RADIO TEST REPORT

Product	:	Gigabit Broadband Router
Model Name	:	Vigor 2915ac, Vigor 2915Fac
FCC ID	:	VGY2915
Test Regulation	:	FCC 47 CFR Part 15 Subpart E (Section 15.407)
Received Date	:	Feb. 25, 2019
Test Date	:	Jul. 1, 2019 ~ Jan 22, 2020
Issued Date	:	Mar. 10, 2020
Applicant	:	DrayTek Corp. No.26 Fu Shing Rd., HuKou County, Hsin-Chu Industrial Park, Hsin-Chu, Taiwan 303 R.O.C
Issued By	:	Underwriters Laboratories Taiwan Co., Ltd. Building B and Building E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan

Testing Laboratory
3398

The results reported herein have been performed in accordance with the laboratory's terms of accreditation. This report shall not be reproduced except in full without the written approval of the Laboratory. The results in this report are responsible of the test sample(s) provided by the client only and are not to be used to indicate applicability to other similar products.

REVISION HISTORY

Original Test Report No.: 4788854906-US-R1-V0

Rev.	Test report No.	Date	Page revised	Contents
Original	4788854906-US-R1-V0	Feb. 18, 2020	-	Initial issue
-	4788854906-US-R1-V0	Mar. 9, 2020	P.8	Added S/N number
-	4788854906-US-R1-V0	Mar. 10, 2020	P.8	Modify max output powers

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1. Attestation of Test Results

APPLICANT:	DrayTek Corp. No.26 Fu Shing Rd., HuKou County, Hsin-Chu Industrial Park, Hsin-Chu, Taiwan 303 R.O.C
MANUFACTURER	DrayTek Corp. No.26 Fu Shing Rd., HuKou County, Hsin-Chu Industrial Park, Hsin-Chu, Taiwan 303 R.O.C
EUT DESCRIPTION:	Gigabit Broadband Router
BRAND:	DrayTek
MODEL:	Vigor2915ac, Vigor2915Fac
SAMPLE STAGE:	Production Unit
DATE of TESTED:	Jul. 1, 2019 ~ Jan 22, 2020

APPLICABLE STANDARDS	
STANDARD	**Test Results**
FCC 47 CFR PART 15 Subpart E (Section 15.407)	PASS

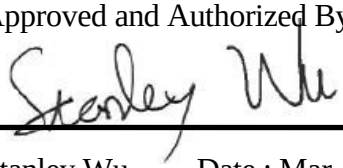
Underwriters Laboratories Taiwan Co., Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by Underwriters Laboratories Taiwan Co., Ltd. based on interpretations and/or observations of test results. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by Underwriters Laboratories Taiwan Co., Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Underwriters Laboratories Taiwan Co., Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Prepared By:

Cindy Hsin Date : Mar. 10, 2020
Project Handler

Approved and Authorized By:



Stanley Wu Date : Mar. 10, 2020
Senior Project Engineer

2. Summary of Test Results

Summary of Test Results		
FCC Clause	**Test Items**	**Result**
15.407(e)	6dB Bandwidth	PASS
15.403(i)	26dB Bandwidth	PASS
2.1049	Occupied Bandwidth	See Note2
15.407(a)(1/2/3)	Conducted Output Power	PASS
15.407(a)(1/2/3)	Power Spectral Density	PASS
15.407(g)	Frequency Stability	PASS
15.407(b) (1/2/3/4(i/ii)/6)	Radiated Emissions and Band Edge Measurement	PASS
15.407(b)(6)	AC Power Conducted Emission	PASS
15.203	Antenna Requirement	PASS

Note:
1. For the Radiated Band Edge and OOBE test plots were recorded in Appendix I, the Radiated Emissions test plots were recorded in Appendix II.
2. The Occupied Bandwidth was reference only.

3. Test Methodology and Reference Procedures

The tests documented in this report were performed in accordance with 47 CFR FCC Part 2, KDB 789033 D02 General UNII Test Procedure New Rules v02r01, KDB414788 D01 Radiated Test Site v01r01, ANSI C63.10-2013 and KDB 662911 D01 Multiple Transmitter Output v02r01.

4. Facilities and Accreditation

Test Location	Underwriters Laboratories Taiwan Co., Ltd.
Address	Building B and Building E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan
Accreditation Certificate	Underwriters Laboratories Taiwan Co., Ltd. is accredited by TAF, Laboratory Code 3398. The full scope of accreditation can be viewed at http://accreditation.taftw.org.tw/taf/public/basic/viewApplyItems.action?unitNo=3398

5. Measurement Uncertainty

For statement of conformity, accuracy method (Section 8.2.4 and 8.2.5 of ISO Guide 98-4) was applied as decision rule for measurement in this test report.

The following uncertainties have been calculated to provide a confidence level of 95 % using a coverage factor k=2.

Test Item	Measurement Frequency Range	K	U(dB)
Conducted disturbance at mains terminals ports	0.15MHz ~ 30MHz	2	1.7
RF Conducted	9 kHz - 40GHz	2	1.0
Radiated disturbance below 30MHz	9 kHz - 30 MHz	2	2.2
Radiated disturbance below 1 GHz	30MHz ~ 1GHz	2	5.3
Radiated disturbance above 1GHz	1GHz ~ 40GHz	2	4.8

6. Equipment under Test

6.1. Description of EUT

Product	Gigabit Broadband Router	
Brand Name	DrayTek	
Model Name	Vigor2915ac, Vigor2915Fac	
S/N	Vigor2915ac: 195001DAA95B734 Vigor2915Fac: 195001DAA95B7A8	
Operating Frequency	5180 ~ 5240 MHz, 5745 ~ 5825 MHz	
Modulation	256QAM, 64QAM, 16QAM, QPSK, BPSK	
Transfer Rate	802.11a: up to 54 Mbps 802.11n: up to MCS15 802.11ac: up to MCS9	
Number of Channel	5180 ~ 5240 MHz	4 for 802.11a, 802.11n (HT20), 802.11ac (VHT20)
		2 for 802.11n (HT40), 802.11 ac (VHT40)
		1 for 802.11ac (VHT80)
	5745 ~ 5825 MHz	5 for 802.11a, 802.11n (HT20), 802.11ac (VHT20)
		2 for 802.11n (HT40), 802.11 ac (VHT40)
		1 for 802.11ac (VHT80)
Maximum Output Power	For CDD Mode : 5180 ~ 5240 MHz: 27.45dBm 5745 ~ 5825 MHz: 25.63dBm For Beamforming Mode : 5180 ~ 5240 MHz: 27.53dBm 5745 ~ 5825 MHz: 26.47dBm	
Normal Voltage	12Vdc from Adapter	
Hardware Version	V2915 V0A	
Software Version	r79916_beta	

Note:

1. The models difference table as below:

Main Model	Function	
	WAN1	
	RJ45	Fiber
Vigor2915ac	V	-
Vigor2915Fac	-	V

- The above models are market segmented by customer statements. The difference between models is the combination of hardware design and appearance, and there are no changes in RF-related parts.

2. The EUT incorporates a MIMO function. Physically, the EUT provides two completed transmitters and two receivers.

Modulation Mode	Tx,Rx Function
802.11a	2TX, 2RX
802.11n (HT20)	2TX, 2RX
802.11n (HT40)	2TX, 2RX
802.11ac (VHT20)	2TX, 2RX
802.11ac (VHT40)	2TX, 2RX
802.11ac (VHT80)	2TX, 2RX

* The modulation and bandwidth are similar for 802.11n mode for HT20 / HT40 and 802.11ac mode for VHT20 / VHT40, therefore investigated worst case to representative mode in test report.

3. The EUT contains following accessory devices.

Product	Brand	Model	Description
Adapter	APD	WA-24Q12FG	Input: 100-40Vac, 0.7A, Output: 12Vdc, 2A 1.7meter, non-shielded cable, without ferrite core
RJ-45 Cable	N/A	N/A	Length:3m

4. The above EUT information is declared by manufacturer and for more detailed features description, please refer the manufacturer's or user's manual.

6.2. Channel List

FOR 5180 ~ 5240MHz

4 channels are provided for 802.11a, 802.11n (HT20), 802.11ac (VHT20):

Channel	Frequency	Channel	Frequency
36	5180 MHz	44	5220 MHz
40	5200 MHz	48	5240 MHz

2 channels are provided for 802.11n (HT40), 802.11ac (VHT40):

Channel	Frequency	Channel	Frequency
38	5190 MHz	46	5230 MHz

1 channel is provided for 802.11ac (VHT80):

Channel	Frequency
42	5210MHz

FOR 5745 ~ 5825MHz:

5 channels are provided for 802.11a, 802.11n (HT20), 802.11ac (VHT20):

Channel	Frequency	Channel	Frequency
149	5745MHz	161	5805MHz
153	5765MHz	165	5825MHz
157	5785MHz	-	-

2 channels are provided for 802.11n (HT40), 802.11ac (VHT40):

Channel	Frequency	Channel	Frequency
151	5755MHz	159	5795MHz

1 channel is provided for 802.11ac (VHT80):

Channel	Frequency
155	5775MHz

6.3. Test Condition

Test Item	Test Site No.	Environmental Condition	Input Power	Test Date	Tested by
Antenna Port Conducted Measurement	SR4	24~26°C / 63~67%RH	120Vac / 60 Hz	Jul. 11, 2019 ~Jan. 20, 2020	Wayne Chen / WaterNil Guan
Radiated Spurious Emission	966-2	23~27°C / 63~70%RH	120Vac / 60 Hz	Jul. 1, 2019 ~Jan. 22, 2020	Wayne Chen / WaterNil Guan
AC power Line Conducted Emission	SR1	23~26°C / 60~64%RH	120Vac / 60 Hz	Sep. 10, 2019 ~ Nov. 12, 2019	Will Chen

FCC Test Firm Registration Number: 498077

6.4. Description Of Available Antennas

Antenna	Brand Name	Model Name	Antenna Type	Antenna Gain(dBi)
Chain(0)	MAG. LAYERS	EDA-1313-25GR2-A9	Dipole	4.12
Chain(1)	MAG. LAYERS	EDA-1313-25GR2-A9	Dipole	4.12

Note: The above antenna information was provided from customer and for more detailed features description, please refer the manufacturer's specification or user's manual.

6.5. Test Mode Applicability and Tested Channel Detail

- Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
- For below 1 GHz radiated emission and AC power line conducted emission have performed all modes of operation were investigated and the worst-case emissions are reported.
- For Antenna Port Conducted Measurement, this item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
- The fundamental of the EUT was investigated in three orthogonal axes X/Y/Z, it was determined that X axis was worst-case . Therefore, all final radiated testing was performed with the EUT in X axis.
- For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel), parallel and perpendicular are the worst orientations, therefore testing was performed on these two orientations only.
- Pre-scan radiation has been determined by the Model: Vigor2915ac (worst case).
- For AC power line conducted emissions, pre-scan has been determined by AC power 120Vac (worst case)

CDD Mode

Model: Vigor2915ac

Test item	Mode	Frequency Band (MHz)	Modulation Technology	Available Channel	Test Channel	Data Rate
Radiated Emissions (Above 1GHz)	802.11a	5180-5240	OFDM	36 to 48	36, 44, 48	6.0
	802.11ac (VHT20)		OFDM	36 to 48	36, 44, 48	MCS0
	802.11ac (VHT40)		OFDM	38 to 46	38, 46	MCS0
	802.11ac (VHT80)		OFDM	42	42	MCS0
	802.11a	5745-5825	OFDM	149 to 165	149, 157, 165	6.0
	802.11ac (VHT20)		OFDM	149 to 165	149, 157, 165	MCS0
	802.11ac (VHT40)		OFDM	151 to 159	151, 159	MCS0
	802.11ac (VHT80)		OFDM	155	155	MCS0
Radiated Emissions (Below 1GHz)	802.11a	5745-5825	OFDM	149 to 165	149	6.0
AC Power Line Conducted Emission	802.11a	5745-5825	OFDM	149 to 165	149	6.0
Antenna Port Conducted Measurement	802.11a	5180-5240	OFDM	36 to 48	36, 44, 48	6.0
	802.11ac (VHT20)		OFDM	36 to 48	36, 44, 48	MCS0
	802.11ac (VHT40)		OFDM	38 to 46	38, 46	MCS0
	802.11ac (VHT80)		OFDM	42	42	MCS0
	802.11a	5745-5825	OFDM	149 to 165	149, 157, 165	6.0
	802.11ac (VHT20)		OFDM	149 to 165	149, 157, 165	MCS0
	802.11ac (VHT40)		OFDM	151 to 159	151, 159	MCS0
	802.11ac (VHT80)		OFDM	155	155	MCS0

Model: Vigor2915Fac

Test item	Mode	Frequency Band (MHz)	Modulation Technology	Available Channel	Test Channel	Data Rate
Radiated Emissions	802.11a	5745-5825	OFDM	149 to 165	149	6.0
AC Power Line Conducted Emission	802.11a	5745-5825	OFDM	149 to 165	149	6.0

Beamforming Mode

Model: Vigor2915ac

Test item	Mode	Frequency Band (MHz)	Modulation Technology	Available Channel	Test Channel	Data Rate
Radiated Emissions (Above 1GHz)	802.11ac (VHT20)	5180-5240	OFDM	36 to 48	36, 44, 48	MCS0 (Nss1)
	802.11ac (VHT40)		OFDM	38 to 46	38, 46	MCS0 (Nss1)
	802.11ac (VHT80)		OFDM	42	42	MCS0 (Nss1)
	802.11ac (VHT20)	5745-5825	OFDM	149 to 165	149, 157, 165	MCS0 (Nss1)
	802.11ac (VHT40)		OFDM	151 to 159	151, 159	MCS0 (Nss1)
	802.11ac (VHT80)		OFDM	155	155	MCS0 (Nss1)
Radiated Emissions (Below 1GHz)	802.11ac (VHT20)	5180-5240	OFDM	36 to 48	36	MCS0 (Nss1)
Antenna Port Conducted Measurement	802.11ac (VHT20)	5180-5240	OFDM	36 to 48	36, 44, 48	MCS0 (Nss1)
	802.11ac (VHT40)		OFDM	38 to 46	38, 46	MCS0 (Nss1)
	802.11ac (VHT80)		OFDM	42	42	MCS0 (Nss1)
	802.11ac (VHT20)	5745-5825	OFDM	149 to 165	149, 157, 165	MCS0 (Nss1)
	802.11ac (VHT40)		OFDM	151 to 159	151, 159	MCS0 (Nss1)
	802.11ac (VHT80)		OFDM	155	155	MCS0 (Nss1)

Model: Vigor2915Fac

Test item	Mode	Frequency Band (MHz)	Modulation Technology	Available Channel	Test Channel	Data Rate
Radiated Emissions	802.11ac (VHT20)	5180-5240	OFDM	36 to 48	36	MCS0 (Nss1)

Co-Location Mode

Model: Vigor2915ac & Model: Vigor2915Fac

Test item	Mode	Modulation Technology	Modulation Type	Available Channel	Test Channel	Data Rate
Radiated Emissions	802.11b	DSSS	DBPSK	1 to 11	1+149	1.0
	802.11a	OFDM	BPSK	36 to 48		6.0
				149 to 165		

6.6. Duty cycle

CDD Mode

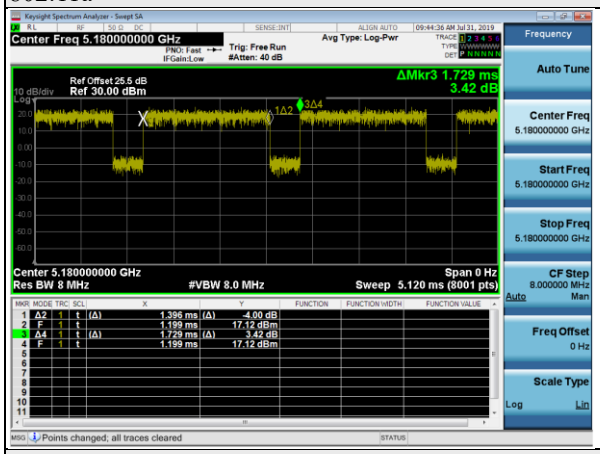
802.11a: Duty cycle = 1.396/1.729 = 0.807, Duty factor = 10 * log(1/0.807) = 0.93

802.11ac (VHT20): Duty cycle = 0.664/0.9878 = 0.672, Duty factor = 10 * log(1/0.672) = 1.73

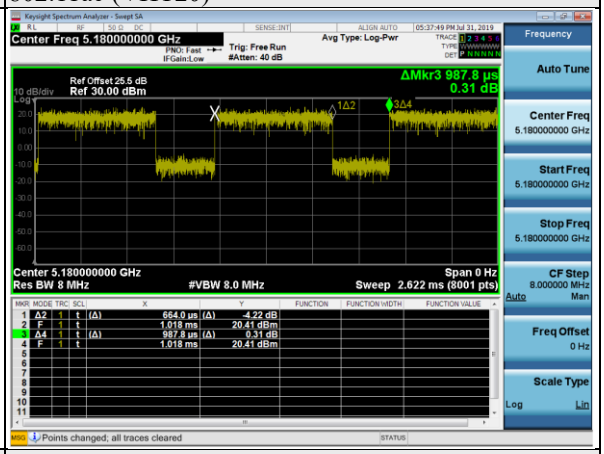
802.11ac (VHT40): Duty cycle = 0.3359/0.668 = 0.503, Duty factor = 10 * log(1/0.503) = 2.99

802.11ac (VHT80): Duty cycle = 0.5437/0.563 = 0.966, Duty factor = 10 * log(1/0.966) = 0.15

802.11a



802.11ac (VHT20)



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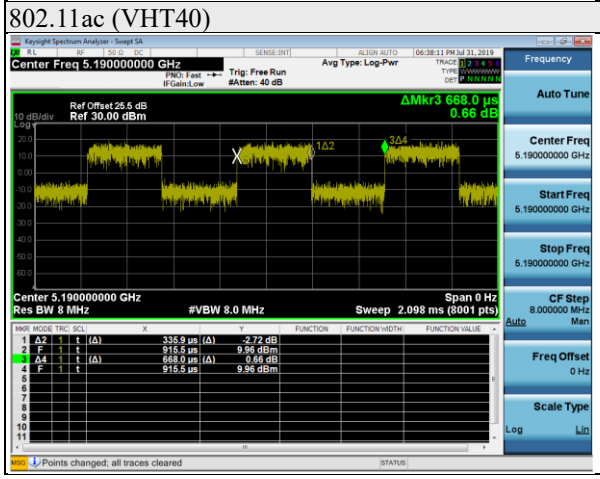
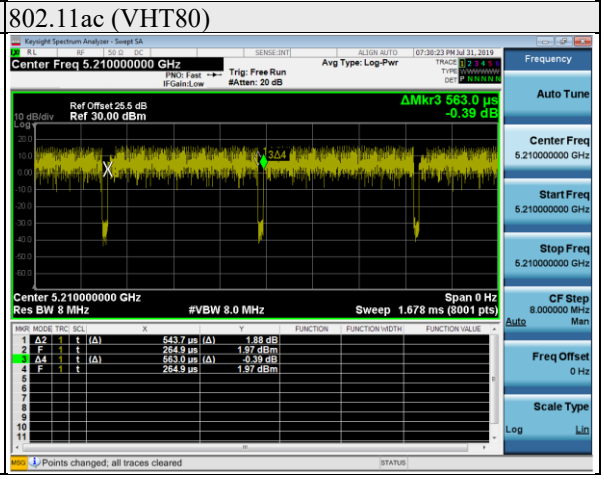


802.11ac (VHT80)



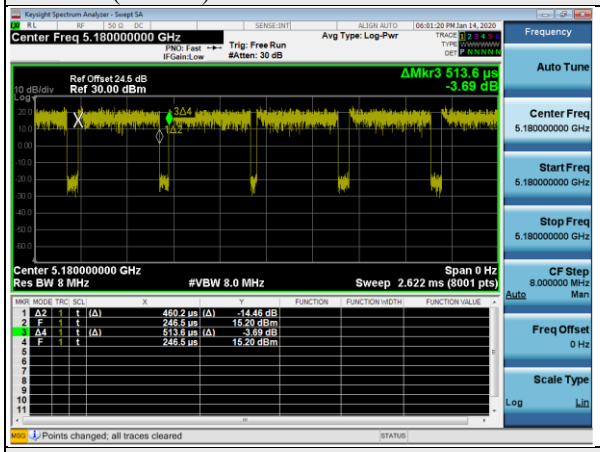
Beamforming Mode

802.11ac (VHT20): Duty cycle = 0.4602/0.5136 = 0.896, Duty factor = 10 * log(1/0.896) = 0.48

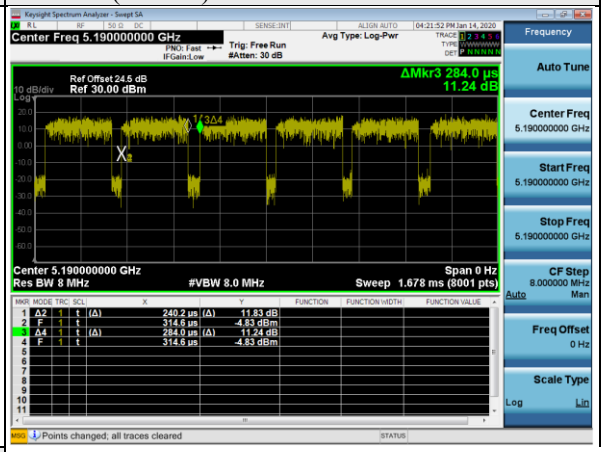
802.11ac (VHT40): Duty cycle = 0.2402/0.284 = 0.846, Duty factor = 10 * log(1/0.846) = 0.73

802.11ac (VHT80): Duty cycle = 0.08912/0.1498 = 0.595, Duty factor = 10 * log(1/0.595) = 2.26

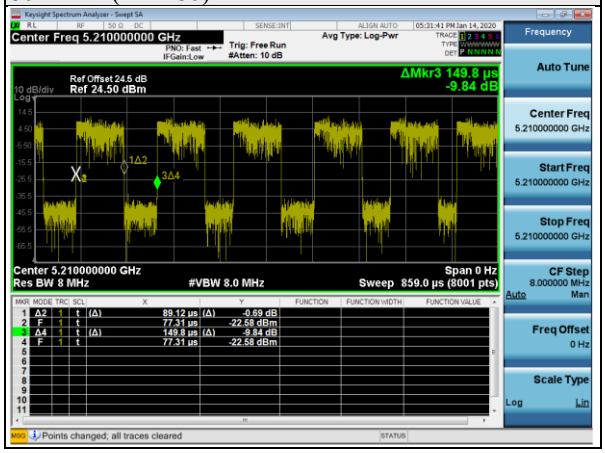
802.11ac (VHT20)



802.11ac (VHT40)



802.11ac (VHT80)



7. Test Equipment

Test Equipment List					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Cal. Date**	**Cal. Interval**
Radiated Spurious Emission					
Spectrum Analyzer	Keysight	N9010A	MY56070827	Nov. 8, 2018 Nov. 13, 2019	1 year
EMI Test Receiver	Rohde & Schwarz	ESR7	101754	Nov. 8, 2018 Dec. 17, 2019	1 year
Loop Antenna	ETS lindgren	6502	00213440	Dec. 11, 2018 Dec. 19, 2019	1 year
Trilog-Broadband Antenna with 5dB Attenuator	Schwarzbeck & EMCI	VULB 9168 & N-6-05	774 & AT-N0538	Jan. 14, 2019 Jan. 3, 2020	1 year
Horn Antenna (1-18 GHz)	Schwarzbeck	BBHA 9120 D	01690	Jan. 25, 2019	1 year
Horn Antenna (18-40 GHz)	Schwarzbeck	BBHA 9170	781	Jan.16, 2019 Dec. 27, 2019	1 year
Preamplifier (30-1000 MHz)	EMCI	EMC330E	980405	Jan.30, 2019	1 year
Preamplifier (1-18 GHz)	EMCI	EMC051835BE	980406	Jan.29, 2019	1 year
Preamplifier (18-40GHz)	EMCI	EMC184040SEE	980426	May 8, 2019	1 year
RF Cable (9 KHz~18 GHz)	UltraPhase & EMC Instrument	A1K50-UP0358-A1K50-1500&EMC106-NM-SM-2500/7000	170111-4&170219/170102	Jan. 29, 2019	1 year
RF Cable (18 GHz~40 GHz)	UltraPhase	K1K50-UP0264-K1K50-2500/2500/600	170214-2/170214-6/170111-1	Jan. 29, 2019	1 year

Test Equipment List					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Cal. Date**	**Cal. Interval**
Antenna Port Conducted Measurement					
Spectrum Analyzer	Keysight	N9010A	MY56070834	Nov. 8, 2018 Nov. 6, 2019	1 year
Pulse Power Sensor	Anrisu	MA2411B	1531202	Dec. 17, 2018 Dec.23,2019	1 year
Power Meter	Anrisu	ML2495A	1645002	Dec.17,2018 Dec.23,2019	1 year
Temperature &Humidity Test Chamber	GIANT FORCE	GTH-150- 40-CP-AR	MAA1701-010	Apr. 3, 2019	1 year
AC power Line Conducted Emission					
EMI Test Receiver	Rohde & Schwarz	ESR7	101753	Nov. 14, 2018 Nov. 19, 2019	1 year
Two-Line V-Network	Rohde & Schwarz	ENV216	102136	Aug. 5, 2018 Aug. 8, 2019	1 year
Impuls-Begrenzer Pulse Limiter	Rohde & Schwarz	ESH3-Z2	102219-Qt	Aug. 2, 2018 Aug. 6, 2019	1 year
Cables	HARBOUR INDUSTRIES	LL142	170205-5000-1	Jan. 29, 2019	1 year

UL Software		
Description	**Name**	**Version**
Radiated measurement	EZ_EMC	1.1.4.2
Conducted measurement	Keysight.TestSystem	1.0.0.0
AC power Line Conducted Emission	EZ_EMC	1.1.4.2

8. Description of Test Setup

Support Equipment

Equipment	Brand Name	Model Name	S/N	Remark
Notebook	DELL	Latitude E5470	3JFKWF2	N/A
Notebook	DELL	Latitude E5470	JVSKWF2	N/A
Connector	N/A	N/A	N/A	RJ-45 to RJ-45
USB Device	Transcend	N/A	N/A	8GB
Fiber Module	Fiberpon	SFP+10G-T	N/A	N/A
Rx Device (BF Client)	DrayTek	Vigor2915ac	N/A	FW: 4.0.2_RC3
Rx Device (BF Client)	DrayTek	Vigor2915Fac	N/A	FW: 4.0.2_RC3

I/O Cables

Equipment	Brand Name	Model Name	S/N	Remark
RJ-45 cable	N/A	N/A	N/A	Length : 10m
RJ-45 cable	N/A	N/A	N/A	Length : 1.5m
RJ-45 cable	N/A	N/A	N/A	Length : 1.5m
RJ-45 cable	N/A	N/A	N/A	Length : 1.5m
RJ-45 cable	N/A	N/A	N/A	Length : 1.5m
RJ-45 cable	N/A	N/A	N/A	Length : 1.5m

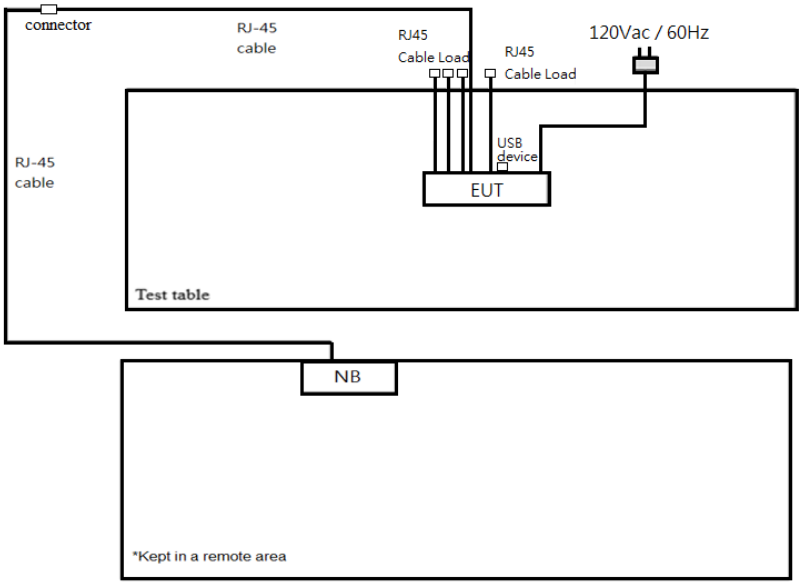
Test Setup

Controlled using a bespoke application (Teraterm469) on a test Notebook. The application was used to enable a continuous transmission mode and to select the test channels, data rates, modulation schemes and power setting as required.

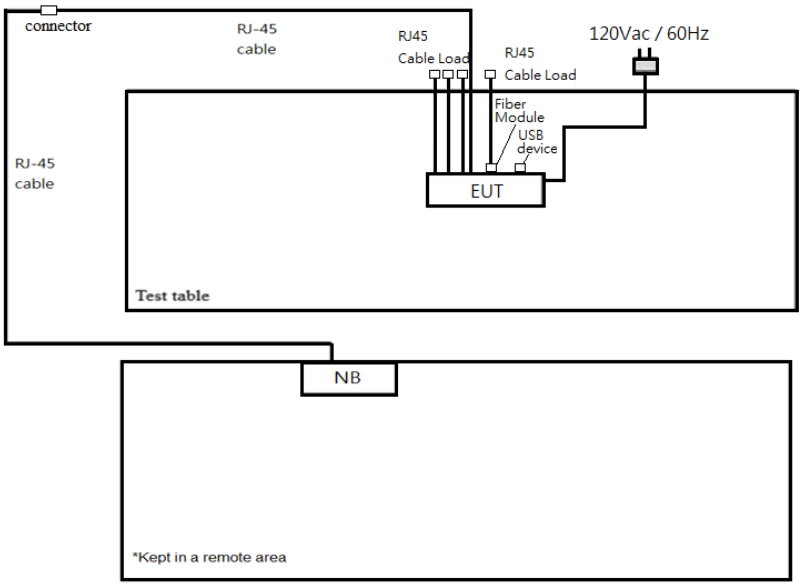
Setup Diagram for Test

CDD Mode

Vigor2915ac

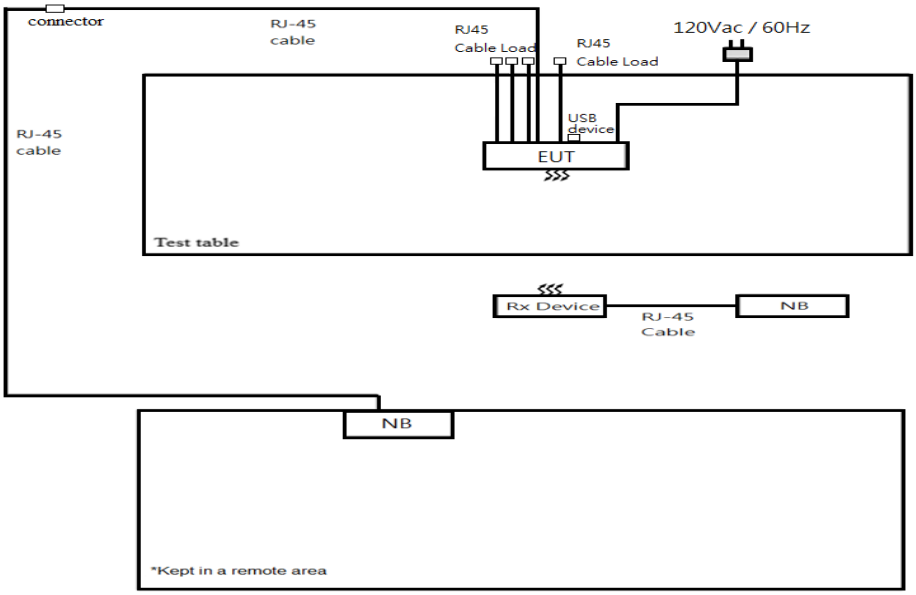


Vigor2915Fac

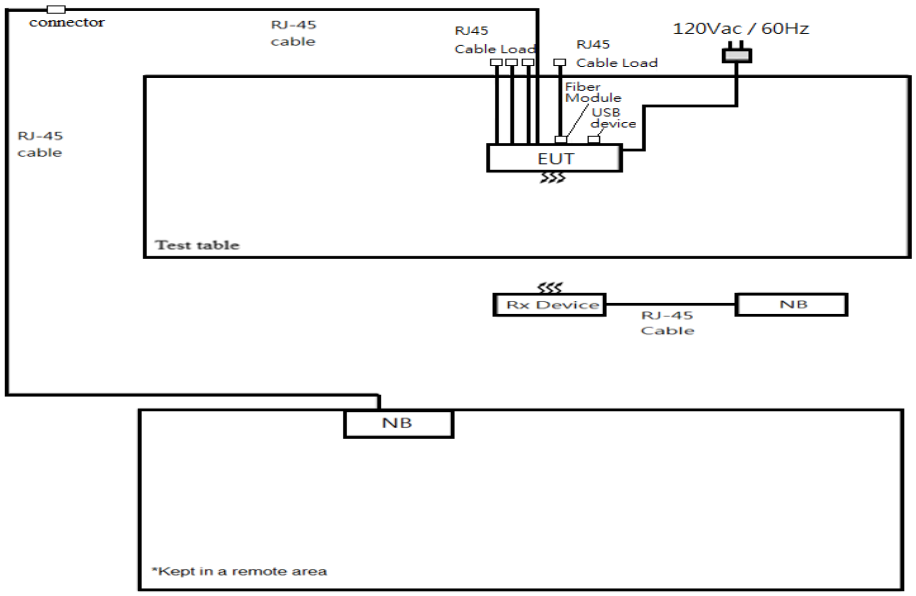


Beamforming Mode

Vigor2915ac



Vigor2915Fac



9. Test Results

9.1. 6dB Bandwidth

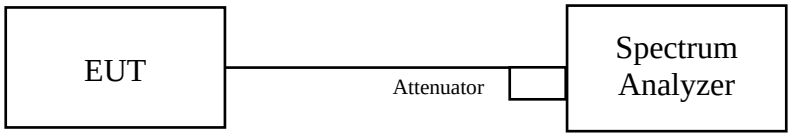
Requirements

The minimum 6 dB bandwidth shall be at least 500 kHz.

Test procedure

a. Set resolution bandwidth (RBW) = 100kHz
b. Set the video bandwidth (VBW) ≥ 3 x RBW, Detector = Peak.
c. Trace mode = max hold.
d. Sweep = auto couple.
e. Measure the maximum width of the emission that is constrained by the frequencies associated with the two amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

CDD Mode

802.11a

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)		Minimum Limit (MHz)	Pass / Fail
		Chain 0	Chain 1		
149	5745	12.998	15.086	0.5	Pass
157	5785	13.838	15.296	0.5	Pass
165	5825	15.090	15.011	0.5	Pass

802.11ac (VHT20)

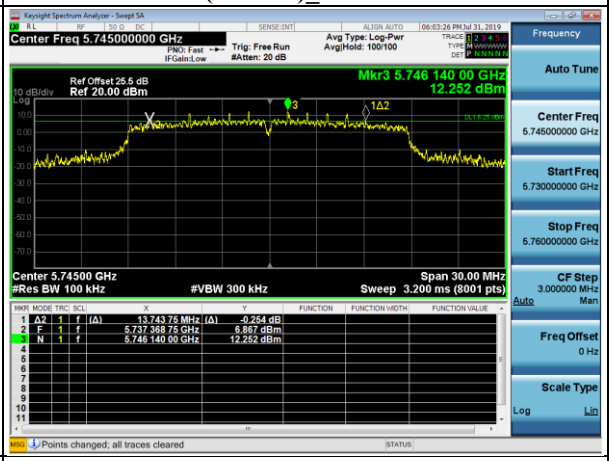
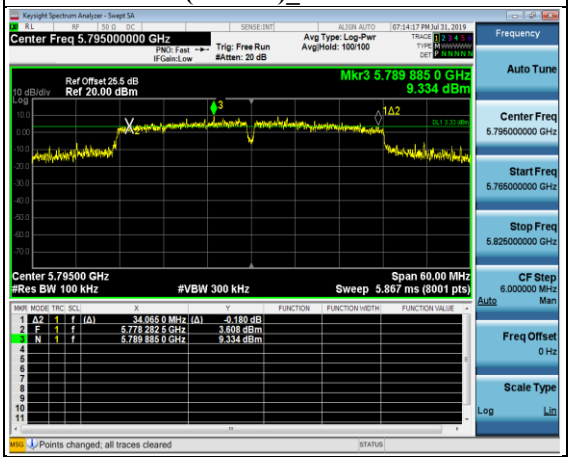
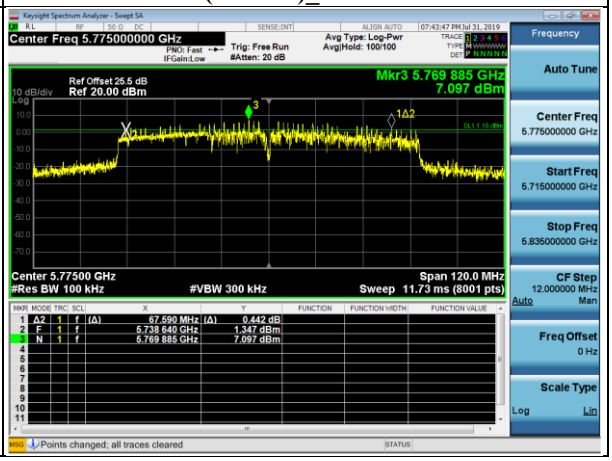
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)		Minimum Limit (MHz)	Pass / Fail
		Chain 0	Chain 1		
149	5745	13.744	13.834	0.5	Pass
157	5785	15.090	15.068	0.5	Pass
165	5825	13.819	15.090	0.5	Pass

802.11ac (VHT40)

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)		Minimum Limit (MHz)	Pass / Fail
		Chain 0	Chain 1		
151	5755	34.170	35.048	0.5	Pass
159	5795	34.065	34.973	0.5	Pass

802.11ac (VHT80)

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)		Minimum Limit (MHz)	Pass / Fail
		Chain 0	Chain 1		
155	5775	67.590	75.060	0.5	Pass

Spectrum Plot of Worst Value	
802.11a_Chain 0 / CH149	**802.11ac (VHT20)_Chain 0 / CH149**
	
802.11ac (VHT40)_Chain 0 / CH159	**802.11ac (VHT80)_Chain 0 / CH155**
	

Beamforming Mode

802.11ac (VHT20)

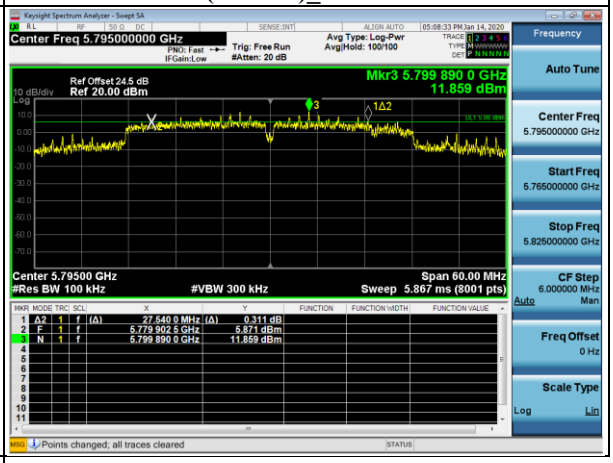
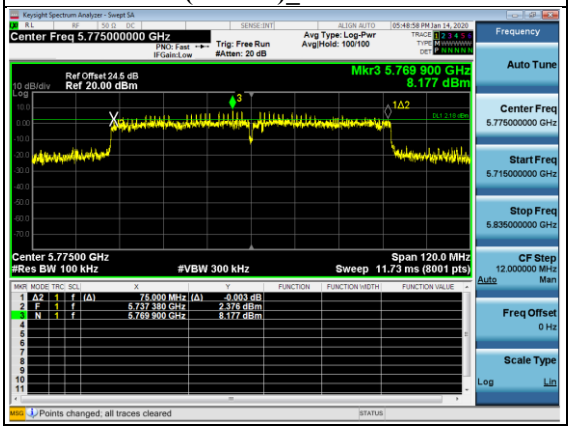
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)		Minimum Limit (MHz)	Pass / Fail
		Chain 0	Chain 1		
149	5745	17.554	15.124	0.5	Pass
157	5785	17.531	16.988	0.5	Pass
165	5825	16.883	17.310	0.5	Pass

802.11ac (VHT40)

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)		Minimum Limit (MHz)	Pass / Fail
		Chain 0	Chain 1		
151	5755	33.848	35.018	0.5	Pass
159	5795	27.540	36.113	0.5	Pass

802.11ac (VHT80)

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)		Minimum Limit (MHz)	Pass / Fail
		Chain 0	Chain 1		
155	5775	75.000	75.780	0.5	Pass

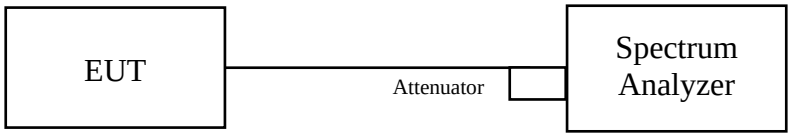
Spectrum Plot of Worst Value	
802.11ac (VHT20)_Chain 1 / CH149	**802.11ac (VHT40)_Chain 0 / CH159**
	
802.11ac (VHT80)_Chain 0 / CH155	
	

9.2. 26dB Bandwidth

Test procedure

a. Set RBW = approximately 1% of the emission bandwidth.
b. Set the VBW > RBW.
c. Detector = Peak.
d. Trace mode = max hold.
e. Measure the maximum width of the emission that is 26 dB down from the peak of the emission. Compare this with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is approximately 1%.

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

CDD Mode

802.11a

CHANNEL	CHANNEL FREQUENCY (MHz)	26 dB Bandwidth (MHz)		PASS / FAIL
		CHAIN 0	CHAIN 1	
36	5180	19.87	19.66	PASS
44	5220	37.87	37.14	PASS
48	5240	37.11	35.47	PASS

802.11ac (VHT20)

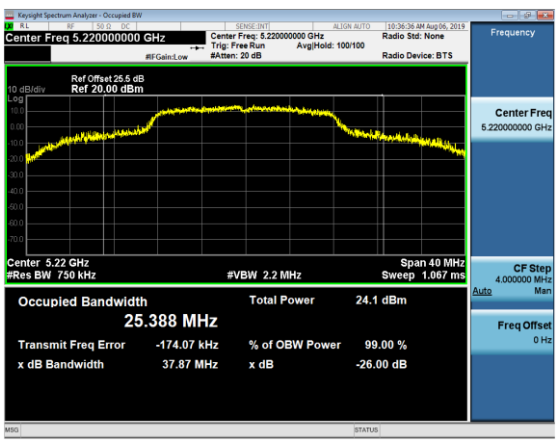
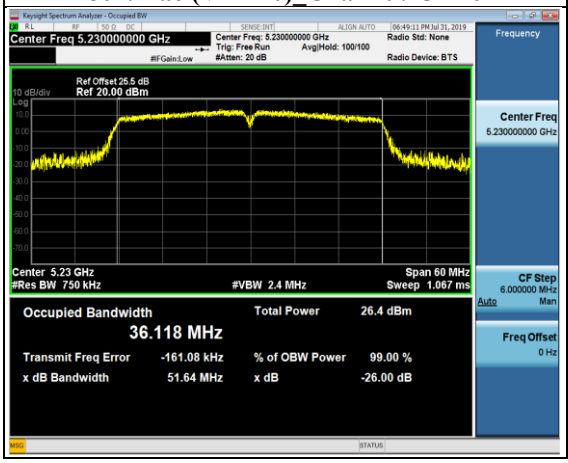
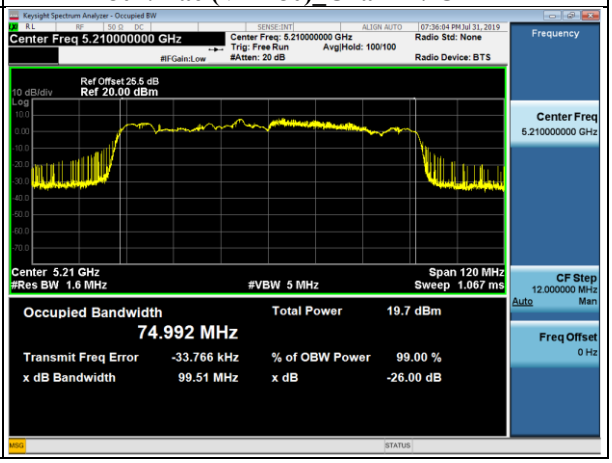
CHANNEL	CHANNEL FREQUENCY (MHz)	26 dB Bandwidth (MHz)		PASS / FAIL
		CHAIN 0	CHAIN 1	
36	5180	20.18	20.16	PASS
44	5220	38.91	37.83	PASS
48	5240	38.53	38.25	PASS

802.11ac (VHT40)

CHANNEL	CHANNEL FREQUENCY (MHz)	26 dB Bandwidth (MHz)		PASS / FAIL
		CHAIN 0	CHAIN 1	
38	5190	40.68	40.28	PASS
46	5230	51.64	44.15	PASS

802.11ac (VHT80)

CHANNEL	CHANNEL FREQUENCY (MHz)	26 dB Bandwidth (MHz)		PASS / FAIL
		CHAIN 0	CHAIN 1	
42	5210	99.45	99.51	PASS

Spectrum Plot of Worst Value	
802.11a_Chain 0 / CH44	**802.11ac (VHT20)_Chain 0 / CH44**
	
802.11ac (VHT40)_Chain 0 / CH46	**802.11ac (VHT80)_Chain 1 / CH42**
	

Beamforming Mode

802.11ac (VHT20)

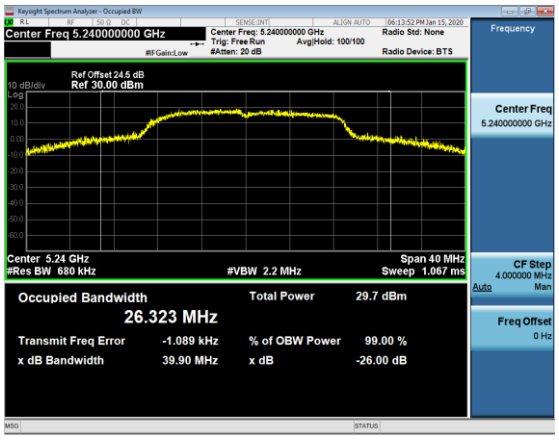
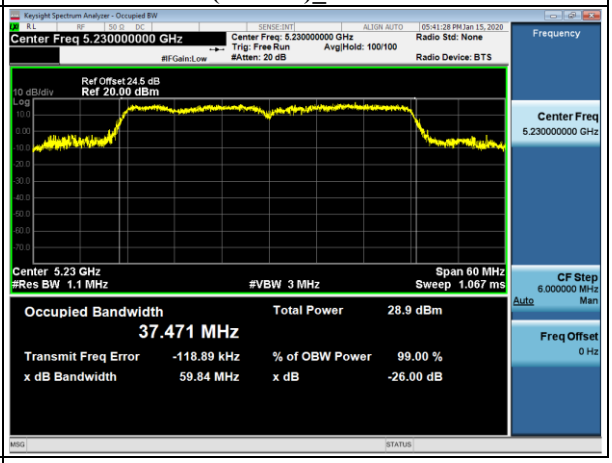
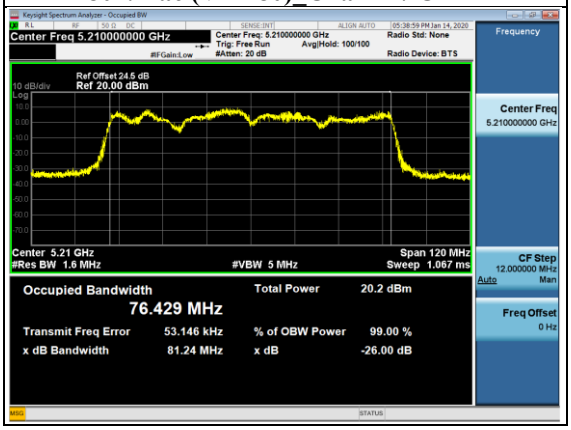
CHANNEL	CHANNEL FREQUENCY (MHz)	26 dB Bandwidth (MHz)		PASS / FAIL
		CHAIN 0	CHAIN 1	
36	5180	20.59	20.29	PASS
44	5220	39.63	37.71	PASS
48	5240	39.9	39.26	PASS

802.11ac (VHT40)

CHANNEL	CHANNEL FREQUENCY (MHz)	26 dB Bandwidth (MHz)		PASS / FAIL
		CHAIN 0	CHAIN 1	
38	5190	41.09	40.63	PASS
46	5230	59.84	53.83	PASS

802.11ac (VHT80)

CHANNEL	CHANNEL FREQUENCY (MHz)	26 dB Bandwidth (MHz)		PASS / FAIL
		CHAIN 0	CHAIN 1	
42	5210	81.18	81.24	PASS

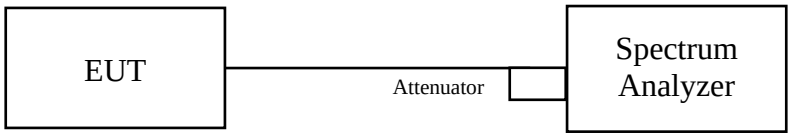
Spectrum Plot of Worst Value	
802.11ac (VHT20)_Chain 0 / CH48	**802.11ac (VHT40)_Chain 0 / CH46**
	
802.11ac (VHT80)_Chain 1 / CH42	
	

9.3. Occupied Bandwidth

Test procedure

a. Set center frequency to the nominal EUT channel center frequency.
b. Set span = 1.5 times to 5.0 times the OBW.
c. Set RBW = 1% to 5% of the OBW
d. Set VBW ≥ 3 x RBW
e. Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.
f. Use the 99% power bandwidth function of the instrument (if available).
g. If the instrument does not have a 99% power bandwidth function, the trace data points are recovered and directly summed in power units. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% occupied bandwidth is the difference between these two frequencies.

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

CDD Mode

802.11a

Channel	Channel Frequency (MHz)	Occupied Bandwidth (MHz)	
		CHAIN 0	CHAIN 1
36	5180	16.555	16.457
44	5220	21.774	20.478
48	5240	19.985	18.329
149	5745	17.17	16.588
157	5785	16.991	16.683
165	5825	17.159	16.704

802.11ac (VHT20)

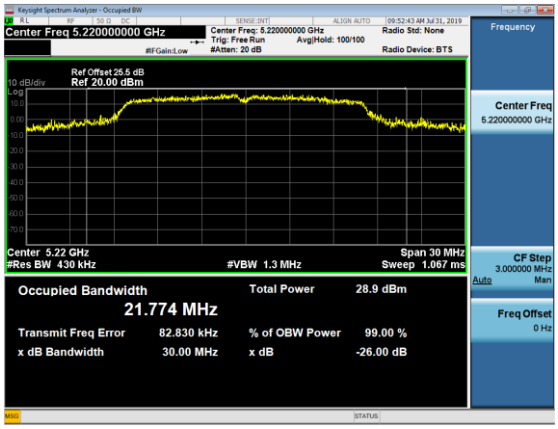
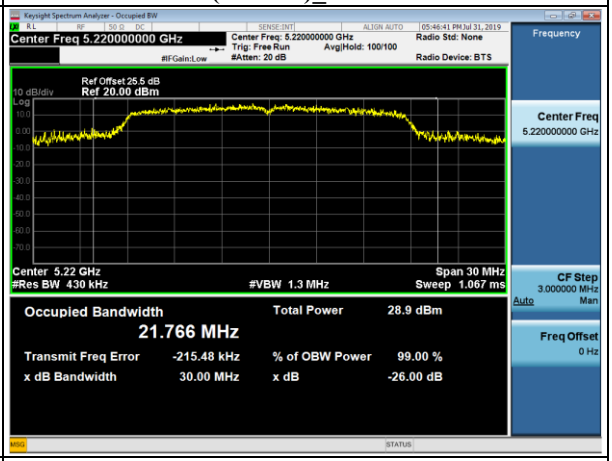
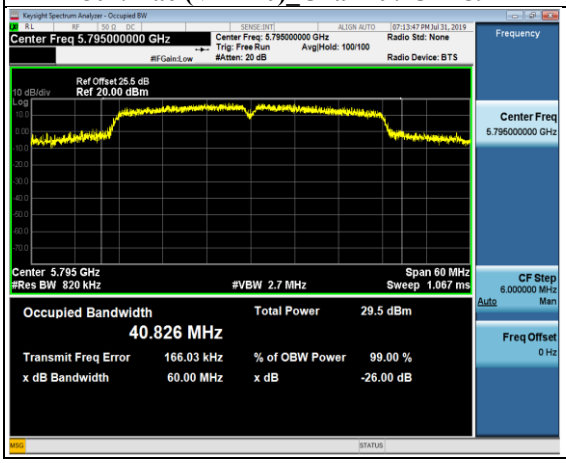
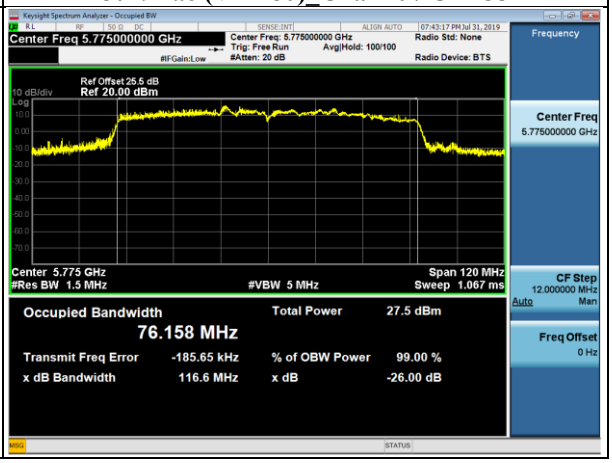
Channel	Channel Frequency (MHz)	Occupied Bandwidth (MHz)	
		CHAIN 0	CHAIN 1
36	5180	17.624	17.637
44	5220	21.766	20.099
48	5240	19.768	18.803
149	5745	18.148	17.733
157	5785	18.027	17.756
165	5825	18.141	17.836

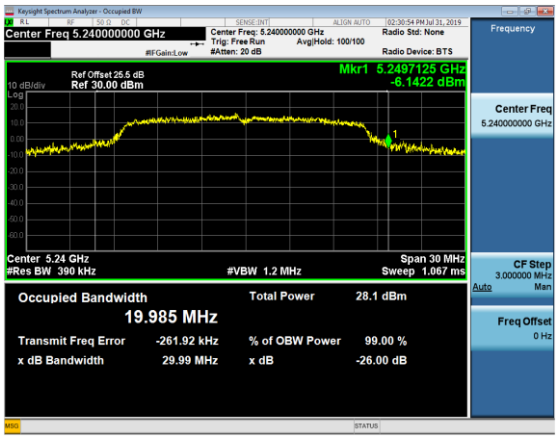
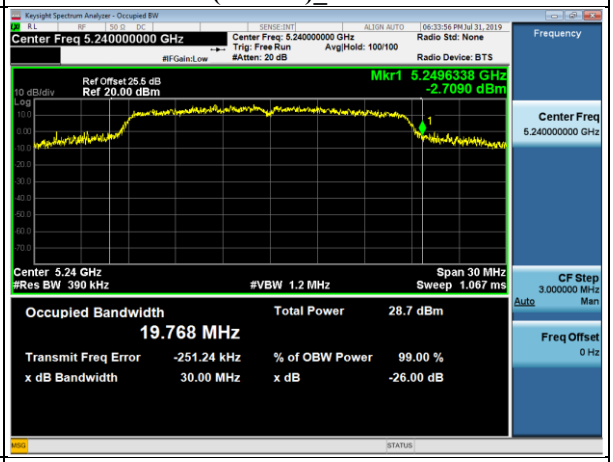
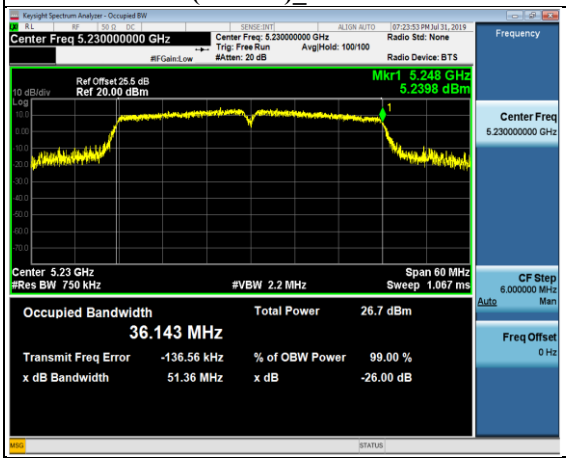
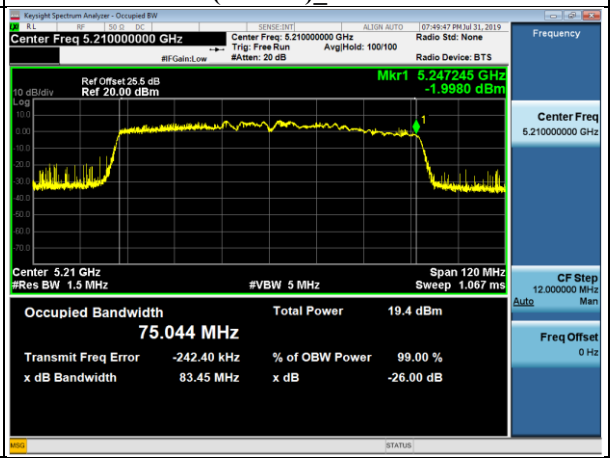
802.11ac (VHT40)

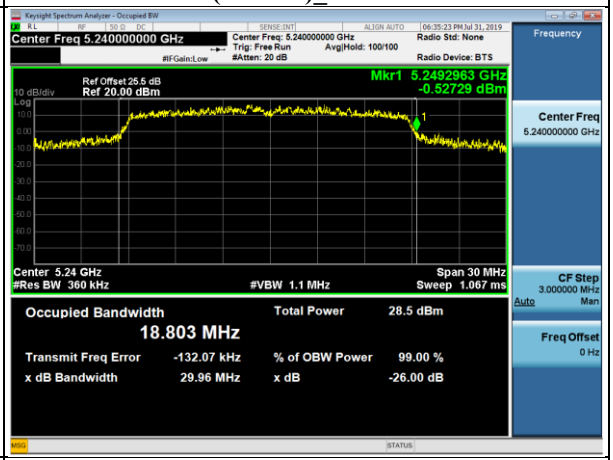
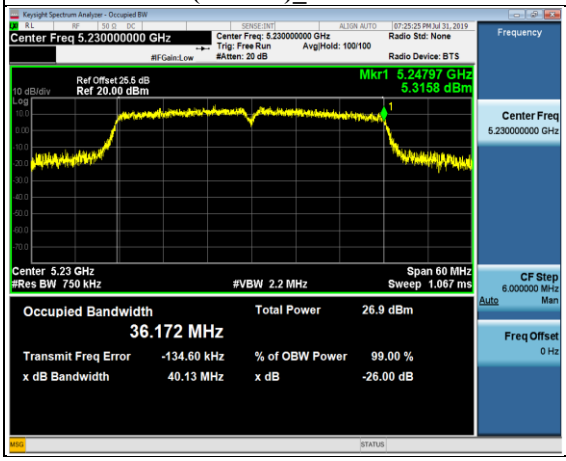
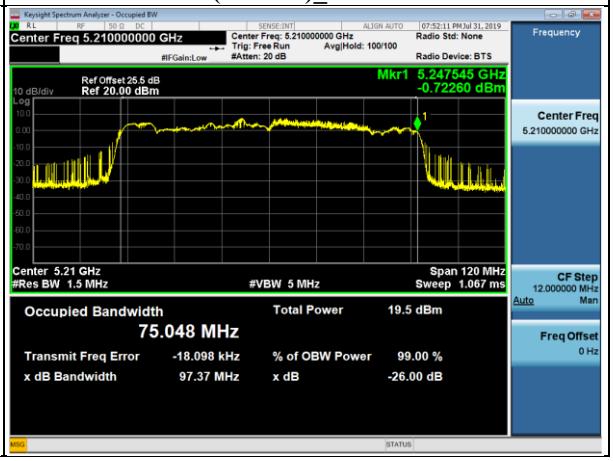
Channel	Channel Frequency (MHz)	Occupied Bandwidth (MHz)	
		CHAIN 0	CHAIN 1
38	5190	36.015	36.055
46	5230	36.143	36.172
151	5755	36.734	36.071
159	5795	40.826	36.961

802.11ac (VHT80)

Channel	Channel Frequency (MHz)	Occupied Bandwidth (MHz)	
		CHAIN 0	CHAIN 1
42	5210	75.044	75.048
155	5775	76.158	76.001

Spectrum Plot of Worst Value	
802.11a_Chain 0 / CH44	**802.11ac (VHT20)_Chain 0 / CH44**
	
802.11ac (VHT40)_Chain 0 / CH159	**802.11ac (VHT80)_Chain 0 / CH155**
	

Spectrum Plot for near by DFS band (DFS is required, if 99% OCP straddle into U-NII-2A band)	
802.11a_Chain 0 / CH48	**802.11ac (VHT20)_Chain 0 / CH48**
	
802.11ac (VHT40)_Chain 0 / CH46	**802.11ac (VHT80)_Chain 0 / CH42**
	

Spectrum Plot for near by DFS band (DFS is required, if 99% OCP straddle into U-NII-2A band)	
802.11a_Chain 1 / CH48	**802.11ac (VHT20)_Chain 1 / CH48**
	
802.11ac (VHT40)_Chain 1 / CH46	**802.11ac (VHT80)_Chain 1 / CH42**
	

Beamforming Mode

802.11ac (VHT20)

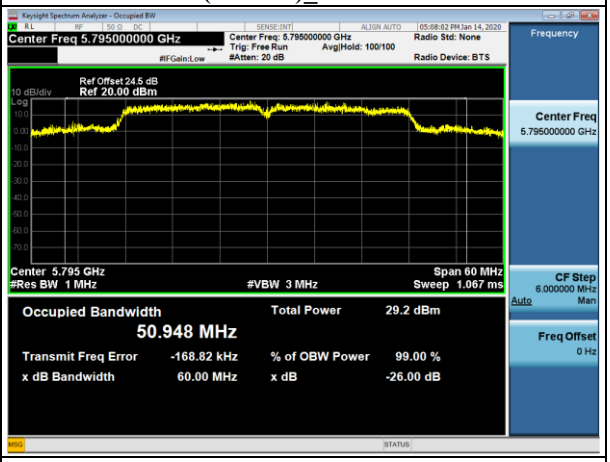
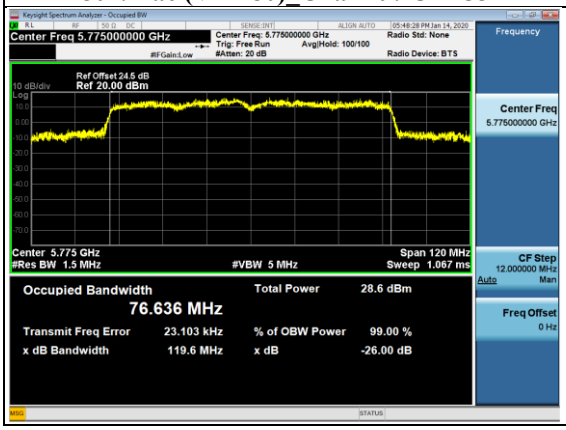
Channel	Channel Frequency (MHz)	Occupied Bandwidth (MHz)	
		CHAIN 0	CHAIN 1
36	5180	17.735	17.913
44	5220	21.764	18.798
48	5240	20.832	18.075
149	5745	25.468	21.691
157	5785	25.543	22.547
165	5825	25.921	25.508

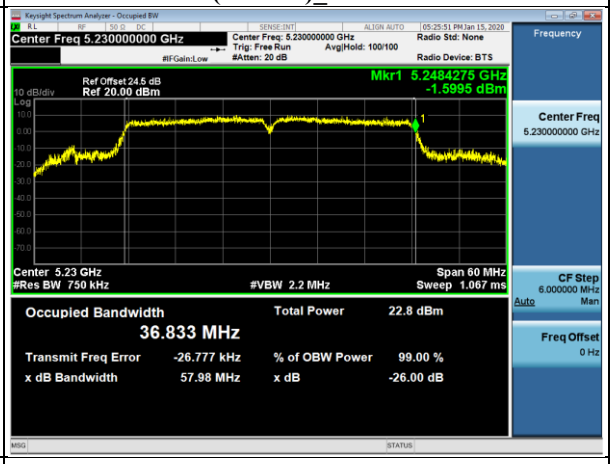
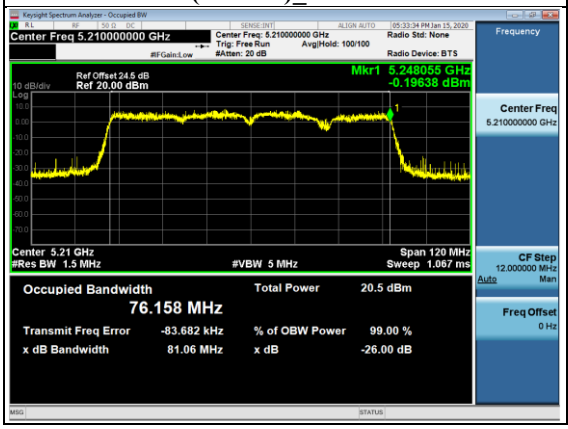
802.11ac (VHT40)

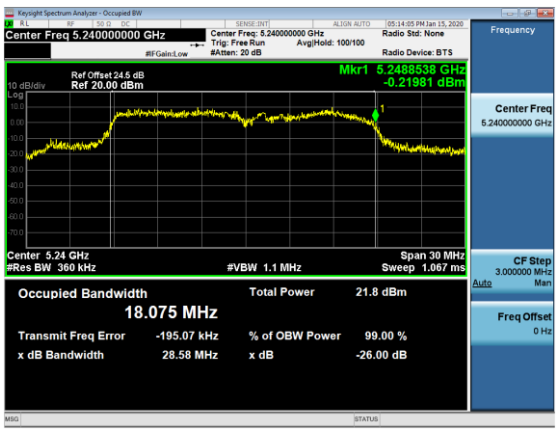
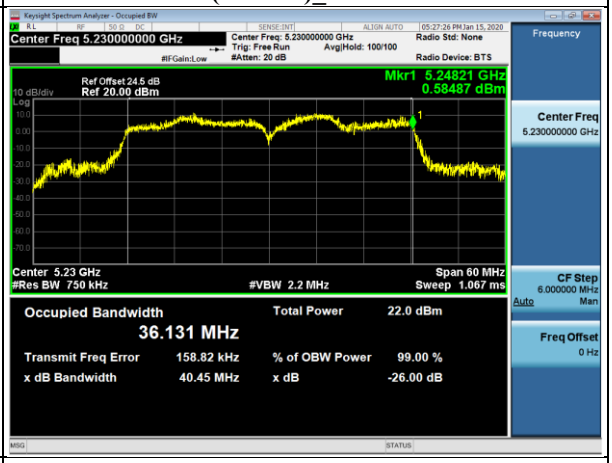
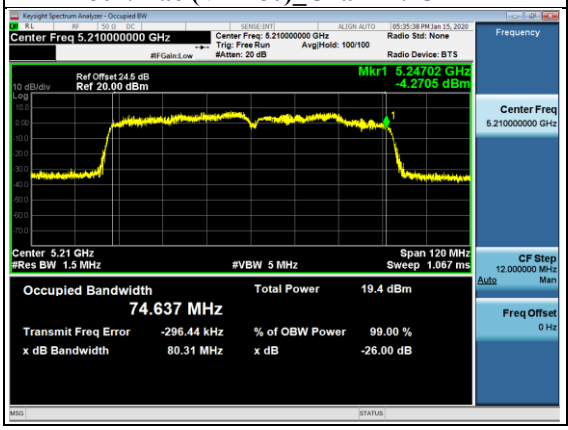
Channel	Channel Frequency (MHz)	Occupied Bandwidth (MHz)	
		CHAIN 0	CHAIN 1
38	5190	36.122	36.652
46	5230	36.833	36.131
151	5755	48.383	42.041
159	5795	50.948	46.538

802.11ac (VHT80)

Channel	Channel Frequency (MHz)	Occupied Bandwidth (MHz)	
		CHAIN 0	CHAIN 1
42	5210	76.158	74.637
155	5775	76.636	76.369

Spectrum Plot of Worst Value	
802.11ac (VHT20)_Chain 0 / CH165	**802.11ac (VHT40)_Chain 0 / CH159**
	
802.11ac (VHT80)_Chain 0 / CH155	
	

Spectrum Plot for near by DFS band (DFS is required, if 99% OCP straddle into U-NII-2A band)	
802.11ac (VHT20)_Chain 0 / CH48	**802.11ac (VHT40)_Chain 0 / CH46**
	
802.11ac (VHT80)_Chain 0 / CH42	
	

Spectrum Plot for near by DFS band (DFS is required, if 99% OCP straddle into U-NII-2A band)	
802.11ac (VHT20)_Chain 1 / CH48	**802.11ac (VHT40)_Chain 1 / CH46**
	
802.11ac (VHT80)_Chain 1 / CH42	
	

9.4. Conducted output power

Requirements

Operation Band	EUT Category		Limit
U-NII-1		Outdoor Access Point	1 Watt (30 dBm) Max. e.i.r.p ≦ 125mW(21 dBm) at any elevation angle above 30 degrees as measured from the horizon If G_{TX} > 6 dBi, then P_{Out} = 30 – (G_{TX} – 6)
		Fixed point-to-point Access Point	1 Watt (30 dBm) If G_{TX} > 23 dBi, then P_{Out} = 30 – (G_{TX} – 23)
	√	Indoor Access Point	1 Watt (30 dBm) If G_{TX} > 6 dBi, then P_{Out} = 30 – (G_{TX} – 6)
		Client device	250mW (24 dBm) If G_{TX} > 6 dBi, then P_{Out} = 24 – (G_{TX} – 6)
U-NII-3	---		For Point-to-multipoint systems (P2M): 1 Watt (30 dBm). If G_{TX} > 6 dBi, then P_{Out} = 30 – (G_{TX} – 6) For Point-to-point systems (P2P): 1 Watt (30 dBm)

Note:
1. P_{Out} = maximum conducted output power in dBm,
2. G_{TX} = the maximum transmitting antenna directional gain in dBi.
3. Directional Gain = G_{ant} + 10 log (Nant) dBi.

   Nant: Number of Transmit Antennas
   G1, G2,..., Gn: Gain of Individual Antennas (Same for Each Antenna)

4. B is the 26 dB emission bandwidth in megahertz

   Per KDB 662911 Method of conducted output power measurement on IEEE 802.11 devices,

   Array Gain = 0 dB (i.e., no array gain) for $N_{ANT} \leq 4$;
   Array Gain = 0 dB (i.e., no array gain) for channel widths ≥ 40 MHz for any N_{ANT};
   Array Gain = 5 log(N_{ANT}/N_{SS}) dB or 3 dB, whichever is less for 20-MHz channel widths with $N_{ANT} \geq 5$.

   For power measurements on all other devices: Array Gain = 10 log(N_{ANT}/N_{SS}) dB.

Test Procedure

Test method PM-G

For 802.11a, 802.11ac (VHT20), 802.11ac (VHT40)

Method PM is used to perform output power measurement, trigger and gating function of wide band power meter is enabled to measure max output power of TX on burst and set the detector to AVERAGE. Duty factor is not added to measured value.

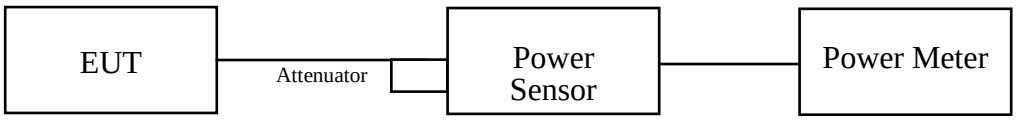
Test method SA-1

For 802.11ac (VHT80)

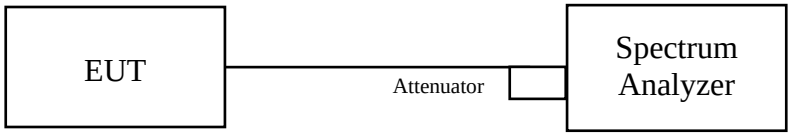
1) Set span to encompass the entire 26 dB EBW (or, alternatively, the entire 99% occupied bandwidth) of the signal.
2) Set sweep trigger*.
3) Set RBW = 1 MHz.
4) Set VBW ≥ 3 MHz
5) Number of points in sweep ≥ 2 Span / RBW.
6) Sweep time ≤ (number of points in sweep) * T
7) Using emission bandwidth to determine the frequency span for integration the channel bandwidth.
8) Detector = RMS.
9) Trace mode = max hold.
10) Allow max hold to run for at least 60 seconds, or longer as needed to allow the trace to stabilize.

* If transmit duty cycle < 98%, 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%, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to "free run."

Test Setup



The loss between RF output port of the EUT and the input port of the Power Meter has been taken into consideration.



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

CDD Mode

802.11a

CHAN.	FREQ. (MHz)	MAXIMUM CONDUCTED POWER (dBm)		TOTAL POWER (mW)	TOTAL POWER (dBm)	POWER LIMIT (dBm)	PASS / FAIL
		chain 0	chain 1				
36	5180	18.67	18.56	145.4	21.63	30	PASS
44	5220	24.46	24.39	554.043	27.44	30	PASS
48	5240	24.11	23.92	504.236	27.03	30	PASS
149	5745	21.83	17.96	214.922	23.32	30	PASS
157	5785	22.39	17.97	236.041	23.73	30	PASS
165	5825	22.36	17.95	234.56	23.70	30	PASS

802.11ac (VHT20)

CHAN.	FREQ. (MHz)	MAXIMUM CONDUCTED POWER (dBm)		TOTAL POWER (mW)	TOTAL POWER (dBm)	POWER LIMIT (dBm)	PASS / FAIL
		chain 0	chain 1				
36	5180	18.98	18.92	157.051	21.96	30	PASS
44	5220	24.47	24.41	555.956	27.45	30	PASS
48	5240	24.02	23.97	501.807	27.01	30	PASS
149	5745	23.05	19.52	291.373	24.64	30	PASS
157	5785	22.62	18.36	251.359	24.00	30	PASS
165	5825	22.83	18.37	260.574	24.16	30	PASS

802.11ac (VHT40)

CHAN.	FREQ. (MHz)	MAXIMUM CONDUCTED POWER (dBm)		TOTAL POWER (mW)	TOTAL POWER (dBm)	POWER LIMIT (dBm)	PASS / FAIL
		chain 0	chain 1				
38	5190	16.13	15.94	80.284	19.05	30	PASS
46	5230	21.89	21.65	300.743	24.78	30	PASS
151	5755	23.16	19.43	294.714	24.69	30	PASS
159	5795	24.46	19.36	365.552	25.63	30	PASS

802.11ac (VHT80)

CHAN.	CHAN. FREQ. (MHz)	MAXIMUM CONDUCTED POWER (dBm)		TOTAL POWER (mW)	TOTAL POWER (dBm)	POWER LIMIT (dBm)	PASS / FAIL
		chain 0	chain 1				
42	5210	13.67	13.45	45.412	16.57	30	PASS
155	5775	21.92	18.21	221.819	23.46	30	PASS

Beamforming Mode

802.11ac (VHT20)

CHAN.	FREQ. (MHz)	MAXIMUM CONDUCTED POWER (dBm)		TOTAL POWER (mW)	TOTAL POWER (dBm)	POWER LIMIT (dBm)	PASS / FAIL
		chain 0	chain 1				
36	5180	18.03	16.79	111.286	20.46	28.87	PASS
44	5220	24.58	24.46	566.332	27.53	28.87	PASS
48	5240	24.38	24.08	530.016	27.24	28.87	PASS
149	5745	24.98	21.11	443.897	26.47	28.87	PASS
157	5785	24.76	20.51	411.686	26.15	28.87	PASS
165	5825	24.58	20.24	392.76	25.94	28.87	PASS

NOTE: Directional gain = 7.13 dBi > 6 dBi, so the limit shall be reduced.

802.11ac (VHT40)

CHAN.	FREQ. (MHz)	MAXIMUM CONDUCTED POWER (dBm)		TOTAL POWER (mW)	TOTAL POWER (dBm)	POWER LIMIT (dBm)	PASS / FAIL
		chain 0	chain 1				
38	5190	16.35	14.71	72.732	18.62	28.87	PASS
46	5230	22.93	20.57	310.361	24.92	28.87	PASS
151	5755	24.37	20.76	392.651	25.94	28.87	PASS
159	5795	24.86	20.94	430.361	26.34	28.87	PASS

NOTE: Directional gain = 7.13 dBi > 6 dBi, so the limit shall be reduced.

802.11ac (VHT80)

CHAN.	CHAN. FREQ. (MHz)	MAXIMUM CONDUCTED POWER (dBm)		TOTAL POWER (mW)	TOTAL POWER (dBm)	POWER LIMIT (dBm)	PASS / FAIL
		chain 0	chain 1				
42	5210	13.69	12.49	41.13	16.14	28.87	PASS
155	5775	21.33	18.47	206.138	23.14	28.87	PASS

NOTE: Directional gain = 7.13 dBi > 6 dBi, so the limit shall be reduced.

9.5. Power Spectral Density

Requirements

Operation Band	EUT Category		Limit
U-NII-1		Outdoor Access Point	17dBm/ MHz If G_{TX} > 6 dBi, then PSD = 17 – (G_{TX} – 6)
		Fixed point-to-point Access Point	17dBm/ MHz If G_{TX} > 23 dBi, then PSD = 17 – (G_{TX} – 23)
	√	Indoor Access Point	17dBm/ MHz If G_{TX} > 6 dBi, then PSD = 17 – (G_{TX} – 6)
		Client device	11dBm/ MHz If G_{TX} > 6 dBi, then PSD = 11 – (G_{TX} – 6)
U-NII-3	---		For Point-to-multipoint systems (P2M): 30dBm/ 500kHz. If G_{TX} > 6 dBi, then PSD = 30 – (G_{TX} – 6) For Point-to-point systems (P2P): 30dBm/ 500kHz

Note:
1. PSD = power spectral density that he same method as used to determine the conducted output power shall be used to determine the power spectral density. And power spectral density in dBm/MHz
2. G_{TX} = the maximum transmitting antenna directional gain in dBi.
3. Directional Gain = G_{ant} + 10 log (Nant) dBi.

   Nant: Number of Transmit Antennas
   G1, G2,..., Gn: Gain of Individual Antennas (Same for Each Antenna)

Test procedure

For U-NII-1 band:

Using method SA-2_with Duty cycle <98 %

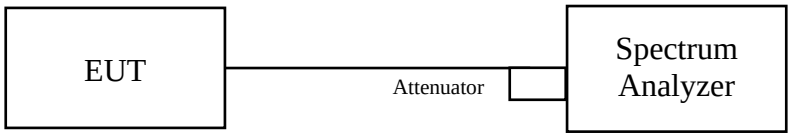
1. Set span to encompass the entire emission bandwidth (EBW) of the signal.
2. Set RBW = 1 MHz, Set VBW ≥ 3 RBW, Detector = RMS
3. Sweep time = auto, trigger set to “free run”.
4. Trace average at least 100 traces in power averaging mode.
5. Record the max value and add 10 log (1/duty cycle)

For U-NII-3:

with Duty cycle <98 %

1. Set span to encompass the entire emission bandwidth (EBW) of the signal.
2. Set RBW = 300 kHz, Set VBW ≥ 1 MHz, Detector = RMS
3. Use the peak marker function to determine the maximum power level in any 300 kHz band segment within the fundamental EBW.
4. Scale the observed power level to an equivalent value in 500 kHz by adjusting (reducing) the measured power by a bandwidth correction factor (BWCF) where BWCF = 10log(500 kHz/300kHz)
5. Sweep time = auto, trigger set to “free run”.
6. Trace average at least 100 traces in power averaging mode.
7. Record the max value and add 10 log (1/duty cycle)

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

For U-NII-1 band

CDD Mode

802.11a

CHAN.	CHAN. FREQ. (MHz)	PSD (dBm)		TOTAL PSD with duty factor (dBm)	MAX. LIMIT (dBm)	PASS / FAIL
		CHAIN 0	CHAIN 1			
36	5180	-2.858	-1.584	1.77	15.87	PASS
44	5220	2.853	2.364	6.56	15.87	PASS
48	5240	1.989	0.447	5.23	15.87	PASS

Note:

1. Method a) of power density measurement of KDB 662911 is using for calculating total power density. Total power density is summing entire spectra across corresponding frequency bins on the various outputs by computer.
2. Directional gain = 7.13 dBi > 6 dBi, so the limit shall be reduced.
3. Refer to section 6.6 for duty cycle spectrum plot.

802.11ac (VHT20)

CHAN.	CHAN. FREQ. (MHz)	PSD (dBm)		TOTAL PSD with duty factor (dBm)	MAX. LIMIT (dBm)	PASS / FAIL
		CHAIN 0	CHAIN 1			
36	5180	-9.090	-9.510	-4.56	15.87	PASS
44	5220	-5.102	-2.485	1.14	15.87	PASS
48	5240	-4.957	-6.247	-0.82	15.87	PASS

1. Method a) of power density measurement of KDB 662911 is using for calculating total power density. Total power density is summing entire spectra across corresponding frequency bins on the various outputs by computer.
2. Directional gain = 7.13 dBi > 6 dBi, so the limit shall be reduced.
3. Refer to section 6.6 for duty cycle spectrum plot.

802.11ac (VHT40)

CHAN.	CHAN. FREQ. (MHz)	PSD (dBm)		TOTAL PSD with duty factor (dBm)	MAX. LIMIT (dBm)	PASS / FAIL
		CHAIN 0	CHAIN 1			
38	5190	-16.392	-19.082	-11.52	15.87	PASS
46	5230	-15.414	-19.856	-11.11	15.87	PASS

Note:

1. Method a) of power density measurement of KDB 662911 is using for calculating total power density. Total power density is summing entire spectra across corresponding frequency bins on the various outputs by computer.
2. Directional gain = 7.13 dBi > 6 dBi, so the limit shall be reduced.
3. Refer to section 6.6 for duty cycle spectrum plot.

802.11ac (VHT80)

CHAN.	CHAN. FREQ. (MHz)	PSD (dBm)		TOTAL PSD with duty factor (dBm)	MAX. LIMIT (dBm)	PASS / FAIL
		CHAIN 0	CHAIN 1			
42	5210	-6.327	-6.000	-3.00	15.87	PASS

Note:

1. Method a) of power density measurement of KDB 662911 is using for calculating total power density. Total power density is summing entire spectra across corresponding frequency bins on the various outputs by computer.
2. Directional gain = 7.13 dBi > 6 dBi, so the limit shall be reduced.
3. Refer to section 6.6 for duty cycle spectrum plot.

Spectrum Plot of Worst Value	
802.11a_Chain 0 / CH44	**802.11ac (VHT20)_Chain 1 / CH44**
	
802.11ac (VHT40)_Chain 0 / CH46	**802.11ac (VHT80)_Chain 1 / CH42**