FCC PART 15.407

TEST REPORT

For

Roku, Inc.

150 Winchester Cir,
Los Gatos, CA 95032, USA

FCC ID: TC2-R1033

Report Type:	**Model Number:**
Original Report	9201X

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Report Number:	R1907165-407
Report Date:	2019-08-21
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ACCREDITED
CERTIFICATE #3297.02

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1907165-407	Original Report	2019-08-21

1 General Description

1.1 Product Description for Equipment under Test (EUT)

This test and measurement report was prepared on behalf of *Roku, Inc.*, FCC ID: TC2-R1033.

1.2 Objective

This report is prepared on behalf of Roku, Inc. in accordance with FCC CFR47 §15.407.

The objective is to determine compliance with FCC Part 15.407 rules for Output Power, Antenna Requirements, AC Line Conducted Emissions, Emission Bandwidth, Power spectral density, Conducted and Radiated Spurious Emissions.

1.3 Related Submittal(s)/Grant(s)

FCC Part 15, Subpart C, Equipment DTS with FCC ID: TC2-R1033

1.4 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz, and FCC KDB 789033 D02 General UNII Test Procedure New Rules v02r01.

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 & Fixed Radio Services;
  - 4 All Scope 4-Licensed Maritime & Aviation Radio Services;
  - 5 All Scope 5-Licensed Fixed Microwave Radio Services
  - 6 All Broadcasting Technical Standards (BETS) in the Category I Equipment Standards List.
- For Singapore (Info-Communications Development Authority (IDA)):
  - 1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
  - 2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2
- For the Hong Kong Special Administrative Region:
  - 1 All Radio Equipment, per KHCA 10XX-series Specifications;
  - 2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
  - 3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.
- For Japan:
  - 1 MIC Telecommunication Business Law (Terminal Equipment):
    - All Scope A1 - Terminal Equipment for the Purpose of Calls;
    - All Scope A2 - Other Terminal Equipment
  - 2 Radio Law (Radio Equipment):
    - All Scope B1 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 1 of the Radio Law
    - All Scope B2 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 2 of the Radio Law
    - All Scope B3 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 3 of the Radio Law

C- ***A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 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 & Cable Boxes (ver. 4.1)
- for Televisions (ver. 6.1)
- for Computers (ver. 6.0)
- for Displays (ver. 6.0)
- for Imaging Equipment (ver. 2.0)
- for Computer Servers (ver. 2.0)

2 Commercial Food Service Equipment
- for Commercial Dishwashers (ver. 2.0)
- for Commercial Ice Machines (ver. 2.0)
- for Commercial Ovens (ver. 2.1)
- for Commercial Refrigerators and Freezers

3 Lighting Products
- For Decorative Light Strings (ver. 1.5)
- For Luminaires (including sub-components) and Lamps (ver. 1.2)
- For Compact Fluorescent Lamps (CFLs) (ver. 4.3)
- For Integral LED Lamps (ver. 1.4)

4 Heating, Ventilation, and AC Products
- for Residential Ceiling Fans (ver. 3.0)
- for Residential Ventilating Fans (ver. 3.2)

5 Other
- For Water Coolers (ver. 3.0)

D- ***A NIST Designated Phase-I and Phase-II Conformity Assessment Body (CAB) for the following economies and regulatory authorities under the terms of the stated MRAs/Treaties:***

- Australia: ACMA (Australian Communication and Media Authority) – APEC Tel MRA -Phase I;
- Canada: (Innovation, Science and Economic development Canada - ISEDC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
  - BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
  - NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
  - EMC Directive 2014/30/EU US-EU EMC & Telecom MRA CAB (NB)
  - Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
  - Low Voltage Directive (LVD) 2014/35/EU
- Hong Kong Special Administrative Region: (Office of the Telecommunications Authority – OFTA) APEC Tel MRA -Phase I & Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Media Development Authority - IMDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-
- USA:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - Telecommunications Certification Body (TCB) – US FCC;
  - Nationally Recognized Test Laboratory (NRTL) – US OSHA
- Vietnam: APEC Tel MRA -Phase I;

2 EUT Test Configuration

2.1 Justification

The EUT was configured for testing according to ANSI C63.10-2013 and FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01.

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 by measuring the average power, peak power and PPSD across all data rates bandwidths, and modulations.

2.2 EUT Exercise Software

The test software used was TeraTerm, the software compliant with the standard requirements being tested against.

Please refer to the following power setting table.

Modulation	Channel	Frequency (MHz)	Power Setting
802.11a mode	36	5180	53
	44	5220	52
	48	5240	51
	149	5745	51
	157	5785	51
	165	5825	52
802.11n20 mode	36	5180	54
	44	5220	52
	48	5240	52
	149	5745	51
	157	5785	51
	165	5825	52
802.11ac20 mode	36	5180	54
	44	5220	52
	48	5240	51
	149	5745	51
	157	5785	51
	165	5825	52

*Data rates tested:
802.11a mode: 6Mbps
802.11n HT20: MCS0
802.11ac VHT20: MCS0

2.3 Duty Cycle Correction Factor

According to KDB 789033 D02 General UNII Test Procedures New Rules v02r01 section B:

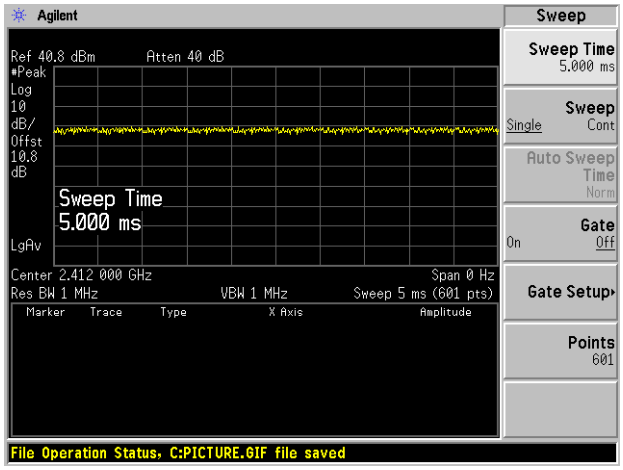
All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximum-power transmission duration, T, are required for each tested mode of operation.

Radio Mode	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
802.11a	-	-	100	0
802.11n20	-	-	100	0
802.11ac20	-	-	100	0

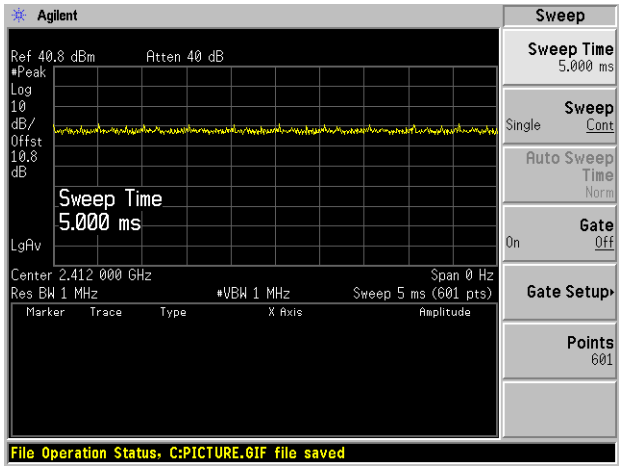
Note: Duty Cycle Correction Factor = 10*log(1/duty cycle)

Please refer to the following plots.

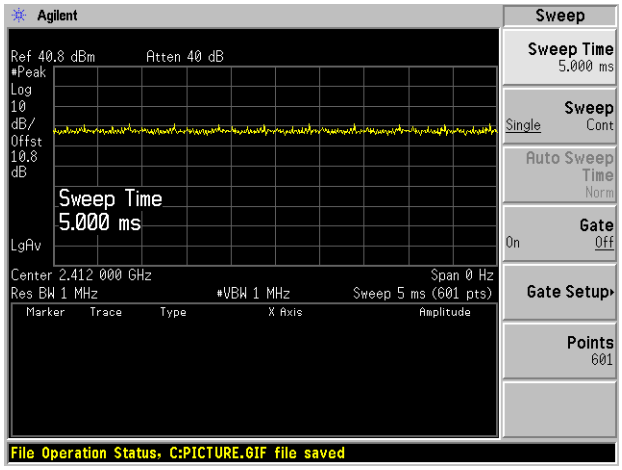
802.11a mode



802.11n20 mode



802.11ac20 mode



2.4 Local Support Equipment

Manufacturer	Description	Model
Dell	Laptop	Latitude E7450

2.5 Support Equipment

Manufacturer	Description	Model
Roku	Debug Board	Unknown

2.6 Interface Ports and Cabling

Cable Description	Length (m)	To	From
USB Cable	< 1 m	Laptop	EUT
RF Cable	< 1 m	EUT	PSA

3 Summary of Test Results

FCC Rules	Description of Test	Result
FCC §2.1091, §15.407(f)	RF Exposure	Compliant
FCC §15.203	Antenna Requirement	Compliant
FCC §15.207	AC Power Line Conducted Emissions	Compliant
FCC §2.1053, §15.205, §15.209, 15.407(b)	Spurious Radiated Emissions	Compliant
FCC §15.407(e)	Emission Bandwidth	Compliant
FCC §407(a)	Output Power	Compliant
FCC §2.1051, §15.407(b)	Band Edges	Compliant
FCC §15.407(a)	Power Spectral Density	Compliant
FCC §2.1051, §15.407(b)	Spurious Emissions at Antenna Terminals	Compliant

4 FCC §2.1091, §15.407(f) - RF Exposure

4.1 Applicable Standards

According to FCC §15.247(f) 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

4.2 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

4.3 MPE Results

5GHz Wifi

Maximum output power at antenna input terminal (dBm):	16.11
Maximum output power at antenna input terminal (tune-up) (mW):	17.11
Maximum output power at antenna input terminal (tune-up) (mW):	51.40
Prediction distance (cm):	20
Prediction frequency (MHz):	5180
Maximum Antenna Gain, typical (dBi):	4
Maximum Antenna Gain (numeric):	2.51
Power density of prediction frequency at 20.0 cm (mW/cm^2):	0.0257
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 maximum power density at the distance of 20 cm is $0.03mW/cm^2$. Limit is 1.0 mW/cm^2.

5 FCC §15.203 - Antenna Requirements

5.1 Applicable Standards

According to FCC §15.203:

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

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

5.2 Antenna List

The antennas used by the EUT are permanent attached antennas.

Antenna usage	Frequency Range (MHz)	Maximum Antenna Gain (dBi)
2.4GHz Wi-Fi	2400-2480	4
5GHz Wi-Fi	5180-5240,5745-5825	4

6 FCC §15.207 - AC Power Line Conducted Emissions

6.1 Applicable Standards

As per FCC §15.207

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

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

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

6.2 Test Setup

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

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

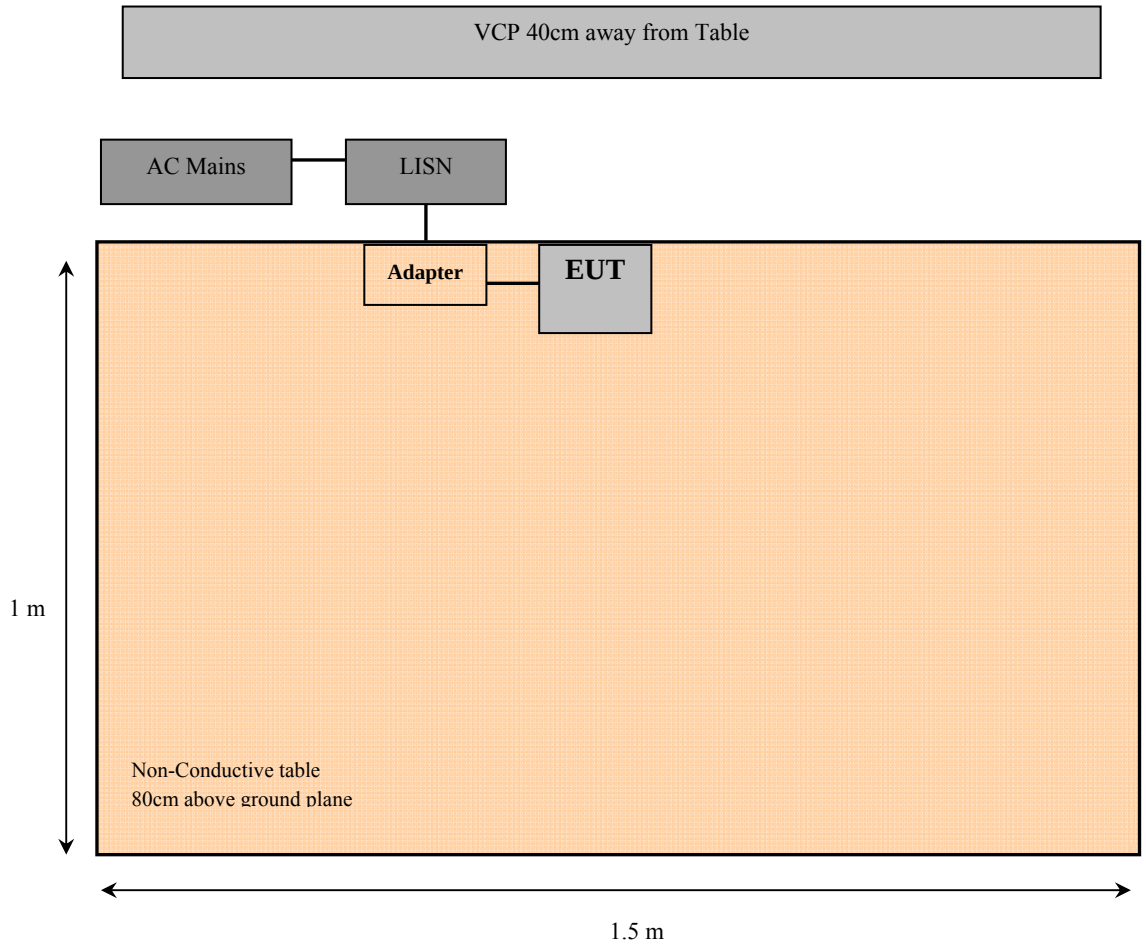
6.3 Test Procedure

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

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

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

6.4 Test Setup Block Diagram



6.5 Corrected Amplitude and Margin Calculation

The Corrected Amplitude (CA) is calculated by adding the 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

6.6 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde and Schwarz	Receiver, EMI Test	ESCI 1166.5950.03	100338	2018-07-05	2 years
Rohde and Schwarz	Impulse Limiter	ESH3-Z2	101964	2019-07-31	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	2019-04-11	1 year
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

6.7 Test Environmental Conditions

Temperature:	23º C
Relative Humidity:	42 %
ATM Pressure:	101.31 kPa

The testing was performed by Corey Phan on 2019-08-09 at chamber 5m 3 test site.

6.8 Summary of Test Results

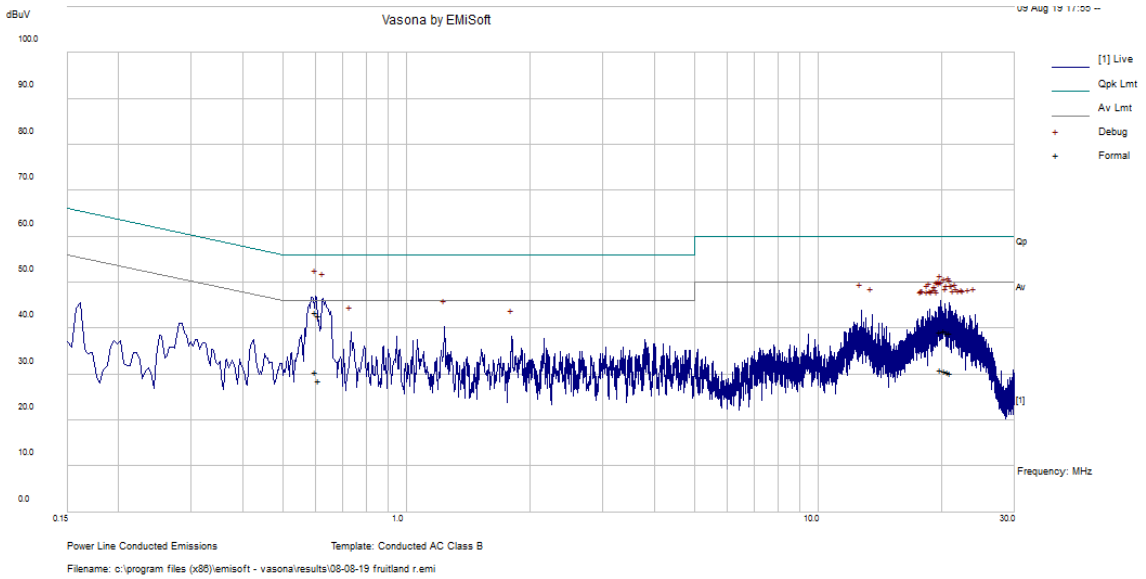
According to the recorded data in following table, the EUT complied with the FCC Part 15 and RSS-Gen standards' conducted emissions limits, with the margin reading of:

Connection: AC/DC adapter connected to 120 V/60 Hz, AC			
Margin (dB)	**Frequency (MHz)**	**Conductor Mode (Live/Neutral)**	**Range (MHz)**
-12.60	0.602682	Live	0.15-30

6.9 Conducted Emissions Test Plots and Data

Note: testing was performed at worst case.

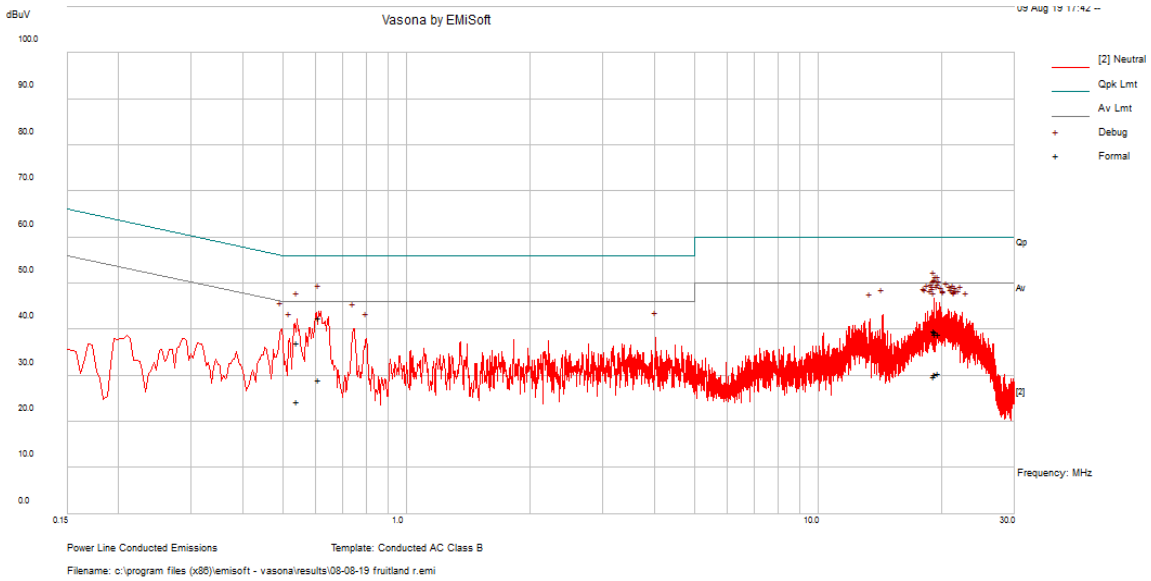
120 V, 60 Hz – Line



Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.602682	43.4	Line	56	**-12.6**	QP
0.611342	42.7	Line	56	-13.3	QP
19.838081	39.24	Line	60	-20.76	QP
20.784199	39.07	Line	60	-20.93	QP
20.337206	39.49	Line	60	-20.51	QP
20.952793	38.91	Line	60	-21.09	QP

Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.602682	30.48	Line	46	-15.52	Ave.
0.611342	28.61	Line	46	-17.39	Ave.
19.838081	30.88	Line	50	-19.12	Ave.
20.784199	30.56	Line	50	-19.44	Ave.
20.337206	30.78	Line	50	-19.22	Ave.
20.952793	30.31	Line	50	-19.69	Ave.

120 V, 60 Hz – Neutral



Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.614884	42.5	Neutral	56	-13.5	QP
19.11244	39.66	Neutral	60	-20.34	QP
0.54377	37.02	Neutral	56	-18.98	QP
19.327168	38.92	Neutral	60	-21.08	QP
19.666727	39.02	Neutral	60	-20.98	QP
19.300462	39.37	Neutral	60	-20.63	QP

Frequency (MHz)	Corrected Amplitude (dBµV)	Conductor (Line/Neutral)	Limit (dBµV)	Margin (dB)	Detector (QP/Ave.)
0.614884	28.98	Neutral	46	-17.02	Ave.
19.11244	29.68	Neutral	50	-20.32	Ave.
0.54377	24.32	Neutral	46	-21.68	Ave.
19.327168	30.28	Neutral	50	-19.72	Ave.
19.666727	30.53	Neutral	50	-19.47	Ave.
19.300462	30.19	Neutral	50	-19.81	Ave.

7 FCC §15.209, §15.407(b) - Spurious Radiated Emissions

7.1 Applicable Standard

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

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	960 – 1240	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	1300 – 1427	5. 35 – 5. 46
2.1735 – 2.1905	25.5 – 25.67	1435 – 1626.5	7.25 – 7.75
4.125 – 4.128	37.5 – 38.25	1645.5 – 1646.5	8.025 – 8.5
4.17725 – 4.17775	73 – 74.6	1660 – 1710	9.0 – 9.2
4.20725 – 4.20775	74.8 – 75.2	1718.8 – 1722.2	9.3 – 9.5
6.215 – 6.218	108 – 121.94	2200 – 2300	10.6 – 12.7
6.26775 – 6.26825	123 – 138	2310 – 2390	13.25 – 13.4
6.31175 – 6.31225	149.9 – 150.05	2483.5 – 2500	14.47 – 14.5
8.291 – 8.294	156.52475 – 156.52525	2690 – 2900	15.35 – 16.2
8.362 – 8.366	156.7 – 156.9	3260 – 3267	17.7 – 21.4
8.37625 – 8.38675	162.0125 –167.17	3.332 – 3.339	22.01 – 23.12
8.41425 – 8.41475	167.72 – 173.2	3 3458 – 3 358	23.6 – 24.0
12.29 – 12.293	240 – 285	3.600 – 4.400	31.2 – 31.8
12.51975 – 12.52025	322 – 335.4		36.43 – 36.5
12.57675 – 12.57725	399.9 – 410		Above 38.6
13.36 – 13.41	608 – 614		

As per FCC §15.209: 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 Note 1	3
88 - 216	150 Note 1	3
216 - 960	200 Note 1	3
Above 960	500	3

Note 1: 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 Part 15.407 (b)

(1) For transmitters operating in the 5.15-5.25 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(2) For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(3) For transmitters operating in the 5.47 -5.725 GHz band: All emissions outside of the 5.47-5725 GHz band shall not exceed an ei.r.p. of -27 dBm/MHz.

(4) For transmitters operating in the 5.725-5.85 GHz band: All emissions within the frequency range from the band edge to 10 MHz above or below the band edge shall not exceed an e.i.r.p. of -17 dBm/MHz; for frequencies 10 MHz or greater above or below the band edge, emissions shall noet exceed an e.i.r.p. of -27 dBm/MHz.

(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

(7) The provisions of §15.205 apply to intentional radiators operating under this section.

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 15.407 limits.

The spacing between the peripherals was 10 centimeters.

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

7.3 Test Procedure

For the radiated emissions test, the EUT host, and all support equipment power cords 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 is set 3 meter away from the testing antenna, which is varied from 1-4 meter, and the EUT is placed on a turntable, which is 0.8 meter or 1.5 meter above ground plane, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna should be changed the polarization both of horizontal and vertical.

The spectrum analyzer or receiver is set as:

Below 1000 MHz:

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

Above 1000 MHz:

(1) Peak: RBW = 1MHz / VBW = 3MHz / Sweep = 100ms
(2) Average: RBW = 1MHz / VBW = 10Hz / 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 for Class A. 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	100044	2018-10-26	2 years
Agilent	Analyzer, Spectrum	E4440A	US45303156	2019-03-19	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
EMCO	Antenna, Horn	3115	9511-4627	2018-03-28	2 years
Agilent	Amplifier, Pre	8447D	2443A04374	2018-08-13	1 year
AH Systems	Pre-Amplifier 18-40GHz	PAM-1840VH	170	2018-09-10	1 year
Insulated Wire INC	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1501AN-3960-KPS	DC 1807	2018-03-13	2 years
-	SMA cable	-	C0002	Each time[1]	N/A
HP/Agilent	Pre-Amplifier	8449B	3008A01978	2018-08-17	1 year
Wisewave	Antenna, Horn 18-26.5GHz	ARH-4223-02	10555-02	2017-12-15	2 years
Wisewave	Antenna, Horn 26.5-40GHz	ARH-2823-02	10555-01	2017-09-18	2 years
Sunol Sciences	Antenna, Horn	DRH-118	A052704	2019-04-02	2 years
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Note[1]: cables and attenuators included in the test set-up will be checked each time before testing.
Statement of Traceability: BACL *attests that all calibrations have been performed per the A2LA requirements, traceable to NIST.*

7.6 Test Environmental Conditions

Temperature:	22-24 ºC
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Christian McCaig and Corey Phan 2019-08-06 to 2019-08-09 in 5m chamber 3.

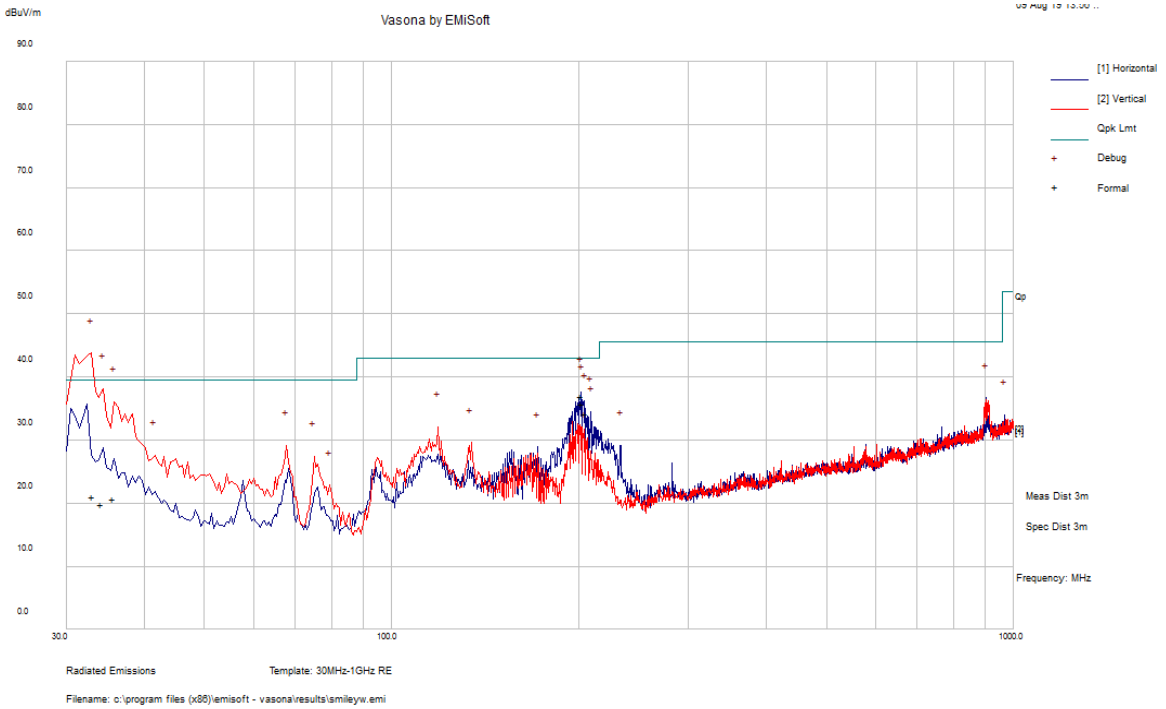
7.7 Summary of Test Results

According to the data hereinafter, the EUT complied with the FCC Part 15.407 and RSS-247 standards' radiated emissions limits, and had the worst margin of:

Mode: Transmitting			
Margin (dB)	**Frequency (MHz)**	**Polarization (Horizontal/Vertical)**	**Mode, Channel**
-0.11	11650	Vertical	802.11ac20 mode, 5825 MHz

7.8 Radiated Emissions Test Result Data

1) 30 MHz – 1 GHz



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
33.02525	21	167	V	195	39.5	-18.5	QP
34.17325	19.85	167	V	103	39.5	-19.65	QP
35.652	20.64	165	V	155	39.5	-18.86	QP
201.72275	36.93	134	H	271	43	-6.07	QP
202.8885	35.83	122	H	267	43	-7.17	QP
205.2685	34.27	106	H	287	43	-8.73	QP

2) 1–40 GHz

5150 - 5250 MHz

802.11a mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5180 MHz											
5150	60.99	225	254	H	33.59	8.958	35.515	68.02	74	-5.98	PK
5150	46.30	225	254	H	33.59	8.958	35.515	53.33	54	-0.67	AV
5150	59.58	64	100	V	33.542	8.958	35.515	66.56	74	-7.44	PK
5150	45.15	64	100	V	33.542	8.958	35.515	52.13	54	-1.87	AV
10360	44.65	0	100	H	38.17	13.71	35.42	61.11	68	-6.89	PK
10360	44.31	0	100	V	38.13	13.71	35.42	60.73	68	-7.27	PK
Middle Channel 5220 MHz											
10440	43.78	0	100	H	38.17	11.06	35.42	57.59	74	-10.41	PK
10440	43.11	0	100	V	38.13	11.06	35.42	56.88	74	-11.12	PK
High Channel 5240 MHz											
10480	44.25	0	100	H	38.17	11.06	35.42	58.06	74	-9.94	PK
10480	43.60	0	100	V	38.13	11.06	35.42	57.37	74	-10.63	PK

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 (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5180 MHz											
5150	57.19	164	228	H	33.59	8.958	35.515	64.22	74	-9.78	PK
5150	39.91	164	228	H	33.59	8.958	35.515	46.94	54	-7.06	AV
5150	58.74	63	100	V	33.542	8.958	35.515	65.72	74	-8.28	PK
5150	41.45	63	100	V	33.542	8.958	35.515	48.43	54	-5.57	AV
10360	43.60	0	100	H	38.17	13.71	35.42	60.06	68	-7.94	PK
10360	43.73	0	100	V	38.13	13.71	35.42	60.15	68	-7.85	PK
Middle Channel 5220 MHz											
10440	43.72	0	100	H	38.17	11.06	35.42	57.53	68	-10.47	PK
10440	43.75	0	100	V	38.13	11.06	35.42	57.52	68	-10.48	PK
High Channel 5240 MHz											
10480	43.80	0	100	H	38.17	11.06	35.42	57.61	68	-10.39	PK
10480	44.34	0	100	V	38.13	11.06	35.42	58.11	68	-9.89	PK

802.11ac20 mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5180 MHz											
5150	56.46	74	100	H	33.59	8.958	35.515	63.49	74	-10.51	PK
5150	40.64	74	100	H	33.59	8.958	35.515	47.67	54	-6.33	AV
5150	58.51	64	100	V	33.542	8.958	35.515	65.49	74	-8.51	PK
5150	42.82	64	100	V	33.542	8.958	35.515	49.80	54	-4.20	AV
10360	43.21	0	100	H	38.17	13.71	35.42	59.67	68	-8.33	PK
10360	43.49	0	100	V	38.13	13.71	35.42	59.91	68	-8.09	PK
Middle Channel 5220 MHz											
10440	42.63	0	100	H	38.17	11.06	35.42	56.44	68	-11.56	PK
10440	42.48	0	100	V	38.13	11.06	35.42	56.25	68	-11.75	PK
High Channel 5240 MHz											
10480	44.45	0	100	H	38.17	11.06	35.42	58.26	68	-9.74	PK
10480	43.09	0	100	V	38.13	11.06	35.42	56.86	68	-11.14	PK

5725 - 5850 MHz

802.11a mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5745 MHz											
11490	43.41	0	100	H	38.44	15.393	33.832	63.41	74.00	-10.59	PK
11490	31.61	0	100	H	38.44	15.393	33.832	51.61	54.00	-2.39	AV
11490	43.13	0	100	V	38.43	15.393	33.832	63.12	74.00	-10.88	PK
11490	31.71	0	100	V	38.43	15.393	33.832	51.70	54.00	-2.30	AV
Middle Channel 5785 MHz											
11570	41.93	0	100	H	38.44	15.393	33.832	61.93	74.00	-12.07	PK
11570	30.35	0	100	H	38.44	15.393	33.832	50.35	54.00	-3.65	AV
11570	41.82	0	100	V	38.43	15.393	33.832	61.81	74.00	-12.19	PK
11570	30.23	0	100	V	38.43	15.393	33.832	50.22	54.00	-3.78	AV
High Channel 5825 MHz											
11650	42.06	0	100	H	38.44	15.393	33.832	62.06	74.00	-11.94	PK
11650	31.42	0	100	H	38.44	15.393	33.832	51.42	54.00	-2.58	AV
11650	42.54	0	100	V	38.43	15.393	33.832	62.53	74.00	-11.47	PK
11650	31.24	0	100	V	38.43	15.393	33.832	51.23	54.00	-2.77	AV

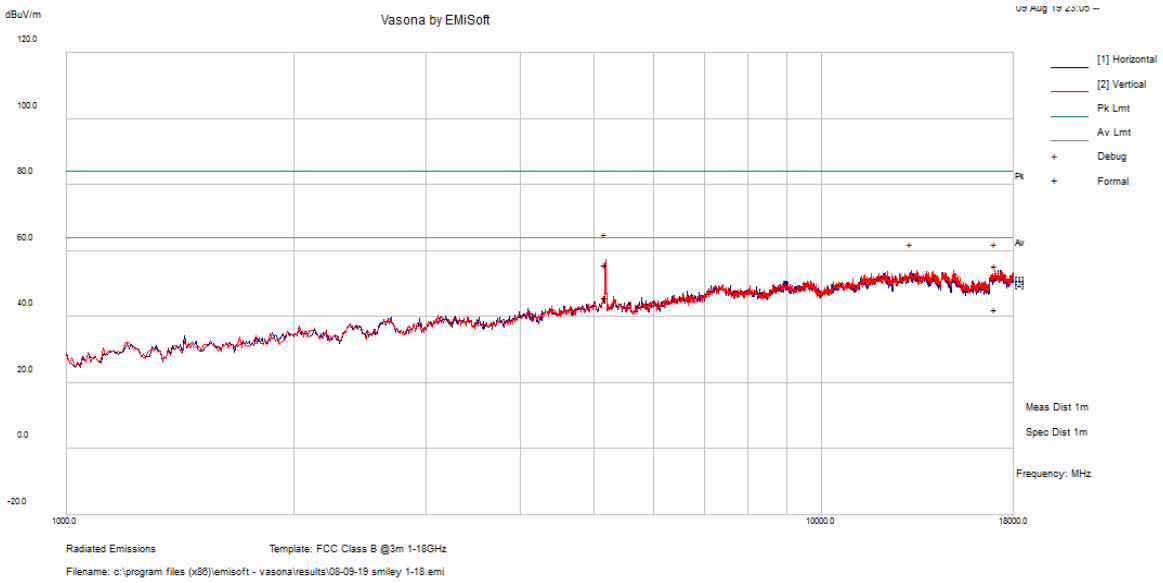
802.11n20 mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5745 MHz											
11490	42.93	0	100	H	38.44	15.393	33.832	62.93	74.00	-11.07	PK
11490	31.47	0	100	H	38.44	15.393	33.832	51.47	54.00	-2.53	AV
11490	42.85	0	100	V	38.43	15.393	33.832	62.84	74.00	-11.16	PK
11490	32.02	0	100	V	38.43	15.393	33.832	52.01	54.00	-1.99	AV
Middle Channel 5785 MHz											
11570	42.49	0	100	H	38.44	15.393	33.832	62.49	74.00	-11.51	PK
11570	31.40	0	100	H	38.44	15.393	33.832	51.40	54.00	-2.60	AV
11570	42.87	0	100	V	38.43	15.393	33.832	62.86	74.00	-11.14	PK
11570	31.33	0	100	V	38.43	15.393	33.832	51.32	54.00	-2.68	AV
High Channel 5825 MHz											
11650	41.68	0	100	H	38.44	15.393	33.832	61.68	74.00	-12.32	PK
11650	31.11	0	100	H	38.44	15.393	33.832	51.11	54.00	-2.89	AV
11650	42.68	0	100	V	38.43	15.393	33.832	62.67	74.00	-11.33	PK
11650	31.20	0	100	V	38.43	15.393	33.832	51.19	54.00	-2.81	AV

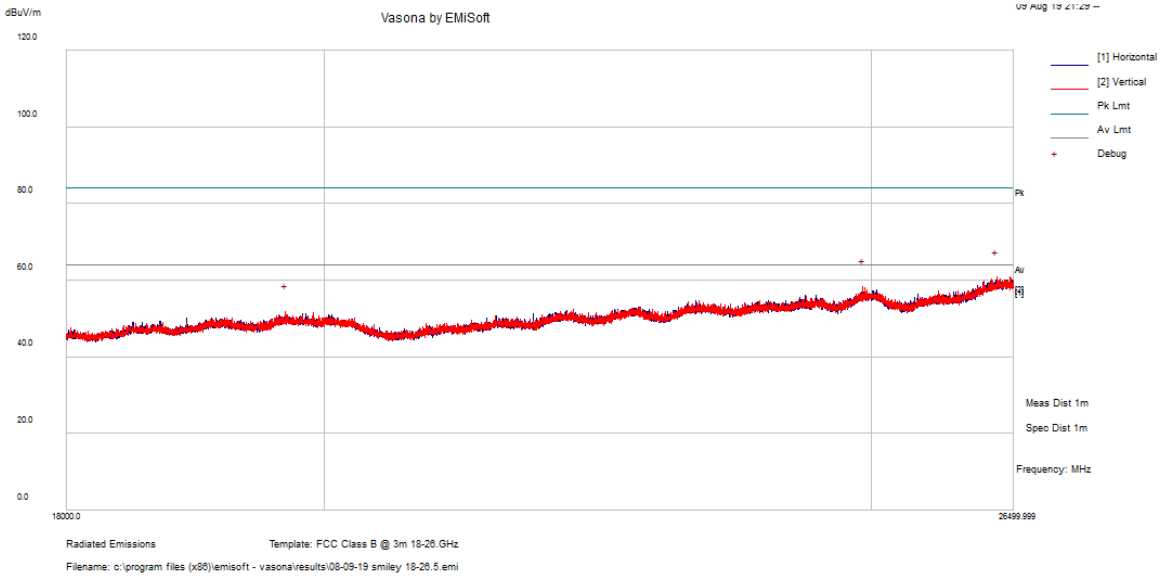
802.11ac20 mode

Frequency (MHz)	S.A. Reading (dBµV)	Turntable Azimuth (degrees)	Test Antenna			Cable Loss (dB)	Pre-Amp. (dB)	Cord. Reading (dBµV/m)	FCC		Comments (PK/Ave.)
			Height (cm)	Polarity (H/V)	Factor (dB/m)				Limit (dBµV/m)	Margin (dB)	
Low Channel 5745 MHz											
11490	43.56	0	100	H	38.44	15.393	33.832	63.56	74.00	-10.44	PK
11490	31.27	0	100	H	38.44	15.393	33.832	51.27	54.00	-2.73	AV
11490	42.14	0	100	V	38.43	15.393	33.832	62.13	74.00	-11.87	PK
11490	31.50	0	100	V	38.43	15.393	33.832	51.49	54.00	-2.51	AV
Middle Channel 5785 MHz											
11570	42.39	0	100	H	38.44	15.393	33.832	62.39	74.00	-11.61	PK
11570	31.28	0	100	H	38.44	15.393	33.832	51.28	54.00	-2.72	AV
11570	42.38	0	100	V	38.43	15.393	33.832	62.37	74.00	-11.63	PK
11570	31.42	0	100	V	38.43	15.393	33.832	51.41	54.00	-2.59	AV
High Channel 5825 MHz											
11650	42.26	0	100	H	38.44	15.393	33.832	62.26	74.00	-11.74	PK
11650	31.33	0	100	H	38.44	15.393	33.832	51.33	54.00	-2.67	AV
11650	42.59	0	100	V	38.43	15.393	33.832	62.58	74.00	-11.42	PK
11650	33.90	0	100	V	38.43	15.393	33.832	53.89	54.00	**-0.11**	AV

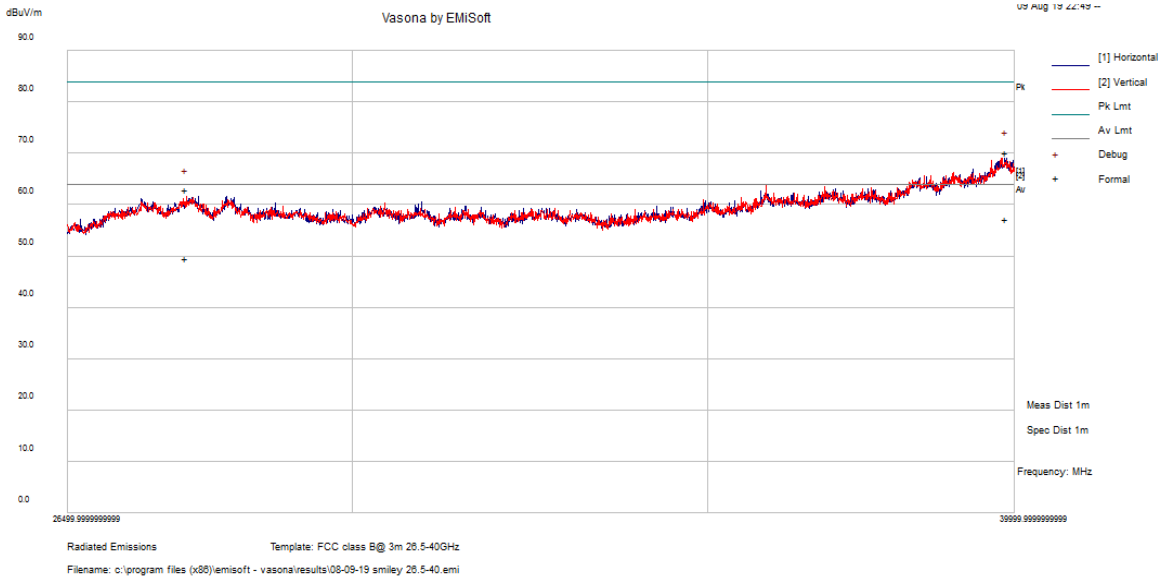
1 GHz – 18 GHz Worst Case Scan
Notch filter has been added



18 GHz – 26.5 GHz Worst Case Scan



26.5 GHz – 40 Worst Case GHz Scan at 1 Meter



8 FCC §15.407(e) - 6 dB, 26 dB, & 99% - Occupied Bandwidth

8.1 Applicable Standards

As per FCC §15.407(e): for equipment operating in the band 5725 – 5850 MHz, the minimum 6 dB bandwidth of U-NII devices shall be 500 kHz.

8.2 Measurement Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 6 or 26 dB from the reference level. Record the frequency difference as the minimum emission or emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

8.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2019-03-19	1 year
-	10dB attenuator	-	-	Each time[1]	N/A
-	RF cable	-	-	Each time[1]	N/A

Note[1]: cable and attenuator included in the test set-up will be checked each time before testing.
Statement of Traceability: BACL Corp. *attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.*

8.4 Test Environmental Conditions

Temperature:	22-24 ºC
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Christian McCaig on 2019-07-29 at RF site.

8.5 Test Results

Please refer to the following tables and plots.

5150 - 5250 MHz

Channel	Frequency (MHz)	99% OBW (kHz)	26 dB OBW (kHz)
802.11 a mode			
36	5180	16593.0	26286
44	5220	16562.6	23658
48	5240	16521.2	22263
802.11n20 mode			
36	5180	17648.6	25089
44	5220	17694.9	24352
48	5240	17742.3	25847
802.11ac20 mode			
36	5180	17698.4	24641
44	5220	17721.7	23111
48	5240	17662.0	25848

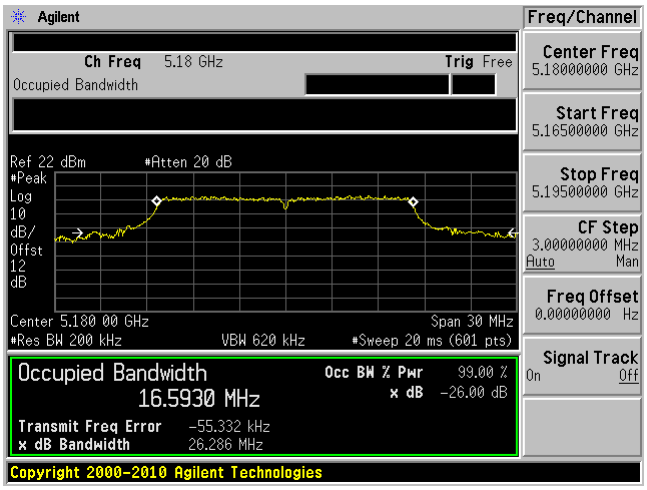
5725 - 5850 MHz

Channel	Frequency (MHz)	99% OBW (kHz)	6 dB OBW (kHz)	6 dB OBW Limit(kHz)	26 dB OBW (kHz)
802.11 a mode					
149	5745	16784.3	16466	500	27912
157	5785	16817.5	16511	500	27331
165	5825	16845.9	16503	500	27729
802.11n20 mode					
149	5745	17958.0	17732	500	28938
157	5785	17937.8	17767	500	29957
165	5825	17937.0	17729	500	29494
802.11ac20 mode					
149	5745	17944.0	17726	500	28722
157	5785	17935.5	17746	500	28686
165	5825	17964.3	17690	500	29965

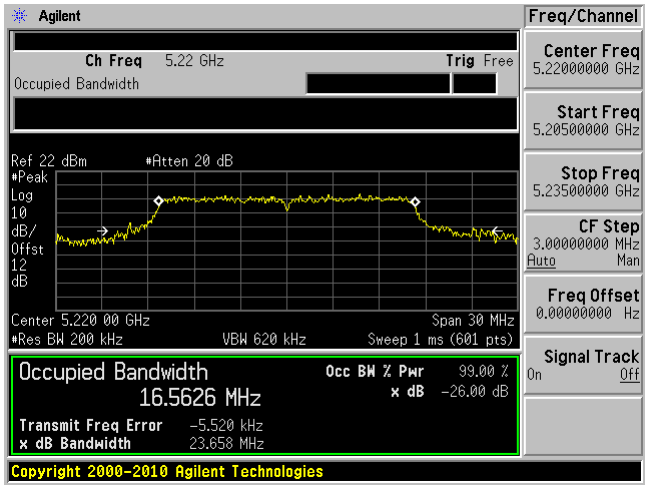
5150 – 5250 MHz

802.11a mode

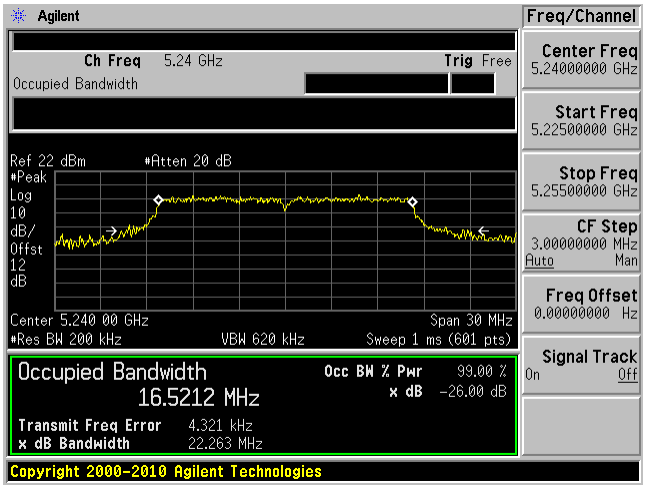
5180 MHz



5220 MHz

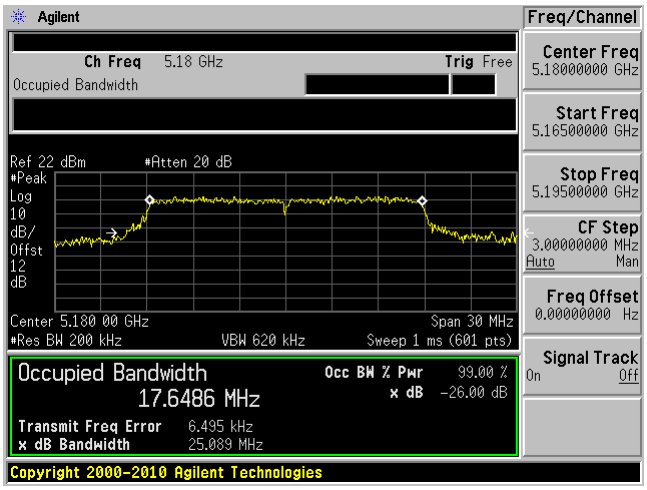


5240 MHz

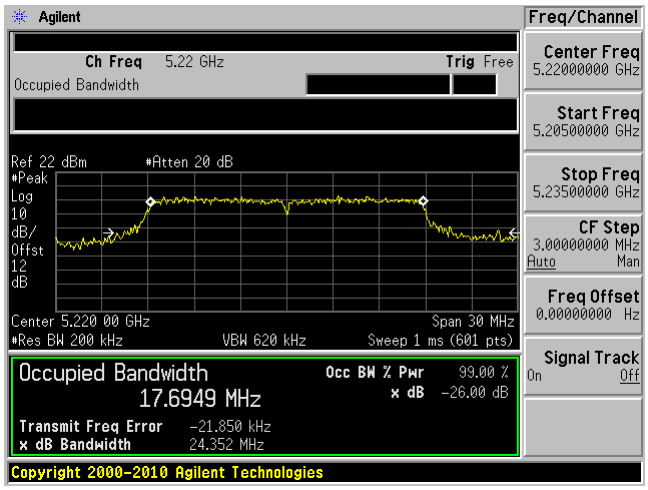


802.11n20 mode

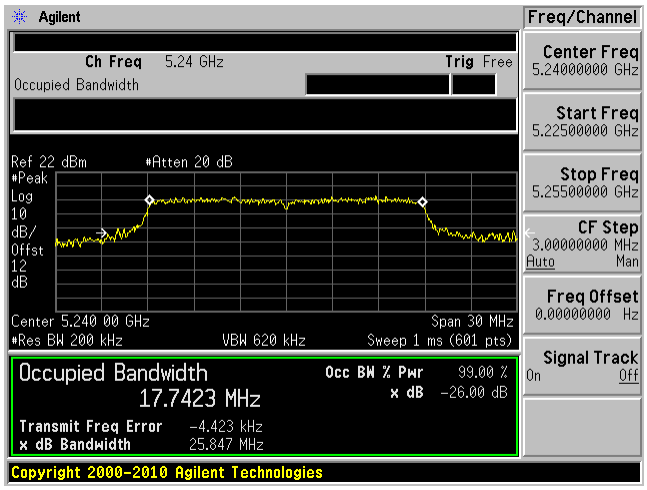
5180 MHz



5220 MHz

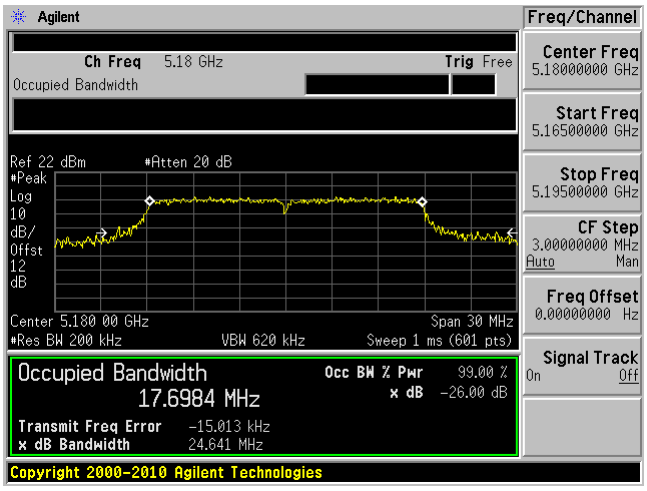


5240 MHz

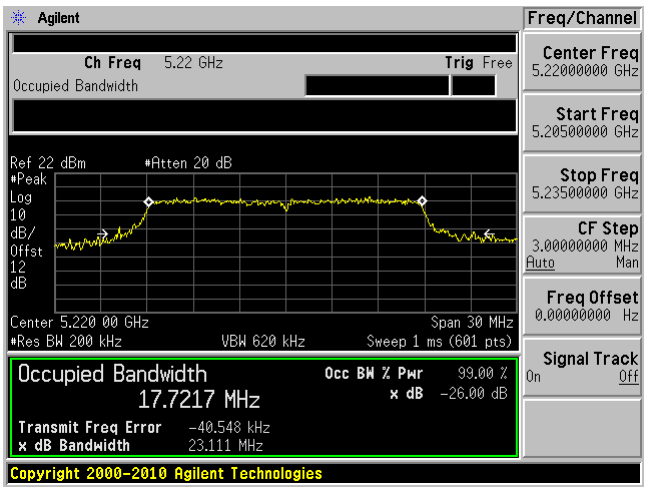


802.11ac20 mode

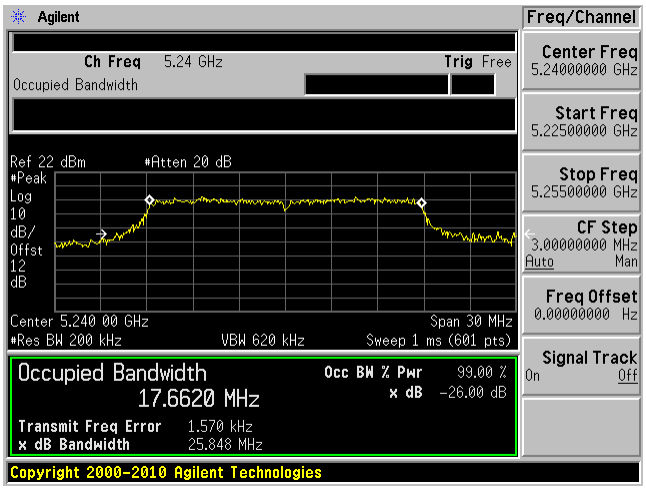
5180 MHz



5220 MHz



5240 MHz

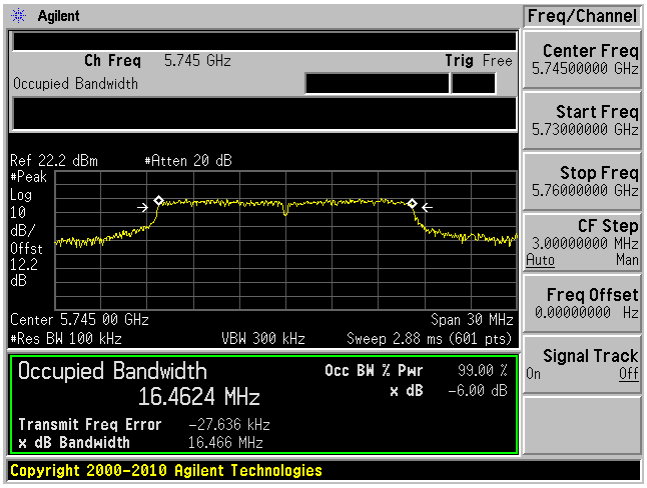


5725 – 5850 MHz

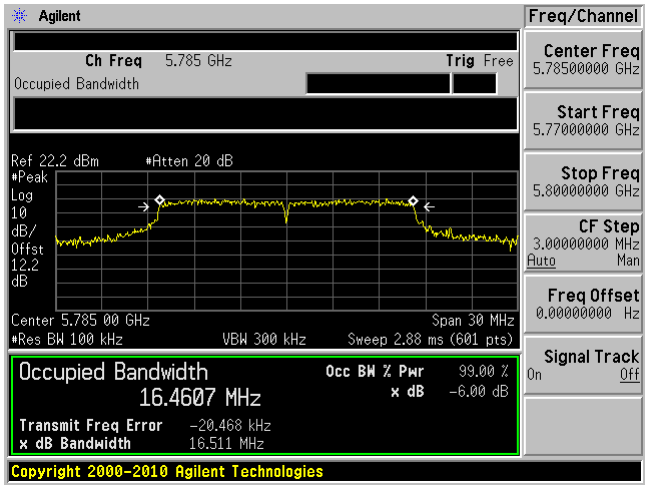
-6dB

802.11a mode

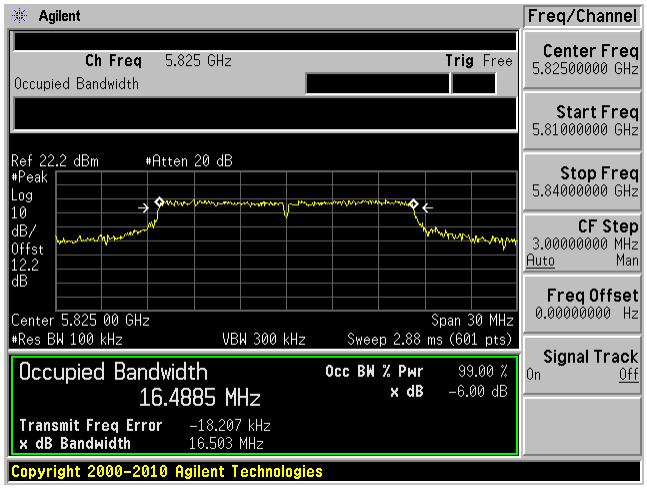
5745 MHz



5785 MHz

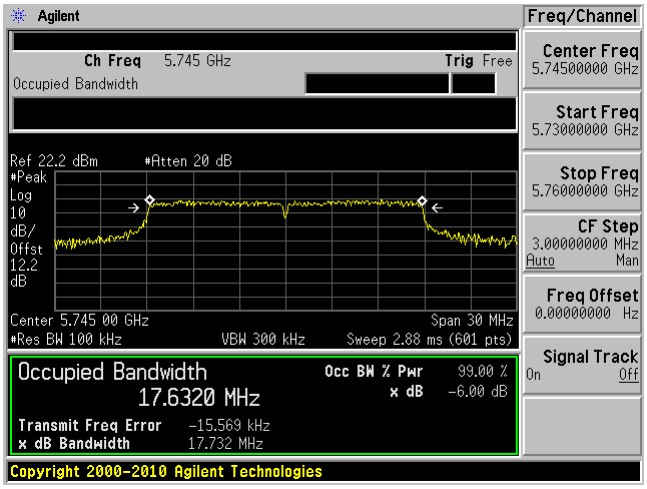


5825 MHz

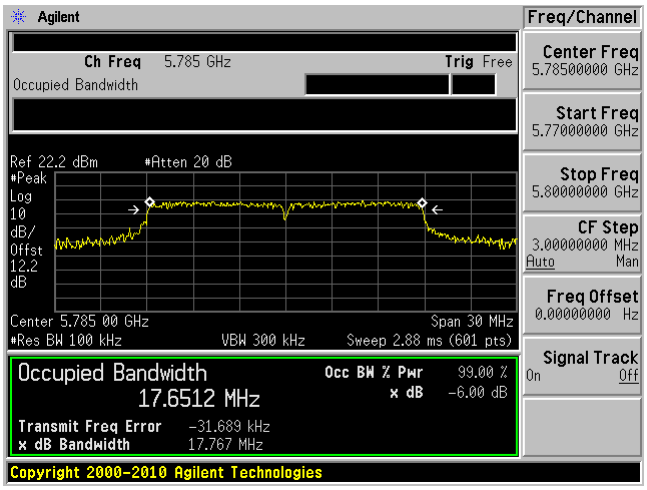


802.11n20 mode

5745 MHz



5785 MHz



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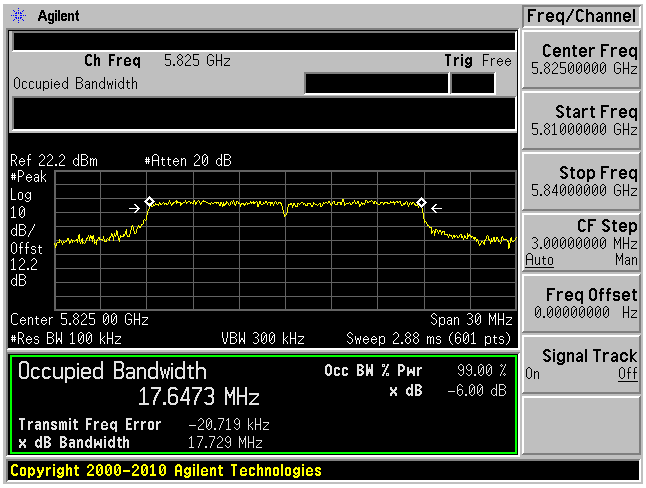
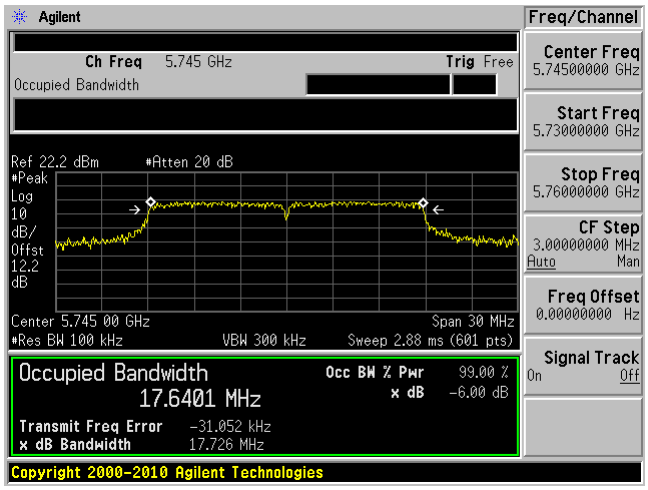
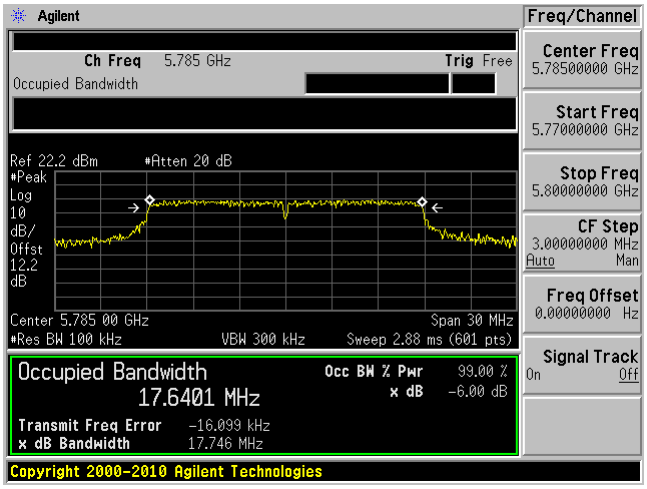


802.11ac20 mode

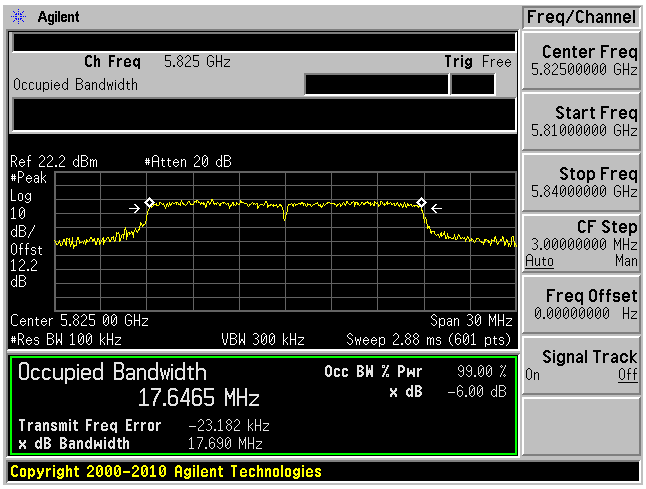
5745 MHz



5785 MHz



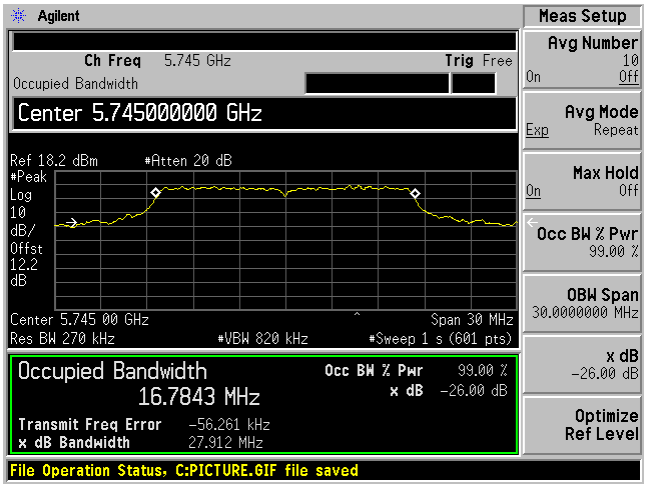
5825 MHz



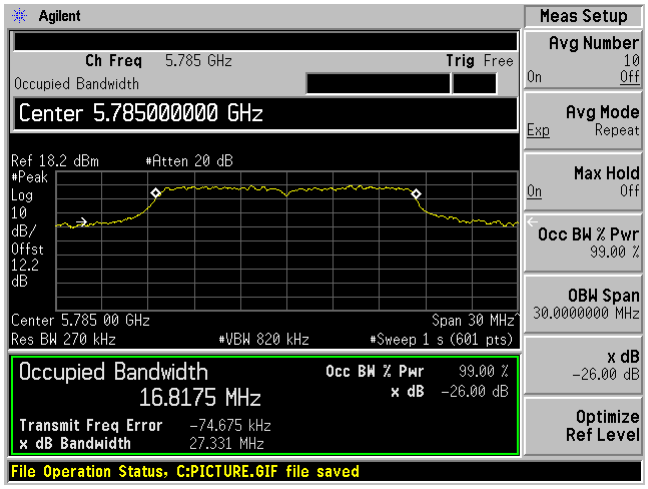
99% OBW & -26dB

802.11a mode

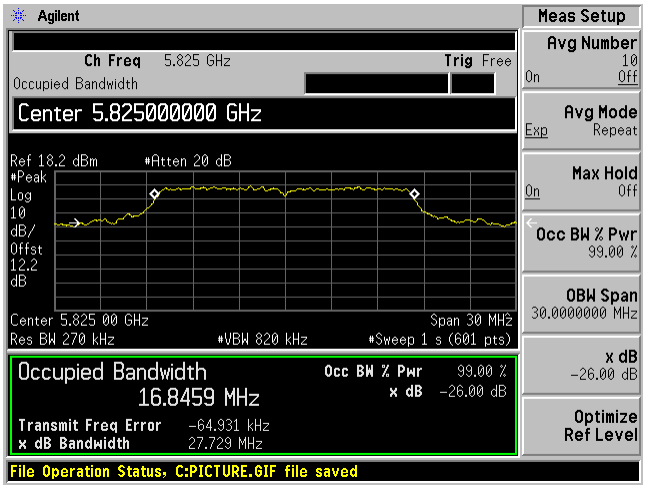
5745 MHz



5785 MHz

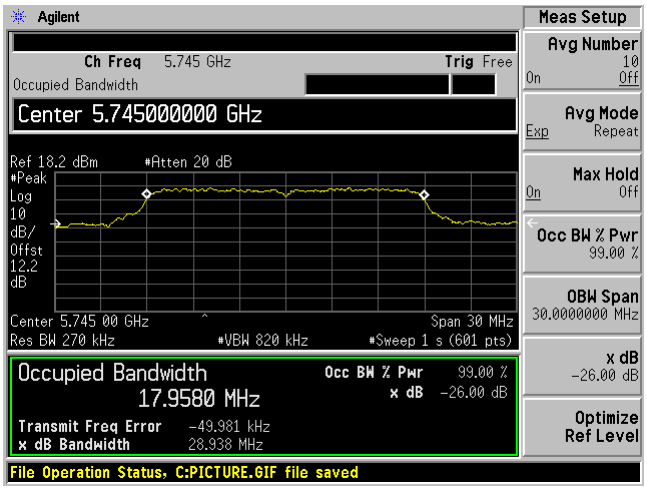


5825 MHz

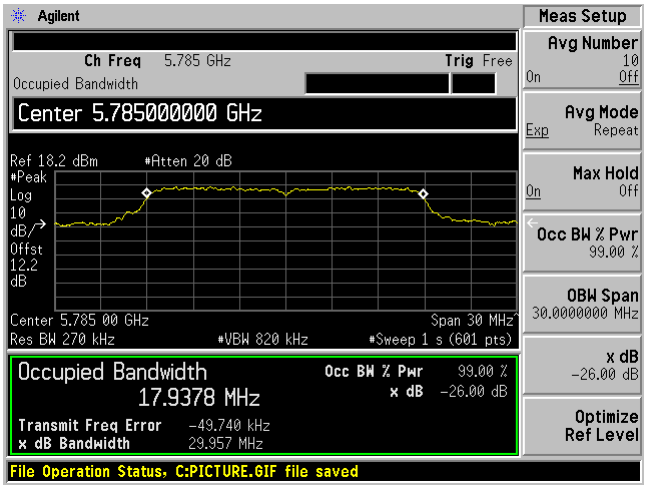


802.11n20 mode

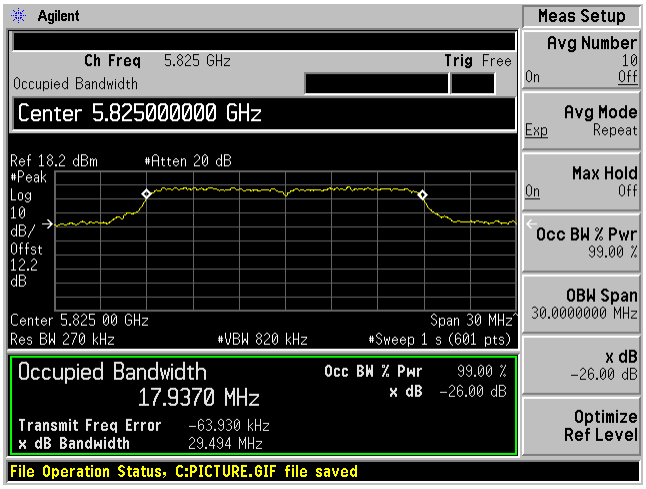
5745 MHz



5785 MHz

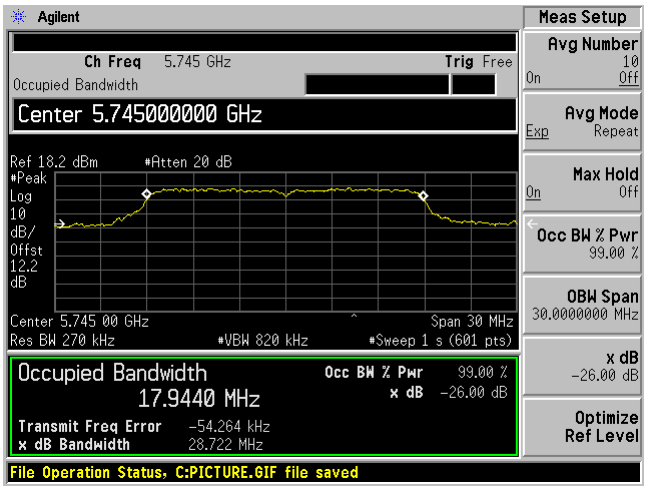


5825 MHz

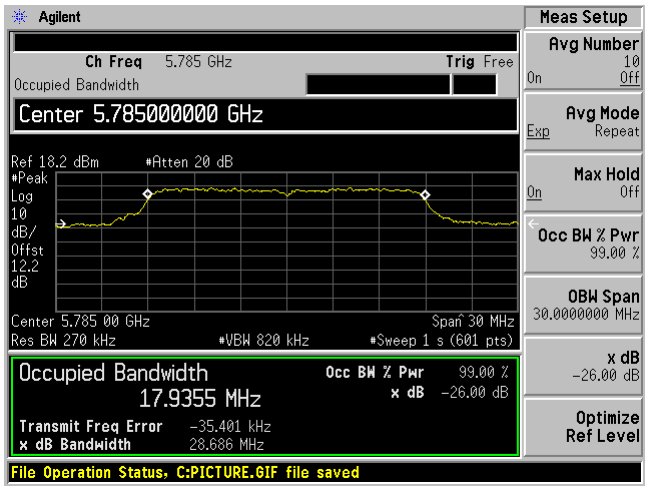


802.11ac20 mode

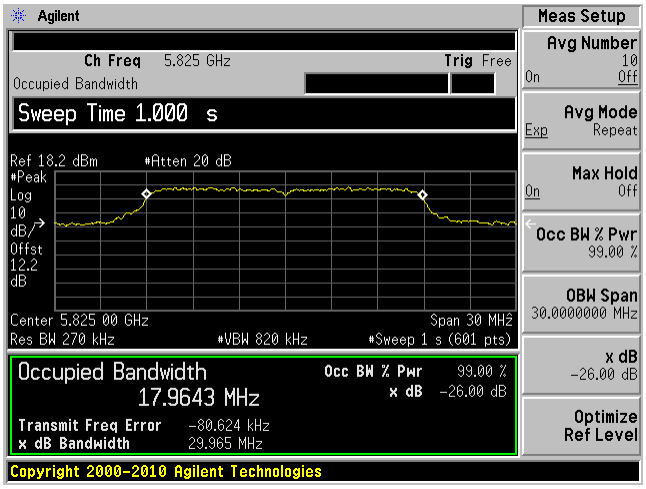
5745 MHz



5785 MHz



5825 MHz



9 FCC §407(a) §6.2 - Output Power

9.1 Applicable Standards

According to FCC §15.407(a):

For mobile and portable client devices in the 5.15-5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

9.2 Measurement Procedure

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to a power meter.

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
-	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 calibrations have been performed per the A2LA requirements, traceable to the NIST.*

9.4 Test Environmental Conditions

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

The testing was performed by Christian McCaig on 2019-08-07 in RF site.

9.5 Test Results

5150 - 5250 MHz

Frequency (MHz)	Conducted Average Power (dBm)	FCC Limit (dBm)
802.11a mode		
5180	15.58	24
5220	16.05	24
5240	15.88	24
802.11n20 mode		
5180	16.10	24
5220	16.06	24
5240	16.17	24
802.11ac20 mode		
5180	16.11	24
5220	16.05	24
5240	15.86	24

5725 - 5850 MHz

Frequency (MHz)	Conducted Average Power (dBm)	FCC Limit (dBm)
802.11a mode		
5745	16.09	30
5785	16.06	30
5825	15.98	30
802.11n20 mode		
5745	16.03	30
5785	15.99	30
5825	15.85	30
802.11ac20 mode		
5745	15.99	30
5785	15.97	30
5825	15.98	30

10 FCC §15.407(a) - Power Spectral Density

10.1 Applicable Standards

According to FCC §15.407(a):

For mobile and portable client devices in the 5.15-5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

10.2 Measurement Procedure

(i) Set span to encompass the entire emission bandwidth (EBW) of the signal.
(ii) Set RBW = 1 MHz.
(iii) Set VBW ≥ 3 MHz.
(iv) Number of points in sweep ≥ 2 Span / RBW. (This ensures that bin-to-bin spacing is ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
(v) Sweep time = auto.
(vi) Detector = RMS (i.e., power averaging), if available. Otherwise, use sample detector mode.
(vii) If transmit duty cycle < 98 percent, use a video trigger with the trigger level set to enable triggering only on full power pulses. Transmitter must operate at maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no off intervals) or at duty cycle ≥ 98 percent, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to “free run”.
(viii) Trace average at least 100 traces in power averaging (i.e., RMS) mode.
(ix) Compute power by integrating the spectrum across the 26 dB EBW of the signal using the spectrum analyzer’s band power measurement function with band limits set equal to the EBW band edges. If the spectrum analyzer does not have a band power function, sum the spectrum levels (in power units) at 1 MHz intervals extending across the 26 dB EBW of the spectrum.

10.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2019-03-19	1 year
-	RF Cable	-	-	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 calibrations have been performed per the A2LA requirements, traceable to the NIST.*

10.4 Test Environmental Conditions

Temperature:	22-24 ℃
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Christian McCaig on 2019-07-29 at RF site.

10.5 Test Results

5150 – 5250 MHz

Frequency (MHz)	Measured PSD (dBm/MHz)	Corrected PSD (dBm/MHz)	FCC Limit (dBm/MHz)
802.11a mode			
5180	4.767	4.767	11
5220	4.832	4.832	11
5240	4.642	4.642	11
802.11n20 mode			
5180	5.100	5.100	11
5220	4.783	4.783	11
5240	4.888	4.888	11
802.11ac20 mode			
5180	4.842	4.842	11
5220	4.843	4.843	11
5240	4.446	4.446	11

5725 - 5850 MHz

Frequency (MHz)	Measured PSD (dBm/100 kHz)	Corrected PSD (dBm/500 kHz)	FCC Limit (dBm/500 kHz)
802.11a mode			
5745	-4.048	2.9417	30
5785	-4.049	2.9407	30
5825	-4.162	2.8277	30
802.11n20 mode			
5745	-4.372	2.6177	30
5785	-4.256	2.7337	30
5825	-4.287	2.7027	30
802.11ac20 mode			
5745	-4.405	2.5847	30
5785	-4.108	2.8817	30
5825	-4.327	2.6627	30

Corrected PSD (dBm/MHz) = PSD (dBm/MHz) + Duty Cycle Correction (dB)

Note: For the 5725-5850 MHz band, the Corrected PSD (dBm/500 kHz) is equal to:

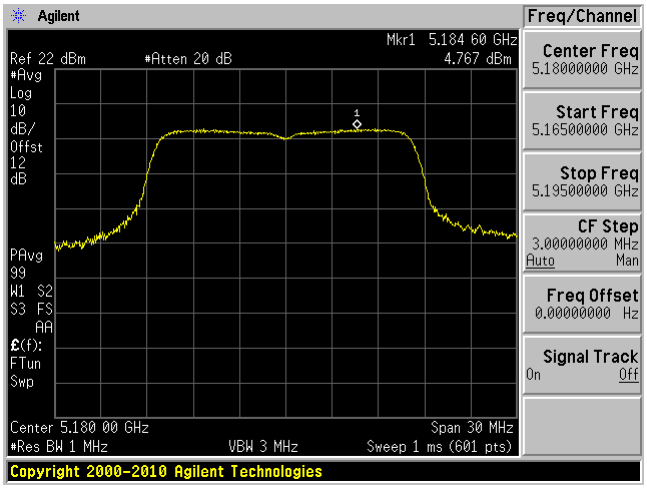
Correct PSD (dBm/500 kHz) = PSD (dBm/100 kHz) + Duty Cycle Correction (dB) + 10*log(500 kHz/100 kHz)

Please refer to the following plots.

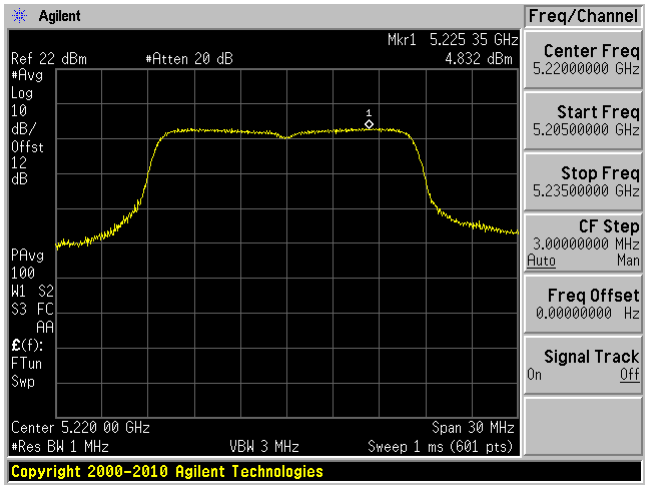
5150 – 5250 MHz

802.11a mode

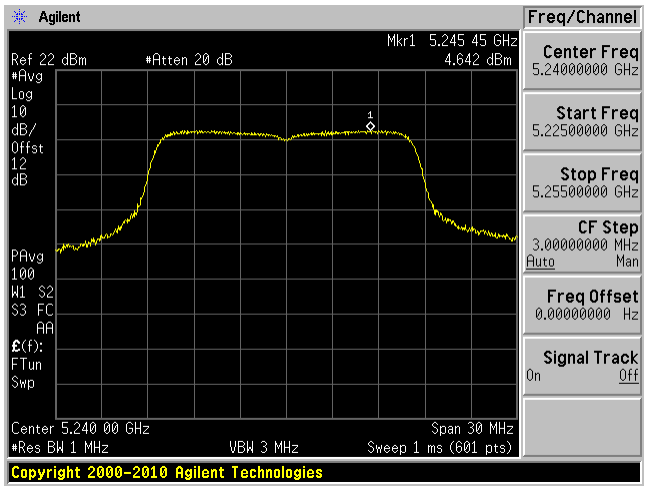
5180 MHz



5220 MHz

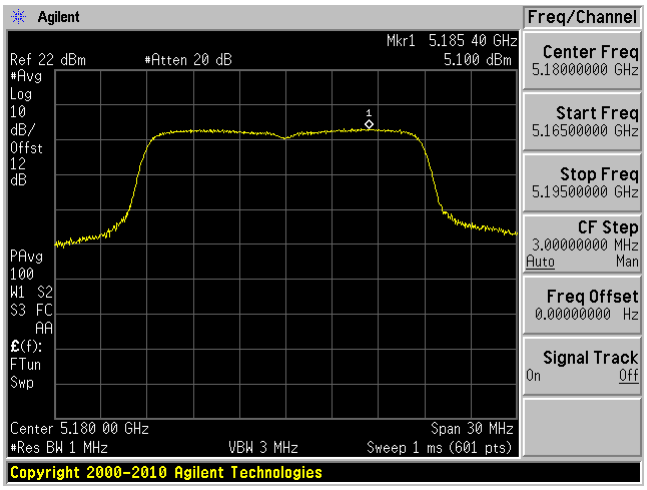


5240 MHz

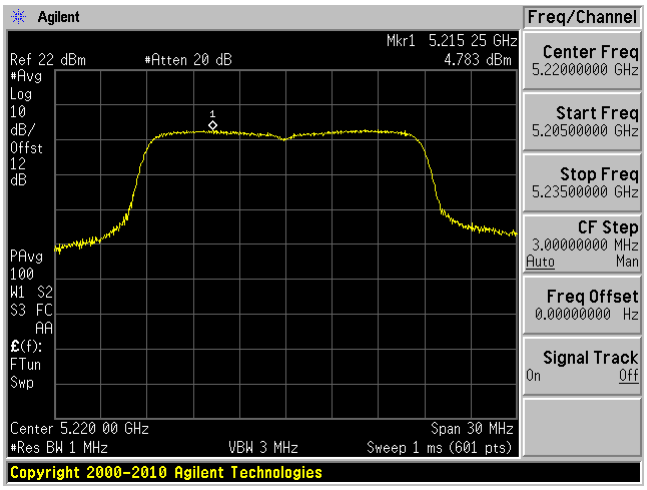


802.11n20 mode

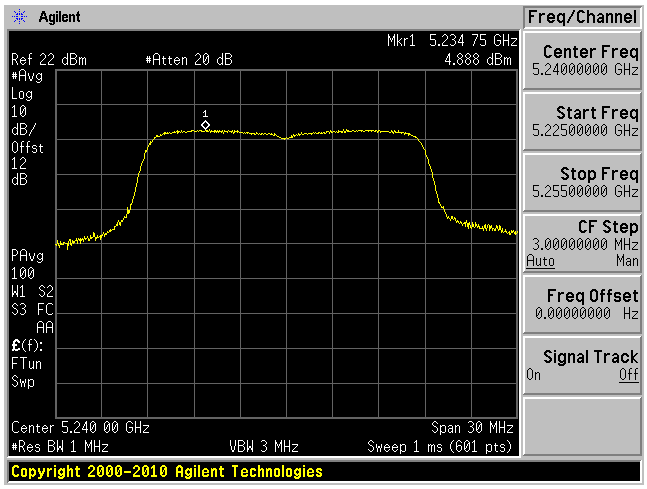
5180 MHz



5220 MHz

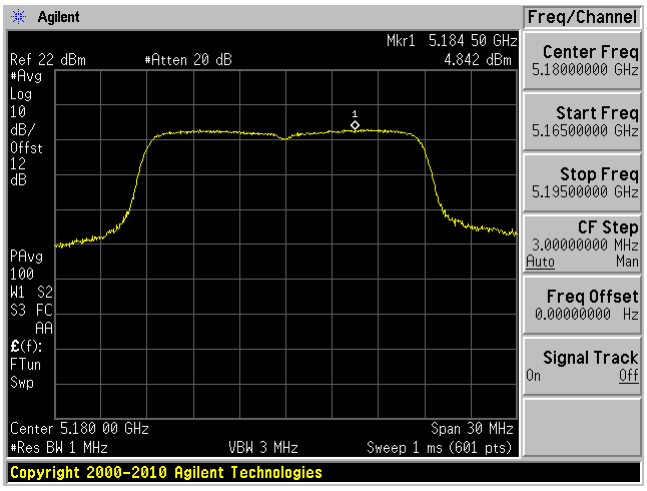


5240 MHz

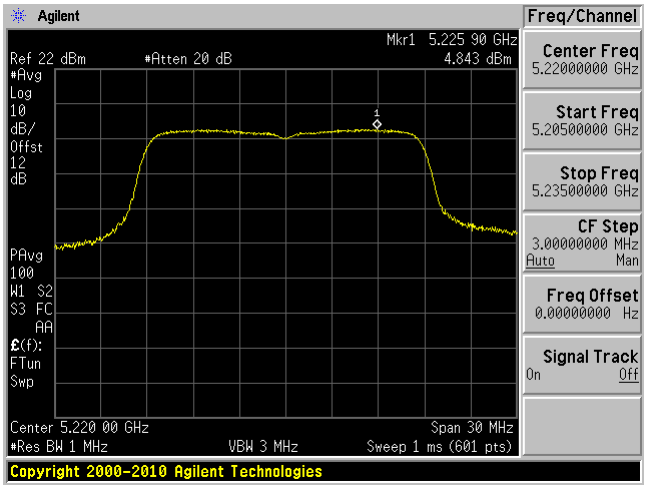


802.11ac20 mode

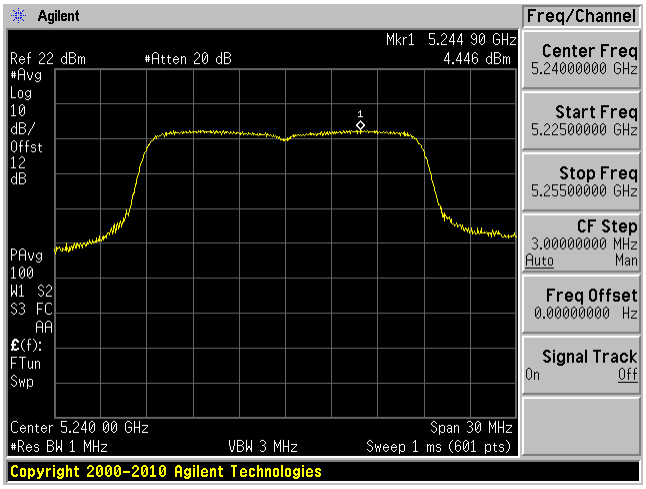
5180 MHz



5220 MHz



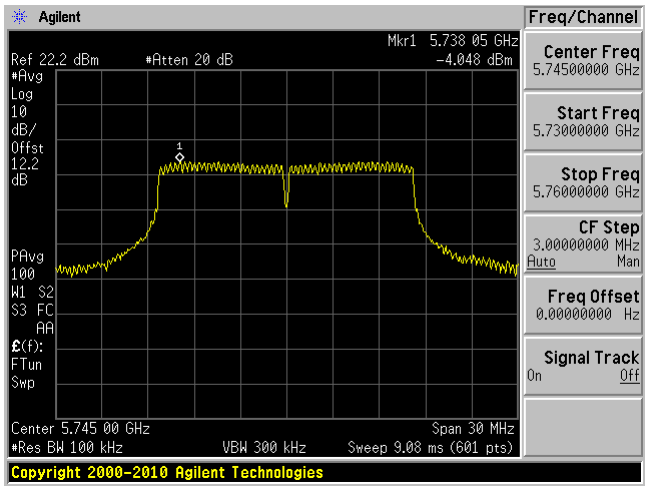
5240 MHz



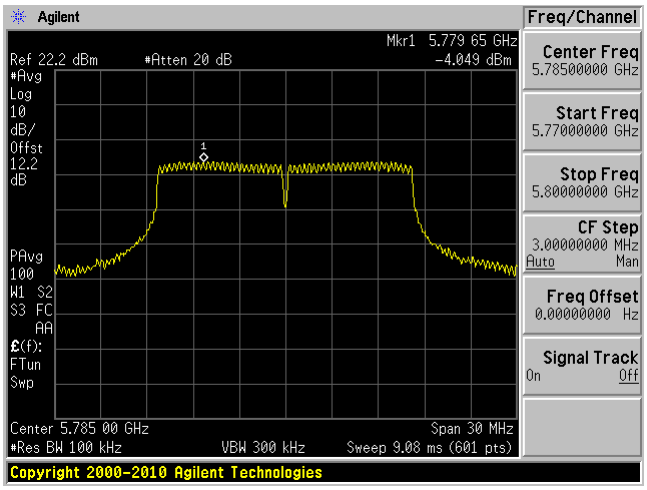
5725 – 5850 MHz

802.11a mode

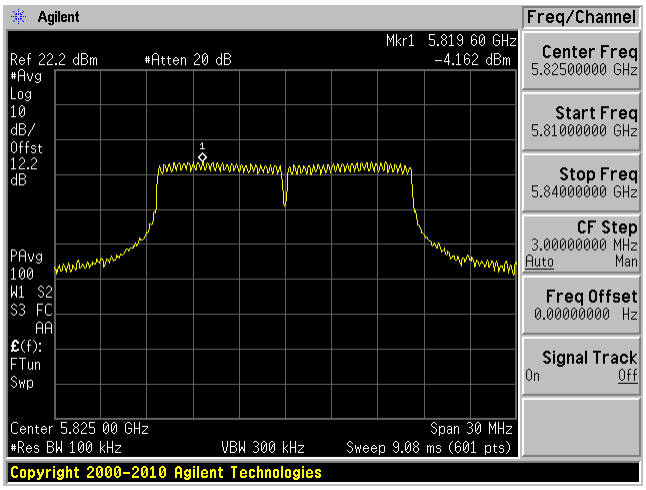
5745 MHz



5785 MHz

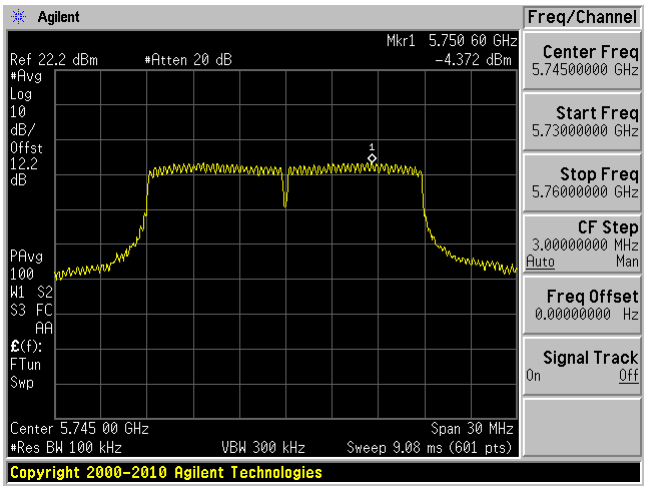


5825 MHz

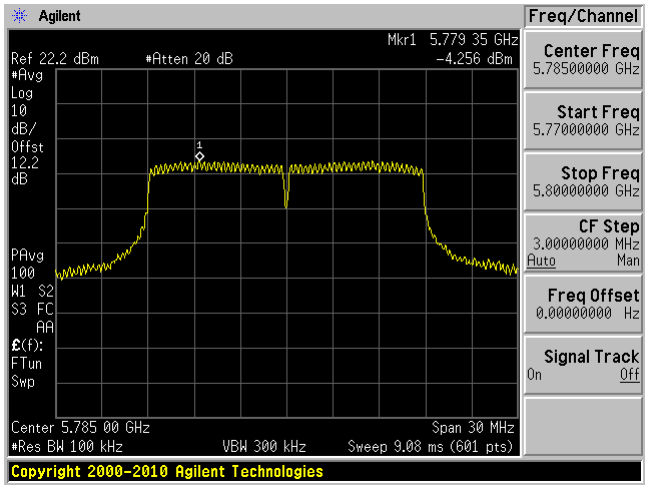


802.11n20 mode

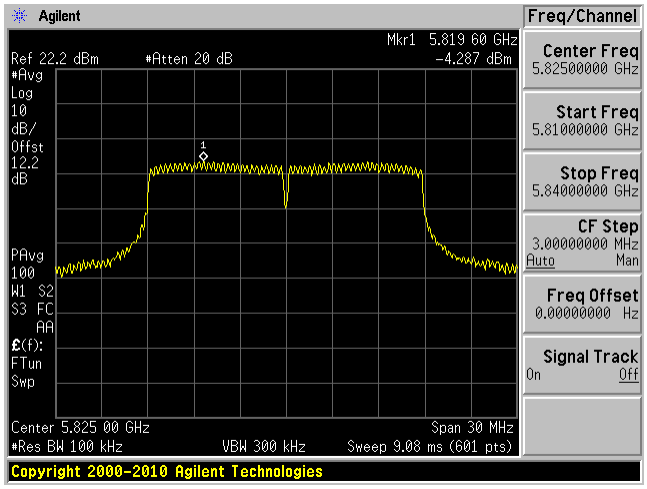
5745 MHz



5785 MHz

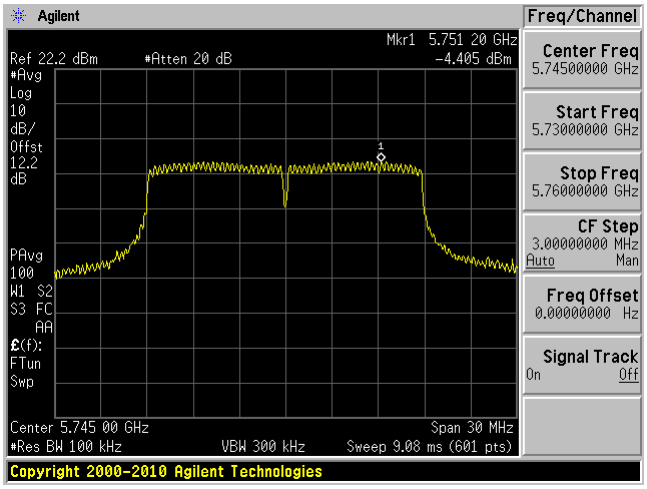


5825 MHz

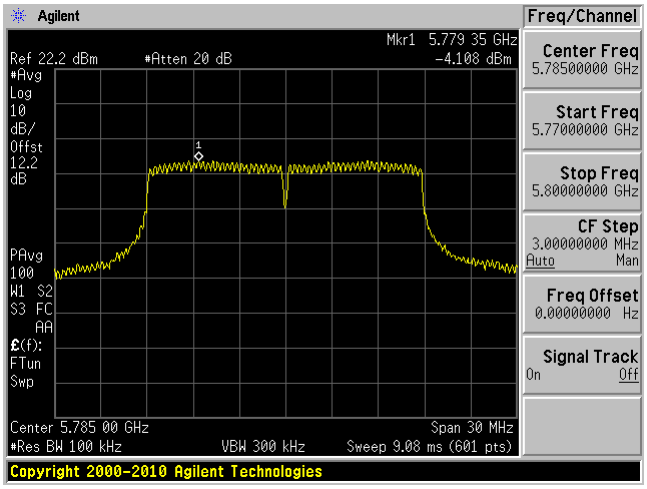


802.11ac20 mode

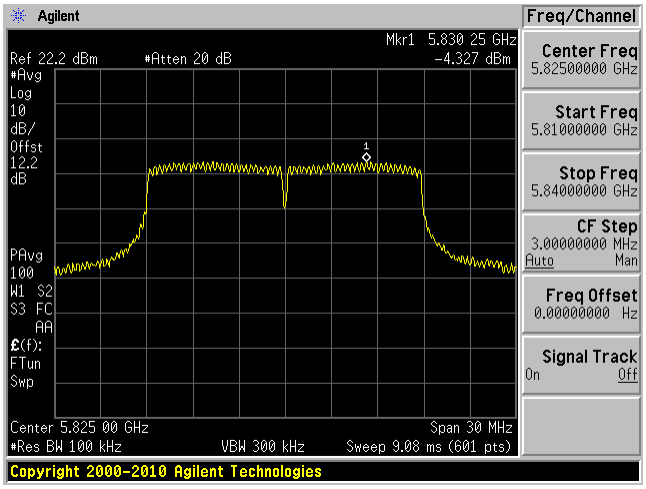
5745 MHz



5785 MHz



5825 MHz



11 FCC §15.407(b) - Out of Band Emissions

11.1 Applicable Standards

According to FCC §15.407(b):

For transmitters operating in the 5.15-5.25 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.725-5.85 GHz band: All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

The provisions of §15.205 apply to intentional radiators operating under this section.

11.2 Measurement Procedure

Add a correction factor (antenna gain+ Attenuator loss+cable loss) to the offset of the spectrum analyzer.
Integration Method

1. For peak emissions measurements, follow the procedures described in section H)5), "Procedures for Peak Unwanted Emissions Measurements above 1000 MHz", except for the following changes:

- Set RBW = 100 kHz
- Set VBW = 3RBW
- Perform a band-power integration across the 1 MHz bandwidth in which the band-edge emission level is to be measured. CAUTION: You must ensure that the spectrum analyzer or EMI receiver is set for peak-detection and max-hold for this measurement.

2. For average emissions measurements, follow the procedures described in section H)6), "Procedures for Average Unwanted Emissions Measurements above 1000 MHz", except for the following changes:

- Set RBW = 100 kHz
- Set VBW = 3RBW
- Perform a band-power integration across the 1 MHz bandwidth in which the band-edge emission level is to be measured.

11.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US45303156	2019-03-19	1 year
-	RF Cable	-	-	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 calibrations have been performed per the A2LA requirements, traceable to the NIST.*

11.4 Test Environmental Conditions

Temperature:	22-24º C
Relative Humidity:	40-41 %
ATM Pressure:	103.1-104.1 kPa

The testing was performed by Christian McCaig 2019-07-27 at RF site.

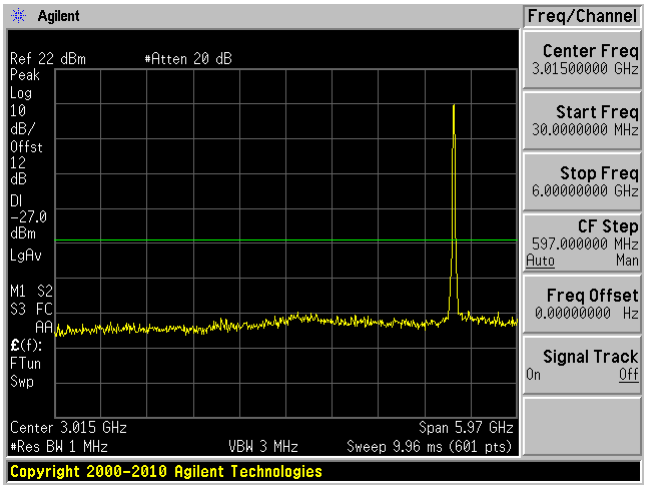
11.5 Test Results

Please refer to the following plots

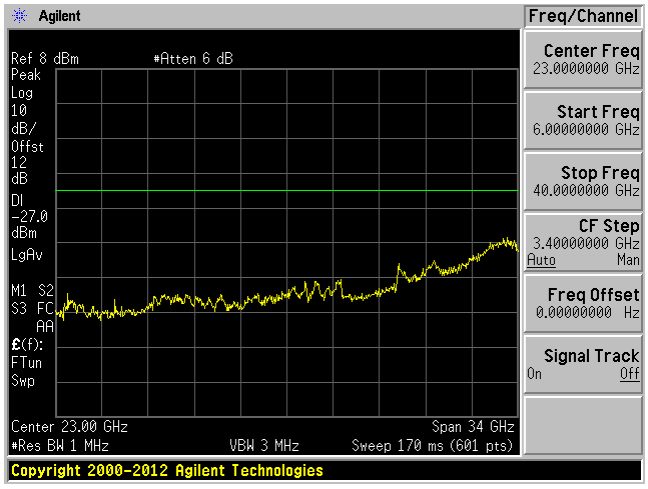
5150 - 5250 MHz

802.11a mode

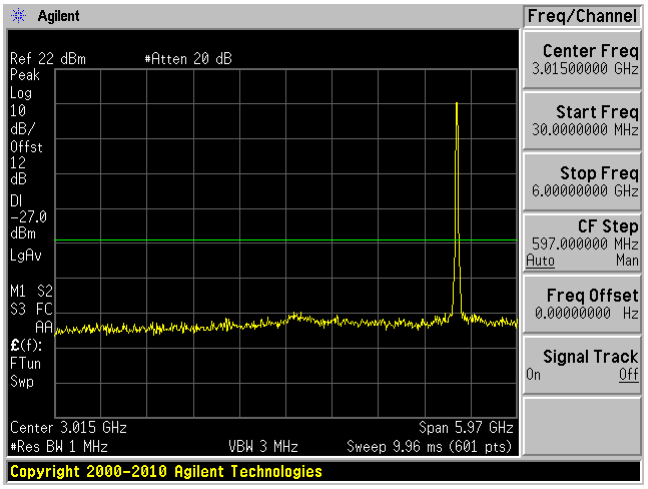
Low Channel 5180MHz (30MHz-6GHz)



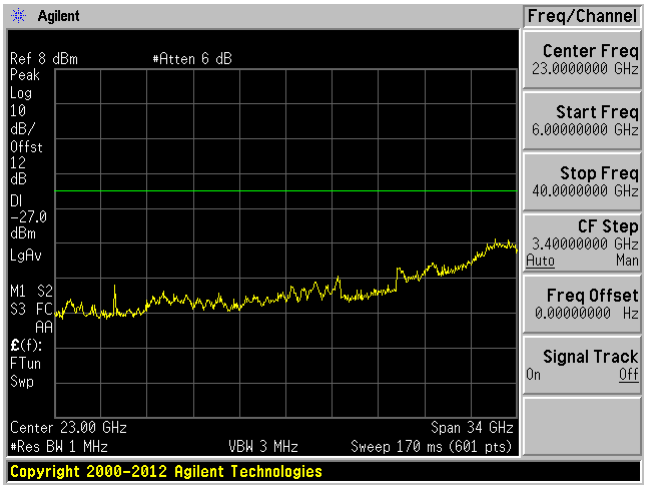
Low Channel 5180 MHz (6-40GHz)



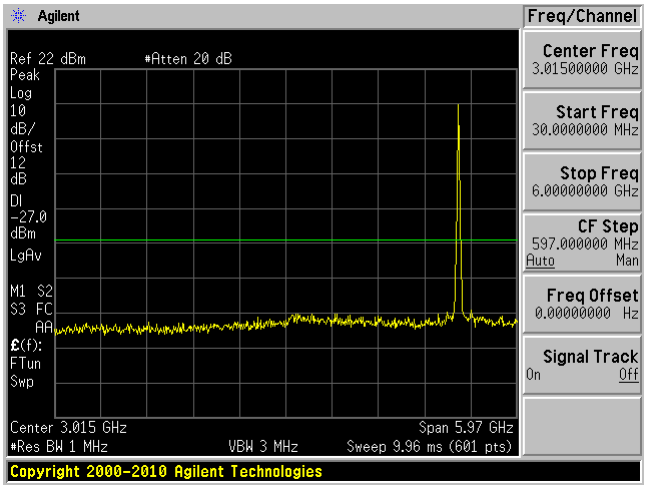
Middle Channel 5220MHz (30MHz-6GHz)



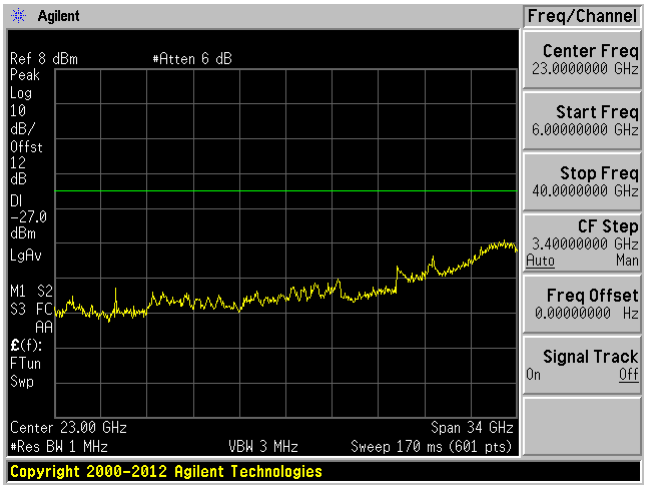
Middle Channel 5220 MHz (6-40GHz)



High Channel 5240MHz (30MHz-6GHz)

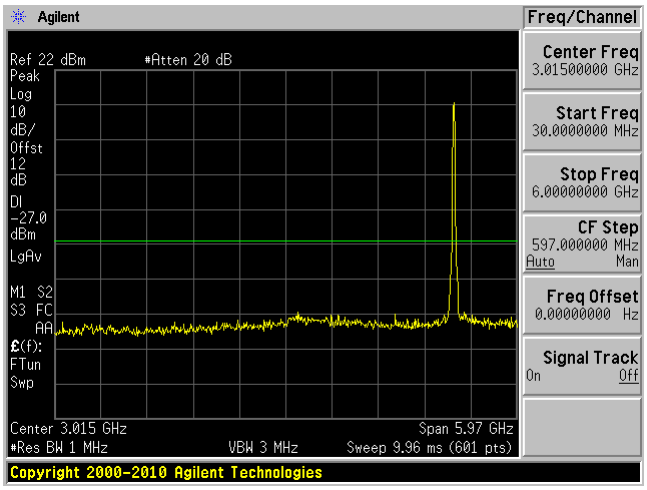


High Channel 5240 MHz (6-40GHz)

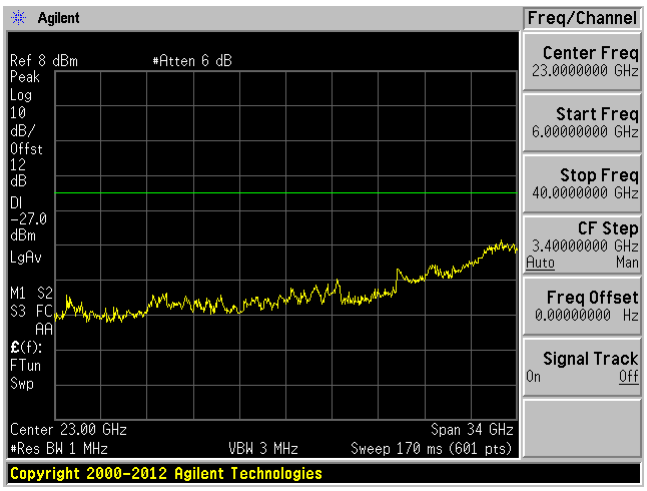


802.11n20 mode

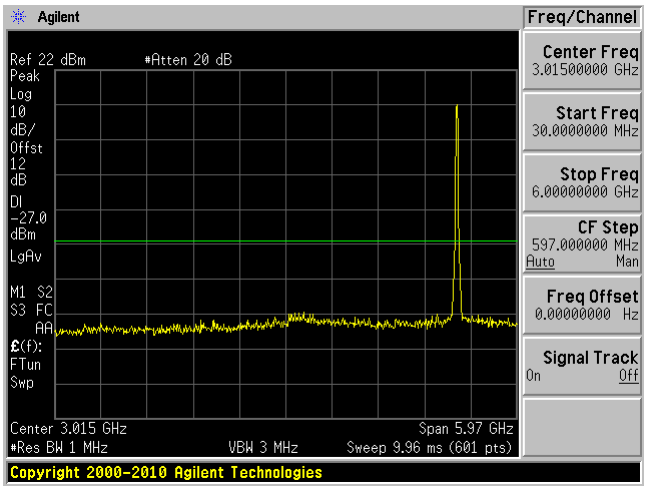
Low Channel 5180MHz (30MHz-6GHz)



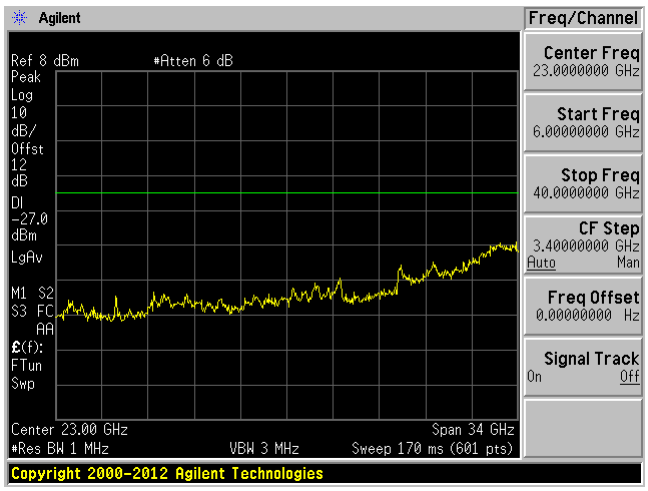
Low Channel 5180 MHz (6-40GHz)



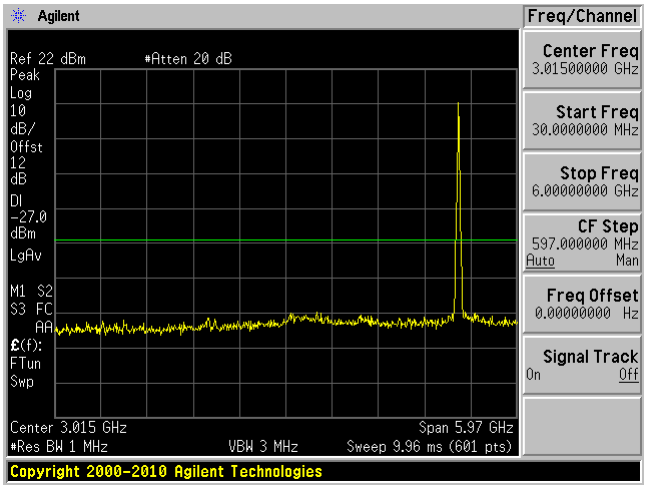
Middle Channel 5220MHz (30MHz-7GHz)



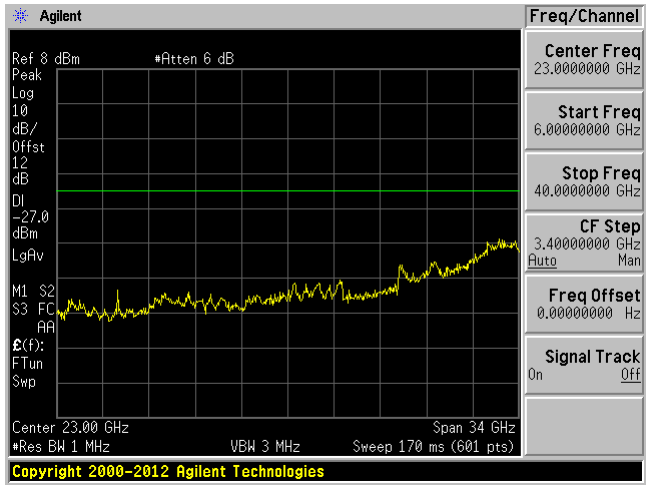
Middle Channel 5220 MHz (6-40GHz)



High Channel 5240MHz (30MHz-6GHz)

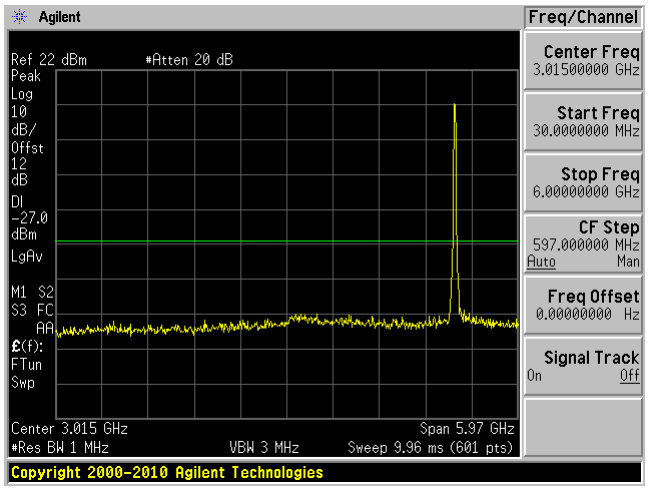


High Channel 5240 MHz (6-40GHz)

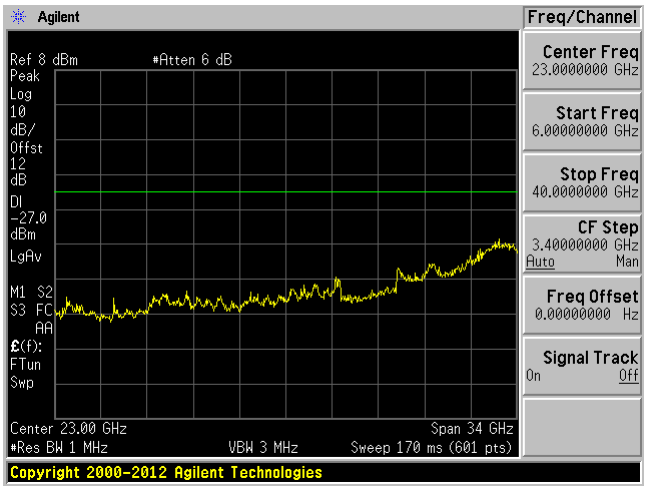


802.11ac20 mode

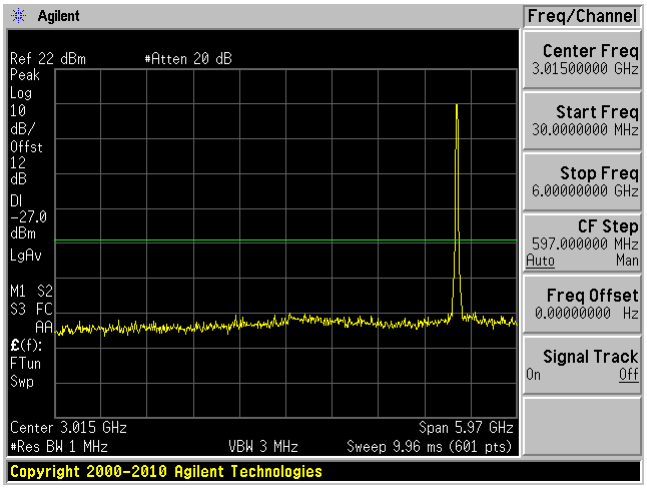
Low Channel 5180MHz (30MHz-6GHz)



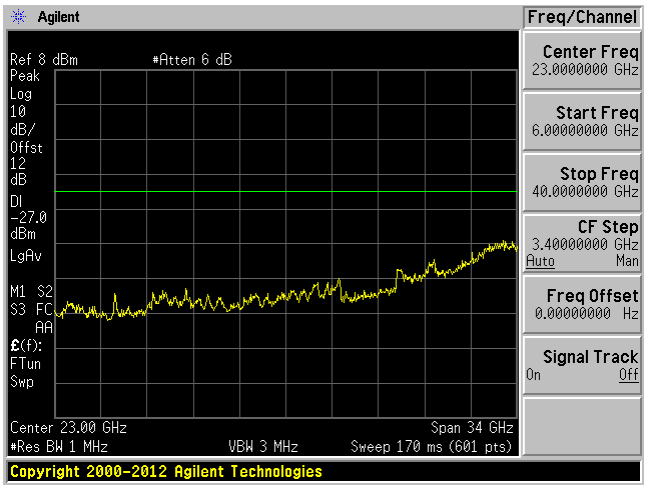
Low Channel 5180 MHz (6-40GHz)



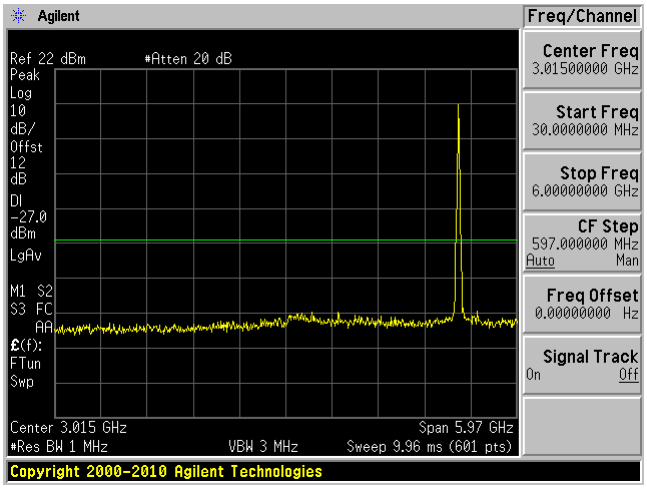
Middle Channel 5220MHz (30MHz-6GHz)



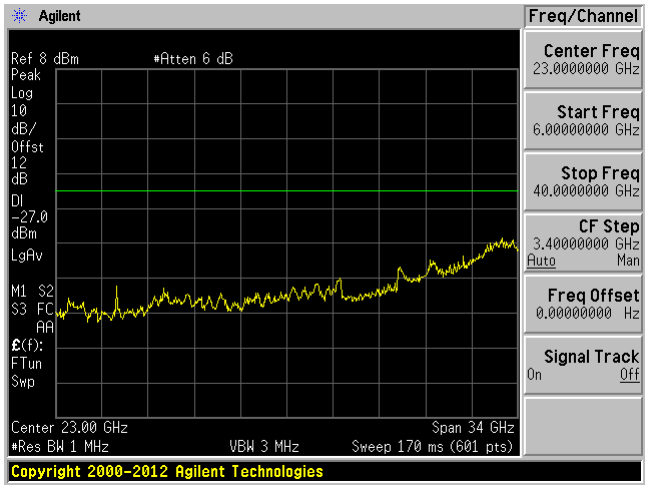
Middle Channel 5220 MHz (6GHz – 40GHz)



High Channel 5240MHz (30MHz-6GHz)



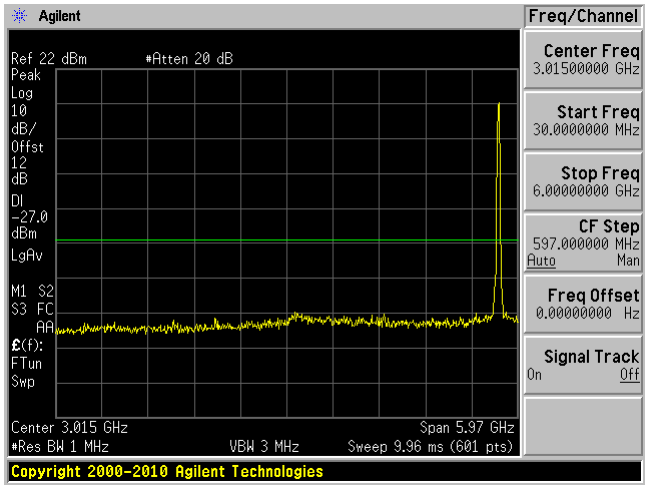
High Channel 5240 MHz (6GHz – 40GHz)



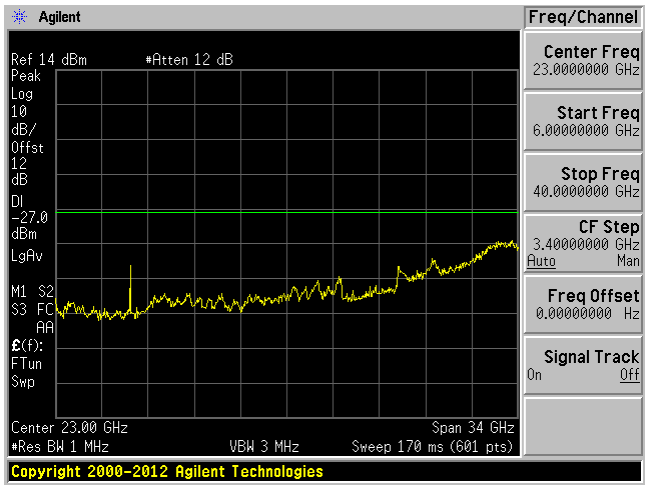
5725 – 5850 MHz

802.11a

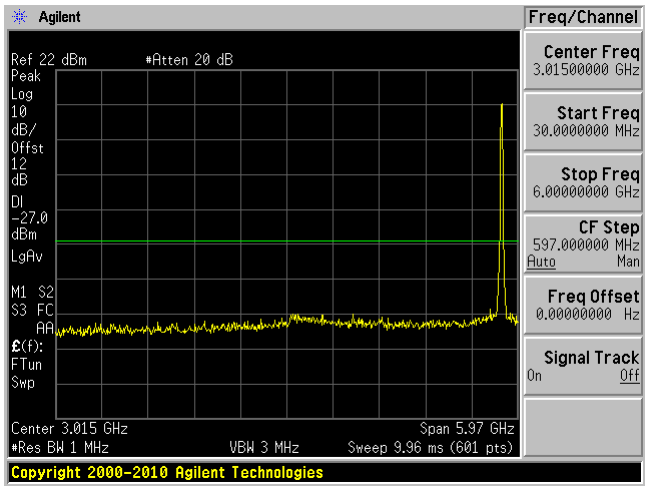
Low Channel 5745 MHz (30MHz-6GHz)



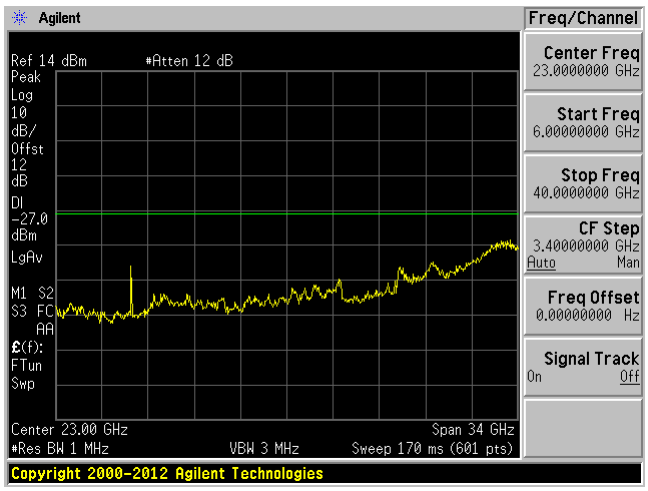
Low Channel 5745 MHz (6-40GHz)



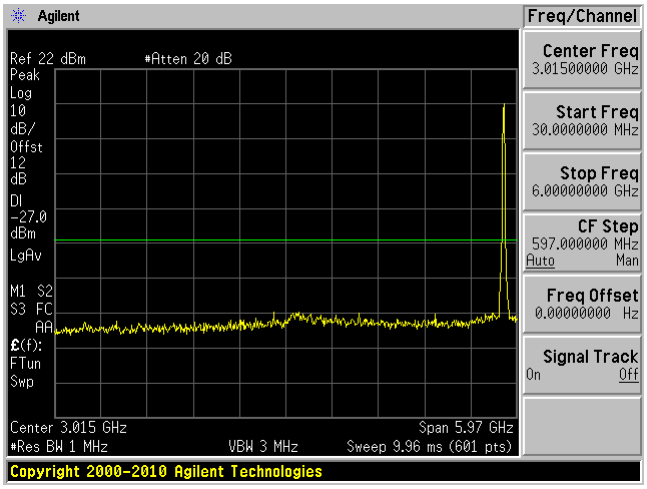
Middle Channel 5785 MHz (30MHz-6GHz)



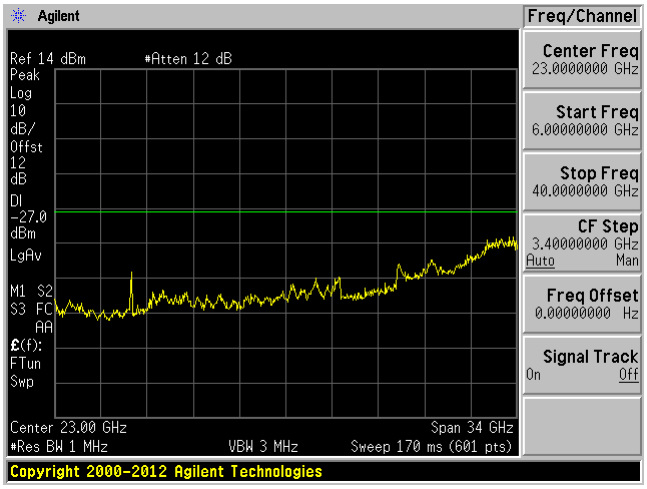
Middle Channel 5785 MHz (6-40GHz)



High Channel 5825 MHz (30MHz-6GHz)

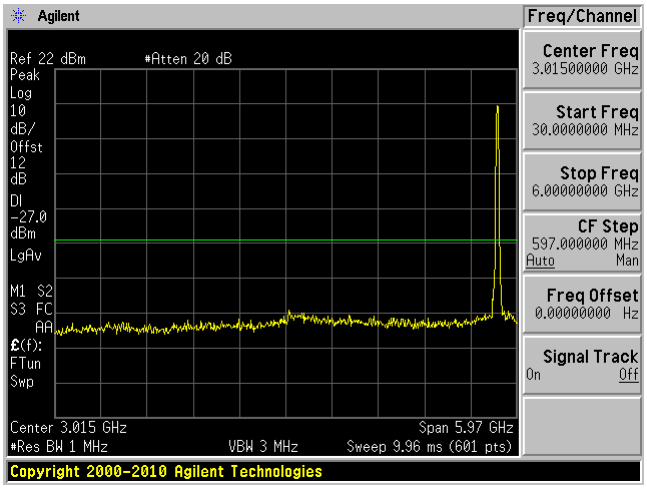


High Channel 5825 MHz (6-40GHz)

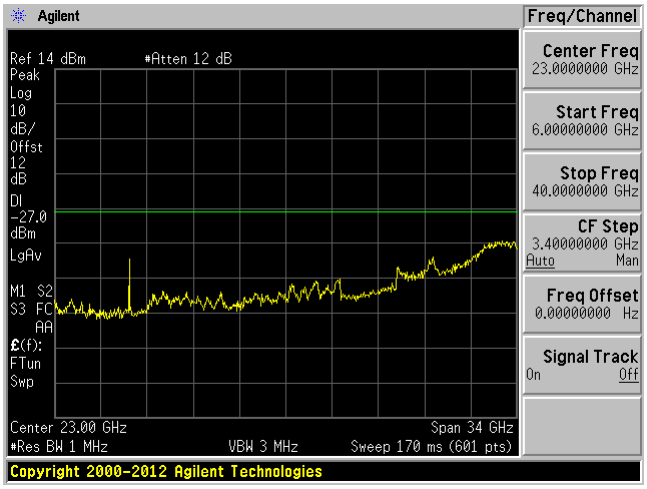


802.11n20 mode

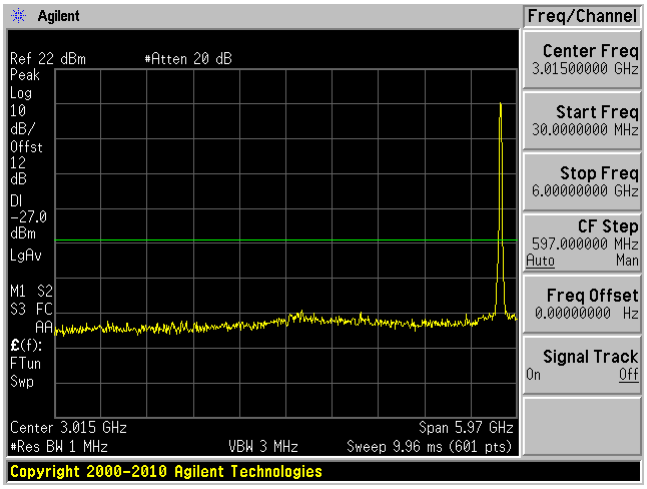
Low Channel 5745 MHz (30MHz-6GHz)



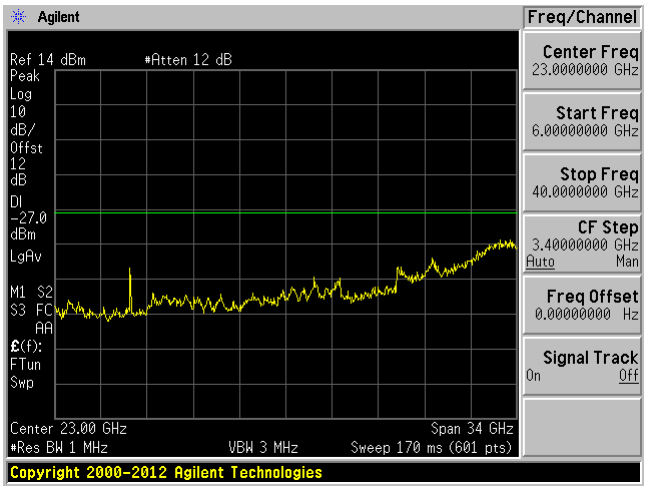
Low Channel 5745 MHz (6-40GHz)



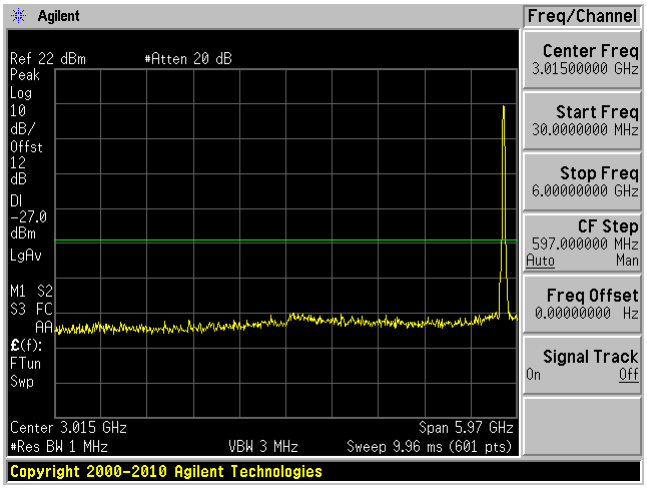
Middle Channel 5785 MHz (30MHz-6GHz)



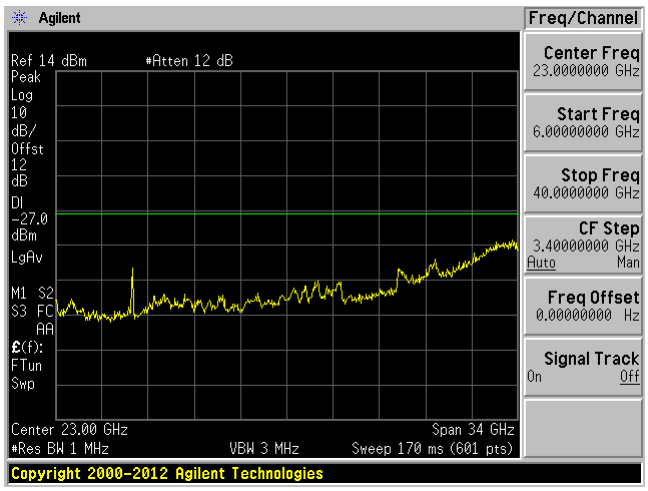
Middle Channel 5785 MHz (6-40GHz)



High Channel 5825 MHz (30MHz-6GHz)

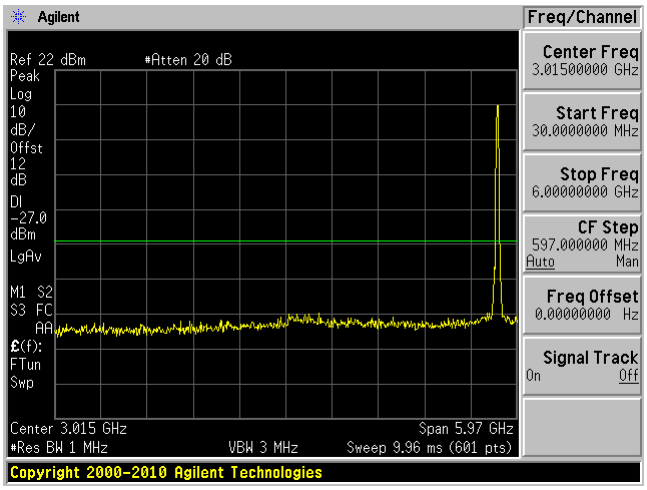


High Channel 5825 MHz (6-40GHz)

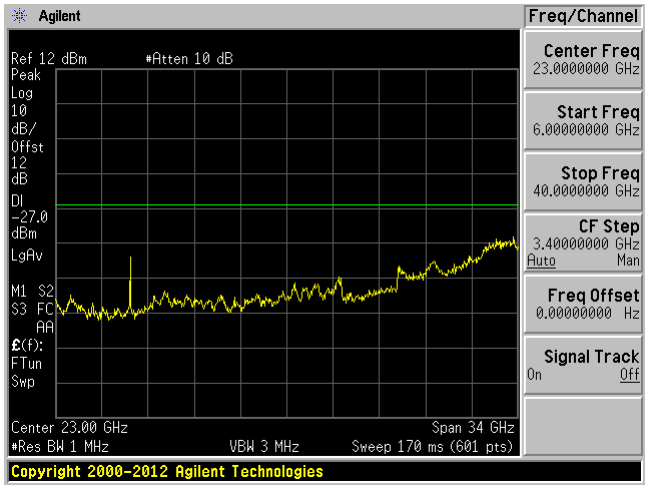


802.11ac20 mode

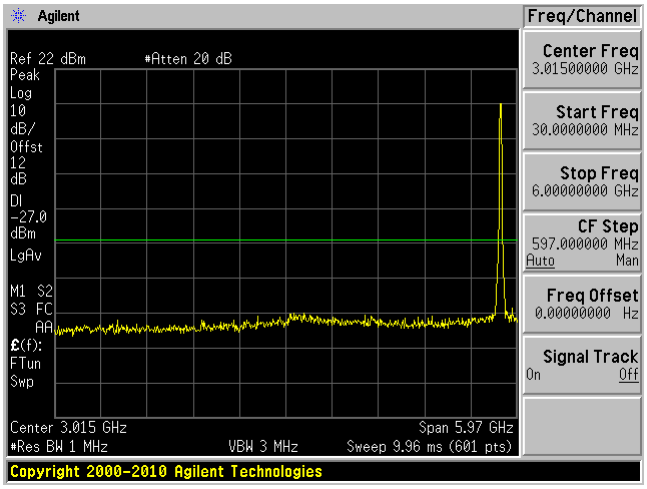
Low Channel 5745 MHz (30MHz-6GHz)



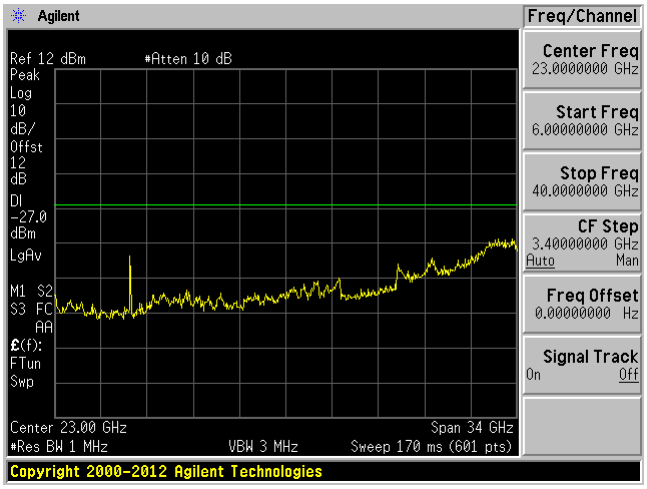
Low Channel 5745 MHz (6-40GHz)



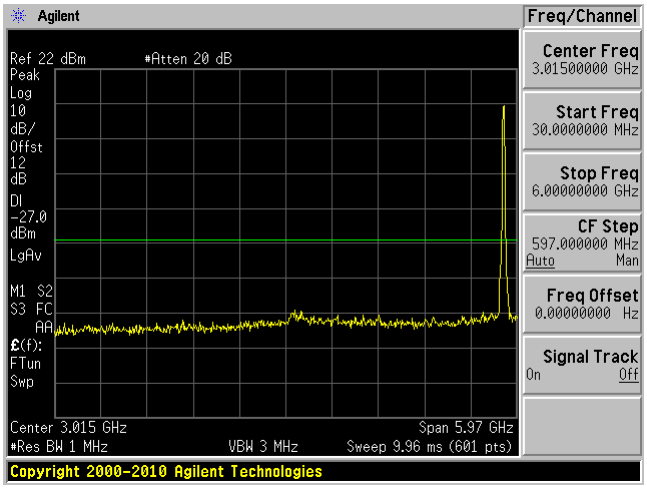
Middle Channel 5785 MHz (30MHz-6GHz)



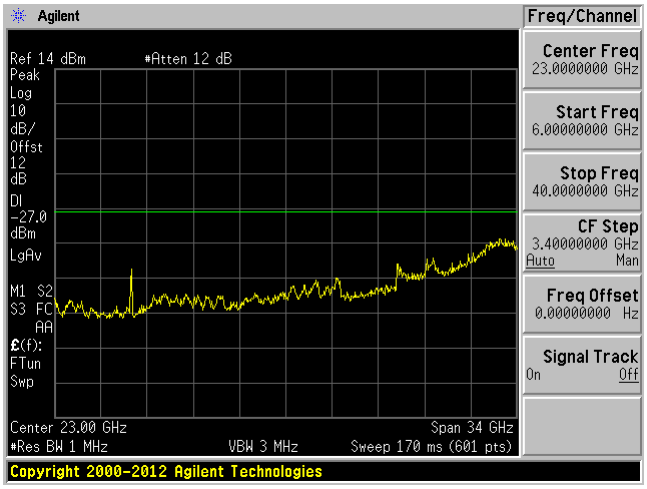
Middle Channel 5785 MHz (6-40GHz)



High Channel 5825 MHz (30MHz-6GHz)



High Channel 5825 MHz (6-40GHz)



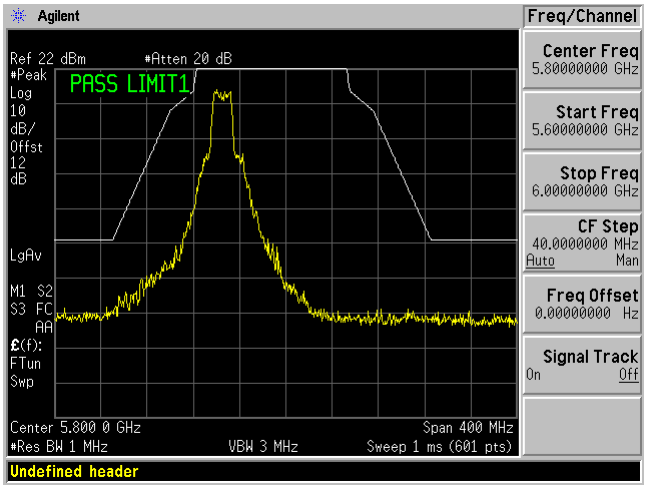
Band Edge Emissions

5725 – 5850 MHz

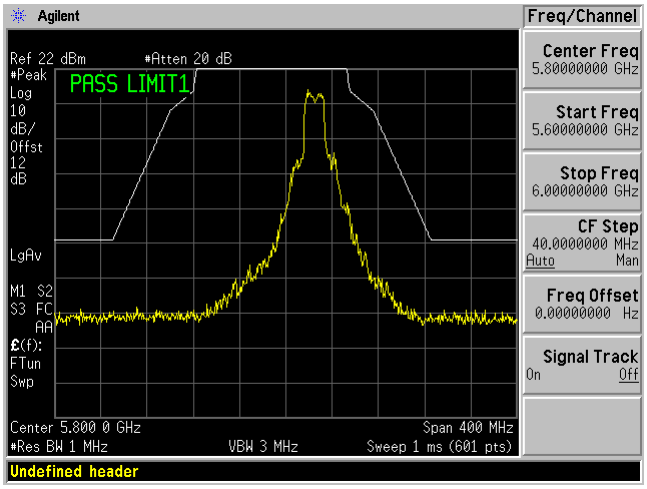
FCC Emission Mask

802.11a mode

5745 MHz

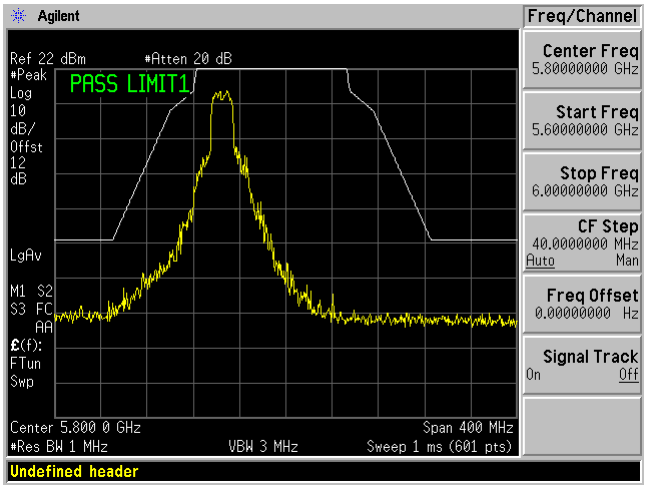


5825 MHz

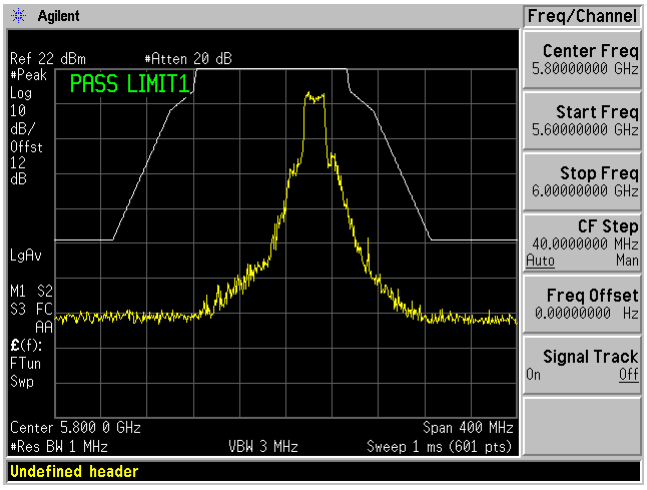


802.11n20 mode

5745 MHz

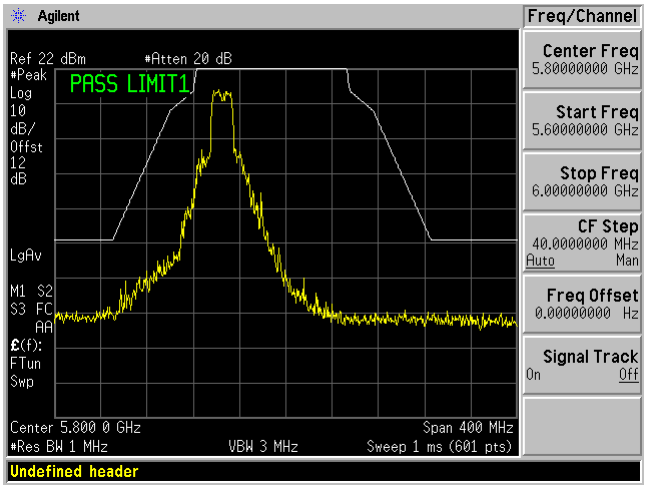


5825 MHz

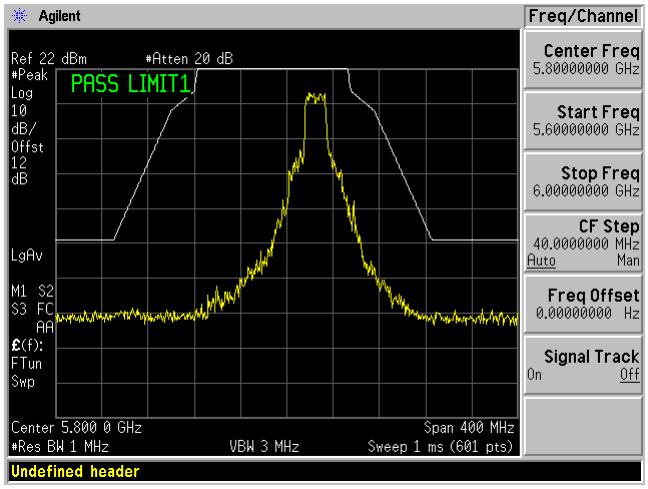


802.11ac20 mode

5745 MHz



5825 MHz



12 Annex A (Normative) – EUT Test Setup Photographs

Please refer to the attachment.

13 Annex B (Normative) – EUT External Photographs

Please refer to the attachment.

14 Annex C (Normative) – EUT Internal Photographs

Please refer to the attachment.

15 Annex D (Normative) - A2LA Electrical Testing Certificate

Accredited Laboratory

A2LA has accredited

BAY AREA COMPLIANCE LABORATORIES CORP.

Sunnyvale, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *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

--- END OF REPORT ---