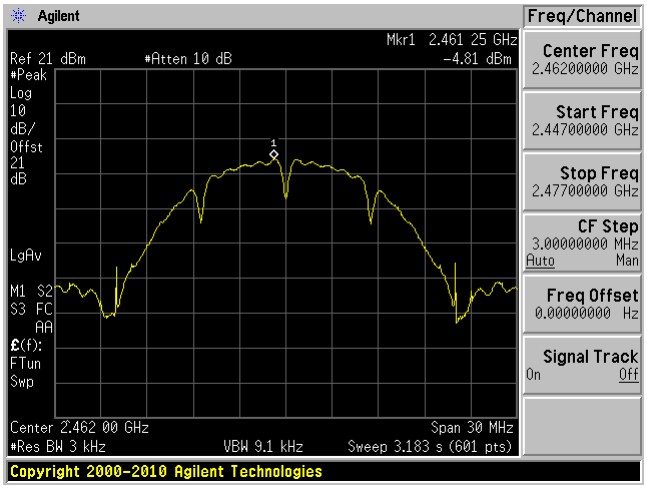
Low Channel 2412 MHz



Middle Channel 2437 MHz

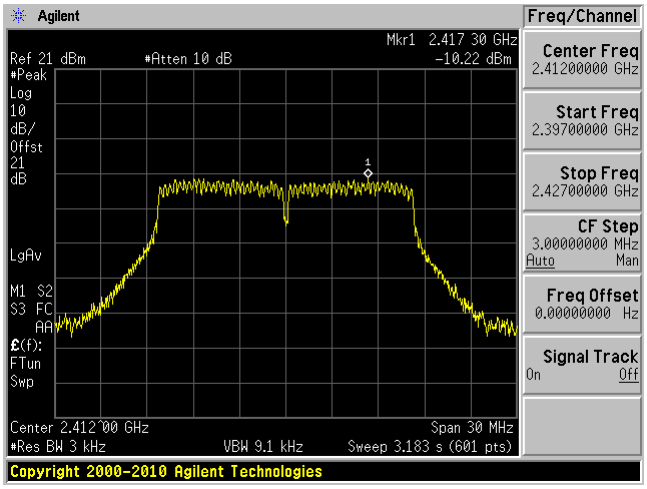


High Channel 2462 MHz

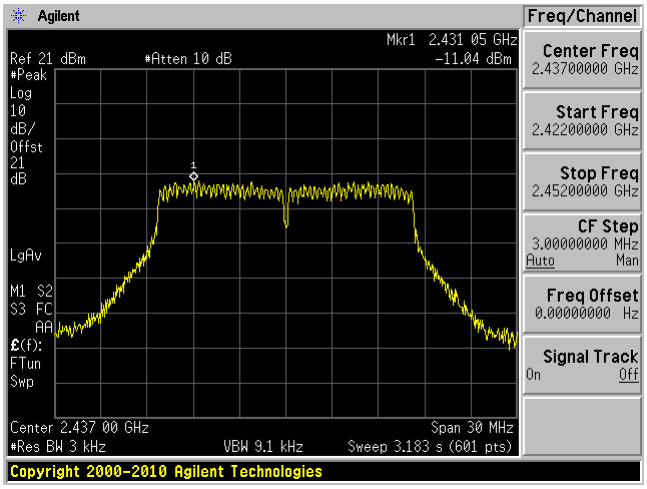


802.11g mode Chain 0

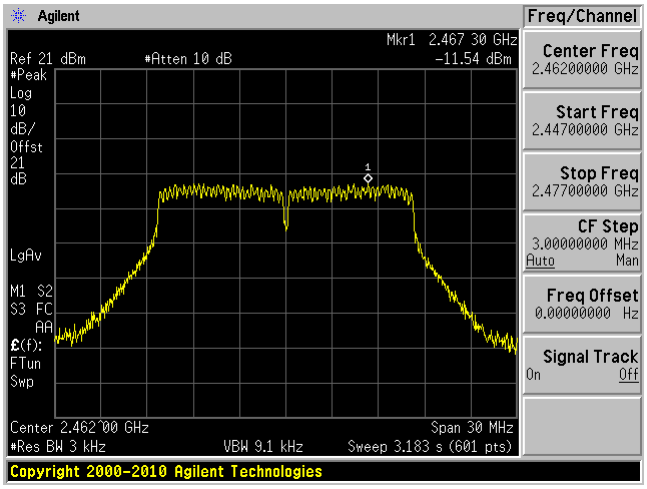
Low Channel 2412 MHz



Middle Channel 2437 MHz

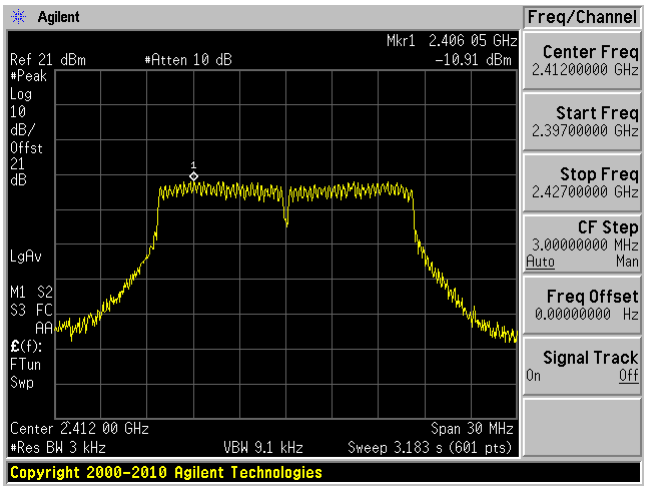


High Channel 2462 MHz

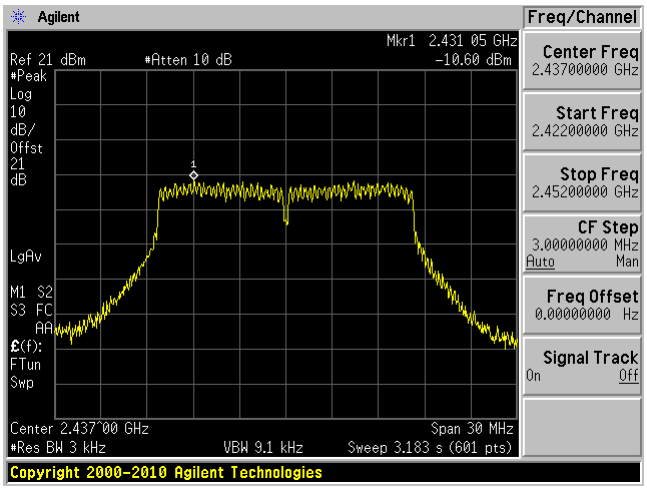


802.11g mode Chain 1

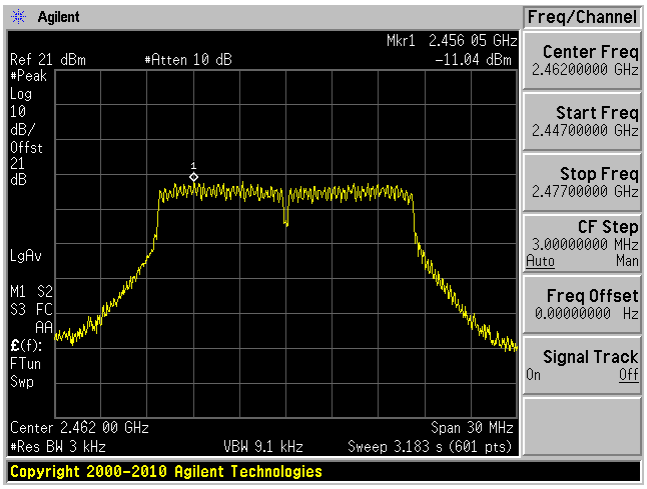
Low Channel 2412 MHz



Middle Channel 2437 MHz

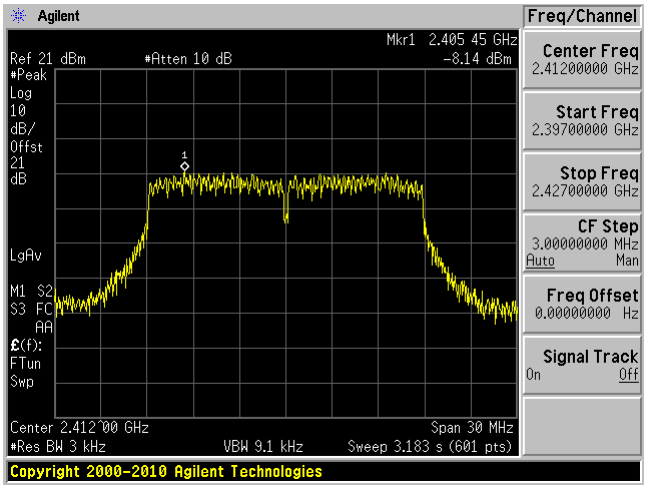


High Channel 2462 MHz

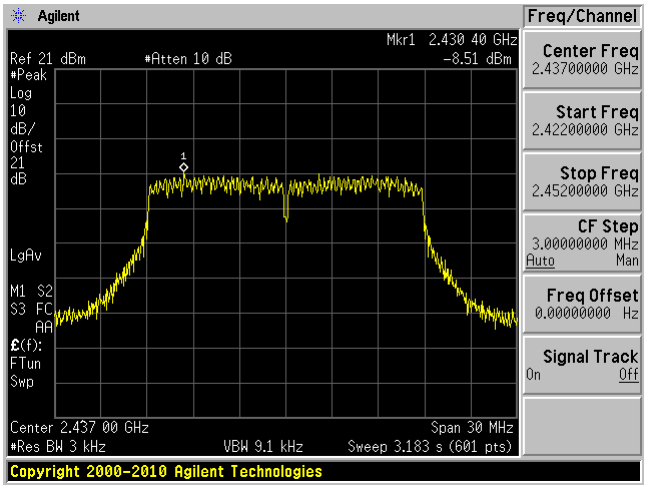


802.11n20 mode Chain 0

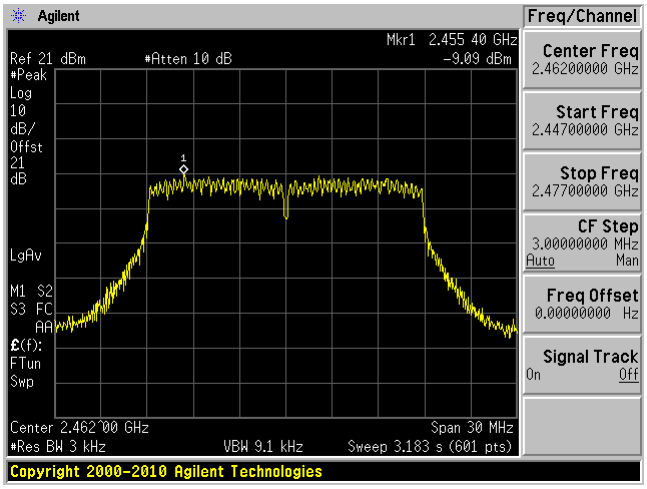
Low Channel 2412 MHz



Middle Channel 2437 MHz

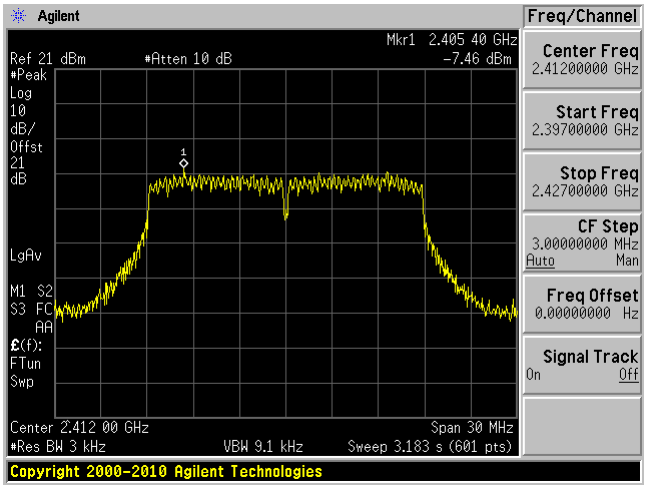


High Channel 2462 MHz

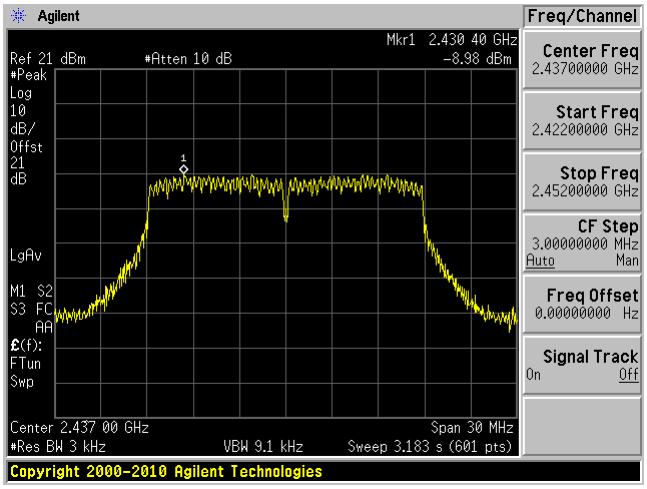


802.11n20 mode Chain 1

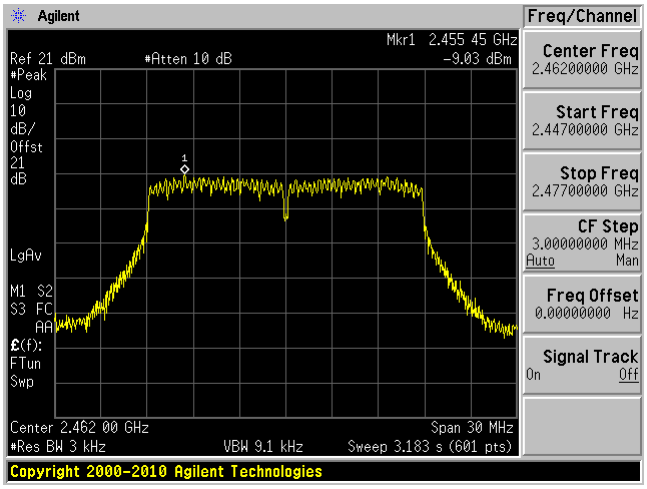
Low Channel 2412 MHz



Middle Channel 2437 MHz

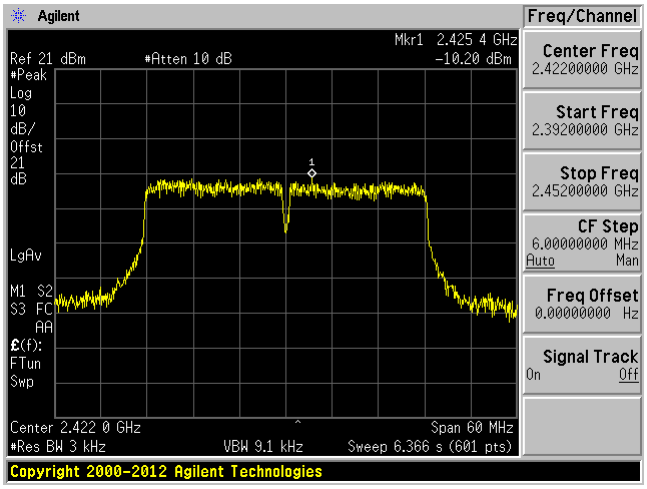


High Channel 2462 MHz

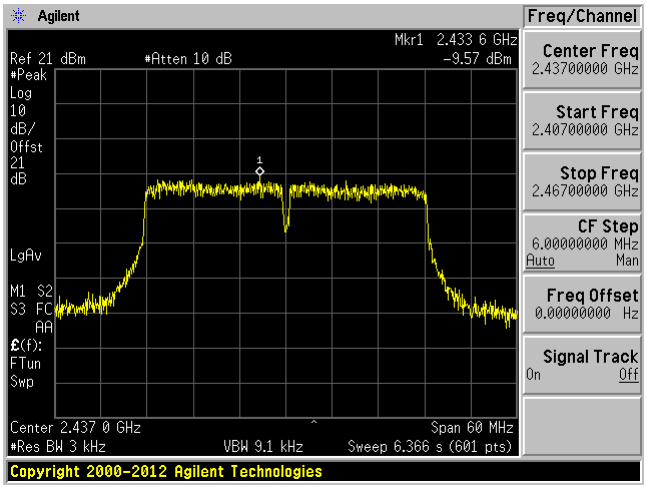


802.11n40 mode Chain 0

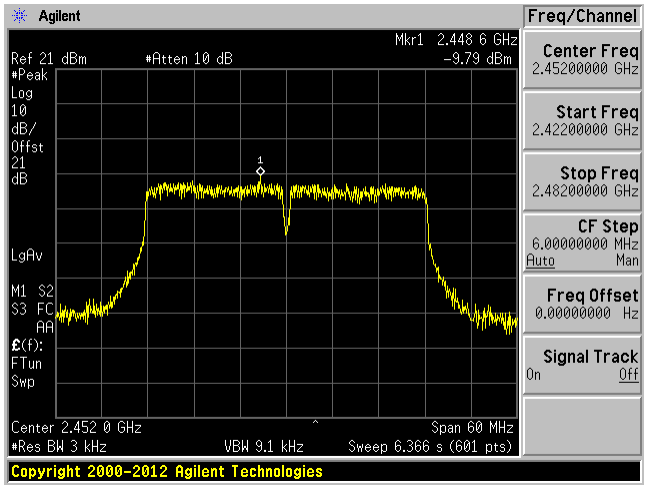
Low Channel 2422 MHz



Middle Channel 2437 MHz

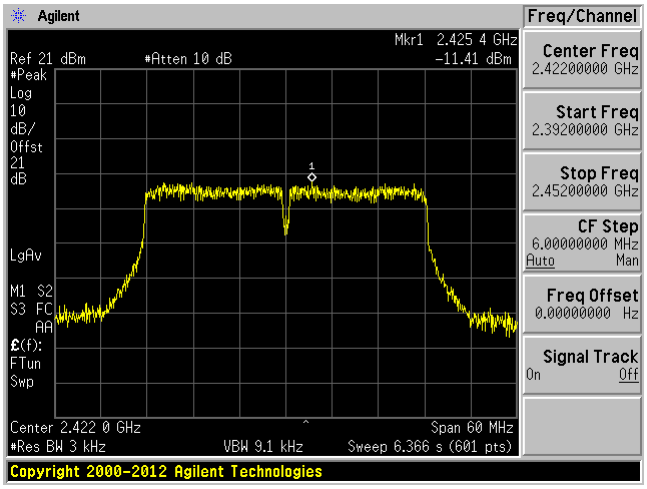


High Channel 2452 MHz

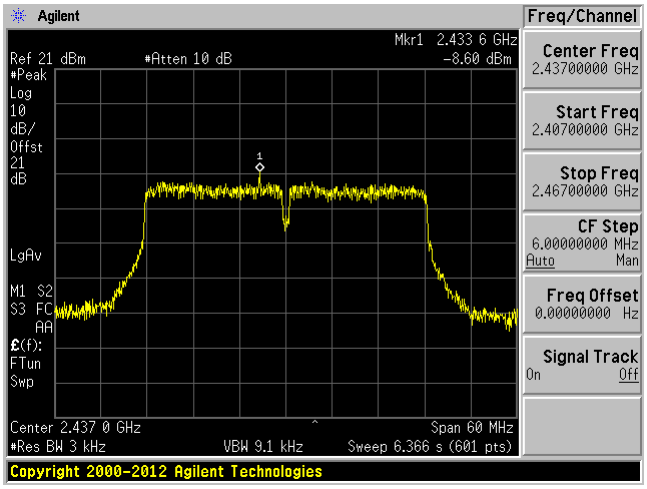


802.11n40 mode Chain 1

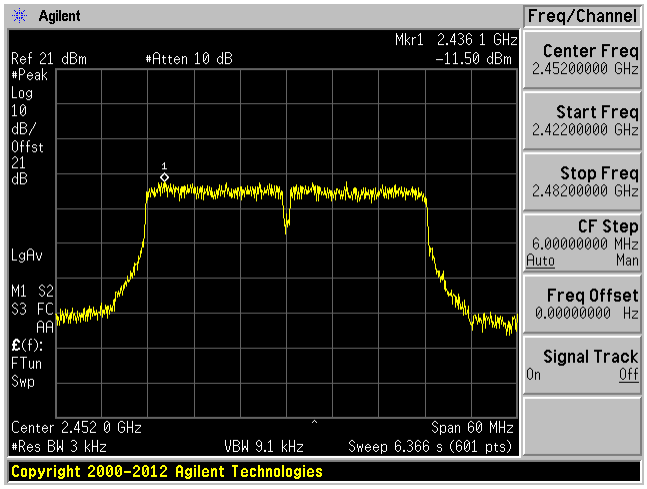
Low Channel 2422 MHz



Middle Channel 2437 MHz

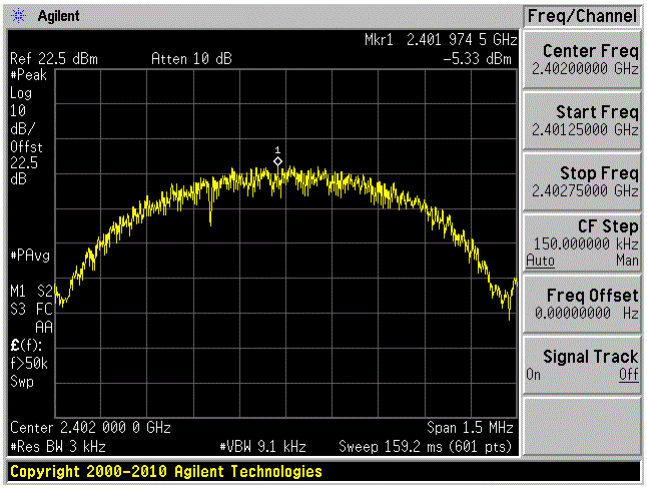


High Channel 2452 MHz

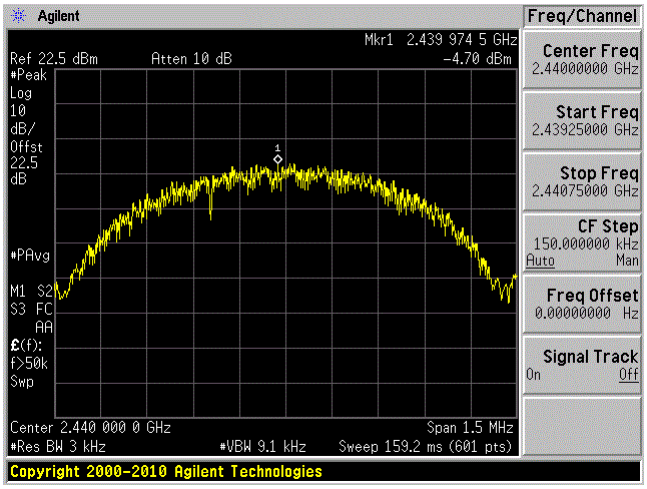


BLE mode

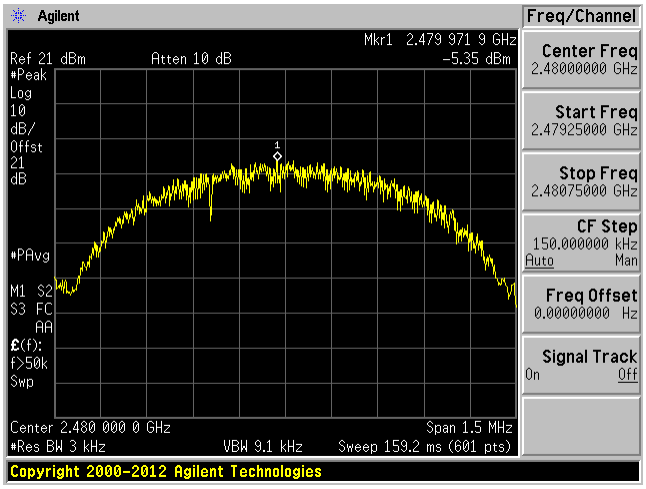
Low Channel 2402 MHz



Middle Channel 2440 MHz



High Channel 2480 MHz



12 FCC §15.247(d) - Spurious Emissions at Antenna Terminals

12.1 Applicable Standards

For 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)).

12.2 Test Procedure

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

12.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4446A	MY48250238	2018-05-08	1 year
-	RF cable	-	-	Each time[1]	N/A
-	20dB attenuator	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
***Statement of Traceability*:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "A2LA Policy on Metrological Traceability".

12.4 Test Environmental Conditions

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

The testing was performed by Alexandrae Duran 2019-03-26 and 2019-03-27 in RF site.

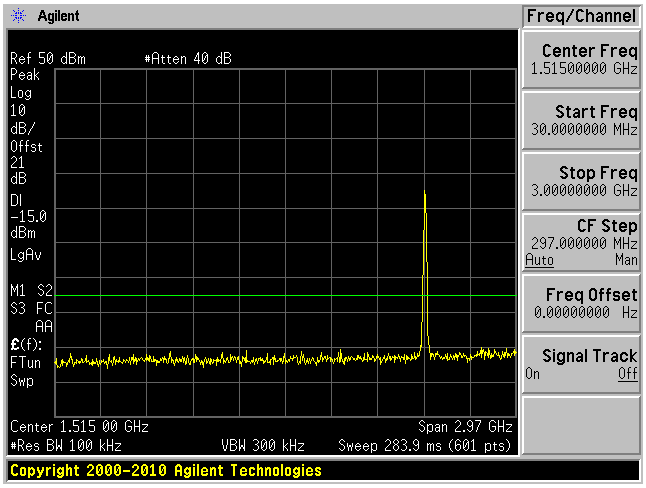
12.5 Test Results

Please refer to following plots.

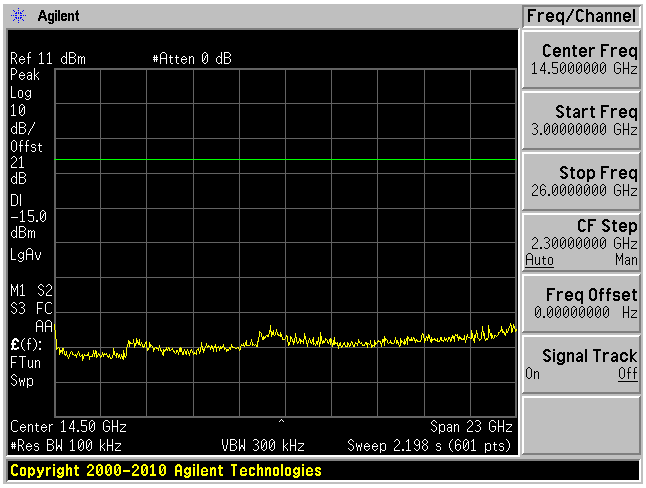
802.11b mode Chain 0

Low Channel 2412 MHz

30 MHz – 3 GHz

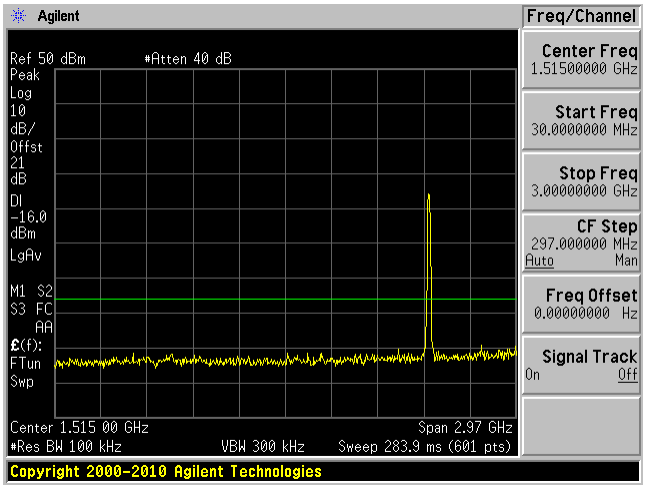


3 GHz – 26 GHz

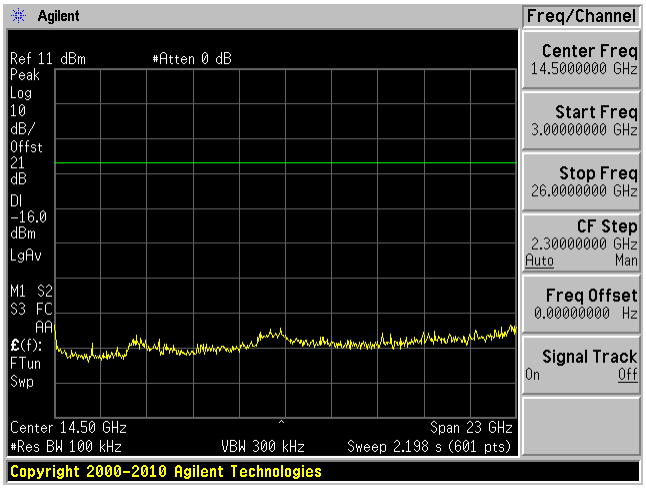


Middle Channel 2437 MHz

30 MHz – 3 GHz

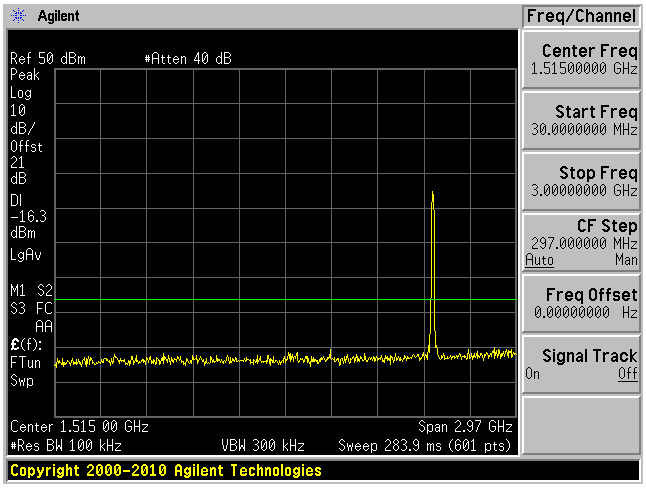


3 GHz – 26 GHz

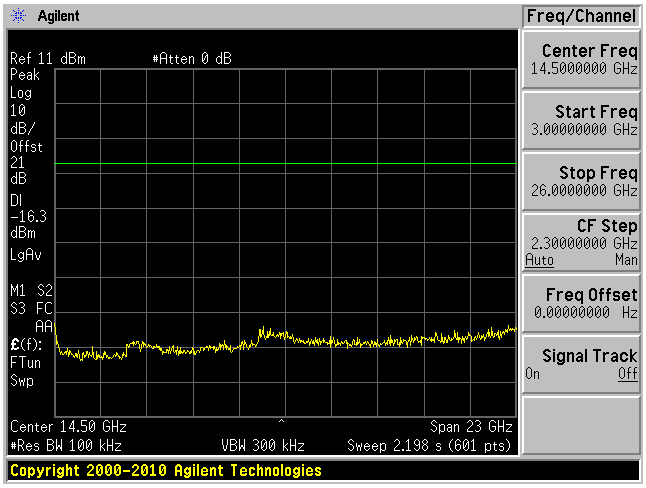


High Channel 2462 MHz

30 MHz – 3 GHz

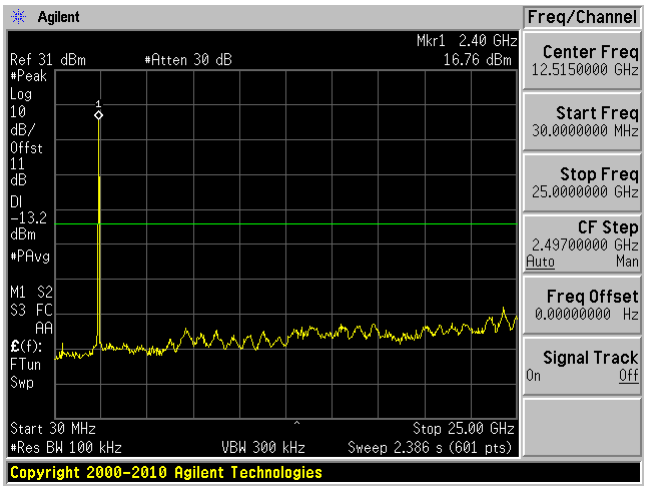


3 GHz – 26 GHz



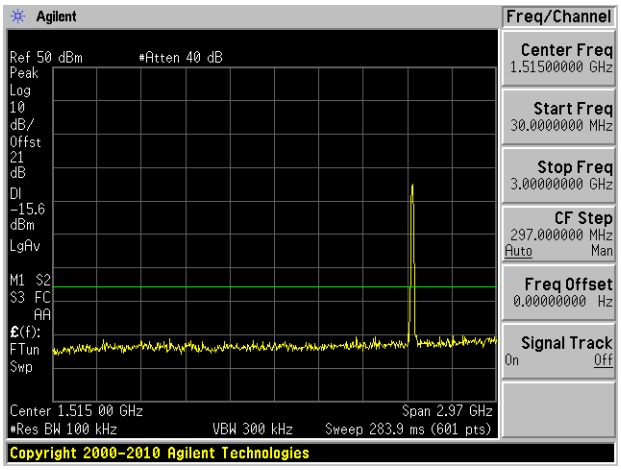
802.11b mode Chain 1

Low Channel 2412 MHz
30 MHz – 25 GHz

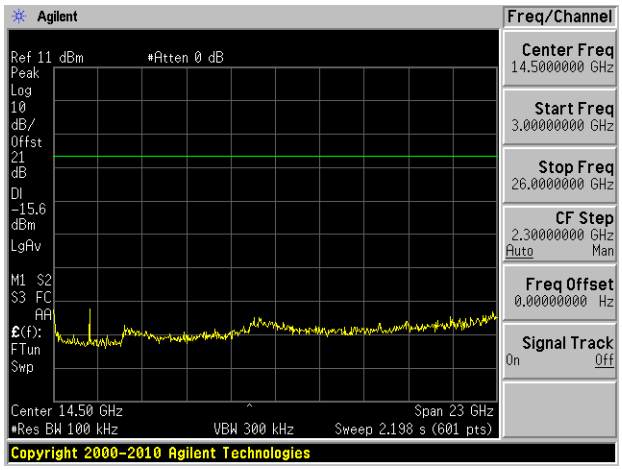


Middle Channel 2437 MHz

30 MHz – 3 GHz

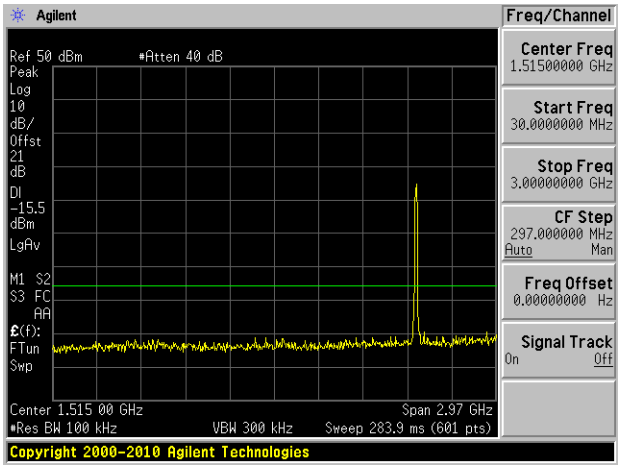


3 GHz - 26 GHz

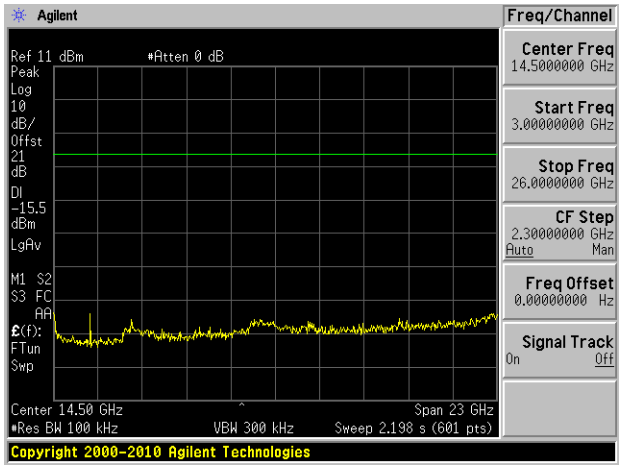


High Channel 2462 MHz

30 MHz – 3 GHz



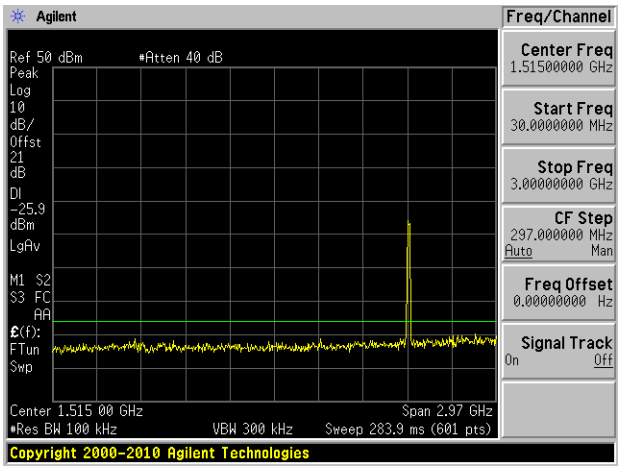
3 GHz – 26 GHz



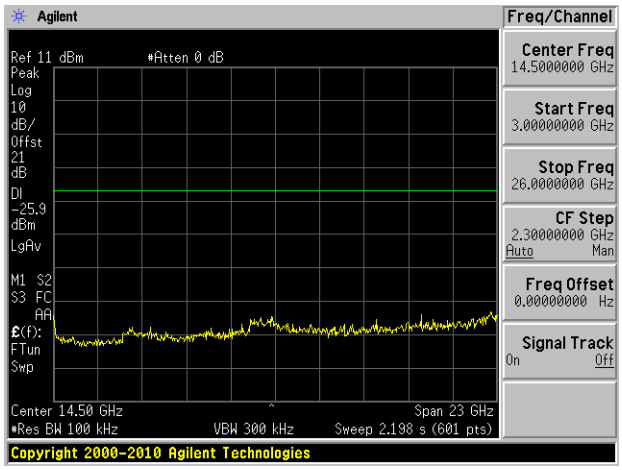
802.11g mode Chain 0

Low Channel 2412 MHz

30 MHz – 3 GHz

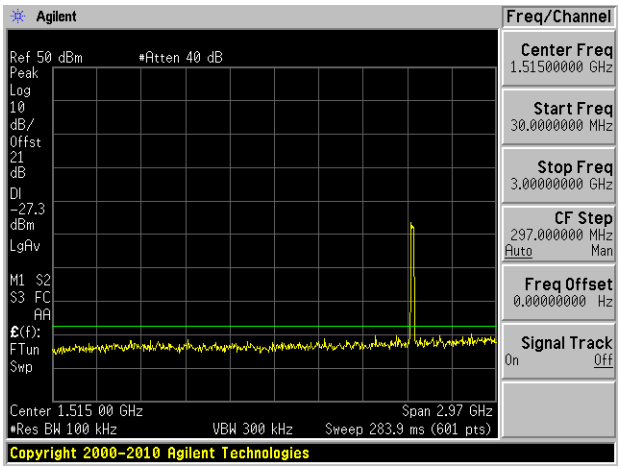


3 GHz – 26 GHz

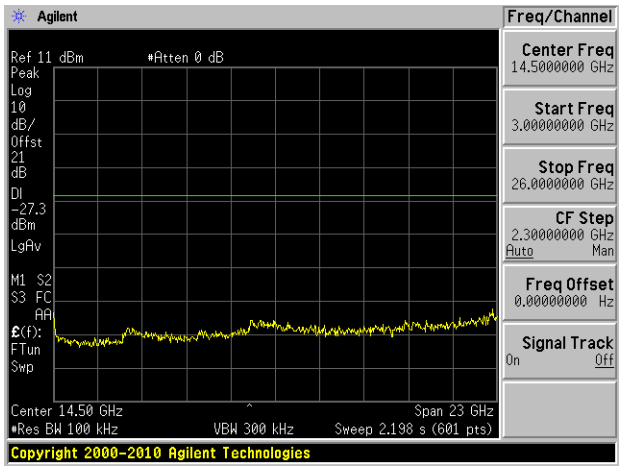


Middle Channel 2437 MHz

30 MHz – 3 GHz

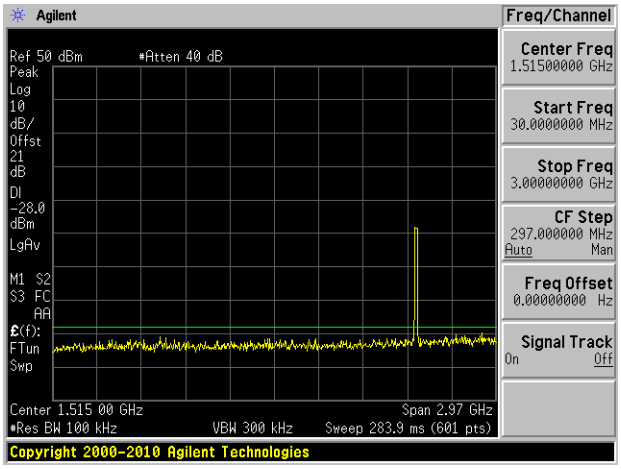


3 GHz – 26 GHz

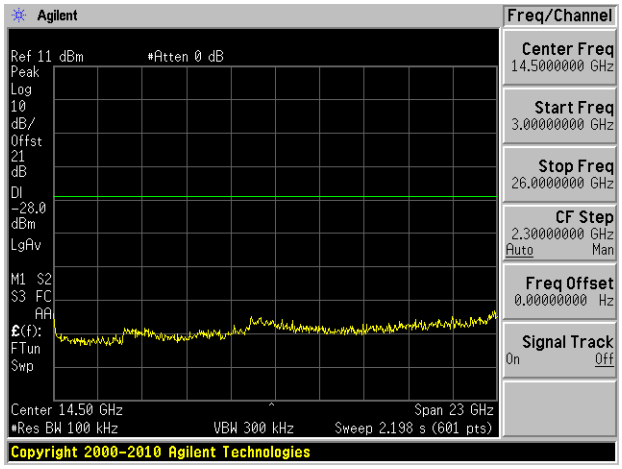


High Channel 2462 MHz

30 MHz – 3 GHz



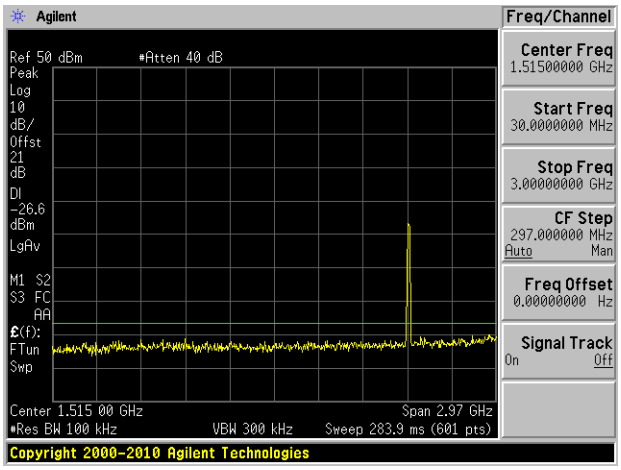
3 GHz – 26 GHz



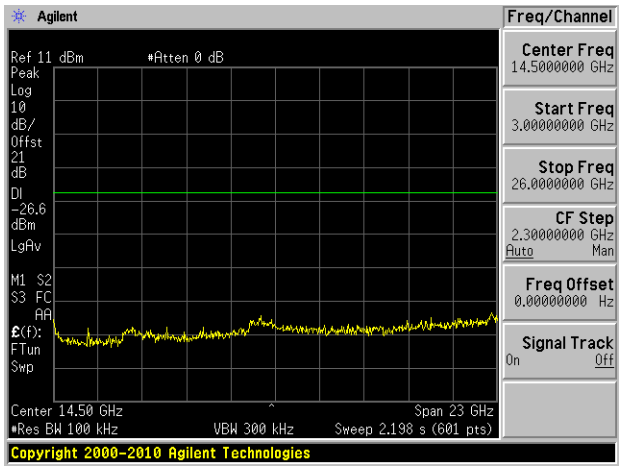
802.11g mode Chain 1

Low Channel 2412 MHz

30 MHz – 3 GHz

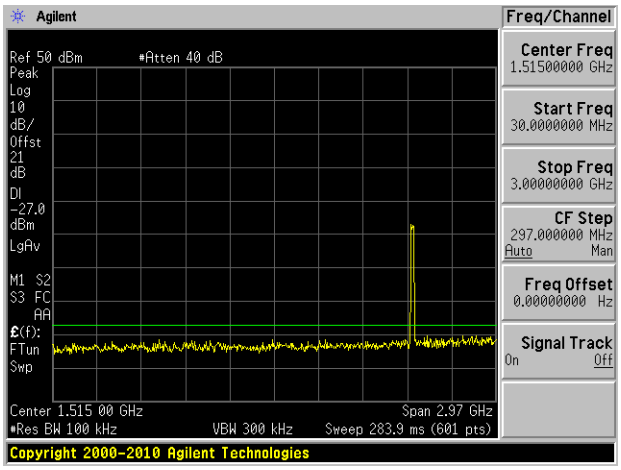


3 GHz – 26 GHz

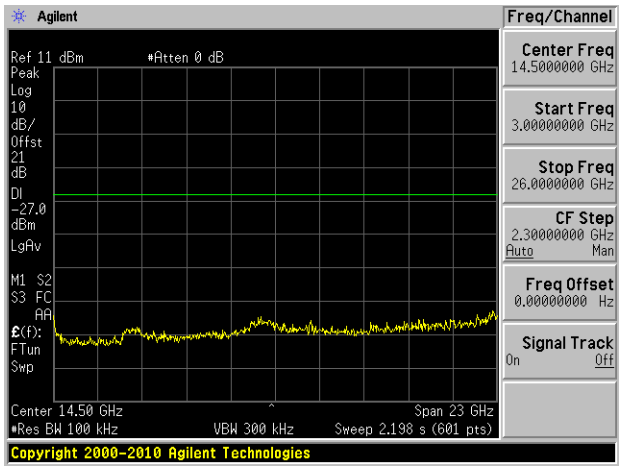


Middle Channel 2437 MHz

30 MHz – 3 GHz

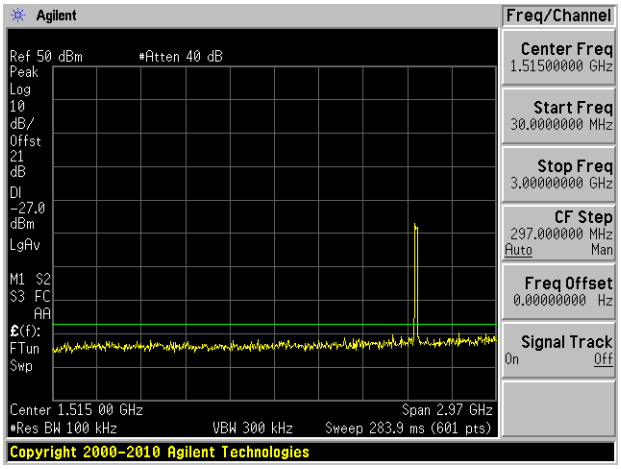


3 GHz – 26 GHz

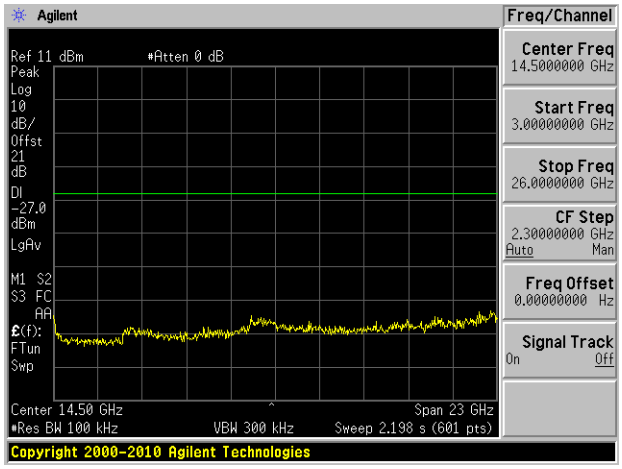


High Channel 2462 MHz

30 MHz – 3 GHz



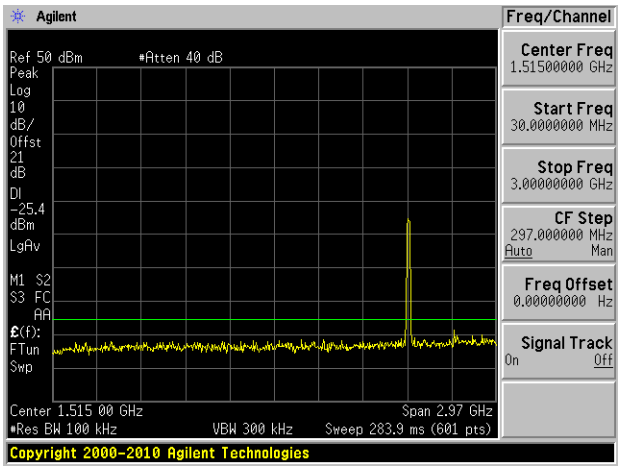
3 GHz – 26 GHz



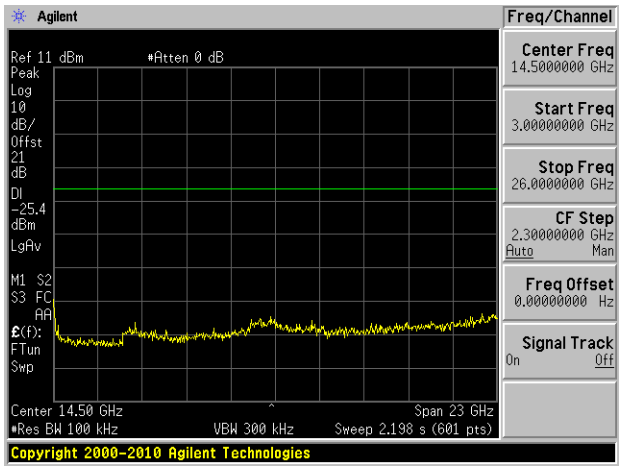
802.11n20 mode Chain 0

Low Channel 2412 MHz

30 MHz – 3 GHz

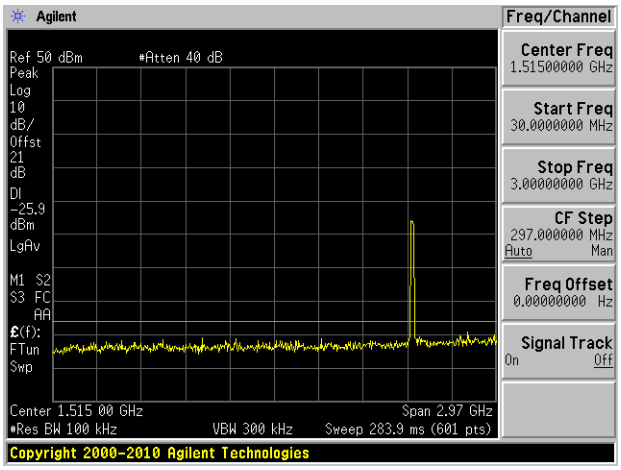


3 GHz – 26 GHz

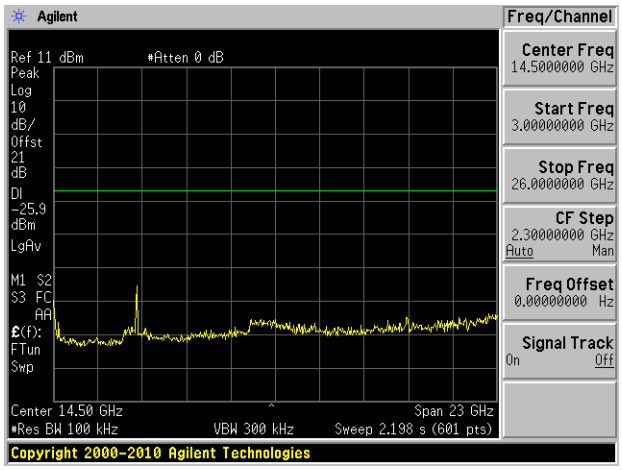


Middle Channel 2437 MHz

30 MHz – 3 GHz

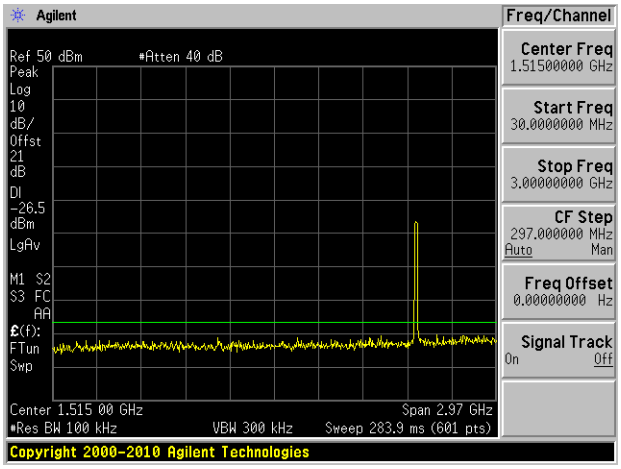


3 GHz – 26 GHz

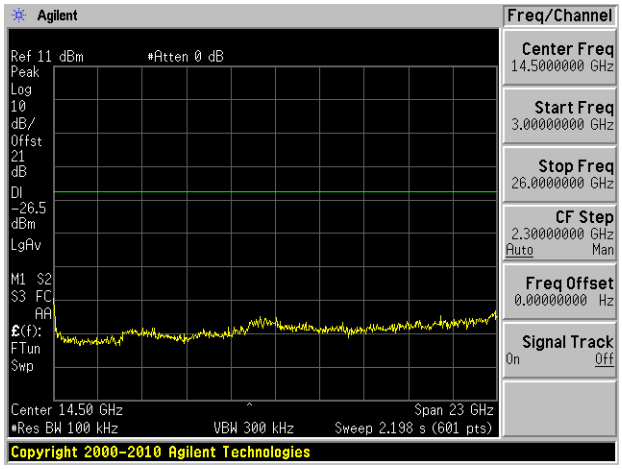


High Channel 2462 MHz

30 MHz – 3 GHz



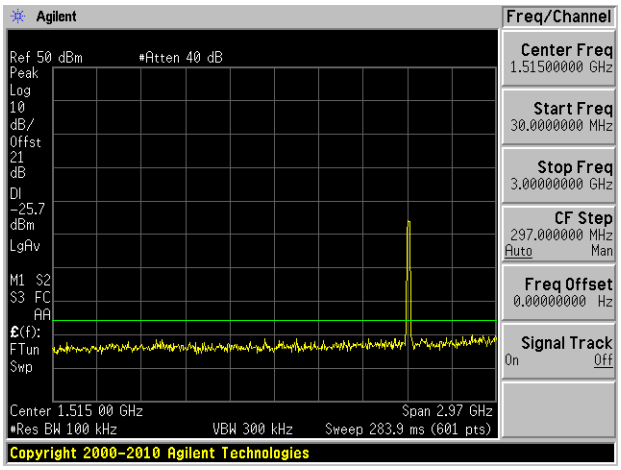
3 GHz – 26 GHz



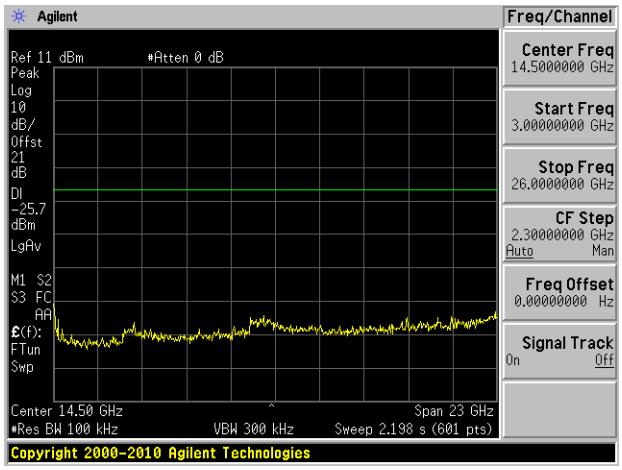
802.11n20 mode Chain 1

Low Channel 2412 MHz

30 MHz – 3 GHz

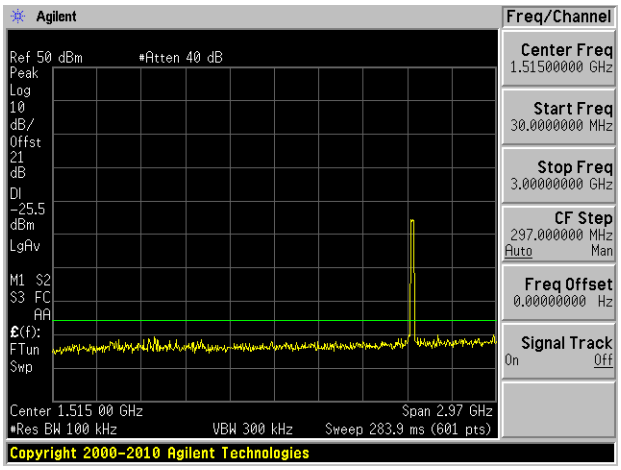


3 GHz – 26 GHz

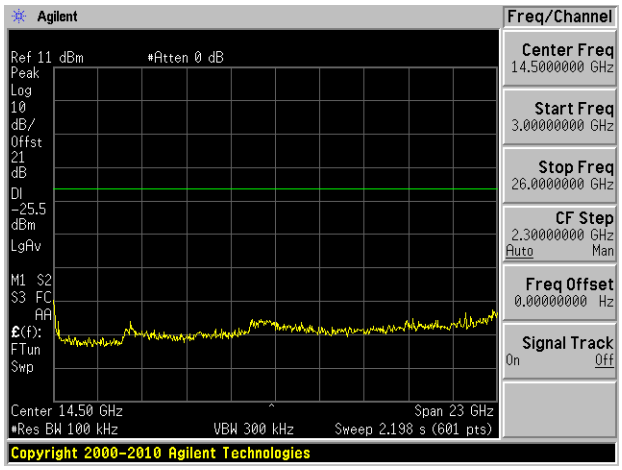


Middle Channel 2437 MHz

30 MHz – 3 GHz

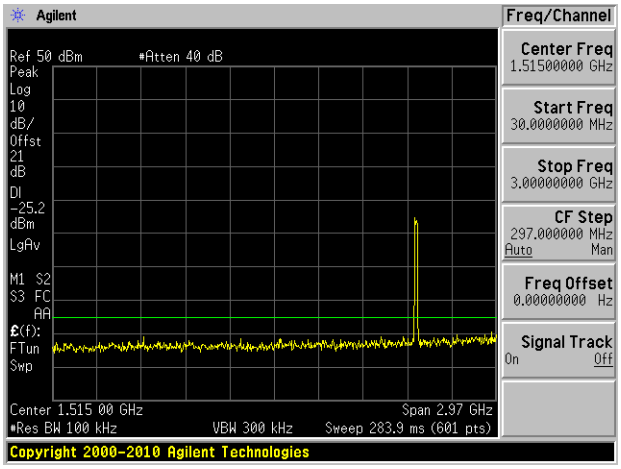


3 GHz – 26 GHz

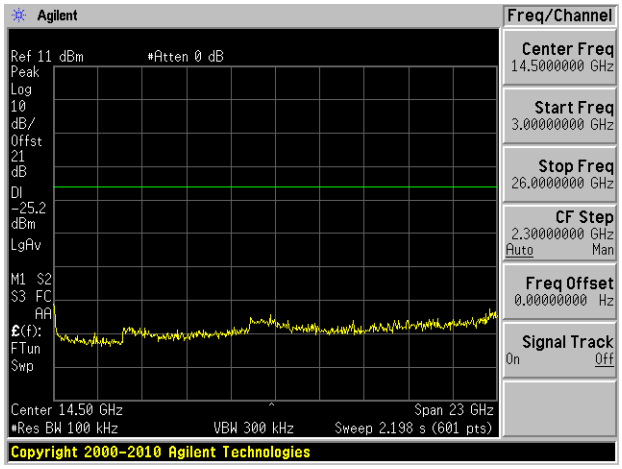


High Channel 2462 MHz

30 MHz – 3 GHz



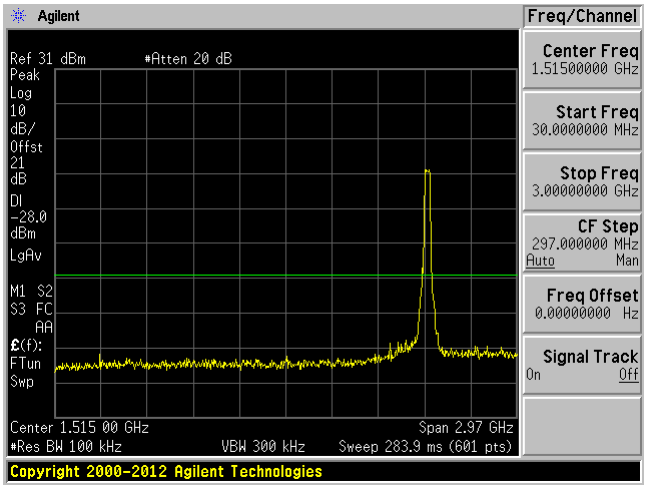
3 GHz – 26 GHz



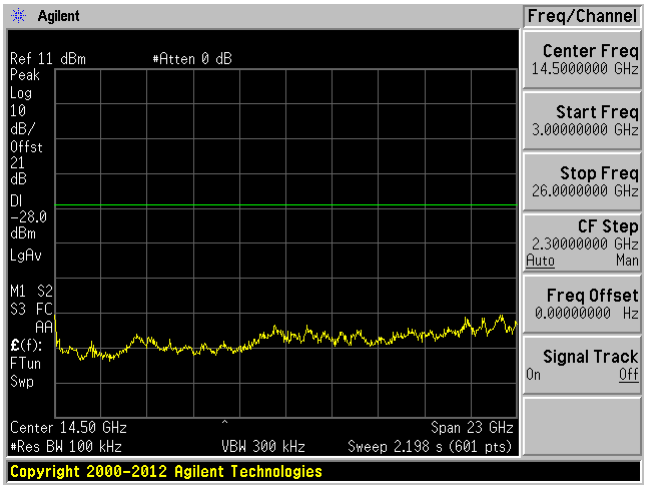
802.11n40 mode Chain 0

Low Channel 2422 MHz

30 MHz – 3 GHz

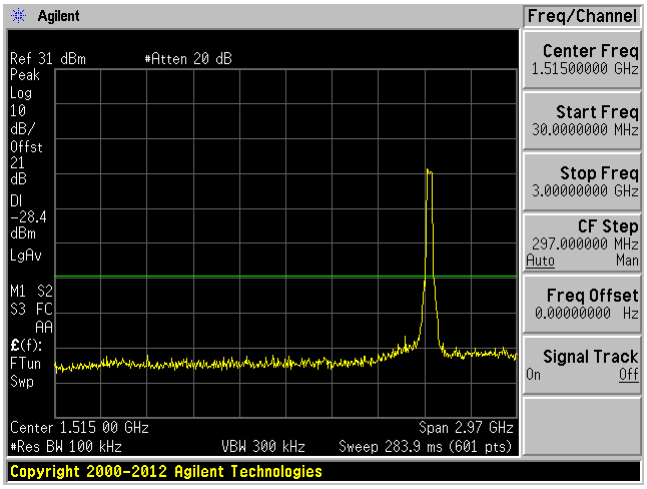


3 GHz – 26 GHz

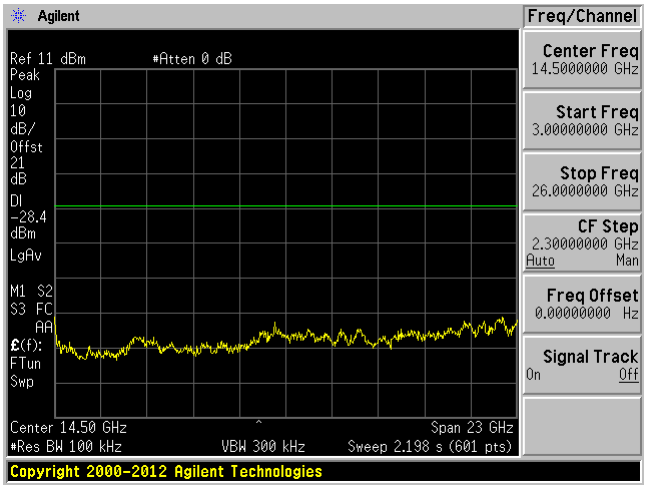


Middle Channel 2437 MHz

30 MHz – 3 GHz

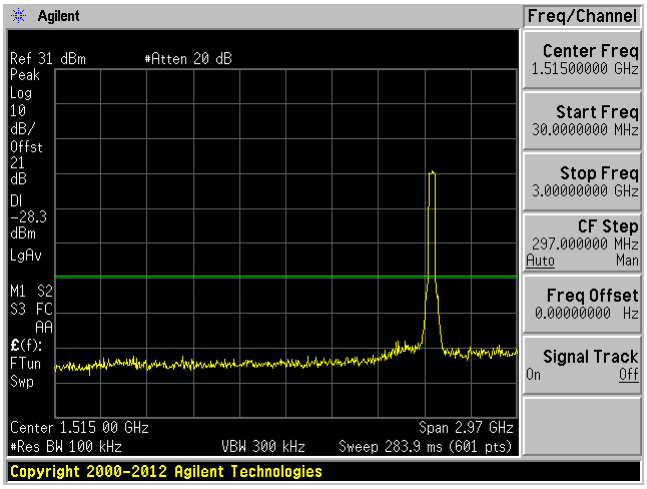


3 GHz – 26 GHz

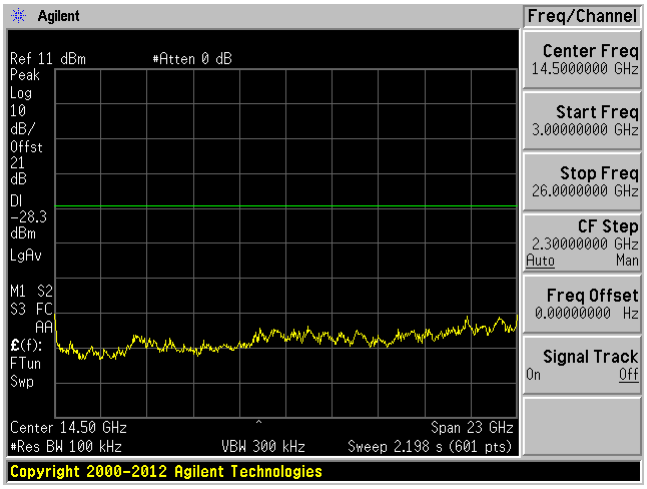


High Channel 2462 MHz

30 MHz – 3 GHz



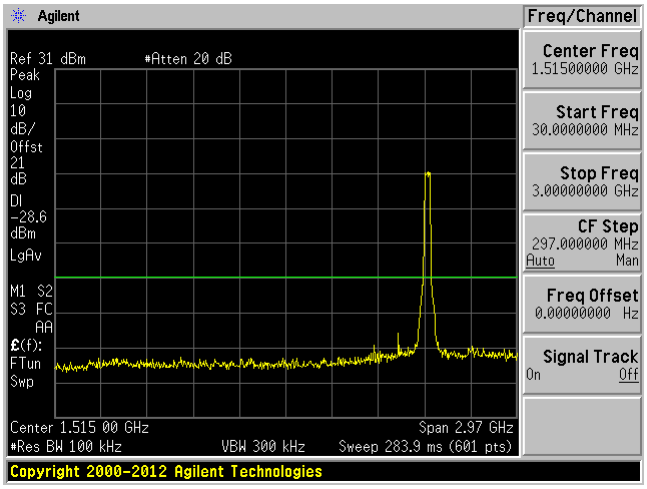
3 GHz – 26 GHz



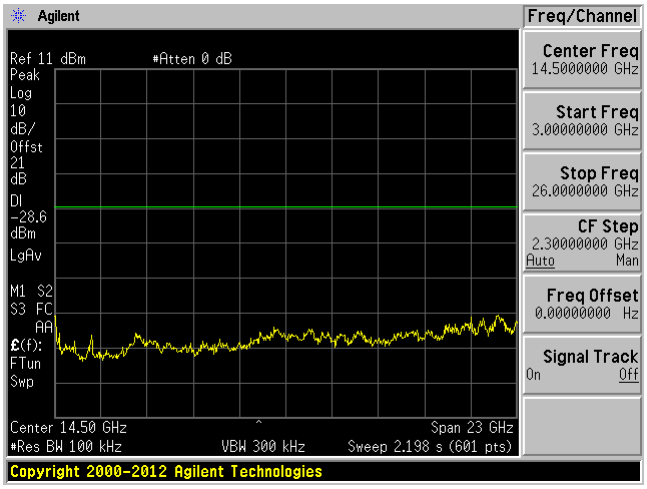
802.11n20 mode Chain 1

Low Channel 2422 MHz

30 MHz – 3 GHz

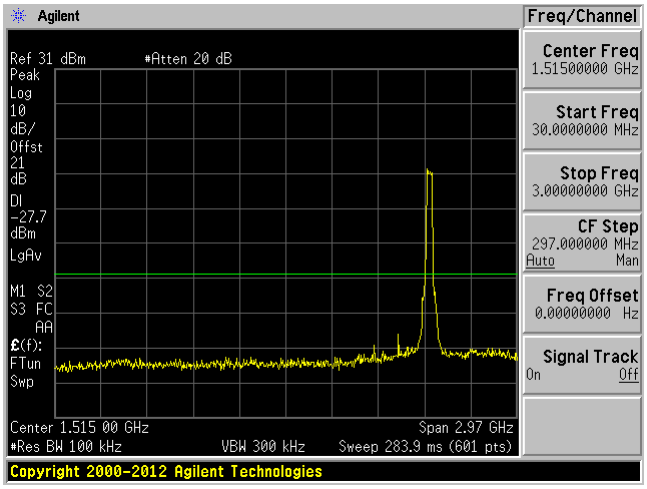


3 GHz – 26 GHz

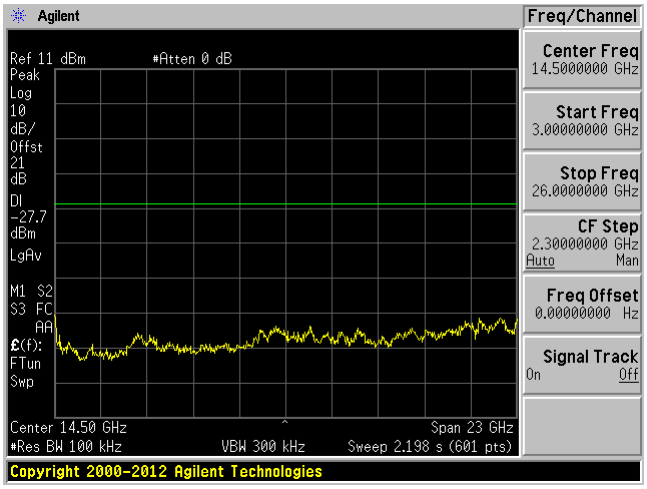


Middle Channel 2437 MHz

30 MHz – 3 GHz

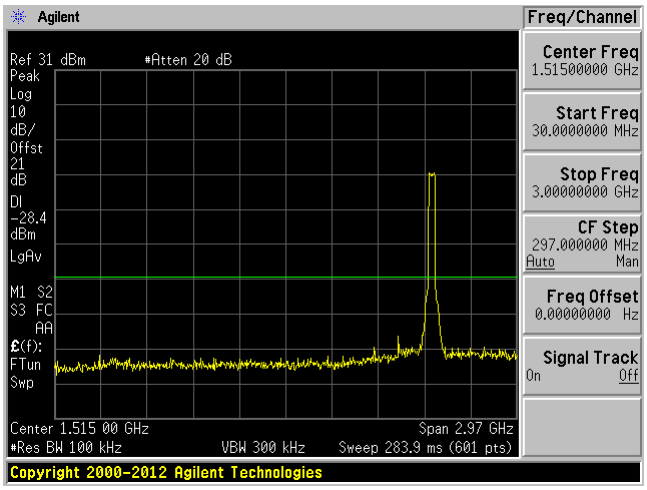


3 GHz – 26 GHz

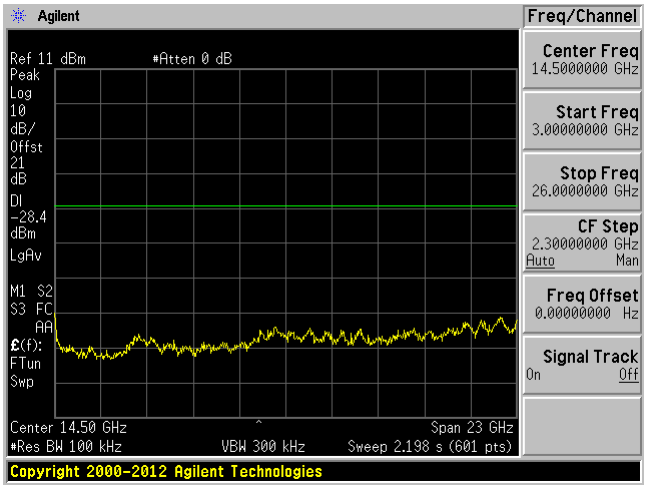


High Channel 2452 MHz

30 MHz – 3 GHz

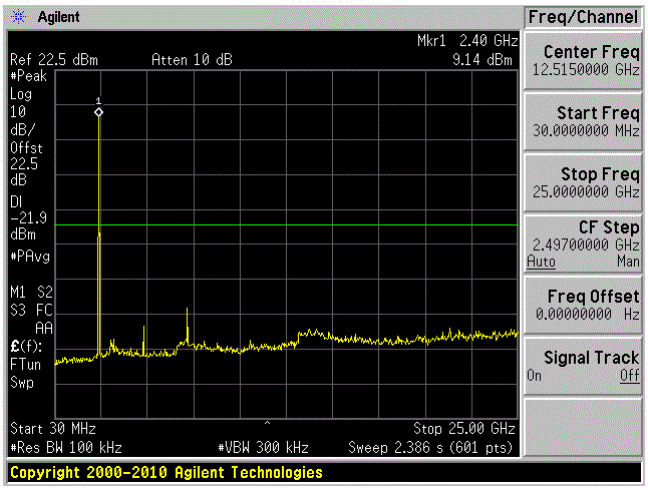


3 GHz – 26 GHz

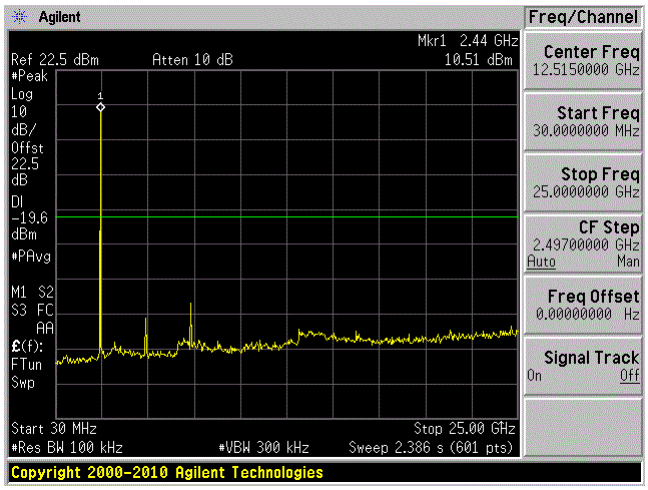


BLE mode Chain 0

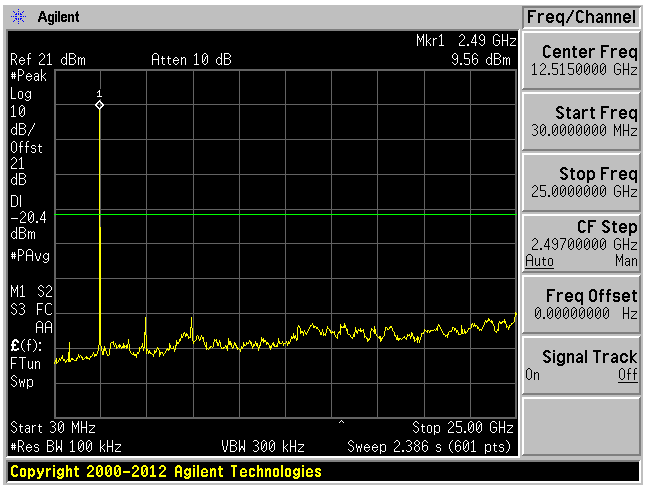
Low Channel 2402 MHz
30 MHz – 25 GHz



Middle Channel 2440 MHz
30 MHz – 25 GHz



High Channel 2480 MHz
30 MHz – 25 GHz



13 Annex A (Normative) – EUT 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 17025:2005 *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 September 30, 2020
Revised June 5, 2019

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

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